A generative spatial adaptation model for constrained-based housing transformations.

P4 presentation Jens C. Slagter

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27 Jan 2023

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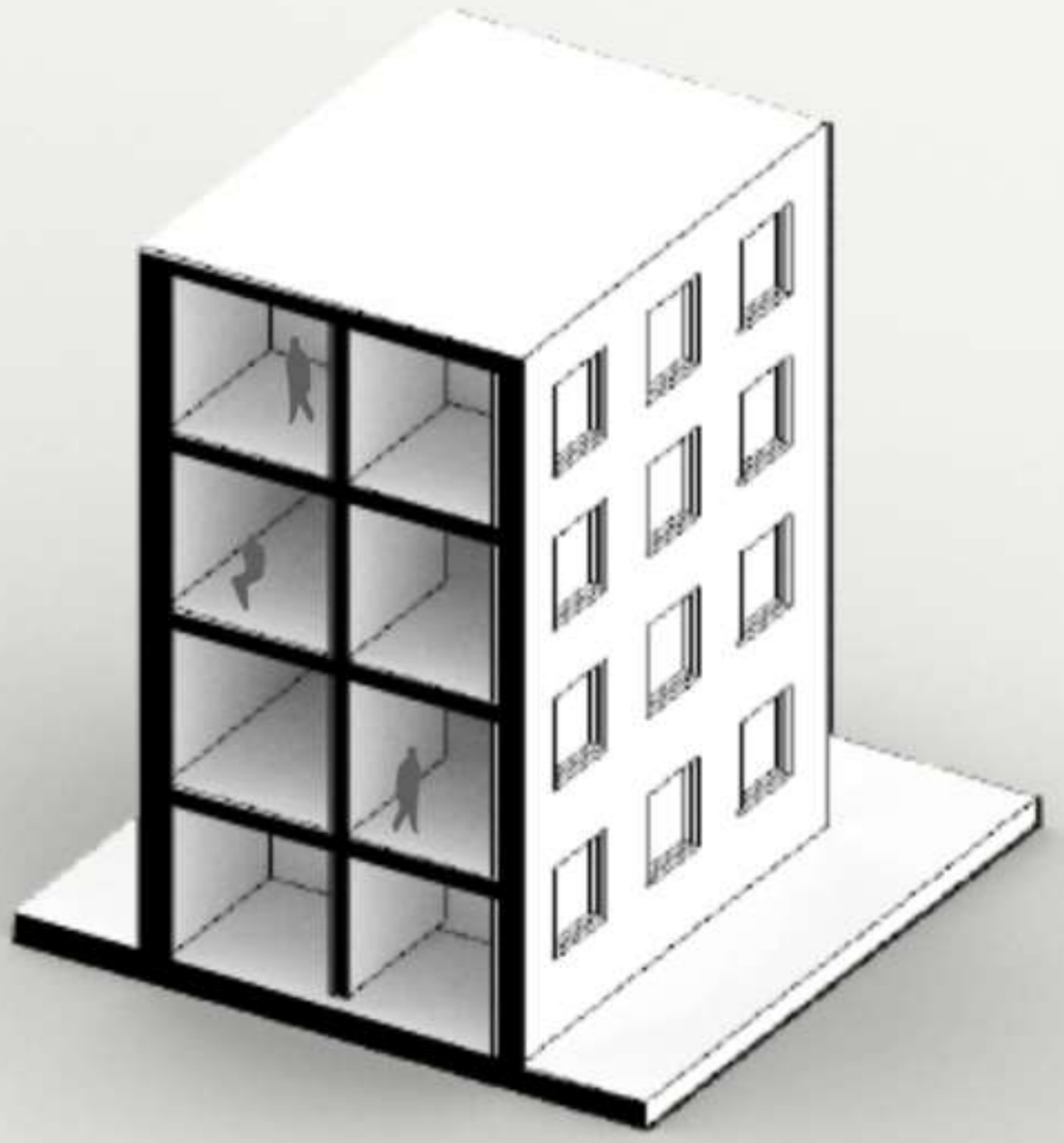

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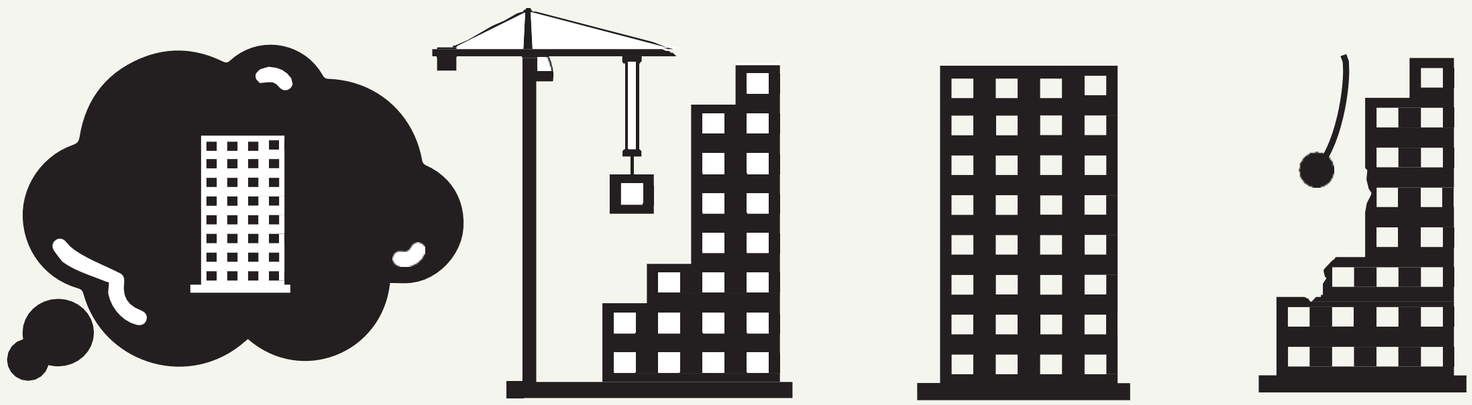
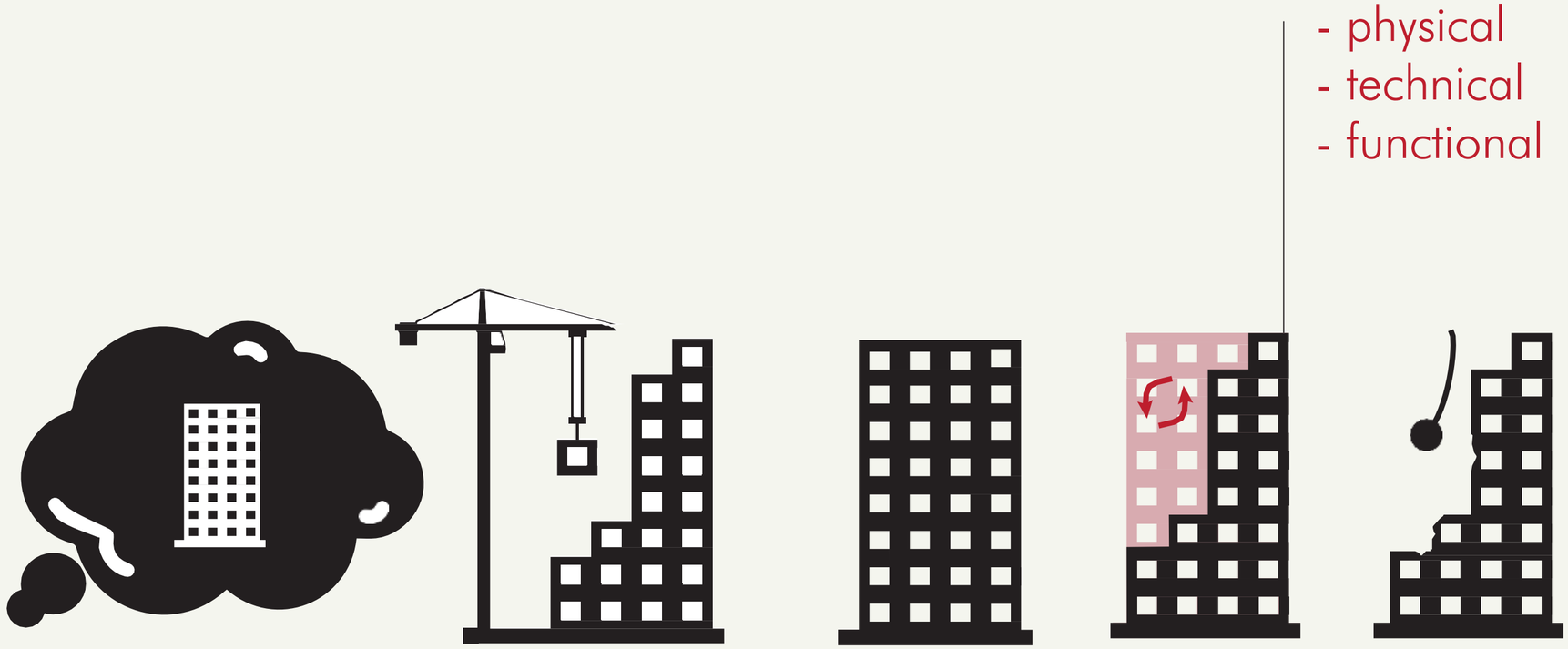


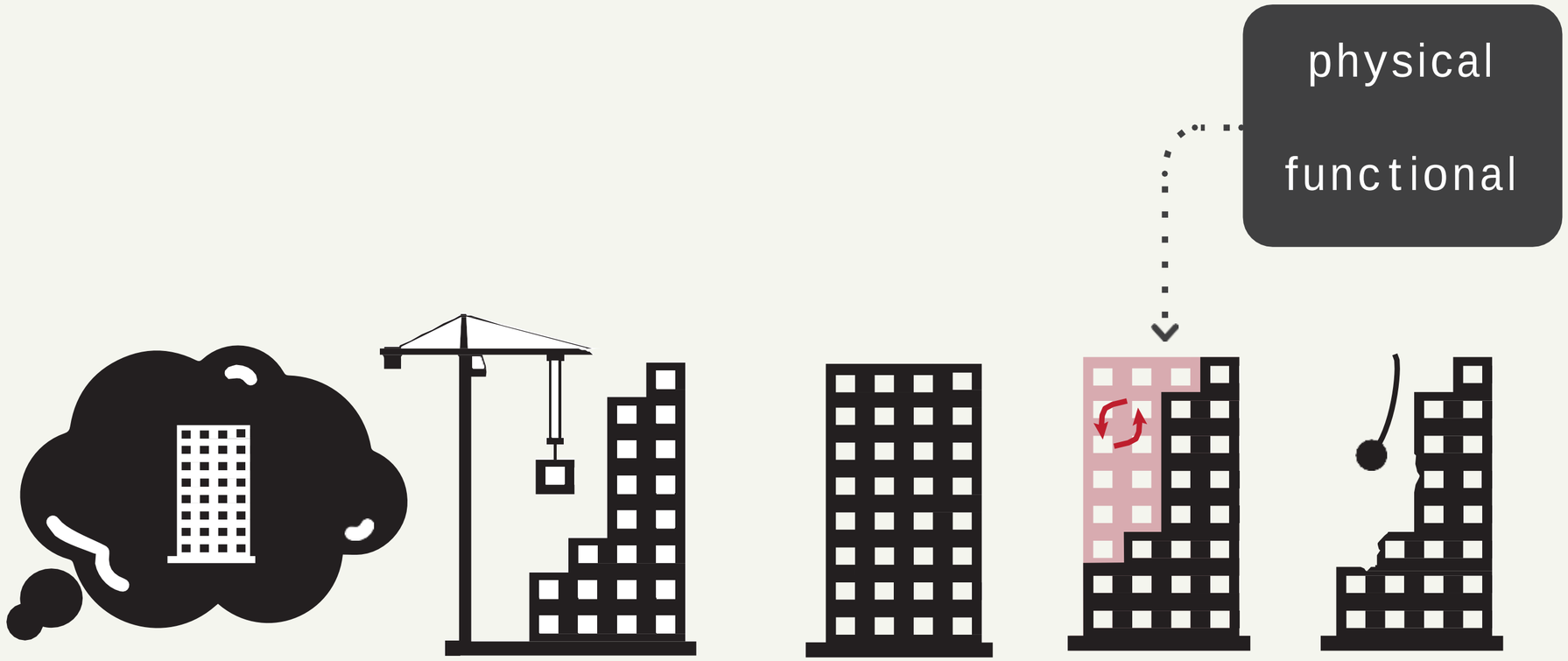
Design Construct Occupy Demolish

- physical
- technical
- functional
- social
- economic
- legal
- political

Design Construct Occupy Demolish

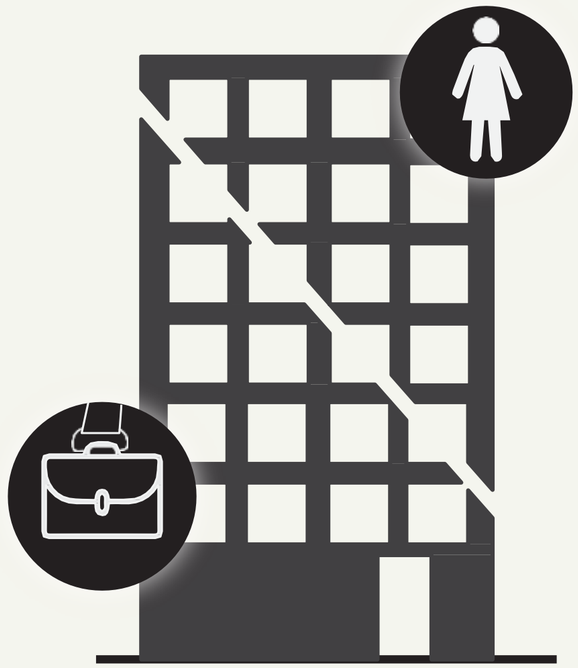


Design Construct Occupy Adapt Demolish

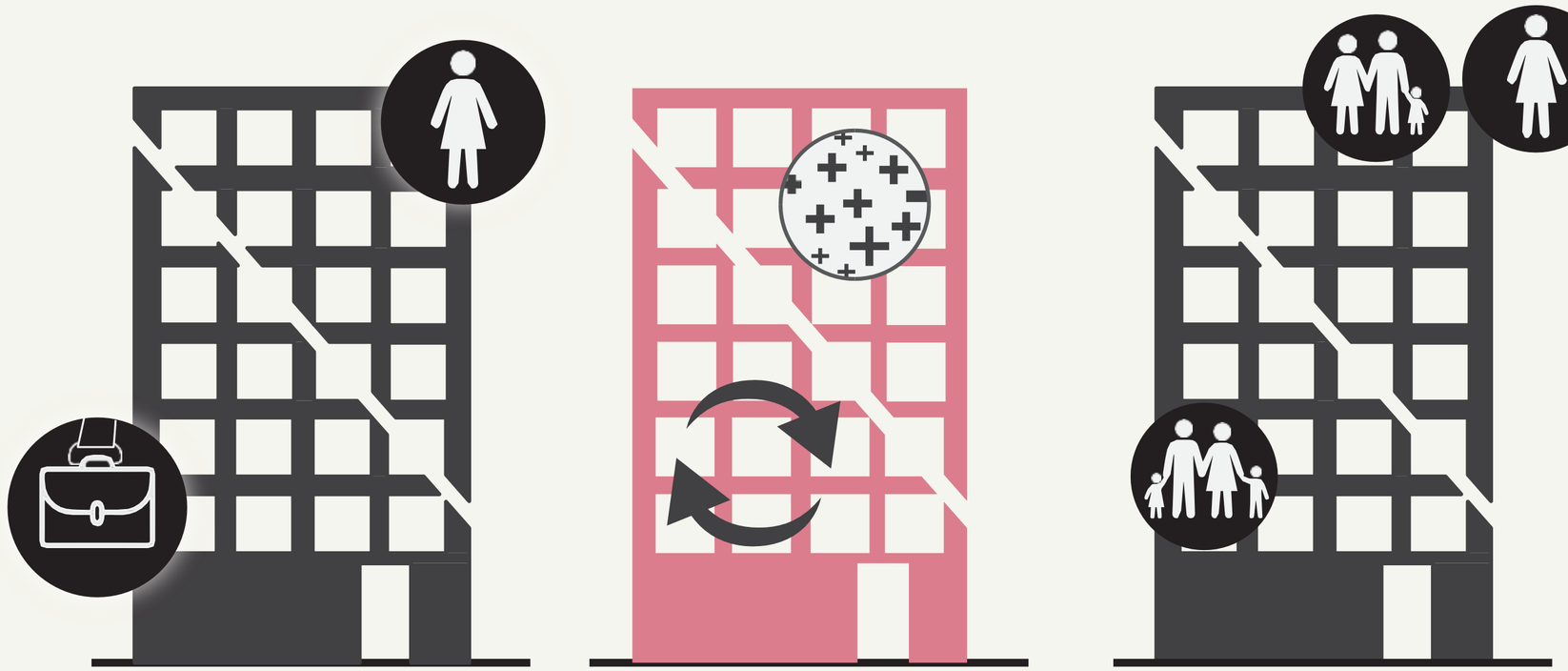


Design Construct Occupy **Adapt** Demolish

Functionally



Functionally



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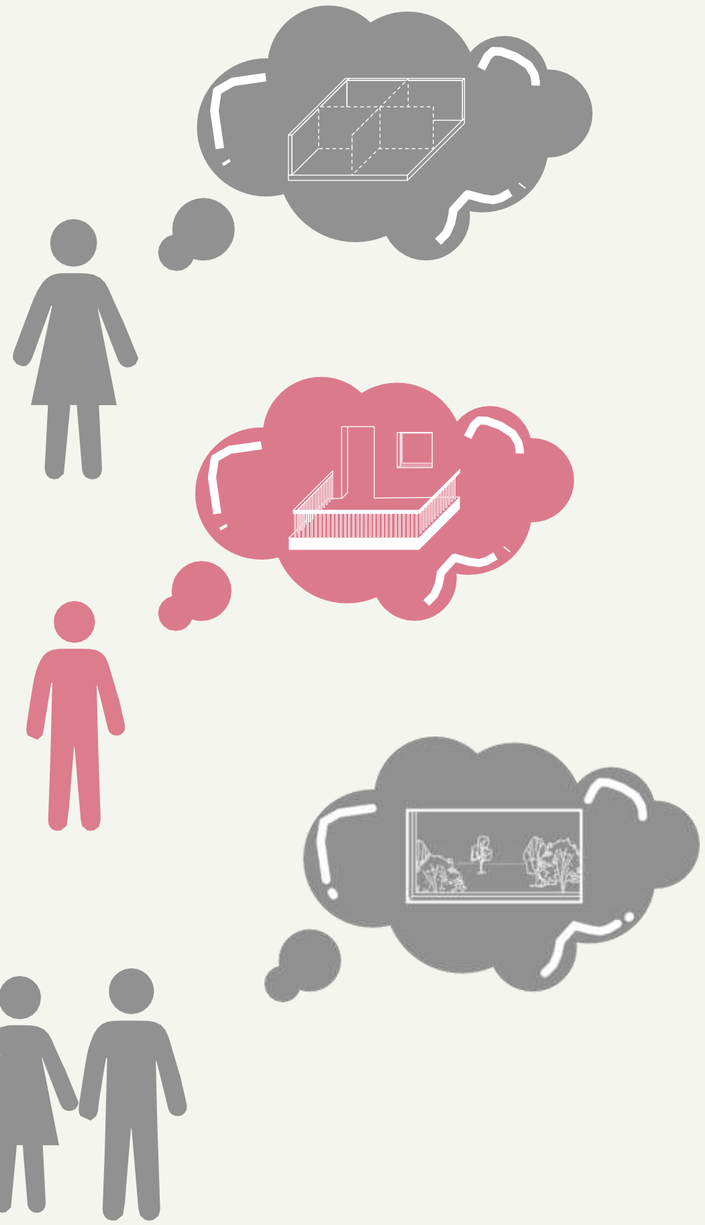
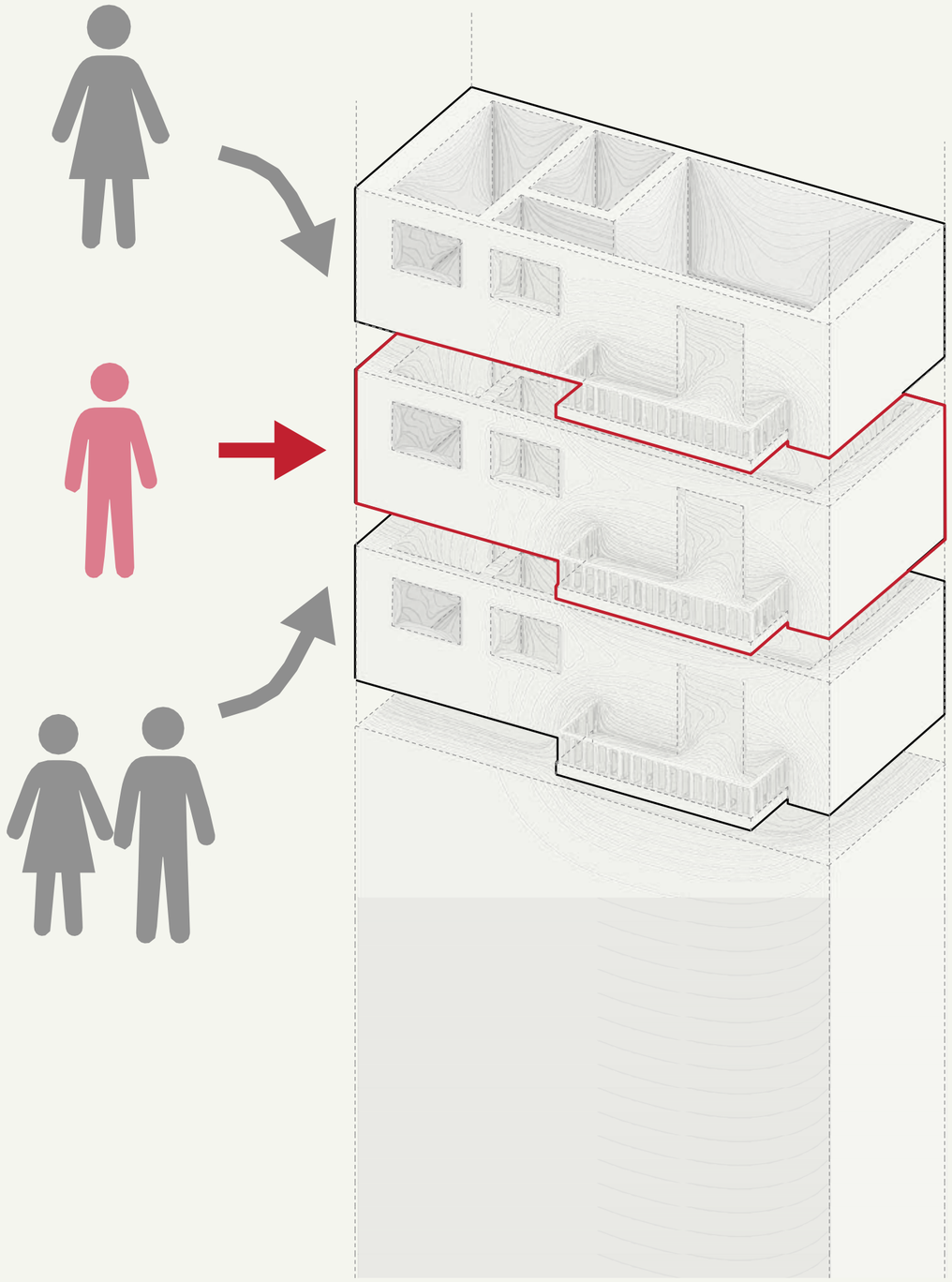


