A transformation grammar-based methodology for housing rehabilitation: meeting contemporary functional and ICT requirements

dwellings characterization and transformation rules

Sara Eloy | 2012

ABSTRACT

Title:	**A transformation grammar-based methodology for housing rehabilitation: meeting contemporary functional and ICT requirements**
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PhD:	Architecture
Supervisor:	Professor Doutor Arq. José Pinto Duarte
Co-supervisors:	Professora Doutora Arq. Isabel Plácido
	Professor Doutor Eng. Renato Nunes

This research starts from the premise that the future of the real estate market in Portugal will require the rehabilitation of existing residential areas in order to respond to new life-styles and dwelling requirements that have emerged in an era in which information plays a structuring role in society.

The goal of this research is the definition of design guidelines and a rehabilitation methodology to support architects involved in the process of adapting existing dwellings, allowing them to balance sustainability requirements and economic feasibility with new dwelling trends such as the incorporation and updating of Information Communication and Automation Technologies and the need to solve emerging conflicts affecting the use of space prompted by the introduction of new functions associated with such technologies.

In addition to defining a general methodology applicable to all the building types, the study focuses on a specific type, called "rabo-de-bacalhau" ("cod-tail"), built in Lisbon between 1945 and 1965 for which a specifc methodology has been generated. Both shape grammar and space syntax were used as part of the rehabilitation methodology as tools to identify and encode the principles and rules behind the adaptation of existing houses to new requirements.

Keywords: Housing Rehabilitation; Domotics; Information and Communication Technologies; Transformation Grammar; "Rabo-de-bacalhau"; Rehabilitation Methodology; Shape Grammar; Space Syntax; Information Society; New lifestyles.

RESUMO

Título: **Metodologia de reabilitação habitacional baseada numa gramática de transformação: resposta às exigências funcionais e de TIC contemporâneas**

Nome: Sara Eloy Cardoso Rodrigues Freire da Cruz

Doutoramento em: Arquitectura

Orientador: Professor Doutor Arq. José Pinto Duarte

Co-orientadores: Professora Doutora Arq. Isabel Plácido

Professor Doutor Eng. Renato Nunes

Esta investigação parte do pressuposto de que o futuro do mercado imobiliário em Portugal irá passar pela reabilitação e requalificação das áreas residenciais, de modo a responder aos novos modos de vida e exigências da habitação que surgiram numa era na qual a informação desempenha um papel estruturante na sociedade devido às novas tecnologias.

O objectivo desta investigação é a definição de uma metodologia de reabilitação que apoie os arquitectos na adaptação do parque habitacional existente, permitindo-lhes compatibilizar as exigências de sustentabilidade e de viabilidade económica com as novas tendências do "habitar" nomeadamente no que respeita à integração/actualização de Tecnologias da Informação, Comunicação e Automação e à necessidade de responder a conflitos emergentes no uso dos espaços originados pela introdução de novas funções associadas ao uso dessas tecnologias.

Para além da definição de uma metodologia geral aplicável a todos os edifícios, este estudo focou-se num tipo específico de edifício, designado na gíria profissional por "rabo-de-bacalhau", que foi construído em Lisboa entre 1945 e 1965 para o qual é proposta uma metodologia específica.

As gramáticas de forma e a sintaxe especial foram utilizadas como parte da metodologia de reabilitação enquanto formalismos para incorporar os princípios e regras definidos para a adaptação das habitações existentes às novas exigências.

Palavras chave: Reabilitação Habitacional; Domótica; Tecnologias de Informação, Comunicação; Gramática de transformação; "rabo-de-bacalhau"; Metodologia de reabilitação; Gramáticas da forma; Sintaxe espacial; Sociedade da Informação; Novos modos de vida.

This volume includes the appendix of the PhD thesis with the following sections:

- The analysis of the case study sample of "rabo-de-bacalhau" buildings,
- Step 1, 2 and 3 of the experiment;
- The transformation grammar rules;
- A dwelling transformation.

UNIVERSIDADE TÉCNICA DE LISBOA
INSTITUTO SUPERIOR TÉCNICO

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APPENDIX

Sara Eloy Cardoso Rodrigues Freire da Cruz

Supervisor: Doctor José Manuel Pinto Duarte
Co-Supervisor: Doctor Maria Isabel Plácido Barbosa
Co-Supervisor: Doctor Renato Jorge Caleira Nunes

Thesis approved in public session to obtain the PhD Degree in Architecture
Jury final classification: Pass with Merit

Jury

Chairperson:

Chairman of the IST Scientific Board

Members of the Committee:

Doctor Terry Weissman Knight, Full Professor, Massachusetts Institute of Technology

Doctor José Manuel Pinto Duarte, Full Professor, Faculdade de Arquitectura UTL

Doctor Teresa Frederica Tojal de Valsassina Heitor, Full Professor, Instituto Superior Técnico UTL

Doctor Renato Jorge Caleira Nunes, Assistant Professor, Instituto Superior Técnico UTL

Doctor Maria Alexandra de Lacerda Nave Alegre, Assistant Professor, Instituto Superior Técnico UTL

Doctor Maria Isabel Plácido Barbosa, Assistant Researcher, Laboratório Nacional de Engenharia Civil

Funding Institutions – Fundação para a Ciência e Tecnologia

2012

APPENDIX 1

Analysis of the case study sample

Front façade

Date: 1954

Number of floors: 8

Project authorship: Arch. António Manuel Bentes

Door of building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift and service lift; One staircase
Number of dwellings	14
Non habitable divisions	Condominium store-rooms Caretaker's home Parking space in the open space in the rear of the building Shops in the ground floor

Brief constructional characterization

Structure and foundations	Hydraulic and reinforced concrete walls reaching the ground floor. Upward the exterior structure is made of reinforced concrete frame (pillars, beams and slabs). Continuous foundations and in some cases isolated concrete foundations. Reinforced solid concrete slabs. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m, thicknesses of 0.4m including plaster. Side wall built from reinforced concrete with thicknesses of 0.2m in the last 4 floors and 0.3m in the remaining floors.
Interior walls	Partition walls between different dwellings and staircase partition walls - floor, ground floor, 1st and 2nd floor in solid header bond brick masonry and remaining floors in hollow header bond brick masonry. Partition walls between divisions - hollow stretcher bond brick masonry using cement and sand mortar (1/4): ground floor and 1st floor – solid header bond brick masonry; 2nd floor - double solid stretcher bond brick masonry; 3rd and 4th floor - solid stretcher bond brick masonry; 5th and 6th floor - hollow stretcher bond brick masonry.

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. Double window frames in one case resulting in a

Av. Roma, 47

Net floor area: 100.2m² | Gross floor area: 127m²

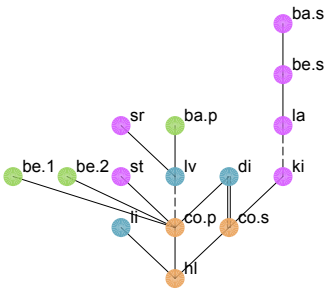
type **a**

Original dwelling

Floor plan

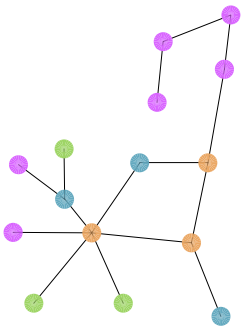
Justified graph

Graph with a tree configuration with 1 ring
Graph with 6 levels of depth
15 spaces/nodes
15 arcs/connections



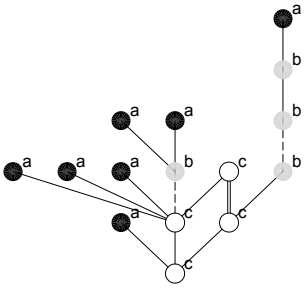
Social area
Private area
Circulation area
Service area

Convex map



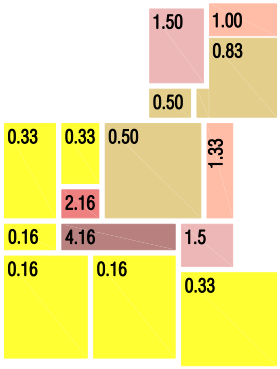
Social area
Private area
Circulation area
Service area

Distributness



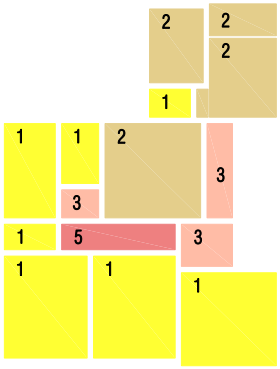
a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring

Controle

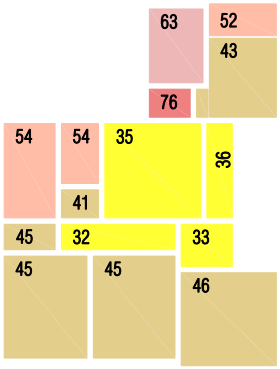


Entire dwelling
Mean: 1.00

Contiguity

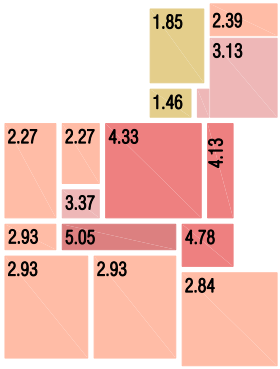


Depth



Entire dwelling
Mean: 46.66

Integration



Entire dwelling
Mean: 3.11

Adjacency (arcs)
merged
door (single)
door (double)
passage
window

Higher
Lower

1 2 3 4 5 10

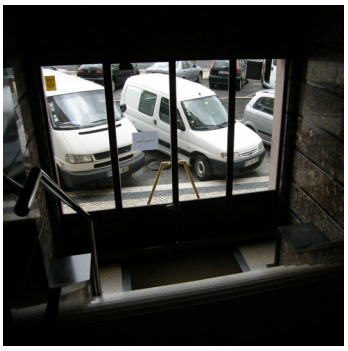
Front façade

Date: 1955

Number of floors: 9

Project authorship: Arch. n.154 (illegible signature)

Door of building



Building entrance hall

Brief functional characterization

Access	Two access to the building; main and service lift; one staircase
Number of dwellings	16
Non habitable divisions	Condominium store-rooms Caretaker's home

Brief constructional characterization

Structure and foundations	Hydraulic and reinforced concrete walls reaching the ground floor. Upward the exterior structure is made of reinforced concrete frame (pillars, beams and slabs). Continuous foundations and in some cases isolated concrete foundations. Reinforced solid concrete slabs. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m, thicknesses of 0.4m including plaster.
Interior walls	Partition walls between different dwellings and staircase partition walls - floor, ground floor, 1st and 2nd floor in solid header bond brick masonry and remaining floors in hollow header bond brick masonry. Partition walls between divisions - hollow stretcher bond brick masonry using cement and sand mortar (1/4): ground floor and 1st floor – solid header bond brick masonry; 2nd floor - double solid stretcher bond brick masonry; 3rd and 4th floor - solid stretcher bond brick masonry; 5th , 6th and 7th floor - hollow stretcher bond brick masonry.

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. 5 apartments with closed balconies. Few cables through the building's main façade.

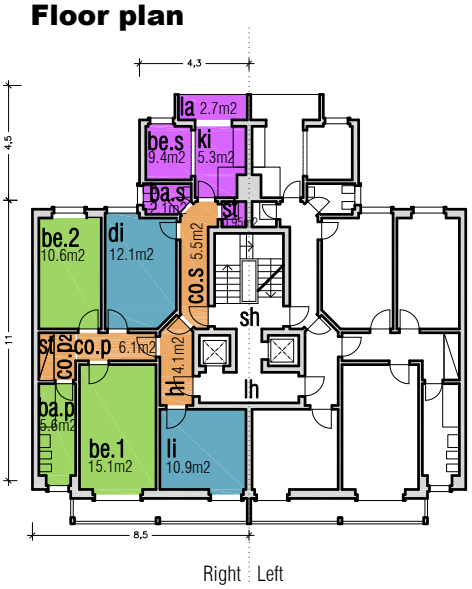
Av. Roma, 82

Net floor area: 85.1m² | Gross floor area: 103.m²

type **b**

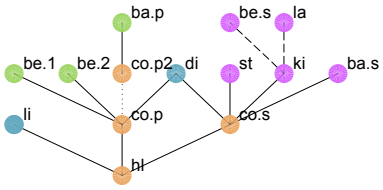
Original dwelling

Floor plan



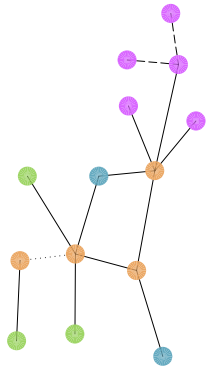
Justified graph

Graph with a tree configuration with 1 ring
Graph with 4 levels of depth
14 spaces/nodes
14 arcs/connections



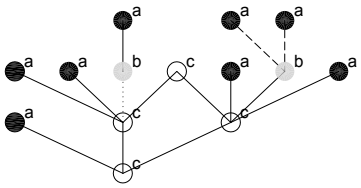
Social area
Private area
Circulation area
Service area

Convex map



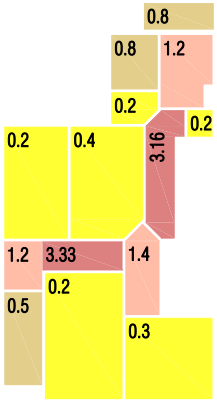
Social area
Private area
Circulation area
Service area

Distributness



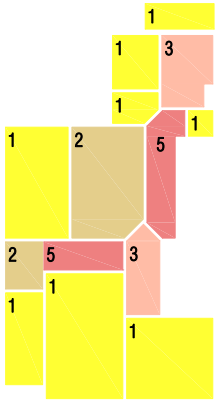
a _ terminal spaces
b _ reached by two or more arc
c _ reached by two or more arc and connected in a ring

Controle

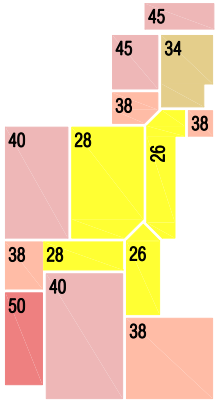


Entire dwelling
Mean: 1.00

Contiguity

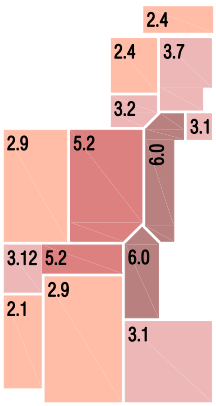


Depth



Entire dwelling
Mean: 36.7

Integration



Entire dwelling
Mean: 3.7

Adjacency (arcs)
merged
door (single)
door (double)
passage
window

Higher
Lower

1 2 3 4 5 10

Front façade

Date: 1955

Number of floors: 9

Project authorship: Arch. Joaquim Ferreira

Door of building

Building entrance hall

Brief functional characterization

Access	Two access to the building; main lift and service lift; one staircase.
Number of dwellings	16
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Structure is made of reinforced concrete frame (pillars, beams and slabs). Continuous foundations and in some cases isolated concrete foundations. Concrete slabs. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m, thicknesses of 0.35m including plaster. Exterior parament is covered with *marmorite*. Exterior openings are embellished with cut stone masonry and bottom parament is also covered with cut stone masonry (limestone - lioz). In balconies the protective panel consists of a low masonry wall with a wrought or cast iron enamel painted railing on top. Side walls in brick masonry, thicknesses of 0.25m. Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m, thicknesses of 0.35m including plaster.
Interior walls	Reinforced concrete beam structure on alternated floors. Partition walls between different dwellings and staircase partition walls - hollow header bond brick masonry. Partition walls between divisions - hollow stretcher bond brick masonry (in basement solid bricks were used). Interior walls have structure in beam and column, in alternate floors. Partitions and walls of the stairs tenants - brickwork stuck to since. Brickwork stuck to half time (in the basement is solid brick).

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. Double window frames resulting in a more advance window surface with aesthetic impact on the main façade. Several closed balconies by glass windows. Last floor, retreated mansard from the façade. Air conditioning unit on the facade. Shop, with alteration of the original openings.

Av. Roma, 85

Net floor area: 87.4m² | Gross floor area: 108m²

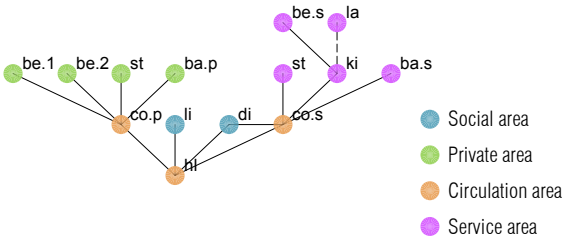
type **a**

Original dwelling

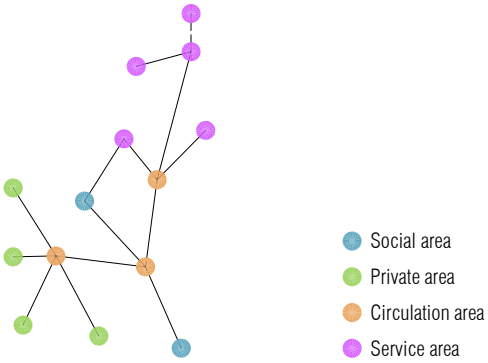
Floor plan

Justified graph

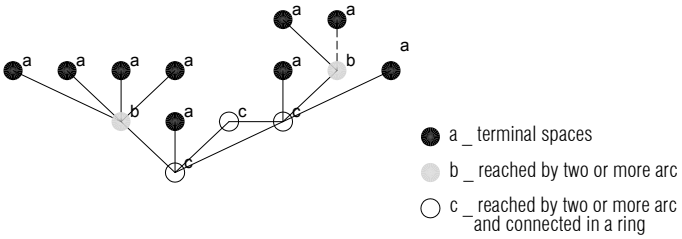
Graph with a tree configuration with 1 ring
Graph with 4 levels of depth
14 spaces/nodes
13 arcs/connections



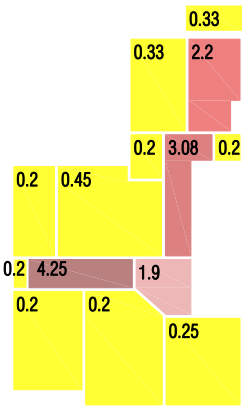
Convex map



Distributness

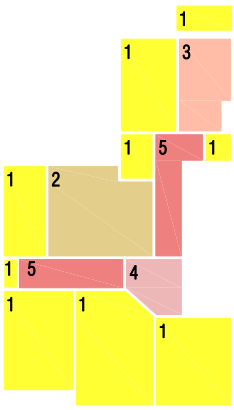


Controle

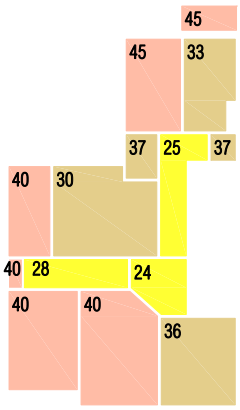


Entire dwelling
Mean: 1.00

Contiguity

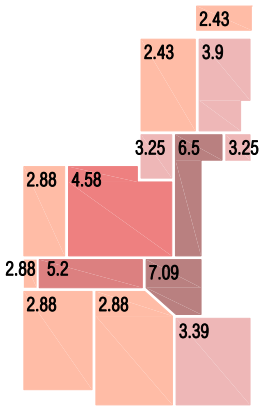


Depth



Entire dwelling
Mean: 35.71

Integration



Entire dwelling
Mean: 3.82

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1956

Number of floors: 9

Project authorship: -

Door of building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift and service lift; one staircase
Number of dwellings	18
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Foundations made of hydraulics masonry and concrete. Structure is made of reinforced concrete frame (pillars, beams and slabs).
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m. Exterior walls are covered with a painted coating (made of cement and sand mortar) Cut stone masonry covers the ground floor of the main façade up to the level of the first floor. Side wall made of reinforced concrete beam and pillar structure filled with, filled with 2 holes bricks, with a thickness of 22cm.
Interior walls	The partition walls are built from stretcher bond brick masonry with thickness of: 0.15m on 6th floor and upper floors; 0.18m on the ground floor up to the 5th floor; 0.25m on the basement. Beams in interior walls on the 2nd, 4th and 6th floors. Interior walls are plastered with a lime and sand mortar. In the bathroom, kitchen and laundry areas the walls are covered with decorative tiles to a height of 1.5m and the rest of the wall is enamel-painted.

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. Double window frames in one case resulting in a more advance window surface. New green blinds on the last floor different from all the building's blinds.
In the last floor, the retreated mansard was forward to the main façade surface. Several air conditioning devices mounted on the façade. Several cables through the building's main façade.

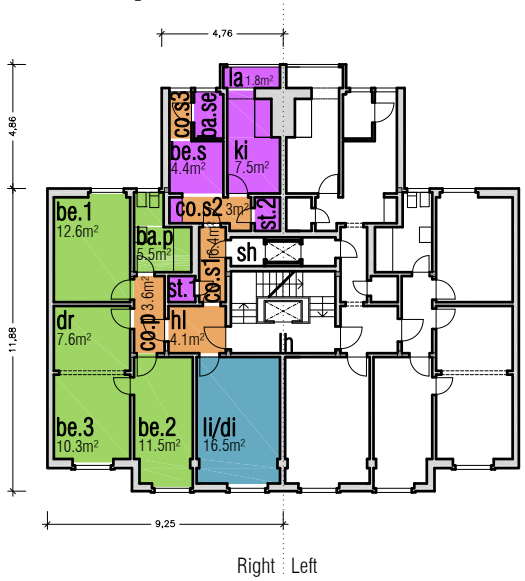
Av. Roma, 89

Net floor area: 97m² | Gross floor area: 118m²

type **a**

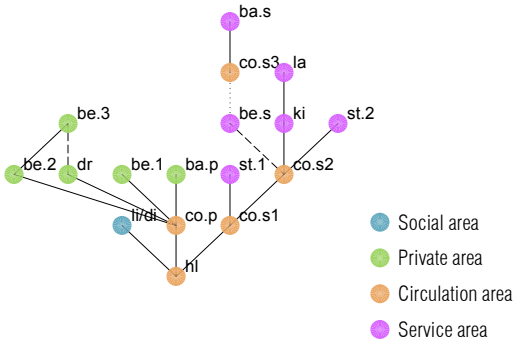
Original dwelling

Floor plan

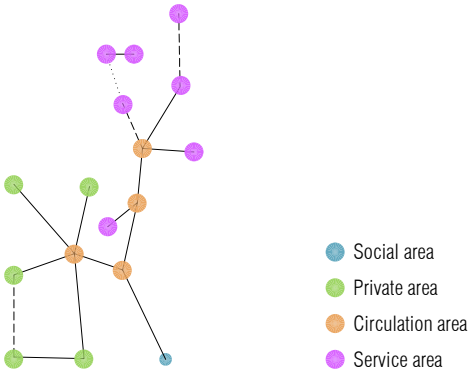


Justified graph

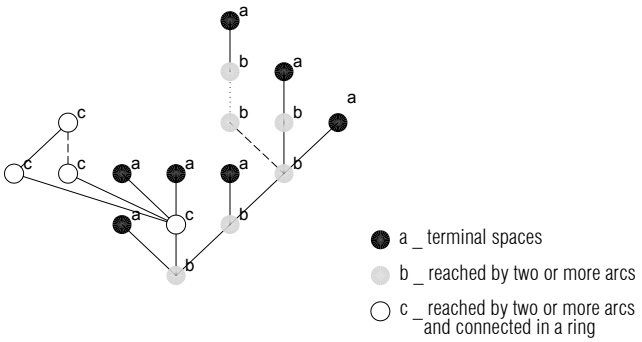
Graph with a tree configuration with 1 ring
Graph with 6 levels of depth
17 spaces/nodes
17 arcs/connections



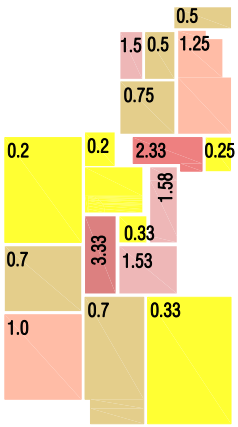
Convex map



Distributness

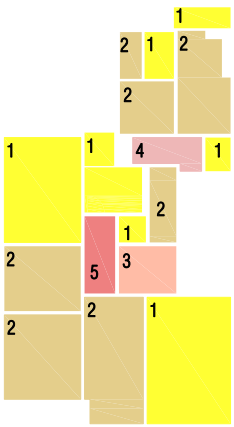


Controle

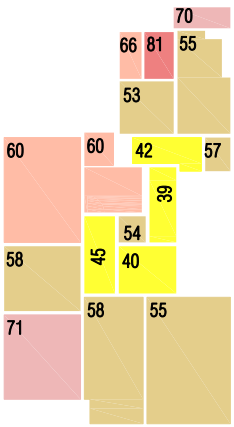


Entire dwelling
Mean: 1.00

Contiguity

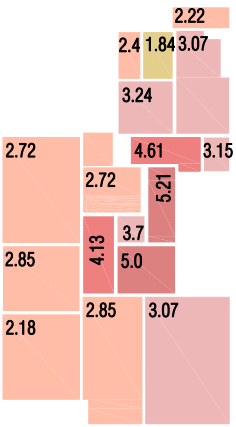


Depth



Entire dwelling
Mean: 57

Integration



Entire dwelling
Mean: 3.2

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1955

Number of floors: 8

Project authorship: Arch. n.77 (illegible signature)

Door of building

Building entrance hall

Brief functional characterization

Access	Two access to the building; main lift and service lift; one staircse.
Number of dwellings	16
Non habitable divisions	Caretaker's home

Brief constructional characterization

Structure and foundations	Continuous foundations. Structure is made of reinforced concrete frame (pillars, beams and slabs).
Exterior walls (façades and side walls)	Main and rear façade (exterior wall) made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m - thicknesses of 0.35m. Side walls made of reinforced concrete beam and pillar structure filled of special brick.
Interior walls	On the 4th, 5th, 6th and 7th floors interior walls are non loadbearing. Partition walls between different dwellings and staircase and lift partition walls in header bond brick masonry and remaining interior partitions in stretcher bond brick masonry.

Discrepancies, changes in the façade

In the last floor, the retreated mansard was forward to the main façade surface. Few closed balconies by glass windows. Several air conditioning devices mounted on the façade. Several cables through the building's main façade. In the shop the original openings where changed. TV antenna installed on a balcony.

Av. Roma, 96

Net floor area: 95.2m² | Gross floor area: 118m²

type **a**

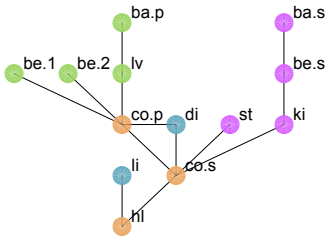
Original dwelling

Floor plan

Right | Left

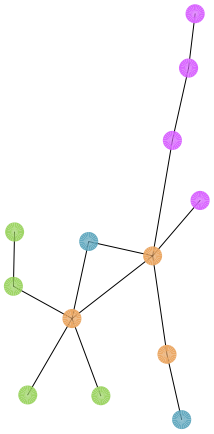
Justified graph

Graph with a tree configuration with 1 ring
Graph with 5 levels of depth
13 spaces/nodes
14 arcs/connections



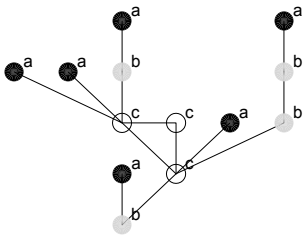
- Social area
- Private area
- Circulation area
- Service area

Convex map



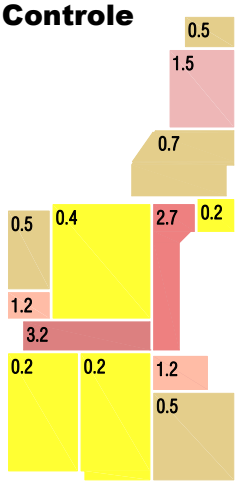
- Social area
- Private area
- Circulation area
- Service area

Distributness



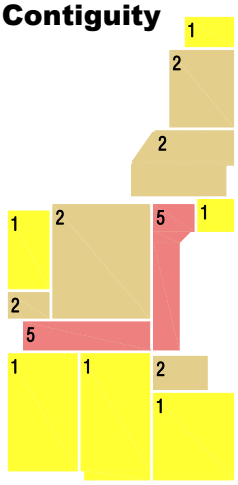
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

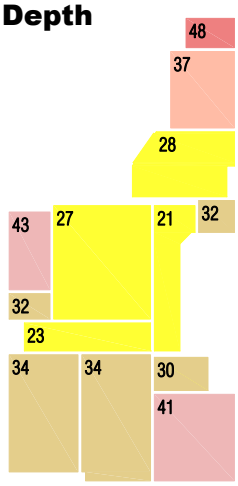


Entire dwelling
Mean: 1.00

Contiguity

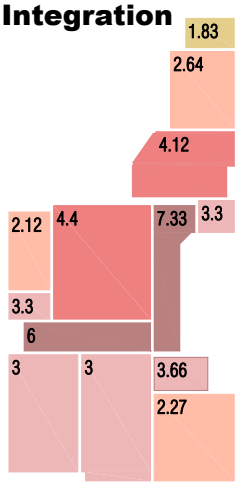


Depth



Entire dwelling
Mean: 33.07

Integration



Entire dwelling
Mean: 3.61

Adjacency (arcs)
merged | door (single) | door (double) | passage | window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1953

Number of floors: 9

Project authorship: Arch. João Simões

Door of building

Building entrance hall

Brief functional characterization

Access	Two access to the building; main lift and service lift; one staircase.
Number of dwellings	15
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Foundations made of timber piles or pier foundations. Light flooring in the form of prefabricated and pre-stressed reinforced concrete components ("*corfeo*" slabs). Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of hollow brick stretcher bonds and airspace of 0.05m.
Interior walls	Partition walls between different dwellings, lift and staircase partition walls in hollow header bond brick masonry. Partition walls between divisions in hollow stretcher bond brick masonry. The interior walls are covered with plaster over a sand-based rendering. The final coating consists of an oil-based paint.

Discrepancies, changes in the façade

In the last floor, the retreated mansard was forward to the main façade surface. Balcony on the 5th floor with a large wood shade structure. Replacement of the windows in several floors with different designs. Double window frames in several floors resulting in a more advance window surface.

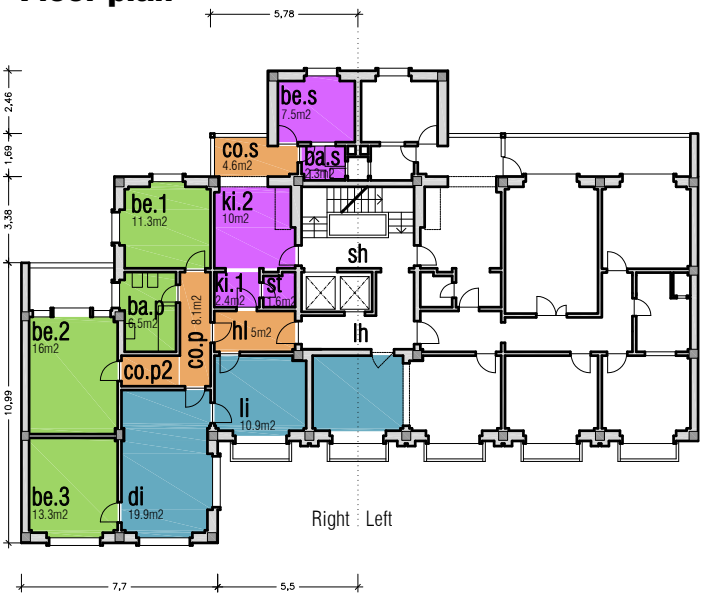
Av. Igreja, 63 [right]

(Left) Net floor area: 121.3m² | Gross floor area: 148m² (Right) Net floor area: 118.6m² | Gross floor area: 144.4m²

type **a**

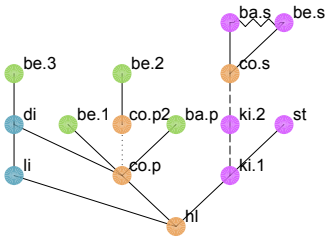
Original dwelling

Floor plan



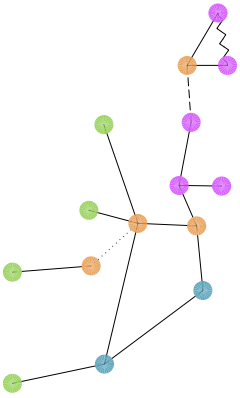
Justified graph

Graph with a tree configuration with 1 ring
Graph with 5 levels of depth
15 spaces/nodes
16 arcs/connections
(windows connections are excluded)



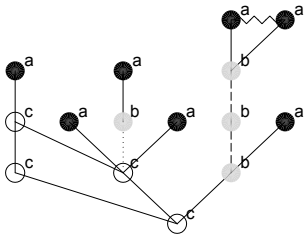
Social area
Private area
Circulation area
Service area

Convex map



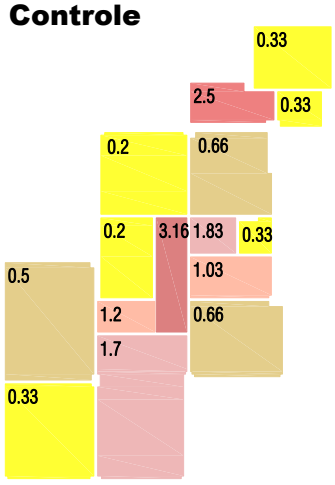
Social area
Private area
Circulation area
Service area

Distributness



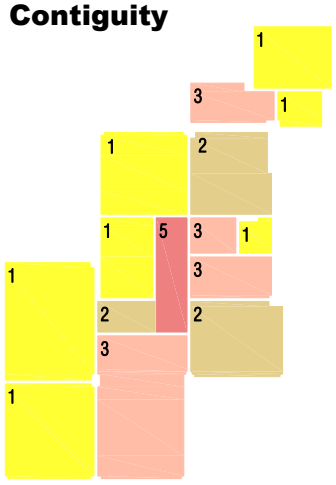
a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring

Controle

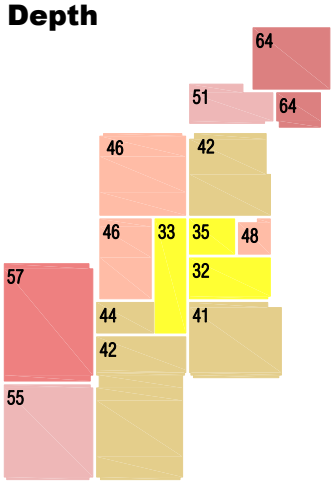


Entire dwelling
Mean: 1.00

Contiguity

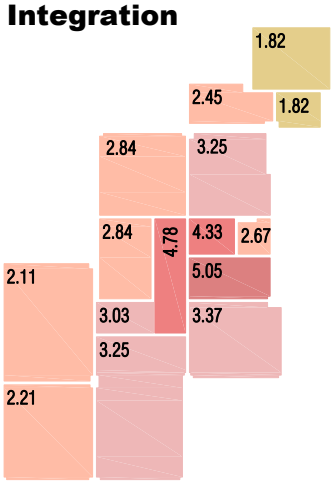


Depth



Entire dwelling
Mean: 46.66

Integration



Entire dwelling
Mean: 3.05

Adjacency (arcs)
merged — door (single) ═ door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

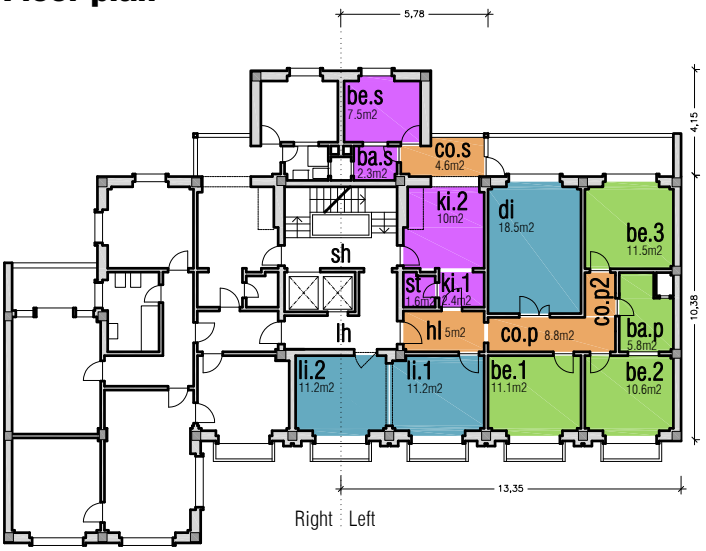
Av. Igreja, 63 [left]

(Left) Net floor area: 121.3m² | Gross floor area: 148m² (Right) Net floor area: 118.6m² | Gross floor area: 144.4m²

type **a**

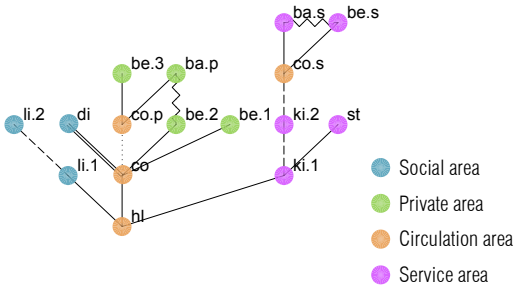
Original dwelling

Floor plan

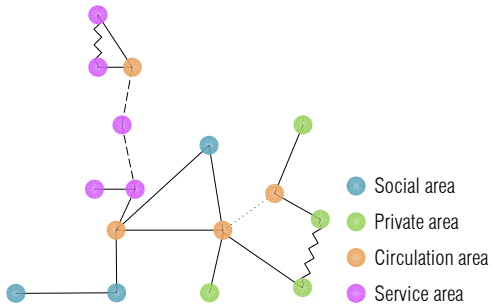


Justified graph

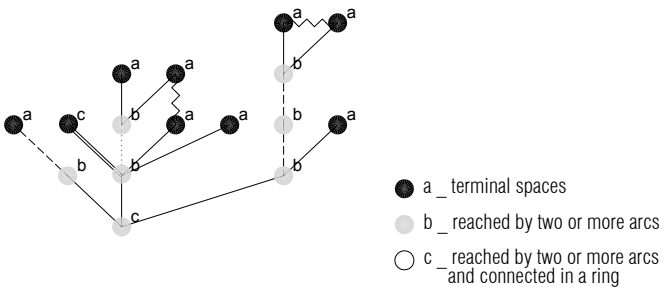
Graph with a tree configuration
Graph with 5 levels of depth
16 spaces/nodes
17 arcs/connections
(windows connections are excluded)



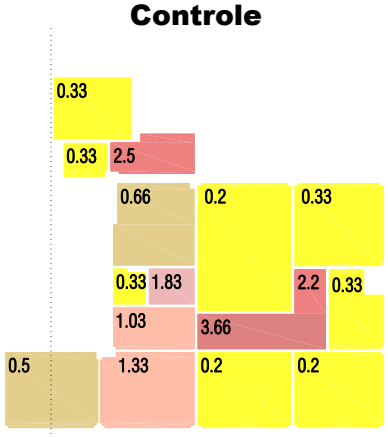
Convex map



Distributness

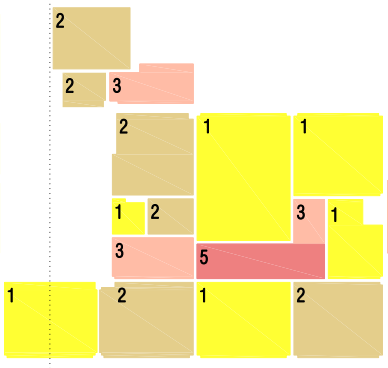


Controle

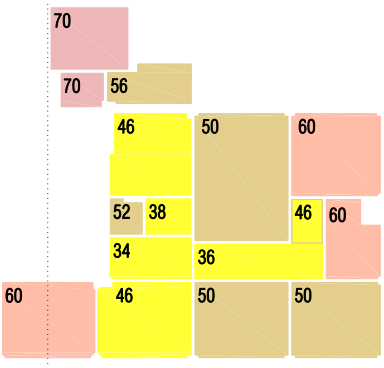


Entire dwelling
Mean: 1.00

Contiguity

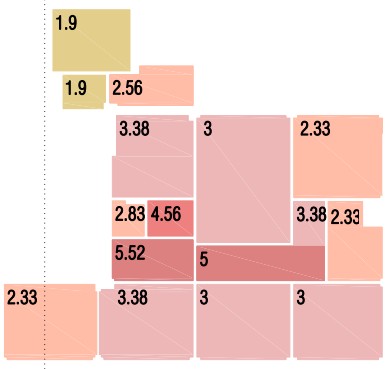


Depth



Entire dwelling
Mean: 51.5

Integration



Entire dwelling
Mean: 3.15

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

This process was burned in a fire occurred in the CML archives some years ago.

Date: -

Number of floors: 7

Project authorship: -

Door of building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift; two staircases.
Number of dwellings	12
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	-
Interior walls	-

Discrepancies, changes in the façade

Few cables through the building's main façade. Coexistence of green and white blinds.

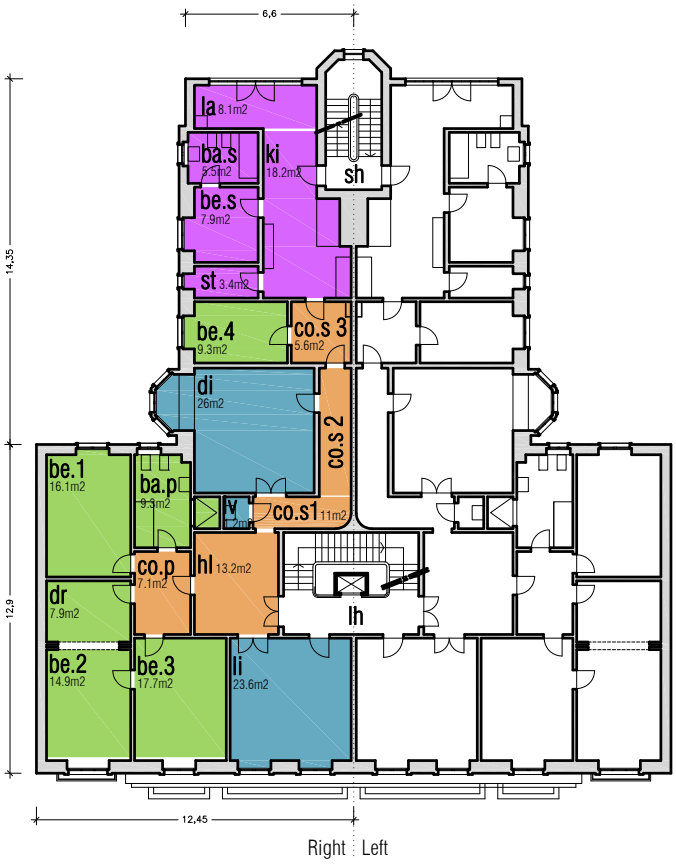
Av. Guerra Junqueiro, 7

Net floor area: 206m² | Gross floor area: 244m²

type **c**

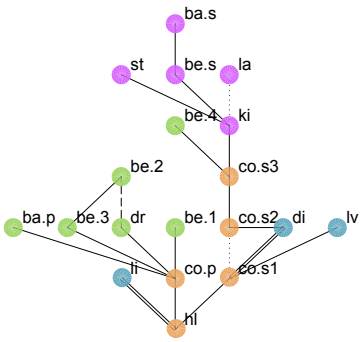
Original dwelling

Floor plan

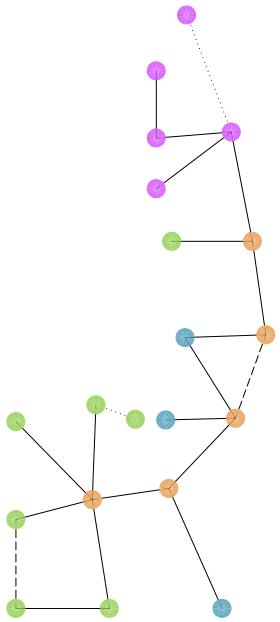


Justified graph

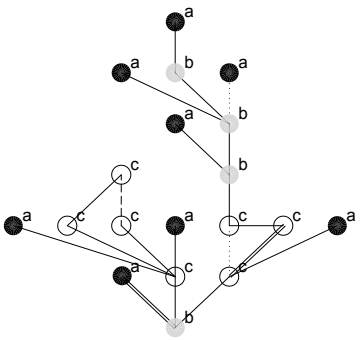
Graph with a tree configuration with 2 ring
Graph with 7 levels of depth
19 spaces/nodes
20 arcs/connections



Convex map

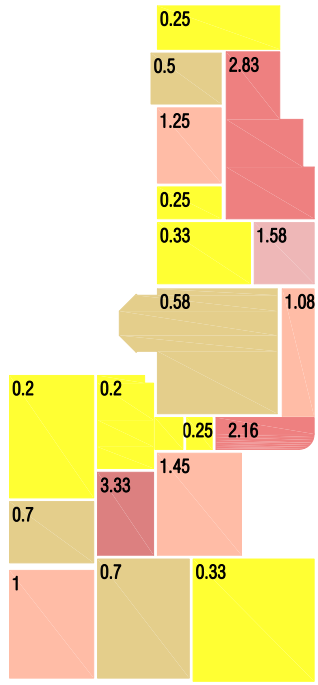


Distributness



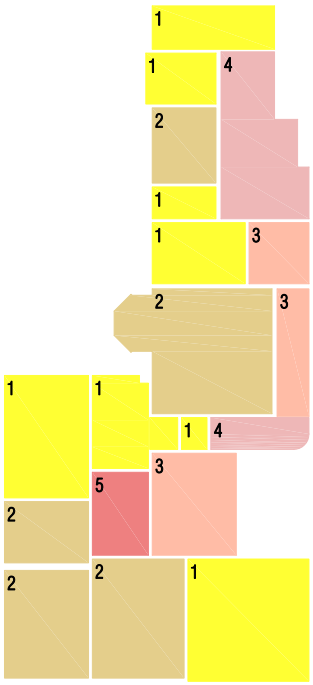
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

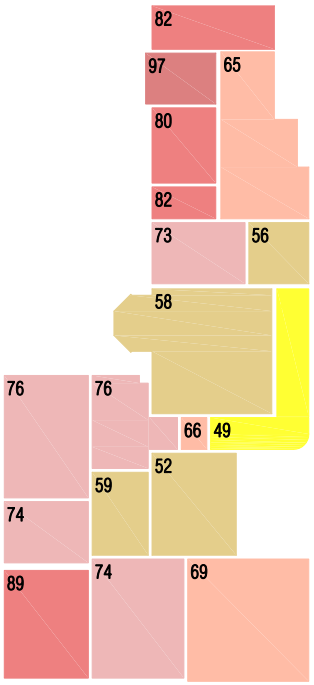


Entire dwelling
Mean: 1.00

Contiguity

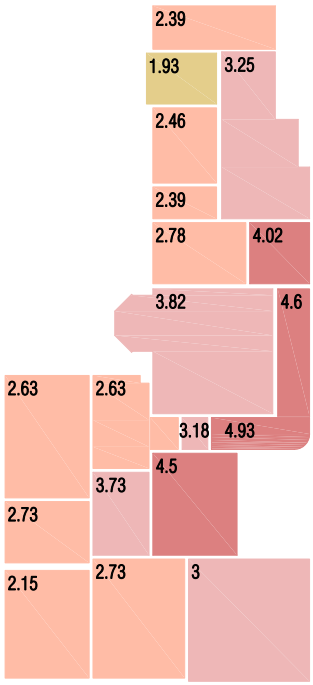


Depth



Entire dwelling
Mean: 69.89

Integration



Entire dwelling
Mean: 3.15

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1953

Number of floors: 7

Project authorship: Eng. n.115

Door of building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift; two staircases.
Number of dwellings	12
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Reinforced concrete structure.
Exterior walls (façades and side walls)	Main façade made of reinforced concrete – continuous wall on the outside panel - with airspace and a brick panel on the interior side of the wall. Rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.1m. Side wall made of reinforced concrete.
Interior walls	The interior walls and ceilings are covered with plaster over a sand-based rendering. The final coating consists of an oil-based paint.

Discrepancies, changes in the façade

Several cables through the building's main façade. Several air conditioning devices mounted on the façade.

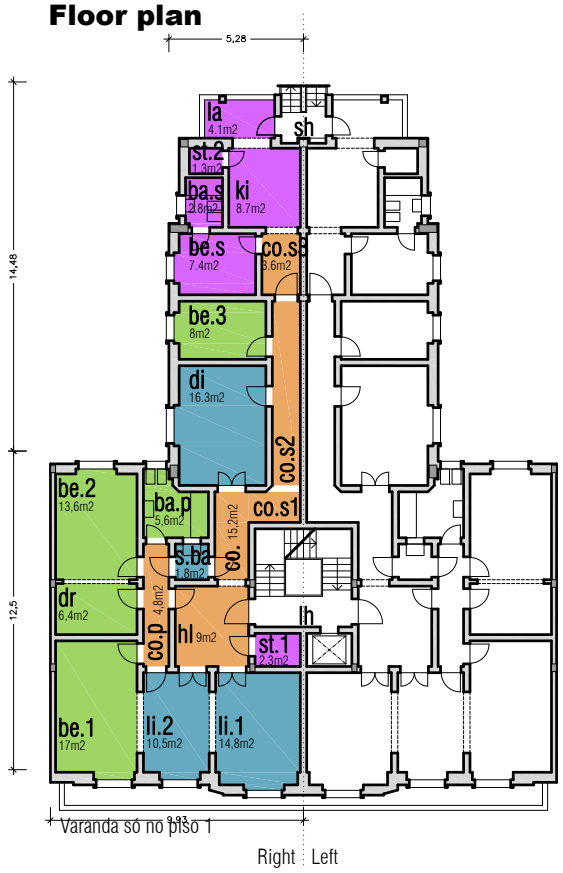
Av. Guerra Junqueiro, 14

Net floor area: 153.5m² | Gross floor area: 188m²

type **c**

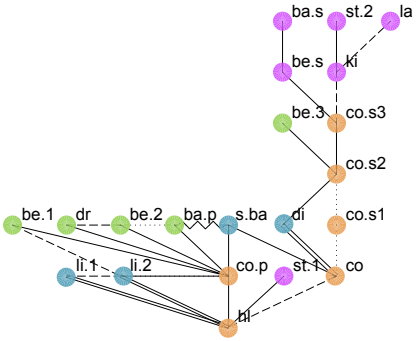
Original dwelling

Floor plan

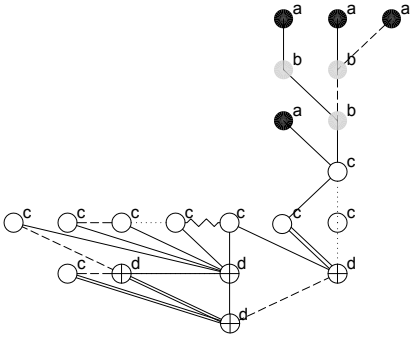


Justified graph

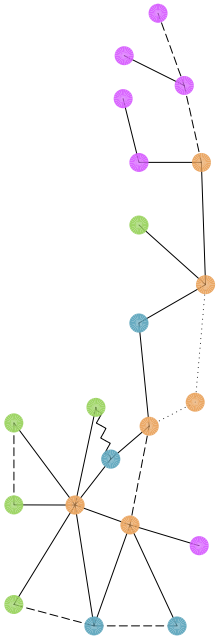
Graph with a tree configuration with 6 rings
Graph with 7 levels of depth
21 spaces/nodes
26 arcs/connections
(windows connections are excluded)



Distributness

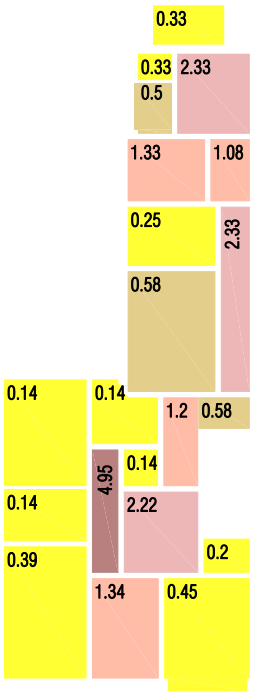


Convex map



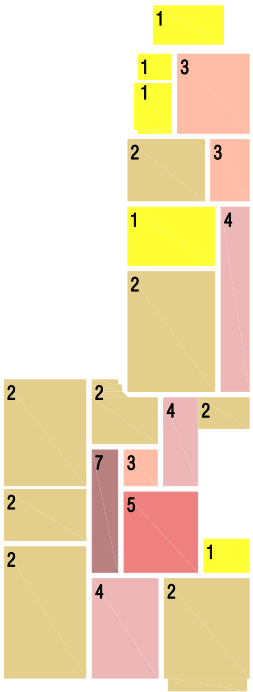
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- d _ reached by two or more arcs and connected by ≥ 2 rings

Controle

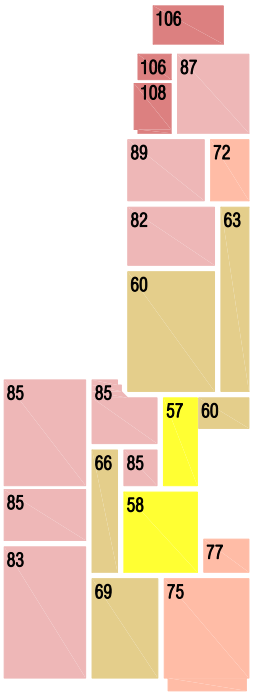


Entire dwelling
Mean: 1.00

Contiguity

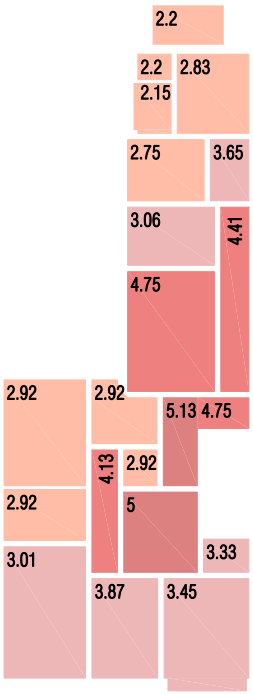


Depth



Entire dwelling
Mean: 78.95

Integration



Entire dwelling
Mean: 3.44

Adjacency (arcs)
merged — door (single) ═ door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1953

Number of floors: 5

Project authorship: -

Door of building

Building entrance hall

Brief functional characterization

Access	One exterior access to the building; main lift and service lift, one staircase.
Number of dwellings	10
Non habitable divisions	Condominium store-rooms Caretaker's home

Brief constructional characterization

Structure and foundations	Continuous foundations made of hydraulics masonry beneath dividing walls. Reinforced concrete structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace of 0.08m, thicknesses of 0.35m including plaster. Side walls made of continuous reinforced concrete, thickness of 0.3m on the upper 4 floors and 0.3m on the ground one and basement.
Interior walls	Partition walls between divisions - hollow stretcher bond brick masonry: 0.25m on the basement; 0.18 on the ground floor; 0.15m on the remaining floors. Concrete beams on the ceiling of the 2nd floor and ground floor.

Discrepancies, changes in the façade

Replacement of the window frame in one of the floors with other of different colour and material. Different type of blinds along the building (colour and material). Several cables through the building's main façade.

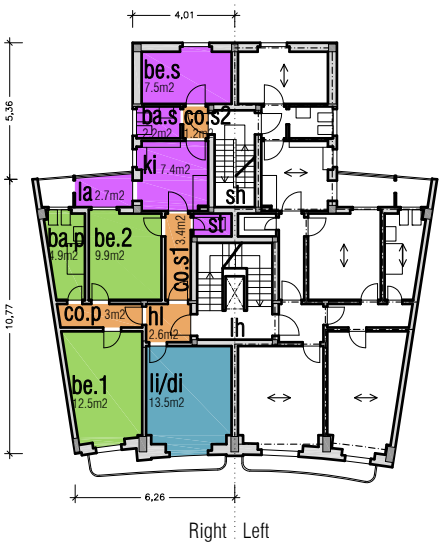
Pr. Afrânio Peixoto, 12

Net floor area: 72.1m² | Gross floor area: 88.6m²

type **b**

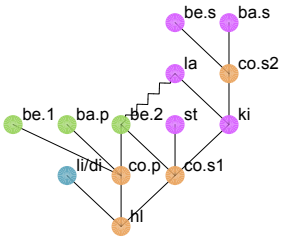
Original dwelling

Floor plan



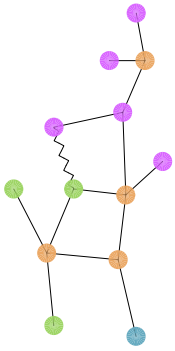
Justified graph

Graph with a tree configuration with 1 ring
Graph with 5 levels of depth
13 spaces/nodes
14 arcs/connections
(windows connections are excluded)



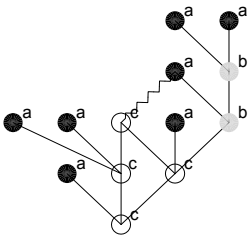
- Social area
- Private area
- Circulation area
- Service area

Convex map



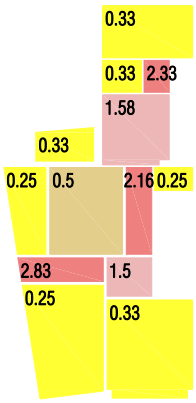
- Social area
- Private area
- Circulation area
- Service area

Distributness



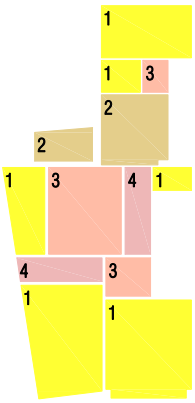
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

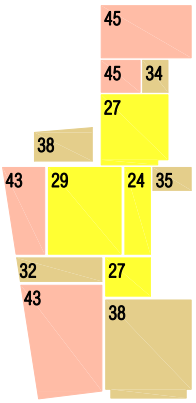


Entire dwelling
Mean: 1.00

Contiguity

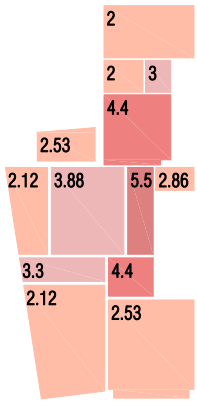


Depth



Entire dwelling
Mean: 35.38

Integration



Entire dwelling
Mean: 3.12

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

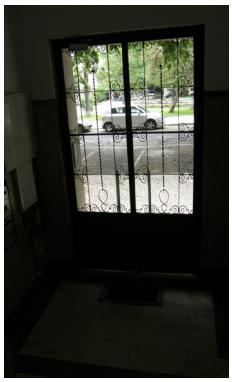
Front façade

Date: 1950

Number of floors: 5

Project authorship: -

Door of building



Building entrance hall

Brief functional characterization

Access	Two exterior access to the building; main lift and service lift, both only with stair.
Number of dwellings	10
Non habitable divisions	Caretaker's home

Brief constructional characterization

Structure and foundations	Reinforced concrete structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds hollow brick masonry and airspace. Continuous reinforced concrete wall on the ground floor, thickness of 0.8m. Side walls made of reinforced concrete.
Interior walls	Interior walls: stretcher bonds hollow brick masonry (4^{th} and 5^{th} floors); stretcher bonds solid brick masonry (2^{nd} and 3^{rd} floors); double stretcher bonds solid brick masonry (ground -floor); header bonds solid brick masonry (basement) – thickness 0.25m

Discrepancies, changes in the façade

Blinds with different colours along the building. Several cables through the building's main façade.

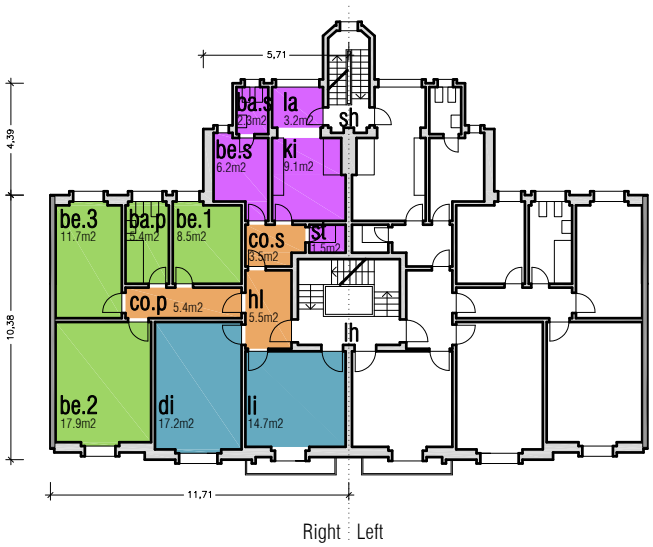
Pr. Afrânio Peixoto, 13

Net floor area: 112.1m² | Gross floor area: 135m²

type **a**

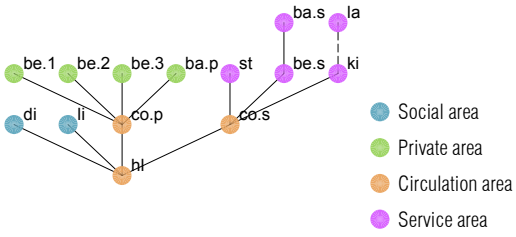
Original dwelling

Floor plan

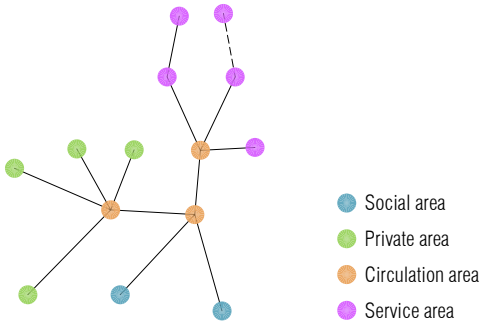


Justified graph

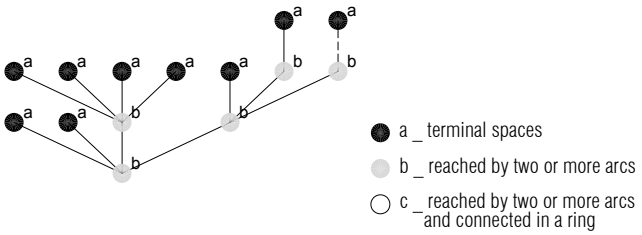
Graph with a tree configuration
Graph with 4 levels of depth
14 spaces/nodes
13 arcs/connections



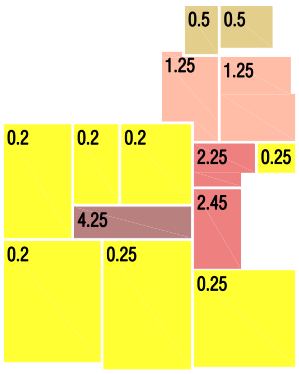
Convex map



Distributness

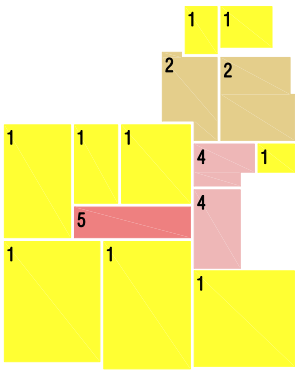


Controle

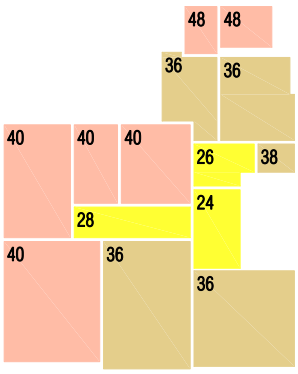


Entire dwelling
Mean: 1.00

Contiguity

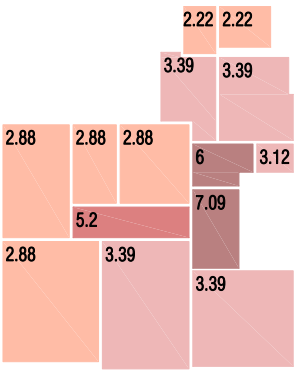


Depth



Entire dwelling
Mean: 36.85

Integration



Entire dwelling
Mean: 3.64

Front façade

Date: 1943

Number of floors: 6

Project authorship: Eng. n.139 (illegible signature)

Main door of building and service door

Building entrance hall

Brief functional characterization

Access	One exterior access to the building; main lift, two staircases.
Number of dwellings	12
Non habitable divisions	Condominium store-rooms Caretaker's home

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	-
Interior walls	-

Discrepancies, changes in the façade

Two air condition devices mounted on the façade. Cables through the building's main façade.

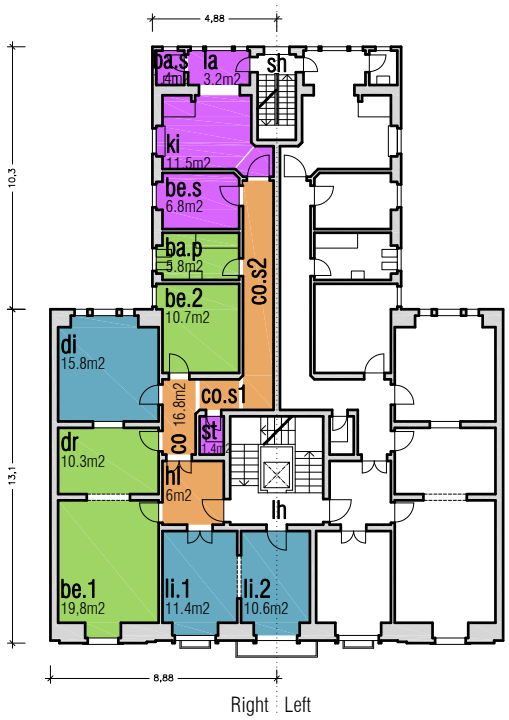
Pr. Dom João do Rio, 6 [right]

(Left) Net floor area: 120.8m² | Gross floor area: 148.7m² (Right) Net floor area: 131.4m² | Gross floor area: 161.7m²

type **d**

Original dwelling

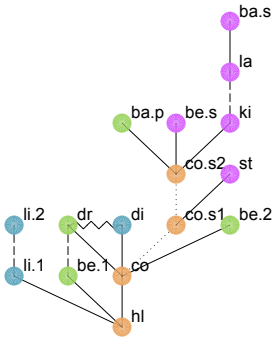
Floor plan



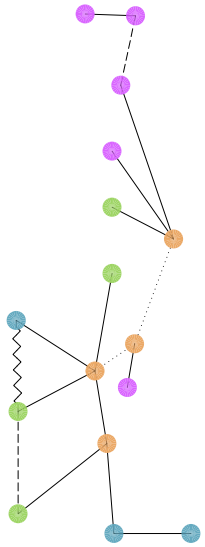
Right | Left

Justified graph

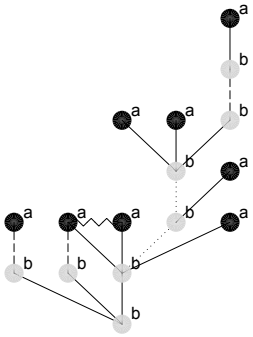
Graph with a tree configuration with 1 ring
Graph with 7 levels of depth
16 spaces/nodes
16 arcs/connections
(windows connections are excluded)



Convex map

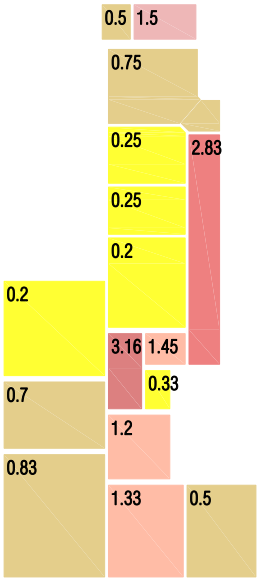


Distributness



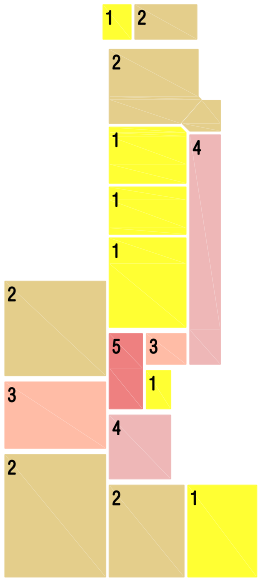
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

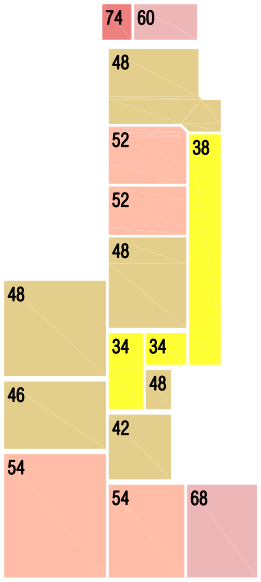


Entire dwelling
Mean: 1.00

Contiguity

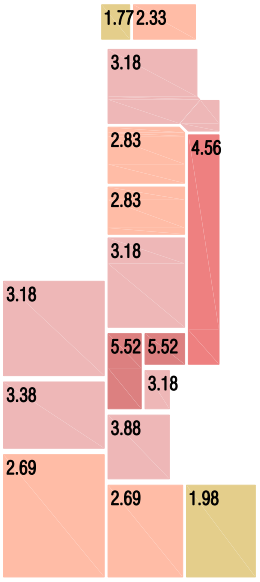


Depth



Entire dwelling
Mean: 44.26

Integration



Entire dwelling
Mean: 3.2

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

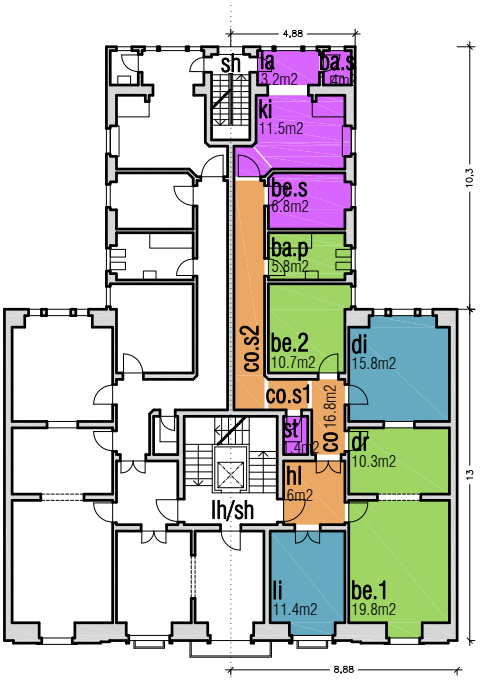
Pr. Dom João do Rio, 6 [left]

(Left) Net floor area: 120.8m² | Gross floor area: 148.7m² (Right) Net floor area: 131.4m² | Gross floor area: 161.7m²

type **d**

Original dwelling

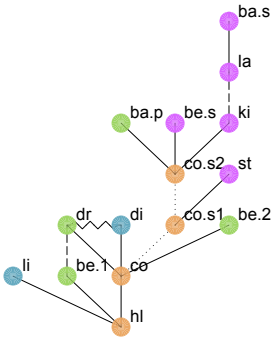
Floor plan



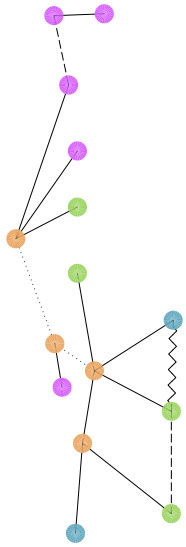
Right Left

Justified graph

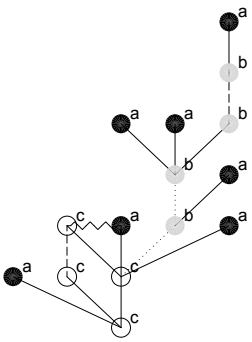
Graph with a tree configuration with 1 ring
Graph with 7 levels of depth
15 spaces/nodes
15 arcs/connections
(windows connections are excluded)



Convex map

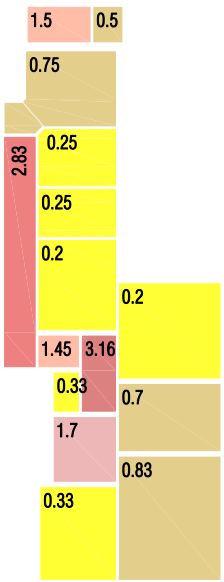


Distributness



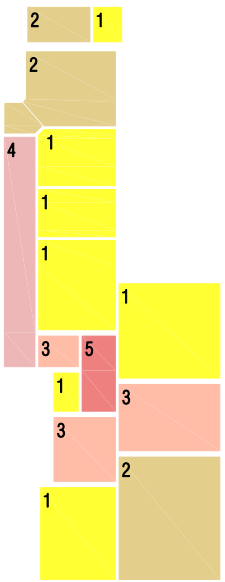
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

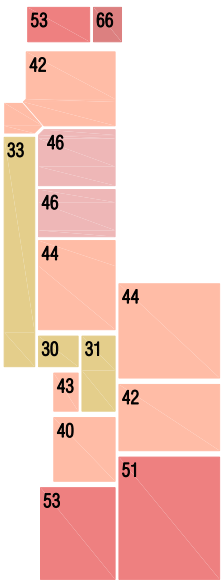


Entire dwelling
Mean: 1.00

Contiguity

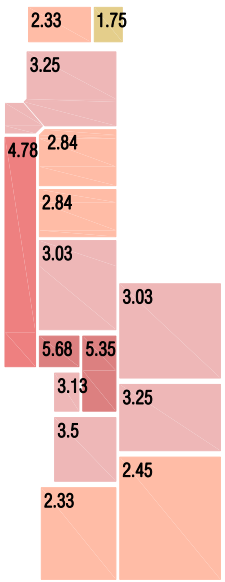


Depth



Entire dwelling
Mean: 44.26

Integration



Entire dwelling
Mean: 3.3

Adjacency (arcs)
merged — door (single) ═ door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1939

Number of floors: 4

Project authorship: Arch. João Simões

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; two staircases.
Number of dwellings	8
Non habitable divisions	Caretaker's home

Brief constructional characterization

Structure and foundations	Continuous walls made of hydraulics masonry. Foundations made of reinforced concrete beneath pillars. Reinforced concrete structure.
Exterior walls (façades and side walls)	Main façade made of hydraulics stone masonry. Rear façade made of hydraulics stone masonry and solid header bond brick masonry.
Interior walls	Hollow header bond brick masonry.

Discrepancies, changes in the façade

Replacement of the windows in some floors with different designs. Few cables through the building's main façade

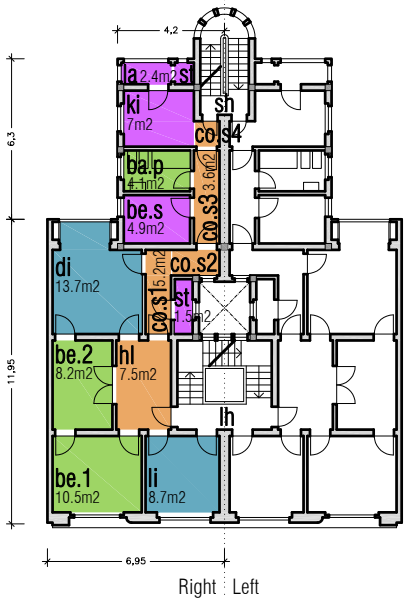
R. Actor Isidoro, 11

Net floor area: 77.3m² | Gross floor area: 98.3m²

type **d**

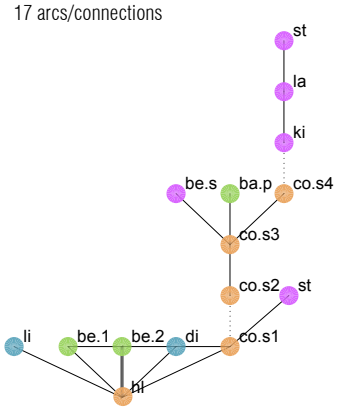
Original dwelling

Floor plan



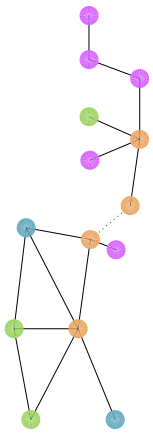
Justified graph

Graph with a tree configuration with 3 rings
Graph with 8 levels of depth
15 spaces/nodes
17 arcs/connections



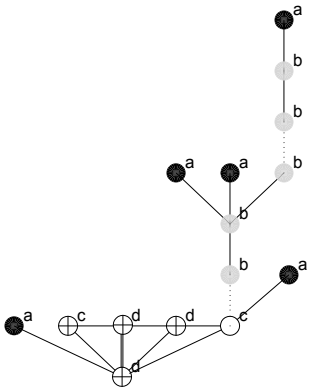
Social area
Private area
Circulation area
Service area

Convex map



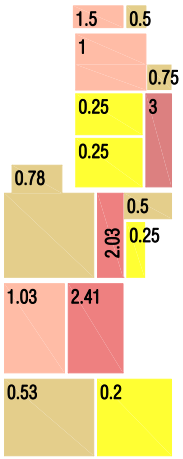
Social area
Private area
Circulation area
Service area

Distributness



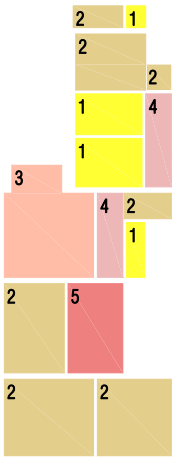
a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring
d _ reached by two or more arcs and connected by ≥ 2 rings

Controle

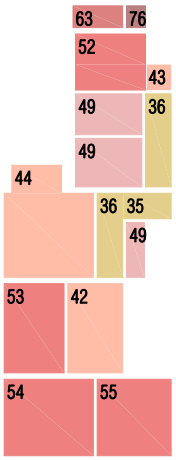


Entire dwelling
Mean: 1.00

Contiguity

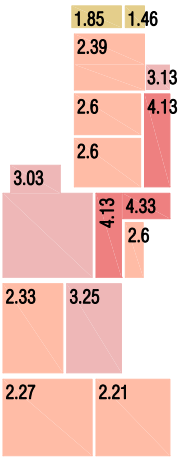


Depth



Entire dwelling
Mean: 46.06

Integration



Entire dwelling
Mean: 2.82

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1943

Number of floors: 4

Project authorship: Eng. Jacinto Bethencourt

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; two staircases.
Number of dwellings	8
Non habitable divisions	Condominium store-rooms Caretaker's home

Brief constructional characterization

Structure and foundations	Foundations made of concrete up to ground level. Load-bearing stone masonry and cement blocks masonry.
Exterior walls (façades and side walls)	Main façade made of stone masonry with cement mortar. Rear façade and side walls made of cement blocks with cement mortar. The walls of the basement are made of cement blocks with thickness of 0.6m
Interior walls	Partition walls - hollow stretcher bond brick masonry using cement mortar: ground floor, 1st floor and kitchen and bathroom walls – solid stretcher bond brick masonry; ground floor and 1st floor when walls are non load-bearing – hollow stretcher bond brick masonry; ground floor and 1st floor when walls are load-bearing – solid header bond brick masonry; 2nd and 3rd floor - hollow stretcher bond brick masonry.

Discrepancies, changes in the façade

Several air condition devices mounted on the façade. Cables through the building's main façade.

R. Actor Isidoro, 16

Net floor area: 99.1m² | Gross floor area: 125.5m²

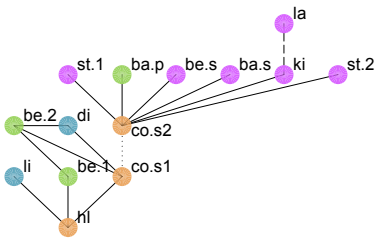
type **d**

Original dwelling

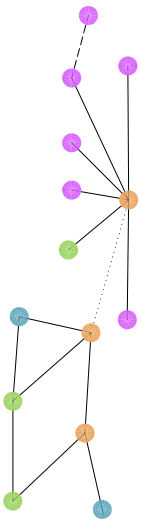
Floor plan

Justified graph

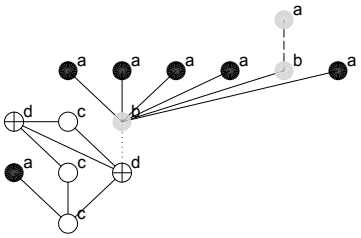
Graph with a tree configuration with 2 rings
Graph with 5 levels of depth
14 spaces/nodes
15 arcs/connections



Convex map

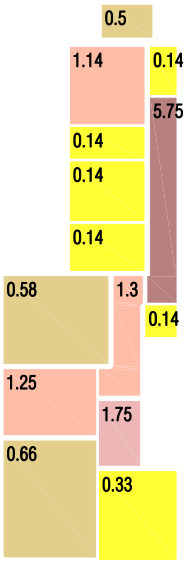


Distributness



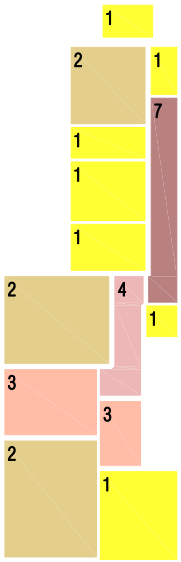
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- d _ reached by two or more arcs and connected by ≥ 2 rings

Controle

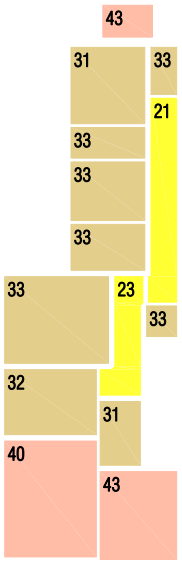


Entire dwelling
Mean: 1.00

Contiguity

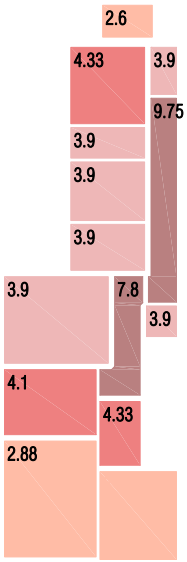


Depth



Entire dwelling
Mean: 33.00

Integration



Entire dwelling
Mean: 4.41

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1956

Number of floors: 8

Project authorship: Arch. n.147

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift and service lift, one staircase.
Number of dwellings	16
Non habitable divisions	Caretaker's home

Brief constructional characterization

Structure and foundations	Foundations made of reinforced concrete beneath pillars and continuous foundations beneath dividing walls and exterior walls. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Main and rear façade made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds brick masonry and airspace. Side walls made of continuous reinforced concrete on the ground floor and concrete frame filled with bricks on the remaining floors.
Interior walls	Partition walls made of hollow stretcher brick masonry with cement mortar.

Discrepancies, changes in the façade

One air conditioning device mounted on the façade. Few cables through the building's main façade.

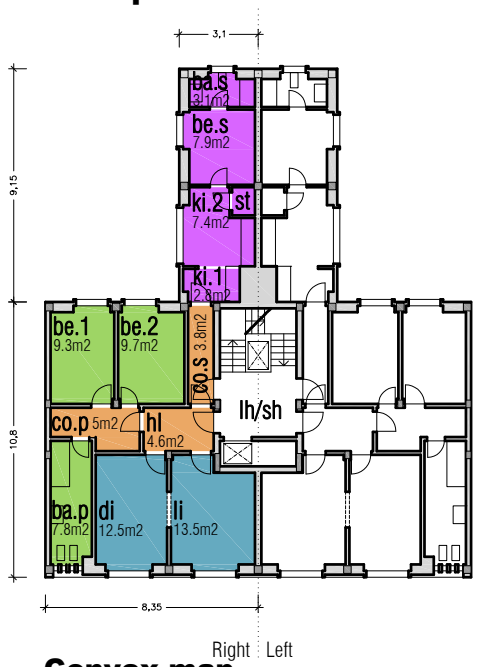
Av. Oscar Monteiro Torres, 14

Net floor area: 88.5m² | Gross floor area: 108.4m²

type **b**

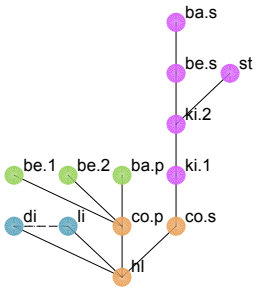
Original dwelling

Floor plan



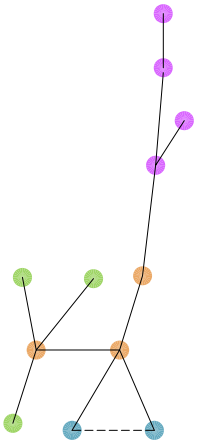
Justified graph

Graph with a tree configuration with 1 ring
Graph with 6 levels of depth
13 spaces/nodes
13 arcs/connections



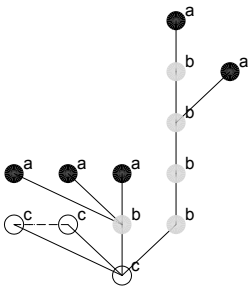
Social area
Private area
Circulation area
Service area

Convex map



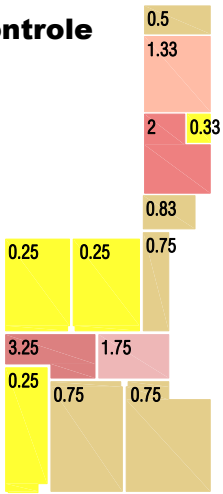
Social area
Private area
Circulation area
Service area

Distributness



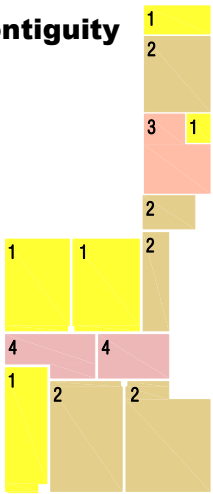
a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring

Controle

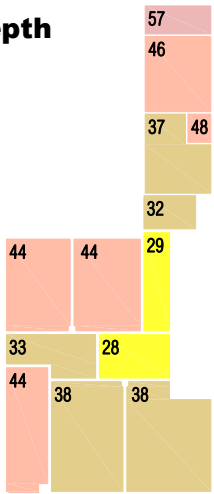


Entire dwelling
Mean: 1.00

Contiguity

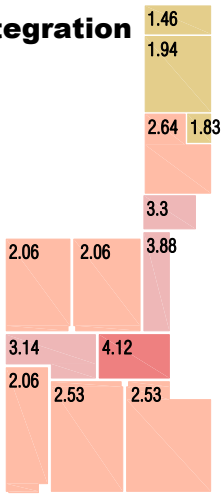


Depth



Entire dwelling
Mean: 39.84

Integration



Entire dwelling
Mean: 2.58

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

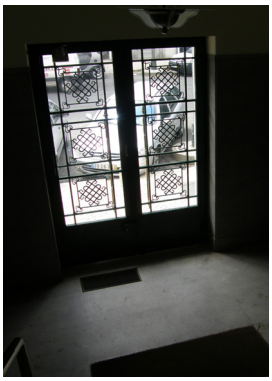
Front façade

Date: 1949

Number of floors: 7

Project authorship: Arch. Pardal Monteiro

Door of the building



Building entrance hall

Brief functional characterization

Access	Two access to the building; main lift, two staircases.
Number of dwellings	12
Non habitable divisions	Caretaker's home (in the back yard, outside the building) Shops in the ground floor (garage)

Brief constructional characterization

Structure and foundations	Foundations made of reinforced concrete beneath pillars and continuous foundations of hydraulics stone masonry beneath dividing walls. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Reinforced concrete structure filled with two panels of hollow stretcher bonds brick masonry and airspace of 0.07m. Side walls made of reinforced concrete, thicknesses of 0.3m on the first three floors and 0.2m on the remaining floors.
Interior walls	Partition walls made of brick masonry – hollow stretcher bond brick masonry on the 5th and 6th floor; solid stretcher bond brick masonry on the 3rd and 4th floor; double solid stretcher bond brick masonry on the 2nd floor; solid header bond brick masonry on the ground floor.

Discrepancies, changes in the façade

Original blinds and new ones with different colours (green and white)

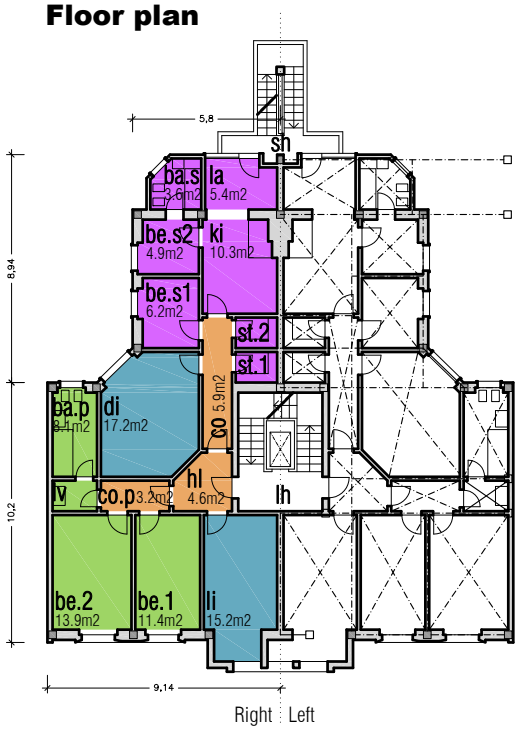
Av. João Crisóstomo, 70

(Left) Net floor area: 114.9m² | Gross floor area: 139.7m² (Right) Net floor area: 113.7m² | Gross floor area: 138.1m²

type **c**

Original dwelling

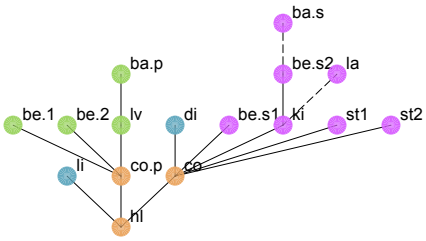
Floor plan



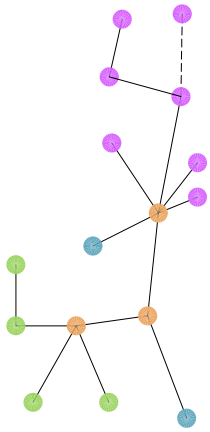
Right Left

Justified graph

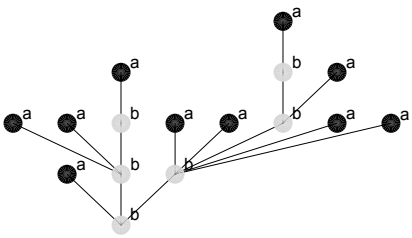
Graph with a tree configuration
Graph with 5 levels of depth
16 spaces/nodes
15 arcs/connections



Convex map

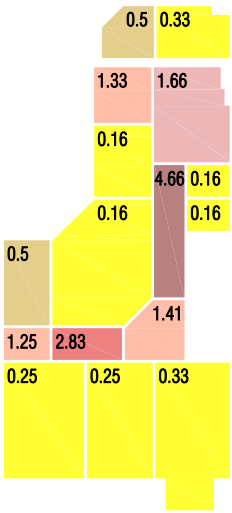


Distributness



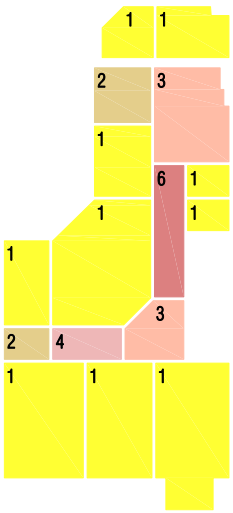
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

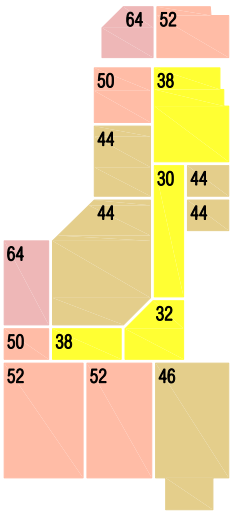


Entire dwelling
Mean: 1.00

Contiguity

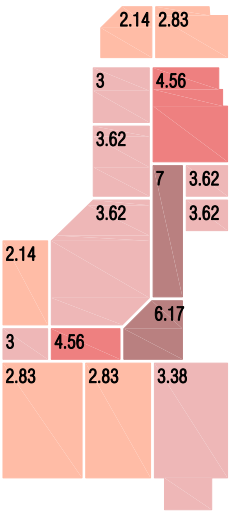


Depth



Entire dwelling
Mean: 46.50

Integration



Entire dwelling
Mean: 3.68

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1950

Number of floors: 7

Project authorship: Eng. Jacinto Bethencourt

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift, two staircases.
Number of dwellings	12
Non habitable divisions	Caretaker's home Shops in the ground floor (garage)

Brief constructional characterization

Structure and foundations	Foundations beneath the main and rear façade made of simple concrete. Foundations beneath the pillars made of simple concrete or reinforced concrete. Reinforced concrete structure.
Exterior walls (façades and side walls)	Main façade made of continuous reinforced concrete. Remaining area of the main façade and rear façade made of reinforced concrete beam and pillar structure filled with two panels of solid stretcher bonds brick masonry and airspace. Side walls made of reinforced concrete.
Interior walls	Partition walls made of brick masonry – hollow stretcher bond brick masonry on the 5th and 6th floor; solid stretcher bond brick masonry on the 3rd and 4th floor; double solid stretcher bond brick masonry on the 2nd floor; solid header bond brick masonry on the ground floor.

Discrepancies, changes in the façade

Several cables through the building's main façade. Lack of general maintenance.

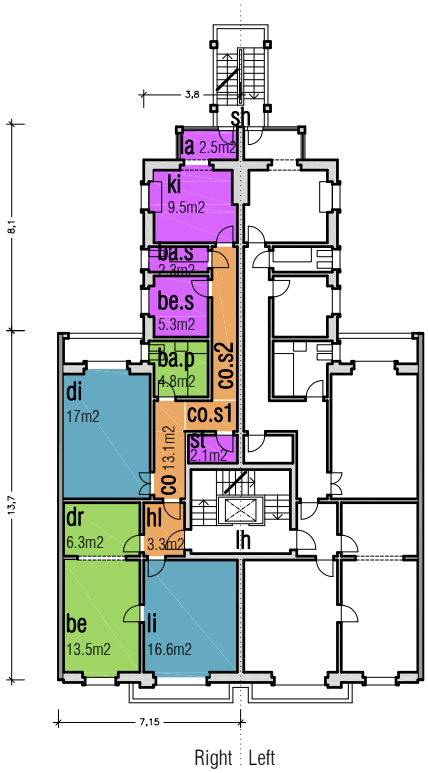
Av. Visconde Valmor, 36

Net floor area: 96.3m² | Gross floor area: 117m²

type **d**

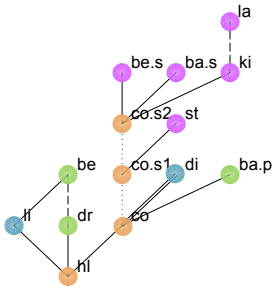
Original dwelling

Floor plan

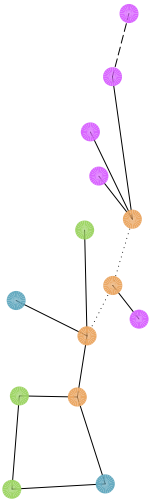


Justified graph

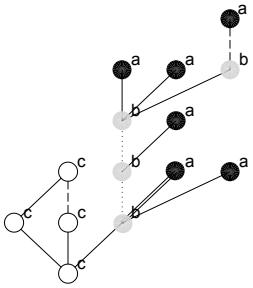
Graph with a tree configuration with 1 rings
Graph with 6 levels of depth
14 spaces/nodes
14 arcs/connections



Convex map

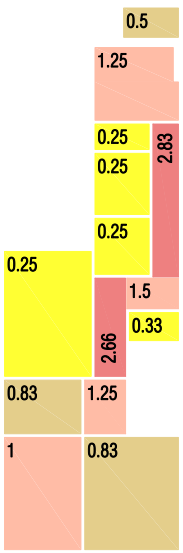


Distributness



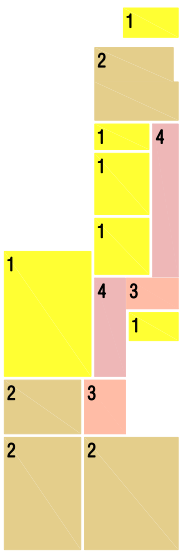
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

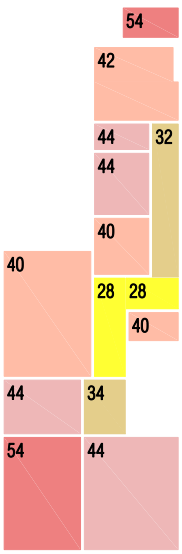


Entire dwelling
Mean: 1.00

Contiguity

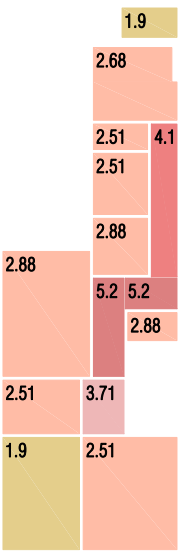


Depth



Entire dwelling
Mean: 40.57

Integration



Entire dwelling
Mean: 3.1

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1950

Number of floors: 7

Project authorship: Eng, Ventura Rego

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building and one access to the back yard; main lift; two staircases
Number of dwellings	12
Non habitable divisions	Caretaker's home (in the back yard, outside the building) Shops in the ground floor (garage)

Brief constructional characterization

Structure and foundations	Foundations made of stone masonry over clay compacted ground. Foundations are made of concrete beneath pillars (depth superior to ½ of the foundation width) and continuous foundations of concrete blocks masonry beneath dividing walls. Reinforced concrete beam and pillar structure.
Exterior walls (façades and side walls)	Concrete structure filled with two panels of stretcher bonds and airspace of 0.08m. Side walls made of continuous reinforced concrete, thickness 0.2m on 4th, 5thand 6th floor, thickness 0.3m on 1st, 2nd, 3rd, ground floor.
Interior walls	Partition walls between divisions: ground floor, 1st and 2nd floor - hollow header bond brick masonry; 3rd, 4th, 5th and 6th - solid header bond brick masonry. Remaining partition walls – brick masonry with cement and sand mortar: ground floor, 1st and 2nd floor - double solid header bond brick masonry; 3rd and 4th floor – solid stretcher bond; 5th and 6th floor - hollow stretcher bond.

Discrepancies, changes in the façade

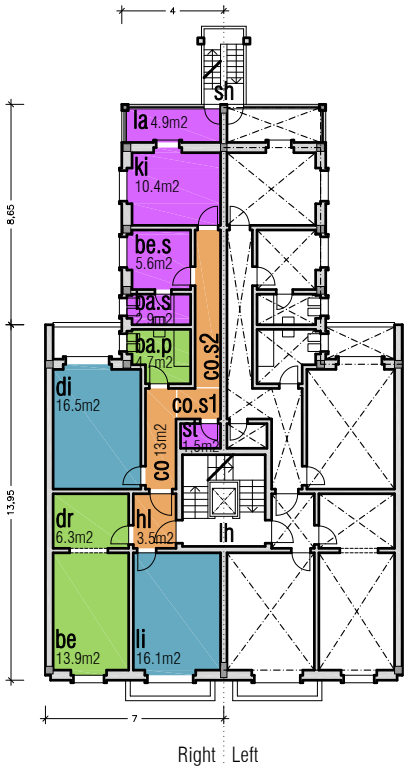
Few cables through the building's main façade

Av. Barbosa du Bocage, 90

Net floor area: 99.3m² | Gross floor area: 122.3m²

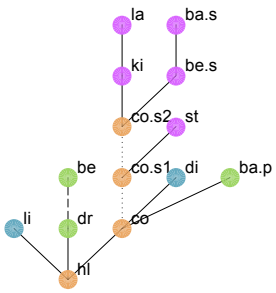
type **d**

Original dwelling

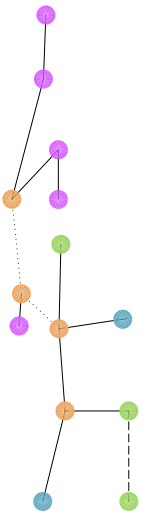


Justified graph

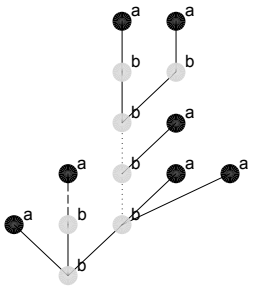
Graph with a tree configuration
Graph with 6 levels of depth
14 spaces/nodes
13 arcs/connections



Convex map

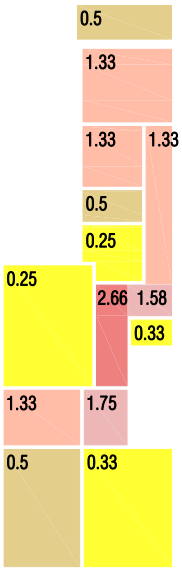


Distributness



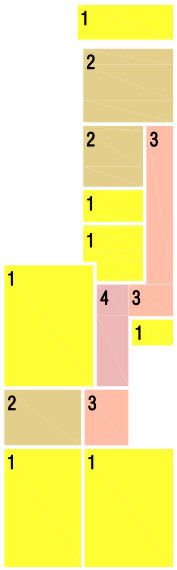
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

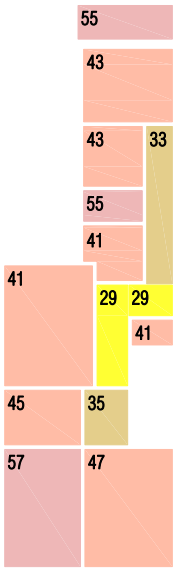


Entire dwelling
Mean: 1.00

Contiguity

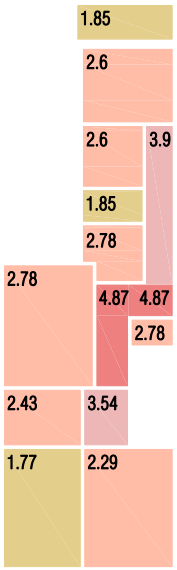


Depth



Entire dwelling
Mean: 42.42

Integration



Entire dwelling
Mean: 2.92

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1942

Number of floors: 7

Project authorship: Arch. Miguel Jacobetty

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; two staircases.
Number of dwellings	12
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Foundations made of concrete. Reinforced concrete structure.
Exterior walls (façades and side walls)	Main and rear façade made of concrete structure, thickness 0.5m. Reinforced concrete beams on all the floors. Side walls made of reinforced concrete, thickness from 0.2 on the upper floor to 0.4m on the basement.
Interior walls	Partition walls made of brick masonry.

Discrepancies, changes in the façade

Few cables through the building's main façade. Several air conditioning devices mounted on the main façade.

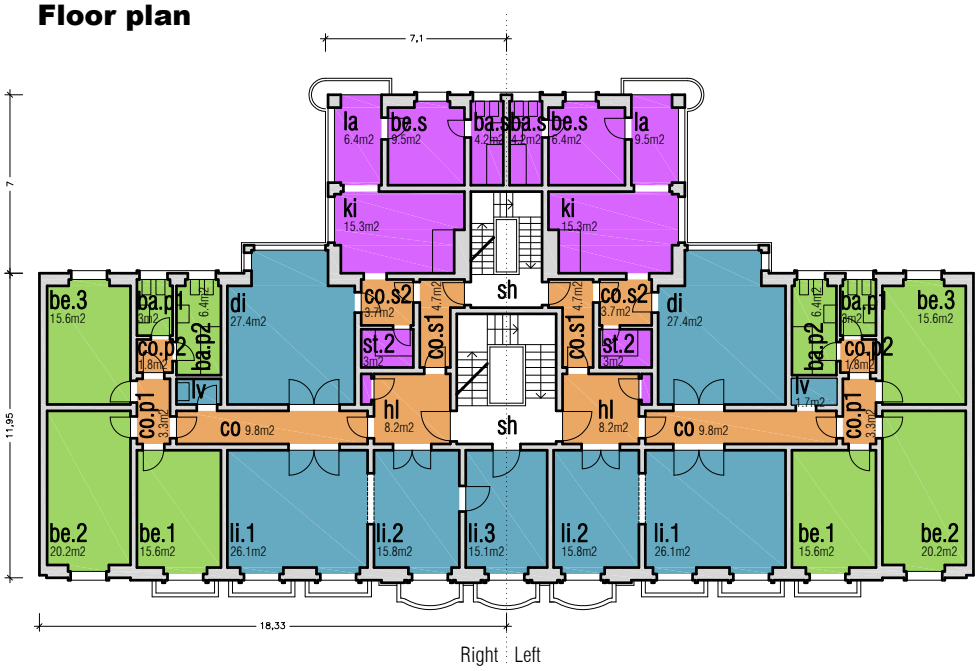
Av. António Augusto de Aguiar, 9 (1/3)

(Left) Net floor area: 213.1m² | Gross floor area: 265.6m² (Right) Net floor area: 198m² | Gross floor area: 247.1m²

type **a**

Original dwelling

Floor plan

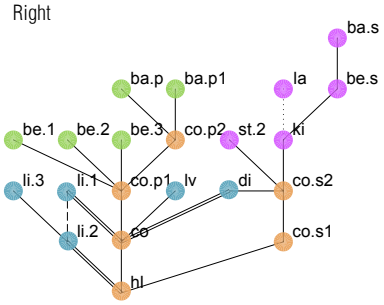


Right Left

Justified graph

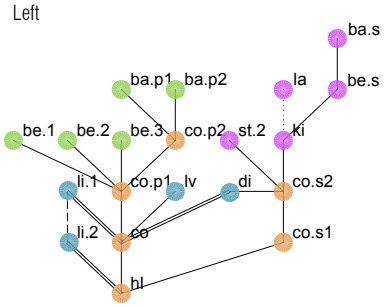
Graph with a tree configuration with 2 rings
Graph with 6 levels of depth
22 spaces/nodes
23 arcs/connections

Right

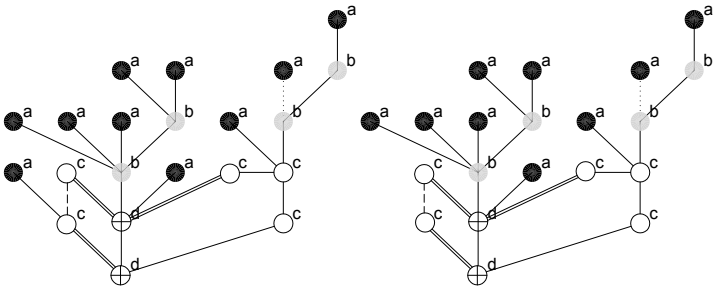


Graph with a tree configuration with 2 rings
Graph with 6 levels of depth
21 spaces/nodes
22 arcs/connections

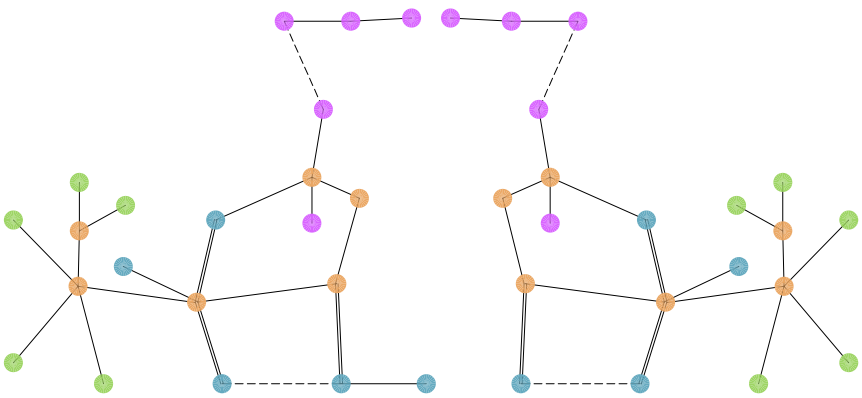
Left



Distributness



Convex map



- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- d _ reached by two or more arcs and connected by ≥ 2 rings

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

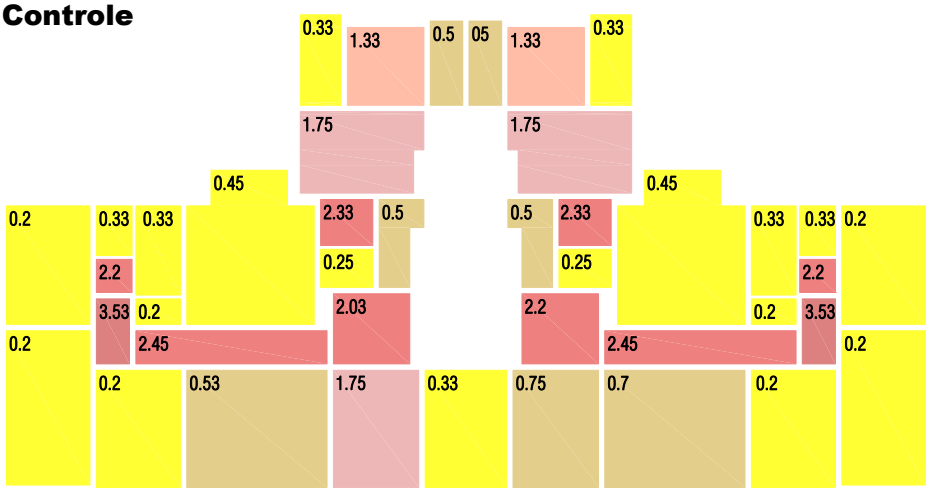
Av. António Augusto de Aguiar, 9 (2/3)

(Left) Net floor area: 213.1m² | Gross floor area: 265.6m² (Right) Net floor area: 198m² | Gross floor area: 247.1m²

type **a**

Original dwelling

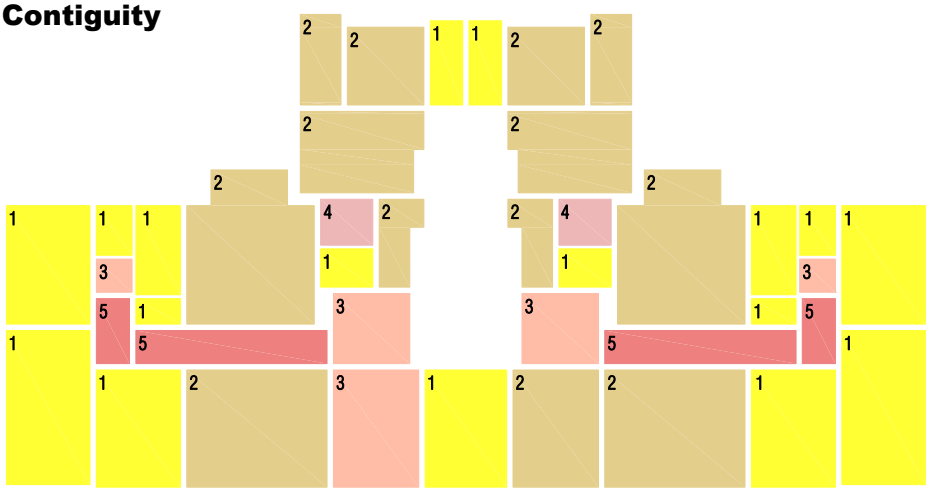
Controle



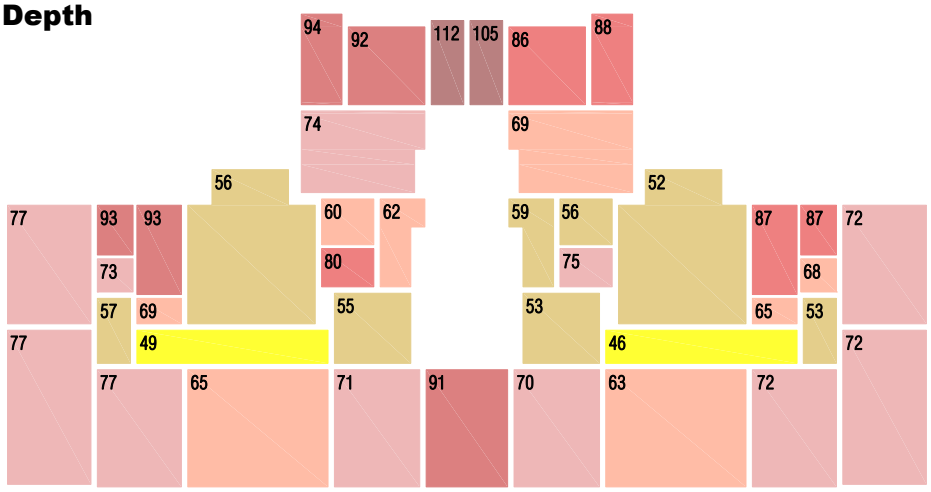
Entire dwelling
Mean: 1.00

Entire dwelling
Mean: 1.00

Contiguity



Depth



Entire dwelling
Mean: 75.09

Entire dwelling
Mean: 70.00

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

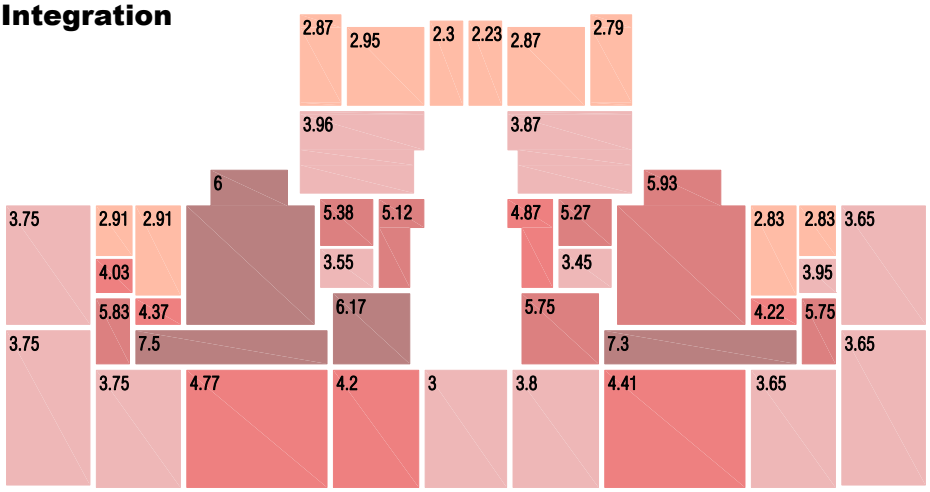
Av. António Augusto de Aguiar, 9 (3/3)

(Left) Net floor area: 213.1m² | Gross floor area: 265.6m² (Right) Net floor area: 198m² | Gross floor area: 247.1m²

type **a**

Original dwelling

Integration



Entire dwelling
Mean: 4.22

Entire dwelling
Mean: 4.13

Adjacency (arcs)
merged — door (single) — door (double) - - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: c.1949

Number of floors: 4

Project authorship: Arch. Fernando Silva

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building. One staircase.
Number of dwellings	6
Non habitable divisions	Shops in the ground floor

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	-
Interior walls	-

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. Double window frames resulting in a more advance window surface with aesthetic impact on the main façade. One closed balcony by glass windows. Air conditioning unit on the façade. Shops with alteration of the original openings. Few cables through the building's main façade.

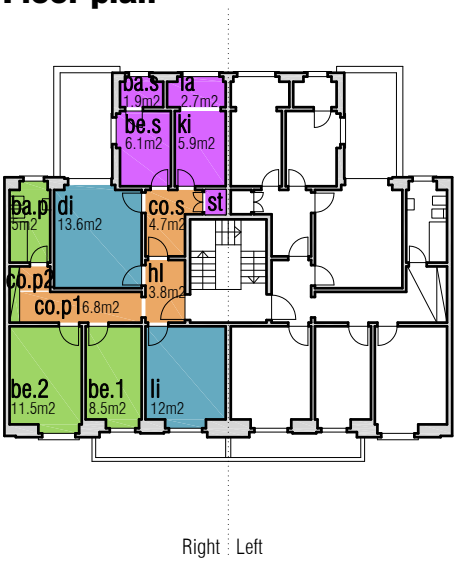
R. José d'Esaguy, 7 (Type 4 from the *célula 3* of *Bairro de Alvalade*)

Net floor area: 84.2m² | Gross floor area: 107m²

type **a**

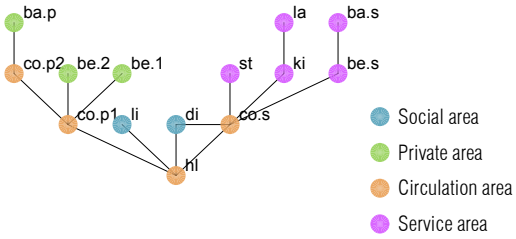
Original dwelling

Floor plan

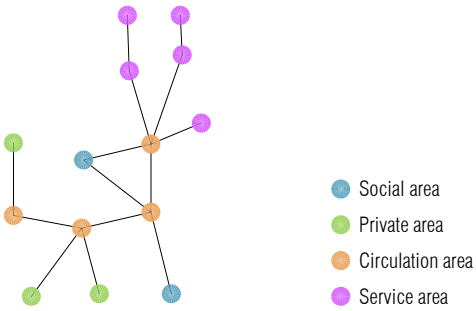


Justified graph

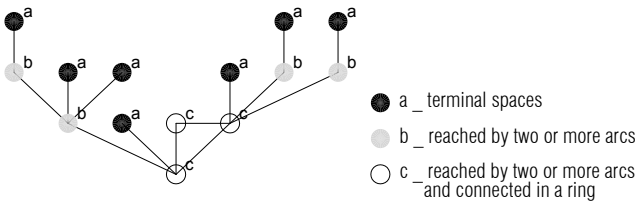
Graph with a tree configuration with 1 ring
Graph with 4 levels of depth
14 spaces/nodes
14 arcs/connections



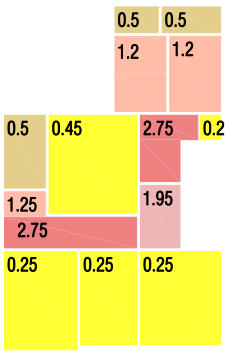
Convex map



Distributness

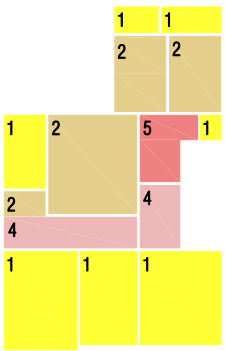


Controle

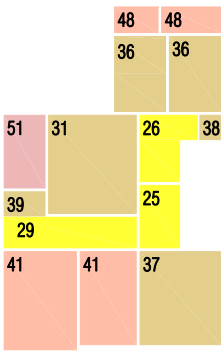


Entire dwelling
Mean: 1,00

Contiguity

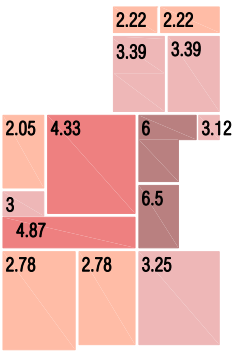


Depth



Entire dwelling
Mean: 37,57

Integration



Entire dwelling
Mean: 3.56

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1947

Number of floors: 5

Project authorship: Eng. Jacinto Bethencourt

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift, two staircases.
Number of dwellings	8
Non habitable divisions	Caretaker's home (in the back yard) Shops in the ground floor (garage)

Brief constructional characterization

Structure and foundations	Foundations made of simple concrete upon compacted clay ground. Reinforced concrete structure.
Exterior walls (façades and side walls)	Main and rear façades made of continuous reinforced concrete on the ground floor, thickness 0.5m. From the 1st floor up these façades are made of reinforced concrete beam and pillar structure filled with two panels of stretcher bonds and airspace. Side walls made of continuous reinforced concrete.
Interior walls	Partition walls made of brick masonry with cement mortar: on the 3rd and 4th floor made of hollow stretcher bond brick masonry; on the 1st and 2nd floor made of solid stretcher bond brick masonry; partition walls between stores in the ground floor made of solid header bond brick masonry; partition walls between different dwellings and staircase made of solid stretcher bond brick masonry on the ground floor (hollow brick above the ground floor).

Discrepancies, changes in the façade

One air conditioning device mounted on the façade. Several advertisement structures of large dimensions mounted on the façade.

R. Palmira, 62

Net floor area: 111.4m² | Gross floor area: 135m²

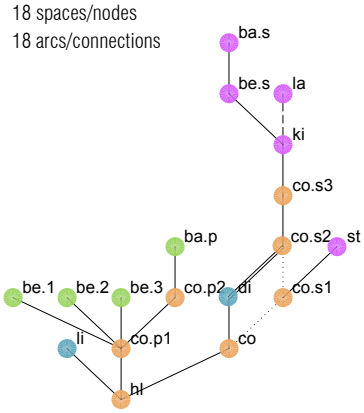
type **c**

Original dwelling

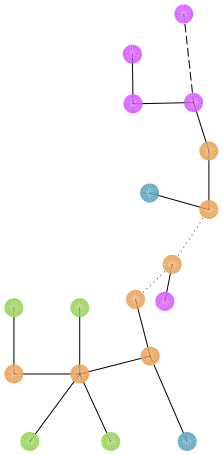
Floor plan

Justified graph

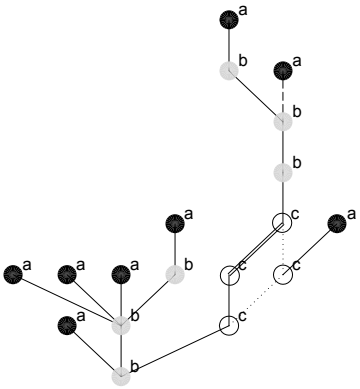
Graph with a tree configuration with 1 ring
Graph with 8 levels of depth
18 spaces/nodes
18 arcs/connections



Convex map

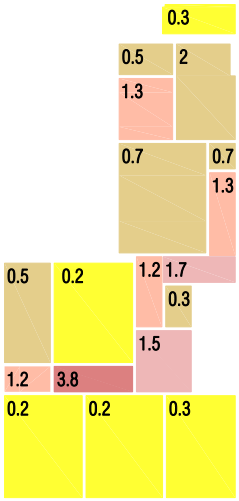


Distributness



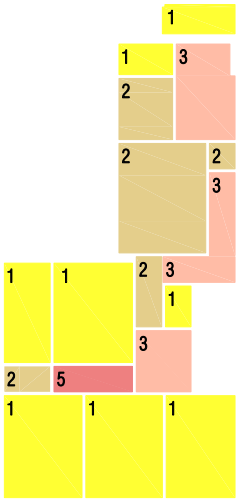
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

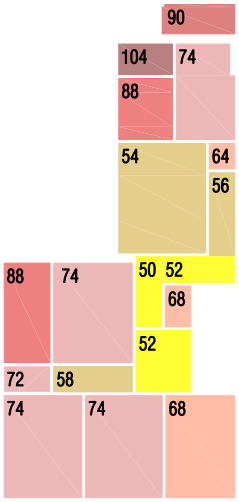


Entire dwelling
Mean: 1.00

Contiguity

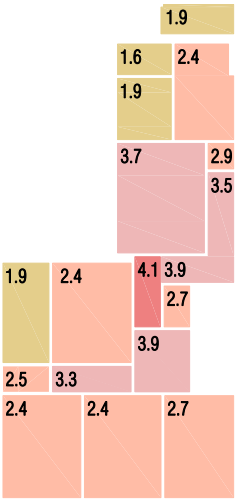


Depth



Entire dwelling
Mean: 70

Integration



Entire dwelling
Mean: 2.8

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1951

Number of floors: 4

Project authorship: Eng.n.92 (illegible signature)

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; one staircase.
Number of dwellings	7
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Foundations made of hydraulic stone masonry with cement and sand mortar. Reinforced concrete beam and pillar structure on the main and rear façade.
Exterior walls (façades and side walls)	Main and rear façades made of concrete structure filled with two panels of stretcher bonds and airspace of 0.1m, thicknesses of 0.4m. Side walls made of concrete structure filled with concrete blocks with a water repellent product coating.
Interior walls	Partition walls made of brick masonry with cement and sand mortar: 2nd and 3rd floor in hollow stretcher bond brick masonry, ground floor and 1st floor in solid stretcher bond brick masonry, thickness 0.15m.