PD RQ D C

Physical



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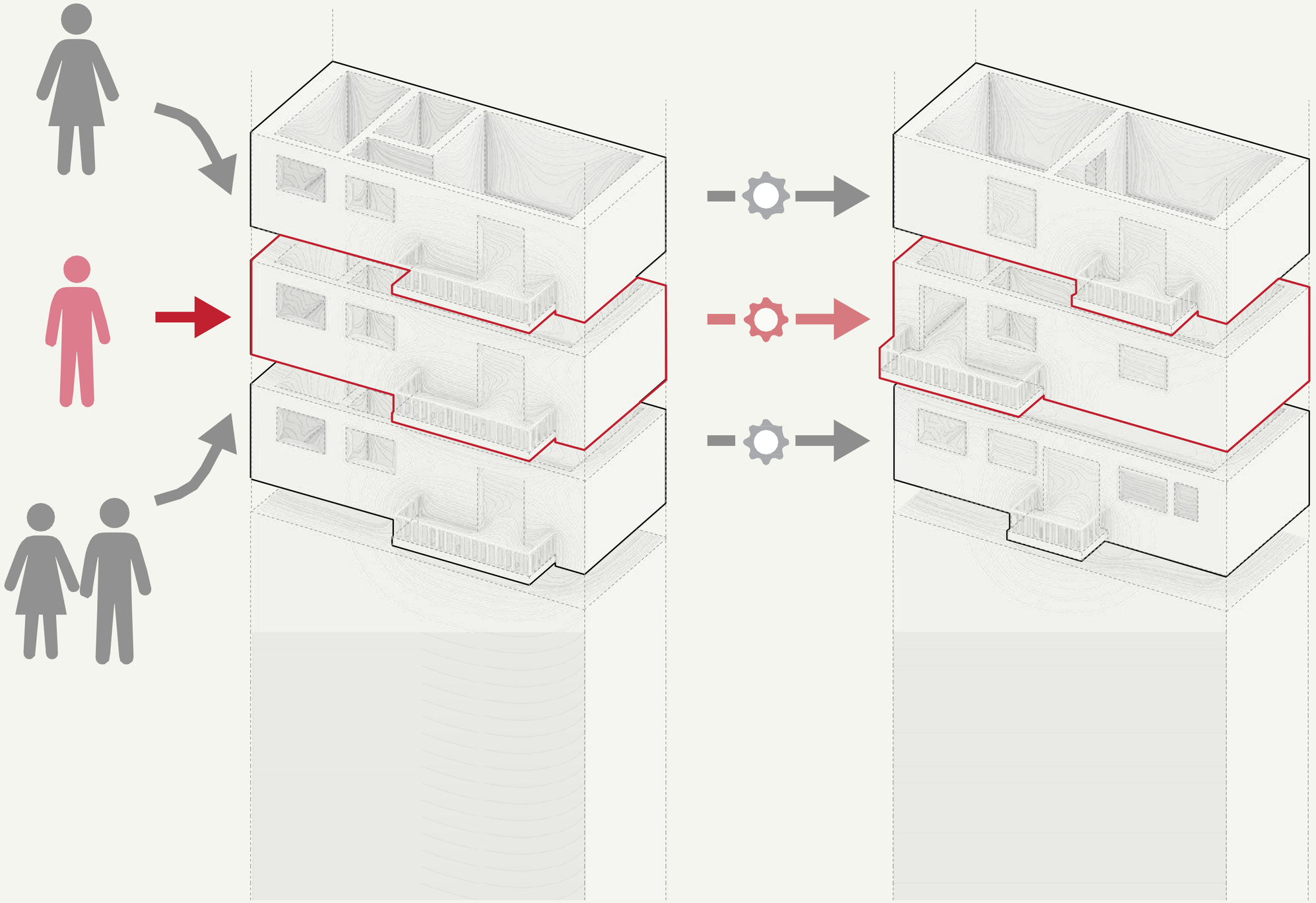


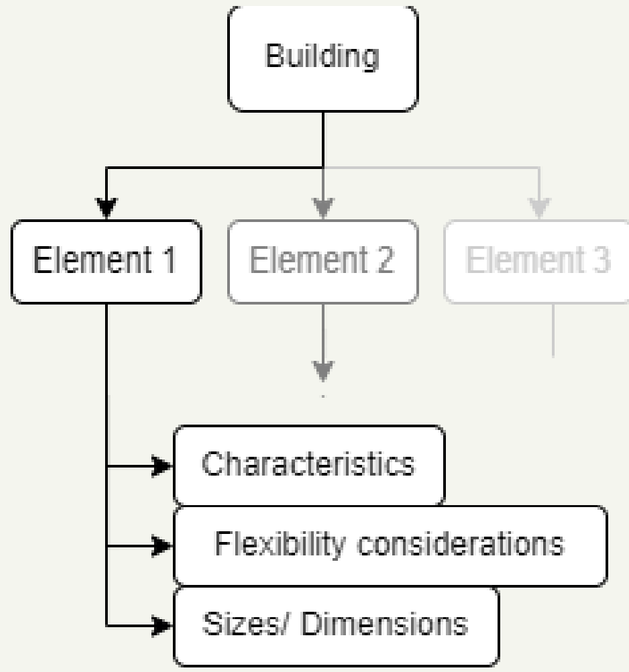
Main research question:

“How can the extent of spatial alternatives of an apartment configuration be explicated within a building **design?”**

Research question 1

what is the effect of different building elements and systems on the spatial flexibility of a layout?

Research question 2



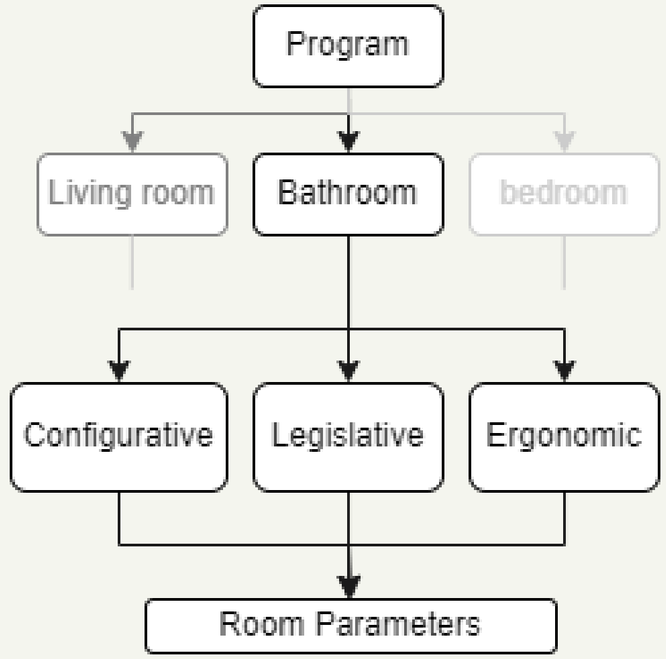
Research question 3

Research question 4

Research question 1

Research question 2

“what are the requirements and dimensions of the different spaces of an apartment and how do they relate to each other?”

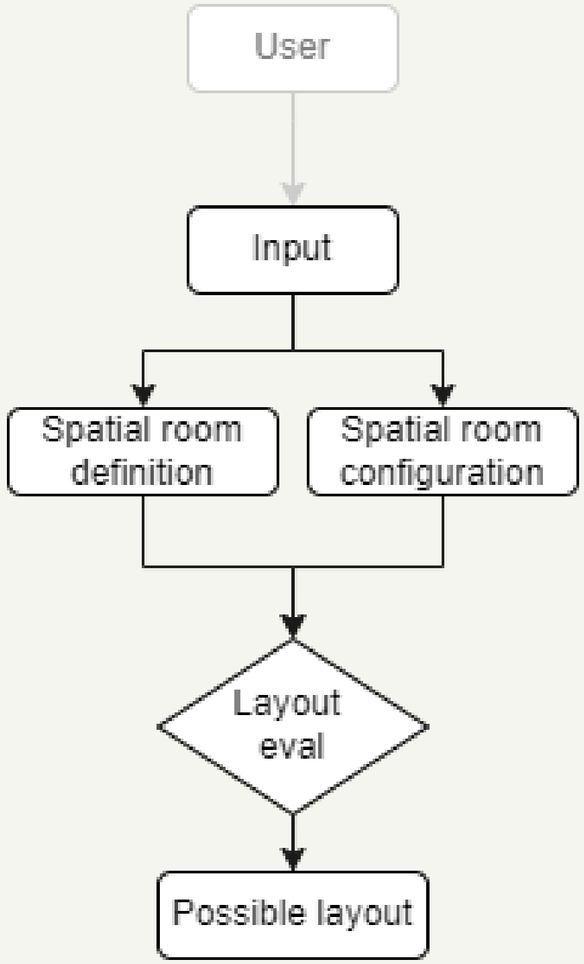


Research question 3

Research question 4

Research question 1

Research question 2

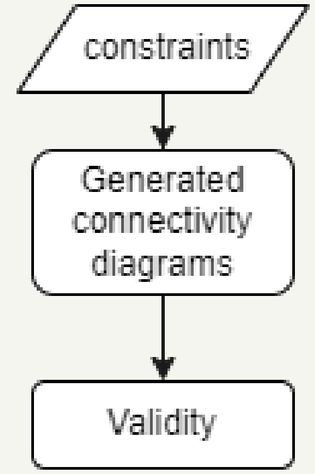


Research question 3

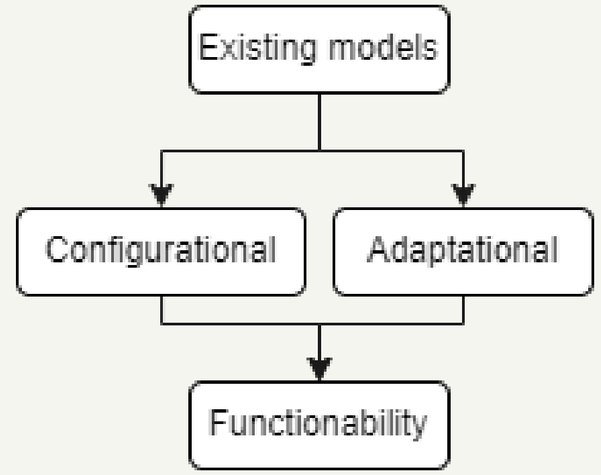
"how can all layout configurations be generated given a set of building constraints?"

Research question 4

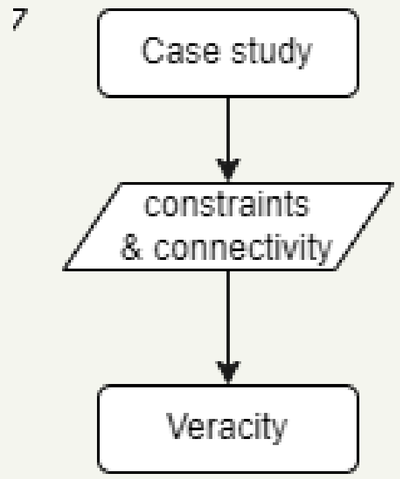
Research question 1



Research question 2



Research question 3

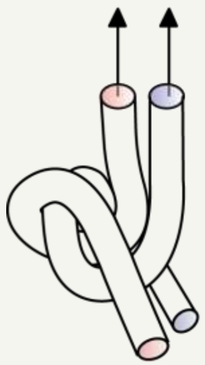


Research question 4

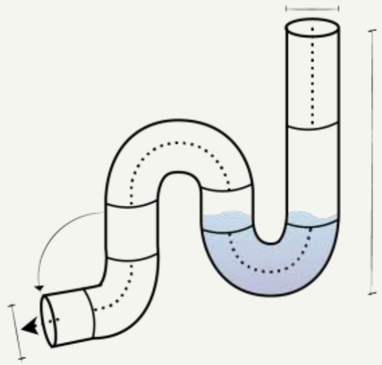
“what can be established about the usability of the new generative configuration tool for floorplan transformation?”

Building Parameters

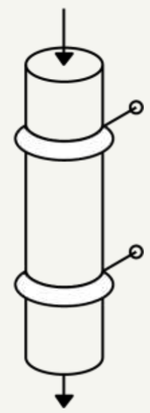
Supply Water



Water Drainage



Rain

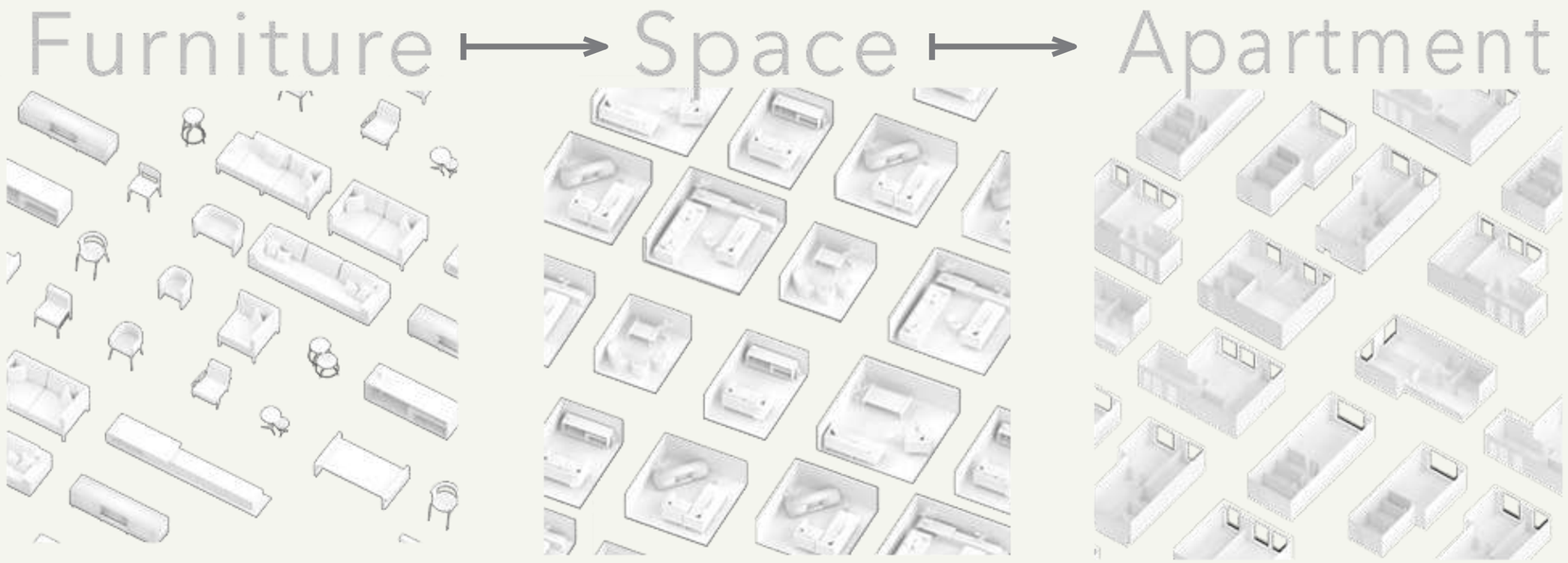


Site | Structure | Skin | Systems | Space plan

Layer Typology Concluding remarks

Site	Sunlight direction	**Not using specific sunlight** analysis from Bouwbesluit § 3.11. 10% is considered minimum for residential area so if there is a window adjacent to a residential room it is considered to be suffice
	Restrictions	For proof of concept, only regulations in regards of implementing simple health (**daylight**) and installations (**water drainage**) guides will be used.
Structure	Materials	The choice to use a sustainable material that can be used in a panel structure has resulted in the choice for **LVL timber.** This makes it easier to cut holes and connect sub-structure
	General Construction typology	The project will only regard the **panel structure**. Other methods do not provide constrains (skeleton/fixed core) or to many constrains (Unit/hybrid) to facilitate different outcomes.
	Grid (main & sub)	Only the position of the **main load-bearing structure** is taken into account. Therefore the grid is used to identify and to relocate the rest of the space-plan. For further details see section (space-plan: load-bearing)
	Access	**Gallery apartments,** due to their 2 sided facades per apartment. This makes the rules for configuration more interesting and more flexible
Skin	Placement openings	For the development of the concept, the openings can be **(re)placed anywhere** on the façade of the building.
Services	Water	Supply of hot and cold water is relatively easy and will therefore not be discussed. However, the adaptability of the **sewage/drainage** will be looked into.
	Lighting	Artificial lighting is considered to be placed in every room. **Daylight** is taken into consideration by rule of thumb (see section site:sunlight).
Space-plan	Apartment diversity	Typology **PMC 6** is considered to be the starting apartment.
	Program	The program consist of the **spaces according to the apartment type**. The new program is in line with the same and other typologies
	Walls	Infill walls are considered to be fully demountable. S**mall modifications in the structural walls are possible** in the form of door openings.
	Openings	Windows, doors and openings can be made in **any wall at any place.**