Discrepancies, changes in the façade

Replacement of the windows in several floors with different designs. Few cables through the building's main façade. Changes on the façade design on the ground floor in the area occupied by stores. Gas infra-structure mounted on the ground floor façade.

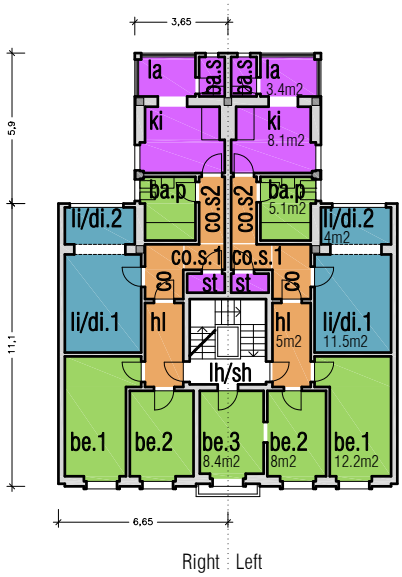
Estrada de Benfica, 490

(Left) Net floor area: 68m² | Gross floor area: 85.3m² (Right) Net floor area: 75.8m² | Gross floor area: 95m²

type **d**

Original dwelling

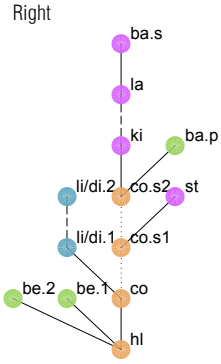
Floor plan



Justified graph

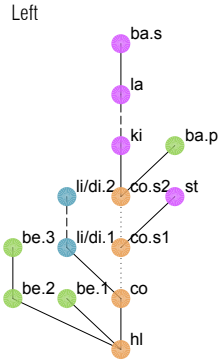
Graph with a tree configuration
Graph with 7 levels of depth
13 spaces/nodes
12 arcs/connections

Right



Graph with a tree configuration
Graph with 7 levels of depth
14 spaces/nodes
13 arcs/connections

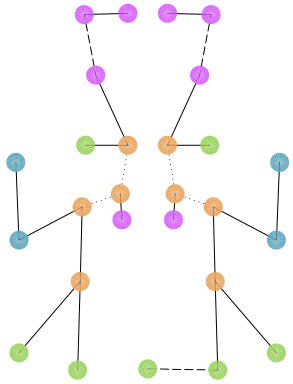
Left



Social area Private area Circulation area Service area

Convex map

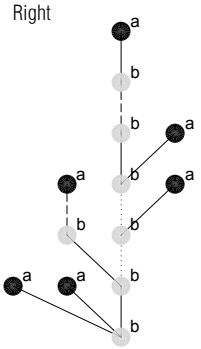
Right Left



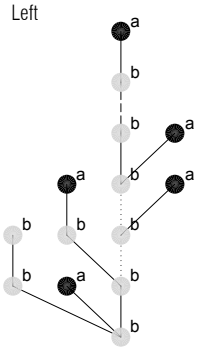
Social area
Private area
Circulation area
Service area

Distributness

Right

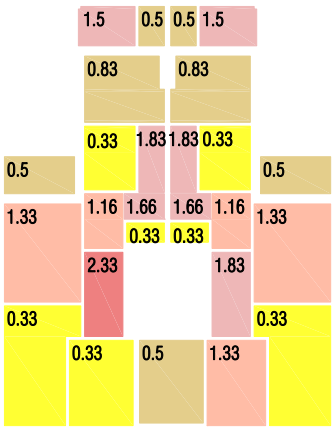


Left



a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring

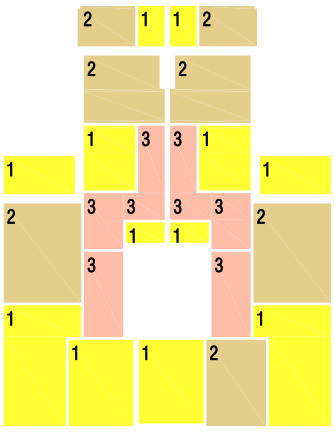
Controle



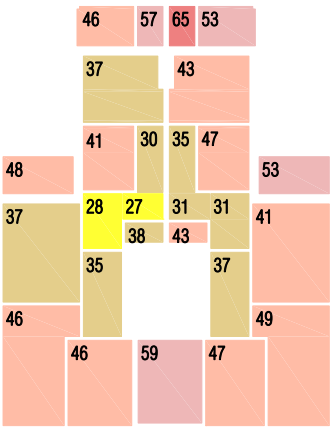
Entire dwelling
Mean: 1.00

Entire dwelling
Mean: 1.00

Contiguity



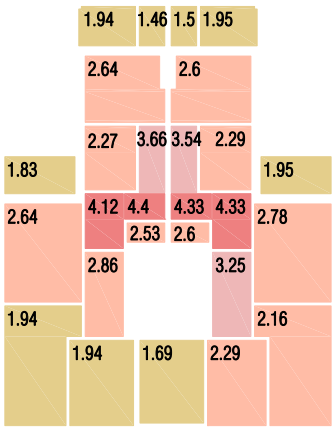
Depth



Entire dwelling
Mean: 39.69

Entire dwelling
Mean: 45.28

Integration



Entire dwelling
Mean: 2.63

Entire dwelli
Mean: 2.6

Adjacency (arcs)
merged door (single) door (double) passage window

Higher Lower

1 2 3 4 5 10

Front façade

Date: 1945

Number of floors: 4

Project authorship: -

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; two staircases.
Number of dwellings	7
Non habitable divisions	Caretaker's home

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	Main and rear walls made of ordinary stone masonry with cement and sand mortar. Side walls made of cement and sand blocks.
Interior walls	Partition walls made of brick masonry.

Discrepancies, changes in the façade

Air conditioning devices mounted on the main façade of the building

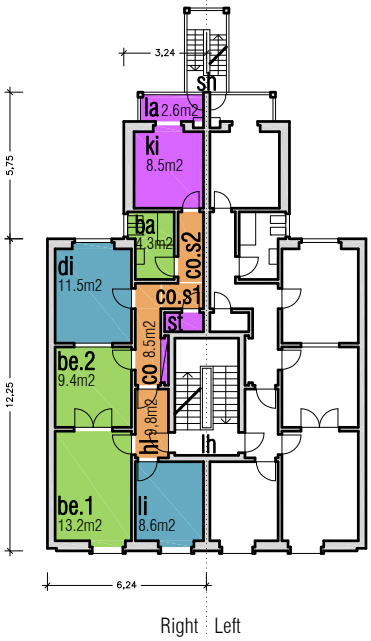
R. Bica do Marquês, 7

Net floor area: 78m² | Gross floor area: 88.8m²

type **d**

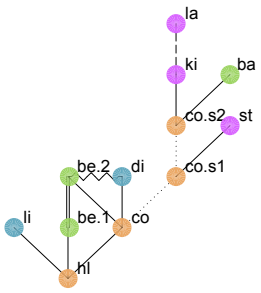
Original dwelling

Floor plan



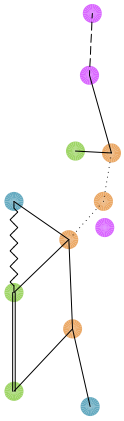
Justified graph

Graph with a tree configuration with 1 ring
Graph with 6 levels of depth
12 spaces/nodes
12 arcs/connections
(windows connections are excluded)



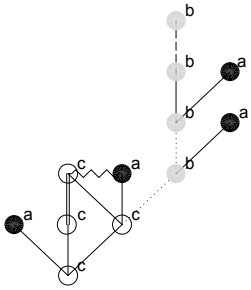
- Social area
- Private area
- Circulation area
- Service area

Convex map



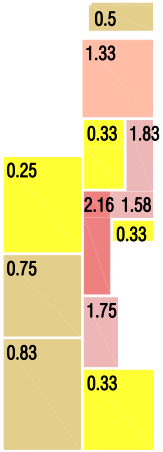
- Social area
- Private area
- Circulation area
- Service area

Distributness



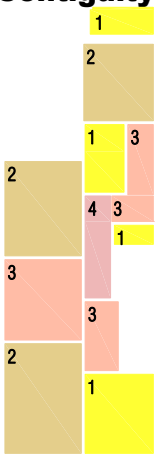
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

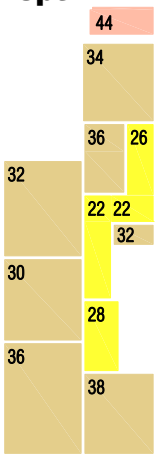


Entire dwelling
Mean: 1.00

Contiguity

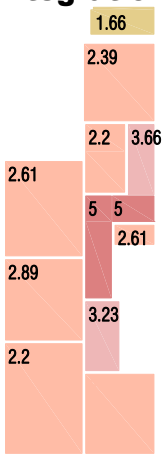


Depth



Entire dwelling
Mean: 31.66

Integration



Entire dwelling
Mean: 2,96

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1948

Number of floors: 4

Project authorship: Eng. n.220 (illegible signature)

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; one staircase.
Number of dwellings	7
Non habitable divisions	Condominium store-rooms Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	Foundations made of concrete with 0.5m height and above made of hydraulic stone masonry with cement and sand mortar. Main façade made of stone masonry, rear façade and side walls made of concrete blocks with cement and sand mortar.
Exterior walls (façades and side walls)	Main façade thickness: ground floor 0.7m; 1st floor 0.6m; 2nd floor 0.5m; 3rd floor 0.4m. Rear façade thickness: ground floor 0.5m; 1st floor 0.4m; 2nd floor 0.4m; 3rd floor 0.3m. Side walls thickness: 3rd floor 0.2m, remaining floors 0.3m.
Interior walls	Partition walls made of brick masonry thickness: ground floor and 1st floor 0.15m; 2nd and 3rd floor 0.1m.

Discrepancies, changes in the façade

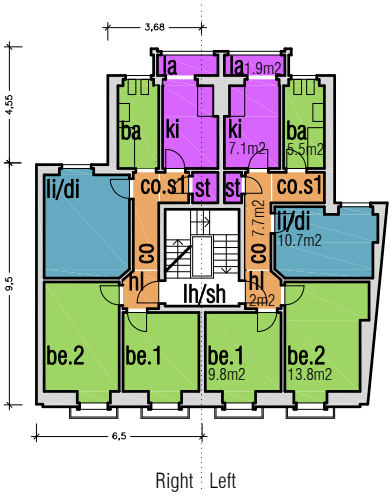
Several cables through the building's main façade.

Calçada do Galvão, 58

(Left) Net floor area: 59.8m² | Gross floor area: 75.6m² (Right) Net floor area: 58m² | Gross floor area: 74m²

type **b**

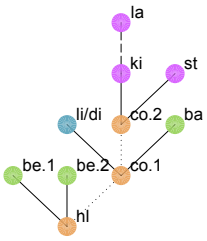
Original dwelling



Justified graph

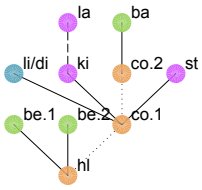
Graph with a tree configuration
Graph with 5 levels of depth
10 spaces/nodes
9 arcs/connections

Right



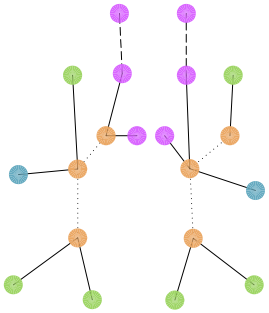
Graph with a tree configuration
Graph with 4 levels of depth
10 spaces/nodes
9 arcs/connections

Left



Social area Private area Circulation area Service area

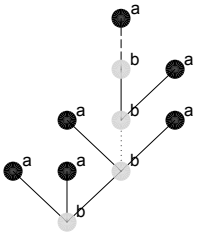
Convex map



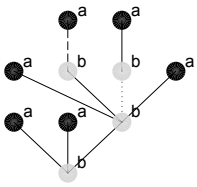
Social area
Private area
Circulation area
Service area

Distributness

Right



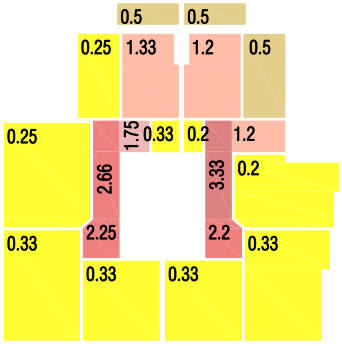
Left



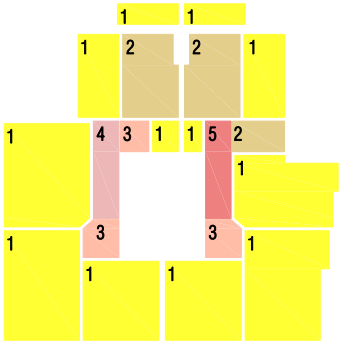
a _ terminal spaces
b _ reached by two or more arcs

c _ reached by two or more arcs and connected in a ring

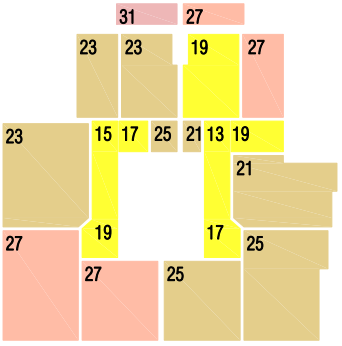
Controle



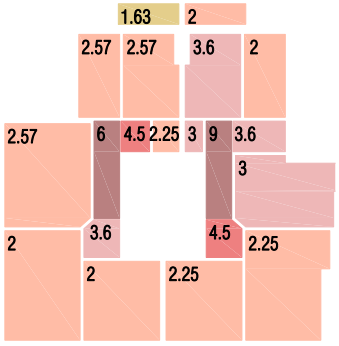
Contiguity



Depth



Integration



Entire dwelling
Mean: 1.00 (right) / 1.00 (left)

Entire dwelling
Mean: 23 (right) / 21.04 (left)

Entire dwelling
Mean: 2.97 (right) / 3.52 (left)

Adjacency (arcs)
merged door (single) door (double) passage window

Higher Lower

1 2 3 4 5 10

Front façade

Date: 1944

Number of floors: 3

Project authorship: Eng.n.161 (illegible signature)

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; two staircases
Number of dwellings	6
Non habitable divisions	-

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	-
Interior walls	-

Discrepancies, changes in the façade

Several cables through the building's main façade.

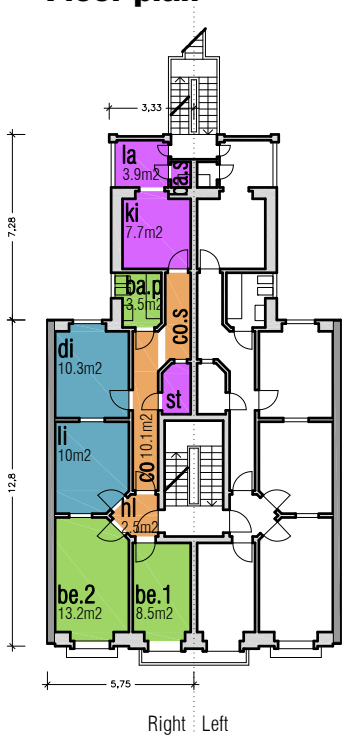
Calçada do Galvão, 135

Net floor area: 72.7m² | Gross floor area: 91.2m²

type **d**

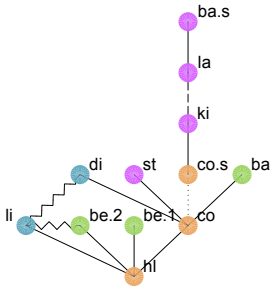
Original dwelling

Floor plan

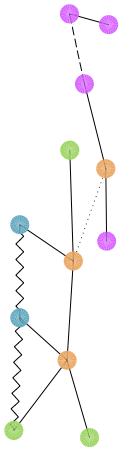


Justified graph

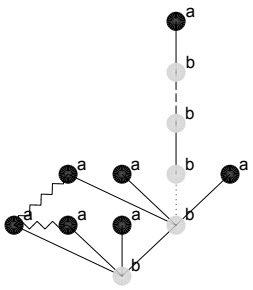
Graph with a tree configuration
Graph with 6 levels of depth
12 spaces/nodes
13 arcs/connections
(windows connections are excluded)



Convex map

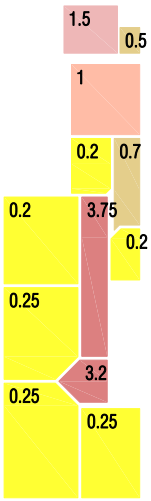


Distributness



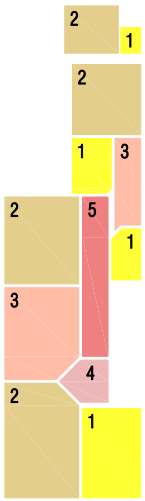
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

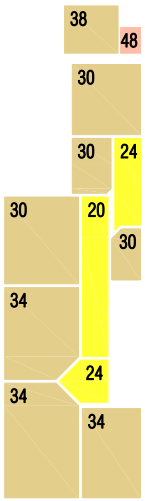


Entire dwelling
Mean: 1.00

Contiguity

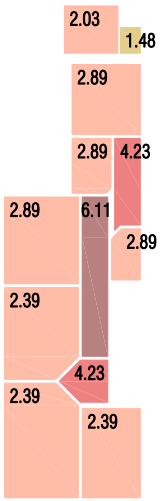


Depth



Entire dwelling
Mean: 31.33

Integration



Entire dwelling
Mean: 3.07

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Front façade

Date: 1948

Number of floors: 5

Project authorship: -

Door of the building

Building entrance hall

Brief functional characterization

Access	One access to the building; main lift, two staircases.
Number of dwellings	8
Non habitable divisions	Caretaker's home Shops in the ground floor

Brief constructional characterization

Structure and foundations	-
Exterior walls (façades and side walls)	-
Interior walls	-

Discrepancies, changes in the façade
Some air conditioning devices mounted on the main façade. Some windows frames where changed and replaced by different types of window (original casement windows where replaced by sliding windows). Few cables through the building's main façade.

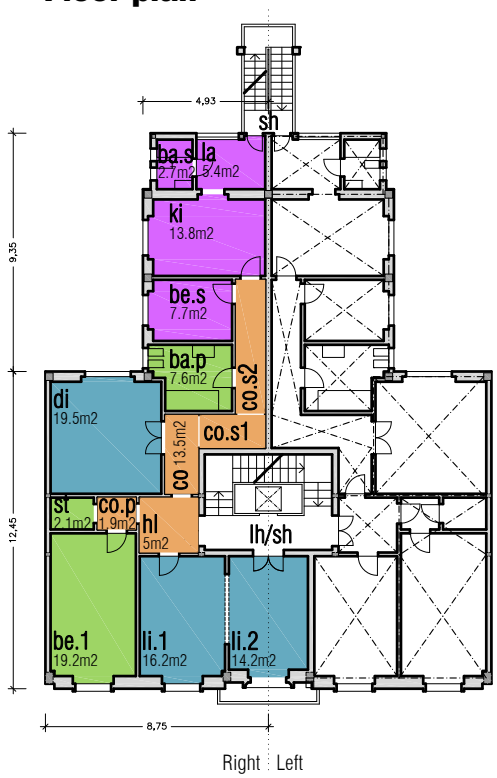
R. Tomás da Anunciação, 5 [right]

(Left) Net floor area: 121.2m² | Gross floor area: 153.1m² (Right) Net floor area: 106.5m² | Gross floor area: 135.7m²

type **d**

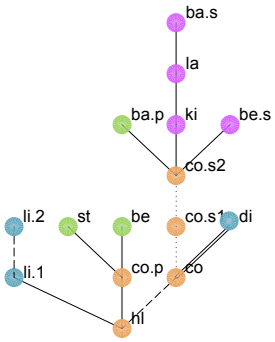
Original dwelling

Floor plan

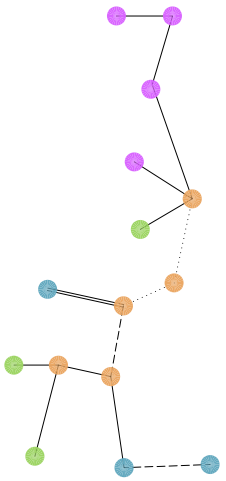


Justified graph

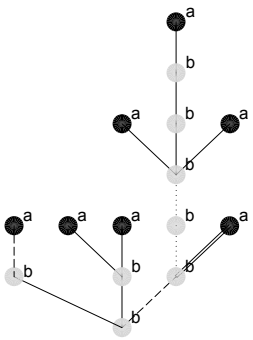
Graph with a tree configuration
Graph with 7 levels of depth
15 spaces/nodes
14 arcs/connections



Convex map

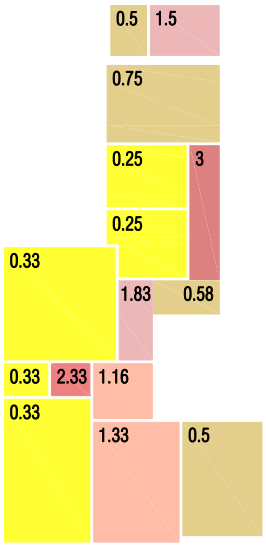


Distributness



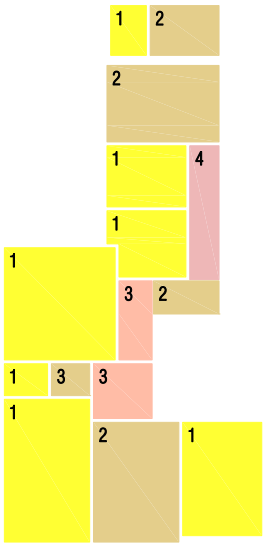
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

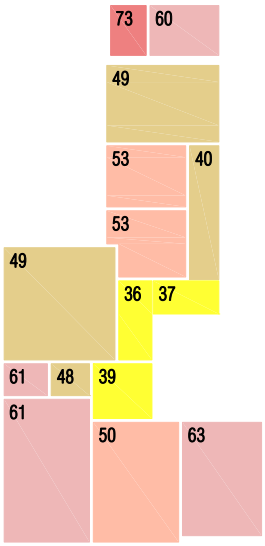


Entire dwelling
Mean: 1.00

Contiguity

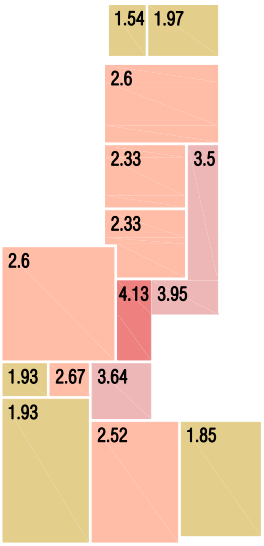


Depth



Entire dwelling
Mean: 51.46

Integration



Entire dwelling
Mean: 2.63

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

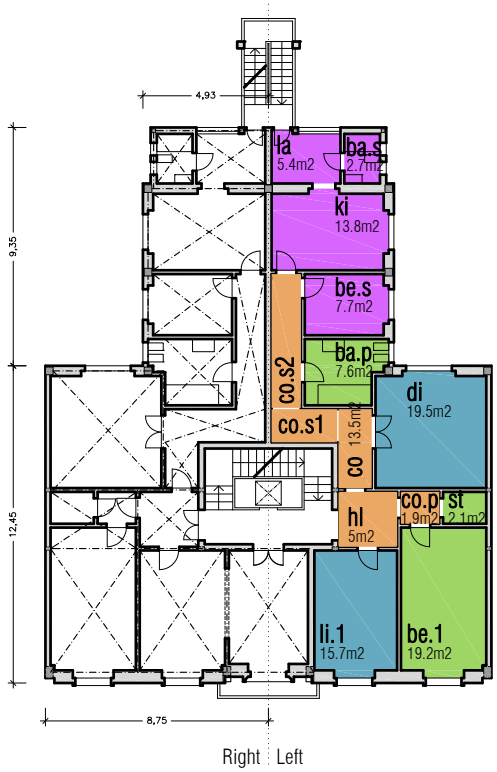
R. Tomás da Anunciação, 5 [left]

(Left) Net floor area: 121.2m² | Gross floor area: 153.1m² (Right) Net floor area: 106.5m² | Gross floor area: 135.7m²

type **d**

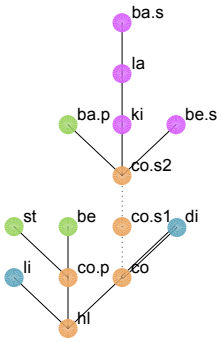
Original dwelling

Floor plan

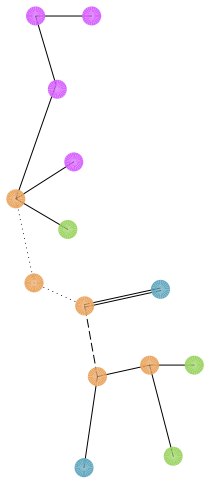


Justified graph

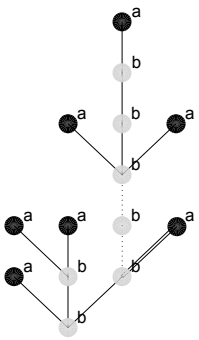
Graph with a tree configuration
Graph with 7 levels of depth
14 spaces/nodes
13 arcs/connections



Convex map

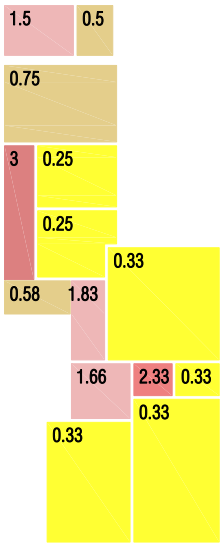


Distributness



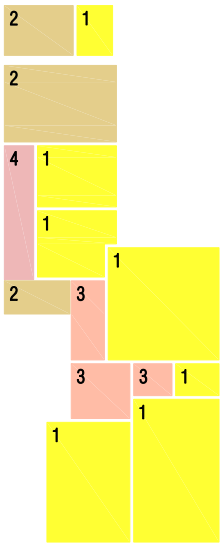
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring

Controle

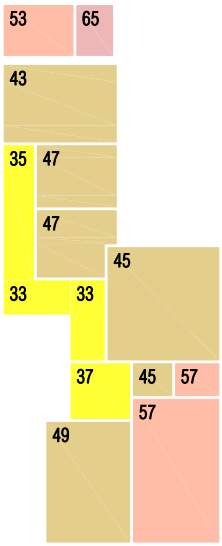


Entire dwelling
Mean: 1.00

Contiguity

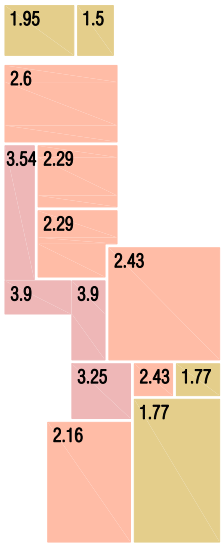


Depth



Entire dwelling
Mean: 46.14

Integration



Entire dwelling
Mean: 2.55

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

APPENDIX 2

Steps 1, 2 and 3 of the experiment

APPENDIX 2: STEPS 1, 2 AND 3 OF THE EXPERIMENT

As stated in *Part 2: Chapter 1.4* the methodology used to infer the transformation grammar was divided into three steps, each corresponding to a particular type of experiment:

- Step 1: testing the feasibility of the experimental setup by the main author of the research and defining a set of preliminary rehabilitation rules that could be transmitted to the experimental subjects in step 2:
- Step 2: finding rehabilitation solutions that could satisfy the functional and constructional requirements of each family in a given dwelling. These solutions, designed by hand, were used to infer transformation rules;
- Step 3: testing the transformation rules inferred in the previous step by verifying whether the solutions generated following these rules were satisfactory.

The goal was to relate domestic groups (families) to dwellings (existing houses). Prior to applying the methodology, data concerning the domestic groups, the case study dwellings, new housing functions, and the pack of ICAT functions was gathered and organised, as described below. These elements were then given to the experimental subjects in steps 1, 2 and 3.

This appendix includes data on these steps that is not cited in the main body of the thesis, namely the data used by the experimental subjects and some examples of the results of the experiment.

DATA USED: FAMILIES AND EXISTING HOUSES

The results of the interviews with the five families are presented in Table 1 to Table 5.

Family 01	Couple with 3 children	**Minimal functional programme**
		1 Double bedroom; 1 Twin bedroom; 1 Single bedroom; 1 Kitchen; 1 Living room; 1 Bathroom (toilet, lavatory, bidet, bath or shower); Storage areas
	Couple Girl aged 5 Girl aged 3 Boy aged 1	**Extra areas or functions in order of priority**
		Small office space; 2 Private bathrooms (toilet, lavatory, bidet, bath or shower); Large living/dining room (≥ 12m^2 and 18m^2); 1 guest bathroom
		Important connections between rooms
		Children's bedrooms near parents' bedroom; Private bathrooms in private area; Living room adjacent to dining room or large combined living/dining room

Table 1 – Results from the interview with family 01

Family 02	Couple with 2 children	**Minimal functional programme**
		1 Double bedroom; 1 Twin bedroom; 1 Kitchen; 1 Living room; 1 Bathroom (toilet, lavatory, bidet, bath or shower); Storage areas
	Couple Girl aged 8 Girl aged 4	**Extra areas or functions in order of priority**
		2 Single bedrooms for children; Living room separated from dining room (≥ 12m^2 and 18m^2); 2 Private bathrooms; 1 guest bathroom; Room for home office which could also be used as a guest bedroom; Laundry room separate from, but near, kitchen
		Important connections between rooms
		Children's bedrooms near parents' bedroom; Private bathroom in private area; Dining room near kitchen; Living room near entrance

Table 2 – Results from the interview with family 02

Family 03	Young couple without children	**Minimal functional program**
		1 Double bedroom; 1 Kitchen; 1 Living room; 1 Bathroom (toilet, lavatory, bidet, bath or shower); Storage areas
	Couple	**Extra areas or functions in order of priority**
		Home office in an independent room; Big living/dining room (≥ 25m^2); Balcony connected to social area; Extra storage areas; 1 guest bathroom
		Important connections between rooms
		Private space (bedroom and bathroom) segregated from the rest of the dwelling

Table 3 – Results from the interview with family 03

Family 04	Elderly couple	**Minimal functional programme**
		1 Double bedroom; 1 Kitchen; 1 Living room; 1 Bathroom (toilet, lavatory, bidet, bath or shower); Storage areas
	Couple 2 grandsons (occasionally)	**Extra areas or functions in order of priority**
		1 Twin bedroom for grandsons (occasional use); Small office space; Dining area in kitchen; Living room separate from dining room; 1 guest bathroom
		Important connections between rooms
		Bedrooms next to each other; Guest bathroom in social area; Dining room near kitchen

Table 4 – Results from the interview with family 04

Family 05	Couple with children (second marriage, children from different marriages) Couple 2 children from mother's previous marriage (girl aged 8, boy aged 10), 1 child from father's previous marriage (boy aged 12)	**Minimal functional programme**
		1 Double bedroom; 1 Twin bedroom; 1 Single bedroom; 1 Kitchen; 1 Living room 1 Bathroom (toilet, lavatory, bidet, bath or shower); Storage areas
		Extra areas or functions in order of priority
		1 Single bedroom for each child; 2 Private bathrooms; 1 guest bathroom; Extra storage areas; Big living room and dining room (1 or 2 rooms) (dining room ≥12m^2 and living room≥20m^2)
		Important connections between rooms
		All bedrooms in private area; Children's bedrooms next to each other; Private space (bedrooms and bathrooms) segregated from the rest of the dwelling

Table 5 – Results from the interview with family 05

The criterion for selecting dwellings for the 1st and 2nd steps was to choose ten dwellings of varying types and areas that could potentially meet the requirements of the functional programmes for the selected families (Table 6).

The 10 chosen dwellings corresponded to 3 "type A" dwellings, 2 "type B" dwellings 2 "type C" dwellings and 3 "type D" dwellings (see Figure 1 and Table 7).

For the third step, three different dwellings were chosen that were not used in the 1st and 2nd experiments.

Family		**Recommended number of bedrooms** (minimal)	***Rabo-de-bacalhau*** (selected types) **A**	**B**	**C**	**D**
Family 01	Couple with 3 children	3				
Family 02	Couple with 2 children	2				
Family 03	Young couple without children	1	*		*	
Family 04	Elderly couple alone	1	*		*	
Family 05	Couple with 3 children from different marriages	3				

Compatible types

* The types indicated are unsuitable for the size of the family. These dwellings may correspond to the functional programme if divided into two different dwellings.

Table 6 – Correspondence between selected dwellings and family size. 1st and 2nd steps of the experiments.

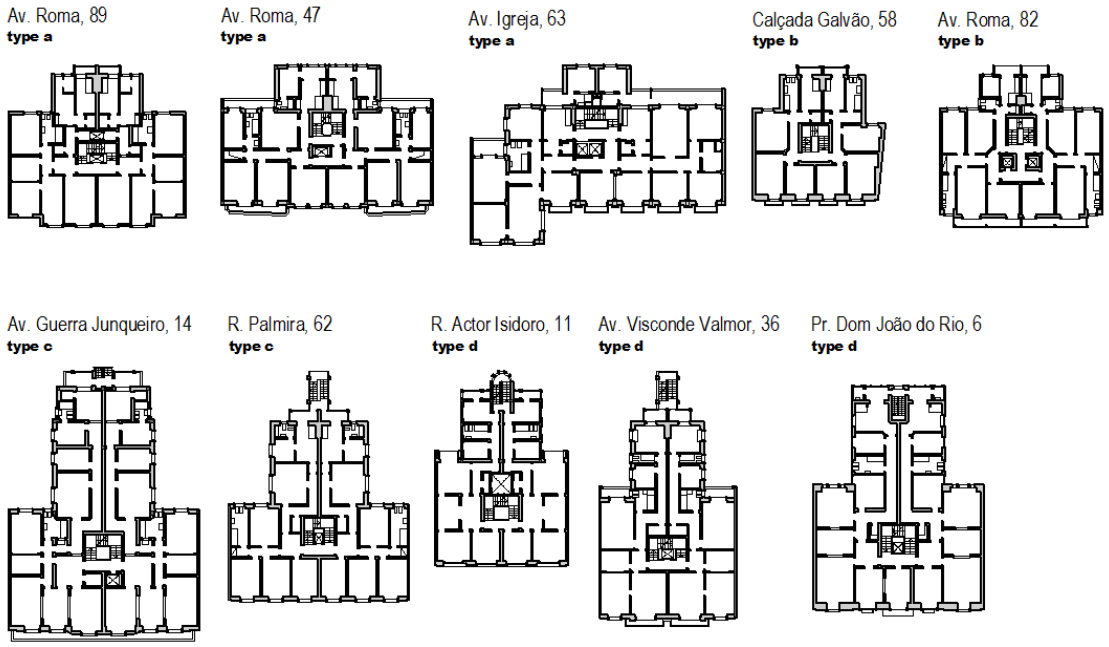


Figure 1 – Dwellings selected for the 1st and 2nd step of the experiment.

Divisions	Family 1 2+3 people 3 bedrooms		Family 2 2+2 people 3 bedrooms		Family 3 2 people 1/2 bedrooms		Family 4 2 people 2 bedrooms		Family 5 2+3 people 4 bedrooms	
	minimum	recom.	minimum	recom.	minimum	recom.	minimum	recom.	minimum	recom.
Double bedroom	10.5	12	10.5	12	10.5	12	10.5	12	10.5	12
Twin bedroom	9	14.5	-	-	-	-	9	14.5	-	-
Single bedroom	6.5	8.5	13	17	-	-	-	-	19.5	25.5
Living room	18	16	16	16	25	25	12	18.5	20	20
Dining room	12	12	12	12	-	-	-	-	12	12
Media room	-	3	-	3	-	-**	-	2	-	-
Kitchen	6	10.5	6	10.5	6	9	6	9	6	11.5
Laundry	2	3.5	2	3.5	2	3.5	2	3.5	2	3.5
Private bathroom 1	3.5	5	3.5	5	3.5	5	3.5	5	3.5	5
Private bathroom 2	1	2	1	2	-	-	-	-	2.5	3
Guest bathroom	-	1	-	1	1	2	1	2	1	2
Storage	4	4	3.75	3.75	3.25	3.25	2.25	2.25	5.25	5.25
Adult work area	2	4	6.5	8.5	2	4	2	4	1	3
Corridor (16%)*	11.92	15.36	11.88	15.08	8.52	10.20	7.72	11.32	13.32	16.44
Net floor area of desired dwelling	**86.42**	**111.36**	**86.13**	**109.33**	**61.77**	**73.95**	**57.13**	**85.55**	**96.57**	**119.19**
Minimum net floor area of dwelling	72,5	111	66,4	99	44,4	66,1	46	65	77,4	114

Rehabilitated dwellings:										
Hyp.1	97	type a	100,2	type a	96,3	type d	85,1	type b	153,5	type c
Hyp.2	111	type c	120,8	type d	59,8	type b	77,3	type d	121,3	type a
Hyp.3									118,6	type a

Not part of the minimum functional programme but requested by the family

Adequate floor area

Excess floor area

* The circulation area was calculated using the ratio resulting from the case study analysis - 16%

** The additional media room area was not considered, since the living room area was indicated by the residents.

Table 7 – Calculations for the net floor area (m^2) for each family based on the minimum values in the functional programme and the needs expressed by each family. Comparison between these values and the net floor area of each of the two dwellings assigned to each family in Steps 1 and 2.

STEP 1

The aim of this first step was to test the rehabilitation hypotheses according to the requirements defined in the functional programme, in addition to the pack of ICAT and the extra requirements specified by each family. As this step was undertaken by the author of the thesis, the information set used was the knowledge of aspects relating to the rehabilitation work acquired up to this stage. The data on the families (the functional programme and ICAT pack) and proposed dwellings was as previously defined.

The procedure for carrying out the experiment, together with the information used and the procedure for assessing the results, was similar to those illustrated in Step 2 (see pages 73 to 80).

STEP 2

In step number 2 the same data from experiment 1 was used, namely, 10 existing dwellings (Figure 1) and 5 different families (Table 1 to Table 5). Besides the dwelling layouts (plotted on a scale of 1:100 or DWG drawing) and the written description of family desires, a brief description of the major functional and constructional aspects the family had to follow was given to the experimental subjects (Figure 3).

The data that resulted from these experiments included sketches (two of the architects designed by computer and therefore did not produce sketches) (Figure 2), final drawings of the proposed layouts, and texts explaining the process followed in each case (two of the architects explained the process verbally and therefore did not write texts.)

Pages 73 to 80 show one example of a pair of family/dwelling transformations produced during Step 1 by experimental subject #1 and during Step 2 by experimental subjects #2a, #2b, #2d and #2e. The first experimental subject proposed three different transformations and all others but one of the experimental subjects proposed only one transformation. The total proposed layouts for this dwelling/family pair was 7. Page 80 shows the evaluation form which was completed for each of the seven layouts in order to assess fulfilment of the functional programme for the dwelling.

A set of forms similar to the sample shown in pages 73 to 79 was completed for each of the 35 resulting dwelling transformations in order to compare them and infer transformation rules.

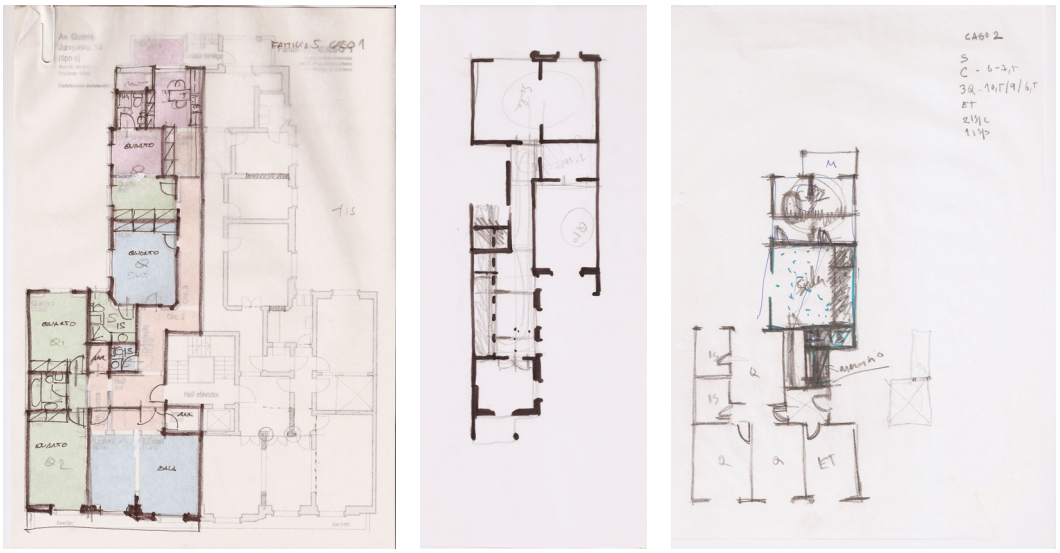


Figure 2 – Drawings produced by the experimental subjects during Step 2 of the experiment

All dwellings must include the following mandatory rooms (MR) and optional rooms (OR). Room net floor areas are shown.			
MR	Kitchen (≥6m²)	OR	Living room (if isolated) (≥10,5m²)
MR	Laundry (can be included in the kitchen) (if apart from kitchen, it must have ≥1,5m²)	OR	Dining room (if isolated) (for 2 persons ≥7,5m²)
MR	Living and dining room (must include living and dining space for, at least, all the members of the family) (for 2 or 3 people ≥18m², for 4 or 5 people ≥20m²)	OR	Guest bathroom (≥1m²)
MR	Private bathroom (toilet, lavatory, bidet, bathtub or shower) (≥3,5m²)	OR	2nd private bathroom (≥2,5m²)
MR	Bedroom(s) (couple ≥10,5m², double ≥9m², single ≥6,5m²)	OR	Home office

Functional areas	Rules
Social area	_ Spaces: living room, dining room, home office, social bathroom. _ Inhabitable spaces must have natural light and ventilation; _ Social area must be near the entrance and permit easy access; _ Living and dining rooms must have a proper access to the circulation area or to other living area; _ Two separated but connected (living and dining) rooms are recommended, rather than one room; _ **The living room must be of the appropriate size and have enough space to accommodate the furniture needed for a large TV set or home cinema;** _ The guest bathroom must be near social and circulation area; access to the social bathroom should not be visible from the entrance; the guest bathroom should not have direct access to living or dining room;
Private area	_ Spaces: Bedroom(s), private bathroom(s) and closet(s) _ Inhabitable spaces must have natural light and ventilation. It is permissible for a bedroom not to have natural light or ventilation if it is only used occasionally, in which case it must receive light and ventilation from another adjacent room; _ The private area must be the most segregated area of the dwelling; _ The circulation area that serves the private area must be separate from the one that serves the social and service areas. **The night-time areas (bedrooms + private bathroom) ought to be separated from the daily-time areas (living and dining rooms + kitchen) by doors or hallways**. _ Bedrooms must have a proper access from a circulation areas or access from a home office or a play room. _ Bedrooms must have easy and direct access to private bathroom without crossing social areas; _ Connexion between bedrooms and entrance door must be done by one or two circulation spaces apart from living and dining rooms.
Service area	_ Spaces: kitchen, laundry, storeroom; _ The kitchen must have natural light and ventilation or light and ventilation via the laundry; _ The kitchen must have proper access to the circulation area although it may also have access via a living or dining room (permissible if this is not the only division in the social area) _ The kitchen must include an area for informal meals or, alternatively, direct access to the dining room; _ The kitchen must be near the laundry and have easy access to it.
Circulation area	_ The circulation area must be reduced and used more efficiently (e.g. by adding closets or enlarging the social area); _ Circulation spaces within different areas must not have breaks (e.g. doors between two different private corridors)
Demolition / new construction	_ Rehabilitation work must involve little demolition and only in "surgical" situations. _ Entire walls cannot be demolished. Demolition work must obey two rules: the length of the demolished section should be 2m or less and it cannot total more than half the wall; _ Beams for new openings must be considered in any demolition work; _ Bathrooms can be relocated if this proves to be the best solution (we used maceration technology or a new vertical line of sewage). _ New walls must be constructed using a light partition wall system as plasterboard, wood panelling, etc.
Floor areas	_ The criterion of minimal floor area is used to achieve a sustainable solution. This criterion can only be reformulated in accordance with new requirements by residents

Figure 3 – Information given to the experimental subjects for use in creating their rehabilitation proposals. Summary of the functional programme for the dwellings and the rules for transformations.

STEP 3

As explained in *Part 2: Chapter 1.4.3*, the goal of Step 3 was to test the proposed grammar on dwellings that had not been used to infer the rules in order to check whether they provided the compositional means for making new transformations in other existing dwellings for other families.

This experiment was carried out by a class of 22 architecture students. The final layouts obtained from this experiment were as follows, by experimental subject group (see Figure 4):

- Group 01 – Did not complete the experiment in 3 hours. They failed to obey four shape rules during the derivation. The rules that were not obeyed were concerned with dimension conditions (net area and length and weights (to position new bathrooms). The derivation was performed immediately, without revising any decisions. The final result contained misinterpretations.
- Group 02 – Completed the experiment in 3 hours**.** They obeyed all the shape rules and explored a viable and correct dwelling layout in accordance with the transformation grammar. One rule was misinterpreted but the final result was good and the questions raised by the misinterpretation were transferred to a new grammar rule. The derivation was completed at the second attempt. The final result was positive.
- Group 03 – Completed the experiment in 4 hours (initial session of 3h and second session of 1h). The derivation was performed immediately, without revising decisions. The final result was positive.
- Group 04 – Completed the experiment in 3 hours**.** In some cases, they did not follow the rule application sequence but this was not relevant to completion of the exercise. They failed to obey some shape rules during derivation. The rules that were not obeyed were concerned with dimension conditions (net floor area) and led to an incorrect dwelling layout. The final result contained misinterpretations.
- Group 05 – Did not complete the experiment in 3 hours. They did not obey 1 fundamental shape rule concerning the assignment of the private bathroom and the dwelling layout was therefore incorrect. This group invented new rules and misinterpreted the exercise. The final result was negative.
    - The 5th group tried to accomplish the exercise in a second session of 2 hours using a different dwelling. The dwelling was too small for the family's extra requests. The experimental subjects reached a solution but did not consider the articulation/function conditions of the rules. They also did not explore the rules for changing the shape of rooms. The final result was viable but as the rule conditions were not met, it would have rated badly in terms of functional organisation.
- Group 06 – Completed the experiment in 3 hours**.** They obeyed all the shape rules and explored a viable and correct dwelling layout according to the transformation grammar. The derivation was completed at the second attempt because of a simple mistake that could have been avoided if they had read the rule application sequence carefully. The final result was positive.
- Group 7 – Completed the experiment in 3 hours**.** One demolition not included in the rules was performed and the geometry of the final layout was altered without any apparent benefit. Due to lack of compliance with the rule conditions, a rule was applied

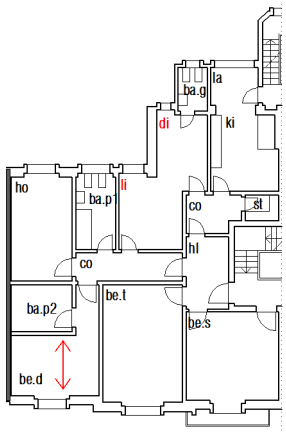
wrongly and an unnecessary new space was created. The derivation was completed at the second attempt because of a simple mistake that could have been avoided if they had read the rule application sequence carefully. The final result contained misinterpretations.

- Group 08 – Completed the experiment in 5 hours (initial session of 3h and second session of 2h). In the first session they anticipated the assignment of the guest bathroom without obeying the rule and reached a dead-end. The final result was negative. In the second session they made new mistakes (altering the order of the rules) but achieved a positive result.
- Group 09 – Completed the experiment in 3 hours. The dwelling assigned to this group contained a special feature that led to a misinterpretation of a shape rule – this new aspect was subsequently included in the grammar. This group added an unnecessary new private bathroom by using a rule wrongly and this led to an incorrect result. They failed to obey some shape rules during derivation. The rules that were not obeyed concerned dimension conditions (net area), functional conditions (functions associated with labels) and weights (demolition of structural elements). The derivation was performed immediately without revising decisions. The final result contained misinterpretations.
- Group 10 – Did not complete the experiment in 3 hours. The given dwelling did not fulfil family needs. They failed to obey some shape rules during derivation. The rules that were not obeyed concerned labels (the left shape rule label did not correspond to the one they used). These wrongly applied rules led to incorrect dwelling layouts. The final result contained misinterpretations.

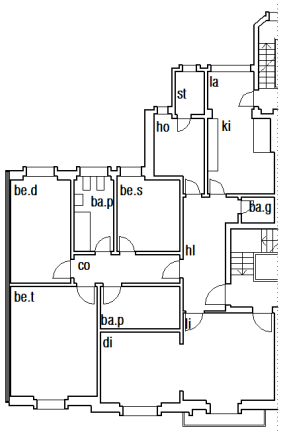
	Dwelling	**Experimental subjects**		
Family 1	(D1) Pr. Afrânio Peixoto, 13 (type a)	**01** 2 people	**02** 2 people	
Family 2	(D1) Pr. Afrânio Peixoto, 13 (type a)	**03** 1 person	**04** 2 people	**05 (1st session)** 3 people
	(D2) R. Actor Isidoro, 16 (type d)			**05 (2nd session)** 3 persons
Family 3	(D3) Calçada do Galvão, 135 (type d)	**06** 2 people	**07** 3 people	
Family 4	(D4) Estrada de Benfica 490 (type d)	**08** 1 person	**09** 3 people	
Family 5	(D5) Av. de Roma, 85 (type a)	**10** 3 people		

Did not complete the experiment and did not comply with all the rules	Completed the experiment but did not comply with all the rules
Did not complete the experiment but complied with the rules	Completed the experiment and complied with all the rules

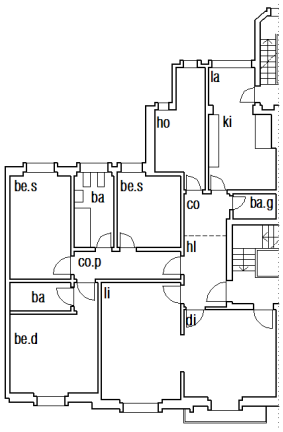
Table 8 – Composition of groups in the 3rd experiment



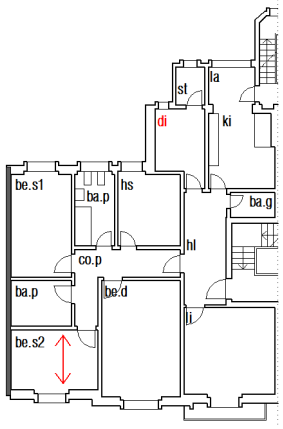
f1_d1_es01



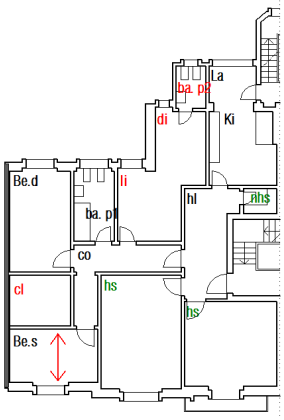
f1_d1_es02



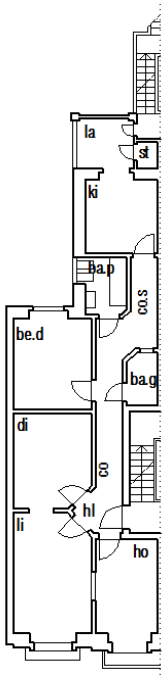
f2_d1_es03



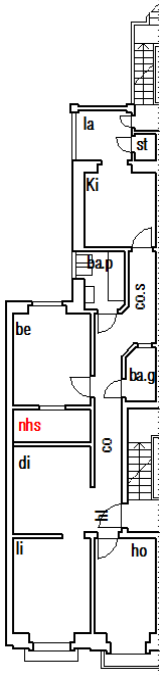
f2_d1_es04



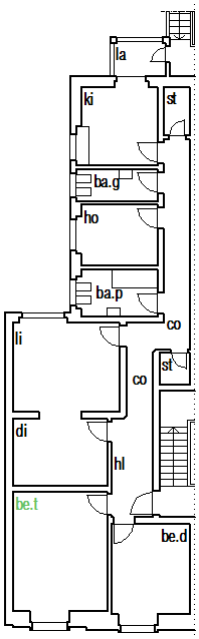
f2_d1_es05(1st)



f3_d3_es06



f3_d3_es07



f2_d2_es05(2nd)

Figure 4 (continued on next page) – Final dwelling layouts at the end of the experiment, by experimental subject groups. f (family); d (dwelling), es (experimental subject)

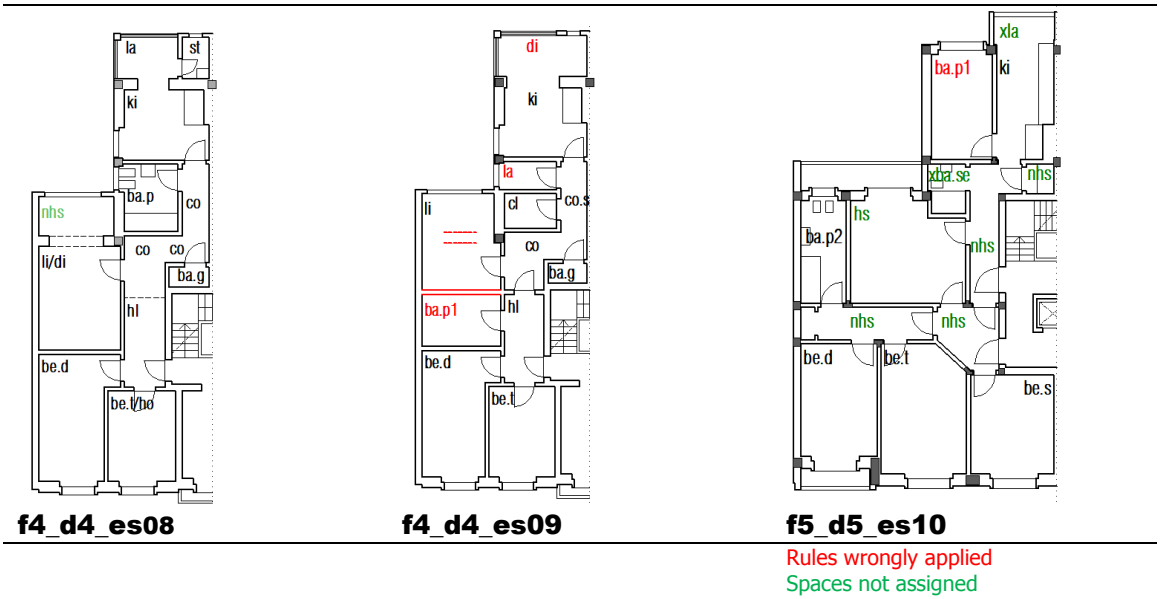


Figure 6 (continuation of the previous page) – Final dwelling layout at the end of the experiment, by experimental subject groups. f (family); d (dwelling), es (experimental subject)

The following conclusions can be drawn from this experience:

- Contrary to what happened in the second step of the experiment, the demolition restrictions were not considered a problem in transforming the dwelling, except in one case involving one group derivation;
- The major difficulty was finding rooms that met the net floor area conditions. Almost all the rooms were smaller than the areas requested. This obstacle led to some possible solutions that need to be integrated into the rules:
  - Assigning a tolerance to the requested area, e.g. 10% (F≥9m2 means that F≥8,1m2) → this was included in the revised grammar rules;
  - Allowing a room, e.g. a double bedroom, to be allocated to a smaller space if the floor area could be enlarged. This possibility is difficult to introduce as a rule because a large number of shape, dimensional and functional conditions have to be met in relation to all the surrounding rooms;
  - Allowing a space to first be enlarged and then assigned a function;
  - Using the areas required for the minimum level, even if the recommended level had been chosen by the family → this was included in the revised grammar rules;
- Instead of having a sequence of *assignment* then *changing shape* rules for each functional area, the experiment revealed that it would be better to have the *assignment* rules for all the functional areas and then all the *changing shape* rules separately. This would enable room shape to be changed whenever necessary rather than based only on the predefined sequence → this conclusion was included in the revised grammar rules;
- Instead of having different *changing shape* rules for each of the functional areas, it was preferable to have the group of *changing shape* rules with the shape part equal and the conditions differing according to functional or dimensional restrictions → this conclusion was included in the revised grammar rules;

- As there are mandatory rooms (those required by the functional programme) and optional rooms (the extra ones required by the family, in order of priority) and it is sometimes not possible to satisfy all requirements, it would be better assign in the following order:
    - Firstly, allocate and ensure the mandatory rooms;
    - Secondly, allocate the optional rooms.

Although this option is an interesting possibility, its application would solve some problems but also create others. The main new problem would be the difficulty in keeping the divisions in the different functional areas together, given that they would be attributed at different stages.