Spatial Parameters

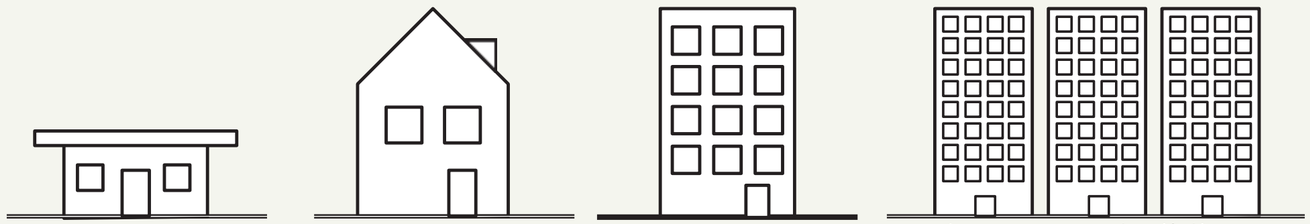


Ergonomics/
Anthropology

Legislation
Program

Configuration

Typology



Occupants

Financials

€	€€	€€€	€€€€
< 24.075	24.075	32.675	> 32.675

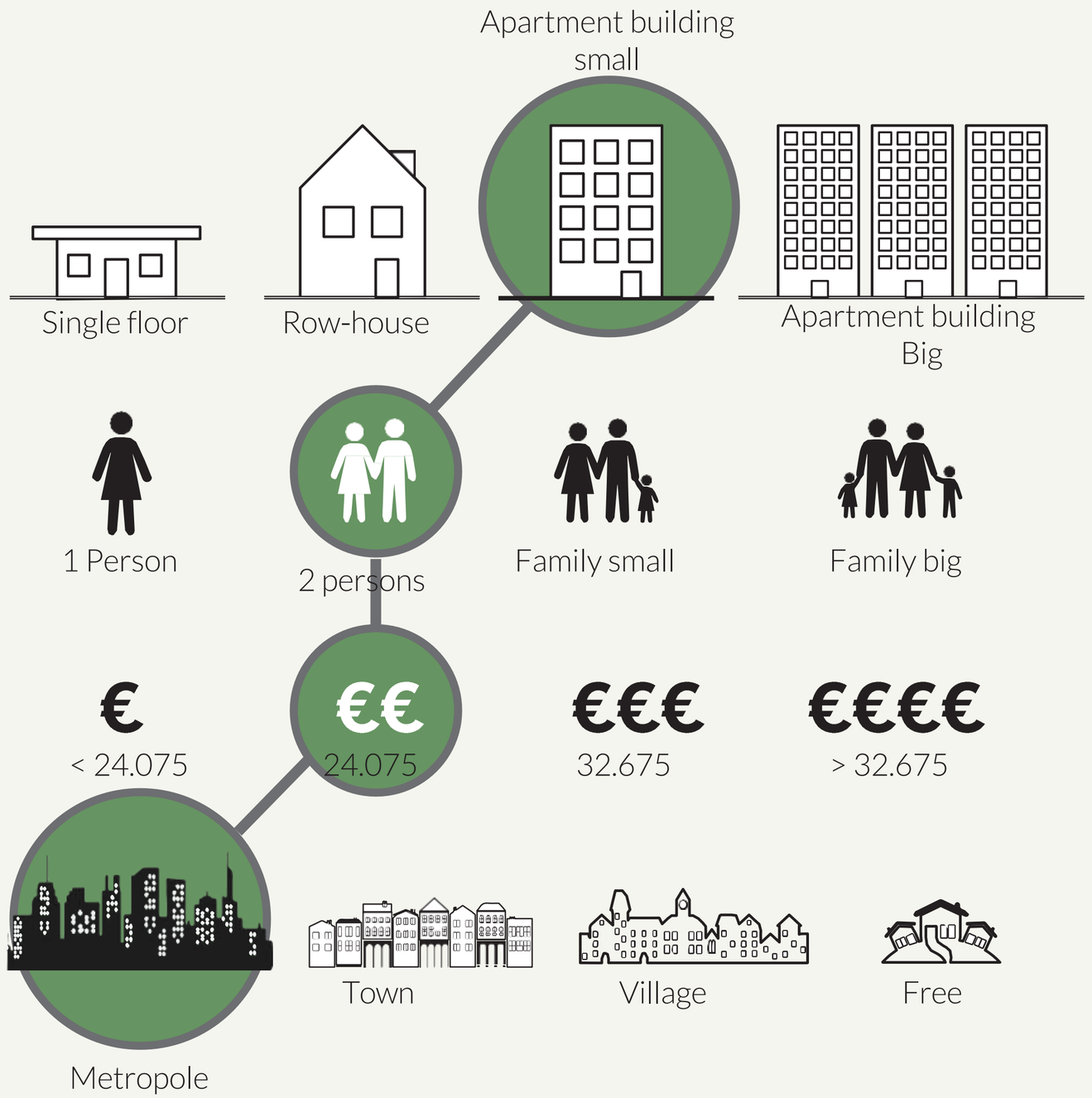
Location

Typology

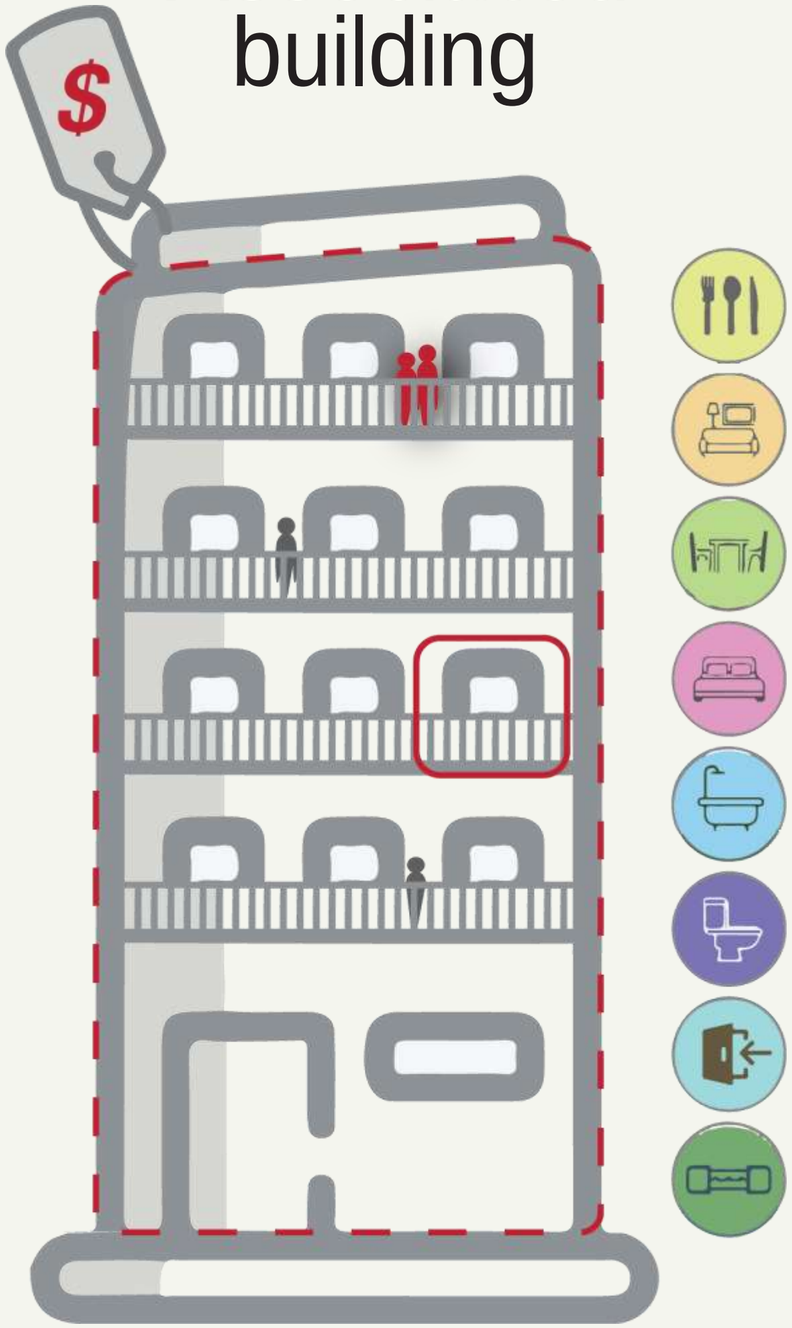
Occupants

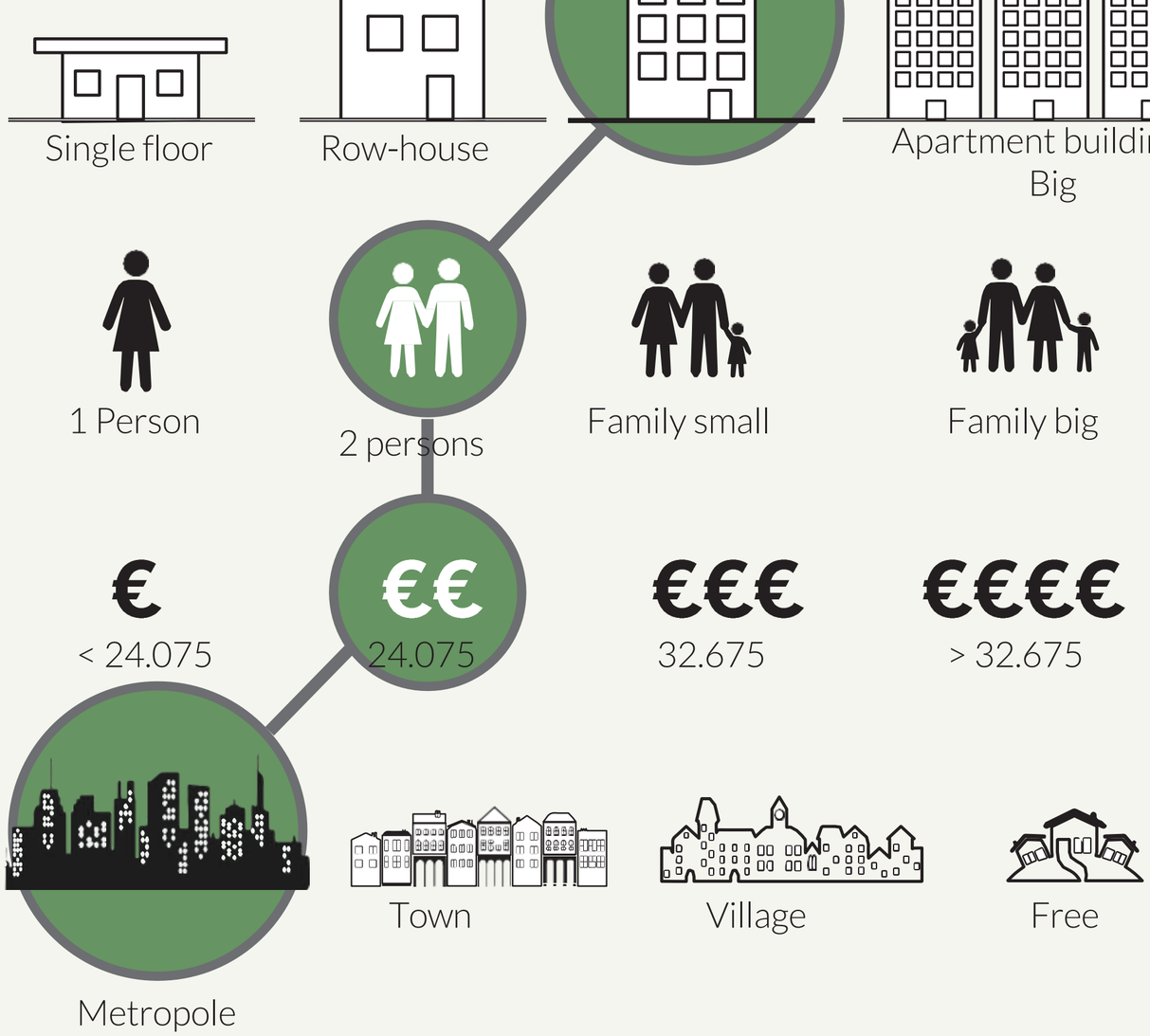
Financials

Location

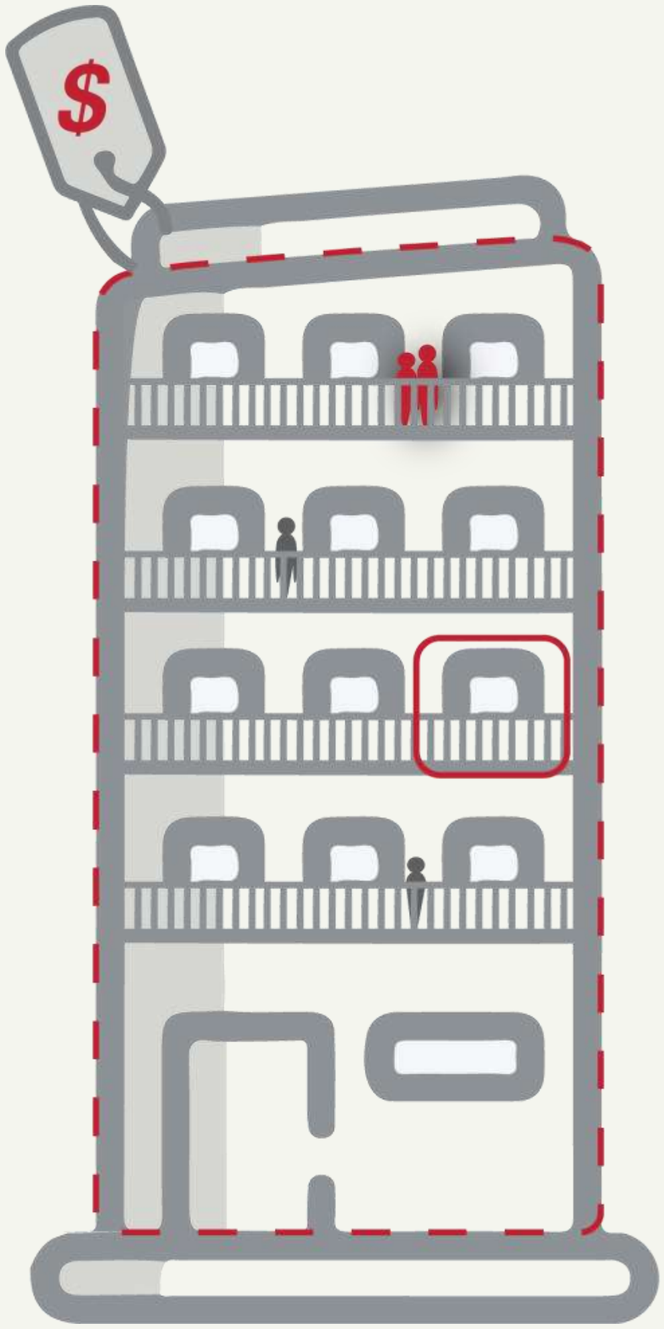


Associated building





Toolbox conceptueel bouwen. (2022, February 10). NCB. https://www.conceptueelbouwen.nl/toolbox

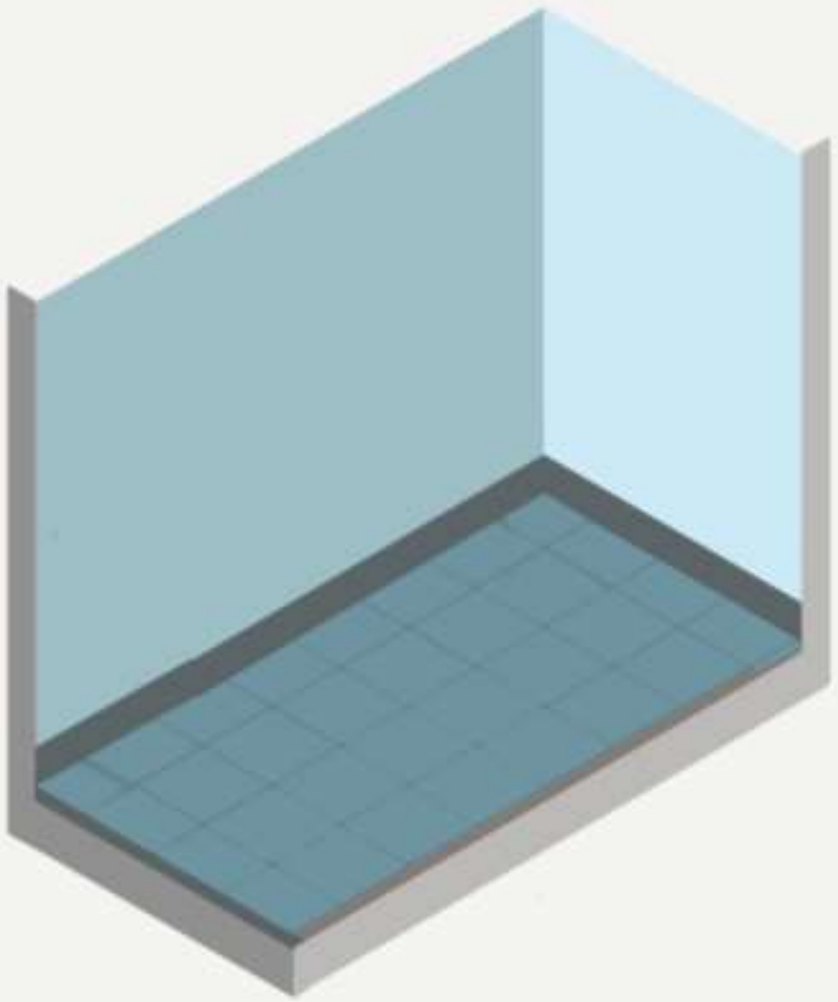


	Dimensions	Configurative	Legislative	Ergonomics
	Kitchenette + sink : Depth = 0,6 [m] Length = 1 [m] **Stove :** Depth = 0,6 [m] Length = 0,6 **Fridge :** Depth = 0,6 [m] Length = 0,8 **Advised (min.) length kitchen = 3 [m]**	In connection with livingroom & hallway Rooms to be connected to: **Dining space** - Adjacent (Open or closed connection) Traffic ar ea only for **dining room**	Daylight: **Yes** (so in 'open' connection with façade) Water dr ainage: **2x** Drainage is needed for sink: 50 [mm] Drainage is needed for dishwasher: 50 [mm]	Usable space: **0,9 [m]** in fr ont of kitchen block
	Staying area: minimal 3 [m] x 3 [m] Minimal total size = 11 [m2]	Rooms with possible connection: **Dining room** - Inside or Adjacent (open/closed connection) Traffic ar ea: Everything outside 3 x 3 [m]	Daylight: **Yes** Water dr ainage: **0** Minimal floor ar ea = 11 [m2] Minimal floor width = 3 [m]	Place for TV + table: 55 [cm] wide x 30 [cm] deep Place for coffee- table Place for sofa and or chair: 2 x 1,2 Aver age distance between tv and couch: 2 [m]
	Dinner table: At least 1,2 x 0,9 [m] Minimal estimated space: 1,4 x 2 [m]	Rooms to be connected to: **Kitchen** - Adjacent (open or closed connection) Rooms with possible connection: **Living room** - Adjacent (open or closed connection) Traffic ar ea e verything e xcept 1,50 x 1,10 [m]	Daylight: **Yes** Water dr ainage: **0**	Size table = 1,2 x 0,9 Space to sit and leave table = 0,5 [m] At least 2 sides of table should be accessible
	Bed: 1,4 [m] x 2 [m] **Wardrobe:** 0,5 [m] x 0,4 [m] **Minimal estimated area: 9,5 [m2]**	If more than 1 bedroom > tra ffi c area = None Rooms to be connected to: **Bathroom** - Adjacent (Closed connectio Rooms with possible connection: **Living room** - Inside or Adjacent Traffic ar ea only for bathr oom Traffic ar ea only for balcony	Daylight: **Yes** Water dr ainage: **0** Minimal 1,85 [m] wide Minimal 5 [m2]	0,6 [m] to get in and out of bed (and place for nightstand) 0,9 [m] depth for a closet + 0,6 [m] to walk in fr ont 1,4 x 2 [m] for a small bed 0,5 x 0,4 [m] (2) for a war drobes If more than 1 bedroom > one bedroom can have bed of 0,8 x 2 [m] and 1 wardrobe
	Shower: 0,9 [m] x 0,9 [m] **Sink:** 0,6 [m] wide x 0,45 [m] deep **Minimal area: 1,215 [m2]** Minimal length = 0,9 [m] = **1,5 [m]** Minimal depth = 0,9 + 0,45 [m] = **1,35 [m]**	If amount of bedroom > 1: Sinksize increases for use of 2 persons (1,15 [m] wide). This also means minimal area grows to 1,9 [m2] If amount of bedroom > 1: No rooms with possible connections and bedroom is not adjacent. Rooms to be connected to: **Bedroom** - Adjacent (Closed connection) Rooms with possible connection **Toilet** - inside Traffic ar ea: **none**	Daylight: **No** Water dr ainage: **2x** Drainage is needed for sink: 50 [mm] Drainage is needed for sho wer: 50 [mm]	If amount of bedroom > 1: Sinksize increases for use of 2 persons (1,15 [m] wide) 0,9 [m] to get in and out of the sho wer 0,6 [m] to stand befor e the sink Cabinets can be placed underneath the sink
	Toilet : Depth = 0,6 [m] width = 0,4 [m] **Advised (min.) L x W toilet = 0,6 x 0,4 [m]**	Rooms to be connected to: (1 of the 2) **Hallway (1)** - Adjacent outside (Closed connection) **Bathroom (2)** - Inside (not if >1 bedr oom) Traffic ar ea: **none**	Daylight: **No** Water dr ainage: **2x** Drainage is needed for sink: 50 [mm] Drainage is needed for toilet: 100 [mm] Minimal size r oom: **0,9 x 1,2 [m]**, If wheelchair access: 1,65 x 2,2 [m]	Space in fr ont of toilet: included in dimensions section. space in fr ont of sink: included in the minimal size room.
	If wheelchair: minimum 1,5 x 1,5 [m]	Rooms to be connected to: **Front door** - Adjacent (Closed connection) Traffic ar ea for **whole apartment**	Daylight: **No** Water dr ainage: **0x** Minimal size r oom: 0,85 [m] wide	0,85 + 0,3 [m] for closing door.
	Minimal size W xD = 750x310 [mm]	Rooms to be connected to: **Front door** - In connection with Traffic ar ea: **None**	Daylight: **No** Water dr ainage: **0x** Maximum distance fr om fr ont door = 3[m]	None

Neufert, E., Kister, J., Lohmann, M., Merkel, P., & Brockhaus, M. (2021b). Bauentwurfslehre: Grundlagen, Normen, Vorschriften. Springer Publishing.

Bouwbesluit

Haak, A. J. H., & Leever-van der Burgh, D. (1980). De menselijke maat; een studie over de relatie tussen gebruiksmaten en menselijke afmetingen, bewegingen en handelingen.

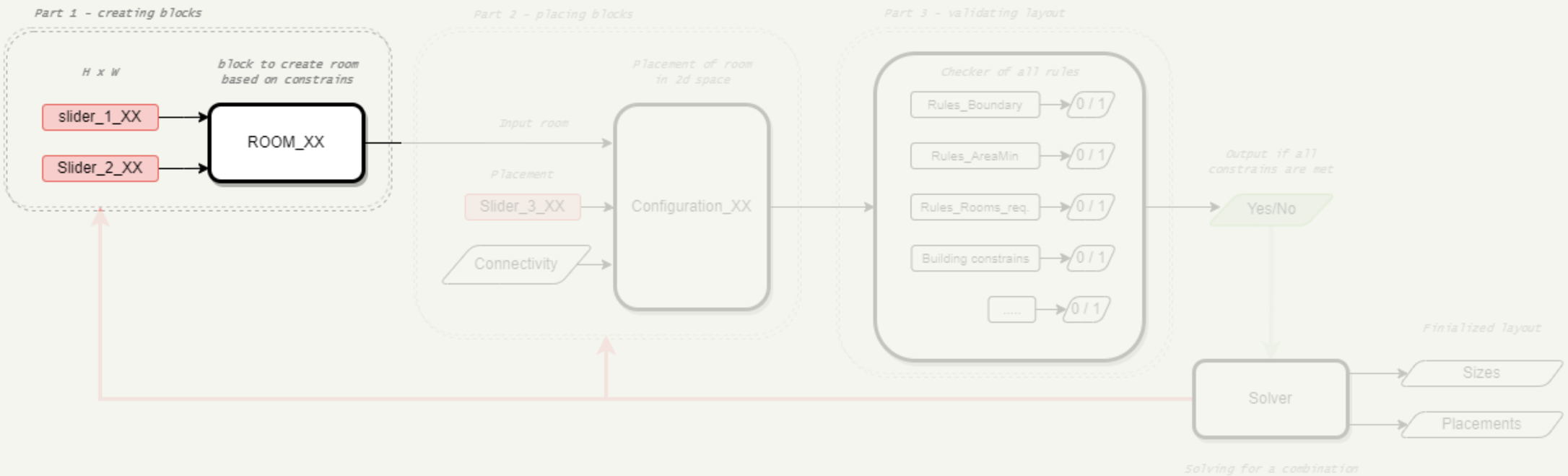


Model Assembly

Part 1
Space Definition

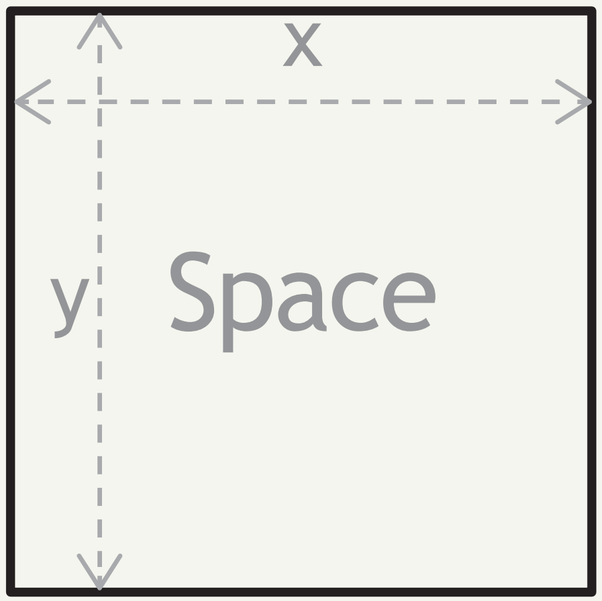
Part 2
Space Configuration

Part 3
Layout evaluation



Part 1

Space Definition



Width $= \{x \in R :$ width min $\leq x \leq$ indicative max $\}$
Lenght $= \{x \in R :$ length min $\leq x \leq$ indicative max $\}$
‘ Lenght x Width should be possible combinations

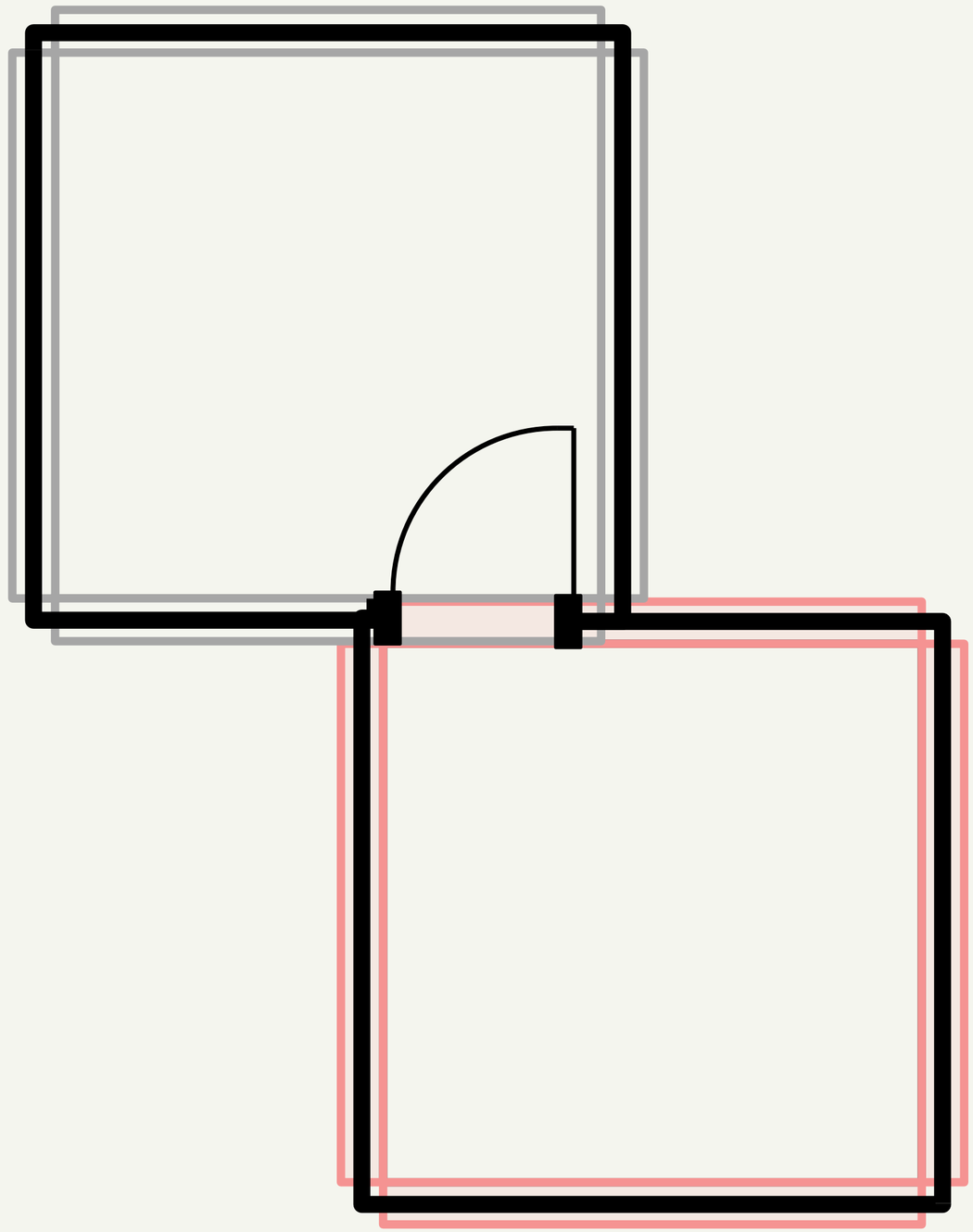
Part 1

Space Definition

Offset edges with 100 [mm]