Av. Roma, 89 (type a)

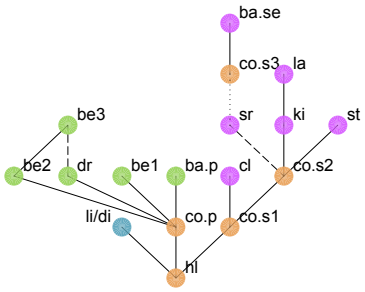
Net floor area: 97m² | Gross floor area: 118m²

Family01_ **CASE 1**

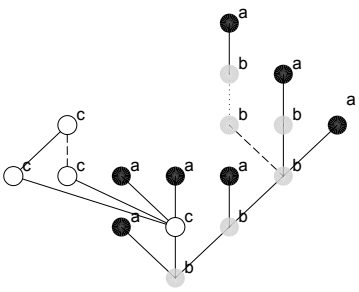
couple with children (2 adults + 3 children, 5, 2, 0 years)

Original dwelling

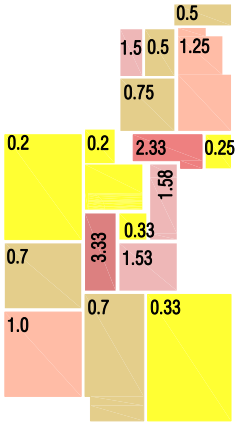
Justified graph



Distributness

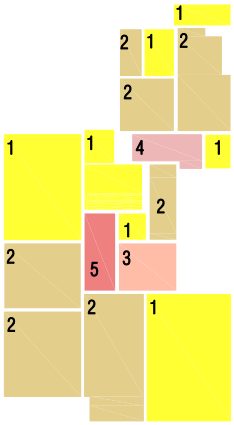


Controle

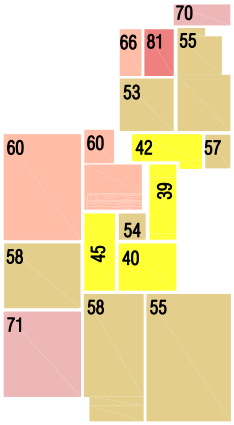


Entire dwelling
Mean: 1.00

Contiguity

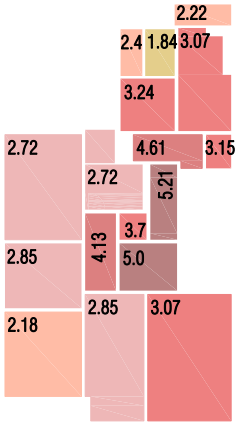


Depth



Entire dwelling
Mean: 57

Integration



Entire dwelling
Mean: 3.2

Rehabilitation programme

Obligatory rooms

_ kitchen
_ double bedroom
_ children bedrooms
_ separate or combined living room and dining room
_ private bathroom (1st)
_ private bathroom (2nd)

Extra divisions requested by the family (in order of priority) and relationships between divisions

_ 1 twin bedroom + 1 single bedroom for children next to double bedroom
_ small work area isolated or integrated with other area
_ 2 fully equipped private bathrooms in private area
_ The dining room and living room should be a big room, combined or separate but adjacent, enabling them to be linked for social events
_ guest bathroom next to social area

a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring
Social area
Private area
Circulation area
Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Av. Roma, 89 (type a)

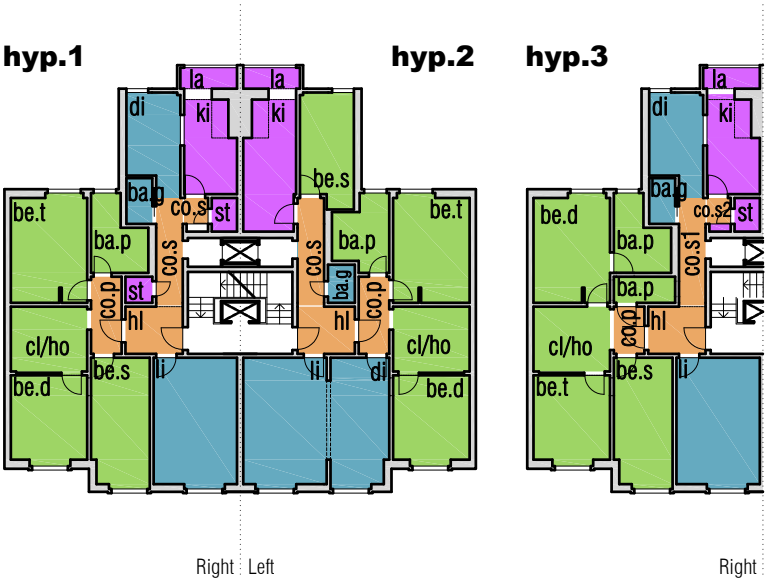
Net floor area: 97m² | Gross floor area: 118m²

Family01_ **CASE 1**

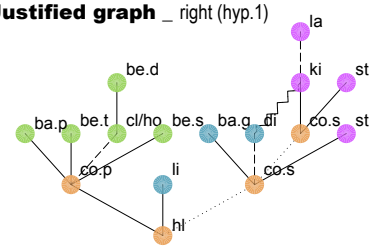
couple with children (2 adults + 3 children, 5, 2, 0 years)

Transformation proposed

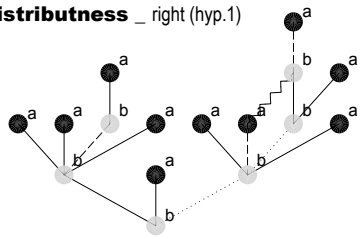
experimental subject #1



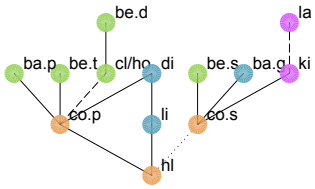
Justified graph _ right (hyp.1)



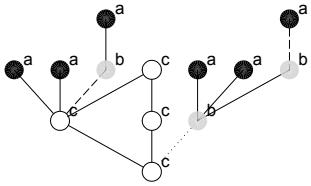
Distributness _ right (hyp.1)



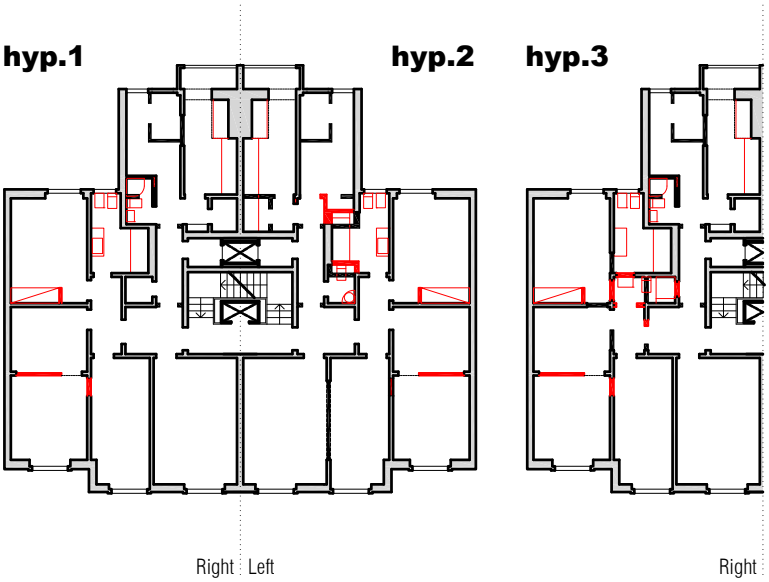
Justified graph _ left (hyp.2)



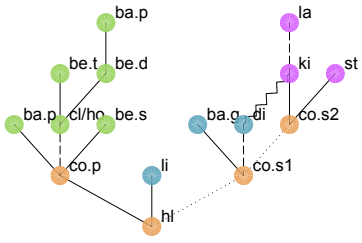
Distributness _ left (hyp.2)



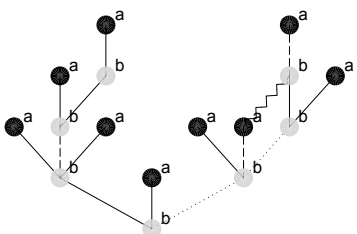
Demolitions / constructions



Justified graph _ right (hyp.3)



Distributness _ right (hyp.3)



Right (hyp.1) _ few demolitions; few new constructions

Left (hyp.2) _ many demolitions; few new constructions

Right (hyp.3) _ many demolitions; few new constructions

- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- Social area
- Private area
- Circulation area
- Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - - passage ~~~ window

Av. Roma, 89 (type a)

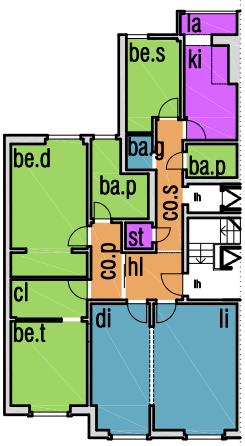
Net floor area: 97m² | Gross floor area: 118m²

Famíly01_ **CASE 1**

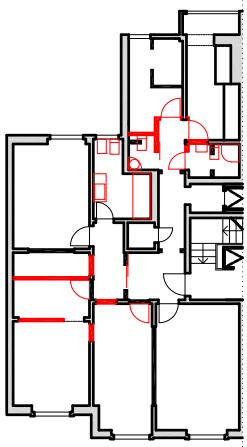
couple with children (2 adults + 3 children, 5, 2, 0 years)

Transformation proposed **Demolitions / constructions**

experimental subject #2a

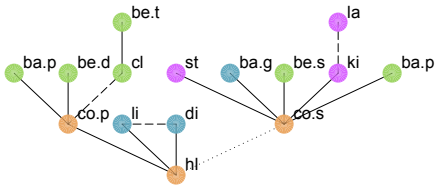


Right

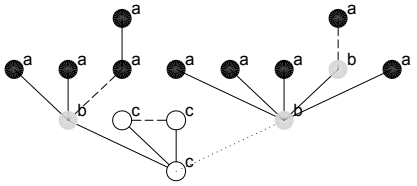


Right

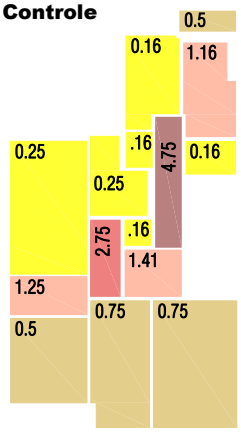
Justified graph



Distributness

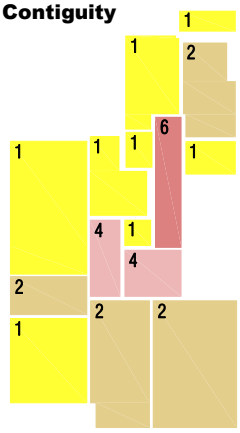


Controle

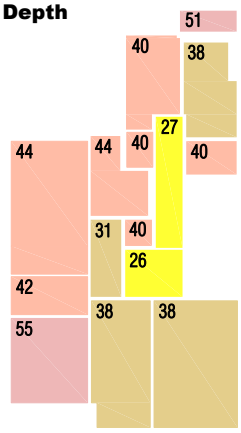


Entire dwelling
Mean: 1.00

Contiguity

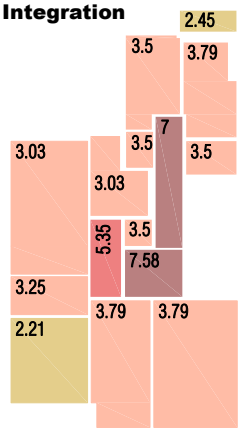


Depth



Entire dwelling
Mean: 39.6

Integration



Entire dwelling
Mean: 3.95

General criteria for transforming the dwellings in the study

- Enlargement of existing living room (usually small) using the adjacent bedroom.
- Living room(s) orientated towards the main facade or towards maximum sunlight, rather than north-facing.
- Bedrooms located close to bathrooms, and creation of suite, if possible.
- Enlargement of kitchen area, (usually very compartmentalised), using the space in adjacent areas.
- Conversion of larders/storerooms into guest bathrooms required by the programme, using a macerator system.
- Reduction of circulation areas to the minimum, including within storerooms.

Specific criteria for transforming this dwelling

- Creation of a large social area consisting of a hall adjacent to two adjoining living rooms - one living room created by converting a bedroom.
- Alterations to the existing private area: 3 bedrooms, 1 interior, converted into 2 bedrooms, both with storage facilities.
- Creation of a guest bathroom in the space where the former service area storeroom was located.
- Creation of a bedroom with storage facilities in the space where the former service bedroom and bathroom were located.
- Bedroom next to kitchen was not used to extend the latter, as it was required in the proposed programme.

- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- Social area
- Private area
- Circulation area
- Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Av. Roma, 89 (type a)

Net floor area: 97m² | Gross floor area: 118m²

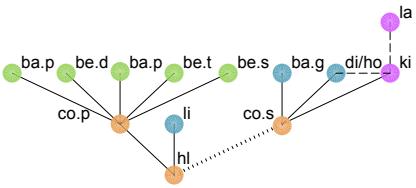
Family01_ **CASE 1**

couple with children (2 adults + 3 children, 5, 2, 0 years)

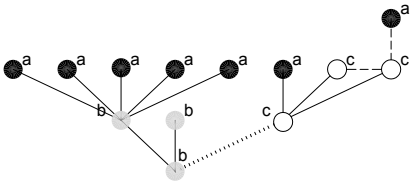
Transformation proposed **Demolitions / constructions**

experimental subject #2b

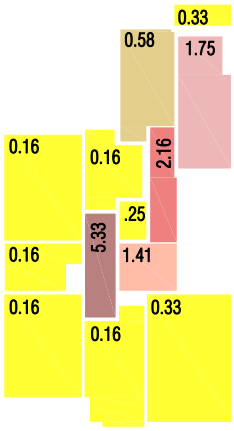
Justified graph



Distributness

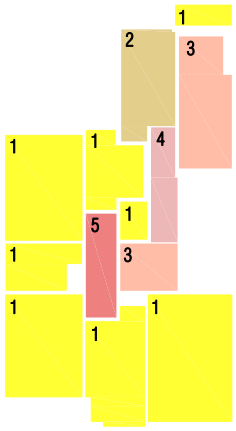


Controle

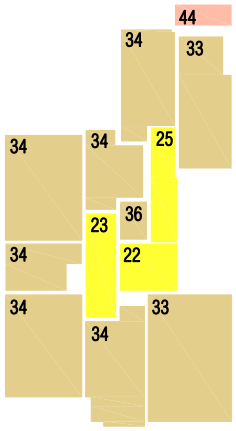


Entire dwelling
Mean: 1.00

Contiguity

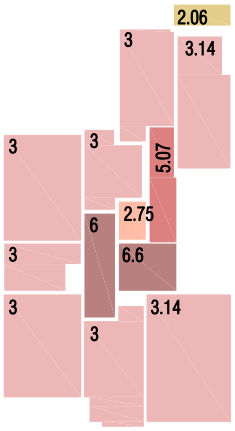


Depth



Entire dwelling
Mean: 32.3

Integration



Entire dwelling
Mean: 3.59

a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring
Social area
Private area
Circulation area
Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Av. Roma, 89 (type a)

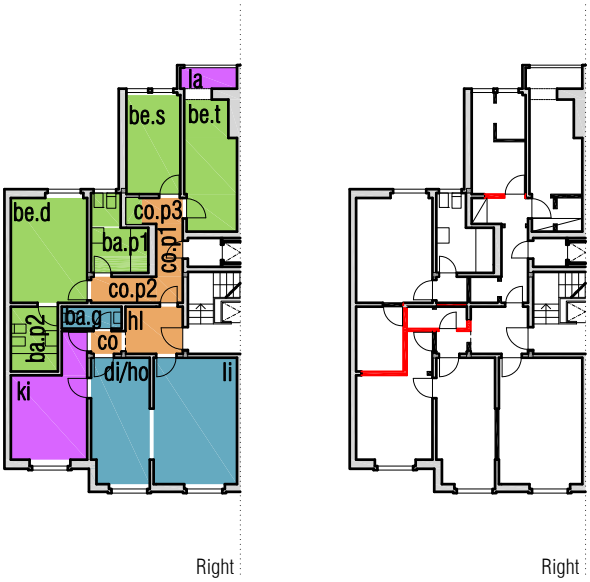
Net floor area: 97m² | Gross floor area: 118m²

Family01_ **CASE 1**

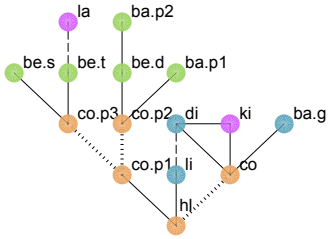
couple with children (2 adults + 3 children, 5, 2, 0 years)

Transformation proposed **Demolitions / constructions**

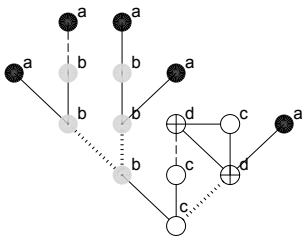
experimental subject #2c



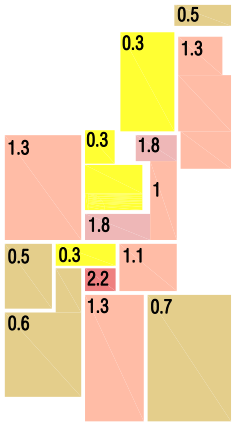
Justified graph



Distributness

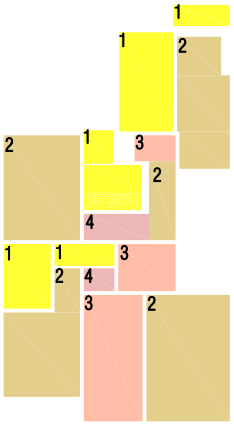


Controle

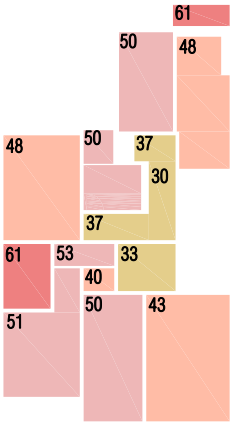


Entire dwelling
Mean: 1.00

Contiguity

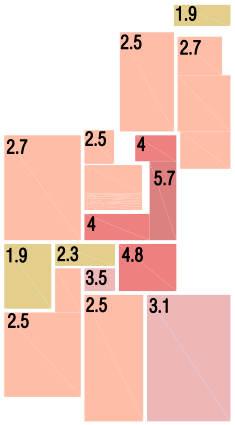


Depth



Entire dwelling
Mean: 46.1

Integration



Entire dwelling
Mean: 3.1

- a _ terminal spaces
- b _ reached by two or more arcs
- c _ reached by two or more arcs and connected in a ring
- d _ reached by two or more arcs and connected by ≥ 2 rings
- Social area
- Private area
- Circulation area
- Service area

Adjacency (arcs): merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Av. Roma, 89 (type a)

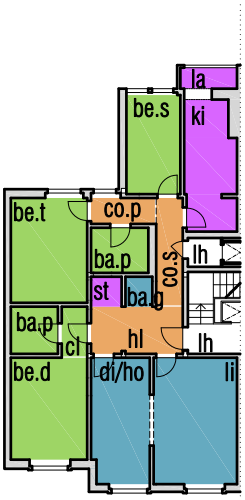
Net floor area: 97m² | Gross floor area: 118m²

Family01_ **CASE 1**

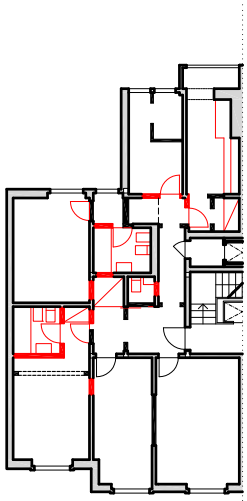
couple with children (2 adults + 3 children, 5, 2, 0 years)

Transformation proposed **Demolitions / constructions**

experimental subject #2d

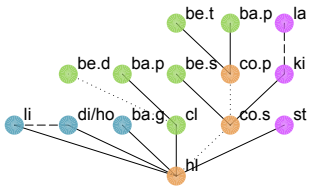


Right Left

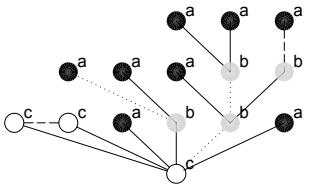


Right Left

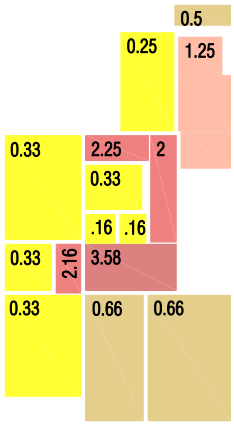
Justified graph



Distributness

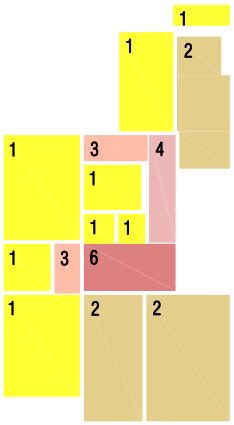


Controle

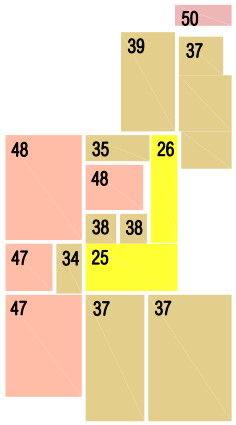


Entire dwelling
Mean: 1.00

Contiguity

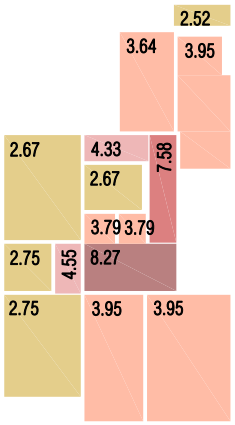


Depth



Entire dwelling
Mean: 39.06

Integration



Entire dwelling
Mean: 4.08

a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring
Social area
Private area
Circulation area
Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Av. Roma, 89 (type a)

Net floor area: 97m² | Gross floor area: 118m²

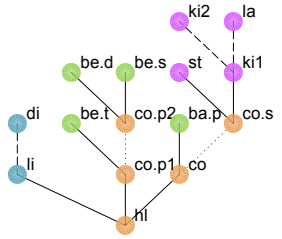
Family01_ **CASE 1**

couple with children (2 adults + 3 children, 5, 2, 0 years)

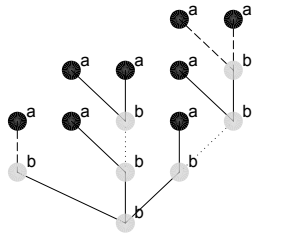
Transformation proposed **Demolitions / constructions**

experimental subject #2e

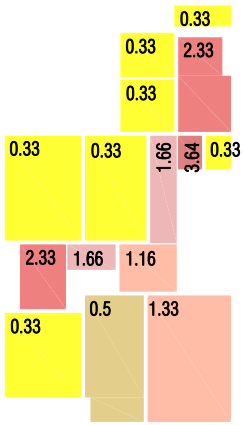
Justified graph



Distributness

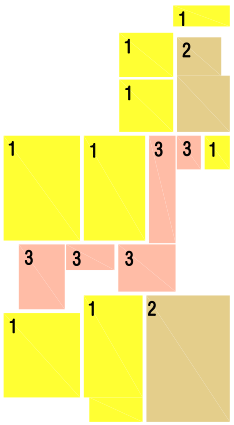


Controle

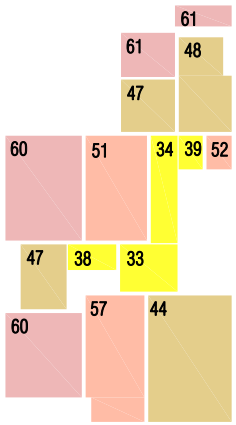


Entire dwelling
Mean: 1.00

Contiguity

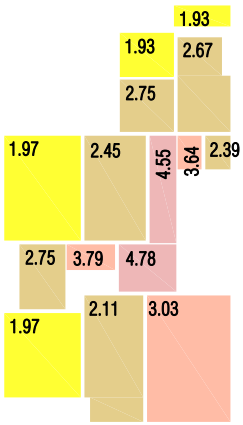


Depth



Entire dwelling
Mean: 48.8

Integration



Entire dwelling
Mean: 2.85

a _ terminal spaces
b _ reached by two or more arcs
c _ reached by two or more arcs and connected in a ring
Social area
Private area
Circulation area
Service area

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Rehabilitation evaluation

Obligatory rooms

_ kitchen ☐
_ laundry ☐
_ double bedroom ☐
_ twin bedroom/single bedroom ☐
_ separate or combined living room and dining room ☐
_ private bathroom (1st) ☐
_ private bathroom (2nd) ☐
_ storeroom ☐

Extra divisions requested by the family (in order of priority) and relationships between divisions

_ 2 bedroom for children ☐
_ small work area ☐
_ 2 fully equipped private bathrooms ☐
_ one large or two separate living rooms ☐
_ bathroom for general use ☐
_ all bedrooms next to each other ☐

General characteristics

_ Bedrooms and living rooms have natural light and ventilation ☐
_ The daytime area (living rooms + kitchens) can be separated from the night-time area (bedrooms and private bathrooms) by doors or a corridor ☐

Social area

_ The social area is accessed via the circulation areas ☐
_ The dining room and living room are combined or separate but adjacent, enabling them to be linked ☐
_ The dining room is close to the kitchen ☐
_ There is a bathroom for general use with easy access that does not involve passing through private or social areas ☐
_ The bathroom for general use has no door opening onto any room ☐
_ Social spaces are close to the entrance for easy access ☐
_ The living room is large enough to allow for the possibility of installing furniture for viewing TV or home cinema from a distance of 3m ☐
_ There is individual access to the living room(s) via a circulation area or other living room ☐
_ All living rooms comply with minimum area requirements ☐

Private area

_ Bedrooms and private bathrooms are accessed from circulation areas other than those of the hall and the social and service zone circulation areas ☐
_ The bedrooms have access to a bathroom within the same private area ☐
_ All bedrooms comply with minimum area requirements ☐

Service area

_ The kitchen is accessed by circulation areas or via a living room, if it is not the only one ☐
_ The kitchen includes an eating area for light meals or is close to an eating area ☐
_ The kitchen includes a space for laundry work or has a direct link to a space reserved for this purpose ☐
_ The kitchen complies with minimum area requirements ☐

Circulation areas

_ The circulation areas allow for alternative paths within the dwelling ☐
_ There are no obstacles to circulation within the social area ☐
_ There are no obstacles to circulation within the service area ☐
_ There are no obstacles to circulation within the private area ☐

Demolition work

_ Linear dimensions of walls demolished

Evaluation of the experiments:

YES answers / total questions

Experimental subject #1

hyp 1 _ 33/36
hyp 2 _ 30/36
hyp 3 _ 34/36

Experimental subject #2a

hyp 1 _ 32/36

Experimental subject #2b

hyp 1 _ 34/36

Experimental subject #2d

hyp 1 _ 30/36

Experimental subject #2e

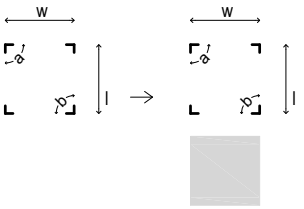
hyp 1 _ 28/36

APPENDIX 3

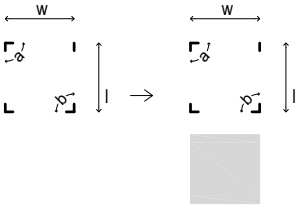
Transformation grammar rules

Rule -1.1a _ Generation of a compound representation – using surfaces to represent rooms

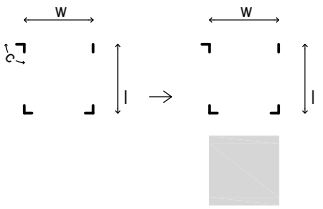
Rule -1.1a1



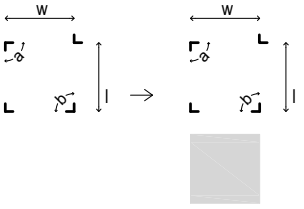
Rule -1.1a2



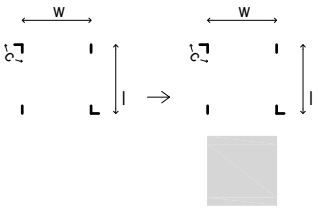
Rule -1.1a3



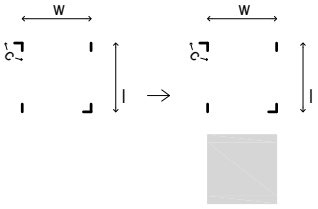
Rule -1.1a4



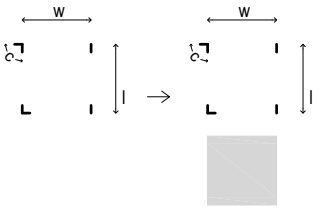
Rule -1.1a5



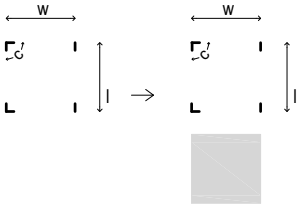
Rule -1.1a6



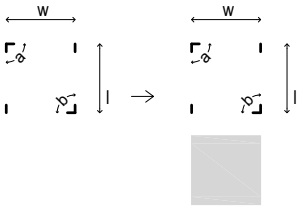
Rule -1.1a7



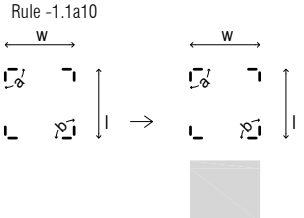
Rule -1.1a8



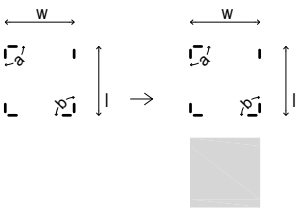
Rule -1.1a9



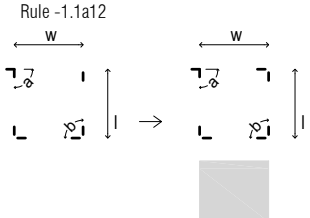
Rule -1.1a10



Rule -1.1a11



Rule -1.1a12



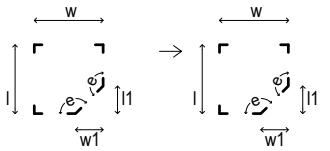
Conditions:

Dimensions:
l, w≥0.65m
l * w≥0.8m^2
$80^0 \leq a \leq 90^o$
$90^0 \leq b \leq 98^o$
$90^0 \leq c \leq 180^o$

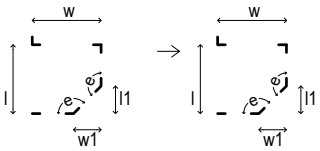
Generating a compound representation

Rule -1.1b _ Generation of a compound representation – using surfaces to represent rooms

Rule -1.1b1



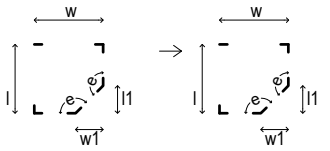
Rule -1.1b4



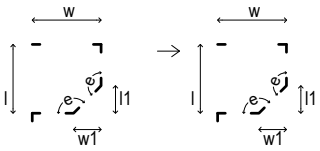
Conditions:

Dimensions:
l, w ≥ 1m
l1, w1 ≥ 0.2m
$45^{o} \leq d \leq 135^{o}$
$e = 135^{o}$

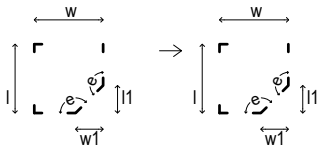
Rule -1.1b2



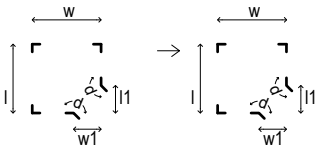
Rule -1.1b5



Rule -1.1b3

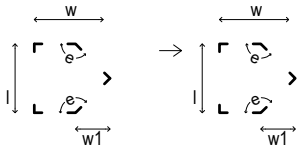


Rule -1.1b6



Rule -1.1c_ Generation of a compound representation – using surfaces to represent rooms

Rule -1.1c1



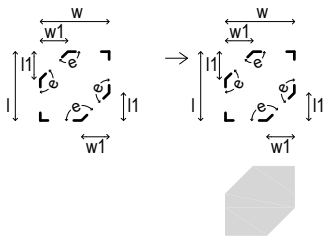
Conditions:

Dimensions:
l, w ≥ 1m
w1 ≥ 0.8m
$l * w \geq 1m^{2}$
$e = 135^{o}$

Generating a compound representation

Rule -1.1d _ Generation of a compound representation – using surfaces to represent rooms

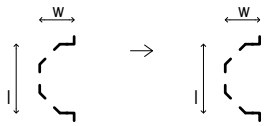
Rule -1.1d1



Conditions:

Dimensions:
l, w≥1m
l1, w1≥0.2m
e = 135°

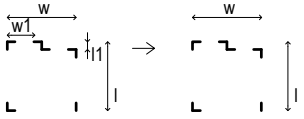
Rule -1.1d2



Conditions:

Dimensions:
l≥2m
w≥1m

Rule -1.1d3

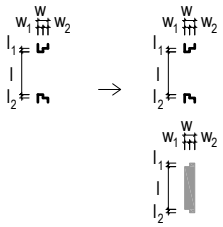


Conditions:

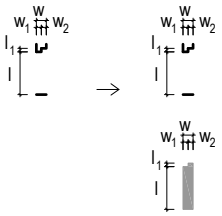
Dimensions:
l, w≥1m
l * w≥1m²
l1, w1≥0.2m

Rule -1.1e _ Generation of a parallel representation – using surfaces (interior passages and windows)

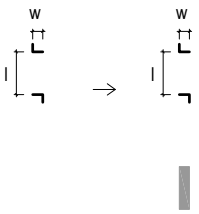
Rule -1.1e1



Rule -1.1e2



Rule -1.1e3

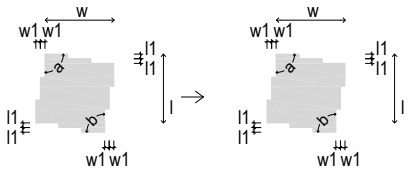


Conditions:

Dimensions:
l≥0,8m
0,10m≤w, w1≤0,55m
0m≤w2≤0,45m
0m≤l1,l2≤0,25m

Rule -1.2 _ Generation of a compound representation – using dots and arcs to represent rooms and connections

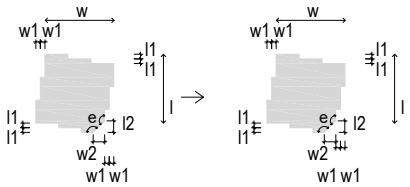
Rule -1.2a _ attribution of a dot to represent one room



Conditions:

Dimensions:
l, w≥0.65m
0.8m²≤l * w≤30m²
0m≤l1, w1≤1m
80º ≤ a ≤ 90º
90º ≤ b ≤ 98º

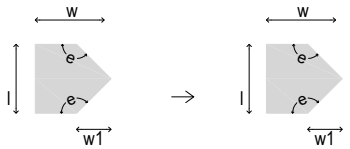
Rule -1.2b _ attribution of a dot to represent one room



Conditions:

Dimensions:
l, w≥1m
1m²≤l * w≤30m²
l2, w2≥0.2m
e = 135º

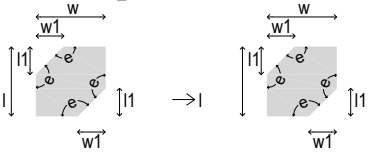
Rule -1.2c _ attribution of a dot to represent one room



Conditions:

Dimensions:
l, w≥1m
w1≥0.8m
0.8m²≤l * w≤30m²
e = 135º

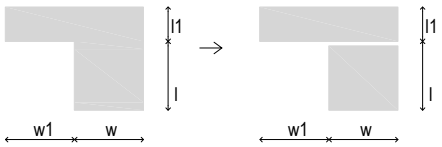
Rule -1.2d _ attribution of a dot to represent one room



Conditions:

Dimensions:
l, w≥1m
0.8m²≤l * w≤30m²
l1, w1≥0.2m
e = 135º

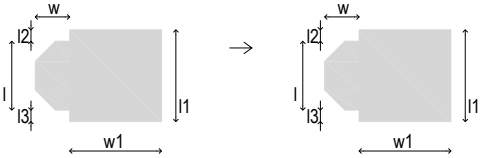
Rule -1.2e _ attribution of a dot to represent one room



Conditions: (this situation happens only once)

Dimensions:
2m≤l, w≤6m
l1≤l
w1≥w

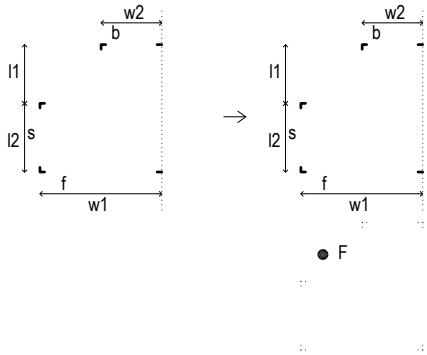
Rule -1.2f _ attribution of a dot to represent one rooms



Conditions:

Dimensions:
l≥2m
w≥1m
l1≥3m
w1≥3m
9m²≤l1 * w1≤30m²
l2,l3≥0.1m
l2=l3 ∨ l2≠l3

Rule -1.2g _ attribution of a dot with a label to the exterior

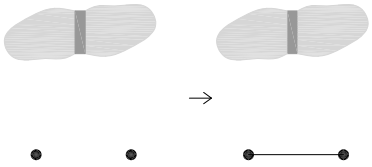


Conditions:

Dimensions:
4m≤l1≤14.5m
9.4m≤l2≤14m
5.7m≤w1≤18.5m
3m≤w2≤7.2m

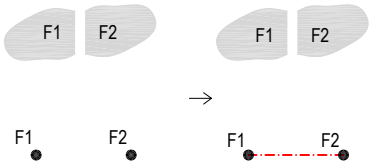
Function:
F=ext

Rule -1.2h _ attribution of an arc between two connecting rooms (with a door between them)



Description (abbreviated):
R-1.2h < D-1: ∅ > → < D-1: passage_to >

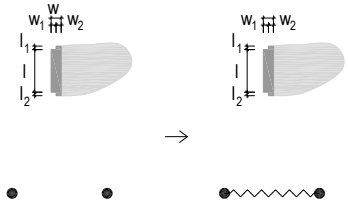
Rule -1.2i _ attribution of an arc between two adjacent rooms (with a wall and no door between them)



Conditions:
F1 (passage_to(F2))=FALSE

Description (abbreviated):
R-1.2i < D-1: ∅ > → < D-1: adjacent_to >

Rule -1.2j _ attribution of an arc between the exterior and a room with a window



Conditions:

Dimensions:
l≥0,8m
0,10m≤w, w1≤0,55m
0m≤w2≤0,45m
0m≤l1,l2≤0,25m

Description (abbreviated):
R-1.2j < D-1: ∅ > → < D-1: window_to >

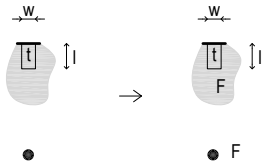
Notes:

Part2: Chapter 4.3

Generating a compound representation

Rule -1.3 _ Attribution of labels for the dwelling rooms

Rule -1.3a _ Attribution of Xba label



Conditions:

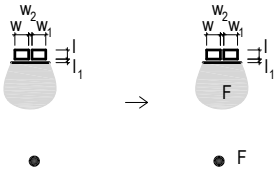
Dimensions:
$0.45m \leq l \leq 0.65m$
$1m^2 \leq F \leq 7m^2$

Function:
Fb=ext
F=Xba

Description (abbreviated):

R-1.3a < D-1: ∅ > → < D-1: Xba >

Rule -1.3b _ Attribution of Xki label



Conditions:

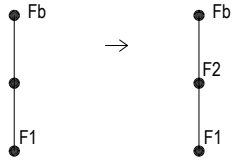
Dimensions:
$0.1m \leq l \leq 0.3m$
$0.2m \leq w \leq 0.5m$
$0m \leq w1 \leq 0.5m$
$0.1m \leq w2, l1 \leq 0.2m$
$F \geq 6m^2$

Function:
F=Xki

Description (abbreviated):

R-1.3b < D-1: ∅ > → < D-1: Xki >

Rule -1.3c _ Attribution of Xla label



Conditions:

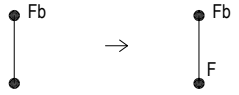
Dimensions:
$1.5m^2 \leq F2 \leq 9m^2$

Function:
F1=Xki
Fb=ext
F2=Xla

Description (abbreviated):

R-1.3c < D-1: Fb, ∅, F1 > → < D-1: Fb, F2, F1 >

Rule -1.3d _ Attribution of hs label



Conditions:

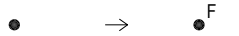
Dimensions:
$F \geq 7m^2 (\pm 10\%)$

Function:
Fb=ext
F=hs

Description (abbreviated):

R-1.3d < D-1: Fb, ∅ > → < D-1: Fb, F >

Rule -1.3e _ Attribution of nhs label



Conditions:

Dimensions:
$F < 7m^2$

Function:
F=nhs

Description (abbreviated):

R-1.3e < D-1: ∅ > → < D-1: nhs >

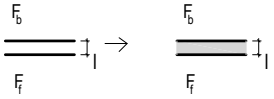
Notes:

Xba label stands for *Existing bathroom; Xki* label stands for *Existing kitchen; Xla* label stands for *Existing laundry; hs* label stands for *Habitable Space; nhs* label stands for *Non-Habitable Space*

See Part2: Chapter 4.2.2

Rule -1.4 _ Attribution of weights for the dwelling walls

Rule -1.4a _ Attribution of brick wall (ub) weight

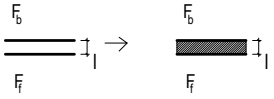


Conditions:

Dimensions:
l≤0.25m

Functions:
Fb, Ff∈{hs, nhs, Xki, Xba, Xla}

Rule -1.4b _ Attribution of structural elements (us) weight

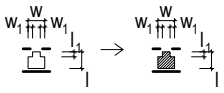


Conditions:

Dimensions:
0.25m≤l≤0.55m

Functions:
Fb∈{ext}

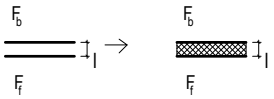
Rule -1.4c _ Attribution of structural elements (us) weight



Conditions:

Dimensions:
0.1m≤l,w≤0.5m
0m≤l,w≤0.2m
l=w ∨ l≠w

Rule -1.4d _ Attribution of side walls (usi) weight



Conditions:

Dimensions:
l>0.25m

Functions:
Fb∈{s}
Ff∈{nhs, hs, Xba}

Rule -1.5 _ Changing from step -1 to step 0

$$\varnothing \rightarrow \varnothing$$

Conditions:

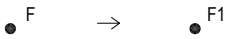
∀ wall: wall∈{w*us*, w*usi*, w*ub*}
∀ connection: connection⊃{arc_connection, surface}
∀ adjacency: adjacency⊃{arc_adjacency}
∀ room: room⊃{surface, dot, label}

Description (abbreviated):

R-1.5 < D-1: S-1 > → < D0: S0 >

Kitchen assignment

Rule 0.1 _ Assignment of isolated kitchen for strategy 2



Conditions:

$Z \supset \{ki\} \wedge Z' \not\supset \{ki\}$

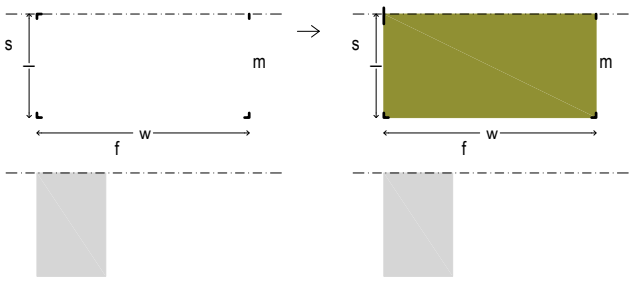
Functions:

$If\{strategy2\} \wedge F \in \{Xki\} \Rightarrow F1 \in \{ki\}$

Description (abbreviated):

R0.1 < D0: F; Z'; E > →
< D0: ki; Z' + {ki}; E - {Xki}, E + {ki}>

Rule 0.2 _ Assignment of area to place new kitchen for strategy 1 and 3



Conditions:

$Z \supset \{ki\} \wedge Z' \not\supset \{ki\}$

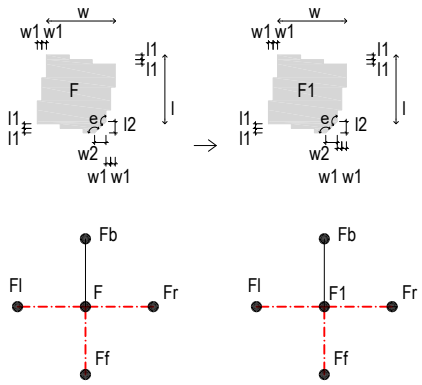
Dimensions:

$5.7m \leq w \leq 18.5m$

Description (abbreviated):

R0.2 < D0: f, m, s; Ø > → < D0: f, m, s; uk >

Rule 0.3.a _ Assignment of isolated kitchen for strategy 1(minimum level)



Conditions:

$Z \supset \{ki\} \wedge Z' \not\supset \{ki\}$

Dimensions:

$6m^2 \leq F \leq 20m^2 \ (\pm 10\%)$

$l, w \geq 1{,}7m$

$0m \leq l1, w1 \leq 1m$

$l2, w2 \geq 0m$

$e \in \{135^o, 180^o\}$

Functions:

$Fb \in \{ext\} \wedge Ff \vee Fr \vee Fl \in \{nhs, hs\} \wedge \exists\, Ff \vee Fr \vee Fl \in \{nhs\} \wedge F \in \{hs\}$

$F\ (inside(x)) = TRUE,\ x \in \{uk\}$

$F \in \{Fa\} \vee F \in \{Fb\} \vee F \in \{Fc\}$

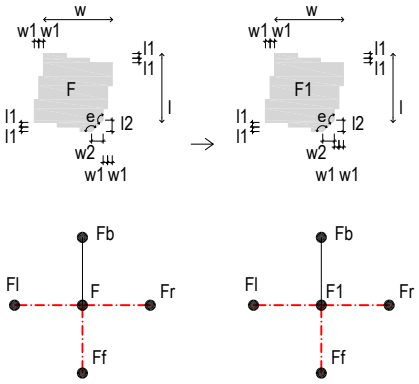
$If\ Fa = min(A) \wedge A \in \{Fa, Fb, Fc\} \Rightarrow F1 = Fa$

$F1 \in \{ki\}$

Description (abbreviated):

R0.3a < D0: {ext}, {nhs}, Fr, Fl; F; Z'; E > →
< D0: {ext}, {nhs}, Fr, Fl; ki; Z' + {ki}; E - {hs}, E + {ki} >

Rule 0.3.b _ Assignment of isolated kitchen for strategy 1 (recommended level)



Conditions:

$Z \supset \{ki\} \wedge Z' \not\supset \{ki\}$

Dimensions:

If $nhab = 4 \Rightarrow 10.5m^2 \leq F \leq 30m^2$ ($\pm 10\%$)

If $nhab \geq 5 \Rightarrow 11{,}5m^2 + 0{,}5m^2(n-5) \leq F \leq 30m^2$ ($\pm 10\%$)

l, w≥1,7m

0m≤l1, w1≤1m

l2, w2≥0m

e ∈{135º, 180º}

Functions:

Fb∈{ext} ∧ Ff∨Fr∨Fl∈{nhs, hs} ∧ ∃ Ff∨Fr∨Fl∈{nhs} ∧ F∈{hs

F (inside(x))=TRUE, x∈{uk}

F∈{Fa} ∨ F∈{Fb} ∨ F∈{Fc}

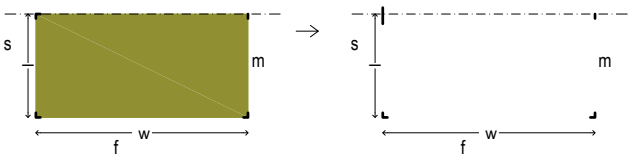
If Fa=min(A) ∧ A∈{Fa, Fb, Fc} ⇒ F1=Fa

F1∈{ki}

Description (abbreviated):

R0.3b < D0: {ext}, {nhs}, Fr, Fl; F; Z'; E > →

Rule 0.4 _ Erasing new kitchen's placement weight



Conditions:

$Z' \supset \{ki\}$

Dimensions:

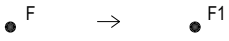
5.7m≤w≤18.5m

3m≤w≤5.7m

Description (abbreviated):

R0.4 < D0: uk > → < D0: Ø>

Rule 0.5 _ Changing Xki label



Conditions:

$Z' \supset \{ki\}$

Functions:

F∈{Xki}

F1∈{hs}

Description (abbreviated):

R0.5 < D0: Xki; E > → < D0: hs; E - {Xki}, E + {hs} >

Kitchen assignment / Hall assignment

Rule 0.6 _ Changing from step 0 to step 1

$\varnothing \rightarrow \varnothing$

S0 → S1

Conditions:

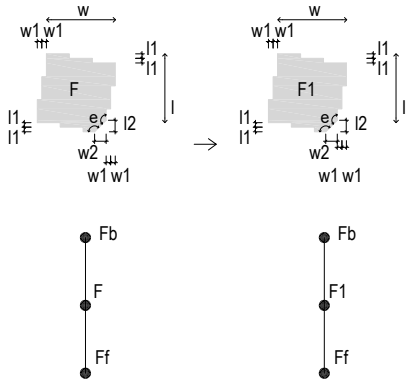
$Z' \supset \{ki\} \wedge E \supset \{Xki\}$

Description (abbreviated):

R0.6 < D0 > → < D1 >

Hall assignment

Rule 1.1 _ Assignment of hall



Conditions:

Dimensions:

$l, w \geq 0{,}9m$

$1m^2 \leq F \leq 20m^2$

$0m \leq l1, w1 \leq 1m$

$l2, w2 \geq 0m$

$e \in \{135^o, 180^o\}$

Functions:

$F \in \{nhs\}$

$Fb \in \{lh\} \wedge F(passage\_to(lh)) = TRUE$

$Ff \in \{nhs\} \wedge F(passage\_to(nhs)) = TRUE$

$\Rightarrow F1 \in \{hl\}$

Description (abbreviated):

R1.1 < D1: lh, nhs; F; Z'; E > →
< D1: lh, nhs; hl ; Z'+{hl}; E - {nhs}, E + {hl} >

Rule 1.2 _ Changing from step 1 to step 2

$\varnothing \rightarrow \varnothing$

S1 → S2

Conditions:

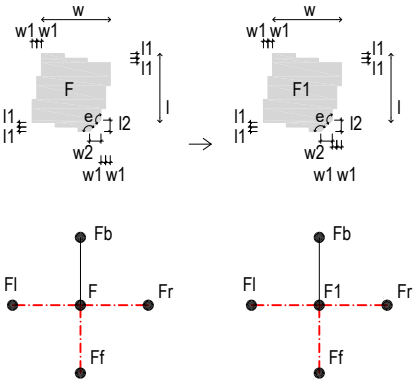
$Z' \supset \{hl\} \wedge E \supset \{hl\}$

Description (abbreviated):

R1.2 < D1: S1 > → < D2: S2 >

Bedrooms assignment

Rule 2.1.a _ Assignment of double bedroom (minimum level)



Conditions:

$Z \supset \{be.dn\} \wedge Z' \supset \{be.dn\}$

Dimensions:

$10{,}5m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 2,7m

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

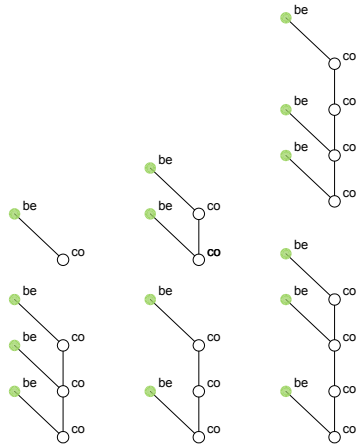
Fb ∈ {ext}

∃ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

Ff ∨ Fr ∨ Fl ∉ {hl}

F ∈ {hs}

F1 ∈ {be.d}

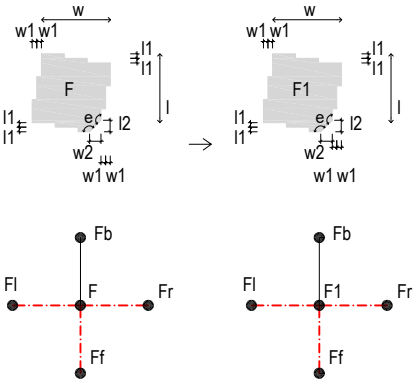


be ≥ 1*{be.d, be.t, be.s}

Description (abbreviated):

R2.1a < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →
< D2: ext, {nhs, co, co.p, cl}, Ff, Fl; be.d ; Z' + {be.d}; E - {hs}, E + {be.d} >

Rule 2.1.b _ Assignment of double bedroom (recommended level)



Conditions:

$Z \supset \{be.dn\} \wedge Z' \supset \{be.dn\}$

Dimensions:

$12m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 3.3m

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

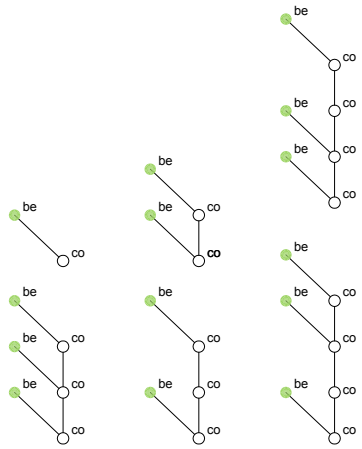
Fb ∈ {ext}

∃ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

Ff ∨ Fr ∨ Fl ∉ {hl}

F ∈ {hs}

F1 ∈ {be.d}

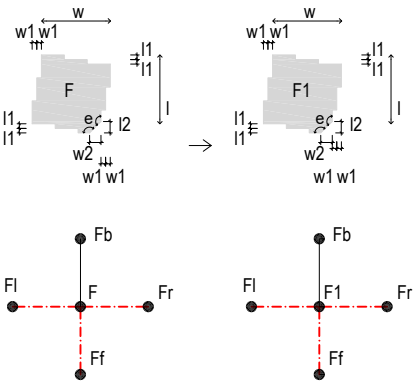


be ≥ 1*{be.d, be.t, be.s}

Description (abbreviated):

R2.1b < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →
< D2: ext, {nhs, co, co.p, cl}, Ff, Fl; be.d ; Z' + {be.d}; E - {hs}, E + {be.d} >

Rule 2.2.a _ Assignment of twin bedrooms (minimum level)



Conditions:

$Z \supset \{be.tn\} \wedge Z' \supset \{be.tn\}$

Dimensions:

$10.5m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 2,1m

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

be.t (next_to(x)) = TRUE ∨ be.t (close_to(x)) = TRUE, x ∈ {be.d}

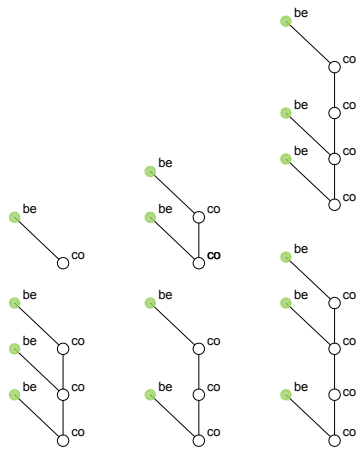
∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {ext, Cbc}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

Fb ∨ Ff ∨ Fr ∨ Fl ∉ {hl}

F ∈ {hs}

F1 ∈ {be.t}

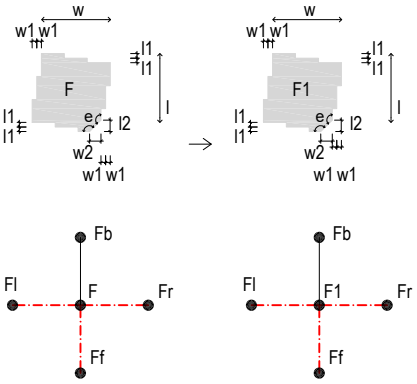


be ≥ 1*{be.d, be.t, be.s}

Description (abbreviated):

R2.2a < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →
< D2: ext, {nhs, co, co.p, cl}, Ff, Fl; be.t ; Z' + {be.t}; E - {hs}, E + {be.t} >

Rule 2.2.b _ Assignment of twin bedrooms (recommended level)



Conditions:

$Z \supset \{be.tn\} \wedge Z' \not\supset \{be.tn\}$

Dimensions:

$14.5m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 2,7m

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

be.t (next_to(x)) = TRUE ∨ be.t (close_to(x)) = TRUE, x ∈ {be.d}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {ext, Cbc}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

Fb ∨ Ff ∨ Fr ∨ Fl ∉ {hl}

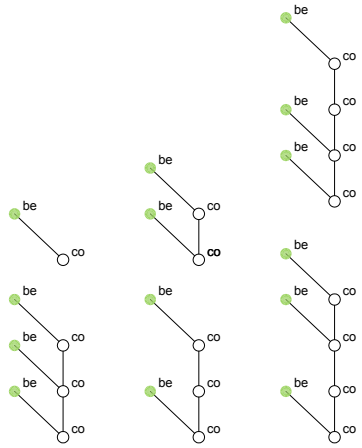
F ∈ {hs}

F1 ∈ {be.t}

Description (abbreviated):

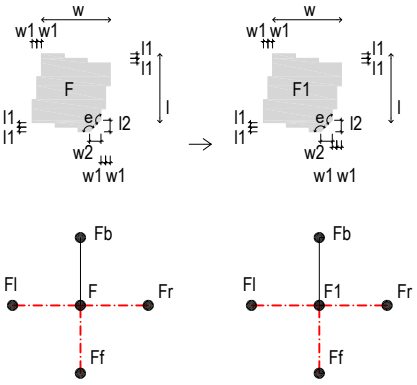
R2.2b < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →

< D2: ext, {nhs, co, co.p, cl}, Ff, Fl; be.t ; Z' + {be.t}; E - {hs}, E + {be.t} >



be ≥ 1*{be.d, be.t, be.s}

Rule 2.3.a_ Assignment of single bedrooms (minimum level)



Conditions:

$Z \supset \{be.sn\} \wedge Z' \not\supset \{be.sn\}$

Dimensions:

$8m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 2,1m

If $Z \supset \{be.s1, be.s2\} \Rightarrow \{be.s1\} \geq 7m^2 \wedge \{be.s2\} \geq 8m^2$

If $Z \supset \{be.s1, be.s2, be.s3, be.s4\} \Rightarrow \{be.s1, be.s2\} \geq 7m^2 \wedge \{be.s3, be.s4\} \geq 8m^2$

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

be.s (near_to(x)) = TRUE ∨ be.s (close_to(x)) = TRUE, x ∈ {be.d, be.t}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {ext, Cbc}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

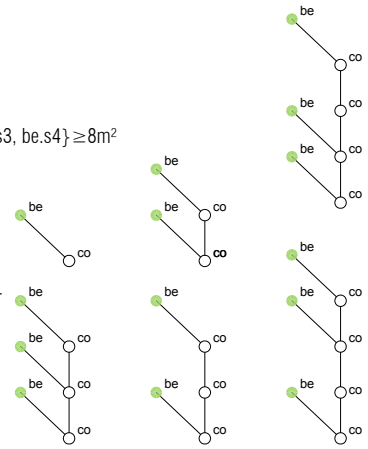
Fb ∨ Ff ∨ Fr ∨ Fl ∉ {hl}

F ∈ {hs}

F1 ∈ {be.s}

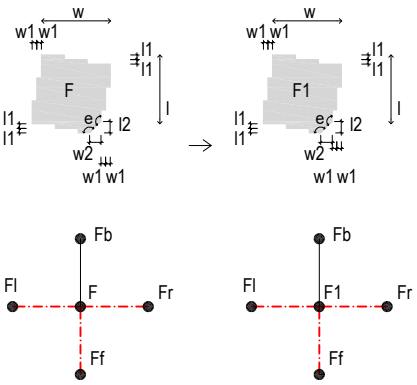
Description (abbreviated):

R2.3a < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →



be ≥ 1*{be.d, be.t, be.s}

Rule 2.3.b _ Assignment of single bedrooms (recommended level)



Conditions:

$Z \supset \{be.sn\} \wedge Z' \not\supset \{be.sn\}$

Dimensions:

$8.5m^2 (\pm 10\%) \leq F \leq 30m^2$

w, l ≥ 2,1m

If $Z \supset \{be.s1, be.s2\} \Rightarrow \{be.s1\} \geq 7m^2 \wedge \{be.s2\} \geq 8,5m^2$

If $Z \supset \{be.s1, be.s2, be.s3, be.s4\} \Rightarrow \{be.s1, be.s2\} \geq 7m^2 \wedge \{be.s3, be.s4\} \geq 8,5m^2$

0m ≤ l1, w1 ≤ 1m

l2, w2 ≥ 0m

e ∈ {135º, 180º}

Functions:

be.s (next_to(x)) = TRUE ∨ be.s (close_to(x)) = TRUE, x ∈ {be.d, be.t}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {ext, Cbc}

∃ Fb ∨ Ff ∨ Fr ∨ Fl ∈ {nhs, co, co.p, cl}

Fb ∨ Ff ∨ Fr ∨ Fl ∉ {hl}

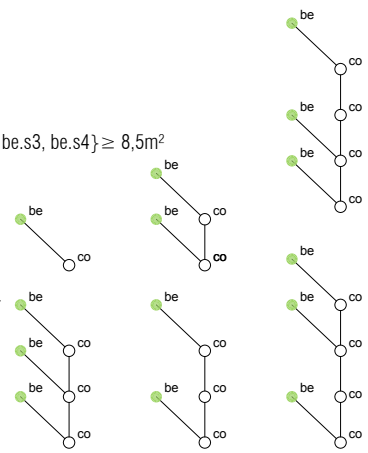
F ∈ {hs}

F1 ∈ {be.s}

Description (abbreviated):

R2.3b < D2: ext, {nhs, co, co.p, cl}, Ff, Fl; F; Z'; E > →

< D2: ext, {nhs, co, co.p, cl}, Ff, Fl; be.s ; Z' + {be.s}; E - {hs}, E + {be.s} >



be ≥ 1*{be.d, be.t, be.s}

Bedrooms assignment

Rule 2.4 _ Changing from step 2 to step 7 if there is no spaces satisfying rules 2.1 to 2.3

$\varnothing \rightarrow \varnothing$

S2 $\rightarrow$ S7

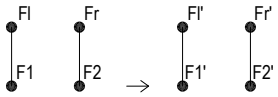
Conditions:

If $\forall$ F: F$\leq$10,5m² ($\pm$10%) (Rule 2.1.a) $\vee$
If $\forall$ F: F$\leq$12m² ($\pm$10%) (Rule 2.1.a) $\vee$
If $\forall$ F: F$\leq$10,5m² ($\pm$10%) (Rule 2.2.a) $\vee$
If $\forall$ F: F$\leq$14,5m² ($\pm$10%) (Rule 2.2.b) $\vee$
If $\forall$ F: F$\leq$8m² ($\pm$10%) (Rule 2.3.a) $\vee$
If $\forall$ F: F$\leq$8,5m² ($\pm$10%) (Rule 2.3.b)
$\Rightarrow$ Rule 7.1.a $\vee$ Rule 7.1.b $\vee$ Rule 7.1.g $\vee$ Rule 7.4.a

Description (abbreviated):

R2.4 < D2: S2 > $\rightarrow$ < D7: S7 >

Rule 2.5 _ Permuting bedroom assignment due to area criteria



Conditions:

Dimensions:

If F1>F2 $\wedge$ F1$\in${be.s} $\wedge$ F2$\in${be.t} $\Rightarrow$ F1'$\in${be.t} $\wedge$ F2'$\in${be.s}
If F1>F2 $\wedge$ F1$\in${be.s} $\wedge$ F2$\in${be.d} $\Rightarrow$ F1'$\in${be.d} $\wedge$ F2'$\in${be.s}
If F1>F2 $\wedge$ F1$\in${be.s} $\wedge$ F2$\in${be.d} $\Rightarrow$ F1'$\in${be.d} $\wedge$ F2'$\in${be.s}

Function:

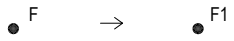
F1, F2, F1', F2'$\in$ {be.d, be.t, be.s}
Fl, Fr$\in$ {nhs, co.p, co, cl}
F1$\neq$F2

Description (abbreviated):

R2.5 < D2: F1, Fl; F2, Fr > $\rightarrow$ < D2: F1', Fl; F2', Fr >

Private bathrooms assignment

Rule 2.6 _ Assignment of main private bathroom (minimum level)



Conditions:

$Z \supset \{ba.pn\} \wedge Z' \not\supset \{ba.pn\}$

Dimensions:

If $F = \max(A) \wedge A \in \{Xba1, Xba2\} \Rightarrow F = F1$

Functions:

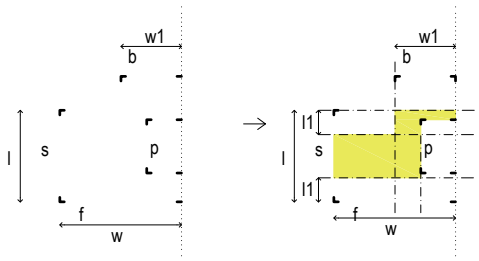
If $E \supset \{Xba1, Xba2\} \wedge Xba1 > Xba2 \Rightarrow F \in \{Xba1\} \wedge F1 \in \{ba.p1\}$

If $E \supset \{Xba1, Xba2\} \wedge Xba2 > Xba1 \Rightarrow F \in \{Xba2\} \wedge F1 \in \{ba.p1\}$

Description (abbreviated):

R2.6 < D2: Xba; Z'; E > → < D2: ba.p1 ; Z' + {ba.p1}; E - {Xba}, E + {ba.p1} >

Rule 2.7.a _ Attribution of new bathrooms placement weight: uba (type a and b)



Conditions:

$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p2\} \wedge Z' \not\supset \{ba.p2\} \vee$
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p3\} \wedge Z' \not\supset \{ba.p3\} \vee$
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.g\} \wedge Z' \not\supset \{ba.g\}$

Dimensions:

$9.4m \leq l \leq 14m$
$5.7m \leq w \leq 18.5m$
$3m \leq w1 \leq 7.2m$
$l1 = 3m$

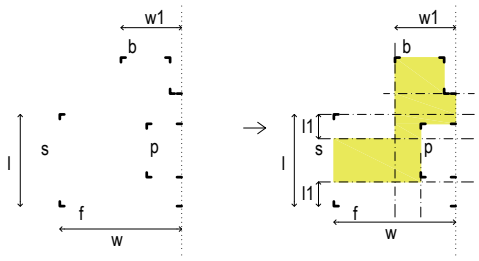
Description (abbreviated):

R2.7a < D2: l, w, w1; Ø > → < D2: l, w, w1, l1; uba >

Note:

-·-·-·- auxiliary lines

Rule 2.7.b _ Attribution of new bathrooms placement weight: uba (type c and d)



Conditions:

$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p2\} \wedge Z' \not\supset \{ba.p2\} \vee$
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p3\} \wedge Z' \not\supset \{ba.p3\} \vee$
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.g\} \wedge Z' \not\supset \{ba.g\}$

Dimensions:

$9.4m \leq l \leq 14m$
$5.7m \leq w \leq 18.5m$
$3.7m \leq w1 \leq 7.2m$
$l1 = 3m$

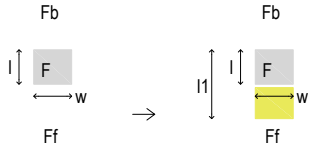
Description (abbreviated):

R2.7b < D2: l, w, w1; Ø > → < D2: l, w, w1, l1; uba >

Note:

-·-·-·- auxiliary lines

Rule 2.7.c _ Assignment of area to place new bathrooms, extending an existing bathroom



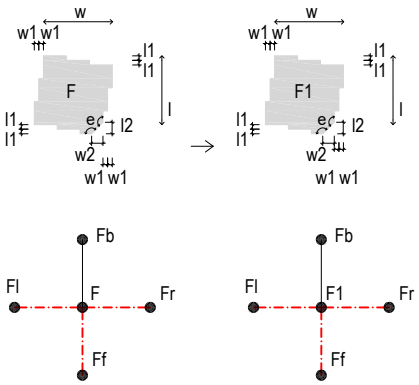
Conditions:

$Z \supset \{ba.p2\} \wedge Z' \not\supset \{ba.p2\} \vee$
$Z \supset \{ba.p3\} \wedge Z' \not\supset \{ba.p3\} \vee$
$Z \supset \{ba.g\} \wedge Z' \not\supset \{ba.g\}$

Dimensions:
$1m \leq l \leq 2m$
$1m \leq w \leq 2m$
$l1 \leq 3m$

Function:
$F \in \{Xba, ba.p1\}$
$Fb \in \{ext\}$
$Ff \in \{nhs\}$

Rule 2.8.a_ Assignment of second private bathroom (minimum level)



Conditions:

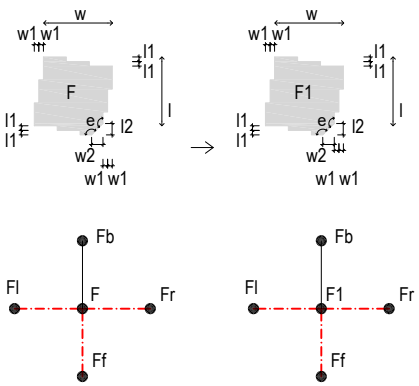
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p2\} \wedge Z' \not\supset \{ba.p2\}$

Dimensions:
If $nhab \leq 6 \Rightarrow 5m^2(\pm 10\%) \geq F \geq 1m^2$
If $nhab \geq 7 \Rightarrow 5m^2(\pm 10\%) \geq F \geq 2{,}5m^2$
$l, w \geq 1m$
$0m \leq l1, w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Functions:
$F \in \{nhs\}$
$F\,(\text{inside}(x)) = \text{TRUE},\ x \in \{uba\}$
$\exists |\ (\text{passage\_to}(y))\ |\ F\,(\text{passage\_to}(y)) = \text{TRUE},\ y \in \{Ff, Fb, Fl, Ff\}$
$F\,(\text{next\_to}(t)) = \text{TRUE},\ t \in \{be.s, be.d, be.t\}$
$\vee\ F\,(\text{close\_to}(t)) = \text{TRUE},\ t \in \{be.s, be.d, be.t\}$
$F1 \in \{ba.p2\}$

Description (abbreviated):
R2.8a < D2: Fb, Ff, Fr, Fl; F; Z'; E > →
< D2: Fb, Ff, Fr, Fl; ba.p2; Z' + {ba.p2}; E - {nhs}, E + {ba.p2} >

Rule 2.8.b_ Assignment of second private bathroom (recommended level)



Conditions:

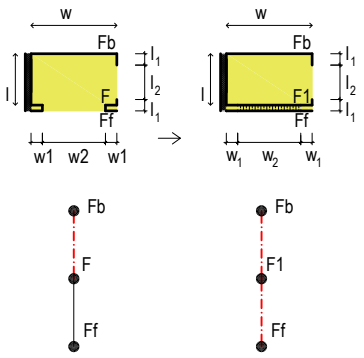
$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p2\} \wedge Z' \not\supset \{ba.p2\}$

Dimensions:
If $nhab \leq 5 \Rightarrow 5m^2(\pm 10\%) \geq F \geq 2m^2$
If $nhab \geq 6 \Rightarrow 5m^2(\pm 10\%) \geq F \geq 3m^2$
$l, w \geq 1m$
$0m \leq l1, w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Functions:
$F \in \{nhs\}$
$F\,(\text{inside}(x)) = \text{TRUE},\ x \in \{uba\}$
$\exists |\ (\text{passage\_to}(y))\ |\ F\,(\text{passage\_to}(y)) = \text{TRUE},\ y \in \{Ff, Fb, Fl, Ff\}$
$F\,(\text{next\_to}(t)) = \text{TRUE},\ t \in \{be.s, be.d, be.t\}$
$\vee\ F\,(\text{close\_to}(t)) = \text{TRUE},\ t \in \{be.s, be.d, be.t\}$
$F1 \in \{ba.p2\}$

Description (abbreviated):
R2.8a < D2: Fb, Ff, Fr, Fl; F; Z'; E > →
< D2: Fb, Ff, Fr, Fl; ba.p2; Z' + {ba.p2}; E - {nhs}, E + {ba.p2} >

Rule 2.9 _ Create a second private bathroom (next to side wall or on a parallel wall)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2}

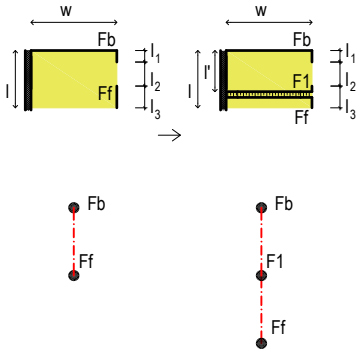
Dimensions:
1m≤l≤2.6m
1m≤w≤4m
0.1m≤w1, l1≤3m
0.8m≤w2≤3.8m
0m≤l2≤3.8m

Function:
F∈{nhs}
Fb, Ff∈{nhs, hs, be.d, be.t, be.s, li, di, li/di, ho, mr, ki}
F (inside(x))=TRUE, x∈{uba}
F (adjacent_to(x))=TRUE, x∈{usi}
F1∈{ba.p2}

Description (abbreviated):

R2.9 < D2: l; F; Z'; E > →
< D2: l; ba.p2; Z' + {ba.p2}; E - {nhs}, E + {ba.p2} >

Rule 2.10 _ Create a second private bathroom (next to side wall)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2}

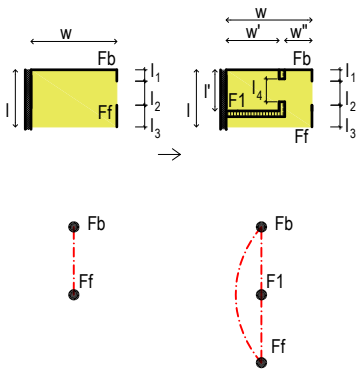
Dimensions:
1.2m≤l≤1.5m
1m≤l'≤1.5m
1m≤w≤4m
0.1m≤l1, l3≤2m
0m≤l2≤1.2m

Function:
Fb, Ff∈{nhs, hs, be.d, be.t, be.s, li, di, li/di, ho, mr, ki}
F (inside(x))=TRUE, x∈{uba}
F (adjacent_to(x))=TRUE, x∈{usi}
F1 ∈{ba.p2}

Description (abbreviated):

R2.10 < D2: Fb, Ff; Z'; E > →
< D2: Fb, ba.p2, Ff; Z' + {ba.p2}; E + {ba.p2} >

Rule 2.11 _ Create a second private bathroom (next to side wall)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2}

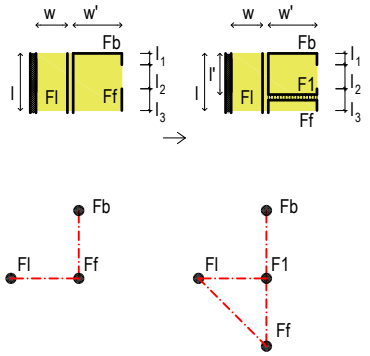
Dimensions:
1.2m≤l≤1.5m
1m≤l'≤1.5m
1m≤w≤4m
1m≤w'≤2.5m
0.9m≤w"≤1.2m
0.1m≤l1, l3≤2m
0m≤l2≤1.2m
l4∈{0.8m}

Function:
Fb, Ff∈{nhs, hs, be.d, be.t, be.s, li, di, li/di, ho, mr, ki}
F (inside(x))=TRUE, x∈{uba}
F (adjacent_to(x))=TRUE, x∈{usi}
F1∈{ba.p2}

Description (abbreviated):

R2.9 < D2: Fb, Ff; Z'; Z > →
< D2: Fb, ba.p2, Ff; Z' + {ba.p2}; E + {ba.p2} >

Rule 2.12 _ Create a second private bathroom (next to a wall parallel to the side wall)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2}

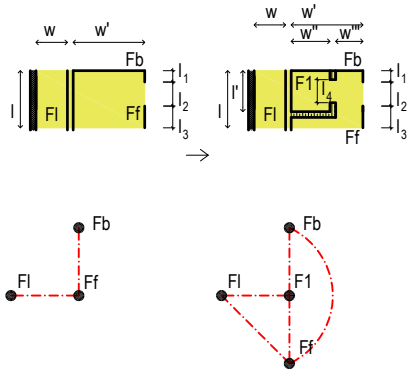
Dimensions:
1.2m≤l≤1.5m
1m≤l'≤1.5m
1m≤w, w'≤4m
0.1m≤l1, l3≤2m
0m≤l2≤1.2m

Function:
Fb, Ff, Fl∈{nhs, hs, be.d, be.t, be.s, li, di, li/di, ho, mr, ki}
F (inside(x))=TRUE, x∈{uba}
F (adjacent_to(x))=TRUE, x∈{usi}
F1∈{ba.p2}

Description (abbreviated):

R2.12 < D2: Fb, Ff, Fl; Z'; E > →
< D2: Fb, ba.p2, Ff, Fl; Z' + {ba.p2}; E + {ba.p2} >

Rule 2.13 _ Create a second private bathroom (next to a wall parallel to the side wall)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2}

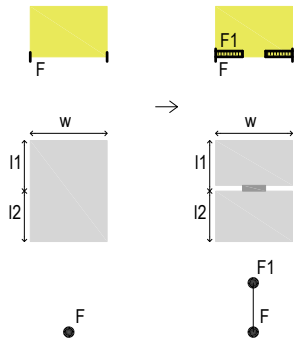
Dimensions:
1.2m≤l≤1.5m
1m≤l'≤1.5m
1m≤w, w'≤4m
1m≤w''≤2.5m
0.9m≤w'''≤1.2m
0.1m≤l1, l3≤2m
0m≤l2≤1.2m
l4∈{0.8m}

Function:
Fb, Ff, Fl∈{nhs, hs, be.d, be.t, be.s, li, di, li/di, ho, mr, ki}
F (inside(x))=TRUE, x∈{uba}
F (adjacent_to(x))=TRUE, x∈{usi}
F1∈{ba.p2}

Description (abbreviated):

R2.13 < D2: Fb, Ff, Fl; Z'; E > →
< D2: Fb, ba.p2, Ff, Fl; Z' + {ba.p2}; E + {ba.p2} >

Rule 2.14 _ Create a second bathroom (in nhs)



Conditions:

Z'⊃{ba.p1} ∧ Z⊃{ba.p2} ∧ Z'Ð{ba.p2} ∨
Z⊃{ba.g} ∧ Z'Ð{ba.g}

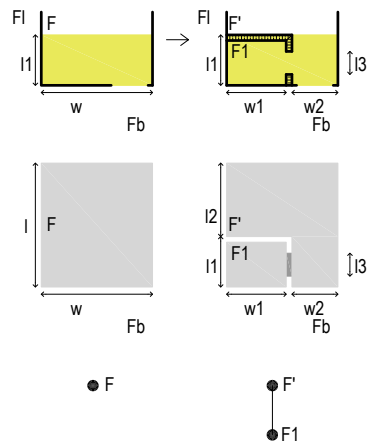
Dimensions:
l2, w≥ 1m
1m≤l1≤1,5m

Function:
F∈{nhs, co, co.s, co.p}
F (inside(x))=TRUE, x∈{uba}
F1∈{ba.p2, ba.g}

Description (abbreviated):

R2.14 < D2: F; Z'; E > →
< D2: F, {ba.p2, ba.g}; Z' + {ba.p2, ba.g}; E + {ba.p2, ba.g}

Rule 2.15 _ Create a second bathroom (inside a bedroom)



Conditions:

$Z' \supset \{ba.p1\} \wedge Z \supset \{ba.p2\} \wedge Z' \eth \{ba.p2\}$

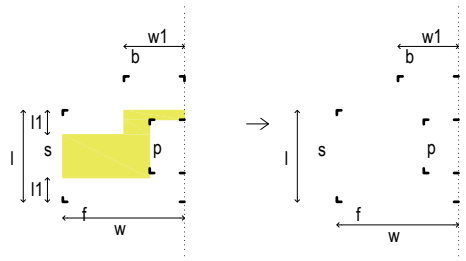
Dimensions:
$l \geq 4{,}4m$
If *mimimum_level* $\wedge$ $F \in \{be.d\} \Rightarrow w, l2 \geq 2{,}7m \wedge F' \geq 10{,}5m^2$
If *mimimum_level* $\wedge$ $F \in \{be.t\} \Rightarrow w \geq 2{,}5m \wedge l2 \geq 2{,}1m \wedge F' \geq 10{,}5m^2$
If *mimimum_level* $\wedge$ $F \in \{be.s\} \Rightarrow w \geq 2{,}5m \wedge l2 \geq 2{,}1m \wedge F' \geq 8m^2$
$w2 \geq 1m$
$1m \leq l1, w1 \leq 1{,}5m$
$l3 \in \{0.8m, 0.9m\}$

Function:
$F,F' \in \{be.d, be.t, be.s\}$
$F = F'$
$Fb \in \{nhs, co, co.s, co.p\}$
$Fl \neq ext$
F1 (inside(x))=TRUE, $x \in \{uba\}$
$F1 \in \{ba.p2\}$

Description (abbreviated):

R2.15 < D2: F; Z'; E > $\rightarrow$
< D2: F', {ba.p2}; Z' + {ba.p2}; E + {ba.p2} >

Rule 2.16.a _ Erasing the new bathrooms placement weight: uba (type a and b)



Conditions:

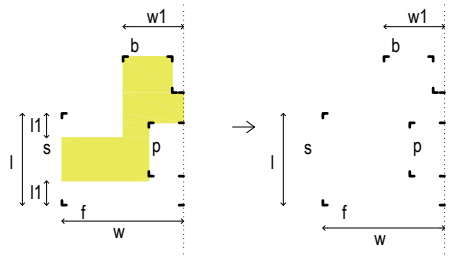
$Z' \supset \{ba.pn, ba.g\} \wedge Z \eth \{ba.pn, ba.g\}$

Dimensions:
$9.4m \leq l \leq 14m$
$5.7m \leq w \leq 18.5m$
$3m \leq w1 \leq 7.2m$
$l1 = 3m$

Description (abbreviated):

R2.16a < D2: l; uba > $\rightarrow$ < D2: l1, l2; Ø >

Rule 2.16.b _ Erasing the new bathrooms placement weight: uba (type c and d)



Conditions:

$Z' \supset \{ba.pn, ba.g\} \wedge Z \eth \{ba.pn, ba.g\}$

Dimensions:
$9.4m \leq l \leq 14m$
$5.7m \leq w \leq 18.5m$
$3.7m \leq w1 \leq 7.2m$
$l1 = 3m$

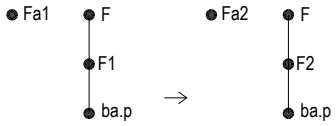
Description (abbreviated):

R2.16b < D2: l; uba > $\rightarrow$ < D2: l1, l2; Ø >

Note:

auxiliary lines

Rule 2.17_ Permuting the function of a bedroom which gives passage to private bathroom



Conditions:

Function:

ba.p (passage_to(x))=FALSE, x∈{F}

F∈{nhs, co, co.s, co.p, hl}

If F1∈{be.t} ∧ Fa1∈{be.d} ⇒ F2∈{be.d} ∧ Fa2∈{be.t}

If F1∈{be.s} ∧ Fa1∈{be.d} ⇒ F2∈{be.d} ∧ Fa2∈{be.s}

Description (abbreviated):

R2.17 < D2: F, F1, ba.p, Fa1 > → < D2: F, F2, ba.p, Fa2 >

Rule 2.18 _ Changing from step 2 to step 7 if there is no spaces satisfying rules 2.8 to 2.15

∅ → ∅

S2 → S7

Conditions:

If ∀ F: F≤2,5m² (±10%) (Rule 2.8.a) ∨

If ∀ F: F≤3m² (±10%) (Rule 2.8.b) ∨

⇒ Rules 7.1 ∨ Rules 7.4

Description (abbreviated):

R2.18 < D2: S2 > → < D7: S7 >

Rule 2.19 _ Changing from step 2 to step 3

∅ → ∅

S2 → S3

Conditions:

If Z⊃{be.d} ∧ Z'⊃{be.d} ∧ E⊃{be.d}

If Z⊃{be.t*n*} ∧ Z'⊃{be.t*n*} ∧ E⊃{be.t*n*}

If Z⊃{be.s*n*} ∧ Z'⊃{be.s*n*} ∧ E⊃{be.s*n*}

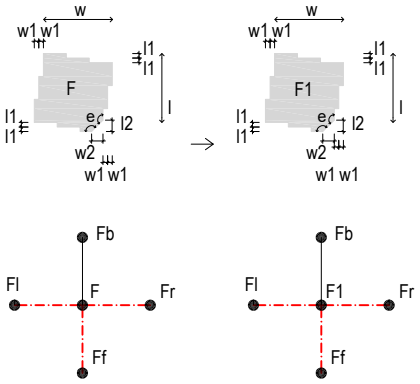
If Z⊃{ba.p*n*} ∧ Z'⊃{ba.p*n*} ∧ E⊃{ba.p*n*}

Description (abbreviated):

R2.19 < D2: S2 > → < D3: S3 >

Social rooms assignment

Rule 3.1.a _ Assignment of living room (minimum level)



Conditions:

Z⊃{li} ∧ Z'Ɒ{li}

Dimensions:

If n*hab* ≤6 ⇒ 13m²(±10%)≤F≤35m²
If n*hab* =7 ⇒ 16m²(±10%)≤F≤35m²
If n*hab* ≥8 ⇒ 19.5m²(±10%)≤F≤35m²
w, l≥3m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

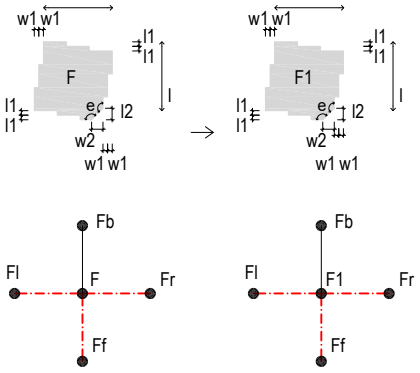
Functions:

Fb∈{ext}
∃ Ff∨Fr∨Fl∈ {nhs, co, co.p, hl}
F∈{hs}
If {strategy1} ⇒ li (next_to(x))=TRUE ∨ li (close_to(x))=TRUE, x∈{ki, hl}
If {strategy2} ⇒ li (next_to(y))=TRUE ∨ li (close_to(y))=TRUE, y∈{di, hl, co, co.s}
F1 ∈{li}

Description (abbreviated):

R3.1a < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; li; Z' + {li}; E - {hs}, E + {li} >

Rule 3.1.b _ Assignment of living room (minimum level)



Conditions:

Z⊃{li} ∧ Z'Ɒ{li}

Dimensions:

If n*hab* =2 ⇒ 11.5m² (±10%)≤F≤35m²
If n*hab* =3 ⇒ 13m² (±10%)≤F≤35m²
If n*hab* ={4,5} ⇒ 16m² (±10%)≤F≤35m²
If n*hab* =6 ⇒ F ≥ 19.5m² (±10%)≤F≤35m²
If n*hab* =7 ⇒ F ≥ 22.5m² (±10%)≤F≤35m²
If n*hab* ≥8 ⇒ F ≥ 26m² (±10%)≤F≤35m²
w, l≥3.5m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

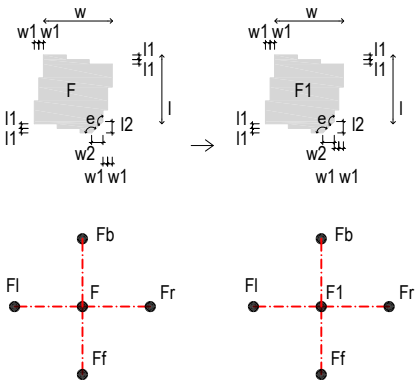
Functions:

Fb∈{ext}
∃ Ff∨Fr∨Fl∈ {nhs, co, co.p, hl}
F∈{hs}
If {strategy1} ⇒ li (next_to(x))=TRUE ∨ li (close_to(x))=TRUE, x∈{ki, hl}
If {strategy2} ⇒ li (next_to(y))=TRUE ∨ li (close_to(y))=TRUE, y∈{di, hl, co, co.s}
F1∈{li}

Description (abbreviated):

R3.1b < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; li; Z' + {li}; E - {hs}, E + {li} >

Rule 3.2.a _ Assignment of dining room (minimum level)



Conditions:

Z⊃{di} ∧ Z'Ɒ{di}

Dimensions:

If n*hab* =(5+*x*) ⇒ (7m² + 1m²(*x*-5)) (±10%)≤F≤35m²
If 7m²<F<9m² ⇒ l ∨ w≥2.1m
If 9.5m²<F<12m² ⇒ l,w≥2.4m
F≥12m² ⇒ l,w≥2.7m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

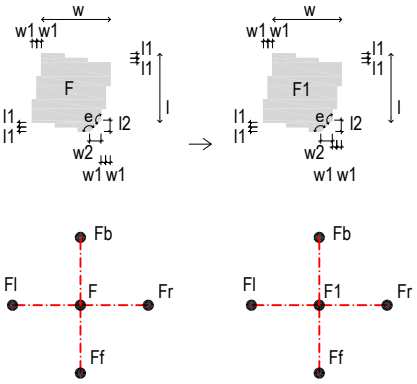
Functions:

∃ Ff∨Fr∨Fl∨Fb∈ {nhs, co, co.p, hl}
F∈{hs} ∨ F∈{nhs} *If* (F (passage_to(x))=TRUE, x∈{li})
If {strategy1} ⇒ di (next_to(x))=TRUE ∨ di (close_to(x))=TRUE, x∈{ki}
If {strategy2} ⇒ di (next_to(y))=TRUE ∨ di (close_to(x))=TRUE, y∈{li, hl, co, co.s, ki}
F1∈{di}

Description (abbreviated):

R3.2a < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; di; Z' + {di}; E - {hs, nhs}, E + {di}>

Rule 3.2.b _ Assignment of dining room (recommended level)



Conditions:

Z⊃{di} ∧ Z'Þ{di}

Dimensions:

If *nhab* ≥ 2 ⇒ F ≥ (7.5m² + 1m²(n-2)) (±10%)≤F≤35m²
7m²<F<9m² ⇒ l ∨ w≥2,1m
9,5m²<F<12m² ⇒ l,w≥2,4m
F≥12m² ⇒ l,w≥2,7m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

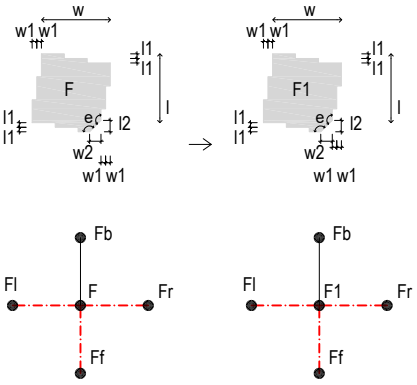
Functions:

∃ Ff∨Fr∨Fl∨Fb∈ {nhs, co, co.p, hl}
F∈{hs} ∨ F∈{nhs} *If* (F (passage_to(x))=TRUE, x∈{li})
If {strategy1} ⇒ di (next_to(x))=TRUE ∨ di (close_to(x))=TRUE, x∈{ki}
If {strategy2} ⇒ di (next_to(y))=TRUE ∨ di (close_to(x))=TRUE, y∈{li, hl, co, co.s, ki}
F1∈{di}

Description (abbreviated):

R3.2b < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; di; Z' + {di}; E - {hs, nhs}, E + {di}>

Rule 3.3.a _ Assignment of combined living/dining room (minimum level)



Description (abbreviated):

R3.3a < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; li/di;
Z' + {li/di}; E - {hs}, E + {li/di} >

Conditions:

Z⊃{di/li, li, di} ∧ Z'Þ{di/li, li, di}

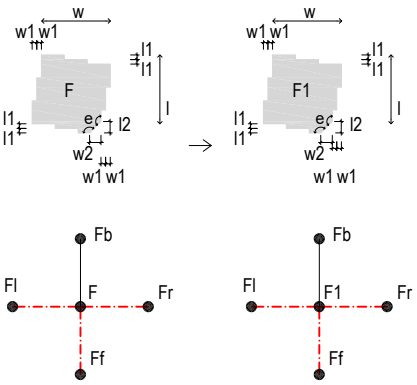
Dimensions:

If *nhab* ={1,2} ⇒ 12m² (±10%)≤F≤35m²
If *npersons* =3 ⇒ 15m² (±10%)≤F≤35m²
If *npersons* =4 ⇒ 17.5m² (±10%)≤F≤35m²
If *npersons* =5 ⇒ 19m² (±10%)≤F≤35m²
If *npersons* =6 ⇒ 21m² (±10%)≤F≤35m²
If *npersons* =7 ⇒ 24m² (±10%)≤F≤35m²
If *npersons* ≥8 ⇒ 29m² (±10%)≤F≤35m²
l,w≥3m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

Functions:

F∈{hs}
Fb∈{ext} ∧ Ff∨Fr∨Fl∈{nhs, co, co.s, hl}
If {strategy1} ⇒ F (next_to(x))=TRUE, x∈{ki}
If {strategy2} ⇒ F (next_to(y))=TRUE, y∈{hl, co, co.s}
F1∈{li/di}

Rule 3.3.b _ Assignment of combined living/dining room (recommended level)



Description (abbreviated):

R3.3b < D3: ext, {nhs, co, co.p, hl}, Ff, Fl; F; Z'; E > →
< D3: ext, {nhs, co, co.p, hl}, Ff, Fl; li/di;
Z' + {li/di}; E - {hs}, E + {li/di} >

Conditions:

Z⊃{di/li, li, di} ∧ Z'Þ{di/li, li, di}

Dimensions:

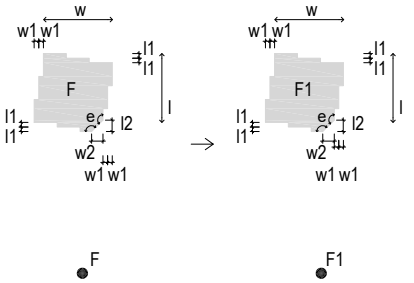
If *nhab* ={1,2} ⇒ 18.5m² (±10%)≤F≤35m²
If *npersons* =3 ⇒ 20.5m² (±10%)≤F≤35m²
If *npersons* =4 ⇒ 23.5m² (±10%)≤F≤35m²
If *npersons* =5 ⇒ 24m² (±10%)≤F≤35m²
If *npersons* =6 ⇒ 26.5m² (±10%)≤F≤35m²
If *npersons* =7 ⇒ 32.5m² (±10%)≤F≤40m²
If *npersons* =8 ⇒ 35.5m² (±10%)≤F≤40m²
If *npersons* =9 ⇒ 36m² (±10%)≤F≤40m²
l,w≥3.5m
l≤2*w
0m≤l1, w1≤1m
l2, w2≥0m
e ∈{135º, 180º}

Functions:

F∈{hs}
Fb∈{ext} ∧ Ff∨Fr∨Fl∈{nhs, co, co.s, hl}
If {strategy1} ⇒ F (next_to(x))=TRUE, x∈{ki}
If {strategy2} ⇒ F (next_to(y))=TRUE, y∈{hl, co, co.s}
F1∈{li/di}

Social rooms assignment

Rule 3.4 _ Assignment of isolated home office (by request of the inhabitant)



Conditions:

$Z \supset \{ho\} \wedge Z' \not\supset \{ho\}$

Dimensions:

$7m^2 (\pm 10\%) \leq F \leq 30m^2$

$w, l \geq 2{,}1m$

$0m \leq l1, w1 \leq 1m$

$l2, w2 \geq 0m$

$e \in \{135^o, 180^o\}$

Functions:

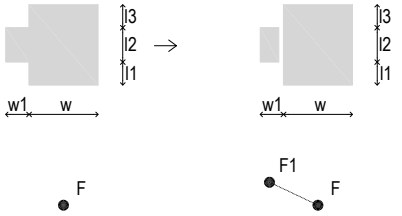
$F \in \{hs\} \vee F \in \{nhs\}$ *If* $F(passage\_to(x)) = TRUE,\ x \in \{li, li/di, be.c, be.t\}$

$F1 \in \{ho\}$

Description (abbreviated):

R3.4 < D3: ext, {nhs, co, co.p, co.s, hl}, Ff, Fl; F; Z' > →
< D3: ext, {nhs, co, co.p, co.s, hl}, Ff, Fl; ho; Z' + {ho}; E - {hs, nhs}, E + {ho} >

Rule 3.5.a _ Assignment of delimited home office (minimum level)



Conditions:

$Z \supset \{ho\} \wedge Z' \not\supset \{ho\}$

Dimensions:

If $n^o hab \geq 2 \Rightarrow 2m^2 \leq F1 \leq 4m^2 (\pm 10\%)$

$1m \leq w, w1, l2 \leq 5m$

$0m \leq l1, l3 \leq 3.5m$

Function:

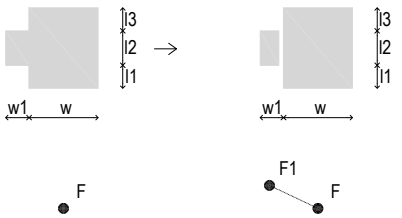
$F \in \{li, di, li/di, be.c, co, co.s, hl, nhs\}$

$F1 \in \{ho\}$

Description (abbreviated):

R3.5a < D3: F; Z'; E > → < D3: F, F1; Z' + {ho}; E + {ho}>

Rule 3.5.b _ Assignment of delimited home office (recommended level)



Conditions:

$Z \supset \{ho\} \wedge Z' \not\supset \{ho\}$

Dimensions:

If $n^o hab \geq 2 \Rightarrow 4m^2 \leq F \leq 6m^2 (\pm 10\%)$

$1m \leq w, w1, l2 \leq 5m$

$0m \leq l1, l3 \leq 3.5m$

Function:

$F \in \{li, di, li/di, be.c, co, co.s, hl, nhs\}$

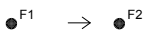
$F1 \in \{ho\}$

Description (abbreviated):

R3.5b < D3: F; Z'; E > → < D3: F, F1; Z' + {ho}; E + {ho}>

Social rooms assignment

Rule 3.6.a _ Adding an home office space to an assigned living room (minimum level)



Conditions:

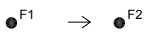
$Z \supset \{ho\} \wedge Z' \not\supset \{ho\}$

Dimensions:
If n*hab* $\leq 6 \Rightarrow$ F2$\geq 14m^2 (\pm 10\%)$
If n*hab* $= 7 \Rightarrow$ F2$\geq 17m^2 (\pm 10\%)$
If n*hab* $\geq 8 \Rightarrow$ F2$\geq 20.5m^2 (\pm 10\%)$

Functions:
F1$\in$ {li}
F2$\in$ {li/ho}

Description (abbreviated):
R3.6a < D3: F1; Z'; E > $\rightarrow$
< D3: F2; Z' - {li}, Z' + {li/ho}; E - {li}, E + {li/ho} >

Rule 3.6.b _ Assignment of living room + included home office (recommended level)



Conditions:

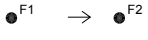
$Z \supset \{ho\} \wedge Z' \not\supset \{ho\}$

Dimensions:
If n*hab* $= 2 \Rightarrow$ F2$\geq 14.5m^2 (\pm 10\%)$
If n*hab* $= 3 \Rightarrow$ F2$\geq 16m^2 (\pm 10\%)$
If n*hab* $= \{4,5\} \Rightarrow$ F2$\geq 19m^2 (\pm 10\%)$
If n*hab* $= 6 \Rightarrow$ F2$\geq 22.5m^2 (\pm 10\%)$
If n*hab* $= 7 \Rightarrow$ F2$\geq 25.5m^2 (\pm 10\%)$
If n*hab* $\geq 8 \Rightarrow$ F2$\geq 29m^2 (\pm 10\%)$

Functions:
F1$\in$ {li}
F2$\in$ {li/ho}

Description (abbreviated):
R3.6b < D3: F1; Z'; E > $\rightarrow$
< D3: F2; Z' - {li}, Z' + {li/ho}; E - {li}, E + {li/ho} >

Rule 3.7 _ Adding an home office space to an assigned bedroom of occasional use



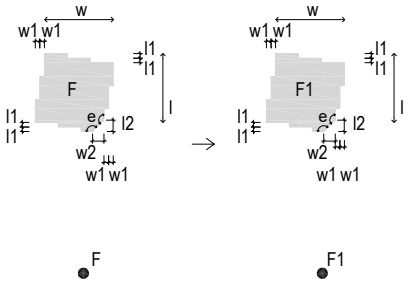
Conditions:

Functions:
F1$\in$ {be.t} $\wedge$ *percentage_occupation*(F1) $\leq 50\% \Rightarrow$ F2$\in$ {be.t/ho}
F1$\in$ {be.s} $\wedge$ *percentage_occupation*(F1) $\leq 50\% \Rightarrow$ F2$\in$ {be.s/ho}

Description (abbreviated):
R3.7 < D3: F1; Z'; E > $\rightarrow$
< D3: F2; Z' - {be.t, be.d}, Z' + {be.t/ho, be.d/ho}; E - {be.t, be.d}, E + {be.t/ho, be.d/ho} >

Social rooms assignment

Rule 3.8 _ Assignment of isolated media room (recommended level)



Conditions:

$Z \supset \{mr\} \wedge Z' \not\supset \{mr\}$

Dimensions:

If $n_{hab} = \{4,5,6\} \Rightarrow 12m^2 (\pm 10\%) \leq F \leq 30m^2$
If $n_{hab} \geq 7 \Rightarrow 14m^2 (\pm 10\%) \leq F \leq 30m^2$
$l,w \geq 3{,}5m$
$0m \leq l1, w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

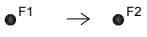
Functions:

$F \in \{hs\} \vee F \in \{nhs\}$ *If* F(passage_to(x))=TRUE, $x \in \{li, li/di\}$
$\exists\ Fb \vee Ff \vee Fr \vee Fl \in \{nhs, co, co.s, hl\}$
$F1 \in \{mr\}$

Description (abbreviated):

R3.8 < D3: {nhs, co, co.s, hl}, Ff, Fl, Fr; F; Z'; E > →
< D3: ext, {nhs, co, co.p, co.s, hl}, Ff, Fl, Fr; mr; Z' + {mr}; E - {hs, nhs}, E + {mr} >

Rule 3.9 _ Adding a media room to an assigned living room (recommended level)



Conditions:

$Z \supset \{mr\} \wedge Z' \not\supset \{mr\}$

Dimensions:

If $n_{hab} = 2 \Rightarrow F1 \geq 11.5m^2 + 2m^2 (\pm 10\%)$
If $n_{hab} = 3 \Rightarrow F1 \geq 13m^2 + 2m^2 (\pm 10\%)$
If $n_{hab} = \{4,5\} \Rightarrow F1 \geq 16m^2 + 3m^2 (\pm 10\%)$
If $n_{hab} = 6 \Rightarrow F1 \geq 19.5m^2 + 3m^2 (\pm 10\%)$
If $n_{hab} = 7 \Rightarrow F1 \geq 22.5m^2 + 4m^2 (\pm 10\%)$
If $n_{hab} \geq 8 \Rightarrow F1 \geq 26m^2 + 4m^2 (\pm 10\%)$

Functions:

$F1 \in \{li\}$
$F2 \in \{li/mr\}$

Description (abbreviated):

R3.9 < D3: F1; Z'; E > →
< D3: F2; Z' - {li}, Z' + {li/mr}; E - {li}, E + {li/mr} >

Rule 3.10 _ Changing from step 3 to step 7 if there is no spaces satisfying rules 3.1a to 3.5b

$\varnothing \rightarrow \varnothing$

S3 → S7

Conditions:

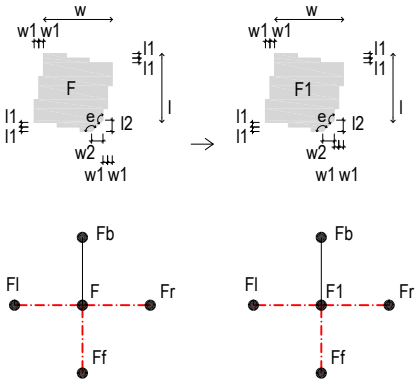
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.1.a)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.1.b)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.2.a)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.2.b)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.3.a)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.3.b)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.4)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.5.a)=TRUE $\vee$
If $\forall$ F: $F \leq$ *dimensions_of*(Rule 3.5.b)=TRUE
$\Rightarrow$ Rule 7.1.a $\vee$ Rule 7.1.b $\vee$ Rule 7.1.g $\vee$ Rule 7.4.a

Description (abbreviated):

R3.10 < D3: S3 > → < D7: S7 >

Guest bathroom assignment

Rule 3.11 _ Assignment of guest bathrooms (recommended level)



Conditions:

$Z \supset \{ba.g\} \wedge Z' \supset \{ba.g\}$

Dimensions:
$1m^2 \leq F \leq 3m^2$
$l, w \geq 1m$
$0m \leq l1, w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

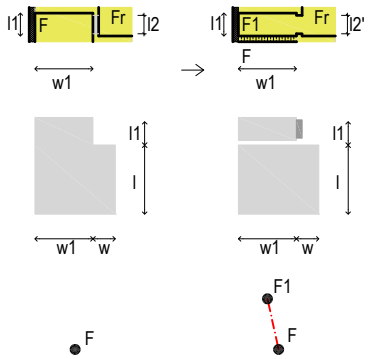
Functions:
$F \in \{nhs\} \wedge F\ (inside(x)) = TRUE,\ x \in \{uba\} \wedge$
$\exists |\ (passage\_to(y))\ |\ F\ (passage\_to(y)) = TRUE,\ y \in \{Ff, Fb, Fl, Ff\} \wedge Fb \vee Ff \vee Fr \vee Fl \in \{nhs, co, co.s\}$
$\vee$
$F \in \{Xba\}$

$F\ (next\_to(t)) = TRUE,\ t \in \{li, di, li/di, ki, mr\} \vee F\ (close\_to(t)) = TRUE,\ t \in \{li, di, li/di, ki, mr\}$
$F1 \in \{ba.g\}$

Description (abbreviated):

R3.11 < D3: Fb, Ff, Fr, Fl; F; Z'; E > →
< D3: Fb, Ff, Fr, Fl; ba.p2; Z' + {ba.p2}; E - {nhs}, E + {ba.p2} >

Rule 3.12 _ Create a guest bathroom (next to side wall)



Conditions:

$Z \supset \{ba.g\} \wedge Z' \supset \{ba.g\}$

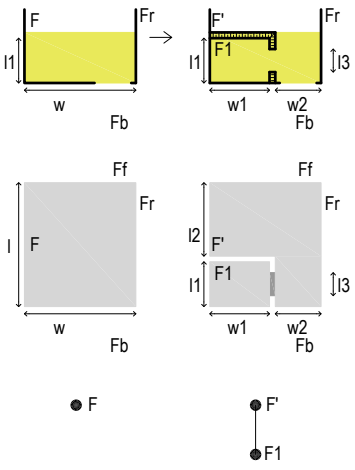
Dimensions:
$0m \leq w \leq 2m$
$3m \leq l \leq 4.5m$
$1.5m \leq w1 \leq 3.5m$
$0.9m \leq l1 \leq 1.5m$
$0m \leq l2 \leq 1.5m$
$l2' = 0{,}8m$

Functions:
$F \in \{be.d, be.t, be.s, di, li, li/di, ho, mr, ki, hs\}$
$Fr \in \{co, co.s, co.p, hl\}$
$F\ (inside(x)) = TRUE,\ x \in \{uba\}$
$F\ (adjacent\_to(x)) = TRUE,\ x \in \{usi\}$
$Fr\ (passage\_to(y)) = TRUE \vee Fr\ (next\_to(y)) = TRUE,\ y \in \{li, di, li/di, mr\}$
$F1 \in \{ba.g\}$

Description (abbreviated):

R3.12 < D3: F, Fr; Z'; E > →
< D3: F, ba.g, F1; Z' + {ba.g}; E + {ba.g} >

Rule 3.13 _ Create a guest bathroom (included in the hall)



Conditions:

$Z \supset \{ba.g\} \wedge Z' \supset \{ba.g\}$

Dimensions:
$l, w \geq 2.4m$
$w2 \geq 1m$
$l2 \geq 1.2m$
$1m \leq l1, w1 \leq 1{,}5m$
$l3 \in \{0.8m, 0.9m\}$

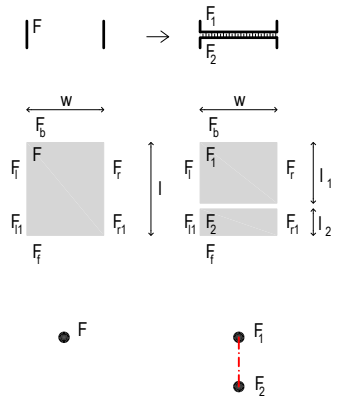
Function:
$F, F' \in \{hl\}$
$F = F'$
$Fb \in \{nhs, co, co.s, co.p\}$
$Fr = lh \vee Ff = lh$
$F1\ (inside(x)) = TRUE,\ x \in \{uba\}$
$F1 \in \{ba.g\}$

Description (abbreviated):

R3.13 < D3: F; Z'; E > →
< D3: F', {ba.g}; Z' + {ba.g}; E + {ba.g} >

Guest bathroom assignment

Rule 3.14 _ Create a guest bathroom by dividing a space in two



Conditions:

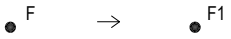
Dimensions:
w, l1, l2≥1m
l≥2.2m
If *mimimum_level* ⇒ F≥5m² ∧ F1≥3,5m²
If *recommended_level* ⇒ F≥7,5m² ∧ F1≥5m²
F2≥1m²

Functions:
F, F1∈{ba.p1, ba.p2}
Fb∨Fl1∨Fr1∈{co, co.s, co.p, nhs}
Fb∨Fl∨Fr∈{co, co.s, co.p, nhs, be.d}
F2∈{ba.g}

Description (abbreviated):

Rule 3.14 < D3: F; Z'; E; w*Ø > →
< D3: F1, {ba.g}; Z' + {ba.g}; E + {ba.g}; w*ul >

Rule 3.15 _ Changing Xba label



Conditions:
Z⊅{ba.p1, ba.p2, ba.p3, ba.g}

Functions:
F∈{Xba}
F1∈{nhs}

Description (abbreviated):
R3.15 < D3: Xba; E > → < D3: nhs; E - {Xba}, E + {nhs} >

Rule 3.16 _ Changing from step 3 to step 7 if there is no spaces satisfying rules 3.11 to 3.14

∅ → ∅

S3 → S7

Conditions:
∀ F: F=*conditions_of*(Rules 3.11, 3.12, 3.13, 3.14)=FALSE

Description (abbreviated):
R3.16 < D3: S3 > → < D7: S7 >

Rule 3.17 _ Changing from step 3 to step 4

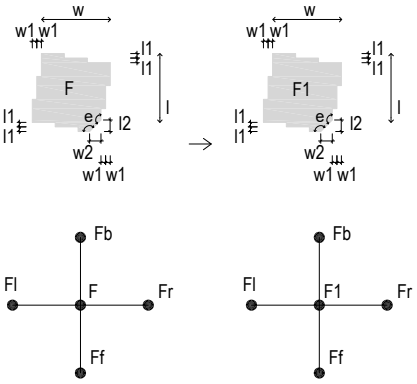
∅ → ∅

S3 → S4

Conditions:
If Z⊃{li} ∧ Z'⊃{li}∧ E⊃{li}
If Z⊃{di} ∧ Z'⊃{di} ∧ E⊃{di}
If Z⊃{ho} ∧ Z'⊃{ho}∧ E⊃{ho}
If Z⊃{mr} ∧ Z'⊃{mr}∧ E⊃{mr}
If Z⊃{ba.g} ∧ Z'⊃{ba.g}∧ E⊃{ba.g}

Description (abbreviated):
R3.17 < D3: S3 > → < D4: S4 >

Rule 4.1 _ Assignment of private corridors



Description (abbreviated):

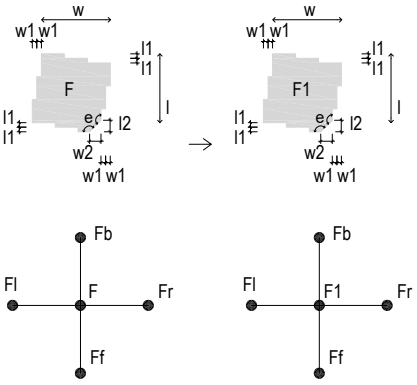
R4.1 < D4: Fb, Ff, Fr, Fl; F; Z'; E > →
< D4:Fb, Ff, Fr, Fl; co.p ; Z' + {co.p}; E - {nhs}, E + {co.p}>

Conditions:

Dimensions:
$0.9m \leq l, w \leq 10m$
$1m^2 \leq F \leq 15m^2$
$0m \leq l1$
$w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Function:
$F \in \{nhs\}$
$\forall$ x: F (passage_to(x))=TRUE, x∈{Fb, Ff, Fr, Fl}
$\wedge$ x∈{be.d, be.t, be.s, cl, ba.p, ho, hl, co, co.s, st, nhs}
$\wedge$ $\exists$ x∈{be.d, be.t, be.s, ba.p}
$\vee$
F (passage_to(x))=TRUE, x∈{Fb, Ff, Fr, Fl}
$\wedge$ x∈{be.d, be.t, be.s, cl, ba.p, ho, hl, co, co.s, st, nhs, li, di, li/di}
$\wedge$ $\exists$ x∈{be.d, be.t, be.s, ba.p}
$\wedge$ If x∈{li, di, li/di} $\Rightarrow$ x (passage_to(y))≥2, y∈{nhs, co, co.s, co.p}
$F1 \in \{co.p\}$

Rule 4.2 _ Assignment of social corridors



Description (abbreviated):

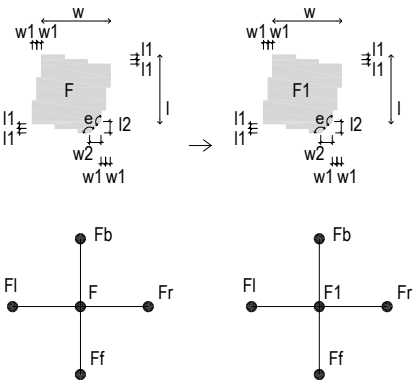
R4.2 < D4: Fb, Ff, Fr, Fl; F; Z'; E > →
< D4:Fb, Ff, Fr, Fl; co ; Z' + {co}; E - {nhs}, E + {co}>

Conditions:

Dimensions:
$0.9m \leq l, w \leq 10m$
$1m^2 \leq F \leq 15m^2$
$0m \leq l1$
$w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Function:
$F \in \{nhs\}$
$\forall$ x: F (passage_to(x))=TRUE, x∈{Fb, Fr, Ff, Fl} $\wedge$
(x ∈ {li, di, li/di, ho, mr, ba.g, hl, co.p, cl, st, nhs} $\vee$
$\exists$ x∈{ki, la, st} $\wedge$ $\exists$ x∈{li, di, li/di, ho, mr, ba.g, hl, co.p, cl, st, nhs } $\vee$
$\exists$ x∈{be.d, be.t, be.s, ba.p, cl} $\wedge$
$\exists$ x∈{li, di, li/di, ho, mr, ba.g, hl, co.p, cl, st, nhs })
$F1 \in \{co\}$

Rule 4.3 _ Assignment of service corridors



Description (abbreviated):

R4.3 < D4: Fb, Ff, Fr, Fl; F; Z'; E > →
< D4:Fb, Ff, Fr, Fl; co.s ; Z' + {co.s}; E - {nhs}, E + {co.s}>

Conditions:

Dimensions:
$0.9m \leq l, w \leq 10m$
$1m^2 \leq F \leq 15m^2$
$0m \leq l1$
$w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Function:
$F \in \{nhs\}$
$\forall$ x: F (passage_to(x))=TRUE, x∈{Fb, Ff, Fr, Fl} $\wedge$ x ∈ {ki, la, cl, st, hl, co, co.s, nhs}
$F1 \in \{co.s\}$

Circulation assignment + laundry assignment

Rule 4.4 _ Changing from step 4 to step 7 if there is assigned rooms with no connections

$\varnothing \rightarrow \varnothing$

S4 → S7

Conditions:

If Z⊃{be.d} ∧ be.d (passage_to(y))=FALSE, y∈{co, co.p, hl, cl}
If Z⊃{be.t} ∧ be.t (passage_to(y))=FALSE, y∈{co, co.p, hl, cl}
If Z⊃{be.s} ∧ be.s (passage_to(y))=FALSE, y∈{co, co.p, hl, cl}
If Z⊃{ba.p} ∧ ba.p (passage_to(y))=FALSE, y∈{co, co.p, cl, be.d, be.t, be.s}
If Z⊃{li} ∧ li (passage_to(y))=FALSE, y∈{co, hl}
If Z⊃{di} ∧ di (passage_to(y))=FALSE, y∈{co, hl, li, ki}
If Z⊃{ho} ∧ ho (passage_to(y))=FALSE, y∈{co, co.p, co.s, hl, cl, li, di}
If Z⊃{mr} ∧ mr (passage_to(y))=FALSE, y∈{co, co.p, co.s, hl, li, di, ho}
If Z⊃{ba.g} ∧ ba.g (passage_to(y))=FALSE, y∈{co, hl}
⇒ Rules 7.3 ∨ Rules 7.5 ∨ Rules 7.6

Description (abbreviated):

R4.4 < D4: S4 > → < D7: S7 >

Rule 4.5 _ Changing from step 4 to step 5

$\varnothing \rightarrow \varnothing$

S4 → S5

Conditions:

∀ be.d: be.d (passage_to(y))=TRUE, y∈{co, co.p, hl, cl}
∀ be.t: be.t (passage_to(y))=TRUE, y∈{co, co.p, hl, cl}
∀ be.s: be.s (passage_to(y))=TRUE, y∈{co, co.p, hl, cl}
∀ ba.p: ba.p (passage_to(y))=TRUE, y∈{co, co.p, cl, be.d, be.t, be.s}
∀ li: li (passage_to(y))=TRUE, y∈{co, hl}
∀ di: di (passage_to(y))=TRUE, y∈{co, hl, li, ki}
∀ ho: ho (passage_to(y))=TRUE, y∈{co, co.p, co.s, hl, cl, li, di}
∀ mr: mr (passage_to(y))=TRUE, y∈{co, co.p, co.s, hl, li, di, ho}
∀ ba.g: ba.g (passage_to(y))=TRUE, y∈{co, hl}

Description (abbreviated):

R5.4 < D5: S4 > → < D5: S5 >

Rule 5.1 _ Assignment of isolated laundry (strategy 2)

F → F1

Conditions:

Z⊃{la} ∧ Z'⊅{la}

Functions:

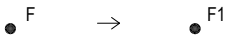
If{strategy2} ∧ F∈{Xla} ⇒ F1∈{la}

Description (abbreviated):

R5.1 < D5: Xla; Z'; E > →
< D5: la; Z' + {la}; E - {Xla}, E + {la} >

Laundry assignment

Rule 5.2.a _ Assignment of included laundry (minimum level) (strategy1)



Conditions:

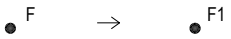
Dimensions:
F≥8m² (±10%)
l, w≥1,7m

Functions:
F ∈{ki}
F1∈{ki/la}

Description (abbreviated):

R5.2a < D5: ki; Z'; E > → < D5: ki/la; Z' - {ki}, Z' + {ki/la}; E - {ki}, E + {ki/la}>

Rule 5.2.b _ Assignment of included laundry (recommended level) (strategy1)



Conditions:

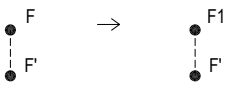
Dimensions:
If n*hab*=4 ⇒ F≥14m² (±10%)
If 7>n*hab*≥5 ⇒ F≥15m²+0,5m²(n-5) (±10%)
If n*hab*≥7 ⇒ F≥16m²+0,5m²(n-5) (±10%)
l, w≥1,7m

Functions:
F ∈{ki}
F1∈{ki/la}

Description (abbreviated):

R5.2b < D5: ki; Z'; E > → < D5: ki/la; Z' - {ki}, Z' + {ki/la}; E - {ki}, E + {ki/la}>

Rule 5.3 _ Changing Xba label (strategy1)



Conditions:

Z'⊃{la}

Functions:
F∈{Xla}
F'∈{be.s, be.t, be.d}
F1∈{cl}

Description (abbreviated):

R5.3 < D5: Xla; E > → < D5: cl; E - {Xla}, E + {cl} >

Rule 5.4 _ Changing from step 5 to step 6

∅ → ∅

S5 → S6

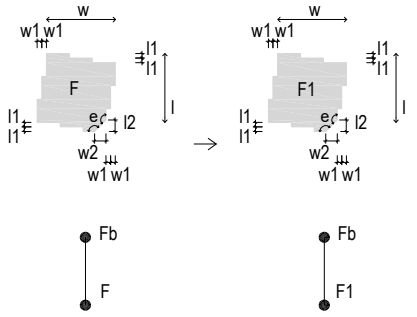
Conditions:

Z⊃{la} ∧ Z'⊃{la} ∧ E⊃{la}

Description (abbreviated):

R5.4 < D5: S5 > → < D6: S6 >

Rule 6.1: Assignment of cloth storage



Conditions:

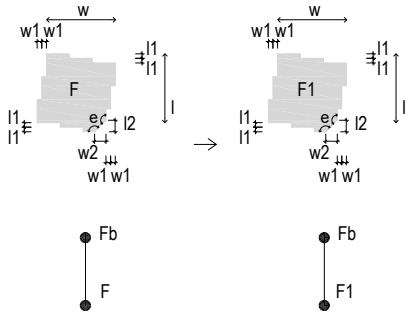
Dimensions:
$0{,}5m^2 < F \leq 6m^2$
$0.6m \leq l, w \leq 3m$
$0m \leq l1$
$w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Functions:
$F \in \{nhs\}$
$Fb \in \{co.p, be.d, be.t, be.s, ba.p\}$
$\exists |\ F\ (passage\_to(y)) = TRUE, y \in \{Fb\}$
$F1 \in \{cl\}$

Description (abbreviated):

R6.1 < D6: Fb; F; Z'; E > $\rightarrow$
< D6: Fb, cl; Z' + {cl}; E - {nhs}, E + {cl} >

Rule 6.2: Assignment of general storage



Conditions:

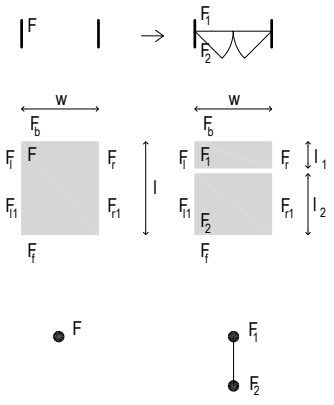
Dimensions:
$0{,}5m^2 < F \leq 6m^2$
$0.6m \leq l, w \leq 3m$
$0m \leq l1$
$w1 \leq 1m$
$l2, w2 \geq 0m$
$e \in \{135^o, 180^o\}$

Functions:
$F \in \{nhs\}$
$Fb \in \{co, co.s, hl, ki, la, ho, mr\}$
$\exists |\ F\ (passage\_to(y)) = TRUE, y \in \{Fb\}$
$F1 \in \{st\}$

Description (abbreviated):

R6.2 < D6: Fb; F; Z'; E > $\rightarrow$
< D6: Fb, st; Z' + {st}; E - {nhs}, E + {st} >

Rule 6.3: Creation of new general or clothes storage



Conditions:

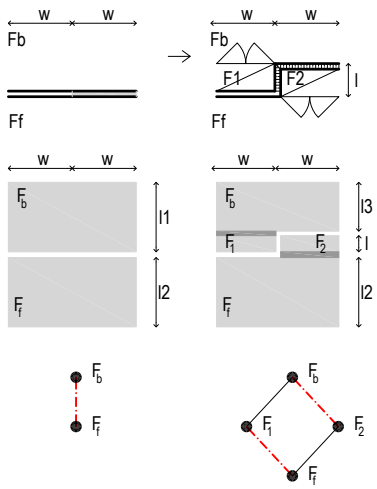
Dimensions:
$0{,}5m^2 < F \leq 6m^2$
$w, l2 \geq 1m$
$l \geq 1.6m$
$l1 \geq 0{,}6m$

Functions:
$Fb, Ff, Fl, Fr, Fl1, Fr1 \in \{Z\}$
// $F \in \{co, co.s\} \wedge F\ (passage\_to(y)) = FALSE, y \in \{Fb, Fl, Fr\} \Rightarrow F1 \in \{st\}$
// $F \in \{co.p\} \wedge F\ (passage\_to(y)) = FALSE, y \in \{Fb, Fl, Fr\} \Rightarrow F1 \in \{cl\}$

Description (abbreviated):

R6.3 < D6: Fb, Ff, Fr, Fl, Fr1, Fl1; F; Z'; E > $\rightarrow$
< D6: Fb, Ff, Fr, Fl, Fr1, Fl1; {st, cl}; Z' + {st, cl}; E + {st, cl} >

Rule 6.4: Assignment of general or clothes storage



Conditions:

Dimensions:
If Ff∈{be.d} ⇒ l2≥2.7m
If Fb∈{be.d} ⇒ l1≥3.45m ∧ l3≥2.7m
If Ff∈{be.t, be.s, ho, mr} ⇒ l2≥2.1m
If Fb∈{be.t, be.s, ho, mr} ⇒ l1≥2.85m ∧ l3≥2.1m
If Ff∈{nhs, co, co.p, co.s, hl} ⇒ l2≥1m
If Fb∈{nhs, co, co.p, co.s, hl} ⇒ l1≥1.75m ∧ l3≥1m
w≥1m
l=0,75m

Functions:
Fb, Ff∈{nhs, co, co.s, co.p, be.d, be.t, be.s, ho, mr}
If Ff∈{be.d, be.t, be.s} ⇒ F2=cl
If Ff∈{ho, mr, nhs, co, co.p, co.s, hl} ⇒ F2∈{st}
If Fb∈{be.d, be.t, be.s} ⇒ F1=cl
If Fb∈{ho, mr, nhs, co, co.p, co.s, hl} ⇒ F1∈{st}

Description (abbreviated):
R6.4 < D6: Fb, Ff; Z'; E > →
< D6: Fb, Ff;{cl,st}; Z' + {cl,st}; E + {cl,st} >

Rule 6.5 _ Changing from step 6 to step 7

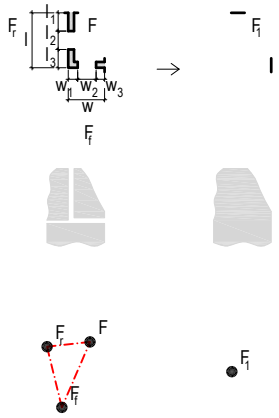
∅ → ∅

S6 → S7

Conditions:
Z⊃{cl} ∧ Z'⊃{cl}∧ E⊃{cl}
Z⊃{st} ∧ Z'⊃{st}∧ E⊃{st}

Description (abbreviated):
R6.5 < D6: S6 > → < D7: S7 >

Rule 7.1.a _ Connecting three adjacent rooms (by eliminating an L-shaped wall)



Conditions:

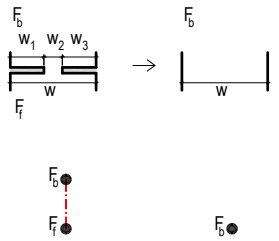
Dimensions:
0.9m≤l≤2m ∧ 0m≤l1, l2, l3≤2m
0.9m≤w≤2m ∧ 0m≤w1, w2, w3≤2m

Function:
F∈{nhs, Xba, Xla, cl, st}
Fr∈{nhs, co, co.p, co.s, cl}
Ff∈{hs, be.d, be.t, be.s, ki, li, di, li/di, ho, mr}
Ff=F1

Description (abbreviated):

R7.1a < D7: Fr, Ff, F; w*w*ub*(F, Ff), l*w*ub*(F, Fr) > → < D7: F1; w*Ø>

Rule 7.1.b _ Connecting two adjacent rooms (by eliminating a straight wall)



Conditions:

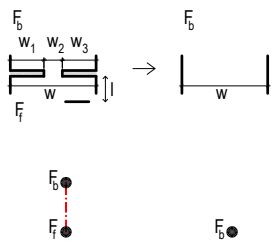
Dimensions:
w≤2m
0m≤w1,w2, w3≤2m

Function:
Fb ∈ {be.d, be.t, be.s} ∧ Ff ∈ {nhs, co, co.p, co.s, cl}
∨
Fb ∈ {li, di, li/di, ho, mr} ∧ Ff ∉{be.d, be.t, be.s, ba.p, ba.g, la, ki}
∨
Fb ∈ {la} ∧ Ff ∈ {Xba, nhs, st}
∨
Fb, Ff ∈ {co,co.s, co.p} ∧ Fb=Ff