Part 1

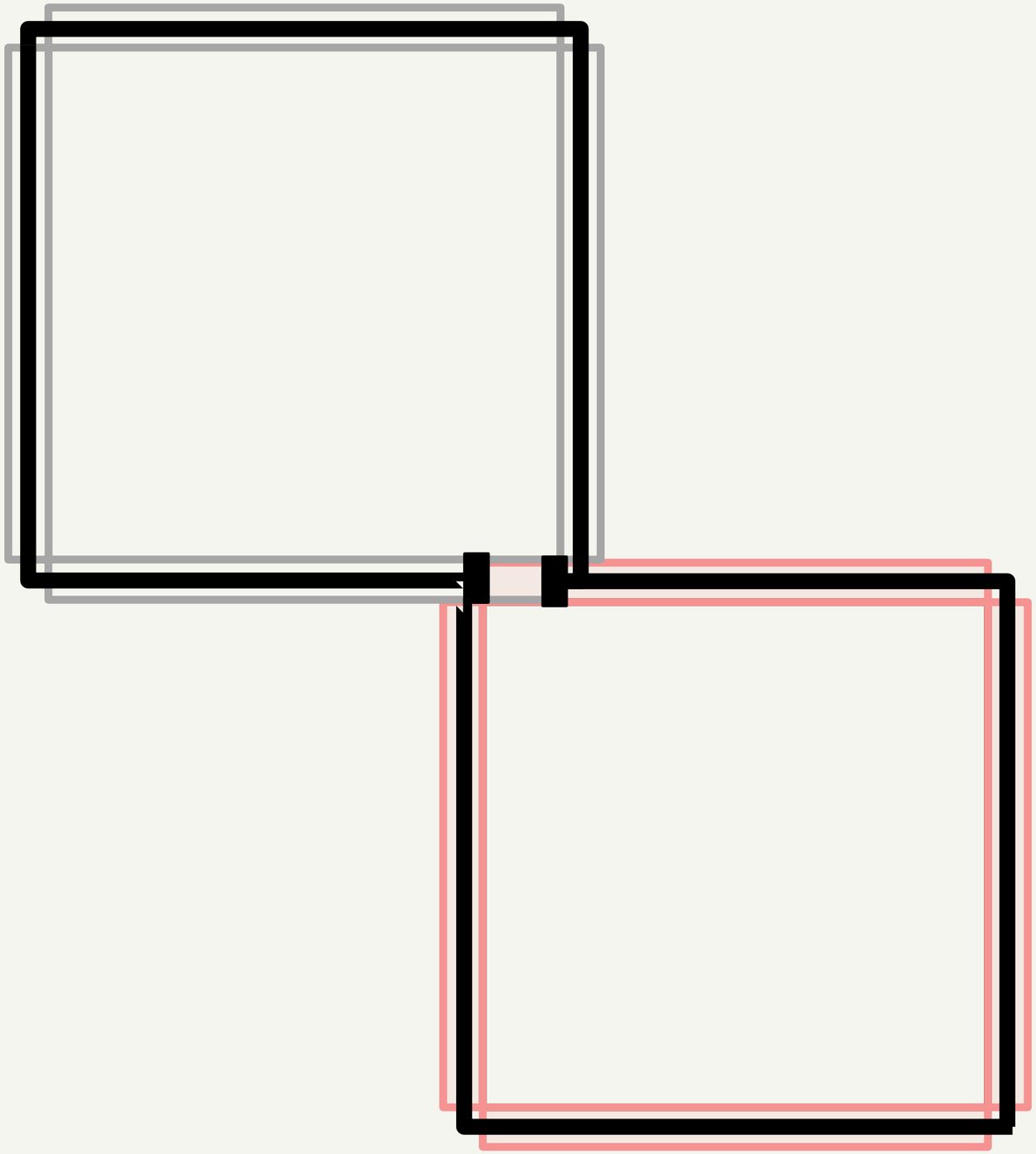
Space Definition



Offset edges with 100 [mm]

Part 1

Space Definition



Offset edges with 100 [mm]

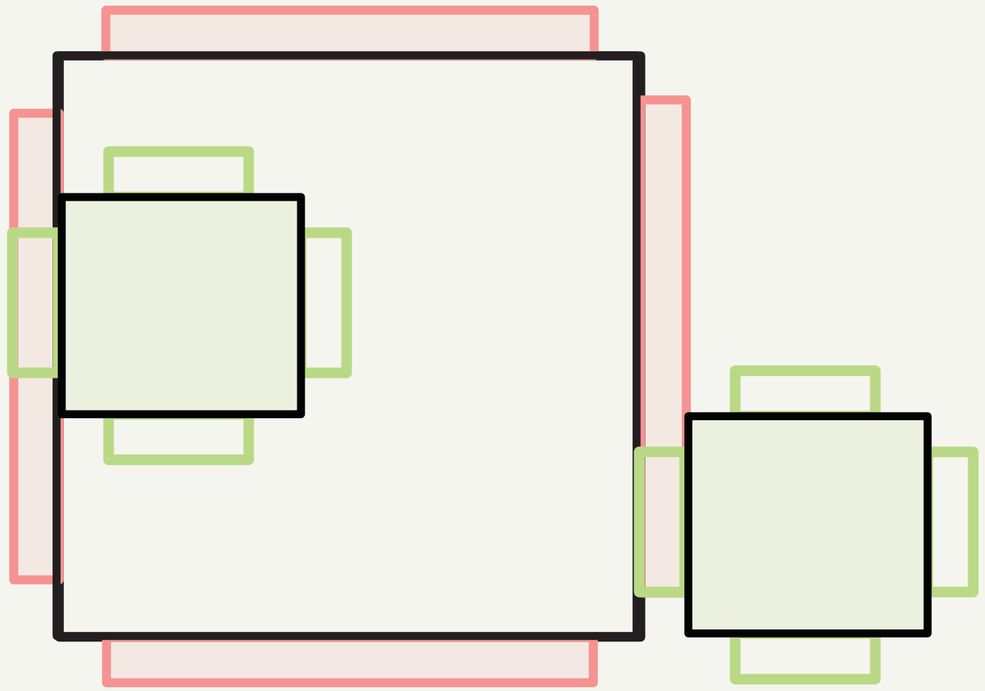
Part 1

Space Definition

Narrow length of connectivity area with 400 [mm]

Part 1

Space Definition



Define what spaces are allowed to be inside

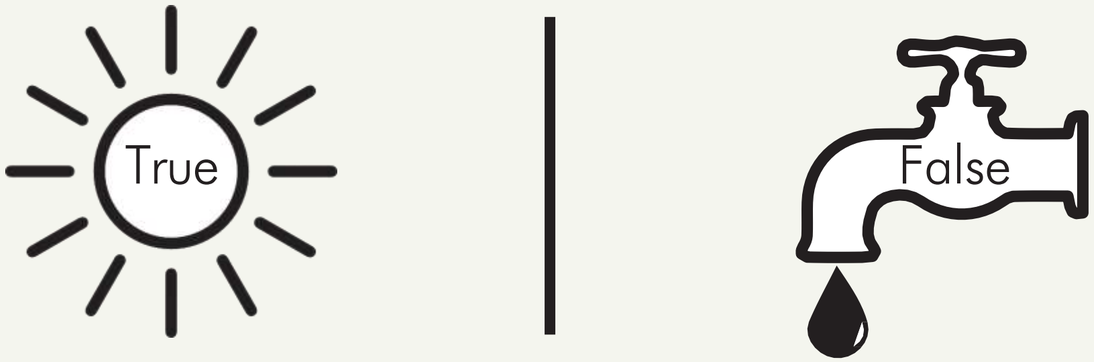
Toilet - Bathroom

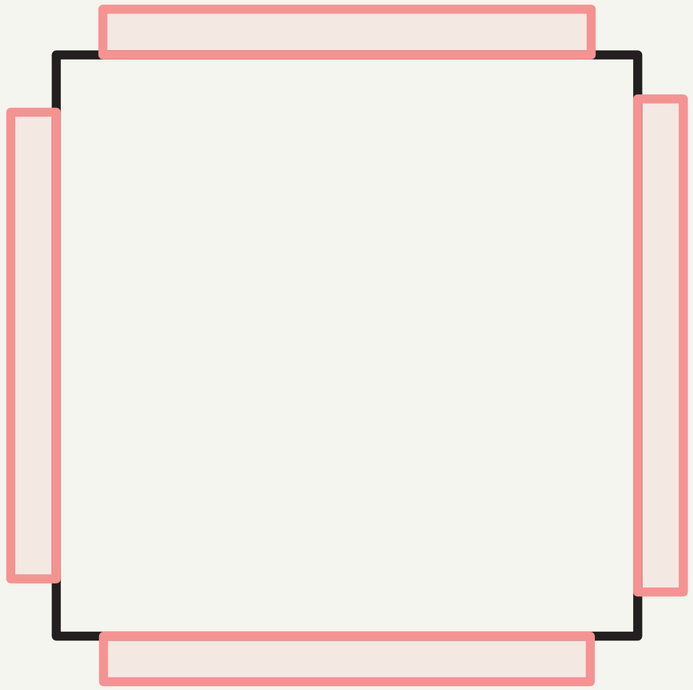
Living room - Dining room

Fusebox - Entry

Part 1

Space Definition

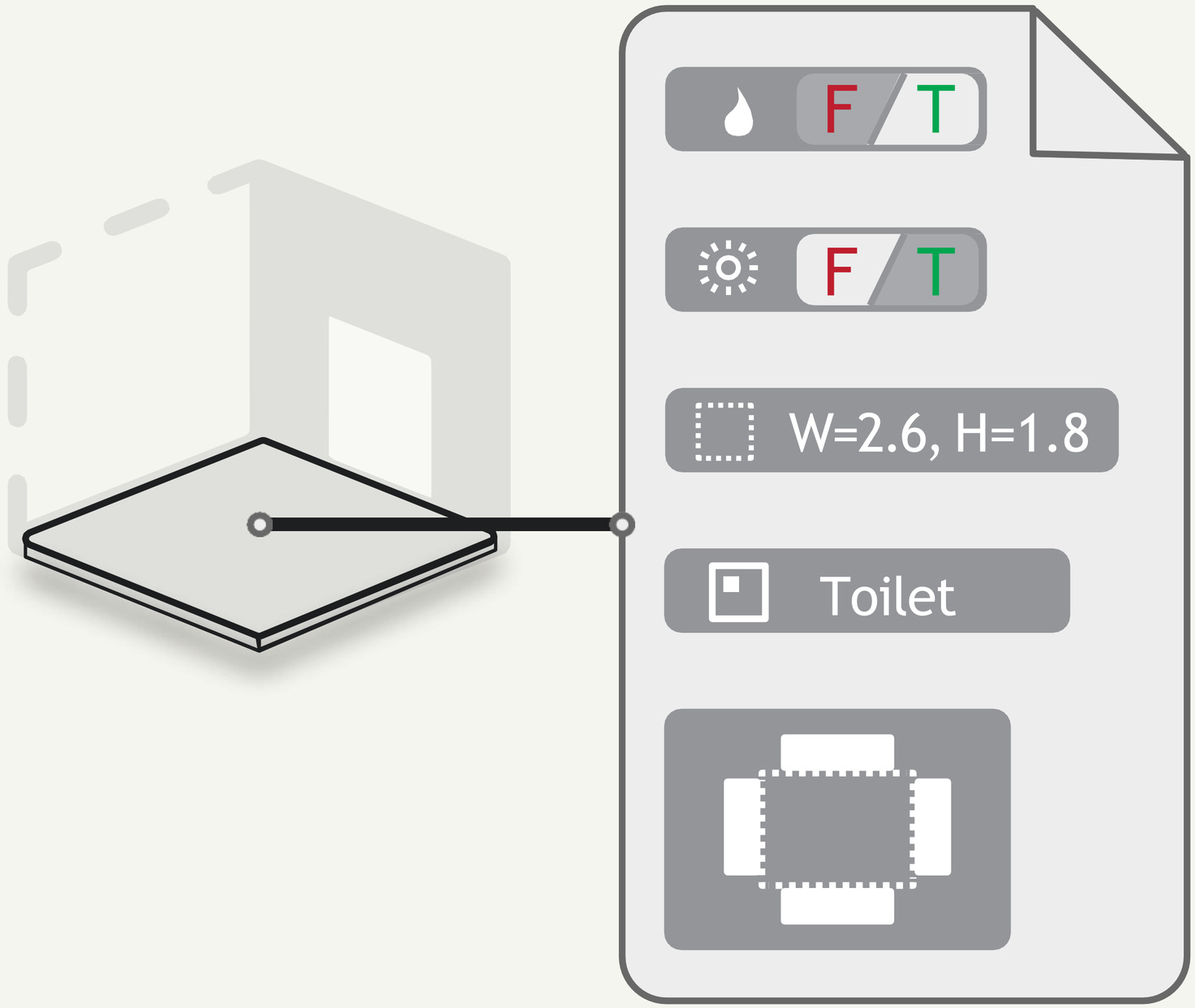




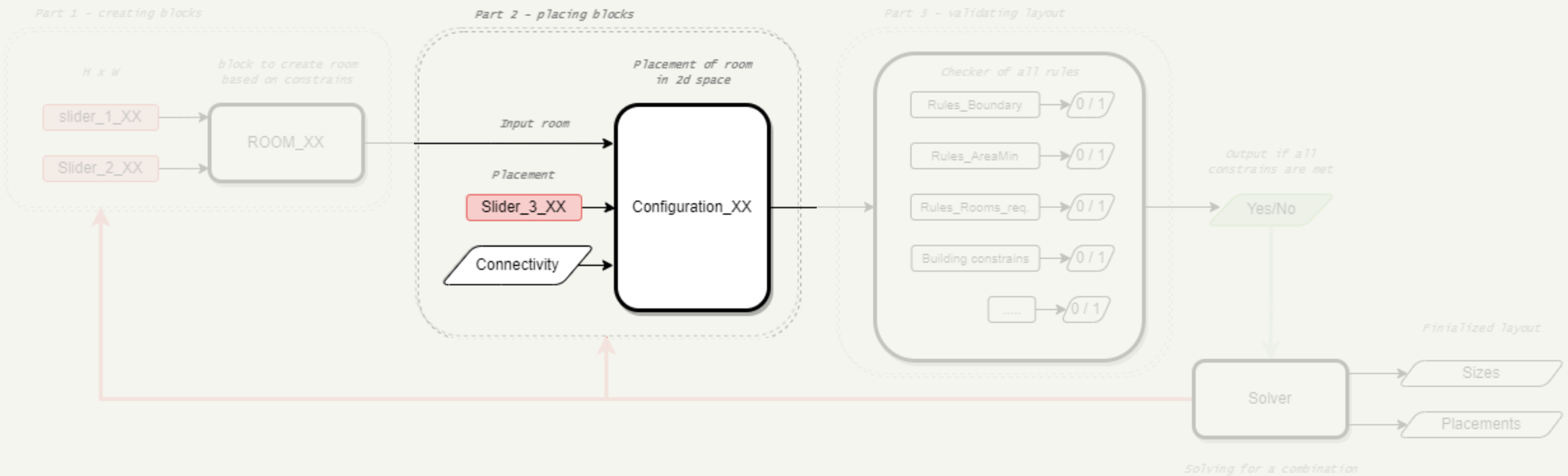
Narrow length of connectivity area with 400 [mm]

Part 1

Space Definition

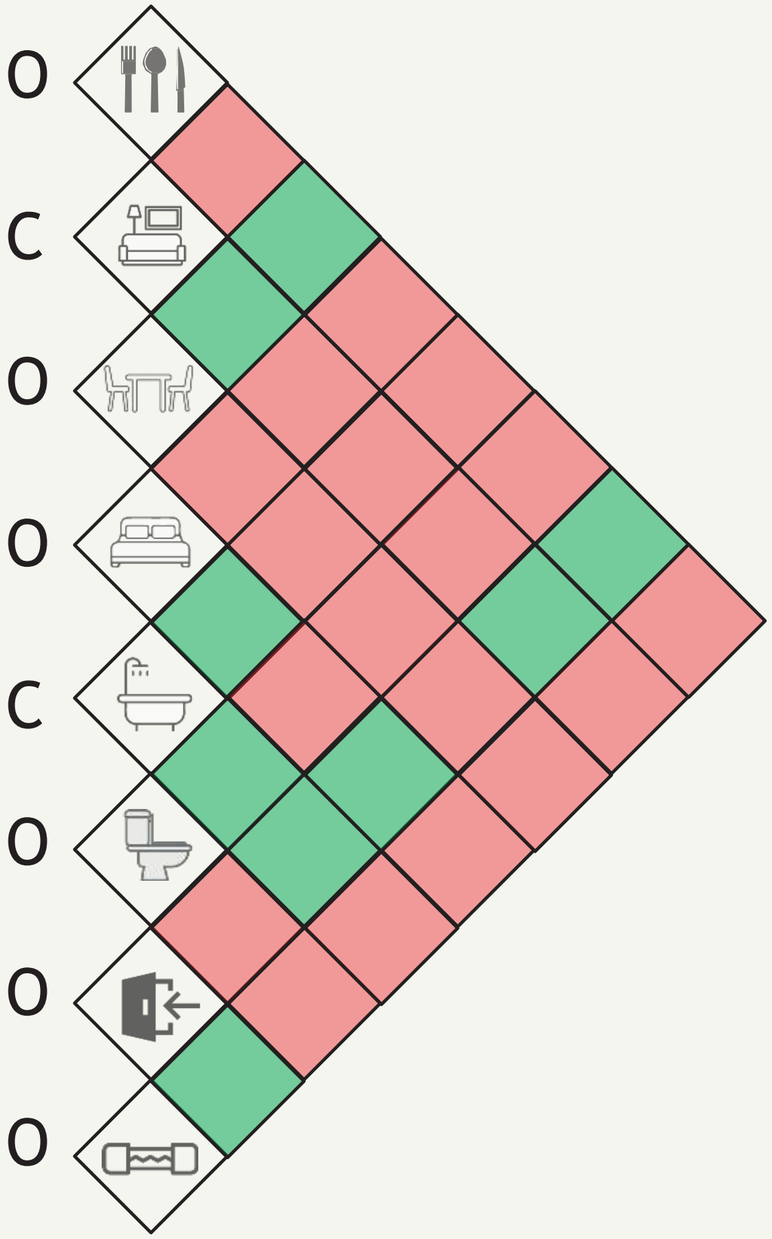


Part 2 - Space Configuration



Part 2

Space Configuration

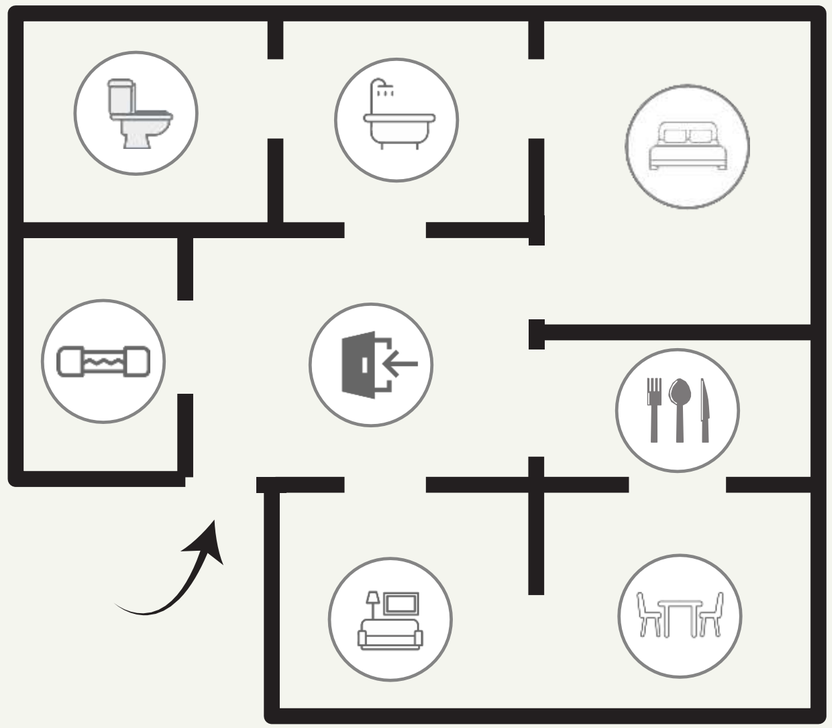


Not wanted (19)

Adjecent (9)

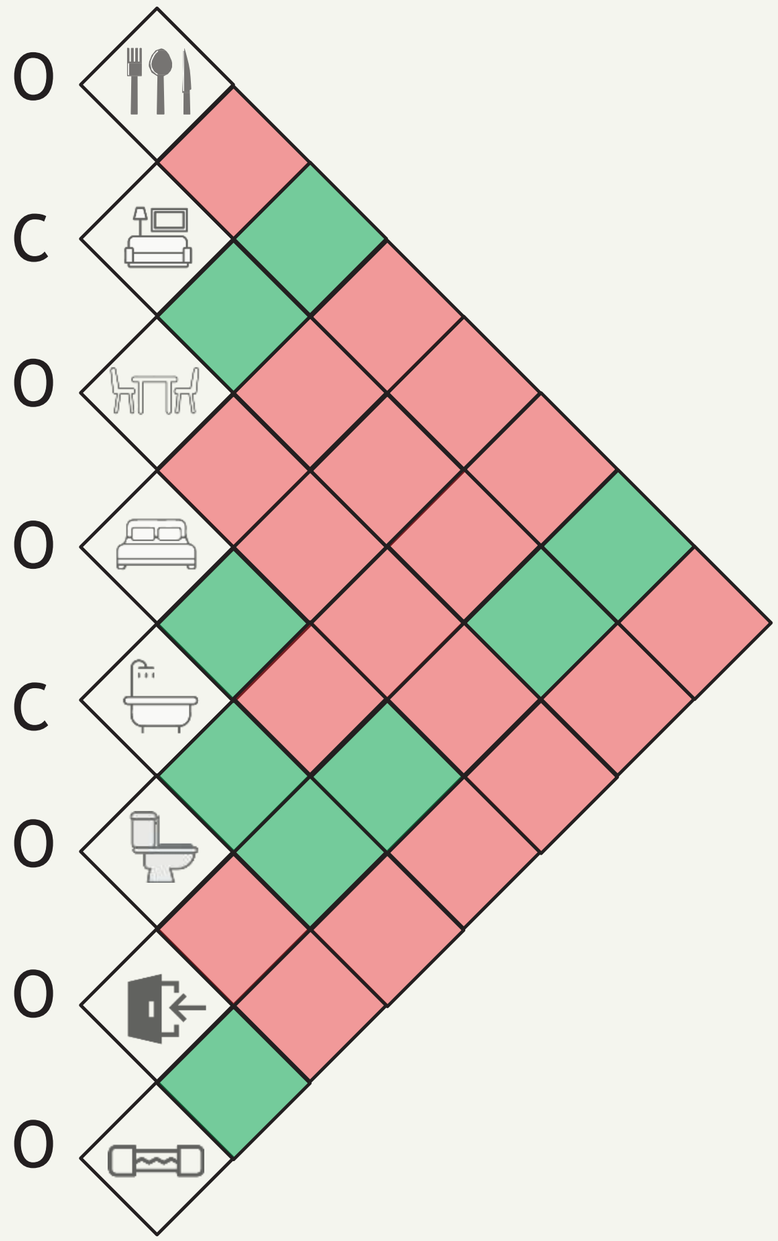
C Privacy required

O ‘Public’ access



Part 2

Space Configuration



Not wanted (19)

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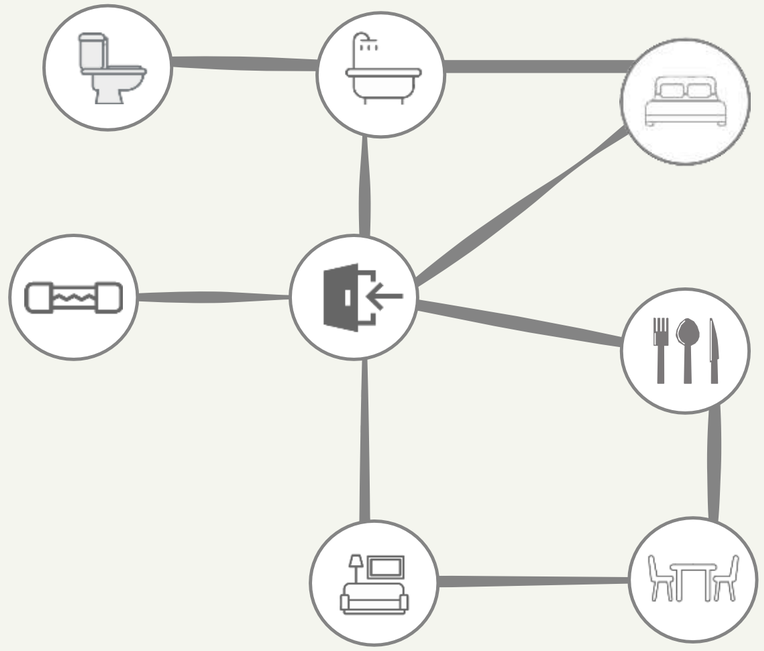
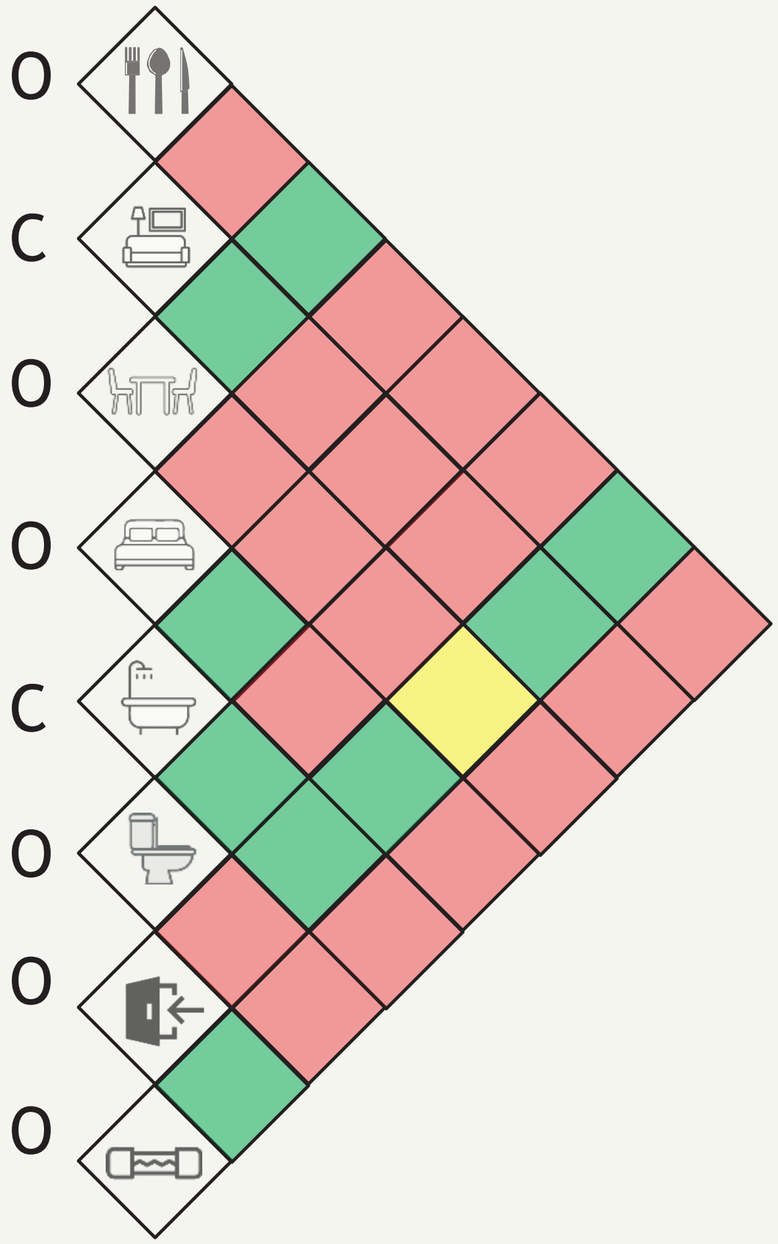


Part 2

Space Configuration



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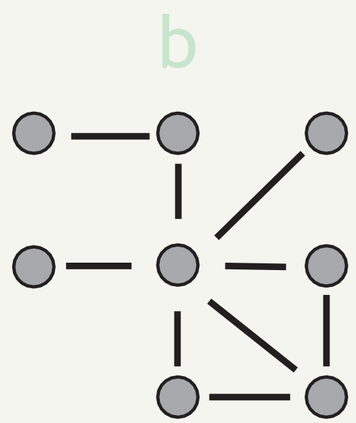
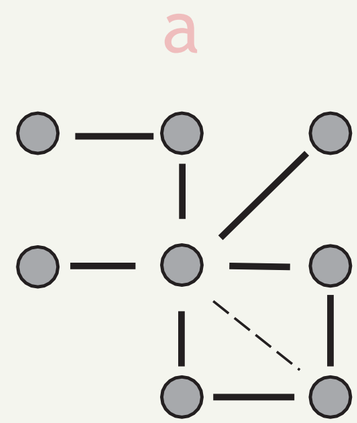
Adjecent (9)

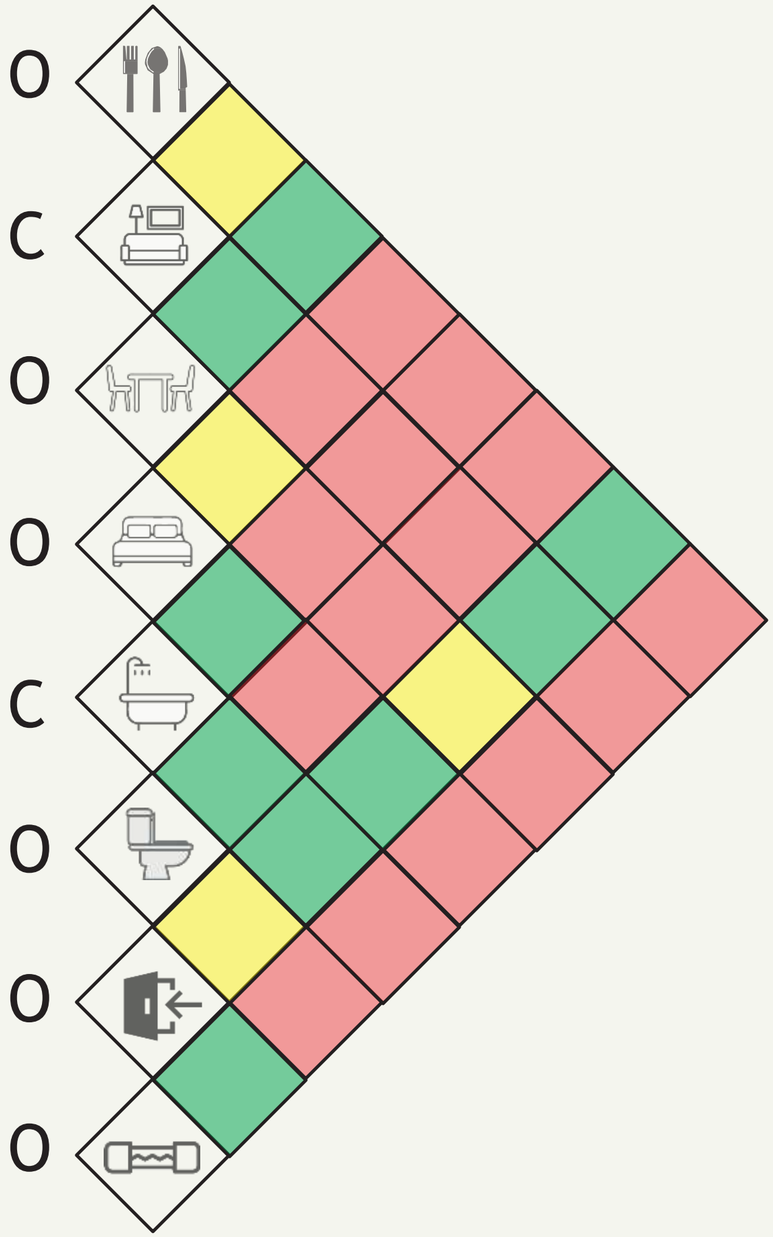
Possible (1) a b

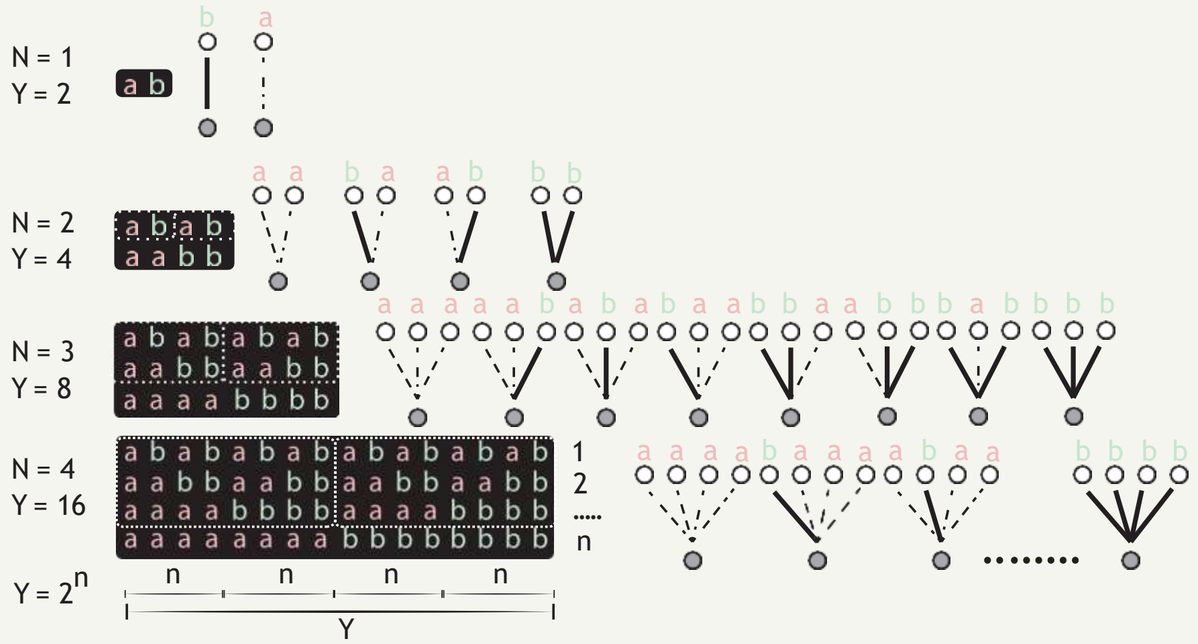




Part 2

Space Configuration

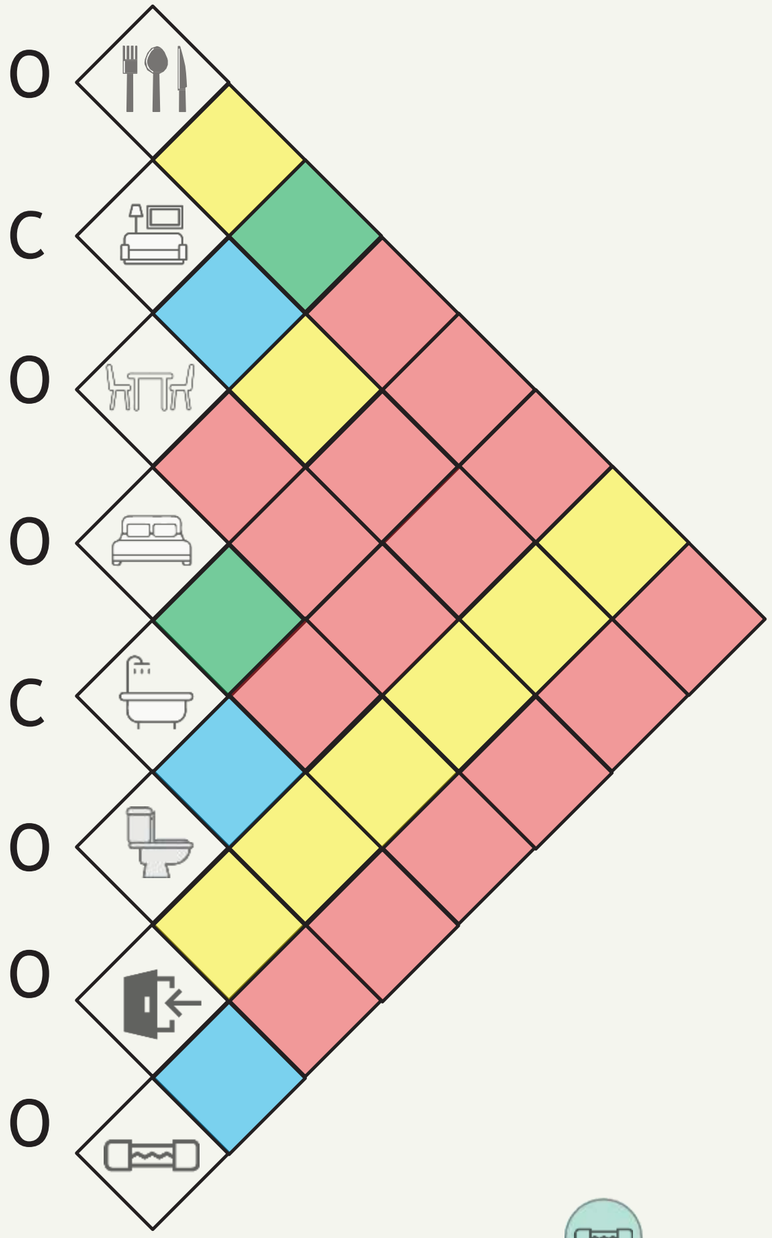




$$Y = n^2$$

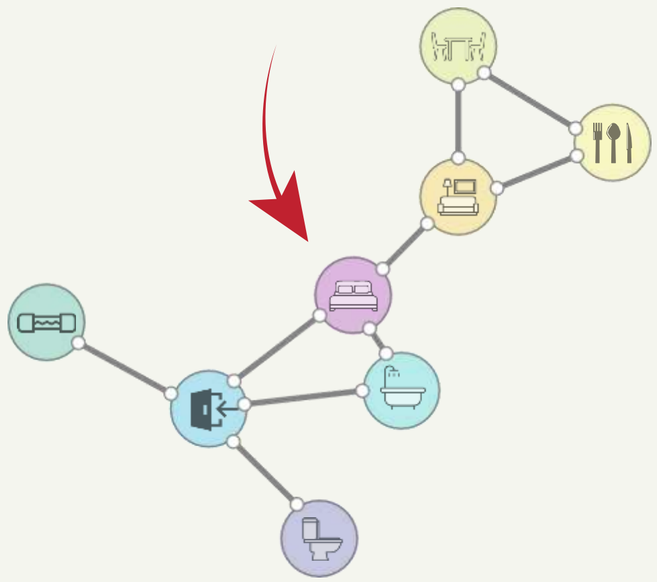
Part 2

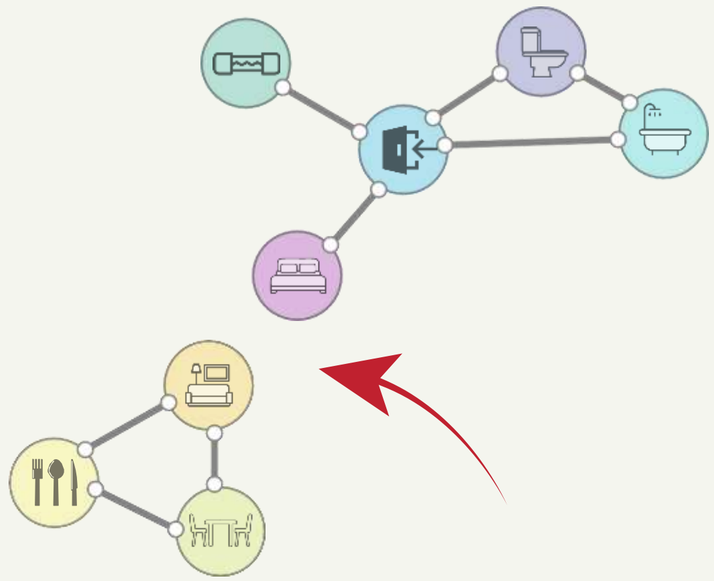
Space Configuration



144 configurations

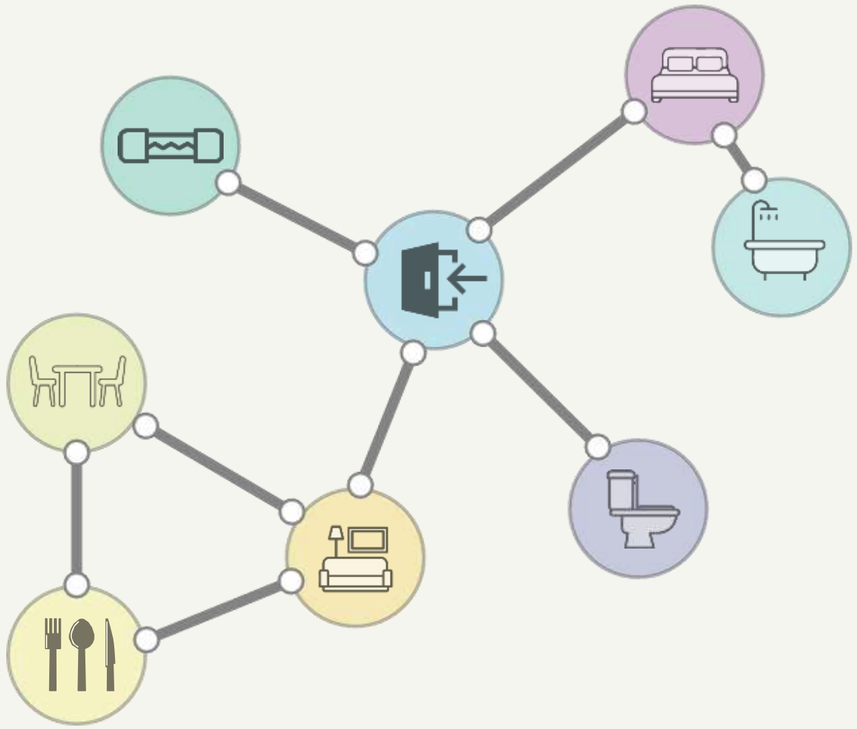
- Not wanted
- Possible
- Inside allowed
- Adjecent
- C Privacy required
- O ‘Public’ access