Description (abbreviated):

R7.1.b < D7: Fb, Ff; w*w*ub*(Fb, Ff) > → < D7: Fb ; w*Ø >

Rule 7.1.c _ Connecting two adjacent rooms (by eliminating a straight wall)



Conditions:

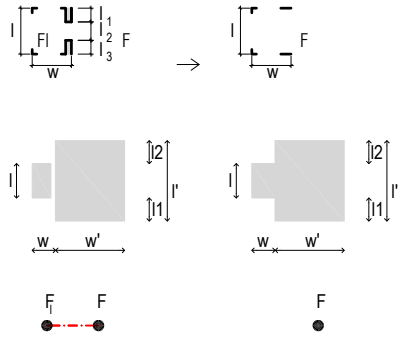
Dimensions:
2m≤w≤3m
0m≤w1,w2, w3≤3m
l≤1,5m

Function:
Fb ∈ {be.d, be.t, be.s} ∧ Ff ∈ {nhs, Xba.se, co, co.p, co.s, cl}
∨
Fb ∈ {li, di, li/di, ho, mr} ∧ Ff ∉{be.d, be.t, be.s, ba.p, ba.g, la, ki}
∨
Fb ∈ {la} ∧ Ff ∈ {Xba.se, nhs, st}

Description (abbreviated):

R7.1.c < D7: Fb, Ff; w*w*ub*(Fb, Ff) > → < D7: Fb ; w*Ø >

Rule 7.1.d _ Connecting two adjacent rooms (by eliminating a wall)



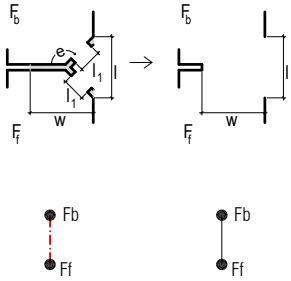
Conditions:

Dimensions:
1m≤w≤3m
0m≤l1,l2≤3m
1m≤l≤2m
1m≤w', l'≤4m

Function:
F∈{ki} ∧ Fl∈{nhs, Xba, st} ∧ ∃| Fl (passage_to(x))=TRUE, x∈{nhs, Xba, st}
∨
F∈{li, di, li/di, ho, mr} ∧ Fl∈{co, co.s} ∧ ∃| Fl (passage_to(x))=TRUE, x∈{co, co.s}

Description (abbreviated):
R7.1.d < D7: Fl, F; l*w*ub*(Fl, F) > → < D7: F; l*Ø >

Rule 7.1.e _ Connecting two adjacent spaces (by eliminating a straight wall)



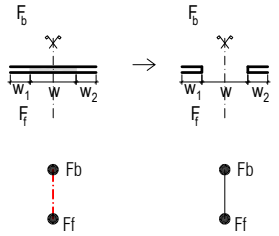
Conditions:

Dimensions:
w, l≤2m
0m≤l1≤2m
e=135º

Function:
Fb∈{li, di, li/di, ho, mr}
Ff ∉{be.d, be.t, be.s, ba.p, ba.g, la, ki}

Description:
R7.1.e < D7: Fb, Ff; w*ub, l*ub > → < D7: Fb ; Ø, Ø>

Rule 7.1.f _ Connecting two adjacent rooms (by eliminating part of a straight wall, in the middle of the wall)



Conditions:

Dimensions:

w1+w+w2≥1m

w∈{0.8m, 0.9m, 1m, 1.2m, 1.6m}

w1,w2≥0m

Function:

Private areas

Fb∈{be.d, be.t, be.s} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co.p, co}) ⇒ w∈{0.8m, 0.9m, 1m}

Fb∈{be.d, be.t, be.s} ∧ Ff∈{cl, ba.p} ∧ Ff (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}

Fb∈{ba.p, cl} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}

Living areas

Fb∈{li, di, li/di, ho, mr} ∧ Ff∈{nhs, co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co, hl})

Fb∈{li} ∧ Ff∈{di, ho, mr}

Fb∈{di, li/di} ∧ Ff∈{li, ho, mr, ki}

Fb∈{ho} ∧ Ff∈{li, di, li/di, mr, co.p, ki, cl, st, be.d}

Fb∈{mr} ∧ Ff∈{li, di, li/di, ho}

Service areas

Fb∈{ki} ∧ Ff∈{co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl}) ⇒ w∈{0.8m, 0.9m, 1m}

Fb∈{ki} ∧ Ff∈{di, li/di, la} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{di, li/di, la})

Circulations areas

Ff, Fb∈{nhs, co, co.p, co.s, hl}

Storage areas

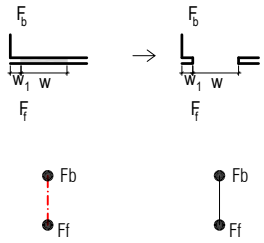
Fb∈{cl} ∧ Ff∈{co, co.p, be.d, be.t, be.s} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.p, be.d, be.t, be.s}) ⇒ w∈{0.8m, 0.9m, 1m}

Fb∈{st} ∧ Ff∈{co, co.s, hl, ki, la, ho, mr} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl, ki, la, ho, mr}) ⇒ w∈{0.8m, 0.9m, 1m}

Description (abbreviated):

R7.1f < D7: Fb, Ff; w*w*ub*(Fb, Ff) > →
< D7: Fb, Ff ; w*Ø >

Rule 7.1.g _ Connecting two adjacent rooms (by eliminating part of a straight wall, next to the perpendicular partition wall)



Conditions:

Dimensions:
w∈{0.8m, 0.9m, 1m, 1.2m, 1.6m}
w1=0,1m

Function:

Private areas
Fb∈{be.d, be.t, be.s} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co.p, co}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{be.d, be.t, be.s} ∧ Ff∈{cl, ba.p} ∧ Ff (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{ba.p, cl} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}

Living areas
Fb∈{li, di, li/di, ho, mr} ∧ Ff∈{nhs, co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co, hl})
Fb∈{li} ∧ Ff∈{di, ho, mr}
Fb∈{di, li/di} ∧ Ff∈{li, ho, mr, ki}
Fb∈{ho} ∧ Ff∈{li, di, li/di, mr, co.p, ki, cl, st, be.d}
Fb∈{mr} ∧ Ff∈{li, di, li/di, ho}

Service areas
Fb∈{ki} ∧ Ff∈{co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{ki} ∧ Ff∈{di, li/di, la} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{di, li/di, la})

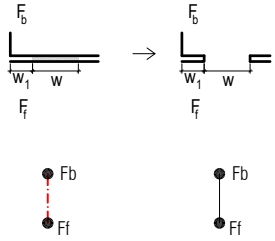
Circulations areas
Ff, Fb∈{nhs, co, co.p, co.s, hl}

Storage areas
Fb∈{cl} ∧ Ff∈{co, co.p, be.d, be.t, be.s} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.p, be.d, be.t, be.s}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{st} ∧ Ff∈{co, co.s, hl, ki, la, ho, mr} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl, ki, la, ho, mr}) ⇒ w∈{0.8m, 0.9m, 1m}

Description (abbreviated):

R7.1g < D7: Fb, Ff; w*w*ub*(Fb, Ff) > →
< D7: Fb, Ff ; w*Ø >

Rule 7.1.h _ Connecting two adjacent rooms (by eliminating part of a straight wall, disting 0,7m to the perpendicular partition wall)



Conditions:

Dimensions:
w∈{0.8m, 0.9m, 1m, 1.2m, 1.6m}
w1=0,7m

Function:

Private areas
Fb∈{be.d, be.t, be.s} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co.p, co}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{be.d, be.t, be.s} ∧ Ff∈{cl, ba.p} ∧ Ff (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{ba.p, cl} ∧ Ff∈{nhs, co.p, co} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{Z, hs, nhs}) ⇒ w∈{0.8m, 0.9m, 1m}

Living areas
Fb∈{li, di, li/di, ho, mr} ∧ Ff∈{nhs, co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{nhs, co, hl})
Fb∈{li} ∧ Ff∈{di, ho, mr}
Fb∈{di, li/di} ∧ Ff∈{li, ho, mr, ki}
Fb∈{ho} ∧ Ff∈{li, di, li/di, mr, co.p, ki, cl, st, be.d}
Fb∈{mr} ∧ Ff∈{li, di, li/di, ho}

Service areas
Fb∈{ki} ∧ Ff∈{co, co.s, hl} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{ki} ∧ Ff∈{di, li/di, la} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{di, li/di, la})

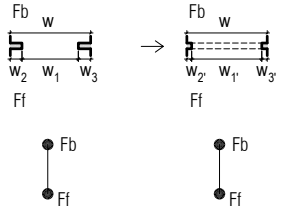
Circulations areas
Ff, Fb∈{nhs, co, co.p, co.s, hl}

Storage areas
Fb∈{cl} ∧ Ff∈{co, co.p, be.d, be.t, be.s} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.p, be.d, be.t, be.s}) ⇒ w∈{0.8m, 0.9m, 1m}
Fb∈{st} ∧ Ff∈{co, co.s, hl, ki, la, ho, mr} ∧ Fb (passage_to(x)=FALSE, ∀ x∈{co, co.s, hl, ki, la, ho, mr}) ⇒ w∈{0.8m, 0.9m, 1m}

Description (abbreviated):

R7.1.h < D7: Fb, Ff; w*w*ub*(Fb, Ff) > →
< D7: Fb, Ff ; w*Ø >

Rule 7.1.i _ Widening the connection between two rooms (by partially eliminating walls on both sides of a door opening)



Conditions:

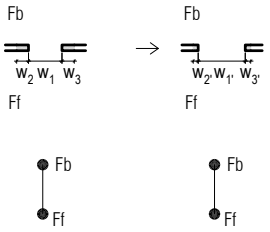
Dimensions:
w1≥1/2 w
w1≥0,9m
w2', w3'≥0m
w1'∈{1m, 1.2m, 1.6m, 2m, 2.2m, 2.5m, w}

Function:
Fb, Ff∈{Z}

Description (abbreviated):

R7.1i < D7: Fb, Ff; w2*w*ub*(Fb, Ff), w3*w*ub*(Fb, Ff) > →
< D7: Fb, Ff; w2'*w*ub*(Fb, Ff), w3'*w*ub*(Fb, Ff) >

Rule 7.1.j _ Widening the connection between two rooms (by partially eliminating walls on both sides of a door opening)



Conditions:

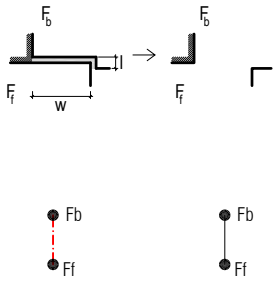
Dimensions:
1m≤w1≤2m
w1∈{1,0m, 1,2m, 1,6m}

Function:
Fb, Ff∈{Z}

Description (abbreviated):

R7.1j < D7: Fb, Ff; w2*w*ub*(Fb, Ff), w3*w*ub*(Fb, Ff) > →
< D7: Fb, Ff; w2'*w*ub*(Fb, Ff), w3'*w*ub*(Fb, Ff) >

Rule 7.1.k _ Connecting two adjacent spaces (by eliminating part of a straight walll)



Conditions:

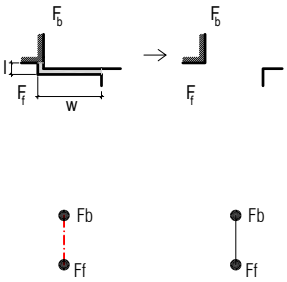
Dimensions:
w≤2m
0,4m≤l≤1m

Function:
Fb, Ff∈{li, di, li/di, ho, mr}
∨
Fb∈{be.d, be.t, be.s} ∧ Ff∈{cl, ho, ba.p}

Description:

R7.1k < D7: Fb, Ff; w*ub, l*ub > →
< D7: Fb, Ff ; w*Ø,l*Ø,>

Rule 7.1.l _ Connecting two adjacent spaces (by eliminating part of a straight walll)



Conditions:

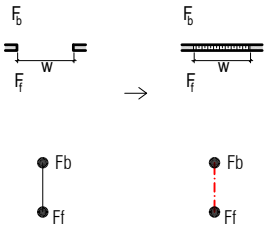
Dimensions:
w≤2m
0,4m≤l≤1m

Function:
Fb, Ff∈{li, di, li/di, ho, mr}
∨
Fb∈{be.d, be.t, be.s} ∧ Ff∈{cl, ho, ba.p}

Description:

R7.1l < D7: Fb, Ff; w*ub, l*ub > →
< D7: Fb, Ff ; w*Ø,l*Ø,>

Rule 7.2.a _ Separating rooms, closing door opening with light partition wall



Conditions:

Function:
Fb≠Ff

Private areas

If (passage_to(Fb))≥2 ∧ Fb∈{be.d, be.t, be.s} ∧ Ff∉{ba.p, cl}
If (passage_to(Fb))=1 ∧ Fb∈{be.d, be.t, be.s} ∧ Ff∉{ba.p, cl, co.p, co}

Living areas

If (passage_to(Fb))≥2 ∧ Fb∈{li} ∧ Ff∉{di, ho, mr}
If (passage_to(Fb))=1 ∧ Fb∈{li} ∧ Ff∉{di, ho, mr, co, hl}
If (passage_to(Fb))≥2 ∧ Fb∈{di, li/di} ∧ Ff∉{li, ho, mr, ki}
If (passage_to(Fb))=1 ∧ Fb∈{di, li/di} ∧ Ff∉{li, ho, mr, ki, co, hl}
If (passage_to(Fb))≥2 ∧ Fb∈{ho} ∧ Ff∉{li, di, li/di, mr, co.p, ki, cl, st, be.d}
If (passage_to(Fb))=1 ∧ Fb∈{ho} ∧ Ff∉{li, di, li/di, mr, co.p, ki, cl, st, be.d, co, hll}
If (passage_to(Fb))≥2 ∧ Fb∈{mr} ∧ Ff∉{li, di, li/di, ho}
If (passage_to(Fb))=1 ∧ Fb∈{mr} ∧ Ff∉{li, di, li/di, ho, co, hl}

Service areas

If (passage_to(Fb))≥2 ∧ Fb∈{ki} ∧ Ff∉{la, di, li/di, st}
If (passage_to(Fb))=1 ∧ Fb∈{ki} ∧ Ff∉{la, di, li/di, st, co.s, co}

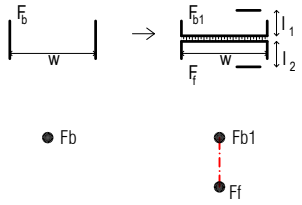
Storage areas

Fb∈{cl} ∧ Ff∉{be.d, be.t, be.s, co.p, co}
Fb∈{st} ∧ Ff∉{co, co.s, ki, la, ho, mr}

Description (abbreviated):

R7.2a < D7: Fb, Ff; w*Ø > → < D7: Fb, Ff; w*w*u*l(Fb, Ff) >

Rule 7.2.b _ Dividing a room in two by adding a wall



Conditions:

7.2.b1 Dividing a bedroom

Dimensions:
If *mimimum_level* ∧ Fb∈{be.d} ⇒ Fb1≥10,5m² ∧ w, l1≥2,7m
If *recommended_level* ∧ Fb∈{be.d} ⇒ Fb1≥12m² ∧ w, l1≥2,7m
If *mimimum_level* ∧ Fb∈{be.t} ⇒ Fb1≥9m² ∧ w, l1≥2,1m
If *recommended_level* ∧ Fb∈{be.t} ⇒ Fb1≥14,5m² ∧ w, l1≥2,1m
If *mimimum_level* ∧ Fb∈{be.s} ⇒ Fb1≥7m² ∧ w, l1≥2,1m
If *recommended_level* ∧ Fb∈{be.s} ⇒ Fb1≥8,5m² ∧ w, l1≥2,1m
Ff≥1m² ∧ l2≥1m

Function:
Fb, Fb1∈{be.d, be.t, be.s}
Ff∈{nhs}
Fb≠Ff

7.2.b2 Dividing a private bathroom

Dimensions:
w, l1, l2≥1m
If *mimimum_level* ⇒ Fb≥5m² ∧ Fb1≥3,5m²
If *recommended_level* ⇒ Fb≥7,5m² ∧ Fb1≥5m²
Ff≥1m²

Functions:
Fb, Fb1∈{ba.p}
Ff∈{ba.p, ba.g, cl, nhs}

7.2.b3 Dividing social rooms

Dimensions:
Fb∈{li} ⇒ Fb1, lb≥*dimensions_of*Rule3.1a
Fb∈{di} ⇒ Fb1, lb≥*dimensions_of*Rule3.2a
Fb∈{li/di} ⇒ Fb1, lb≥*dimensions_of*Rule3.3a
Fb∈{ho} ⇒ Fb1, lb≥*dimension_of*Rule3.4a
Fb∈{mr} ⇒ Fb1, lb≥*dimensions_of*Rule3.5a
Ff≥1m² ∧ l2≥1m

Function:
Fb, Fb1∈{li, di, il/di, ho, mr}
Ff∈{nhs}
Fb≠Ff

7.2.b4 Dividing a kitchen

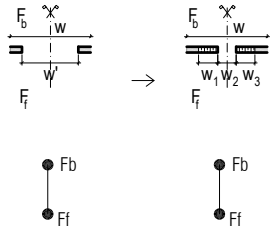
Dimensions:
w, l1, l2≥1m
If *mimimum_level* ⇒ Fb1≥6m² (±10%)
If *recommended_level* ∧ If *nhab=4* ⇒ Fb≥10,5m² (±10%)
If *recommended_level* ∧ If *nhab*≥5 ⇒ Fb≥11,5m²+0,5m²(n-5) (±10%)
Ff≥1m²

Functions:
Fb, Fb1∈{ki}
Ff∈{nhs}

Description (abbreviated):

Rule7.2b < D7: Fb; E > →
< D7: Fb1, Ff; E+ {Ff}; w * *wu*/(Fb1, Ff) >

Rule 7.2.c _ Reducing a door opening with light partition wall



Conditions:

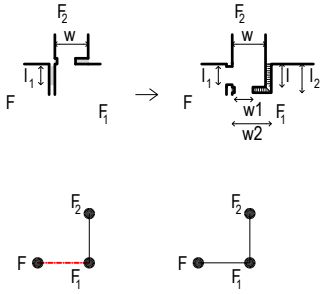
Dimensions:
w'>0.9m ∧ w≥1m
w2∈{0.8m, 1.0m, 1.2m, 1.6m}
w'=w1+w2+w3
w1,w3>0m

Function:
Fb≠Ff

Description (abbreviated):

R7.2c < D7: Fb, Ff; w'*Ø > → < D7: Fb, Ff; w1*w*ul*(Fb, Ff), w2*w*ul*(Fb, Ff) >

Rule 7.3.a _ Remove part of a room to assign to circulation area



Conditions:

Dimensions:
1m≤l<2m
0.9m≤w<2m
l1, w1∈{0.8m, 1.0m, 1.2m,1.6m}

Function:
If (passage_to(F))=0

Private areas

F, F1∈{be.d, be.t, be.s}
F2∈{nhs, co, co.p}

Social areas

F, F1 ∈ {li, di, li/di, ba.g, ho, mr}
F2∈ {nhs, co, co.s, hl}

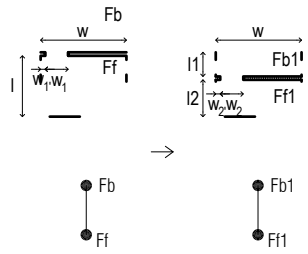
Kitchen

F1 ∈ {ki}
F, F2∈ {Z}

Description (abbreviated):

R7.3a < D7: F, F1, F2; l1*w*ub*(F, F1), w*w*ub*(F1, F2)> →
< D7: Fb ; l1*Ø; w*Ø, w2*w*ul*(F1, F2), l2*w*ul*(F1, F2) >

Rule 7.3.b _ Remove part of a room area to assign to circulation area



Conditions:

Ff: Bedroom or private bathroom

Dimensions:
w≤2m
0m≤w1, w1', w2'≤1.2m
w2∈{0.8m, 0.9m, 1m}
If minimum_level ∧ Ff∈{be.d} ⇒ l≥3,9m ∧ l2≥2,7m ∧ Ff1≥10,5m²
If recommended_level ∧ Ff∈{be.d} ⇒ l≥3,9m ∧ l2≥2,7m ∧ Ff1≥12m²
If minimum_level ∧ Ff∈{be.t} ⇒ l≥3,3m ∧ l2≥2,7m ∧ Ff1≥9m²
If recommended_level ∧ Ff∈{be.t} ⇒ l≥3,3m ∧ l2≥2,7m ∧ Ff1≥14,5m²
If minimum_level ∧ Ff∈{be.s} ⇒ l≥3,3m ∧ l2≥2,1m ∧ Ff1≥8m²
If recommended_level ∧ Ff∈{be.s} ⇒ l≥3,3m ∧ l2≥2,1m ∧ Ff1≥8,5m²
If minimum_level ∧ Ff∈{ba.p} ⇒ l≥2,2m ∧ l2≥1m ∧ Ff1≥3,5m²
If recommended_level ∧ Ff∈{ba.p} ⇒ l≥2,2m ∧ l2≥1m ∧ Ff1≥5m²
1m≤l1<2m

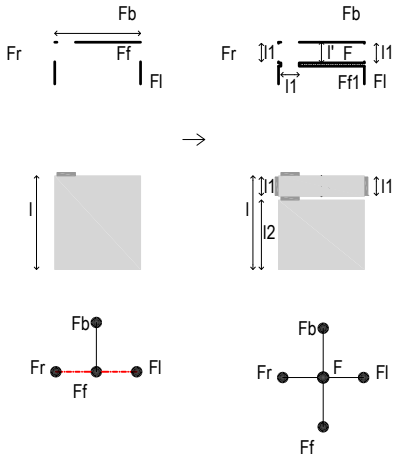
Function:
Ff, Ff1∈{be.d, be.t, be.s, ba.p} ∧ Ff=Ff1
Fb,Fb1∈{nhs, co.p, co, co.s} ∧ Fb=Fb1

Ff: Guest bathroom

Dimensions:
w≤2m
1m≤l1<2m
0m≤w1, w1', w2'≤1.2m
w2∈{0.8m, 0.9m, 1m}
If minimum_level ∧ Ff∈{ba.g} ⇒ l≥2,2m ∧ l2≥1m ∧ Ff1≥1m²
If recommended_level ∧ Ff∈{ba.g} ⇒ l≥2,2m ∧ l2≥1m ∧ Ff1≥2m²

Function:
Ff, Ff1∈{ba.g} ∧ Ff=Ff1
Fb,Fb1∈{Z} ∧ Fb=Fb1

Regra 7.3.c _ Remove part of the bedroom area to assign to circulation area



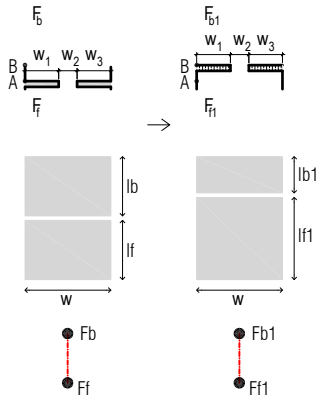
Conditions:

Dimensions:
l1∈{0.8m, 0.9m, 1m}
1m≤l'≤1.5m
If minimum_level ∧ Ff∈{be.s} ⇒ l2≥2,1m ∧ Ff1≥8m²
If recommended_level ∧ Ff∈{be.s} ⇒ l2≥2,1m ∧ Ff1≥8,5m²
If minimum_level ∧ Ff∈{be.t} ⇒ l2≥2,7m ∧ Ff1≥9m²
If recommended_level ∧ Ff∈{be.t} ⇒ l2≥2,7m ∧ Ff1≥14,5m²
If minimum_level ∧ Ff∈{be.d} ⇒ l2≥2,7m ∧ Ff1≥10,5m²
If recommended_level ∧ Ff∈{be.d} ⇒ l2≥2,7m ∧ Ff1≥12m²
F≥1m²

Function:
Ff, Fr, Fl∈{be.d, be.t, be.s, ba.p, cl}
Fb, F∈{nhs, co.p, co, co.s}

Description (abbreviated):
R7.3c < D1: Fb, Ff, Fl, Fr> → < D1: Fb, Ff1, Fl, Fr, F; w*wul(F, Ff1) >

Rule 7.4.a _ Changing a room's dimension (enlarging or reducing) by "moving" a wall (eliminating and adding a wall)



Conditions:

Dimensions:
1m≤w≤2m
0m≤w1, w2, w3≤2m
0,5m≤*dist* (A, B)≤1m

Description (abbreviated):

R7.4a < D7: Fb, Ff; A, w*w*ub*(Fb, Ff) > →
< D7: Fb1, Ff1; B, w*w*ul*(Fb1, Ff1) >

7.4.a1 Changing a bedroom dimension

Dimensions:
(Fb=be.d ⇒ Fb1≥10,5m² ∧ lb1≥2,7m) ∨ (Ff=be.d ⇒ Ff1≥10,5m² ∧ lf1≥2,7m)
(Fb=be.t ⇒ Fb1≥9m² ∧ lb1≥2,1m) ∨ (Ff=be.t ⇒ Ff1≥9m² ∧ lf1≥2,1m)
(Fb=be.s ⇒ Fb1≥8m² ∧ lb1≥2,1m) ∨ (Ff=be.s ⇒ Ff1≥9m² ∧ lf1≥2,1m)

Function:
Fb, Fb1∈{be.d, be.t, be.s} ∧ Ff, Ff1∈{be.d, be.t, be.s, cl, ba.p, nhs} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1
Ff, Ff1∈{be.d, be.t, be.s} ∧ Fb, Fb1∈{be.d, be.t, be.s, cl, ba.p, nhs} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

7.4.a2 Changing a bathroom dimension

Dimensions:
(Fb=ba.p ⇒ Fb1≥3,5m² ∧ lb1≥1m) ∨ (Ff=ba.p ⇒ Ff1≥3,5m² ∧ lf1≥1m)

Function:
Fb, Fb1∈{ba.p} ∧ Ff, Ff1∈{be.d, be.t, be.s, cl, ba.p, nhs, hs} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

7.4.a3 Changing a social room dimension

Dimensions:
(Fb=li ⇒ Fb1, lb1≥*dimensions_of*Rule3.1a ∧ lf1≥1m) ∨ (Ff=li ⇒ Ff1, lf1≥*dimensions_of*Rule3.1a ∧ lb1≥1m)
(Fb=di ⇒ Fb1, lb1≥*dimensions_of*Rule2.2a ∧ lf1≥1m) ∨ (Ff=li ⇒ Ff1, lf1≥*dimensions_of*Rule2.2a ∧ lb1≥1m)
(Fb=li/di ⇒ Fb1, lb1≥*dimensions_of*Rule2.3a ∧ lf1≥1m) ∨ (Ff=li ⇒ Ff1, lf1≥*dimensions_of*Rule2.3a ∧ lb1≥1m)
(Fb=ho ⇒ Fb1, lb1≥*dimension_of*Rule2.4a ∧ lf1≥1m) ∨ (Ff, lf1≥*dimensions_off*Rule2.4a ∧ lb1≥1m)
(Fb=mr ⇒ Fb1, lb1≥*dimensions_of*Rule2.5a ∧ lf1≥1m) ∨ (Ff=li ⇒ Ff1, lf1≥*dimensions_of*Rule2.5a ∧ lb1≥1m)

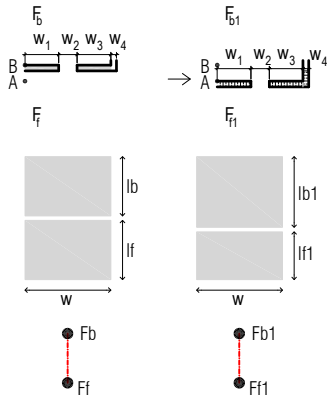
Function:
Fb, Fb1∈{li, di, li/di, ho, mr} ∧ Ff, Ff1∈{Z} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

7.4.a4 Changing a guest bathroom dimension

Dimensions:
(Fb=ba.g ⇒ Fb1≥1m² ∧ lb1≥1m) ∨ (Ff=ba.g ∧ lf≤1,2m ⇒ Ff1≥1m² ∧ 2m≥lf1≥1m)

Function:
Fb, Fb1∈{ba.g} ∧ Ff, Ff1∈{Z} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

Rule 7.4.b _ Changing a room's dimension (enlarging or reducing) by "moving" a wall (eliminating and adding a wall)



Conditions:

Dimensions:
1m≤w≤2m
w1, w2, w3≥0m
0.1m≤w4≤0.3m
0,5m≤*dist* (A, B)≤1m

7.4.b1 Changing a bathroom dimension

Dimensions:
(Fb=ba.p ⇒ Fb1≥3,5m² ∧ lb1≥1m) ∨ (Ff=ba.p ⇒ Ff1≥3,5m² ∧ lf1≥1m)

Function:
Fb, Fb1∈{ba.p} ∧ Ff, Ff1∈{be.d, be.t, be.s, cl, ba.p, nhs, hs} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

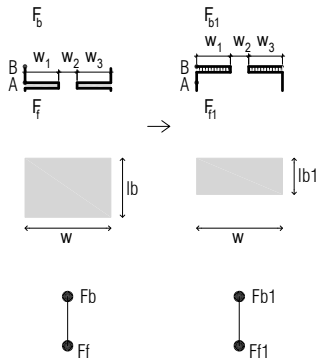
7.4.b2 Changing a guest bathroom dimension

Dimensions:
(Fb=ba.g ⇒ Fb1≥1m² ∧ lb1≥1m) ∨ (Ff=ba.g ∧ lf≤1,2m ⇒ Ff1≥1m² ∧ 2m≥lf1≥1m)

Function:
Fb, Fb1∈{ba.g} ∧ Ff, Ff1∈{Z} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

Description
R7.4b < D7: Fb, Ff; A, w*ub > → < D7: Fb1, Ff1; B, w*ul >

Rule 7.4.c _ Changing a room's dimension - reducing - by "moving" a wall (eliminating and adding a wall)



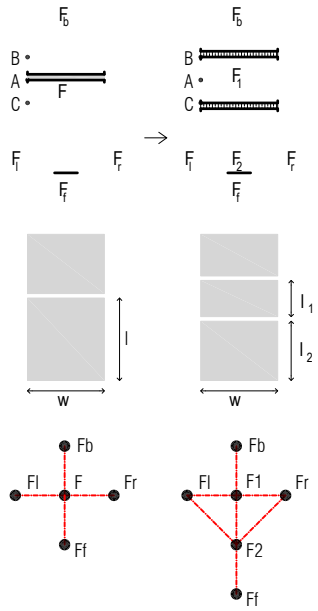
Conditions:

Dimensions:
0,9m≤w≤1,2m
0m≤w1, w2, w3≤1.2m
lb≥2m
lb1≥1m
0,5m≤*dist* (A, B)≤1m
Fb1≥1m²

Function:
Ff, Ff1∈{ba.g} ∧ Fb, Fb1∈{Z} ∧ Fb=Fb1 ∧ Ff=Ff1 ∧ Fb, Fb1≠Ff, Ff1

Description (abbreviated):
R7.4c < D7: Fb, Ff; B, w*w*ub*(Fb, Ff) > →
< D7: Fb1, Ff1; A, w*w*ul*(Fb1, Ff1) >

Rule 7.4.d_ Divide a room in two autonomous ones and enlarging one of them



Conditions:

Dimensions:
1m≤w≤2m
l1≥lm
F1≥1m²
0,5m≤*dist* (A, B)≤1m
0,5m≤*dist* (A, C)≤1m

Function:
Fl∨Fb∨Fr∈{co, co.s, co.p, nhs, hl}
Fl∨Ff∨Fr∈{ext}
F1∈{nhs}

7.4.c1 Dividing a bedroom in two autonomous ones and enlarging the bedroom

Dimensions:
If *mimimum_level* ∧ F∈{be.d} ⇒ F2≥10,5m² ∧ w, l2≥2,7m
If *recommended_level* ∧ F∈{be.d} ⇒ F2≥12m² ∧ w, l2≥2,7m
If *mimimum_level* ∧ F∈{be.t} ⇒ F2≥9m² ∧ w, l2≥2,1m
If *recommended_level* ∧ F∈{be.t} ⇒ F2≥14,5m² ∧ w, l2≥2,1m
If *mimimum_level* ∧ F∈{be.s} ⇒ F2≥7m² ∧ w, l2≥2,1m
If *recommended_level* ∧ F∈{be.s} ⇒ F2≥8,5m² ∧ w, l2≥2,1m

Function:
F, F2∈{be.d, be.t, be.s}
F=F2

7.4.c2 Dividing a social room in two autonomous ones and enlarging the bedroom

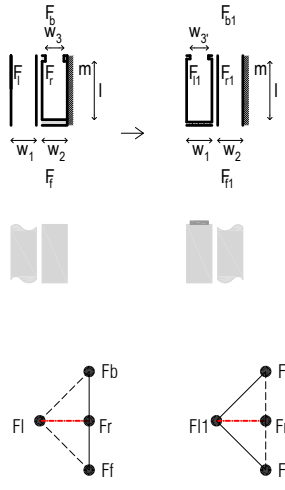
Dimensions:
F∈{li} ⇒ F2, l2≥*dimensions_of*Rule3.1a
F∈{di} ⇒ F2, l2≥*dimensions_of*Rule3.2a
F∈{li/di} ⇒ F2, l2≥*dimensions_of*Rule3.3a
F∈{ho} ⇒ F2, l2≥*dimension_of*Rule3.4a
F∈{mr} ⇒ F2, l2≥*dimensions_of*Rule3.5a

Function:
F, F2∈{li, di, li/di, ho, mr}
F=F2

Description (abbreviated):

R7.4d < D7: F, Ff, Fl, Fr; w*w*ub*(Fb, F) > →
< D7: F1, F2, Ff, Fl, Fr; w*w*ul*(Fb, F1), w*w*ul*(F1, F2) >

Rule 7.5.a _ Changing a room layout and assignment, next to middle wall (types c and d)



Conditions:

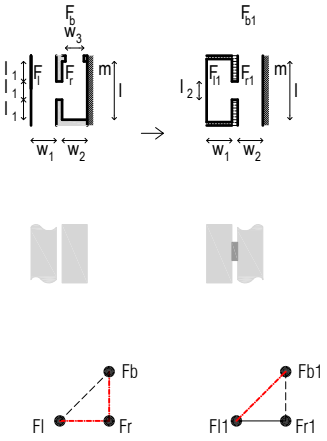
Dimensions:
1m≤w1, w2≤1.5m
1m≤l≤2m
0m≤w3≤0.9m
w3'=0.8m
Fl1≥1m²

Function:
Fl, Fr1, Fb, Fb1, Ff, Ff1∈{nhs, co, co.s, hl}
Fr, Fl1∈{ba.g, st}

Description (abbreviated):

R7.5a < D7: Fl, Fr; w2*w*ub*(Fb, Fr), w2*w*ub*(Fr, Ff) > →
< D7: Fb1, Ff1; w1*w*ul*(Fb1, Fl1), w1*w*ul*(Ff1, Fl1)>

Rule 7.5.b _ Changing room layout and assignment, next to middle wall (types c and d)



Conditions:

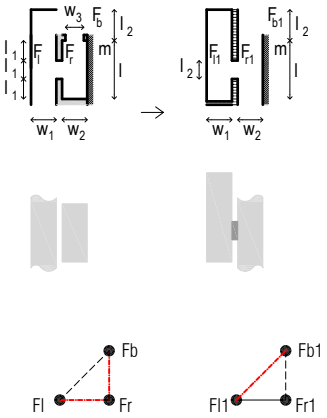
Dimensions:
1m≤w1, w2≤1.5m
1m≤l≤2m
0m≤w3≤0.9m
0m≤l1≤2m
l2=0.8m
Fl1≥1m²

Function:
Fl, Fr1∈{nhs, co, co.s}
Fb, Fb1∈{nhs, co.p, co, co.s}
Fr, Fl1∈{ba.g}

Description

R7.5b < D7: Fl, Fr; w1*∅, w2*ub > →
< D7: Fb1, Ff1; w1*ul, w2*∅>

Rule 7.5c _ Changing room layout and assignment, next to middle wall (types c and d)



Conditions:

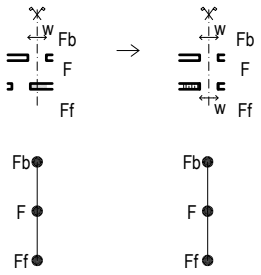
Dimensions:
1m≤w1, w2, l2≤1.5m
1m≤l≤2m
0m≤w3≤0.9m
0m≤l1≤2m
l2=0.8m
Fl1≥1m²

Function:
Fl, Fr1∈{nhs, co, co.s}
Fb, Fb1∈{nhs, co.p, co, co.s}
Fr, Fl1∈{ba.g}

Description

R7.5c < D7: Fl, Fr; w1*∅, w2*ub > →
< D7: Fb1, Ff1; w1*ul, w2*∅>

Rule 7.6.a _ Changing a door position (aligned with door in front)

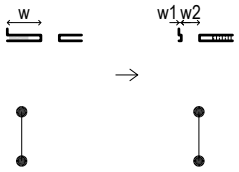


Conditions:

Dimensions:
w∈{0.8m, 0.9m, 1m, 1.2m}

Function:
F∈{nhs, co.p, co.s, co, hl}
Fb, Ff∈{Z}

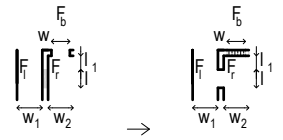
Rule 7.6.b _ Changing a door position (change door next to partition wall)

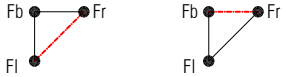


Conditions:

Dimensions:
w≤2.5m
w2∈{0.8m, 0.9m, 1m, 1.2m}
w1=0,1m

Rule 7.6.c _ Changing a door position (change door to a perpendicular wall)





Conditions:

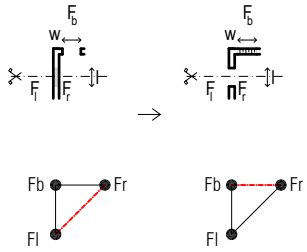
Dimensions:
w1, w2≥0,9m
l, w∈{0.8m, 0.9m, 1m}
l1≥0,7m
1m²≤Fr≤3m²

Function:
Fb∈{co, co.s, co.p} ∧ Fb (passage_to(x))=TRUE, x∈{be.d, be.t, be.s}
Fl∈{co} ∧ Fb (passage_to(x))=TRUE, ∀x: x∈{ki, li, di, li/di, ho, mr, hl}
Fr∈{ba.g}

Description (abbreviated):

R7.6.c < D7: Fl, Fr, Fb; l*w*u**b**(Fl, Fr) > →
< D7: Fl, Fr, Fb; w*w*u**l**(Fb, Fr), l*∅>

Rule 7.6.d _ Changing a door position (change door to a perpendicular wall)



Conditions:

Dimensions:

l, w∈ {0.8m, 0.9m, 1m}

$1m^2 \leq Fr \leq 3m^2$

Function:

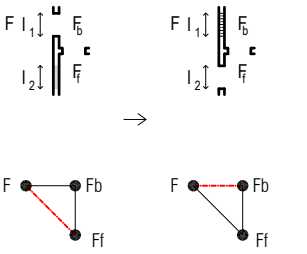
Fl, Fb, Fr∈{Z}

Fl (passage_to(x))=TRUE ∨ Fl (next_to(x))=TRUE, x∈{nhs, co, co.s, hl}

Description (abbreviated):

R7.6.d < D7: Fr, Fb; w*∅, l*w*ub*(Fl, Fr) > →
< D7: Fr, Fb; w*w*ul*(Fb, Fr), l*∅>

Rule 7.6.e _ Changing a door position (change door from co or co.s to co.p)



Conditions:

Dimensions:

l2∈ {0.8m, 0.9m, 1m}

Function:

F∈{be.d, be.t, be.s}

Fb∈{co, co.s, hl}

Ff∈{co.p}

Description (abbreviated):

R7.6.e < D7: Ff, Fr, F; l1*∅, l2*w*ub*(F, Ff) > →
< D7: Ff, Fr, F; l1*w*ul*(F, Fb), l2*∅>

Rule 7.7 _ Changing from step 7 to step 8

∅ → ∅

S7 → S8

Conditions:

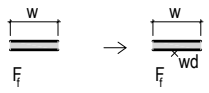
∀ {β6, β7, β8, β9, β10, β11}: {β6, β7, β8, β9, β10, β11} ⊂ E

Description (abbreviated):

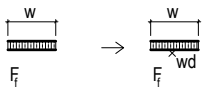
R7.7 < D7: S7 > → < D8: S8 >

Rule 8.1.a _ Allocating of water detectors (wd)

Rule 8.1.a1



Rule 8.1.a2



Conditions:

$X \supset \{wdn\} \wedge X' \not\supset \{wdn\}$

Position:
0,2m≤w≤0,5m
wd (mounted_on(z)) = TRUE $\wedge$ z∈{skirting_board}

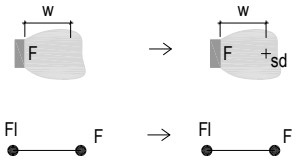
Function:
Ff∈{ba.p, ba.g, ki, la}

Description (abbreviated):

R8.1a1 < D8: Ff; w*ub*(Ff); Ø; X' > → < D8: Ff; w*ub*(Ff); wd; X' + {wd} >

R8.1a2 < D8: Ff; w*ul*(Ff); Ø; X' > → < D8: Ff; w*ul*(Ff); wd; X' + {wd} >

Rule 8.1.b _ Allocating of smoke detectors (sd)



Conditions:

$X \supset \{sdn\} \wedge X' \not\supset \{sdn\} \wedge \overline{sd1\ sd2} \geq 4m$

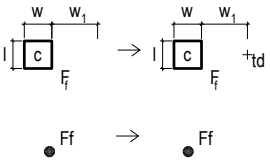
Position:
1m≤w≤1,5m
sd (mounted-on(z)) = TRUE $\wedge$ z∈{ceilling}

Function:
Fl∈{lh, sh}
F∈{hl, co, co.s, co.p}

Description (abbreviated):

R8.1b < D8: F; Ø; X' > → < D8: F; sd; X' + {sd} >

Rule 8.1.c _ Allocating of temperature detectors (td)



Conditions:

$X \supset \{tdn\} \wedge X' \not\supset \{tdn\} \wedge td1\ td2 \geq 4m$

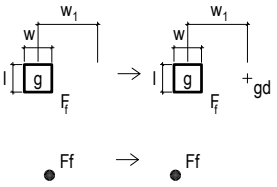
Position:
0,5m≤w, l≤0,7m
1m≤w1≤1,5m
td (mounted-on(z)) = TRUE $\wedge$ z∈{ceilling}

Function:
Ff∈{ki}

Description (abbreviated):

R8.1c < D8: Ff; Ø; X' > → < D8: Ff; td; X' + {td} >

Rule 8.1.d _ Allocating of gas detectors (gd)



Conditions:

$X \supset \{gdn\} \wedge X' \supset \{gdn\} \wedge \overline{gd1\ gd2} \geq 4m$

Position:
$0,2m \leq w \leq 0,7m$
$1m \leq w1 \leq 4m$
If natural_gas gd (mounted-on(z)) = TRUE $\wedge$ $z \in \{ceilling\}$
If propane_gas gd (mounted-on(z)) = TRUE $\wedge$ $z \in \{skirting\_board\}$

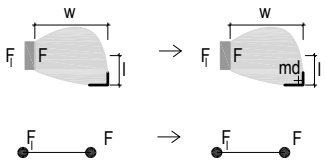
Function:
$Ff \in \{ki, la\}$

Description (abbreviated):

R8.1d < D8: Ff; Ø; X' > → < D8: Ff; gd; X' + {gd} >

Note:
For this rule the representation of the elevation or section of the division would be needed in order to specify the exact position of the sensors from the ceiling and from the floor.
Natural gas detector must be placed lower than 0.30m from the floor.
Propane gas detector must be placed higher than 0.30m from the ceiling.

Rule 8.1.e _ Allocating of movement detectors (md) (for the hall and corridors with doors to the exterior)



Conditions:

$X \supset \{mdn\} \wedge X' \supset \{mdn\}$

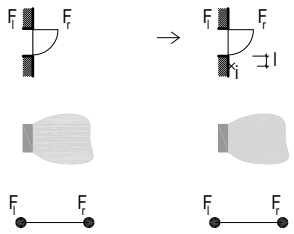
Position:
$1m \leq w \leq 3m$
$0.5m \leq l \leq 3m$
md (mounted-on(z)) = TRUE $\wedge$ $z \in \{moulding\_panels\}$

Function:
$F \in \{hl\}$
$Fl \in \{lh, sh\}$

Description (abbreviated):

R8.1e < D8: F, Fl; Ø; X' > → < D8: F, Fl; md; X' + {md} >

Rule 8.10.a1 _ Allocating of interfaces: control panel (i)



Conditions:

$X \supset \{in\} \wedge X' \not\supset \{in\}$

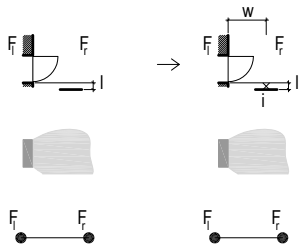
Position:
$0.2m \leq l \leq 0.8m$
i (mounted-on(z)) = TRUE $\wedge$ z∈{wall}

Function:
Fl∈{lh, sh}
Fr∈{hl, co, co.s}

Description (abbreviated):

R8.10a1 < D8: Fl, Fr; w*us*(Fl, Fr); Ø; X' > → < D8: Fl, Fr; w*us*(Fl, Fr); i; X' + {i} >

Rule 8.10.a2 _ Allocating of interfaces: control panel (i)



Conditions:

$X \supset \{in\} \wedge X' \not\supset \{in\}$

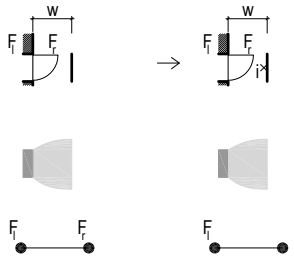
Position:
$l \leq 0.25m$
$0.9m \leq w \leq 1.5m$
i (mounted-on(z)) = TRUE $\wedge$ z∈{wall}

Function:
Fl∈{lh, sh}
Fr∈{hl. co, co.s}

Description (abbreviated):

R8.10a2 < D8: Fl, Fr; Ø; X' > → < D8: Fl, Fr; i; X' + {i} >

Rule 8.10.a3 _ Allocating of interfaces: control panel (i)



Conditions:

$X \supset \{in\} \wedge X' \not\supset \{in\}$

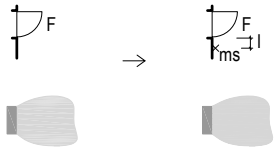
Position:
$1m \leq w \leq 2m$
i (mounted-on(z)) = TRUE $\wedge$ z∈{wall}

Function:
Fl∈{lh, sh}
Fr∈{hl, co, co.s}

Description (abbreviated):

R8.10a3 < D8: Fl, Fr; Ø; X' > → < D8: Fl, Fr; i; X' + {i} >

Rule 8.10.b1 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{ms_n\} \wedge X' \not\supset \{ms_n\}$

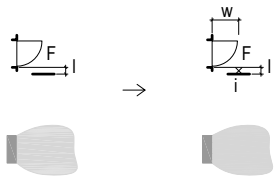
Position:
$0.1m \leq l \leq 0.5m$
ms (mounted-on(z)) = TRUE $\wedge$ $z \in \{wall\}$

Function:
$F \notin \{ba.p, ba.g, cl, st\}$

Description (abbreviated):

R8.10b1 < D8: F; Ø; X' > $\rightarrow$ < D8: F; ms; X' + {ms} >

Rule 8.10.b2 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{ms_n\} \wedge X' \not\supset \{ms_n\}$

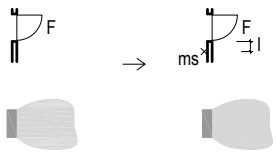
Position:
$l \leq 0.25m$
$0.25m \leq w \leq 1m$
ms (mounted-on(z)) = TRUE $\wedge$ $z \in \{wall\}$

Function:
$F \notin \{ba.p, ba.g, cl, st\}$

Description (abbreviated):

R8.10b2 < D8: F; Ø; X' > $\rightarrow$ < D8: F; ms; X' + {ms} >

Rule 8.10.b3 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{ms_n\} \wedge X' \not\supset \{ms_n\}$

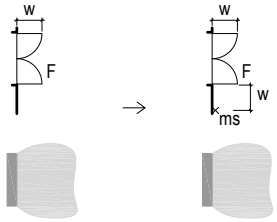
Position:
$0.1m \leq l \leq 0.5m$
ms (mounted-on(z)) = TRUE $\wedge$ $z \in \{wall\}$

Function:
$F \in \{ba.p, ba.g, cl, st\}$

Description (abbreviated):

R8.10b3 < D8: F; Ø; X' + {ms} > $\rightarrow$ < D8: F; ms; X' + {ms} >

Rule 8.10.b4 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{ms_n\} \wedge X' \not\supset \{ms_n\}$

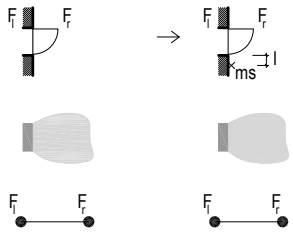
Position:
0.4m≤w≤1m
ms (mounted-on(z)) = TRUE ∧ z∈{wall}

Function:
F∉{ba.p, ba.g, cl, st}

Description (abbreviated):

R8.10b4 < D8: F; Ø; X' > → < D8: F; ms; X' +{ms} >

Rule 8.10.b5 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{ms_n\} \wedge X' \not\supset \{ms_n\}$

Position:
0.2m≤l≤0.8m
ms (mounted-on(z)) = TRUE ∧ z∈{wall}

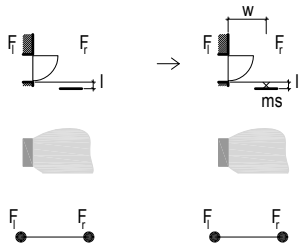
Function:
Fl∈{lh, sh}
Fr∈{hl, co, co.s}

Description (abbreviated):

R8.10b5 < D8: Fl, Fr; Ø; X' > → < D8: Fl, Fr; ms; X' +{ms} >

Note:
For this rule the representation of the elevation or section of the division would be needed in order to specify the exact position of the switch in order not to conflict with the control panel specified by Rule 8.10a1

Rule 8.10.b6 _ Allocating of interfaces: multifunctional switches (ms)



Conditions:

$X \supset \{in\} \wedge X' \not\supset \{in\}$

Position:
l≤0.25m
0.9m≤w≤1.5m
i (mounted-on(z)) = TRUE ∧ z∈{wall}

Function:
Fl∈{lh, sh}
Fr∈{hl, co, co.s}

Description (abbreviated):

R8.10b6 < D8: Fl, Fr; Ø; X' > → < D8: Fl, Fr; ms; X' +{ms} >

Note:
For this rule the representation of the elevation or section of the division would be needed in order to specify the exact position of the switch in order not to conflict with the control panel specified by Rule 8.10a1

APPENDIX 4

A dwelling transformation

This Appendix provides an example of the entire rehabilitation process, from identifying the family characteristics and the existing dwelling to the final design for the adapted dwelling (see Figure 5).

The chosen example shows how the rehabilitation process can be managed using the methodology proposed in this thesis when an architect is confronted with a family and their current dwelling to rehabilitate.

Throughout this 5th chapter tables will be used to show data, as a simulation of what would be used in a computer interface for a generative shape grammar software.

The INPUTs represent the data that users would have to introduce and the OUTPUTs represent the reply data that the system would give to the user.

This example contains a family profile that was used during the experiments described in *Part 2: Chapter 1.4,* and one of the dwellings that belongs to the corpus.

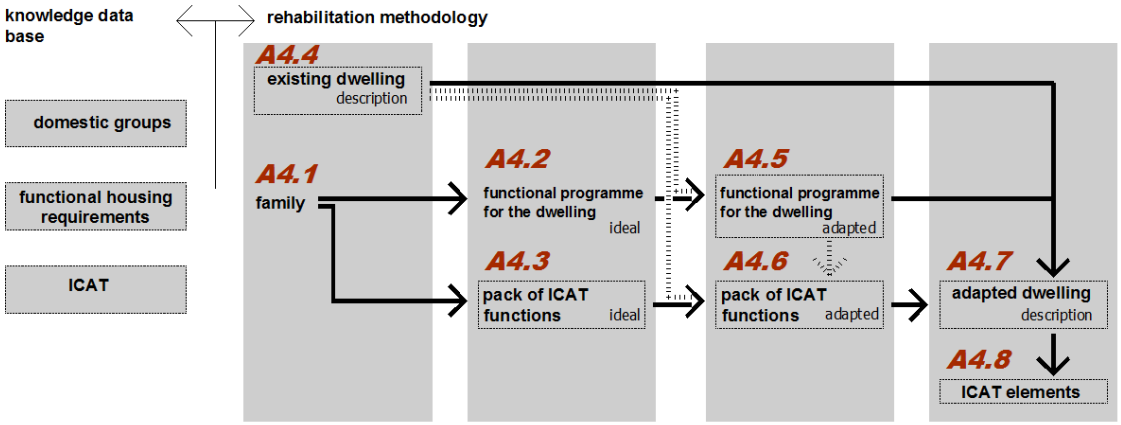
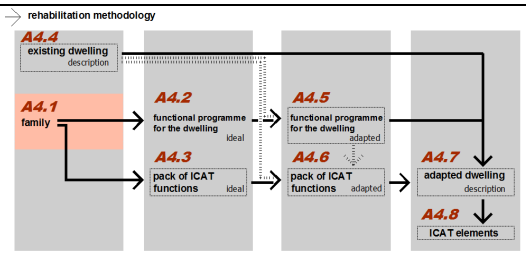


Figure 5 – Rehabilitation methodology – sequence/sub-chapters from which the example derivation is developed.

A4:1 DEFINITION OF THE FAMILY



This section introduces the data on the family characteristics for the purpose of understanding their requirements and proposing the ideal functional programme (see next section A4:2) and ideal ICAT pack (see A4:3). This data is shown in Table 9.

The number of residents and their kinship enables the family size to be understood and the possibilities for grouping different members of the family in bedrooms.

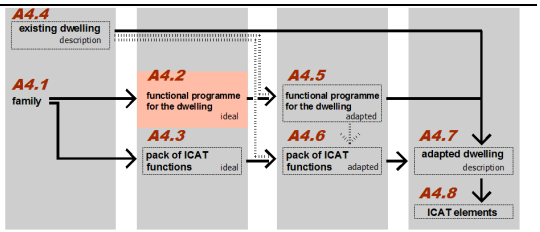
The "period of occupation" essentially refers to the situation regarding children of separated couples, who may stay in the mother's/father's home for short periods of time.

If a member of the family has restricted mobility or a disability, the functional and dimensional requirements for the dwelling will be more demanding, in order to facilitate mobility.

Input	**1**	Define family	
		Composition	
		(number of residents)	*4*
		(names/ages)	*José/40* *Maria/36* *Catarina/8* *Gonçalo/4*
		(kinship)	*José and Maria, couple* *Catarina and Gonçalo, siblings and children of the couple*
		Period of occupation	
			José / 100%, *Maria / 100%* *Catarina / 100%* *Gonçalo / 100%*
		Special needs	
		(restricted mobility)	No
		(disability)	No
		(visual impairment)	No
		(hearing impairment)	No

Table 9 – Definition of the family

A4:2 DEFINITION OF THE IDEAL FUNCTIONAL PROGRAMME



This section exemplifies how the ideal functional programme for the dwelling is structured.

This example is based on the ideal functional programme defined in *Part 2: Chapter 2.2* and the family characteristics are as described in the previous section (A4:1).

In this step the ideal functional programme is generated (using tables and flowcharts or automatically using computer software) as shown in the table below (Table 10). Firstly, the family chooses the desired quality level – minimum or recommended (Input 2). Secondly, the preliminary ideal programme is generated (Output 1). If the functional programme does not completely meet family needs, or if the family wishes to emphasise certain characteristics, the system allows additional spaces and topology to be introduced in order of priority, using Input 3 and Input 4 respectively.

By combining Output 1 with Input 3 and 4 the final ideal functional programme is obtained – Output 2 – which will be used in the following steps of the rehabilitation process.

Input	**2**	Define desired quality level	*Recommended*
Output	**1**	Preliminary ideal functional programme	
			Spaces

(typology)	*T3*
(space/connection / area)	*Double bedroom / **isolated** / 12m²*
	*2 single bedrooms / **isolated** / 8.5x2m²*
	*Kitchen / **isolated** / 10.5m²*
	*Laundry / **demarcated** / 3.5m²*
	*Living room / **demarcated** / 16m²*
	*Dining room / **demarcated** / 9.5m²*
	*Media room / **included** / 3m²*
	*Private bathroom. first / **isolated** / 5m²*
	*Private bathroom. second / **isolated** / 2m²*
	*Guest bathroom / **isolated** / 1m²*
	*Home office / **included** / 3m²*
	*Storage areas / **demarcated** / 4.5m²*
	Hall + circulation area
Priority topology	
	Bedrooms1,2,3 DOOR TO private corridor
	Bedroom1 NEXT/CLOSE TO Bedroom2
	Bedroom1 NEXT/CLOSE TO Bedroom3
	Bedroom2 NEXT/CLOSE TO Bedroom3
	Bedrooms FAR FROM Hall
	Bedrooms have large DEPTH
	Living/dining room PASSAGE TO circulation area
	Living room PASSAGE TO Dining room
	Living room NEXT TO Hall
	Living room CLOSE TO Guest bathroom
	Living/dining room DISTRIBUTEDNESS "c" or "d"
	Dining room CLOSE TO Hall
	Dining room CLOSE TO Guest bathroom
	Dining room PASSAGE/NEXT TO Kitchen
	Home office INCLUDED IN Living or Dining room
	Media room INCLUDED IN Living or Dining room
	Kitchen PASSAGE TO Circulation area
	Kitchen CLOSE TO Hall
	Kitchen PASSAGE/NEXT TO Dining room
	Kitchen CLOSE TO Guest bathroom
	Laundry PASSAGE TO Kitchen
	Private bathroom1 PASSAGE TO circulation area, bedroom
	Private bathroom2 PASSAGE TO circulation area , bedroom
	Guest bathroom PASSAGE TO circulation area

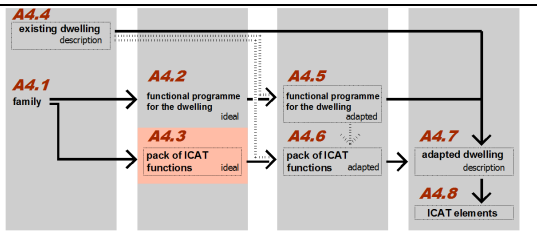
Input 3	Define additional spaces
	1. Dining room / isolated (≥12m²)
	2. Home office / isolated
	3. Two complete private bathrooms (one may be smaller)

Input	**4**	Define additional or priority topology		
			1. Single bedrooms NEXT TO double bedroom	
			2. Private bathroom INSIDE private area	
			3. Dining room NEXT TO kitchen	
			4. Living room NEXT TO hall	
Output	**2**	Final ideal functional program		
			Floor area needed	*105m² (recommended) (95m², minimum)*
			Nº of habitable spaces	*7*
			Spaces	
			(typology)	*T3*
			(space / connection / area)	*(hs) Double bedroom / **isolated** / 12m²*
				*(hs) 2 single bedrooms / **isolated** / 8.5x2m²*
				*(hs) Kitchen / **isolated** / 10.5m²*
				*Laundry / **demarcated** / 3.5m²*
				*(hs) Living room + media room / **demarcated** / 19m²*
				*(hs) Dining room / **isolated** / 12m²*
				*Private Bathroom / **isolated** / 5m²*
				*Private Bathroom / **isolated** / 5m²*
				*Guest bathroom / **isolated** / 1m²*
				*(hs) Home office / **isolated** / 7m²*
				*Storage areas / **demarcated** / 4.5m²*
				Circulations / demarcated / ±16m²
			Priority topology	
				Bedrooms1,2,3 PASSAGE TO private corridor
				1. Bedroom1 NEXT TO Bedroom2
				1. Bedroom1 NEXT TO Bedroom3
				1. Bedroom2 NEXT TO Bedroom3
				Bedrooms FAR FROM Hall
				Bedrooms have large DEPTH
				Living/dining room PASSAGE TO circulation area
				Living room PASSAGE TO Dining room
				4. Living room NEXT TO Hall
				Living room CLOSE TO Guest bathroom
				Living/dining room DISTRIBUTEDNESS "c" or "d"
				Dining room CLOSE TO Hall
				Dining room CLOSE TO Guest bathroom
				3. Dining room NEXT TO Kitchen
				Home office INCLUDED IN Living or Dining room
				Media room INCLUDED IN Living or Dining room
				Kitchen PASSAGE TO Circulation area
				Kitchen CLOSE TO Hall
				3. Kitchen NEXT TO Dining room

	Kitchen CLOSE TO Guest bathroom
	Laundry PASSAGE TO Kitchen
	2. Private bathroom1 PASSAGE TO private corridor, bedroom
	2. Private bathroom2 PASSAGE TO private corridor
	Guest bathroom PASSAGE TO circulation area

Table 10 – Sequence of steps to define the ideal functional programme

A4:3 DEFINITION OF THE IDEAL ICAT PACK

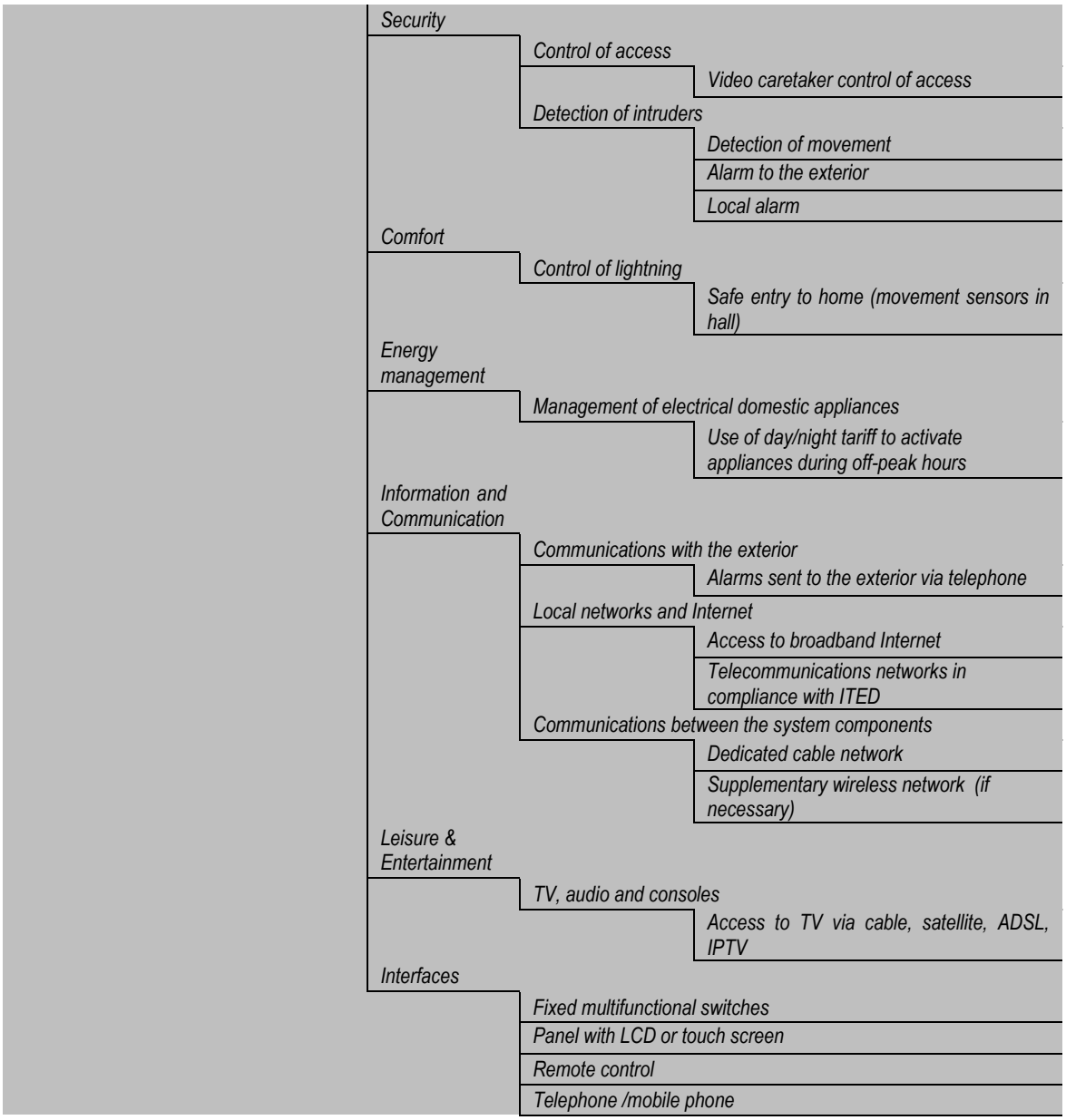


In this step the ideal ICAT pack is generated (using tables and flowcharts or automatically using computer software) as shown in the table below (Table 11) according to the family profile defined in section A4:1.

As with the ideal functional programme, the family first chooses the desired level of ICAT integration – basic, medium or optimum (Input 5). Secondly, the preliminary ideal ICAT pack is generated (Output 3). If the ICAT pack does not completely meet family needs, or if the family wishes to emphasise certain characteristics, the system allows additional technology requirements to be introduced in order of priority, using Input 6.

By combining Output 3 with Input 6 the final ideal ICAT pack is obtained – Output 4 – which will be used in the following steps of the rehabilitation process.

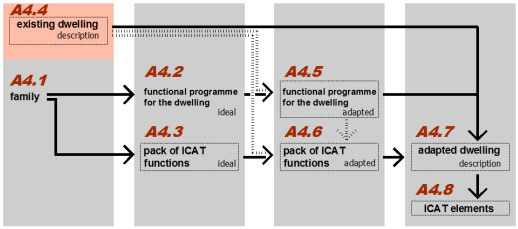
Input	**5**	Define desired quality level	*Basic*		
Output	**3**	Preliminary ideal ICAT pack	*Safety*	*Detection of fire*	*Detection of smoke*
					Detection of temperature
					Electrically operated valve to switch off power and gas
					Local alarm
					Remote alarm
				Detection of gas leaks	*Detection of gas*
					Electrically operated valve to switch off power and gas
					Local alarm
					Remote alarm
				Detection of flooding	*Detection of water leak*
					Electrically operated valve to switch off water
					Local alarm
					Remote alarm


Security
Control of access
Video caretaker control of access
Detection of intruders
Detection of movement
Alarm to the exterior
Local alarm
Comfort
Control of lightning
Safe entry to home (movement sensors in hall)
Energy management
Management of electrical domestic appliances
Use of day/night tariff to activate appliances during off-peak hours
Information and Communication
Communications with the exterior
Alarms sent to the exterior via telephone
Local networks and Internet
Access to broadband Internet
Telecommunications networks in compliance with ITED
Communications between the system components
Dedicated cable network
Supplementary wireless network (if necessary)
Leisure & Entertainment
TV, audio and consoles
Access to TV via cable, satellite, ADSL, IPTV
Interfaces
Fixed multifunctional switches
Panel with LCD or touch screen
Remote control
Telephone /mobile phone
Input 6
Define additional ICAT
Comfort
Control of motors (blinds and curtains)
Automated blinds in all divisions
General open/close control on main panel
Individual open/close control in each division
Remote control
Output 4
Final ideal ICAT pack
Safety
Detection of fire
Detection of smoke
Detection of temperature
Electrically operated valve to switch off power and gas
Local alarm

			Remote alarm
		Detection of gas leaks	
			Detection of gas
			Electrically operated valve to switch off power and gas
			Local alarm
			Remote alarm
		Detection of flooding	
			Detection of water leak
			Electrically operated valve to switch off water
			Local alarm
			Remote alarm
	Security		
		Control of access	
			Video caretaker control of access
		Detection of intruders	
			Detection of movement
			Alarm to the exterior
			Local alarm
	Comfort		
		Control of motors (blinds and curtains)	
			Automated blinds in all divisions
			General open/close control on main panel
			Individual open/close control in each division
			Remote control
	Energy management		
		Management of electrical domestic appliances	
			Use of day/night tariff to activate appliances during off-peak hours
	Information and Communication		
		Communications with the exterior	
			Alarms sent to the exterior via telephone
		Local networks and Internet	
			Access to broadband Internet
			Telecommunications networks in compliance with ITED
		Communications between the system components	
			Dedicated cable network
			Supplementary wireless network (if necessary)
	Leisure & Entertainment		
		TV, audio and consoles	
			Access to TV via cable, satellite, ADSL, IPTV
	Interfaces		
		Fixed multifunctional switches	
		Panel with LCD or touch screen	
		Remote control	
		Telephone /mobile phone	

Table 11 – Sequence of steps to define the ideal ICAT pack

A4:4 DESCRIPTION OF THE EXISTING DWELLING



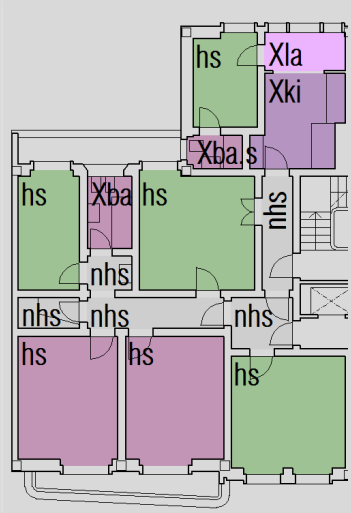
In order to define the adapted housing programme and the adapted ICAT pack in addition to the ideal functional programme (Output 2) and the ideal ICAT pack (Output 4), an existing dwelling is required.

In this step, the description of the existing dwelling is provided - Input 7 – describing the dwelling net floor area, dwelling type, number of habitable spaces, a description of each space (habitable/non habitable, isolated/demarcated/included, net floor area), and the topology (using a graph) (Table 12).

Since this description will also be used in the definition of the ideal ICAT pack, other characteristics are needed, namely the floor on which the dwelling is situated and a definition of the interior spaces that may be accessed from other buildings.

Input 7 Existing dwelling

Net floor area	*100m²*
Type	*A*
Number of habitable spaces	*7*
Building floor	*2ª*
Exterior spaces that can be accessed from other buildings	*YES; rear balcony*
Spaces	
	*(hs) Habitable space / **isolated** / 13.3m²*
	*(hs) Habitable space / **isolated** / 13.1m²*
	*(Xki) Existing Kitchen / **isolated** / 8.1m²*
	*(hs) Habitable space / **isolated** / 14.1m²*
	*(hs) Habitable space / **isolated** / 14.1m²*
	*(hs) Habitable space / **isolated** / 7.6m²*
	*(hs) Habitable space / **isolated** / 6.33m²*
	(Xla) Existing Laundry / demarcated / 3.2m²
	*(Xba) Existing Bathroom / **isolated** / 3.4m²*
	*(Xba.se) Existing service Bathroom / **isolated** / 1.9m²*
	*(nhs) Non habitable space/**demarcated**/ 1.6m²*
	*(nhs) Non habitable space / **isolated** / 2m²*
	*(nhs) Non habitable space / **isolated** / 3.3m²*
	*(nhs) Non habitable space / **isolated** / 4.5m²*
	*(nhs) Non habitable space / **isolated** / 3.7m²*



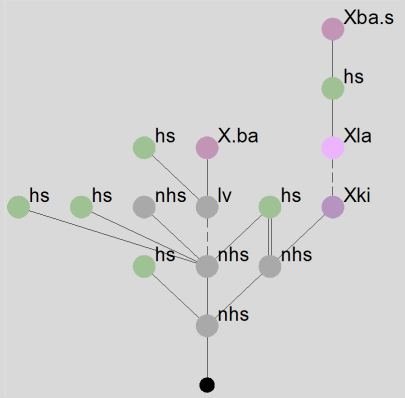
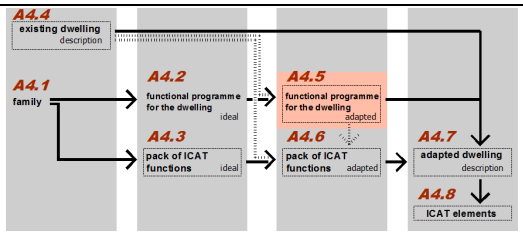
Topology	
	

Table 12 – Sequence of steps to describe the existing dwelling

A4:5 DEFINITION OF THE ADAPTED FUNCTIONAL PROGRAMME



After defining the existing dwelling, the family is asked about the scale of building work they intend to carry out, so that a rehabilitation strategy can be chosen. This choice is the consequence of a series of decisions the family has to make, which are addressed in *Part 2: Chapter 2.3* and introduced in Input 8.

The adapted functional programme (Output 6) combines the ideal functional programme (Output 2) with the existing dwelling (Input 7) in order to create an adapted functional programme (Table 13).

The method used is:

- Comparison of the number of habitable spaces in both the functional programme and the existing dwelling,
- Comparison of the net floor area needed for each room in the functional programme and the existing net floor area.

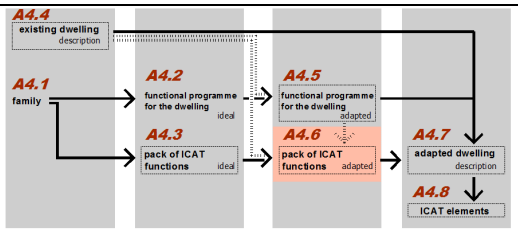
As previously stated, this step will allow for an intermediate evaluation of the capacity of the existing dwelling to fulfil the functional programme required by the family.

Input	**8**	Choosing the dwelling and rehabilitation strategy		
		Does the dwelling correspond to the functional programme?		
			Area needed (94/105m²)	*→ Yes (100m²)*
			Type (A or D)	*→ Yes (A)*
		Rehabilitation of the whole building?	*→ No*	

Output	**5**	*Strategy*	*2*
Output	**6**	Adapted functional programme	
		Spaces	
			T3, 7 habitable spaces
			(hs) Double bedroom / isolated / 12m²
			(hs) Single bedrooms / isolated / 8.5m²
			(hs) Single bedrooms / isolated / 8.5m²
			*(hs) Kitchen / isolated / **<**10.5m²*
			*(hs) Living room + media room / demarcated **or isolated** / **<**19m²*
			*(hs) Dining room / demarcated **or isolated** / 12m²*
			(hs) Home office / isolated / 7m²
			Laundry / demarcated/ 3.5m²
			Private bathroom / isolated / 5m²
			Private bathroom / isolated / 3.5m²
			Guest bathroom / isolated / 1m²
			*Storage areas / demarcated / **<**4.5m²*
			Circulation area / demarcated/ ±16m²
		Priority topology	
			1. Bedroom1 CLOSE TO Bedroom2
			1. Bedroom1 CLOSE TO Bedroom3
			1. Bedroom2 CLOSE TO Bedroom3
			2. Private bathroom1 PASSAGE TO private circulation area, bedroom
			2. Private bathroom2 PASSAGE TO private circulation area, bedroom
			3. Dining room CLOSE/DOOR TO Kitchen
			4. Living room NEXT TO Hall
			Bedrooms1,2,3 PASSAGE TO private corridor
			Bedrooms FAR FROM Hall
			Bedrooms with great DEPTH
			Living/dining room PASSAGE TO circulation area
			Living room PASSAGE TO Dining room
			Living room CLOSE TO Guest bathroom
			Living/dining room DISTRIBUTEDNESS "c" or "d"
			Dining room CLOSE TO Hall
			Dining room CLOSE TO Guest bathroom
			Home office INCLUDED IN Living or Dining room
			Media room INCLUDED IN Living or dining room
			Kitchen PASSAGE TO Circulation area
			Kitchen CLOSE TO Hall
			Kitchen PASSAGE/CLOSE TO Dining room
			Kitchen CLOSE TO Guest bathroom
			Laundry PASSAGE TO Kitchen
			Guest bathroom PASSAGE TO circulation area

Table 13 – Sequence of steps to define the adapted functional programme

A4:6 DEFINITION OF THE ADAPTED ICAT PACK



The adapted ICAT pack (Output 7) combines the ideal ICAT pack (Output 4) with the existing dwelling (Input 7) and the adapted functional programme (Output 6). The method used is:

- Comparison of the ICAT functions prescribed in the ideal ICAT pack and the definition of ICAT functions, by division (*Part 2: Chapter 3.2*);
- Comparison of the ICAT functions prescribed in the ideal ICAT pack and the final divisions prescribed by the adapted functional programme (Output 6).

This step will enable the definition of the ICAT set to be integrated into each division in the adapted functional programme for the dwelling. The sequence of steps needed to define the adapted ICAT pack is shown in the table below (Table 14).

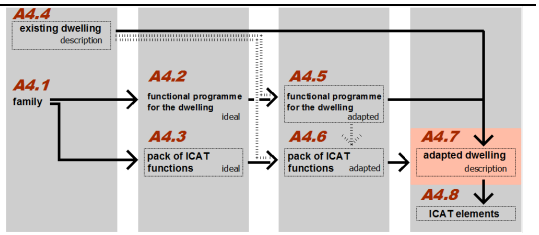
Output 7	Adapted ICAT pack		
		Double bedroom	
			Security: IF window_to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
			Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
			IC: Local networks and Internet - Ethernet and broadband Internet sockets
			IC: Communications - wired infrastructure between the domotic appliances
			Leisure & Entertainment: TV via cable, satellite, ADSL or IPTV
			Interfaces: Wall mounted multifunction interfaces
		2 Single bedrooms	
			Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
			Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
			IC: Local networks and Internet - Ethernet and broadband Internet sockets
			IC: Communications - wired infrastructure between the domotic appliances
			Leisure & Entertainment: TV via cable, satellite, ADSL or IPTV
			Interfaces: Wall mounted multifunction interfaces
		Kitchen	
			Safety: Detection of fire - temperature detector, alarms (local and remote alarm)
			Safety: Detection of gas leaks - gas detector, alarms (local and remote alarm)
			Safety: Detection of flooding - water detector, alarms (local and remote alarm)

		Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
		Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
		Energy management: electrical domestic appliances
		IC: Local networks and Internet - Ethernet and broadband Internet sockets
		IC: Communications - wired infrastructure between the domotic appliances
		Interfaces: Wall mounted multifunction interfaces
	Living room + media room	
		Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
		Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
		IC: Local networks and Internet - Ethernet and broadband Internet sockets
		IC: Communications - wired infrastructure between the domotic appliances
		Leisure & Entertainment: TV via cable, satellite, ADSL or IPTV
		Interfaces: Wall mounted multifunction interfaces, remote control
	Dining room	
		Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
		Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
		IC: Local networks and Internet - Ethernet and broadband Internet sockets
		IC: Communications - wired infrastructure between the domotic appliances
		Interfaces: Wall mounted multifunction interfaces, remote control
	Home office	
		Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
		Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
		IC: Local networks and Internet - Ethernet and broadband Internet sockets
		IC: Communications - wired infrastructure between the domotic appliances
		Leisure & Entertainment: TV via cable, satellite, ADSL or IPTV
		Interfaces: Wall mounted multifunction interfaces, remote control
	Laundry	
		Safety: Detection of gas leaks: gas detector, alarms (local and remote alarm)

			Safety: Detection of flooding: water detector, alarms (local and remote alarm)
			IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
			Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
			Energy management: electrical domestic appliances
			IC: Local networks and Internet - Ethernet and broadband Internet sockets, wired infrastructure
			Interfaces: Wall mounted multifunction interfaces
		Private bathroom	
			Safety: Detection of flooding - water detector, alarms (local and remote alarm)
			Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
			Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
			IC: Communications - wired infrastructure between the domotic appliances
			Interfaces: Wall mounted multifunction interfaces
		Guest bathroom	
			Safety: Detection of flooding - water detector, alarms (local and remote alarm)
			Security: IF window to rear balcony → Detection of intruders: movement detector, alarms (local and remote)
			Comfort: Control of motors (blinds and curtains) – motor, wall mounted switch and remote control, central control
			IC: Communications - wired infrastructure between the domotic appliances
			Interfaces: Wall mounted multifunction interfaces
		Storage areas	
		Circulation area	
			Hall
			Safety: Detection of fire - smoke detector, alarms (local and remote alarm)
			Security: Detection of intruders - movement detector, alarms (local and remote)
			Security: Control of access - entry phone
			Comfort: Lightning controlled by movement sensor (safe entry)
			IC: Communications - wired infrastructure between the domotic appliances; communication to the exterior (e.g. alarms)
			IC: Local networks and Internet - Ethernet and broadband Internet sockets, wired infrastructure
			Interfaces: Wall mounted multifunction interfaces, touch panel, remote control
			Corridors
			IC: Communications - wired infrastructure between the domotic appliances;
			IC: Local networks and Internet - wired infrastructure
			Interfaces: Wall mounted multifunction interfaces

Table 14 – Sequence of steps to define the adapted ICAT pack

A4:7 DEFINITION OF THE ADAPTED DWELLING: APPLICATION OF THE TRANSFORMATION GRAMMAR



After defining both the functional programme and the ICAT pack, all the data needed to start the dwelling transformation is available. Using the data previously defined, one example is given of a possible transformation for the dwelling that fulfils the family requirements to a large extend.

The derivation example shows all the rules applied step by step in order to formulate a viable design for the given family and dwelling.

The schemes presented at the end of this Appendix are, in order of appearance:

- The original dwelling (floor plan and graph) and an evaluation of its space syntax;
- The derivation of the functional transformation of the dwelling, step by step, stating the rule applied in each step;
- The adapted dwelling (floor plan and graph) and an evaluation of its space syntax;
- An evaluation chart that details both fulfilment of family requirements and fulfilment of a set of general housing characteristics expressed in *Part 2: Chapter 2.1*. This evaluation chart was also used for each of the transformation results obtained from the experiments described in *Part 2: Chapter 1.4* and illustrated in *Appendix 2*. A comparison between the transformation hypothesis proposed in this appendix and the ones proposed during the experiments is shown in *Appendix 2*.
- The start of the derivation of ICAT integration for the dwelling, step by step, stating the rule applied in each step. Since not all the rules for the integration of ICAT were designed in the transformation grammar, this derivation shows only a small part of the potential for ICAT integration using shape grammar.

A4:7a Description of the derivation

As stated in *Part 2: Chapter 4.3* the description starts with a description of the initial shape – the original dwelling – and evolves as the transformation occurs, step by step. The description variables are therefore updated each time a rule is applied.

Since this task is very time consuming to perform manually it was only carried out for the first steps following the creation of a parallel representation and in the 12th step to illustrate the application of a rule that eliminates an existing wall and adds a new one.

This indicates that the description of the initial shape will be as complex as the description of the final design, since all the properties of the dwelling are already present in the design from the time the derivation begins.

To perform the description the labels indicated in *Part 2: Chapter 4.2.2* were used and a number was added to each repeated label to differentiate between different spaces with the same label (e.g. *hs1* and *hs2* instead of *hs* and *hs*) (see Figure 6).

The following tables show the description during the transformation process that occurred after the steps shown in the previous section. In each table the **bold** variables indicate what has been changed in relation to the previous table. In Table 18 the underlined variables indicate what has been changed following the application of the rule that changes the room shape.

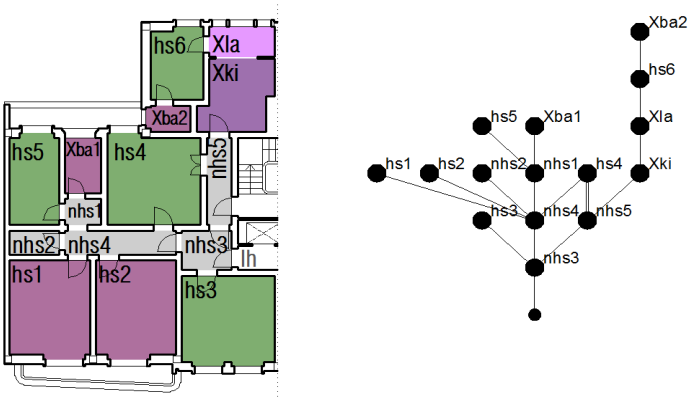


Figure 6 - Dwelling floor plan and justified graph with labels.

STEP #4 _ INSERTION OF LABELS

$\alpha 1 \leftarrow$	< A >
$\alpha 2 \leftarrow$	< [(hs_1,isolated) (hs_2,isolated) (hs_3,isolated) (hs_4,isolated) (hs_5,isolated) (hs_6,isolated) (nhs_1,demarcated) (nhs_2,isolated) (nhs_3,isolated) (nhs_4,isolated) (nhs_5,isolated) (Xki,isolated) (Xla,demarcated) (Xba_1,isolated) (Xba_2,isolated)] >
$\alpha 3 \leftarrow$	< 100 >
$\alpha 4 \leftarrow$	< [(hs1, 13.3) (hs2, 13.1) (hs3, 14.1) (hs4, 14.1) (hs5, 7.6) (hs6, 6.3) (nhs1, 1.6) (nhs2, 2) (nhs3, 3.3) (nhs4, 4.45) (nhs5, 3.7) (Xki, 8.1) (Xla, 3.2) (Xba1, 3.4) (Xba2, 1.9)] >
$\alpha 5 \leftarrow$	< [(hs1,4,3.25) (hs2,4,3.2) (hs3,3.65,3.72) (hs4,3.7,3.75) (hs5, 3.7,2) (hs6, 2.9,2.1) (nhs1,1.1,1.45) (nhs2,1,2) (nhs3,1.65,2) (nhs4,1,4.45) (nhs5,3.7,1) (Xki,3.1,2.62) (Xla,1.25,2.62) (Xba,2.35,1.45) (Xba,1.1,1.3)] >
$\alpha 6 \leftarrow$	< [(hs1, nhs4, passage_to) (hs2, nhs4, passage_to) (hs3, nhs3, passage_to) (hs4, nhs4, passage_to) (hs4, nhs5, passage_to) (hs5, nhs1, passage_to) (hs6, Xla, passage_to) (hs6, Xba2, passage_to) (nhs1, Xba1, passage_to) (nhs1, nhs4, passage_to) (nhs2, nhs4, passage_to) (nhs3, nhs4, passage_to) (nhs3, nhs5, passage_to) (nhs5, Xki, passage_to) (Xki, Xla, passage_to)] [(hs1, nhs3, next_to) (hs1, nhs1, next_to) (hs1, hs4, next_to) (hs2, nhs3, next_to) (hs2, nhs1, next_to) (hs2, hs4, next_to) (nhs2, nhs3, next_to) (nhs2, nhs1, next_to) (nhs2, hs4, next_to) (hs3, nhs5, next_to) (hs4, Xki, next_to) (hs4, nhs3, next_to) (hs4, nhs2, next_to) (hs5, Xba1, next_to) (hs5, nhs4, next_to) (hs6, Xki, next_to) (nhs1, nhs3, next_to) (nhs1, nhs2, next_to) (nhs3, Xki, next_to) (nhs3, nhs2, next_to) (nhs4, Xba1, next_to) (nhs4, nhs5, next_to) (nhs5, Xla, next_to) (Xla, Xba2, next_to)] [(hs1, hs3, close_to) (hs1, hs5, close_to) (hs1, Xba1, close_to) (hs1, nhs5, close_to) (hs2, hs3, close_to) (hs2, hs5, close_to) (hs2, Xba1, close_to) (hs2, nhs5, close_to) (hs3, nhs2, close_to) (hs3, nhs1, close_to) (hs3, hs4, close_to) (hs3, Xki, close_to) (hs4, nhs2, close_to) (hs4, nhs1, close_to) (hs4, Xla, close_to) (hs5, nhs2, close_to) (hs5, nhs3, close_to) (nhs1, nhs5, close_to) (nhs2, Xba1, close_to) (nhs2, nhs5, close_to) (nhs3, Xba1, close_to) (nhs3, Xla, close_to) (nhs4, Xki, close_to) (nhs5, hs6, close_to) (Xki, Xba2, close_to)] [(hs1, Xki, far_from) (hs1, Xla, far_from) (hs1, hs6, far_from) (hs1, Xba2, far_from) (hs2, Xki, far_from) (hs2, Xla, far_from) (hs2, hs6, far_from) (hs2, Xba2, far_from) (nhs1, Xki, far_from) (nhs1, Xla, far_from) (nhs1, hs6, far_from) (nhs1, Xba2, far_from) (nhs2, Xki, far_from) (nhs2, Xla, far_from) (nhs2, hs6, far_from) (nhs2, Xba2, far_from) (hs4, hs6, far_from) (hs4, Xba2, far_from) (hs3, Xla, far_from) (hs3, hs6, far_from) (hs3, Xba2, far_from) (hs5, nhs5, far_from) (hs5, Xki, far_from) (hs5, Xla, far_from) (hs5, hs6, far_from) (hs5, Xba2, far_from) (hs6, Xba1, far_from) (hs6, nhs4, far_from) (hs6, nhs3, far_from) (nhs3, Xba2, far_from) (nhs4, Xla, far_from) (nhs4, Xba2, far_from) (nhs5, Xba1, far_from) (nhs5, Xba2, far_from) (Xba1, Xba2, far_from) (Xba1, Xla, far_from) (Xba1, Xki, far_from)] >

$\alpha 7 \leftarrow$	< [(hs1, hs2, adjacent) (hs1, nhs2, adjacent) (hs1, nhs4, adjacent) (hs2, nhs4, adjacent) (hs2, hs3, adjacent) (hs3, nhs3, adjacent) (hs4, Xba1, adjacent) (hs4, nhs1, adjacent) (hs4, nhs4, adjacent) (hs4, nhs5, adjacent) (hs4, Xba2, adjacent) (hs5, Xba1, adjacent) (hs5, nhs2, adjacent) (hs5, nhs1, adjacent) (hs6 Xba2, adjacent) (hs6, Xki, adjacent) (hs6, Xla, adjacent) (nhs1, Xba1, adjacent) (nhs1, nhs4, adjacent) (nhs2, nhs4, adjacent) (nhs3, nhs4, adjacent) (nhs3, nhs5, adjacent) (nhs5, Xki, adjacent) (Xba2, Xki, adjacent) (Xki, Xla, adjacent)]>
$\alpha 8 \leftarrow$	< (f, us) (b, us) (p, us) (s, usi) >
$\alpha 9 \leftarrow$	< [(w_{ub}(hs1, hs2, 4)) (w_{ub} (hs1, nhs2, 2)) (w_{ub} (hs1, nhs4, 1)) (w_{ub} (hs2, nhs4, 3.2)) (w_{ub} (hs2, hs3, 4)) (w_{ub} (hs3, nhs3, 2)) (w_{ub} (hs4, Xba1, 2.35)) (w_{ub} (hs4, nhs1, 1.1)) (w_{ub} (hs4, nhs4, 2.75)) (w_{ub} (hs4, nhs5, 3.7)) (w_{ub} (hs4, Xba2, 1.6)) (w_{ub} (hs5, Xba1, 3.7)) (w_{ub} (hs5, nhs2, 2)) (w_{ub} (hs5, nhs1, 1.1)) (w_{ub} (hs6, Xba2, 1.6)) (w_{ub} (hs6, Xki, 1.75)) (w_{ub} (hs6, Xla, 1.05)) (w_{ub} (nhs1, Xba1, 1.45)) (w_{ub} (nhs1, nhs4, 1.45)) (w_{ub} (nhs2, nhs4, 1)) (w_{ub} (nhs3, nhs4, 1)) (w_{ub} (nhs3, nhs5, 1)) (w_{ub} (nhs5, Xki, 1)) (w_{ub} (Xba2, Xki, 1.1)) (w_{ub} (Xki, Xla, 2.65))]>
$\alpha 10 \leftarrow$	< S-1 >

Table 15 – Step #4 of the derivation

STEP #5 _ ASSIGNMENT OF ISOLATED KITCHEN

$\alpha 1 \leftarrow$	< A >
$\alpha 2 \leftarrow$	< [(hs_1,isolated) (hs_2,isolated) (hs_3,isolated) (hs_4,isolated) (hs_5,isolated) (hs_6,isolated) (nhs_1,demarcated) (nhs_2,isolated) (nhs_3,isolated) (nhs_4,isolated) (nhs_5,isolated) **(ki,isolated)** (Xla,demarcated) (Xba_1,isolated) (Xba_2,isolated)] >
$\alpha 3 \leftarrow$	< 100 >
$\alpha 4 \leftarrow$	< [(hs1, 13.3) (hs2, 13.1) (hs3, 14.1) (hs4, 14.1) (hs5, 7.6) (hs6, 6.3) (nhs1, 1.6) (nhs2, 2) (nhs3, 3.3) (nhs4, 4.45) (nhs5, 3.7) **(ki, 8.1)** (Xla, 3.2) (Xba1, 3.4) (Xba2, 1.9)] >
$\alpha 5 \leftarrow$	< [(hs1,4,3.25) (hs2,4,3.2) (hs3,3.65,3.72) (hs4,3.7,3.75) (hs5, 3.7,2) (hs6, 2.9,2.1) (nhs1,1.1,1.45) (nhs2,1,2) (nhs3,1.65,2) (nhs4,1,4.45) (nhs5,3.7,1) **(ki,3.1,2.62)** (Xla,1.25,2.62) (Xba,2.35,1.45) (Xba,1.1,1.3)] >
$\alpha 6 \leftarrow$	< [(hs1, nhs4, passage_to) (hs2, nhs4, passage_to) (hs3, nhs3, passage_to) (hs4, nhs4, passage_to) (hs4, nhs5, passage_to) (hs5, nhs1, passage_to) (hs6, Xla, passage_to) (hs6, Xba2, passage_to) (nhs1, Xba1, passage_to) (nhs1, nhs4, passage_to) (nhs2, nhs4, passage_to) (nhs3, nhs4, passage_to) (nhs3, nhs5, passage_to) **(nhs5, ki, passage_to)** (Xki, Xla, passage_to)] [(hs1, nhs3, next_to) (hs1, nhs1, next_to) (hs1, hs4, next_to) (hs2, nhs3, next_to) (hs2, nhs1, next_to) (hs2, hs4, next_to) (nhs2, nhs3, next_to) (nhs2, nhs1, next_to) (nhs2, hs4, next_to) (hs3, nhs5, next_to) **(hs4, ki, next_to)** (hs4, nhs3, next_to) (hs4, nhs2, next_to) (hs5, Xba1, next_to) (hs5, nhs4, next_to) **(hs6, ki, next_to)** (nhs1, nhs3, next_to) (nhs1, nhs2, next_to) **(nhs3, ki, next_to)** (nhs3, nhs2, next_to) (nhs4, Xba1, next_to) (nhs4, nhs5, next_to) (nhs5, Xla, next_to) (Xla, Xba2, next_to)] [(hs1, hs3, close_to) (hs1, hs5, close_to) (hs1, Xba1, close_to) (hs1, nhs5, close_to) (hs2, hs3, close_to) (hs2, hs5, close_to) (hs2, Xba1, close_to) (hs2, nhs5, close_to) (hs3, nhs2, close_to) (hs3, nhs1, close_to) (hs3, hs4, close_to) **(hs3, ki, close_to)** (hs4, nhs2, close_to) (hs4, nhs1, close_to) (hs4, Xla, close_to) (hs5, nhs2, close_to) (hs5, nhs3, close_to) (nhs1, nhs5, close_to) (nhs2, Xba1, close_to) (nhs2, nhs5, close_to) (nhs3, Xba1, close_to) (nhs3, Xla, close_to) **(nhs4, ki, close_to)** (nhs5, hs6, close_to) (Ki, Xba2, close_to)] [**(hs1, ki, far_from)** (hs1, Xla, far_from) (hs1, hs6, far_from) (hs1, Xba2, far_from) **(hs2, ki, far_from)** (hs2, Xla, far_from) (hs2, hs6, far_from) (hs2, Xba2, far_from) **(nhs1, ki, far_from)** (nhs1, Xla, far_from) (nhs1, hs6, far_from) (nhs1, Xba2, far_from) **(nhs2, ki, far_from)** (nhs2, Xla, far_from) (nhs2, hs6, far_from) (nhs2, Xba2, far_from) (hs4, hs6, far_from) (hs4, Xba2, far_from) (hs3, Xla, far_from) (hs3, hs6, far_from) (hs3, Xba2, far_from) (hs5, nhs5, far_from) **(hs5, ki, far_from)** (hs5, Xla, far_from) (hs5, hs6, far_from) (hs5, Xba2, far_from) (hs6, Xba1, far_from) (hs6, nhs4, far_from) (hs6, nhs3, far_from) (nhs3, Xba2, far_from) (nhs4, Xla, far_from) (nhs4, Xba2, far_from) (nhs5, Xba1, far_from) (nhs5, Xba2, far_from) (Xba1, Xba2, far_from) (Xba1, Xla, far_from) **(Xba1, ki, far_from)]** >
$\alpha 7 \leftarrow$	< [(hs1, hs2, adjacent) (hs1, nhs2, adjacent) (hs1, nhs4, adjacent) (hs2, nhs4, adjacent) (hs2, hs3, adjacent) (hs3, nhs3, adjacent) (hs4, Xba1, adjacent) (hs4, nhs1, adjacent) (hs4, nhs4, adjacent) (hs4, nhs5, adjacent) (hs4,

	Xba2, adjacent) (hs5, Xba1, adjacent) (hs5, nhs2, adjacent) (hs5, nhs1, adjacent) (hs6 Xba2, adjacent) **(hs6, ki, adjacent)** (hs6, Xla, adjacent) (nhs1, Xba1, adjacent) (nhs1, nhs4, adjacent) (nhs2, nhs4, adjacent) (nhs3, nhs4, adjacent) (nhs3, nhs5, adjacent) **(nhs5, ki, adjacent) (Xba2, ki, adjacent) (ki, Xla, adjacent)**]>
$\alpha 8 \leftarrow$	< (f, us) (b, us) (p, us) (s, usi) >
$\alpha 9 \leftarrow$	< [(w_{ub}(hs1, hs2, 4)) (w_{ub} (hs1, nhs2, 2)) (w_{ub} (hs1, nhs4, 1)) (w_{ub} (hs2, nhs4, 3.2)) (w_{ub} (hs2, hs3, 4)) (w_{ub} (hs3, nhs3, 2)) (w_{ub} (hs4, Xba1, 2.35)) (w_{ub} (hs4, nhs1, 1.1)) (w_{ub} (hs4, nhs4, 2.75)) (w_{ub} (hs4, nhs5, 3.7)) (w_{ub} (hs4, Xba2, 1.6)) (w_{ub} (hs5, Xba1, 3.7)) (w_{ub} (hs5, nhs2, 2)) (w_{ub} (hs5, nhs1, 1.1)) (w_{ub} (hs6, Xba2, 1.6)) **(w_{ub} (hs6, ki, 1.75))** (w_{ub} (hs6, Xla, 1.05)) (w_{ub} (nhs1, Xba1, 1.45)) (w_{ub} (nhs1, nhs4, 1.45)) (w_{ub} (nhs2, nhs4, 1)) (w_{ub} (nhs3, nhs4, 1)) (w_{ub} (nhs3, nhs5, 1)) **(w_{ub} (nhs5, ki, 1)) (w_{ub} (Xba2, ki, 1.1)) (w_{ub} (ki, Xla, 2.65))**]>
$\alpha 10 \leftarrow$	< S0 >

Table 16 – Step #5 of the derivation

STEP #6 _ ASSIGNMENT OF THE HALL

$\alpha 1 \leftarrow$	< A >
$\alpha 2 \leftarrow$	< [(hs_1,isolated) (hs_2,isolated) (hs_3,isolated) (hs_4,isolated) (hs_5,isolated) (hs_6,isolated) (nhs_1,demarcated) (nhs_2,isolated) **(hl,isolated)** (nhs_4,isolated) (nhs_5,isolated) (ki,isolated) (Xla,demarcated) (Xba_1,isolated) (Xba_2,isolated)] >
$\alpha 3 \leftarrow$	< 100 >
$\alpha 4 \leftarrow$	< [(hs1, 13.3) (hs2, 13.1) (hs3, 14.1) (hs4, 14.1) (hs5, 7.6) (hs6, 6.3) (nhs1, 1.6) (nhs2, 2) **(hl, 3.3)** (nhs4, 4.45) (nhs5, 3.7) (ki, 8.1) (Xla, 3.2) (Xba1, 3.4) (Xba2, 1.9)] >
$\alpha 5 \leftarrow$	< [(hs1,4,3.25) (hs2,4,3.2) (hs3,3.65,3.72) (hs4,3.7,3.75) (hs5, 3.7,2) (hs6, 2.9,2.1) (nhs1,1.1,1.45) (nhs2,1,2) **(hl,1.65,2)** (nhs4,1,4.45) (nhs5,3.7,1) (ki,3.1,2.62) (Xla,1.25,2.62) (Xba,2.35,1.45) (Xba,1.1,1.3)] >
$\alpha 6 \leftarrow$	< [(hs1, nhs4, passage_to) (hs2, nhs4, passage_to) **(hs3, hl, passage_to**) (hs4, nhs4, passage_to) (hs4, nhs5, passage_to) (hs5, nhs1, passage_to) (hs6, Xla, passage_to) (hs6, Xba2, passage_to) (nhs1, Xba1, passage_to) (nhs1, nhs4, passage_to) (nhs2, nhs4, passage_to) **(hl, nhs4, passage_to) (hl, nhs5, passage_to)** (nhs5, ki, passage_to) (Xki, Xla, passage_to)] [**(hs1, hl, next_to)** (hs1, nhs1, next_to) (hs1, hs4, next_to) **(hs2, hl, next_to)** (hs2, nhs1, next_to) (hs2, hs4, next_to) **(nhs2, hl, next_to)** (nhs2, nhs1, next_to) (nhs2, hs4, next_to) (hs3, nhs5, next_to) (hs4, ki, next_to) **(hs4, hl, next_to)** (hs4, nhs2, next_to) (hs5, Xba1, next_to) (hs5, nhs4, next_to) (hs6, ki, next_to) **(nhs1, hl, next_to)** (nhs1, nhs2, next_to) **(hl, ki, next_to) (hl, nhs2, next_to)** (nhs4, Xba1, next_to) (nhs4, nhs5, next_to) (nhs5, Xla, next_to) (Xla, Xba2, next_to)] [(hs1, hs3, close_to) (hs1, hs5, close_to) (hs1, Xba1, close_to) (hs1, nhs5, close_to) (hs2, hs3, close_to) (hs2, hs5, close_to) (hs2, Xba1, close_to) (hs2, nhs5, close_to) (hs3, nhs2, close_to) (hs3, nhs1, close_to) (hs3, hs4, close_to) (hs3, ki, close_to) (hs4, nhs2, close_to) (hs4, nhs1, close_to) (hs4, Xla, close_to) (hs5, nhs2, close_to) **(hs5, hl, close_to)** (nhs1, nhs5, close_to) (nhs2, Xba1, close_to) (nhs2, nhs5, close_to) (hl, Xba1, close_to) **(hl, Xla, close_to)** (nhs4, ki, close_to) (nhs5, hs6, close_to) (Ki, Xba2, close_to)] [(hs1, ki, far_from) (hs1, Xla, far_from) (hs1, hs6, far_from) (hs1, Xba2, far_from) (hs2, ki, far_from) (hs2, Xla, far_from) (hs2, hs6, far_from) (hs2, Xba2, far_from) (nhs1, ki, far_from) (nhs1, Xla, far_from) (nhs1, hs6, far_from) (nhs1, Xba2, far_from) (nhs2, ki, far_from) (nhs2, Xla, far_from) (nhs2, hs6, far_from) (nhs2, Xba2, far_from) (hs4, hs6, far_from) (hs4, Xba2, far_from) (hs3, Xla, far_from) (hs3, hs6, far_from) (hs3, Xba2, far_from) (hs5, nhs5, far_from) (hs5, ki, far_from) (hs5, Xla, far_from) (hs5, hs6, far_from) (hs5, Xba2, far_from) (hs6, Xba1, far_from) (hs6, nhs4, far_from) **(hs6, hl, far_from) (hl, Xba2, far_from)** (nhs4, Xla, far_from) (nhs4, Xba2, far_from) (nhs5, Xba1, far_from) (nhs5, Xba2, far_from) (Xba1, Xba2, far_from) (Xba1, Xla, far_from) (Xba1, ki, far_from)] >
$\alpha 7 \leftarrow$	< [(hs1, hs2, adjacent) (hs1, nhs2, adjacent) (hs1, nhs4, adjacent) (hs2, nhs4, adjacent) (hs2, hs3, adjacent) **(hs3, hl, adjacent)** (hs4, Xba1, adjacent) (hs4, nhs1, adjacent) (hs4, nhs4, adjacent) (hs4, nhs5, adjacent) (hs4, Xba2, adjacent) (hs5, Xba1, adjacent) (hs5, nhs2, adjacent) (hs5, nhs1, adjacent) (hs6 Xba2, adjacent) (hs6, ki, adjacent) (hs6, Xla, adjacent) (nhs1, Xba1, adjacent) (nhs1, nhs4, adjacent) (nhs2, nhs4, adjacent) **(hl, nhs4, adjacent) (hl, nhs5, adjacent)** (nhs5, ki, adjacent) (Xba2, ki, adjacent) (ki, Xla, adjacent)]>

$\alpha 8 \leftarrow$	< (f, us) (b, us) (p, us) (s, usi) >
$\alpha 9 \leftarrow$	< [(w_{ub}(hs1, hs2, 4)) (w_{ub} (hs1, nhs2, 2)) (w_{ub} (hs1, nhs4,1)) (w_{ub} (hs2, nhs4, 3.2)) (w_{ub} (hs2, hs3, 4)) **(w_{ub} (hs3, hl, 2))** (w_{ub} (hs4, Xba1, 2.35)) (w_{ub} (hs4, nhs1, 1.1)) (w_{ub} (hs4, nhs4, 2.75)) (w_{ub} (hs4, nhs5, 3.7)) (w_{ub} (hs4, Xba2, 1.6)) (w_{ub} (hs5, Xba1, 3.7)) (w_{ub} (hs5, nhs2, 2)) (w_{ub} (hs5, nhs1, 1.1)) (w_{ub} (hs6, Xba2, 1.6)) (w_{ub} (hs6, ki, 1.75)) (w_{ub} (hs6, Xla, 1.05)) (w_{ub} (nhs1, Xba1, 1.45)) (w_{ub} (nhs1, nhs4, 1.45)) (w_{ub} (nhs2, nhs4, 1)) **(w_{ub} (hl, nhs4, 1)) (w_{ub} (hl, nhs5, 1))** (w_{ub} (nhs5, ki, 1)) (w_{ub} (Xba2, ki, 1.1)) (w_{ub} (ki, Xla, 2.65))]>
$\alpha 10 \leftarrow$	< S1 >

Table 17 – Step #6 of the derivation

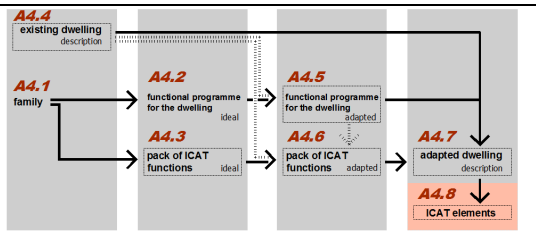
STEP #12 _ CHANGING THE DIMENSIONS OF A ROOM (ENLARGING OR REDUCING) BY "MOVING" A WALL (ELIMINATING AND ADDING A WALL)

$\alpha 1 \leftarrow$	< A >
$\alpha 2 \leftarrow$	< [**(be.d,isolated) (be.s,isolated)** (hs_3,isolated) (hs_4,isolated) **(be.s,isolated)** (hs_6,isolated) (nhs_1,demarcated) **(ba.p,isolated)** (hl,isolated) (nhs_4,isolated) (nhs_5,isolated) (ki,isolated) (Xla,demarcated) **(ba.p,isolated)** (Xba_2,isolated)] >
$\alpha 3 \leftarrow$	< 100 >
$\alpha 4 \leftarrow$	< [**(be.d, 11) (be.s, 13.1)** (hs3, 14.1) (hs4, 14.1) **(be.s, 7.6)** (hs6, 6.3) (nhs1, 1.6) **(ba.p, 4)** (hl, 3.3) (nhs4, 4.45) (nhs5, 3.7) (ki, 8.1) (Xla, 3.2) **(ba.p, 3.4)** (Xba2, 1.9)] >
$\alpha 5 \leftarrow$	< [**(be.d,3,3.25) (be.s,4,3.2)** (hs3,3.65,3.72) (hs4,3.7,3.75) **(be.s,3.7,2)** (hs6,2.9,2.1) (nhs1,1.1,1.45) **(ba.p,2,2) (hl,1.65,2)** (nhs4,1,4.45) (nhs5,3.7,1) (ki,3.1,2.62) (Xla,1.25,2.62) **(ba.p,2.35,1.45)** (Xba,1.1,1.3)] >
$\alpha 6 \leftarrow$	< [**(be.d, nhs4, passage_to) (be.s, nhs4, passage_to)** (hs3, hl, passage_to) (hs4, nhs4, passage_to) (hs4, nhs5, passage_to) **(be.s, nhs1, passage_to)** (hs6, Xla, passage_to) (hs6, Xba2, passage_to) **(nhs1, ba.p, passage_to)** (nhs1, nhs4, passage_to) **(ba.p, nhs4, passage_to)** (hl, nhs4, passage_to) (hl, nhs5, passage_to) (nhs5, ki, passage_to) (Xki, Xla, passage_to)] [**(be.d, hl, next_to) (be.d, nhs1, next_to) (be.d, hs4, next_to) (be.s, hl, next_to) (be.s, nhs1, next_to) (be.s, hs4, next_to) (ba.p, hl, next_to) (ba.p, nhs1, next_to) (ba.p, hs4, next_to)** (hs3, nhs5, next_to) (hs4, ki, next_to) (hs4, hl, next_to) **(hs4, ba.p, next_to) (be.s, ba.p, next_to) (be.s, nhs4, next_to)** (hs6, ki, next_to) (nhs1, hl, next_to) **(nhs1, ba.p, next_to)** (hl, ki, next_to) **(hl, ba.p, next_to) (nhs4, ba.p, next_to)** (nhs4, nhs5, next_to) (nhs5, Xla, next_to) (Xla, Xba2, next_to)] [**(be.d, hs3, close_to) (be.d, be.s, close_to) (be.d, ba.p, close_to) (be.d, nhs5, close_to) (be.s, hs3, close_to) (be.s, be.s, close_to) (be.s, ba.p, close_to) (be.s, nhs5, close_to) (hs3, ba.p, close_to)** (hs3, nhs1, close_to) (hs3, hs4, close_to) (hs3, ki, close_to) **(hs4, ba.p, close_to)** (hs4, nhs1, close_to) (hs4, Xla, close_to) **(be.s, ba.p, close_to) (be.s, hl, close_to)** (nhs1, nhs5, close_to) **(ba.p, ba.p, close_to) (ba.p, nhs5, close_to) (hl, ba.p, close_to)** (hl, Xla, close_to) (nhs4, ki, close_to) (nhs5, hs6, close_to) (Ki, Xba2, close_to)] [**(be.d, ki, far_from) (be.d, Xla, far_from) (be.d, hs6, far_from) (be.d, Xba2, far_from) (be.s, ki, far_from) (be.s, Xla, far_from) (be.s, hs6, far_from) (be.s, Xba2, far_from)** (nhs1, ki, far_from) (nhs1, Xla, far_from) (nhs1, hs6, far_from) (nhs1, Xba2, far_from) **(ba.p, ki, far_from) (ba.p, Xla, far_from) (ba.p, hs6, far_from) (ba.p, Xba2, far_from)** (hs4, hs6, far_from) (hs4, Xba2, far_from) (hs3, Xla, far_from) (hs3, hs6, far_from) (hs3, Xba2, far_from) **(be.s, nhs5, far_from) (be.s, ki, far_from) (be.s, Xla, far_from) (be.s, hs6, far_from) (be.s, Xba2, far_from) (hs6, ba.p, far_from)** (hs6, nhs4, far_from) (hs6, hl, far_from) (hl, Xba2, far_from) (nhs4, Xla, far_from) (nhs4, Xba2, far_from) **(nhs5, ba.p, far_from)** (nhs5, Xba2, far_from) (Xba1, Xba2, far_from) (Xba1, Xla, far_from) (Xba1, ki, far_from)] >
$\alpha 7 \leftarrow$	< [**(be.d, be.s, adjacent) (be.d, ba.p, adjacent) (be.d, nhs4, adjacent) (be.s, nhs4, adjacent) (be.s, hs3, adjacent)** (hs3, hl, adjacent) **(hs4, ba.p, adjacent)** (hs4, nhs1, adjacent) (hs4, nhs4, adjacent) (hs4, nhs5, adjacent) (hs4, Xba2, adjacent) **(be.s, ba.p, adjacent) (be.s, ba.p, adjacent) (be.s, nhs1, adjacent)** (hs6, Xba2, adjacent) (hs6, ki, adjacent) (hs6, Xla, adjacent) **(nhs1, ba.p, adjacent)** (nhs1, nhs4, adjacent) **(ba.p, nhs4, adjacent)** (hl, nhs4, adjacent) (hl, nhs5, adjacent) (nhs5, ki, adjacent) (Xba2, ki,

	adjacent) (ki, Xla, adjacent)]>
$\alpha 8 \leftarrow$	< (f, us) (b, us) (p, us) (s, usi) >
$\alpha 9 \leftarrow$	< [**(w_{ub}(be.d, be.s, 4)) (w_{ub} (be.d, ba.p, 2+0.75)) (w_{ub} (be.d, nhs4,1)) (w_{ub} (be.s, nhs4, 3.2)) (w_{ub} (be.s, hs3, 4)) (w_{ub}** (hs3, hl, 2)) **(w_{ub} (hs4, ba.p, 2.35))** (w_{ub} (hs4, nhs1, 1.1)) (w_{ub} (hs4, nhs4, 2.75)) (w_{ub} (hs4, nhs5, 3.7)) (w_{ub} (hs4, Xba2, 1.6)) **(w_{ub} (be.s, ba.p, 3.7)) (w_{ub} (be.s, ba.p, 2)) (w_{ub} (be.s, nhs1, 1.1))** (w_{ub} (hs6, Xba2, 1.6)) (w_{ub} (hs6, ki, 1.75)) (w_{ub} (hs6, Xla, 1.05)) **(w_{ub} (nhs1, ba.p, 1.45))** (w_{ub} (nhs1, nhs4, 1.45)) **(w_{ub} (ba.p, nhs4, 1))** (w_{ub} (hl, nhs4, 1)) (w_{ub} (hl, nhs5, 1)) (w_{ub} (nhs5, ki, 1)) (w_{ub} (Xba2, ki, 1.1)) (w_{ub} (ki, Xla, 2.65))]>
$\alpha 10 \leftarrow$	< S7 >

Table 18 – Step #10 of the derivation

A4:8 DEFINITION OF THE ICAT ELEMENTS



The following table (Table 19) shows the list of ICAT elements (Output 8) that are needed for the proposed dwelling layout.

After defining the adapted ICAT pack functions, the grammar described in *Part 2: Chapter 4.4* proposes a method of integrating these functions and ICAT elements into the new dwelling layout after the functional transformation has been processed. In this part of the grammar the focus is on adding technologies to the dwelling and not transforming. Thus the process of ICAT integration uses shape grammar rules that are applied after the transformation grammar and that will enable each of the technologies required to be introduced step by step. As previously stated, this part of the grammar is not developed to its full extend and the final layout with the prescribed ICAT is therefore simulated in Appendix 4, omitting some steps that were not developed.

The final layout with all the domotic elements represents the following:

- The position of sensors (movement, water, gas, smoke and temperature);
- The position of motors for the controlled blinds;
- The position of controlled sockets;
- The position of multifunctional switches, entry modules and control panels;
- The position of the controlled lights;
- The position of the bus cable;
- The domotic controls (connection between the controlled device and switch that controls it);

The electrical circuits, electrical components (lighting, electrical domestic appliances, television, etc) and connections between non-automated lighting and the control panels are not represented.

Output 8	
Double bedroom (be.d)	
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Single bedroom (be.s1)	
	Movement detector near the door facing the window
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Single bedroom (be.s2)	
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Kitchen (ki)	
	Temperature detector
	Gas detector
	Water detector
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Energy management: electrical domestic appliances (2 controlled sockets) [1]
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Living room (li)	
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 4 entry module to be embedded in wall (2 for blinds and two for backup)
	Remote control (control for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Dining room (di)	
	Movement detector near the door facing the window
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets

	Bus Cable
Home office (ho)	
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blind and the other for backup)
	Remote control (control for blinds)
	Ethernet and broadband Internet sockets
	TV via cable, satellite, ADSL or IPTV sockets
	Bus Cable
Laundry (la)	
	Gas detector
	Water detector
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control for blinds)
	Energy management: electrical domestic appliances (2 controlled sockets) [1]
	Ethernet and broadband Internet sockets
	Bus Cable
Private bathroom (ba.p1)	
	Water detector
	Movement detector near the door facing the window
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control of blinds)
	Bus Cable
Private bathroom (ba.p2)	
	Water detector
	Wall mounted multifunctional switch near the door (lights)
	Bus Cable
Guest bathroom (ba.g)	
	Water detector
	Movement detector near the door facing the window
	Motor for blinds
	Wall mounted multifunctional switch near the door (controlling automated blinds and lights) / 2 entry module to be embedded in wall (1 for blinds and the other for backup)
	Remote control (control for blinds)
	Bus Cable
Hall (hl)	
	Smoke detector
	Movement detector facing the entrance to the dwelling
	Entry phone
	Bus Cable
	Ethernet and broadband Internet sockets
	Wall mounted multifunction switch (lights)
	Touch panel (control of all the system)
	Alarm
	Electrically operated valve to switch off water, gas and electricity
	Cupboard for domotics with:
	Power module for the entire system
	Exit modules for the 12 blinds
	Exit modules for the controlled sockets for the domestic appliances
	Modem

	Media coupler (allows transmission of RF product messages)
Corridors (co.p1)	
	Bus Cable
	Ethernet and broadband Internet sockets
	Wall mounted multifunction switch (lights)
Corridors (co.p2)	
	Bus Cable
	Ethernet and broadband Internet sockets
	Wall mounted multifunction switch (lights)
Corridors (co1)	
	Movement detector facing the entrance to the dwelling
	Bus Cable
	Ethernet and broadband Internet sockets
	Wall mounted multifunction switch (lights)
Corridors (co2)	
	Bus Cable
	Ethernet and broadband Internet sockets
	Wall mounted multifunction switch (lights)

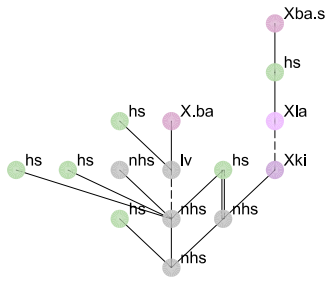
Table 19 – Description of the ICAT elements

[1] Electrical domestic appliances that can be programmed to remain ON without using energy can be remotely controlled by cutting or activating power to the socket to which they are connected. Alternatively, they may use a pre-programmed start function or be activated remotely.