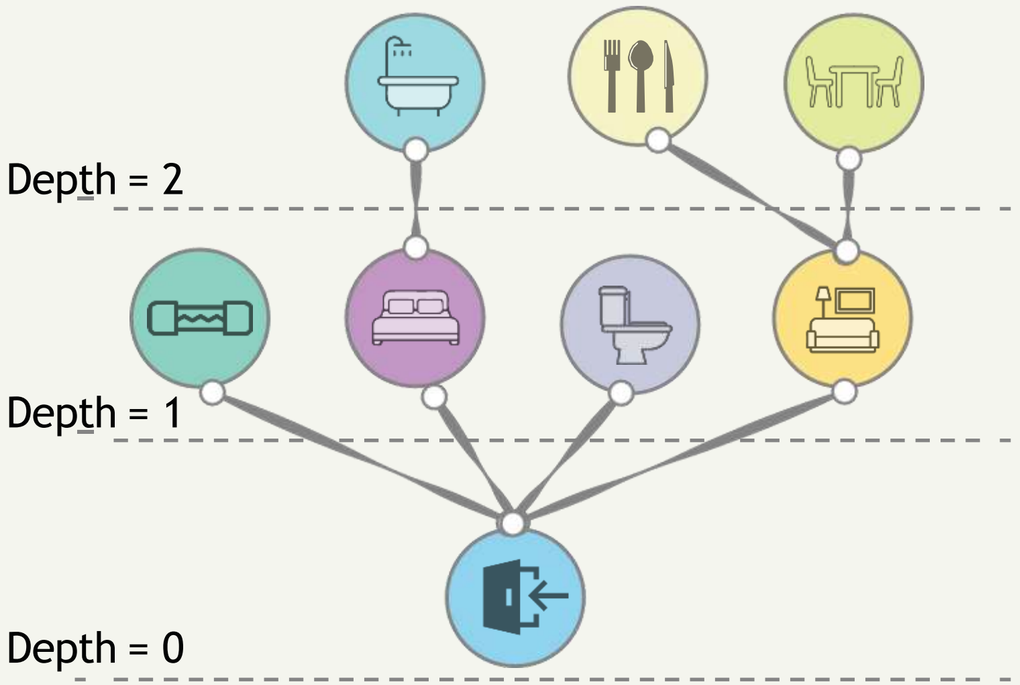




Part 2

Space Configuration



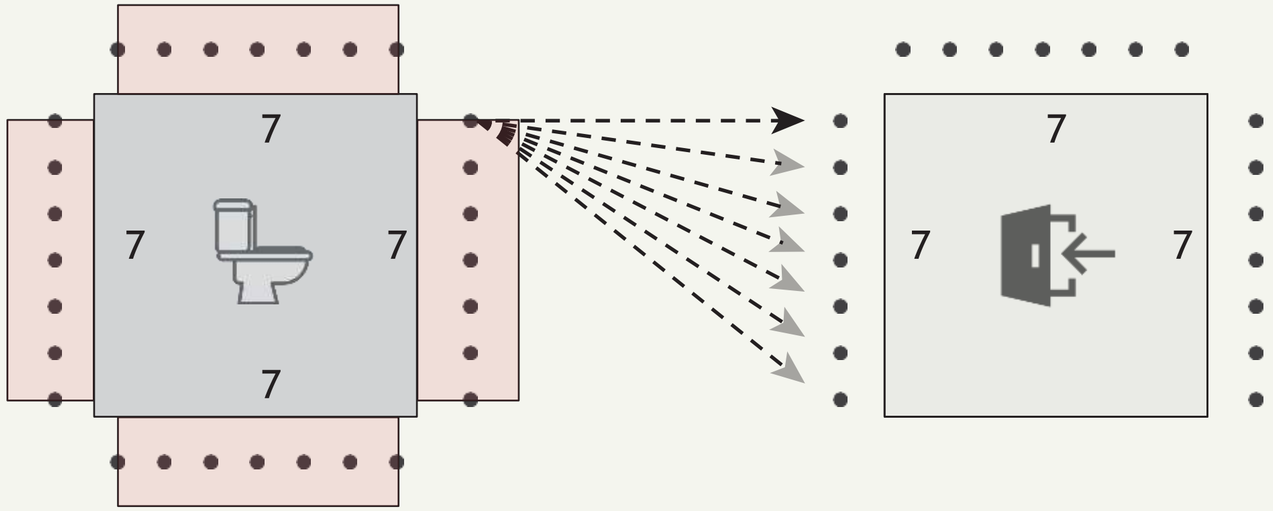


Part 2

Space Configuration

Resolution = 7

Total amount vectors:
7

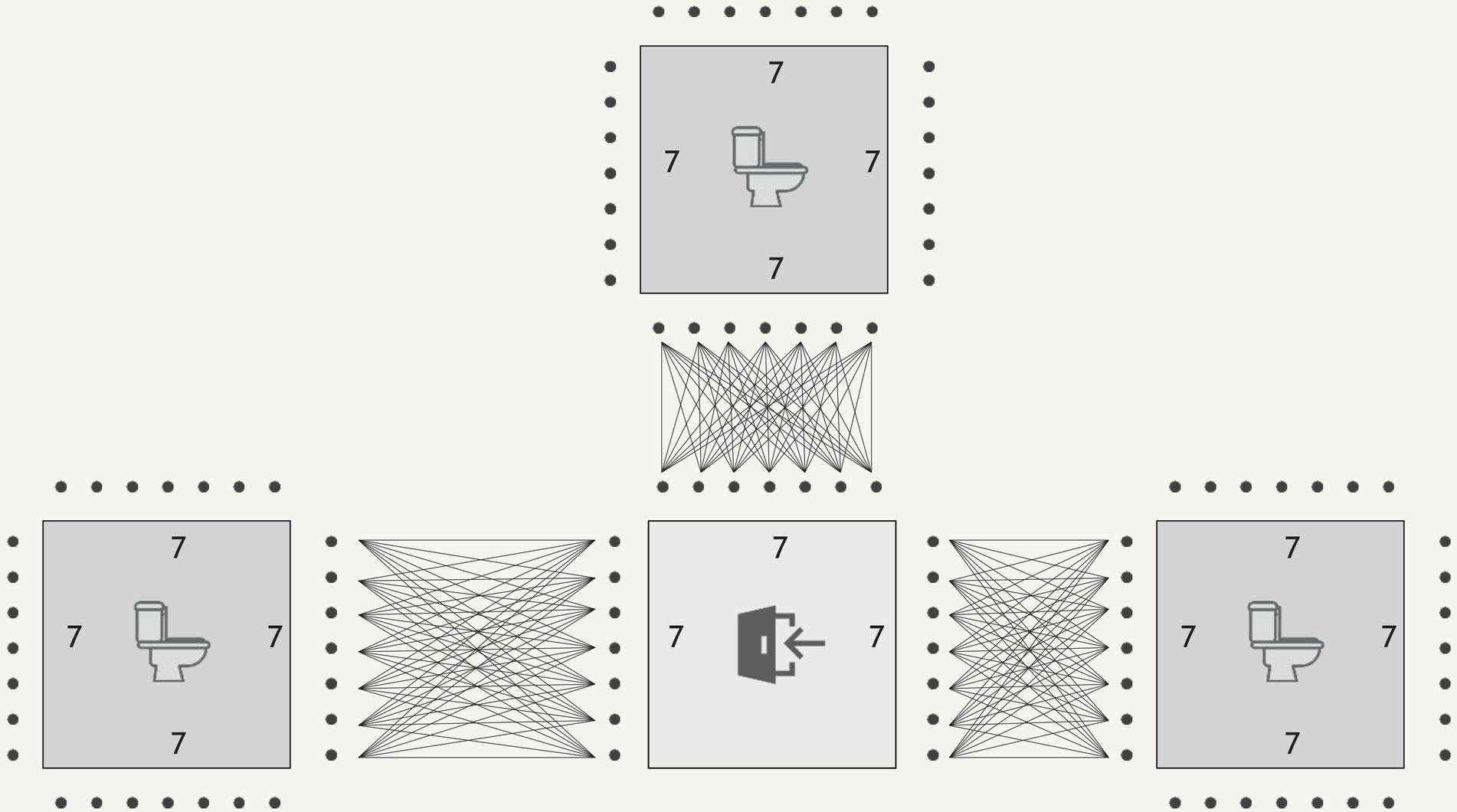


Part 2

Space Configuration

Resolution = 7

Total amount vectors in list for Toilet:
7x7 + 7x7 + 7x7 = 147



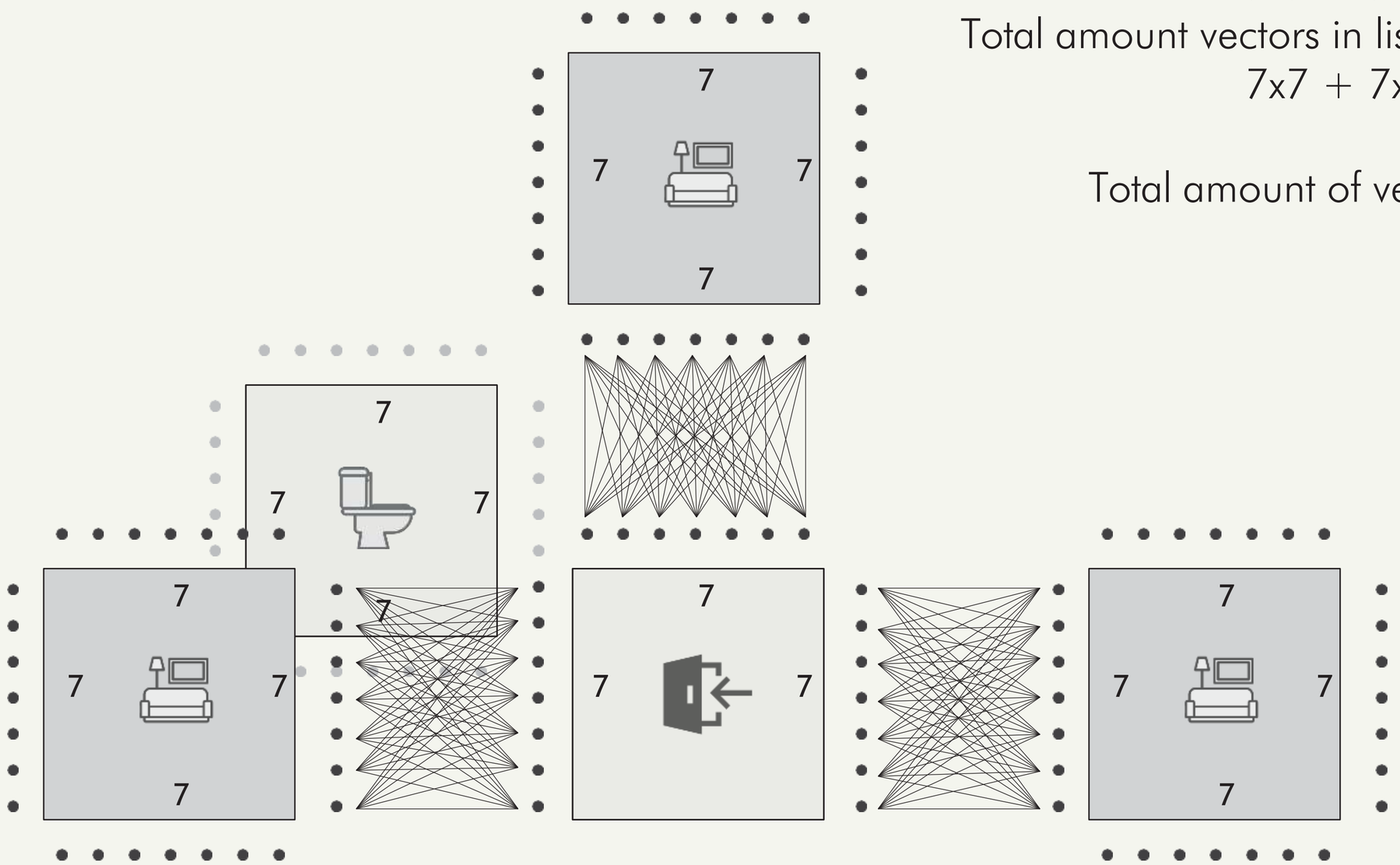
Part 2

Space Configuration

Resolution = 7

Total amount vectors in list for Toilet:
7x7 + 7x7 + 7x7 = 147
Total amount vectors in list for livingroom:
7x7 + 7x7 + 7x7 = 147

Total amount of vectors = 21.609

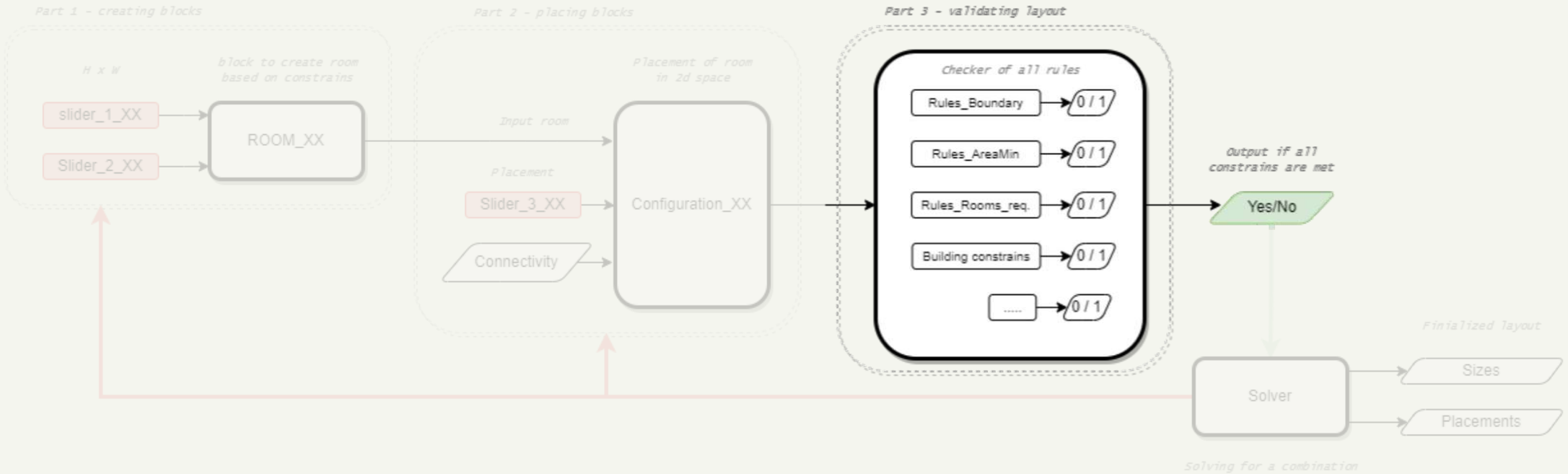


(Amount of rooms)

Amount vectors = ((N side1 x N sideA x 2) + (N side 2 x N sideB x 2))

Amount vectors (8 rooms, 7 nodes, connected to front door) = 218.041.257.467.152.161

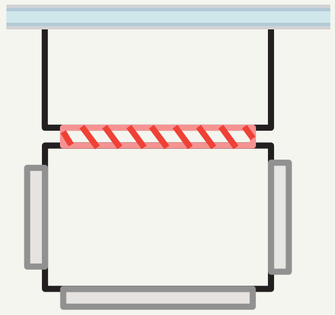
Part 3 - Layout evaluation



Building related rules

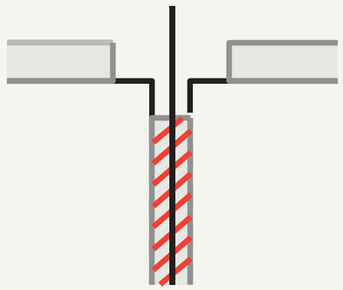
Sunlight:

Connectivity area overlapping with a facade that can have openings



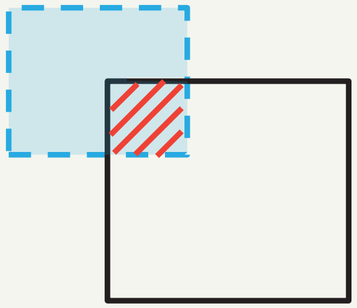
Sunlight:

If no direct sunlight, check for indirect sunlight through adjecent rooms with public-public access



Structure:

Original curves of a space cannot intersect with structural walls



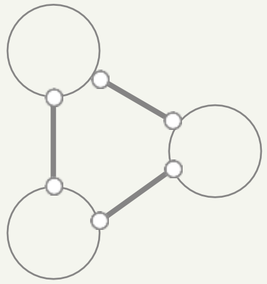
Drainage:

If a space requires drainage, it should overlap with the drainage zone. If more than 1 drainage point is required, There should be 0,6 m2 for each point.

Space related rules

Program:

Every room should be included in the layout

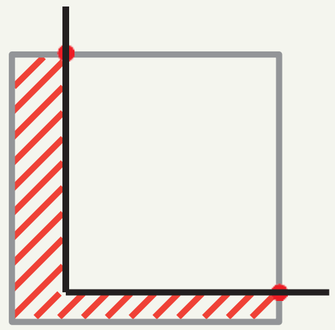


Interconnectivity:

The interconnectivity should be identical to the connectivity diagram used. Overlapping area should intersect.

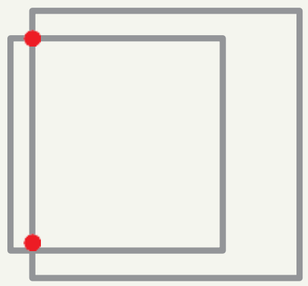
Usable surface area:

The sum of the areas of the rooms should be greater than 45.



Boundary:

The spaces are not allowed to intersect with the absolute boundary of the building

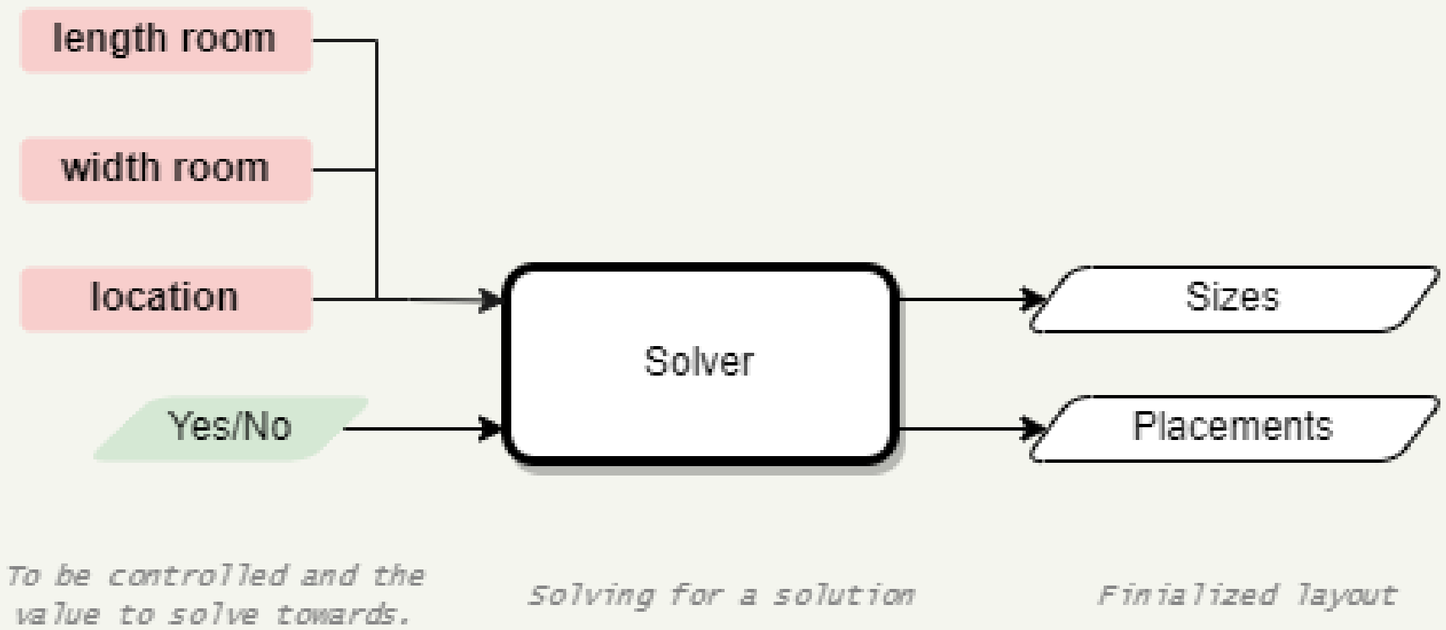


Intersecting spaces:

Spaces are only allowed to intersect if they can exist inside each other.

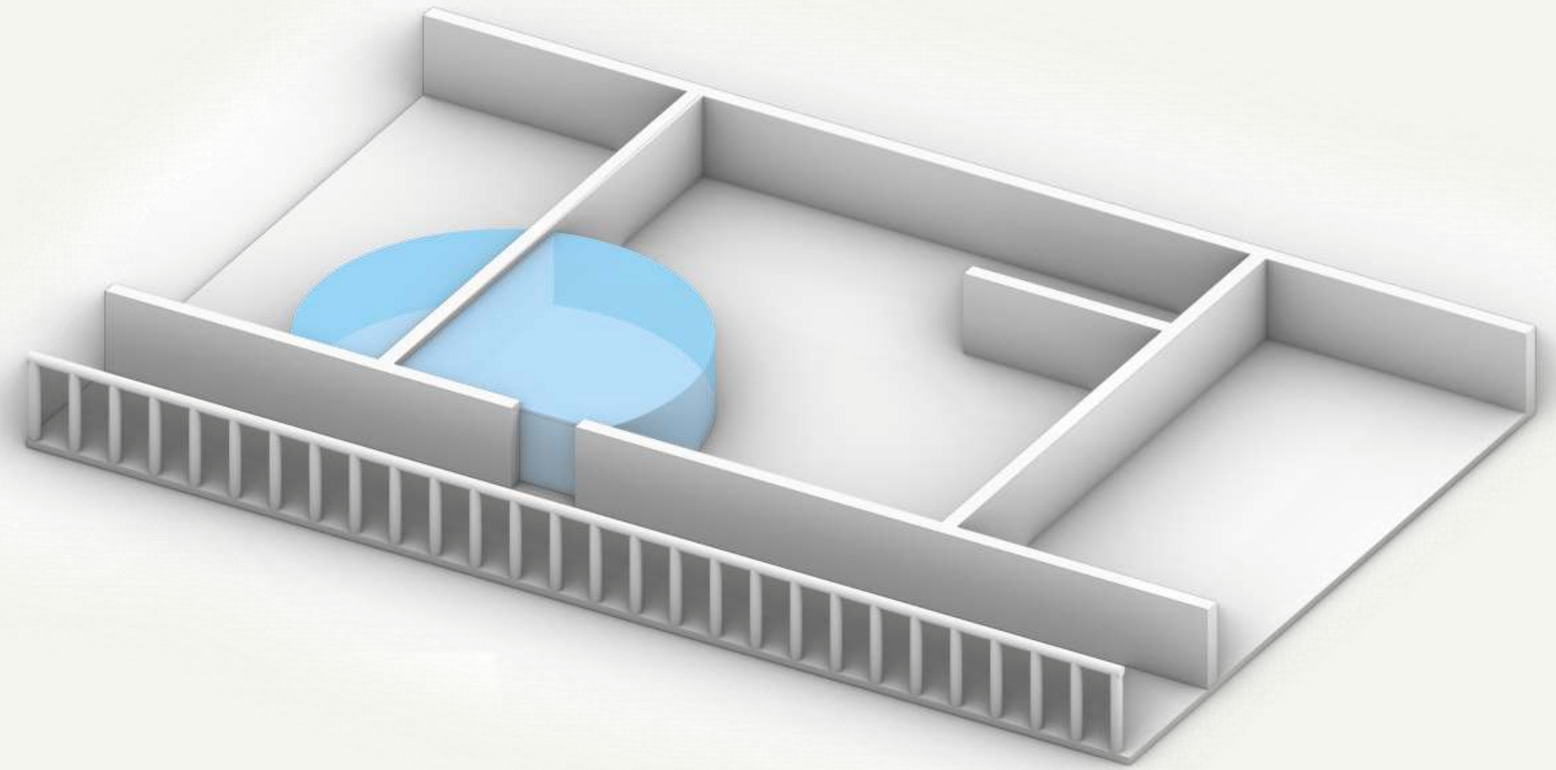
Part 3

Layout evaluation



Evaluation

Validity of output



Width = 7 [m]
Length = 4,8 + 2,2 [m]
Length stability wall = 2,7 [m]
Gallery access
Drainage = 2,5 [m] ⌀
Window placement = Everywhere along facade

Validity of output

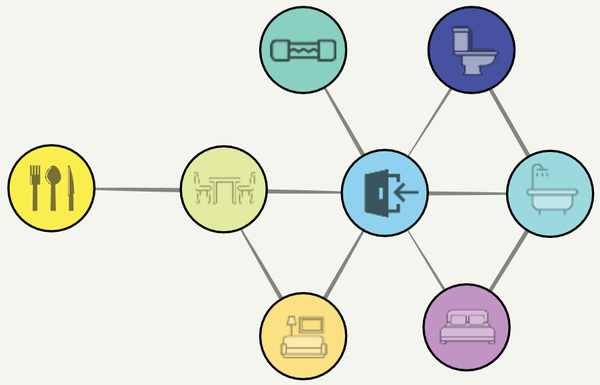


Diagram: 3
Time: 3h.
Errors: 16

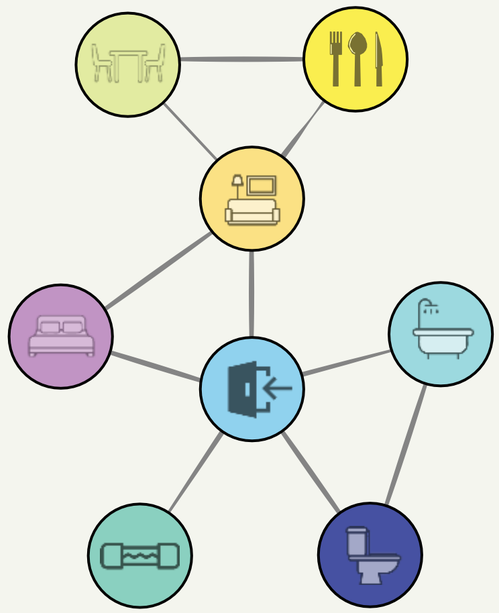


Diagram: 18
Time: 4h.
Errors: 12

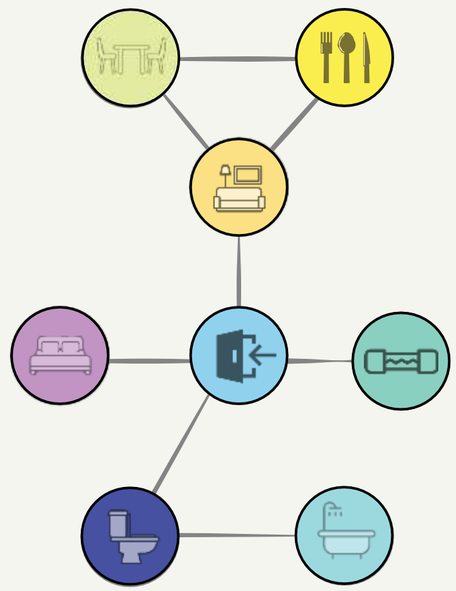
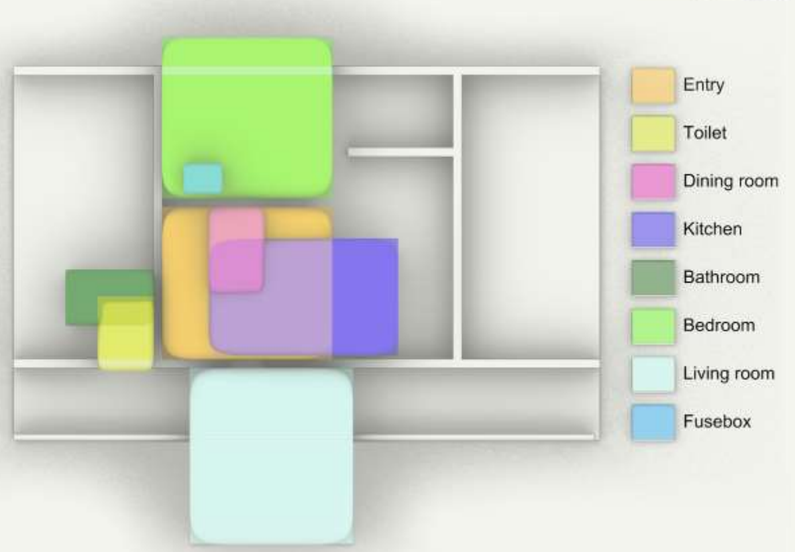
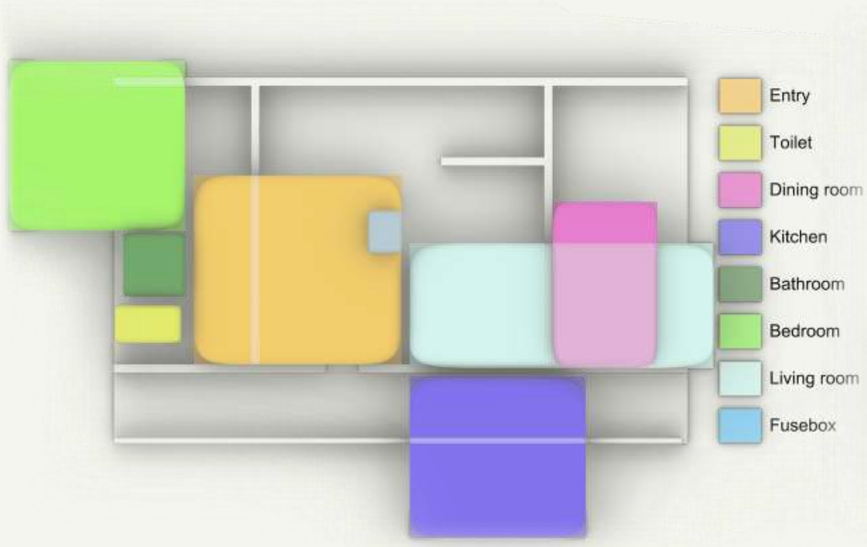
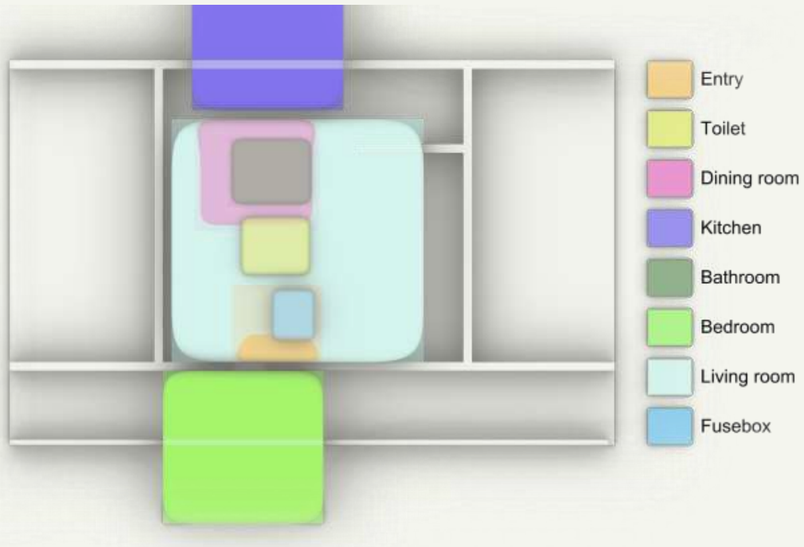
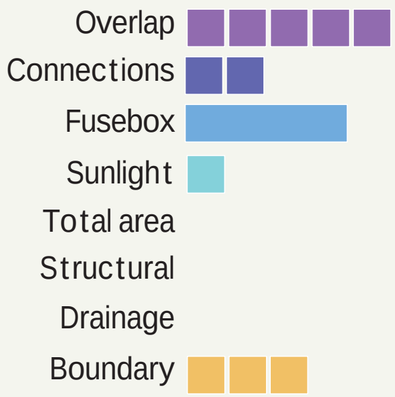


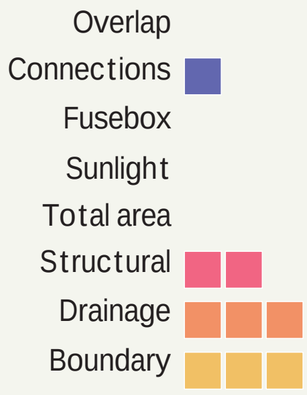
Diagram: 53
Time: 3h.
Errors: 12

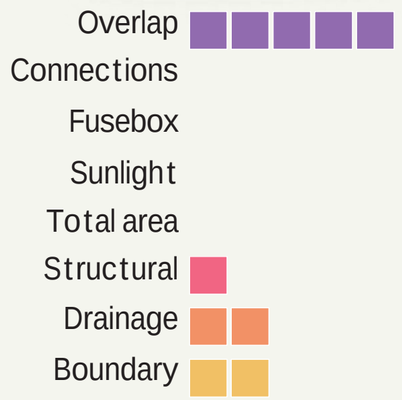




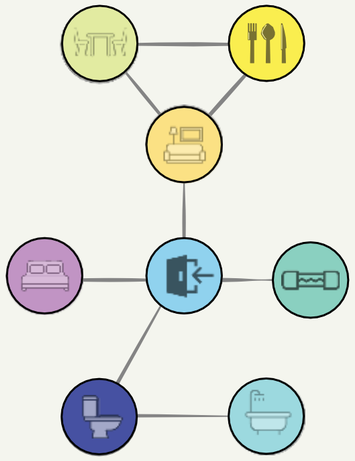




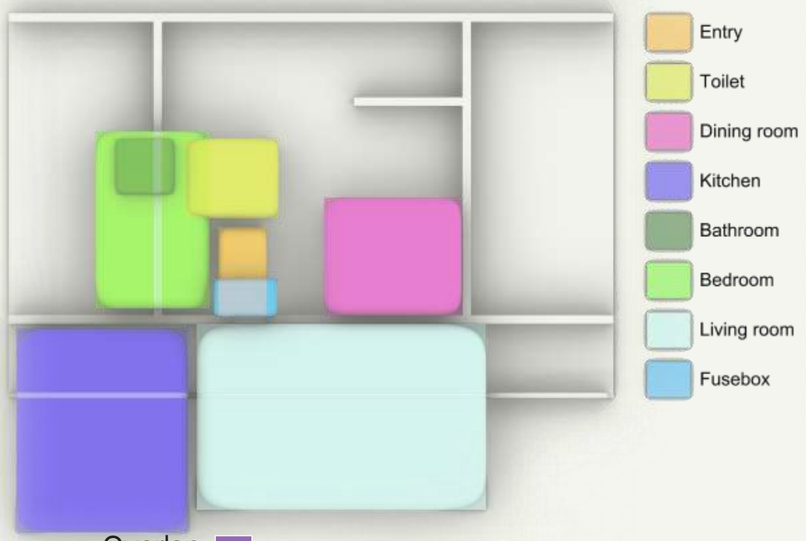




Validity of output

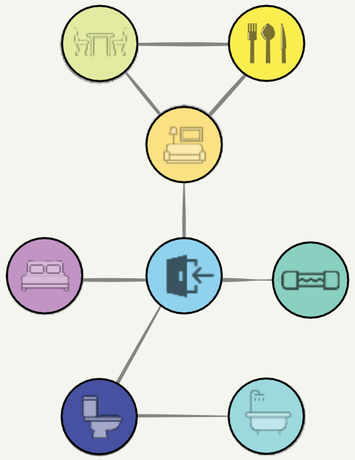


Time: 5h.
Errors: 10

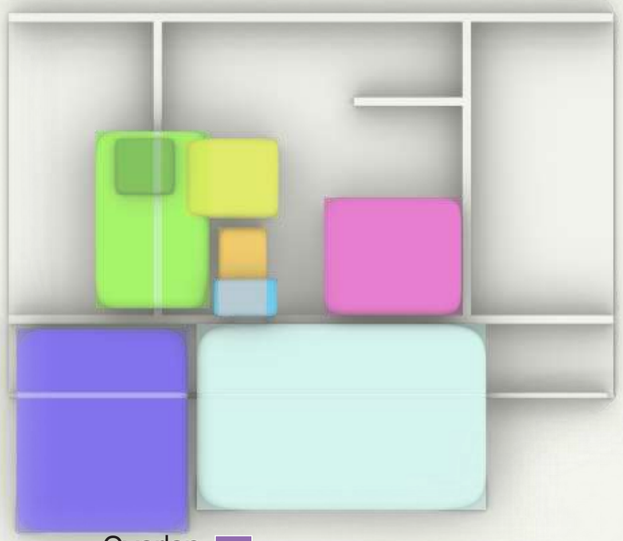


Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

Validity of output

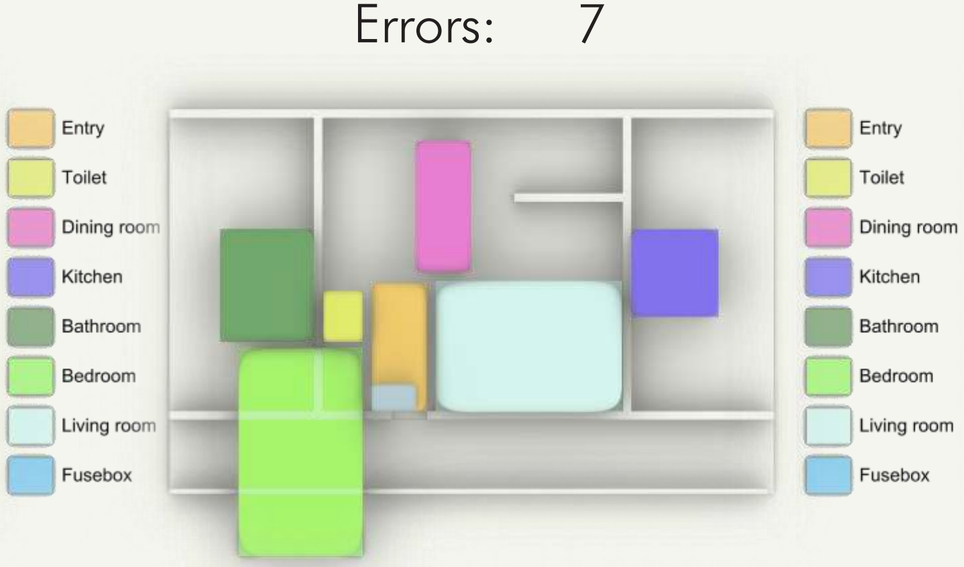


Time: 5h.
Errors: 10



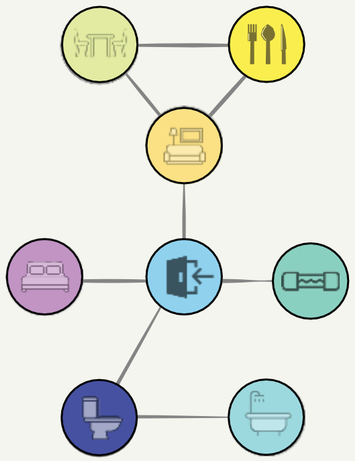
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

Time: 14h.
Errors: 7

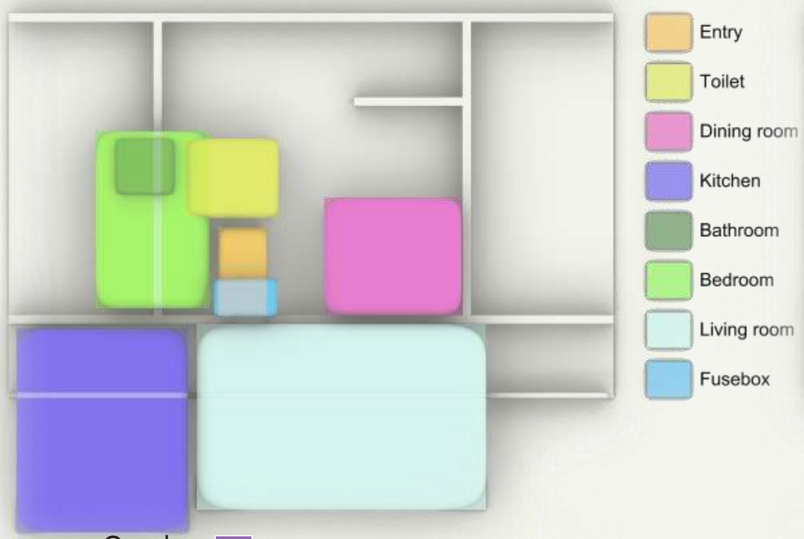


Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

Validity of output

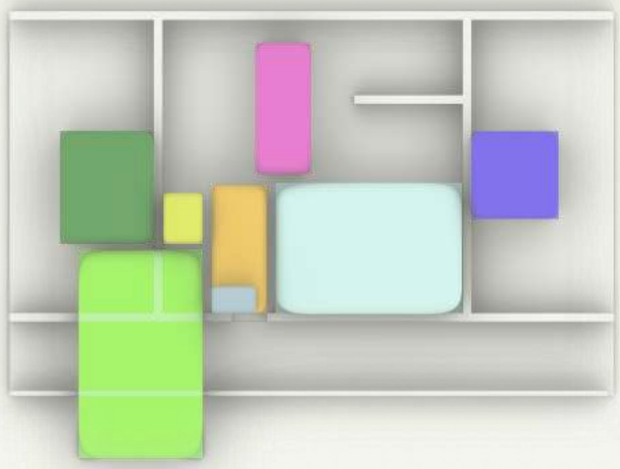


Time: 5h.
Errors: 10



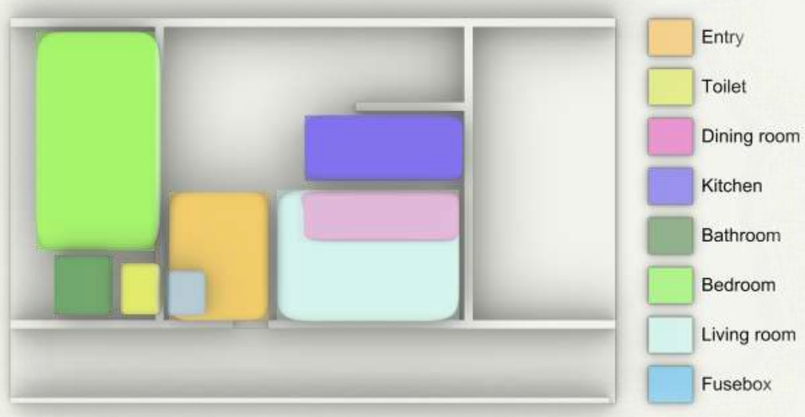
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

Time: 14h.
Errors: 7

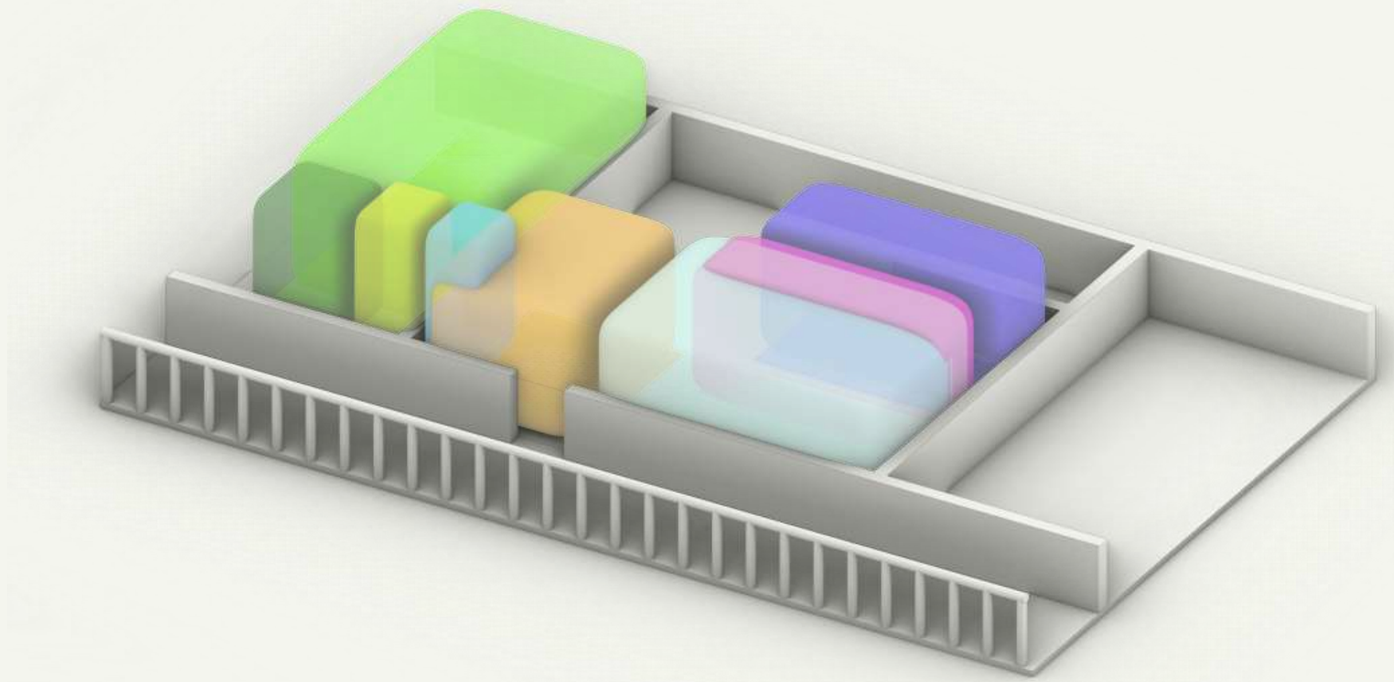


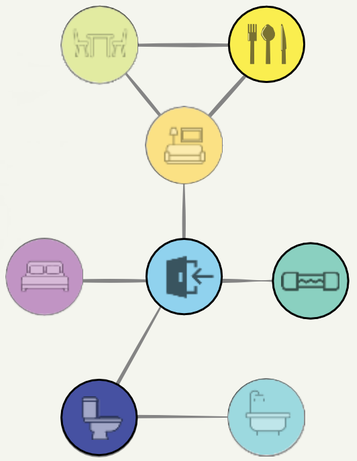
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

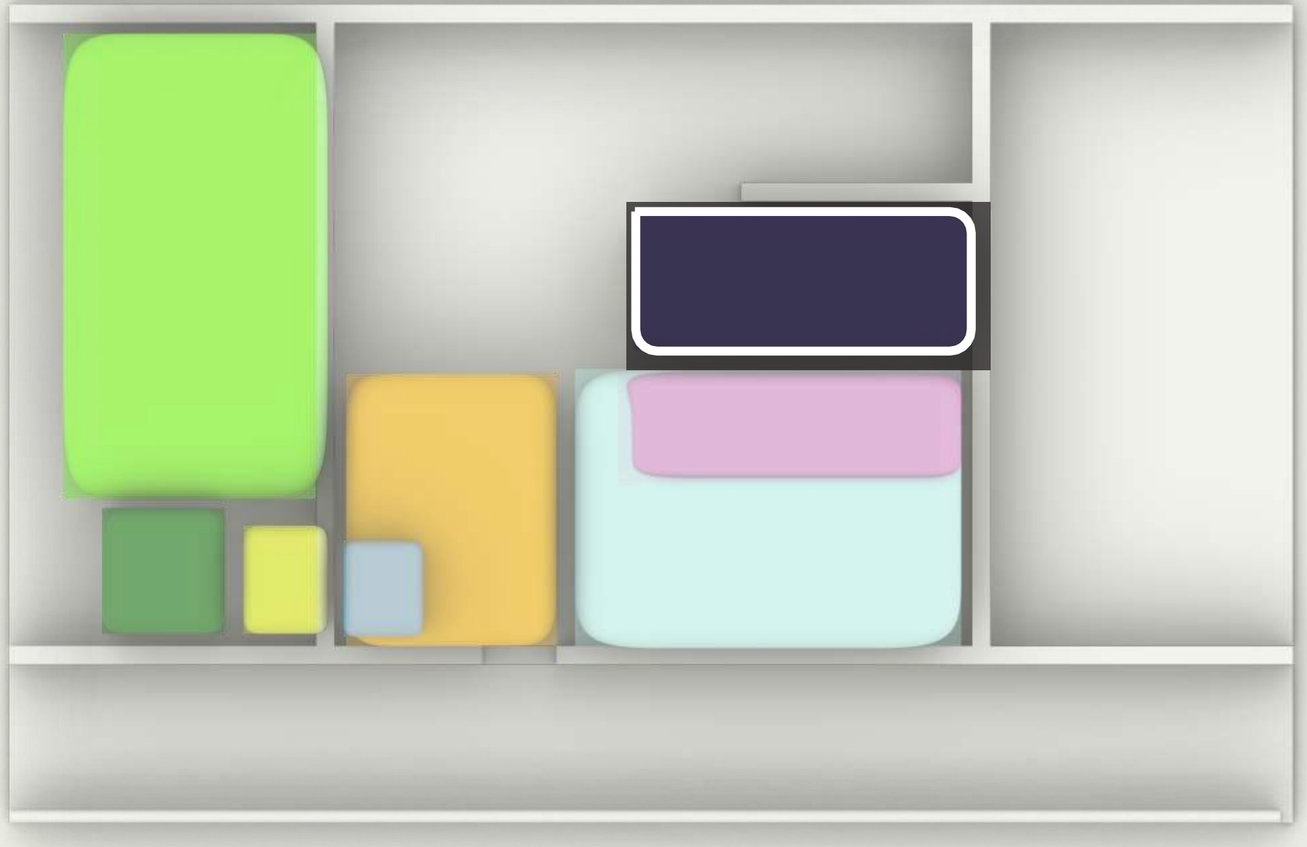
Time: 24h.
Errors: 1



Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary







Entry

Toilet

Dining room

Kitchen

Bathroom

Bedroom

Living room

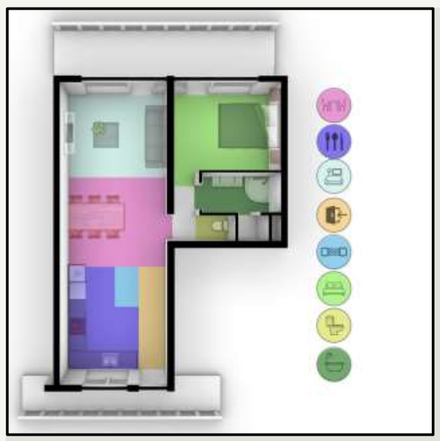
Fusebox

Veracity of outcomes

Kleiburg, Amsrterdam



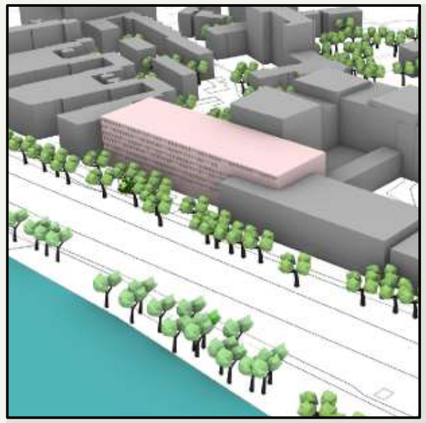


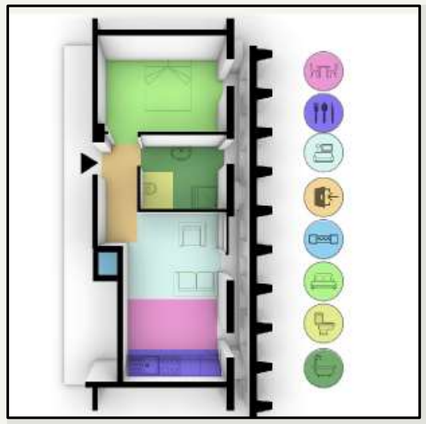
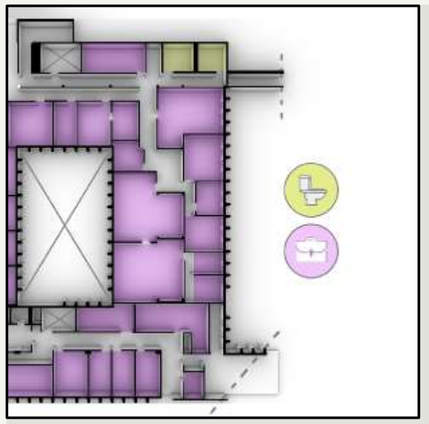



Retrieved from https://hendrikscpo.nl/projecten/kleiburg.
Retrieved from https://www.e-architect.com.
Nabben, T., Doekhie, J., & Korf, D. J. (c.). Uit de schaduw ~ Intro: dynamiek in een multi-etnisch stadsdeel. https://rozenbergquarterly.com/uit-de-schaduw-intro-dynamiek-in-een-multi-etnisch-stadsdeel/

Charenton-le-Pont, Paris



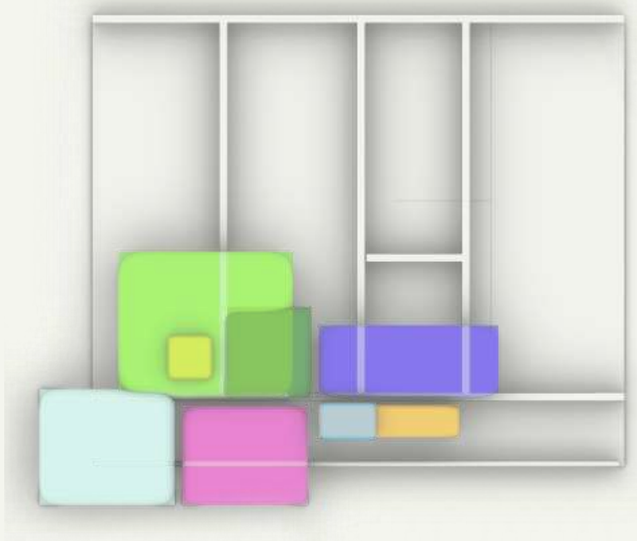


Denacé (n.d.) (94220). http://micheldenance.com/portfolios/md/index.php
Denacé (n.d.) (94221). http://micheldenance.com/portfolios/md/index.php
Archi-Guide (n.d.) retrieved from: https://www.archi-guide.com/AR/moatti.htm

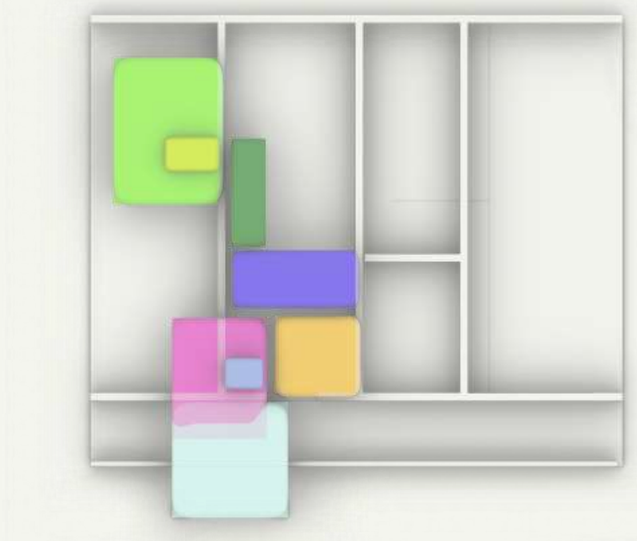
Veracity of outcomes

Kleiburg, Amsrterdam



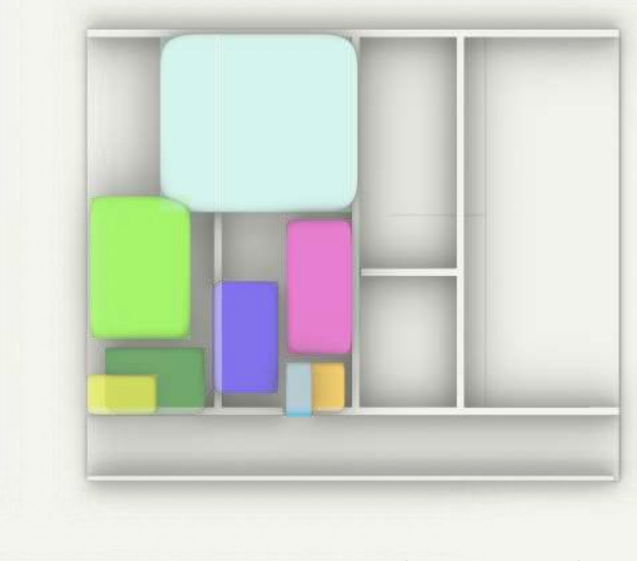
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

10 rule violation (2 hours).