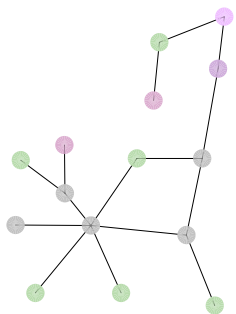
Floor plan

Justified graph

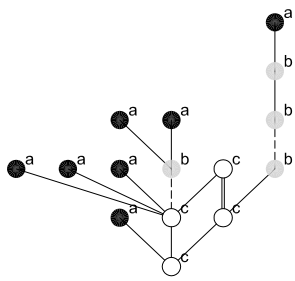
Graph with a tree configuration with 1 ring
Graph with 6 levels of depth
15 spaces/nodes
15 arcs/connections



Convex map

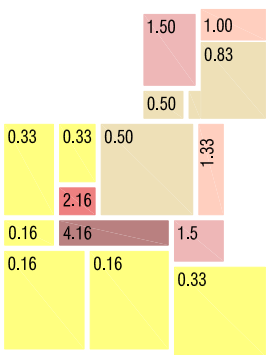


Distributness



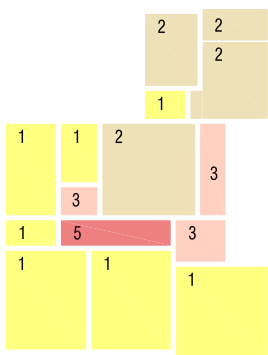
- Habitable spaces (hs)
- Non-habitable spaces (nhs)
- Existing kitchen (Xki)
- Existing bathrooms (Xba)
- Existing laundry (Xla)
- a _ terminal spaces
- b _ reached by two arcs
- c _ reached by two or more arcs and connected in a ring

Controle

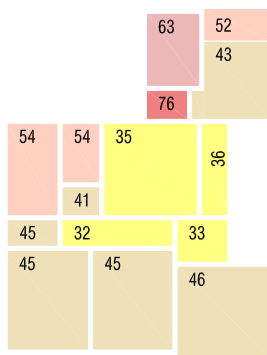


Entire dwelling
Mean: 1,00

Contiguity

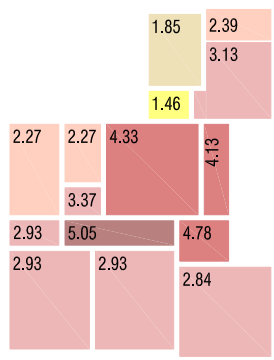


Depth



Entire dwelling
Mean: 46,66

Integration



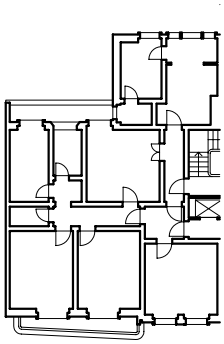
Entire dwelling
Mean: 3,11

Adjacency (arcs)
merged — door (single) — door (double) - - - passage ~ window

Higher — Lower

1 2 3 4 5 10

derivation: functional transformation



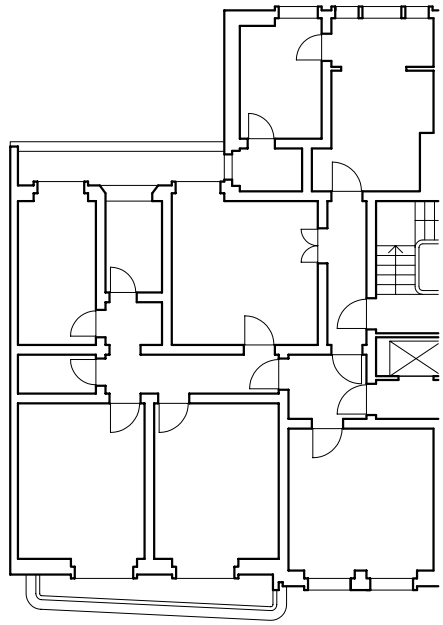
floor plan

spatial void

graphs

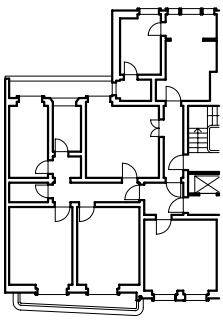
weights

labels



Overlapped representation on the dwelling

derivation: functional transformation



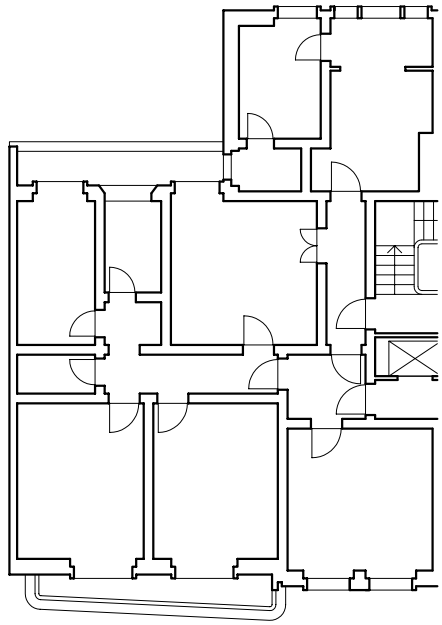
floor plan

spatial void

graphs

weights

labels



Overlapped representation on the dwelling

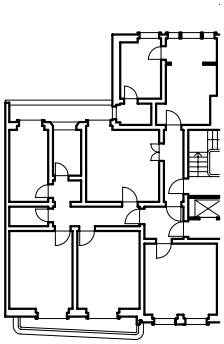
#1

Rules -1.1

Creation of a compound representation

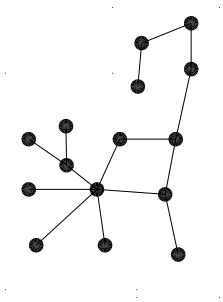
Note: spatial voids will not be represented overlapped with the top representation because it would became graphically too confuse

derivation: functional transformation



floor plan

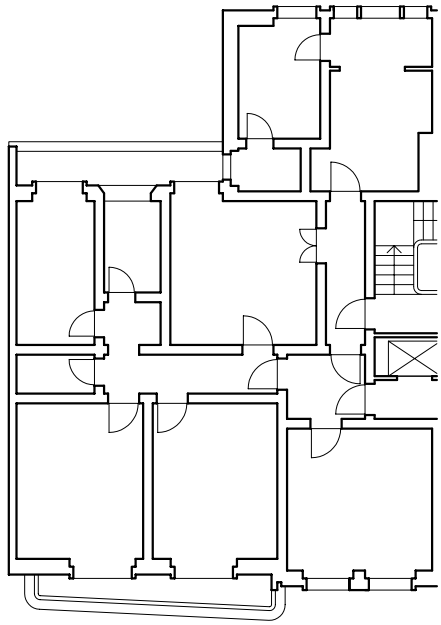
spatial void



graphs

weights

labels



Overlapped representation on the dwelling

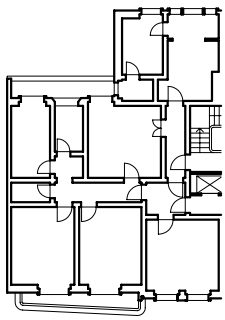
#2

Rules -1.2

Creation of a compound representation

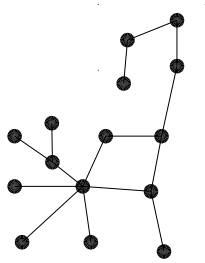
Note: graphs (nodes and links) will not be represented overlapped with the top representation because it would became graphically too confuse

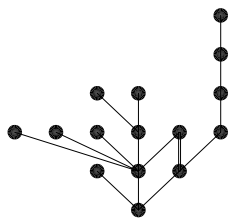
derivation: functional transformation



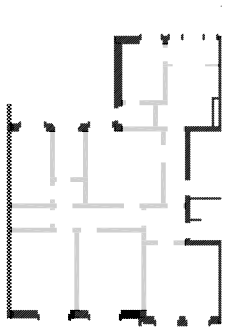
floor plan

spatial void



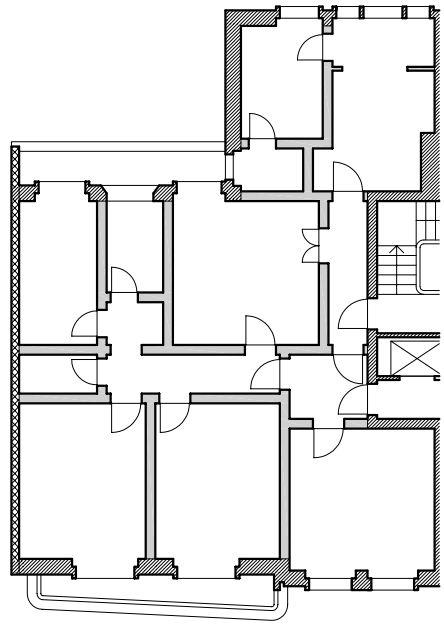


graphs



weights

labels

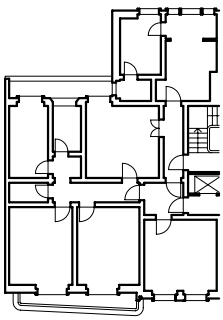


#3

Rules -1.3

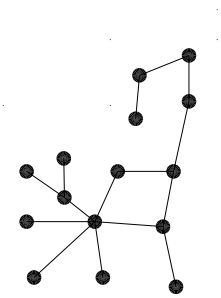
Insertion of weights

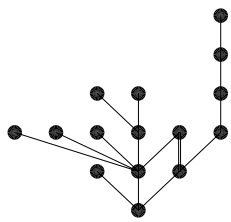
derivation: functional transformation



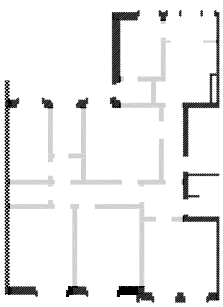
floor plan

spatial void



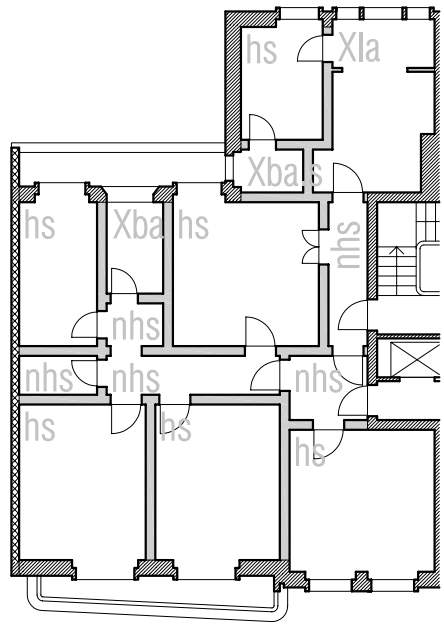


graphs



weights

labels



#4

Rules -1.4

Insertion of labels

derivation: functional transformation

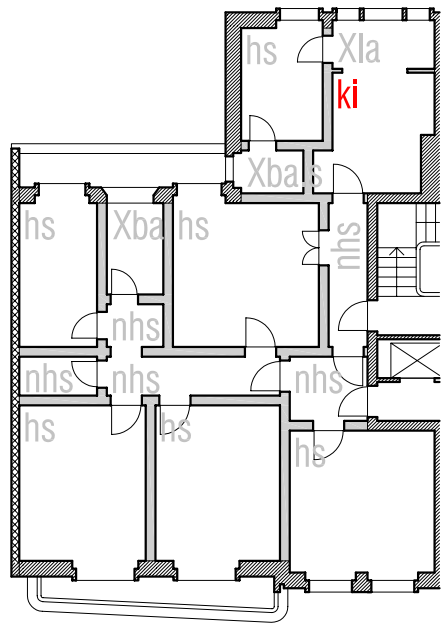
floor plan

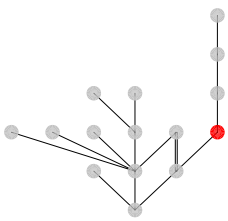
spatial void

graphs

weights

labels





#5

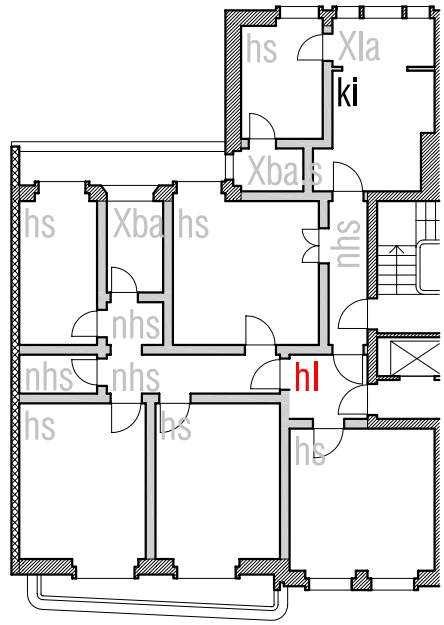
Rules 0.1

Assignment of isolated kitchen for strategy 2

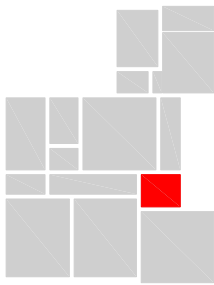
Note. red is used to signal the transformed element

derivation: functional transformation

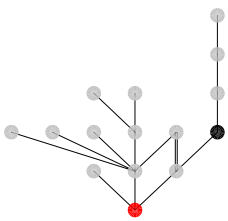
floor plan



spatial void



graphs



weights

#6

Rules 1.1

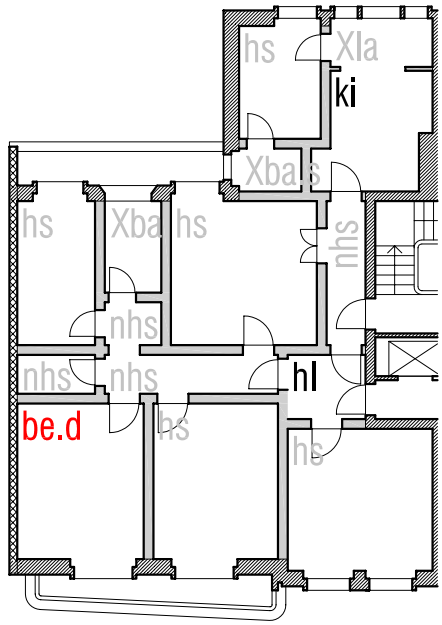
Assignment of hall

labels

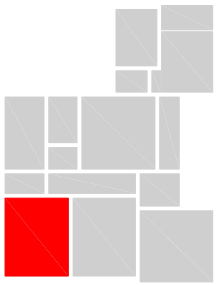
Note. red is used to signal the transformed element

derivation: functional transformation

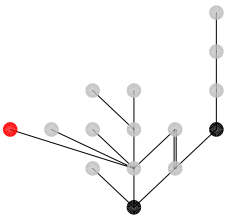
floor plan



spatial void



graphs



weights

#7

Rules 2.1b

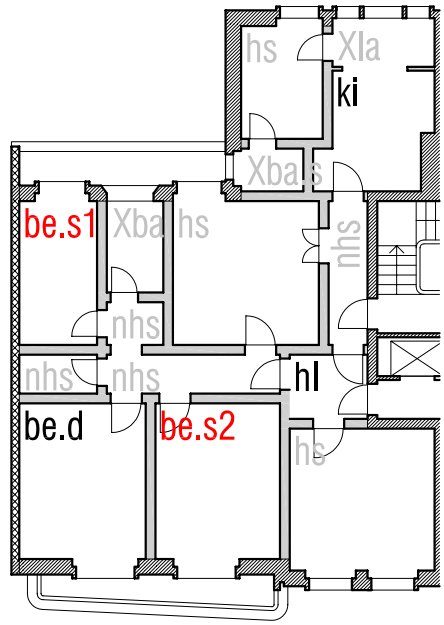
Assignment of double bedroom

labels

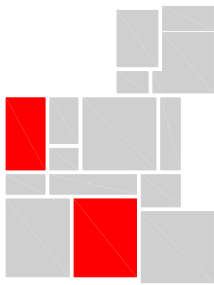
Note. red is used to signal the transformed element

derivation: functional transformation

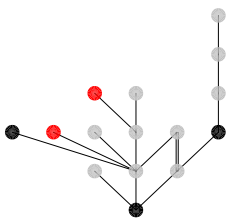
floor plan



spatial void



graphs



weights

#8

Rules 2.3b

Assignment of single bedroom

labels

Note. red is used to signal the transformed element

derivation: functional transformation

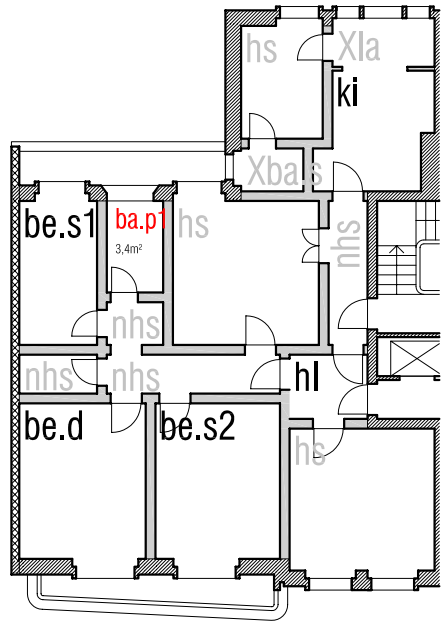
floor plan

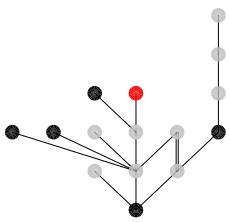
spatial void

graphs

weights

labels





#9

Rules 2.6

Assignment of main private bathroom

Note. red is used to signal the transformed element

derivation: functional transformation

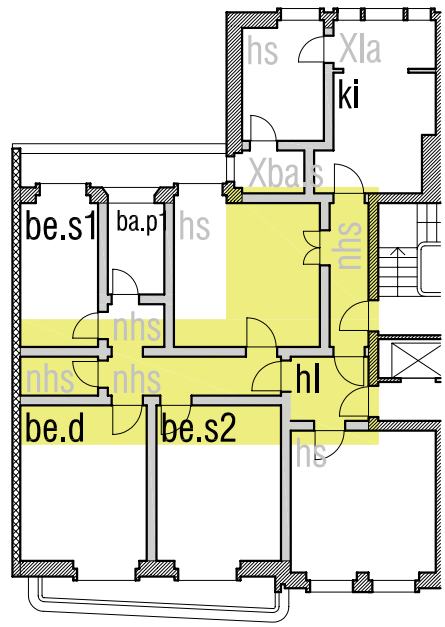
floor plan

spatial void

graphs

weights

labels



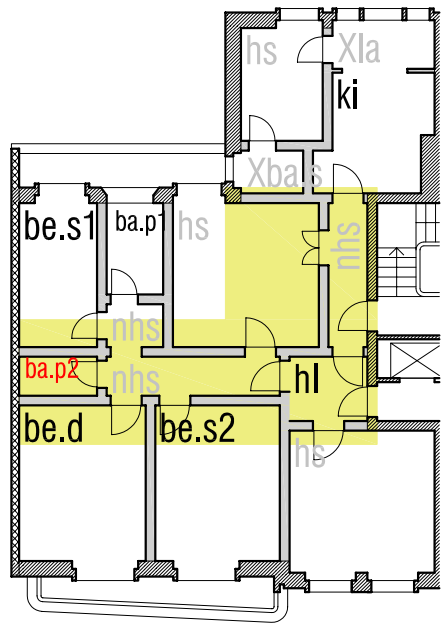
#10

Rules 2.7a

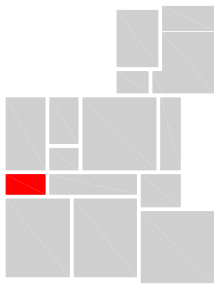
Attribution of new bathroom placement weight (type a and b)

derivation: functional transformation

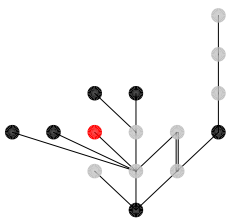
floor plan



spatial void



graphs



weights

labels

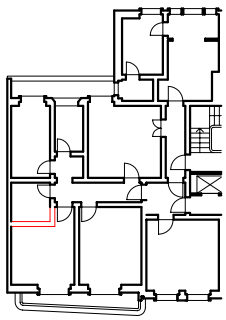
#11

Rules 2.8b

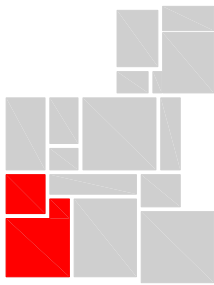
Assignment of second private bathroom

Note. red is used to signal the transformed element

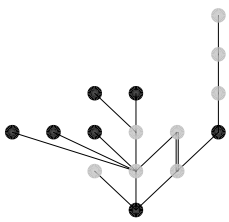
derivation: functional transformation



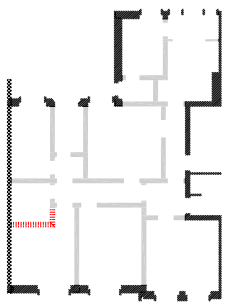
floor plan



spatial void

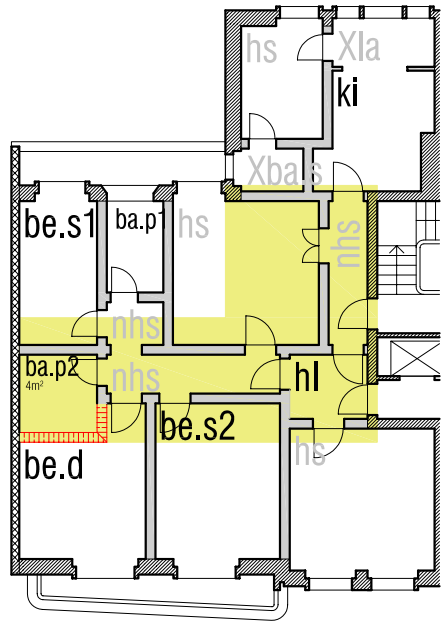


graphs



weights

labels



#12

Rules 7.4b

Changing a room's dimension (enlarging or reducing) by moving a wall

Note. red is used to signal the transformed element

derivation: functional transformation

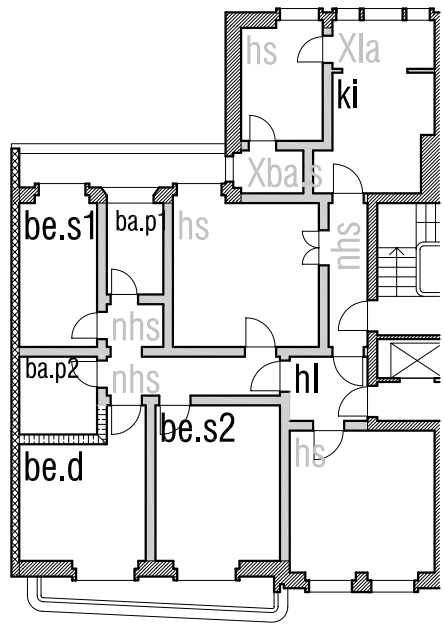
floor plan

spatial void

graphs

weights

labels



#13

Rules 2.16a

Erasing the new bathroom placement weight (type a and b) wall

derivation: functional transformation

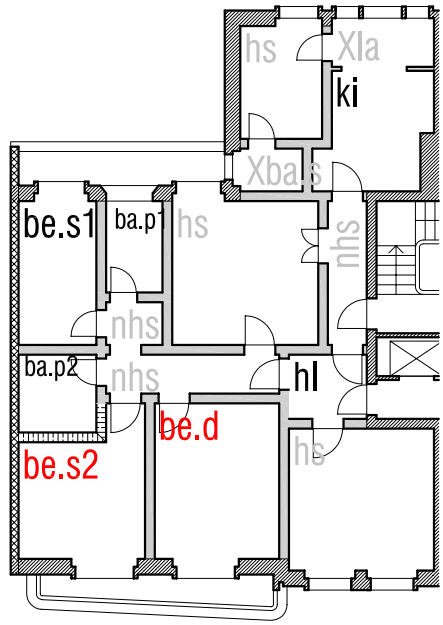
floor plan

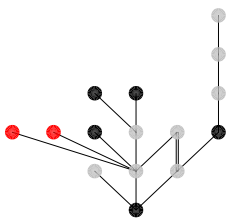
spatial void

graphs

weights

labels





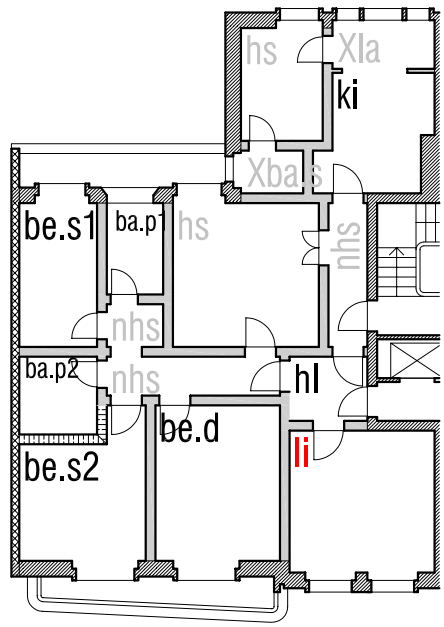
#14

Rules 2.5

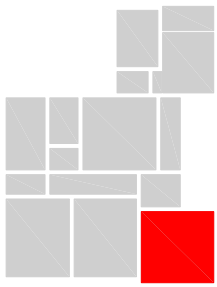
Permuting bedroom assignment due to area criteria

derivation: functional transformation

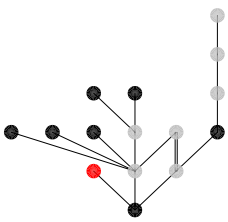
floor plan



spatial void



graphs



weights

labels

#15

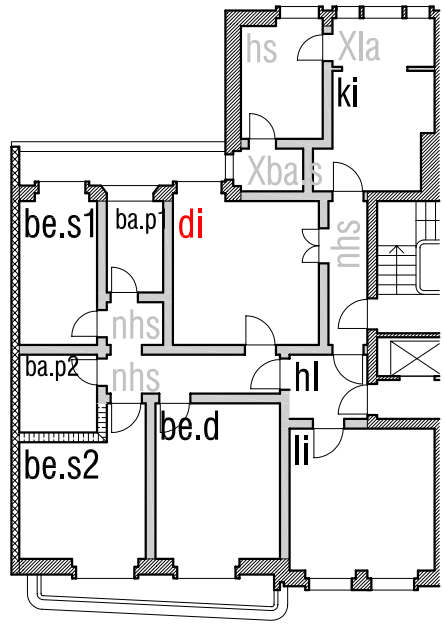
Rules 3.1a

Assignment of living room

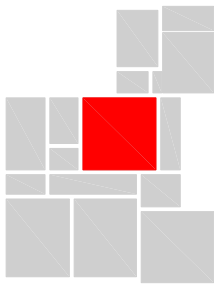
Note. red is used to signal the transformed element

derivation: functional transformation

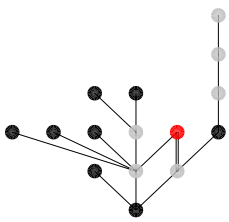
floor plan



spatial void



graphs



weights

#16

Rules 3.2b

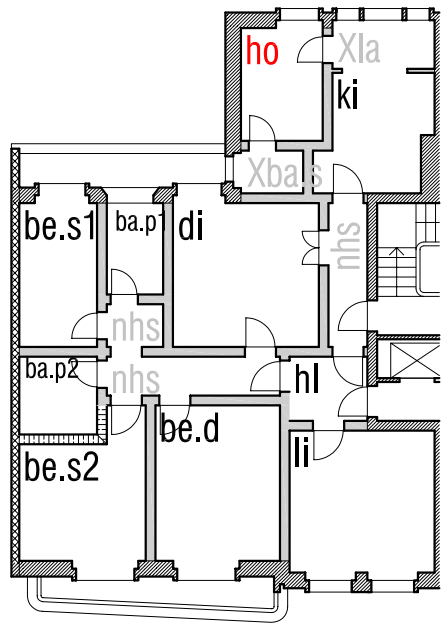
Assignment of dining room

labels

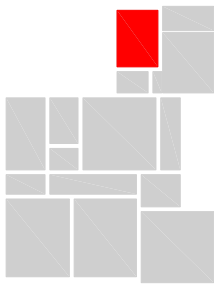
Note. red is used to signal the transformed element

derivation: functional transformation

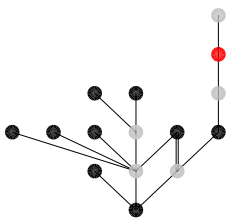
floor plan



spatial void



graphs



#17

weights

Rules 3.4

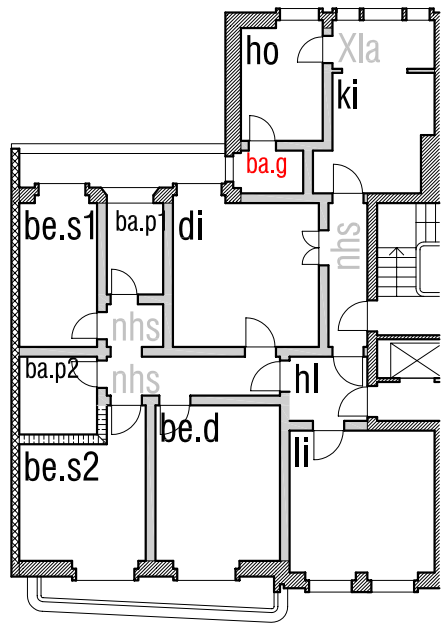
Assignment of isolated home office

labels

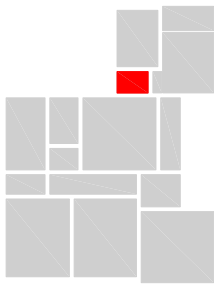
Note. red is used to signal the transformed element

derivation: functional transformation

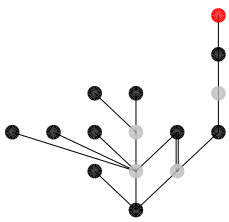
floor plan



spatial void



graphs



weights

#18

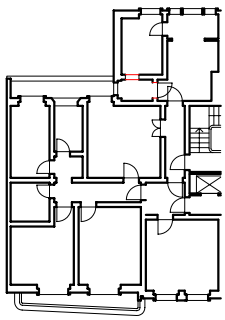
Rules 3.11

Assignment of guest bathroom

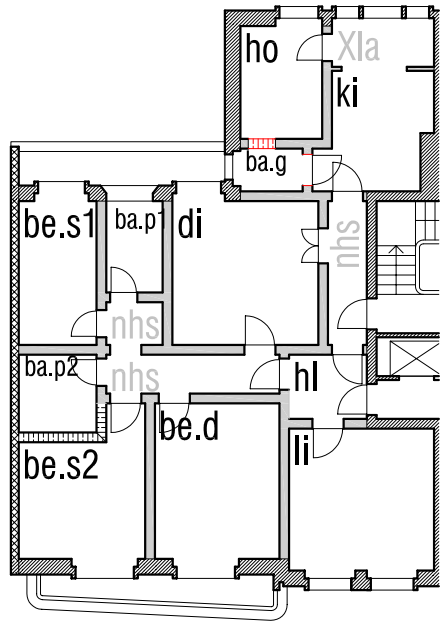
labels

Note. red is used to signal the transformed element

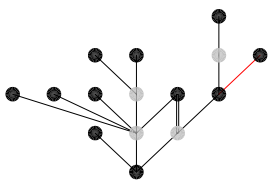
derivation: functional transformation



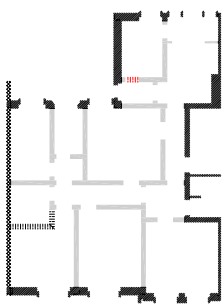
floor plan



spatial void



graphs



weights

labels

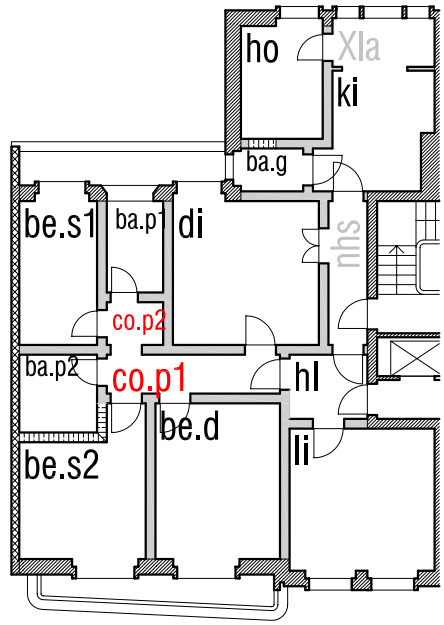
#19

Rules 7.6d

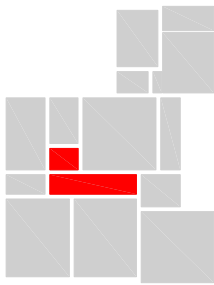
Changing a door position (change door to a perpendicular wall)

derivation: functional transformation

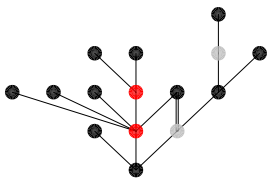
floor plan



spatial void



graphs



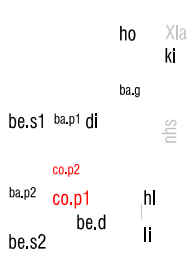
weights

#20

Rules 4.1

Assignment of private corridors

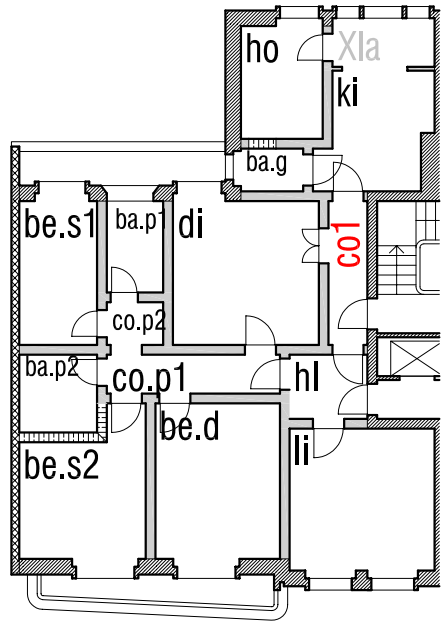
labels



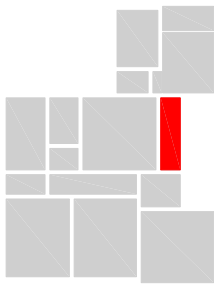
Note. red is used to signal the transformed element

derivation: functional transformation

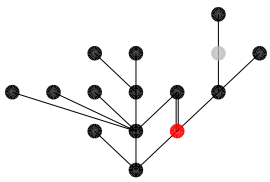
floor plan



spatial void



graphs



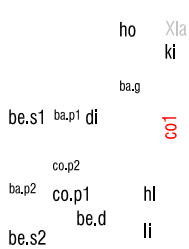
weights

#21

Rules 4.2

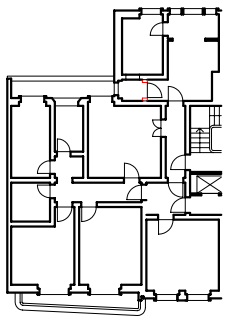
Assignment of corridors

labels

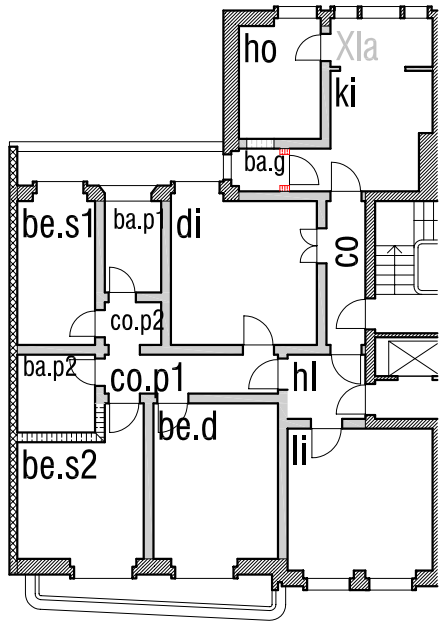


Note. red is used to signal the transformed element

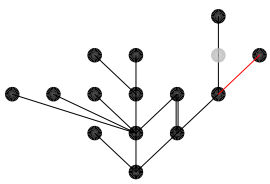
derivation: functional transformation



floor plan

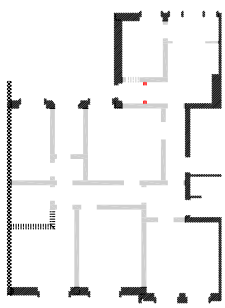


spatial void



graphs

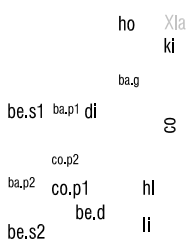
#22



weights

Rules 7.3b

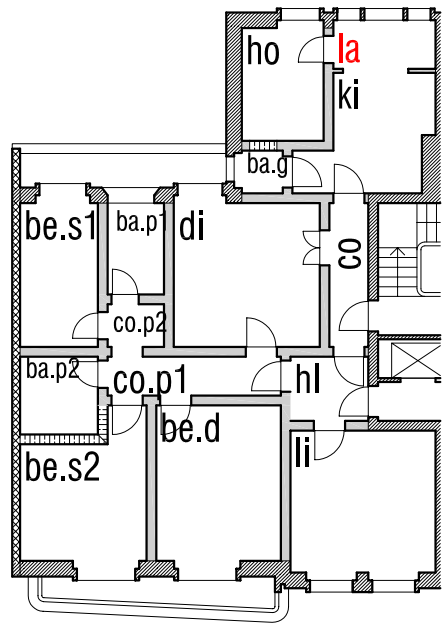
Remove part of a room area to assign to circulation area



labels

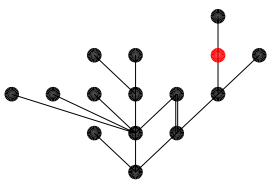
derivation: functional transformation

floor plan



spatial void

graphs



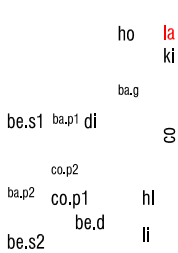
weights

#23

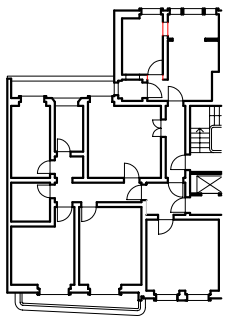
Rules 5.1

Assignment of isolated laundry

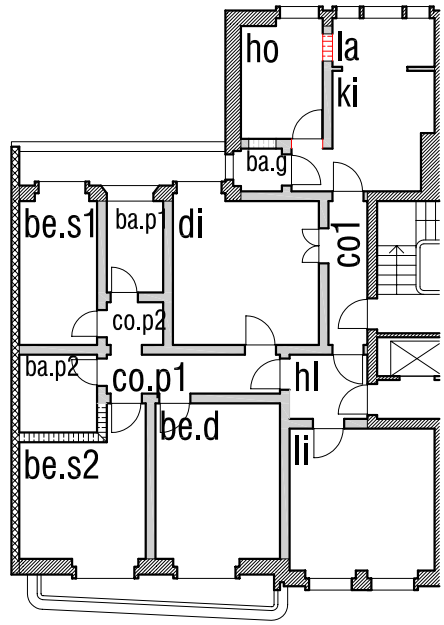
labels



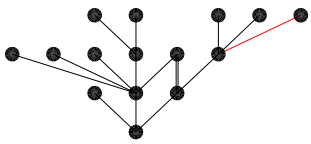
derivation: functional transformation



floor plan

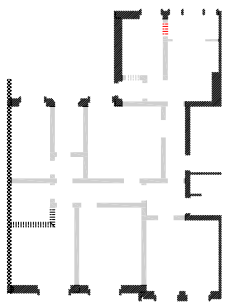


spatial void



graphs

#24



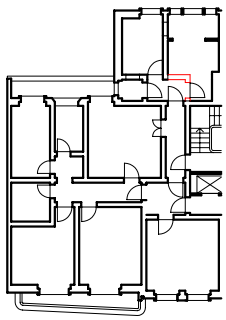
weights

Rules 7.6

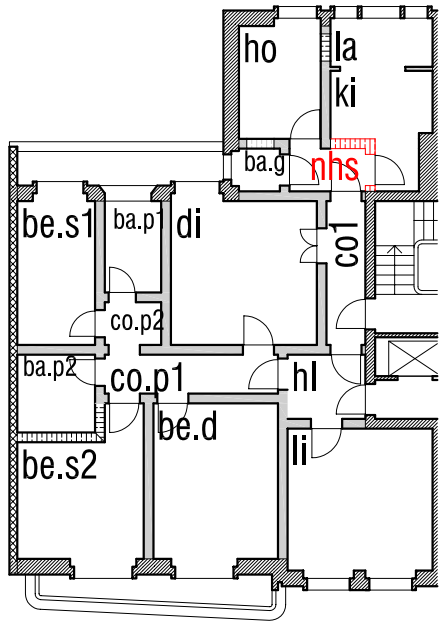
Change door position (change door to a perpendicular wall)

labels

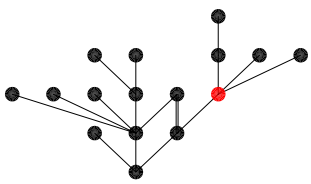
derivation: functional transformation



floor plan

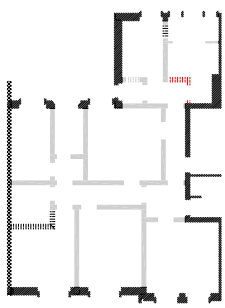


spatial void



graphs

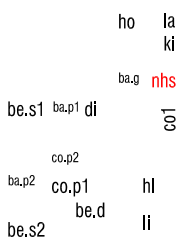
#25



weights

Rules 7.3a

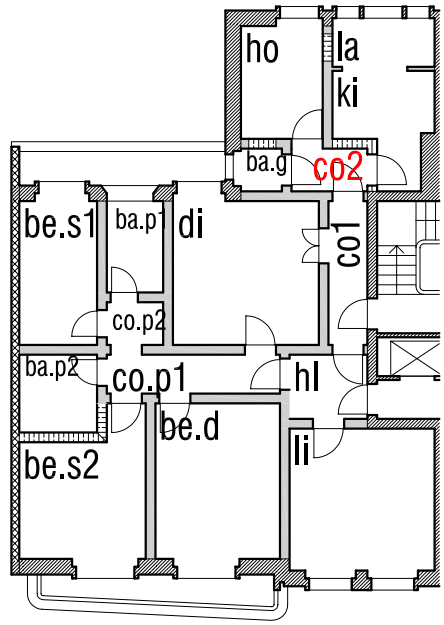
Remove part of a room to assign to circulation area



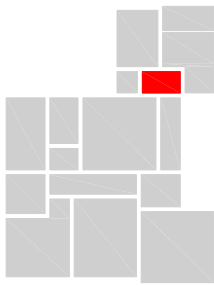
labels

derivation: functional transformation

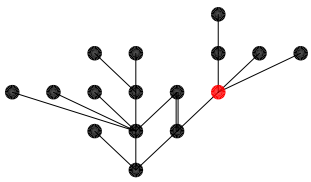
floor plan



spatial void



graphs



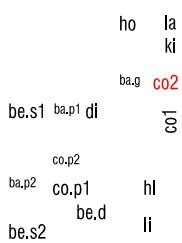
#26

Rules 4.2

Assignment of social corridor

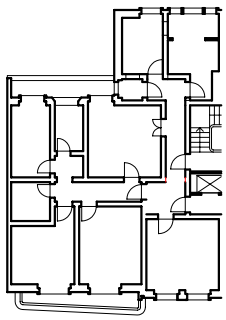
weights

labels

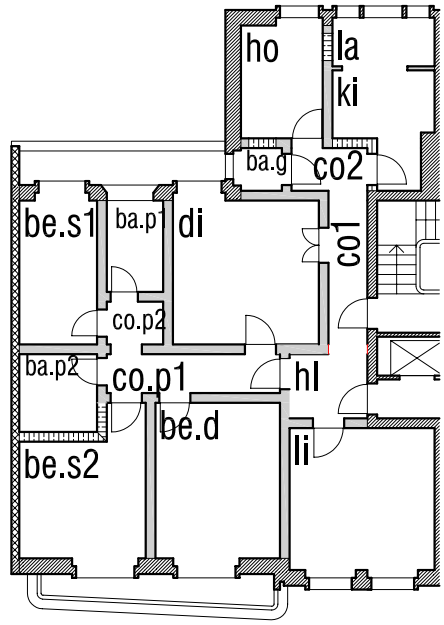


Note. red is used to signal the transformed element

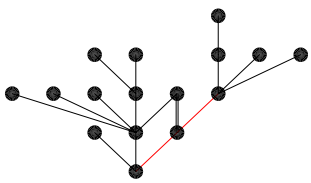
derivation: functional transformation



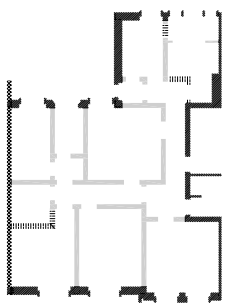
floor plan



spatial void



graphs



weights

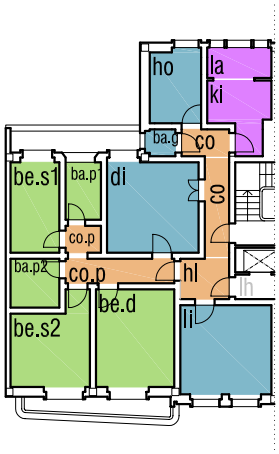
labels

#27

Rules 7.1i

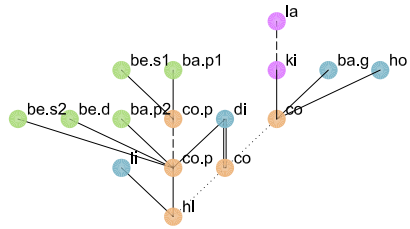
Widening the connection between two rooms /by partially eliminating walls on both sides of a door opening)

Floor plan

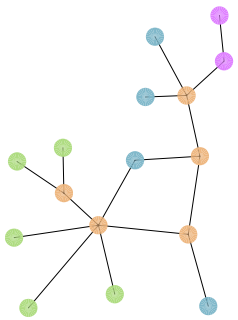


Justified graph

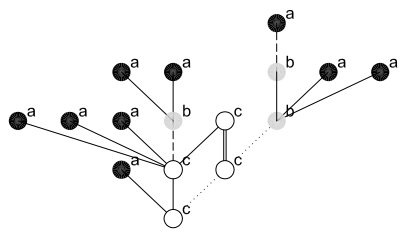
Graph with a tree configuration with 1 ring
Graph with 5 levels of depth
16 spaces/nodes
16 arcs/connections



Convex map

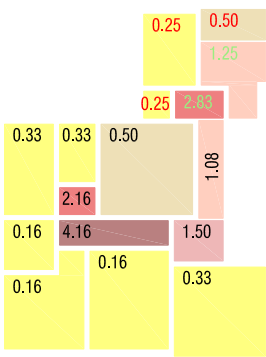


Distributness



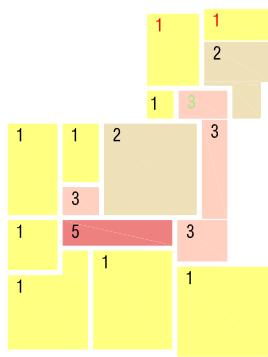
- Social area
- Private area
- Circulation area
- Service area
- a _ terminal spaces
- b _ reached by two arcs
- c _ reached by two or more arcs and connected in a ring

Controle

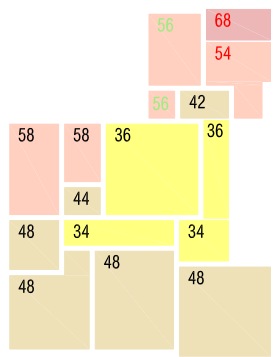


Entire dwelling
Mean: 1,00

Contiguity

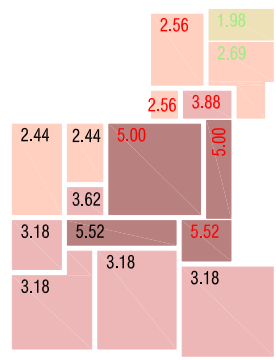


Depth



Entire dwelling
Mean: 48,00

Integration



Entire dwelling
Mean: 3,49

Adjacency (arcs)
merged — door (single) — door (double) - - - - passage ~~~ window

Higher — Lower

1 2 3 4 5 10

Obligatory rooms

_ kitchen ☑
_ laundry ☑
_ double bedroom ☑
_ 2 single bedrooms ☑
_ separate or combined living room and dining room ☑
_ private bathroom (1st) ☑
_ private bathroom (2nd) ☑
_ guest bathroom ☑
_ storeroom ☐

Extra divisions requested by the family (in order of priority) and relationships between divisions

_ all bedrooms next to each other ☑
_ separated living and dining rooms ☑
_ dining room near kitchen ☑
_ living room near entrance ☑
_ 2 fully equipped private bathrooms ☑
_ isolated work area to serve as guest bedroom ☑
_laundry area separate from kitchen ☑

35/37

General characteristics

_ Bedrooms and living rooms have natural light and ventilation ☑
_ The daytime area (living rooms + kitchens) can be separated from the night-time area (bedrooms and private bathrooms) by doors or a corridor ☑

Social area

_ The social area is accessed via the circulation areas ☑
_ The dining room and living room are combined or separate but adjacent, enabling them to be linked ☐
_ The dining room is close to the kitchen ☑
_ There is a bathroom for general use with easy access that does not involve passing through private or social areas ☑
_ Social spaces are close to the entrance for easy access ☑
_ The living room is large enough to allow for the possibility of installing furniture for viewing TV or home cinema from a distance of 3m ☑
_ There is individual access to the living room(s) via a circulation area or other living room ☑
_ All living rooms comply with minimum area requirements ☑

Private area

_ Bedrooms and private bathrooms are accessed from circulation areas other than those of the hall and the social and service zone circulation areas ☑
_ The bedrooms have access to a bathroom within the same private area ☑
_ All bedrooms comply with minimum area requirements ☑

Service area

_ The kitchen is accessed by circulation areas or via a living room, if it is not the only one ☑
_ The kitchen includes an eating area for light meals or is close to an eating area ☑
_ The kitchen includes a space for laundry work or has a direct link to a space reserved for this purpose ☑
_ The kitchen complies with minimum area requirements ☑

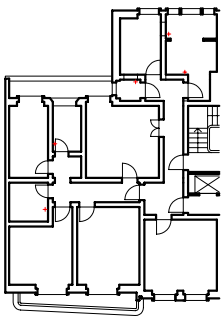
Circulation areas

_ There are at least one for alternative paths within the dwelling ☑
_ There are no obstacles to circulation within the social area ☑
_ There are no obstacles to circulation within the service area ☑
_ There are no obstacles to circulation within the private area ☑

Demolition work

_ Linear dimensions of walls demolished 5,5m

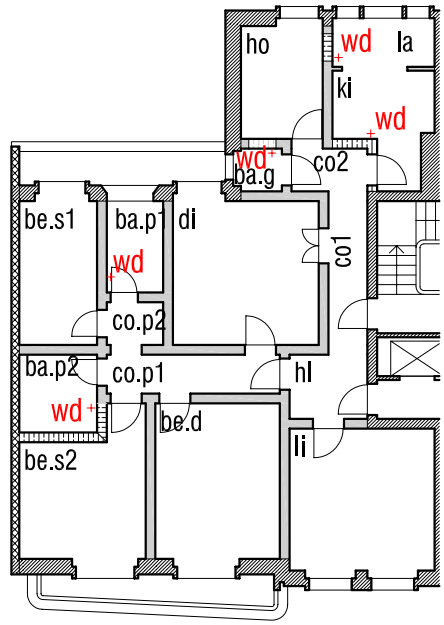
derivation: integration of ICAT



floor plan

spatial void

graphs

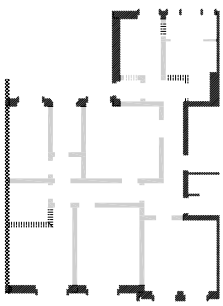


#28

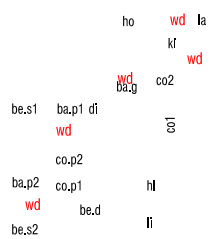
Rules 8.1a

Allocating of water detectors

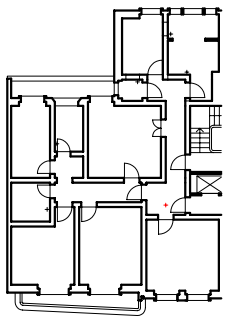
weights



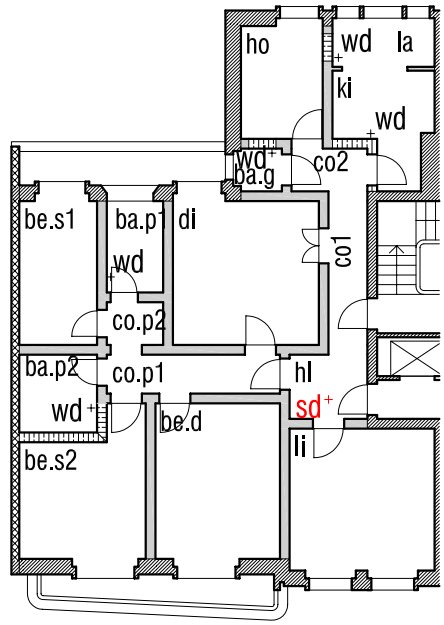
labels



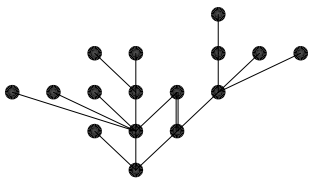
derivation: integration of ICAT



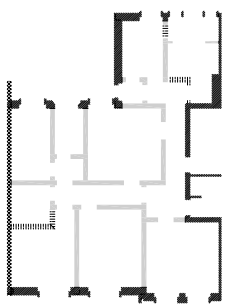
floor plan



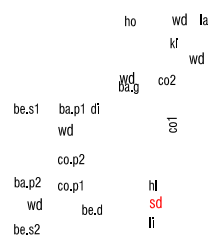
spatial void



graphs



weights



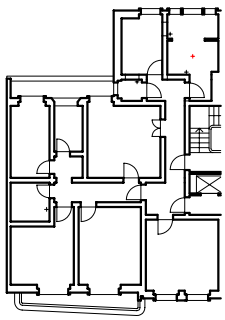
labels

#29

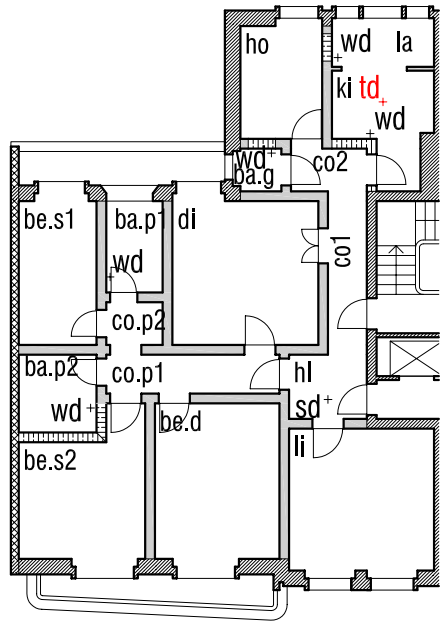
Rules 8.1b

Allocating of smoke detectors

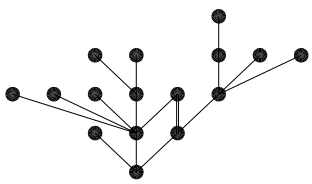
derivation: integration of ICAT



floor plan



spatial void



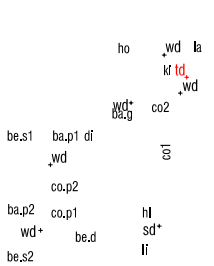
graphs

#30

Rules 8.1c

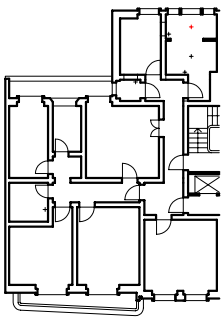
Allocating of temperature detectors

weights

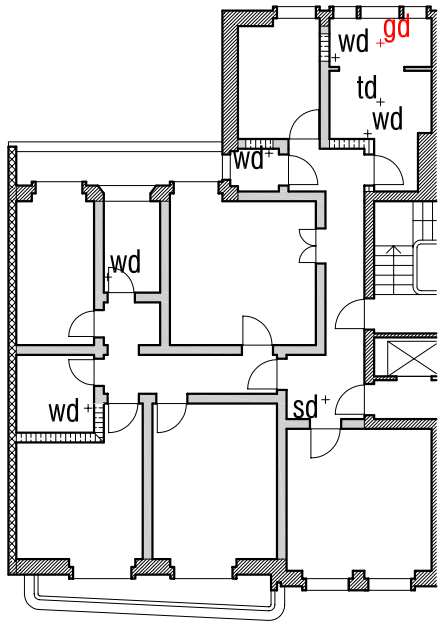


labels

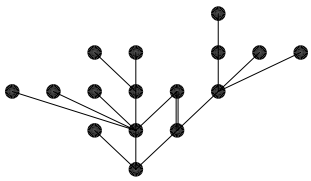
derivation: integration of ICAT



floor plan



spatial void



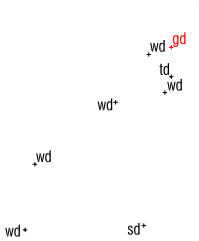
graphs

#31

Rules 8.1d

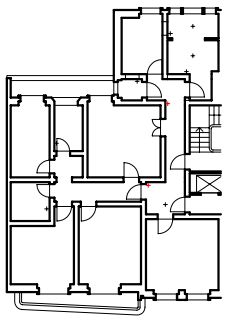
Allocating of gas detectors

weights

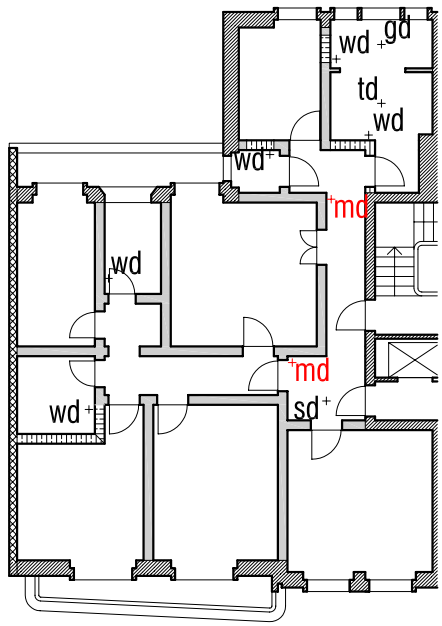


labels

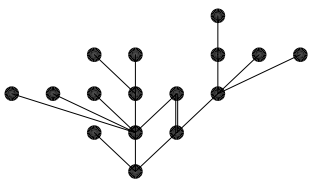
derivation: integration of ICAT



floor plan



spatial void



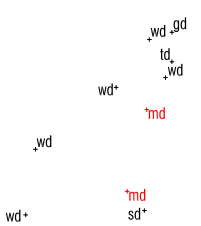
graphs

#32

Rules 8.1d

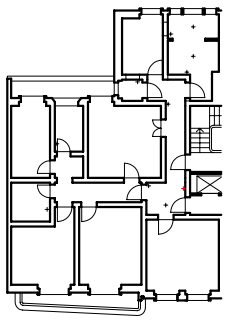
Allocating of movement detectors (for the hall and corridors with door to the exterior)

weights

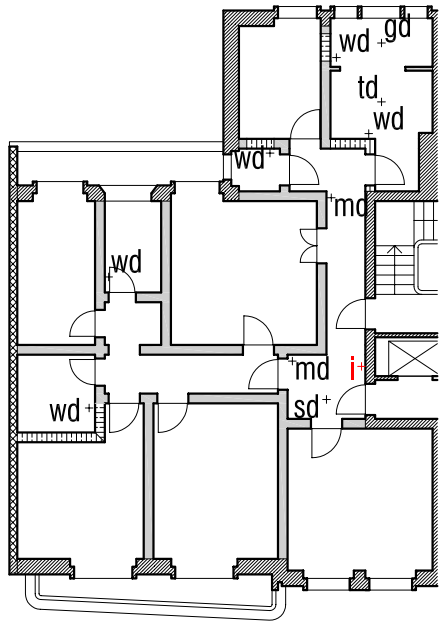


labels

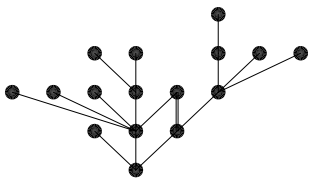
derivation: integration of ICAT



floor plan

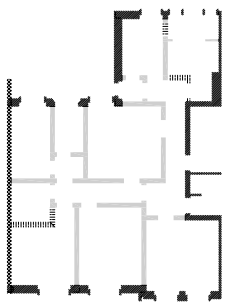


spatial void



graphs

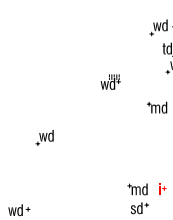
#33



weights

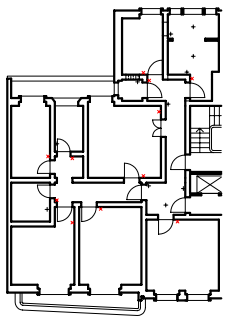
Rules 8.10a1

Allocating of interfaces: control panel

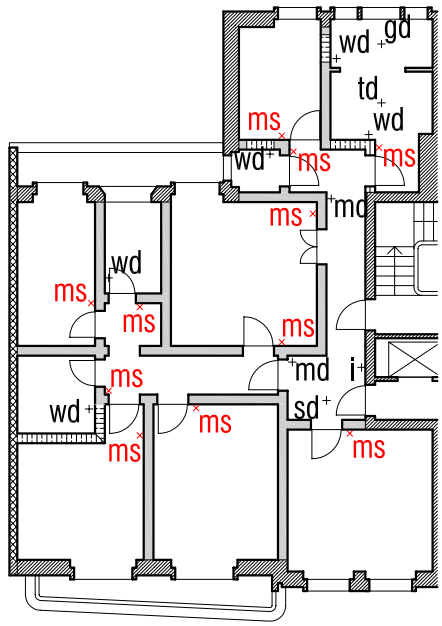


labels

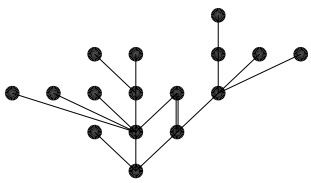
derivation: integration of ICAT



floor plan



spatial void



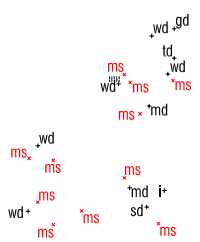
graphs

#34

Rules 8.10b1/2/3

Allocating of interfaces: mulfifunctional switches

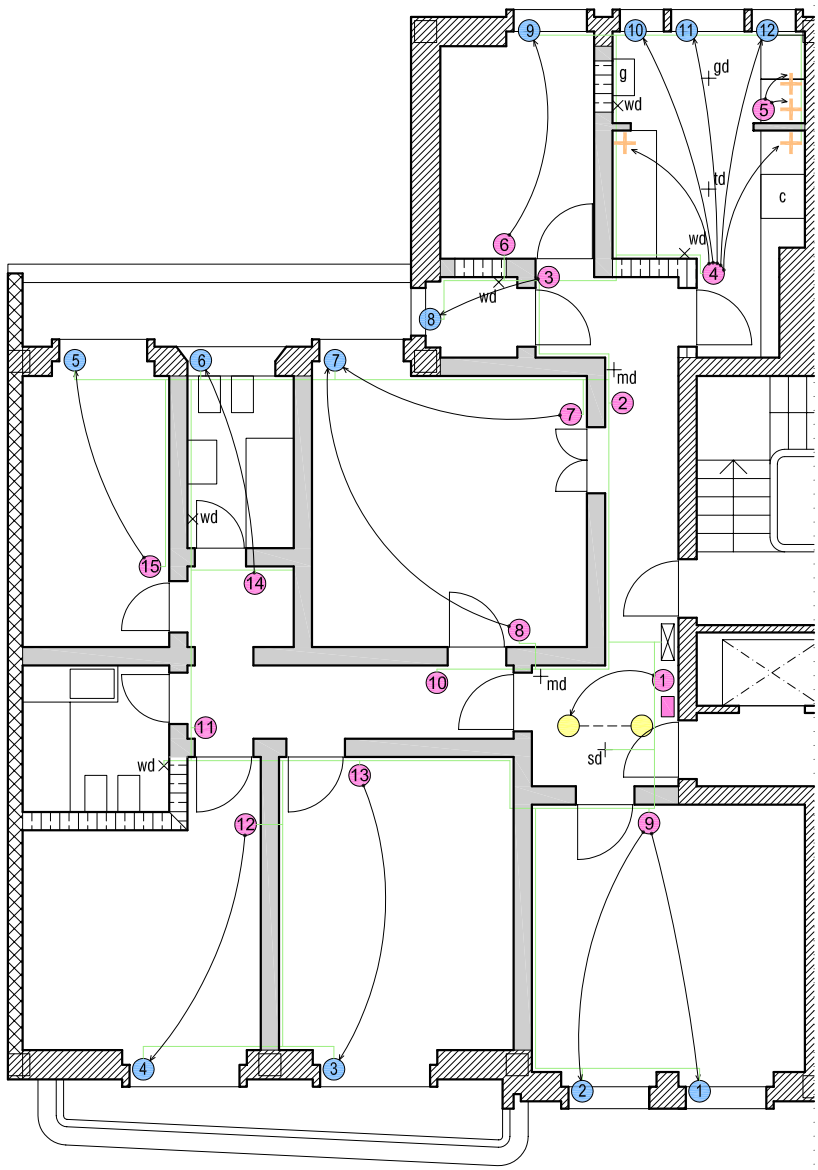
weights



labels

derivation: integration of ICAT

... final



Controlled blinds
Controlled sockets
Multifunctional switches and entry modules
Control panel
Domotic cupboard
Controlled lights
Domotic controls
Number of buttons on each control panel (e.g. 1 button)
Two buttons
Bus cable

+sd Smoke detector
×wd Water detector
+md Movement detector
+td Temperature detector
+gd Gas detector

The representation of the domotic system was adapted from (Teixeira, s.d.)

1 2 3 4 5