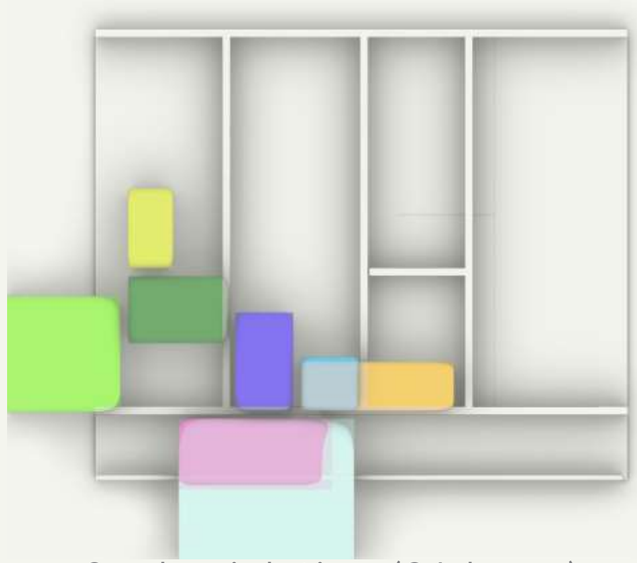
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

10 rule violation (9 hours).



Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

10 rule violation (15 hours).

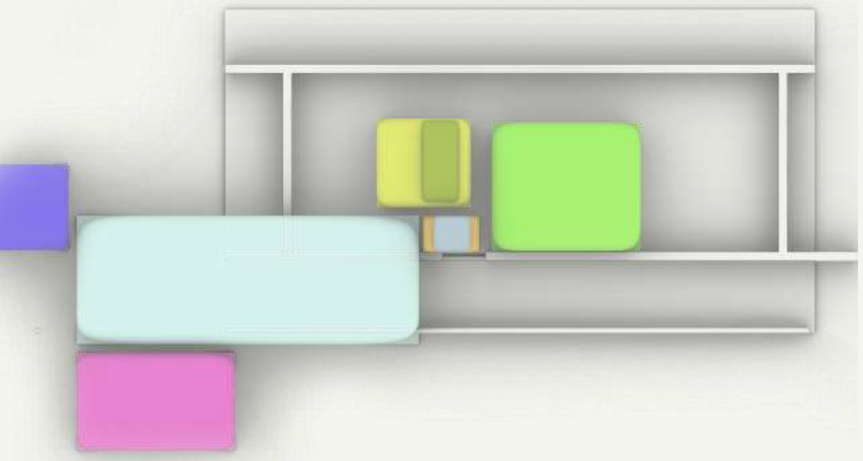


Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

9 rule violation (24 hours).

Veracity of outcomes

Charenton-le-Pont, Paris

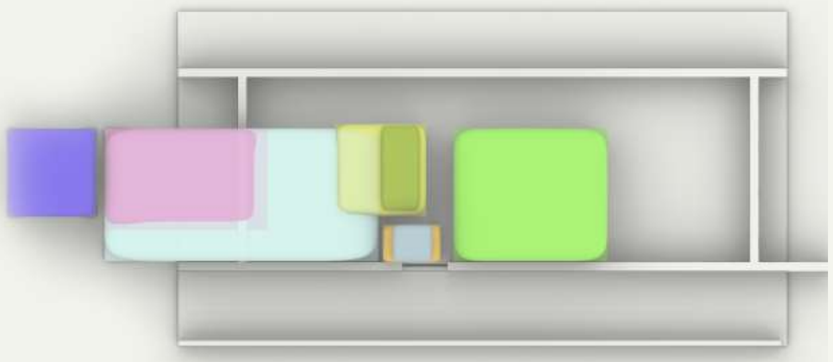


Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

16 rule violation (3 hours).

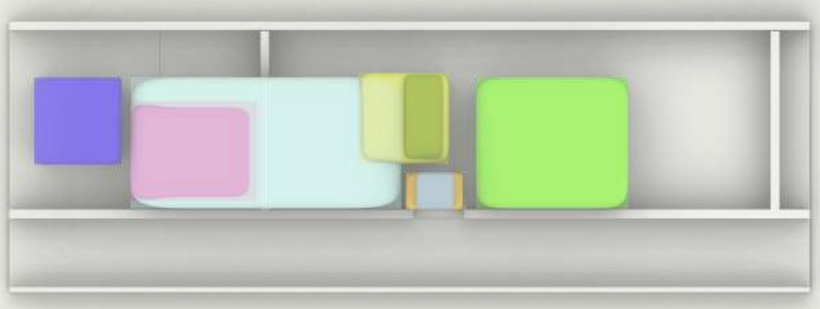
Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

8 rule violation (5 hours).



Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

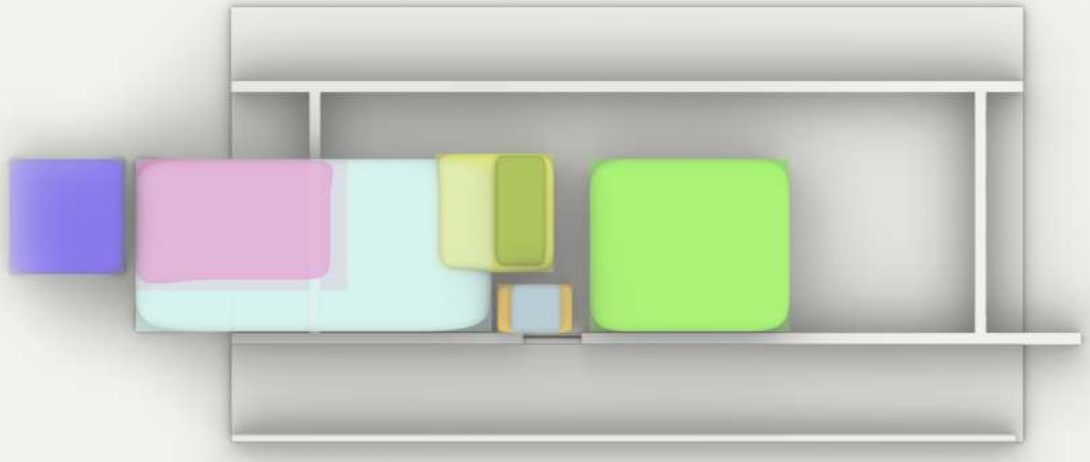
6 rule violation (11 hours).



Overlap
Connections
Fusebox
Sunlight
Total area
Structural
Drainage
Boundary

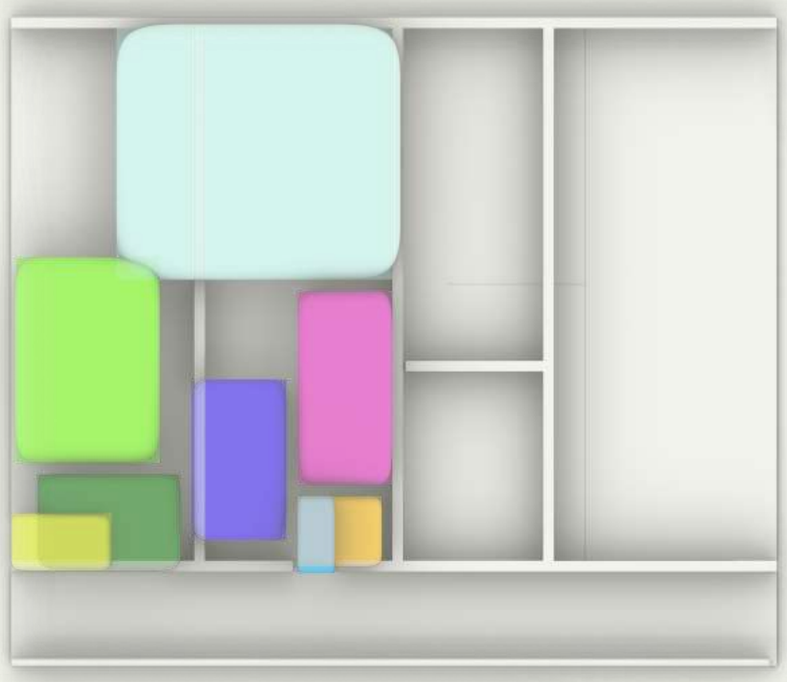
4 rule violation (24 hours).

Charenton-le-Pont, Paris



4 rule violation (24 hours).

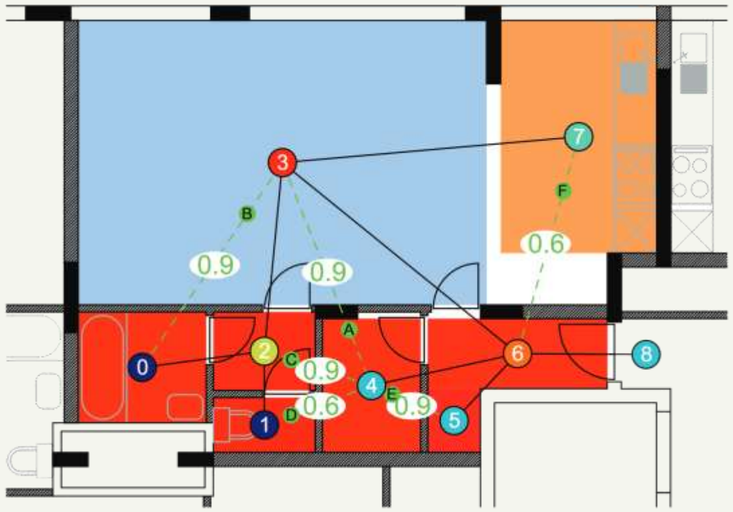
Kleiburg, Amsrterdam

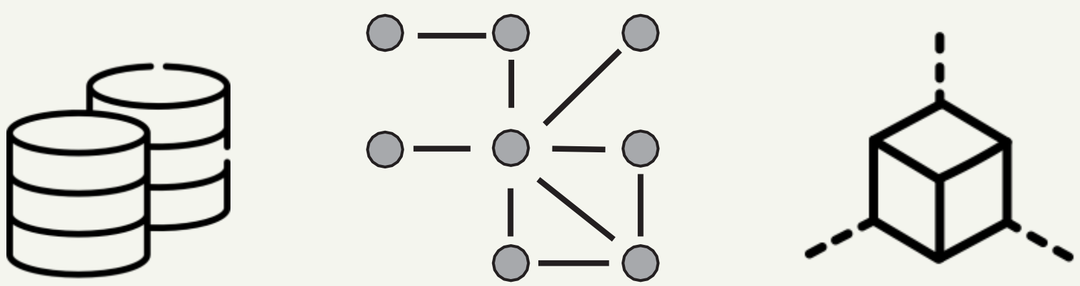


10 rule violation (15 hours).

Functionality of model

The Spatial Assessment of Generality and Adaptability (SAGA)

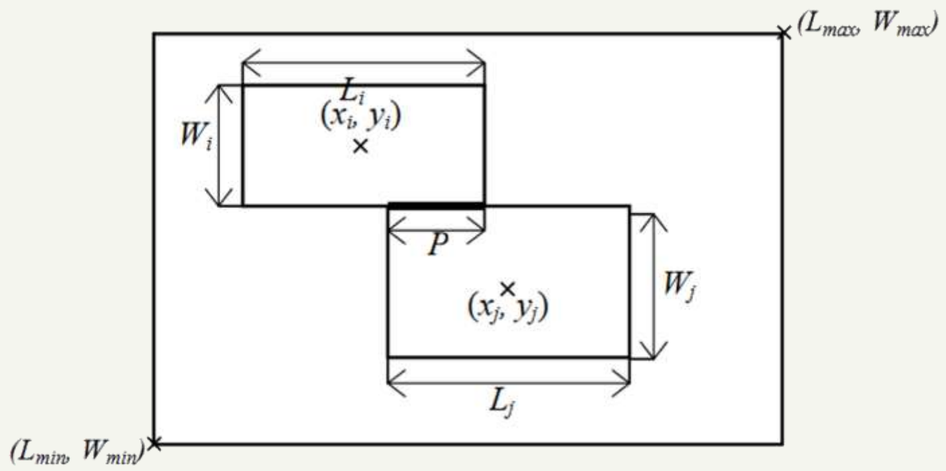


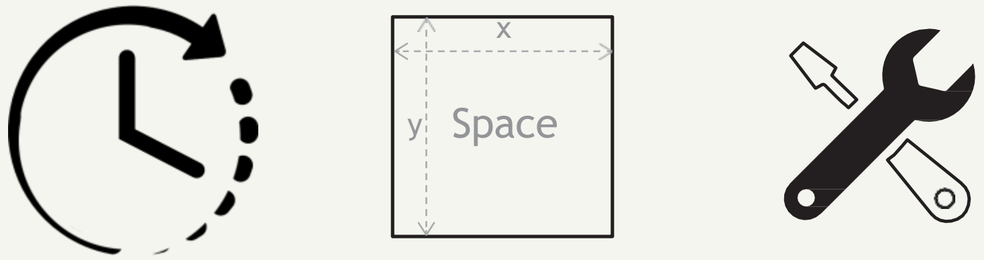


Advantage - simularity - disadvantage

Herthogs, P., Debacker, W., Tunçer, B., De Weerdt, Y., & De Temmerman, N. (2019). Quantifying the Generality and Adaptability of Building Layouts Using Weighted Graphs: The SAGA Method. Buildings, 9(4), 92. https://doi.org/10.3390/buildings9040092

Constrained based generative system for floor layouts





Advantage - simularity - disadvantage

Li, S.-P., Frazer, J. H., & Tang, M.-X. (2005). A CONSTRAINT BASED GENERATIVE SYSTEM FOR FLOOR LAYOUTS.

Discussion

Model limitations

- Designed for one typology & occupation
- Modular techniques
- Intangible characteristics of spaces
- Ergonomic assumptions

Output

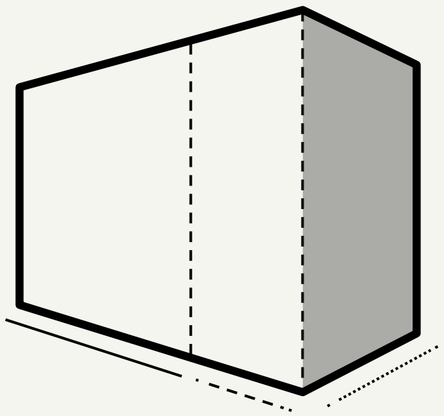
- Open canvas
- Placement strategy
- Optimize graph data usage

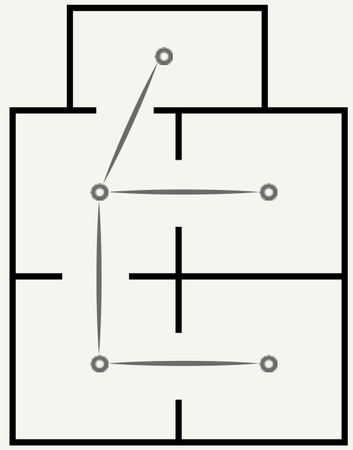
Further developments

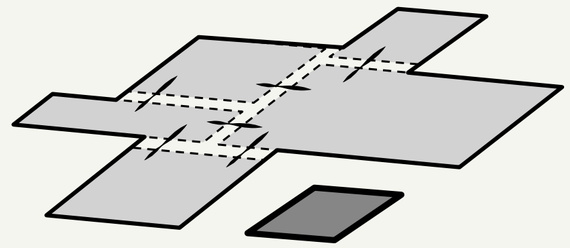
- Encapsulated negative space
- Categorize output
- Mathematical relationships

Main research question:

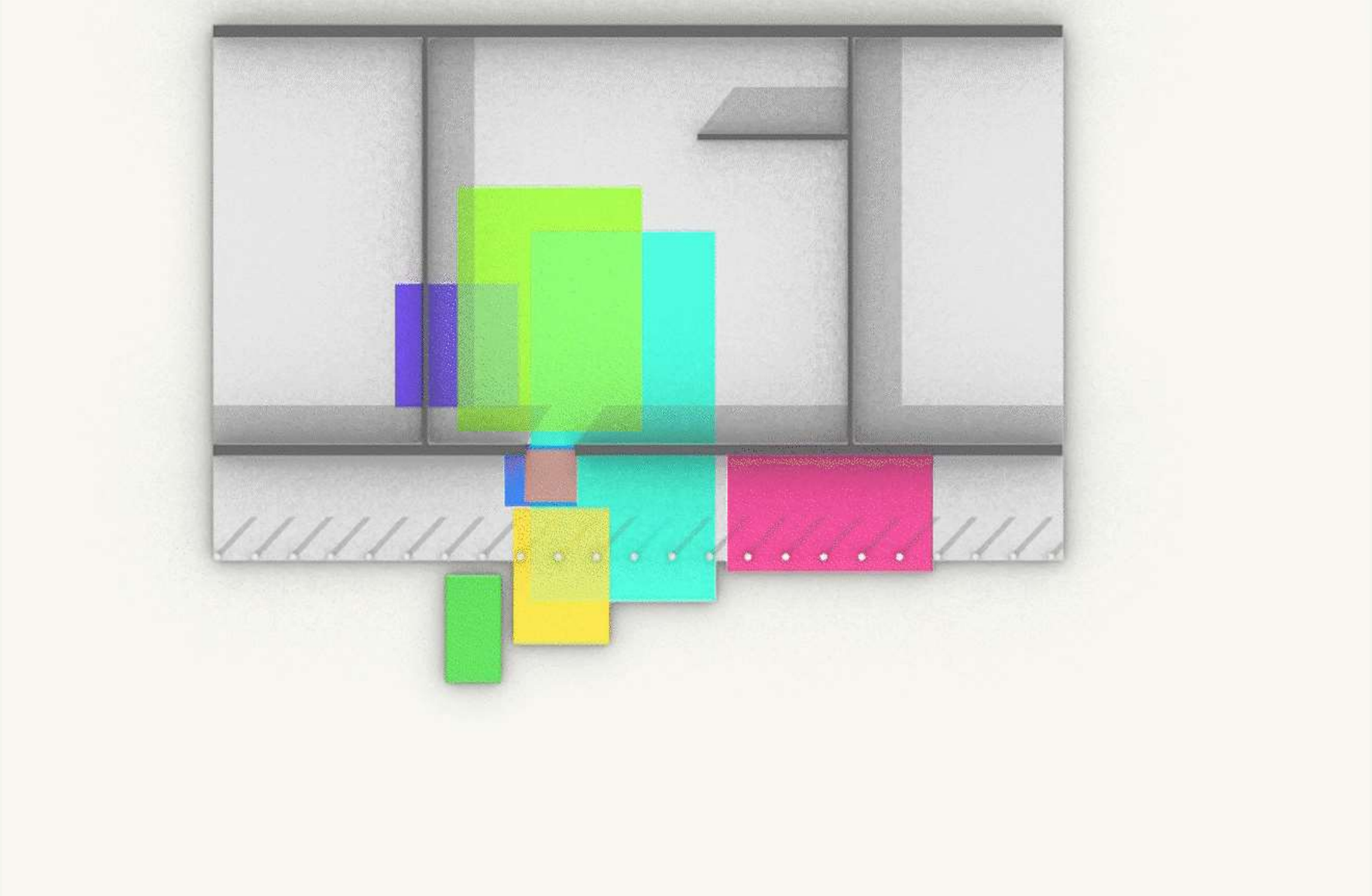
“**How** can the extent of spatial alternatives of an apartment configuration be explicated within a building **design?**”



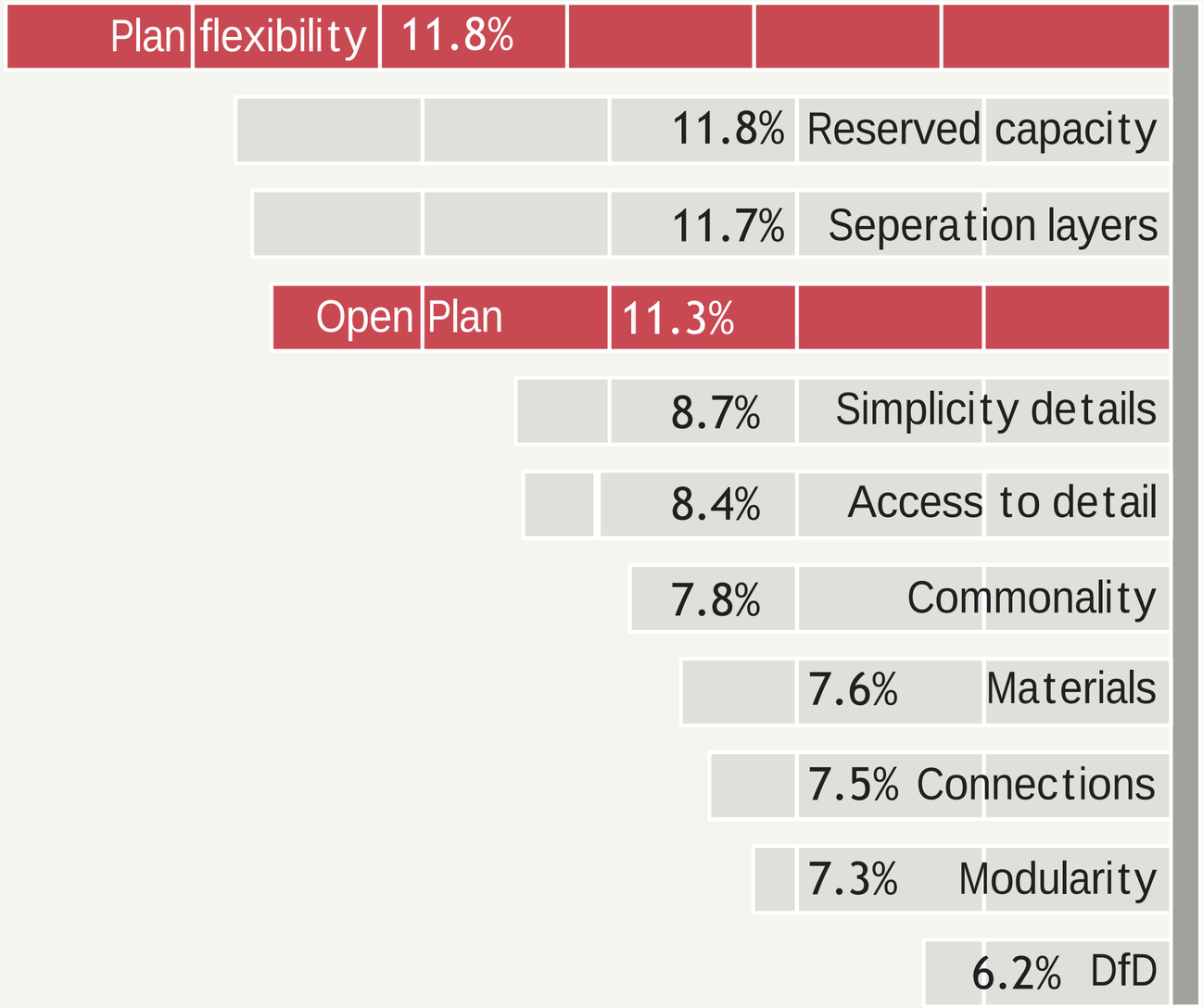




Thank you for your attention!



Thank you for your attention!



Potential of enablers of adaptability from expert survey (Ross, B. E., Chen, D. A., Conejos, S., & Khademi, A. (2016). Enabling Adaptable Buildings: Results of a Preliminary Expert Survey. *Procedia Engineering*, *145*, 420–427. https://doi.org/10.1016/j.proeng.2016.04.009)