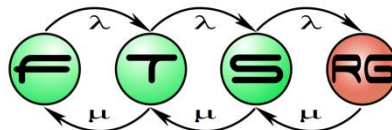


Structural Modelling

Budapesti Műszaki és Gazdaságtudományi Egyetem
Hibatűrő Rendszerek Kutatócsoport



Topics of the Lecture

- Goals and Applications of Structural Modelling
- Decomposition
- Description of the Model Elements by Graphs
- Property Modelling

Goals,
Applications

Decomposition

Graphs

Properties

STATIC MODELLING

How can the structure of complex systems be clearly modelled?

Examples:

- Architecture – Building
- Corporate network

Definition: Structural Model

Structural models are static. Their basis are (sub-)systems that are divided into their ingredients by the relation „**Part of**”.

The **ingredients** can be the followings:

- further divided **subsystems** or
- further not divided (*elementary*) **components**.

The structural model represents the structure of the system according

- its ingredients,
- the **properties** of the ingredients and
- their **relationships** among each other.

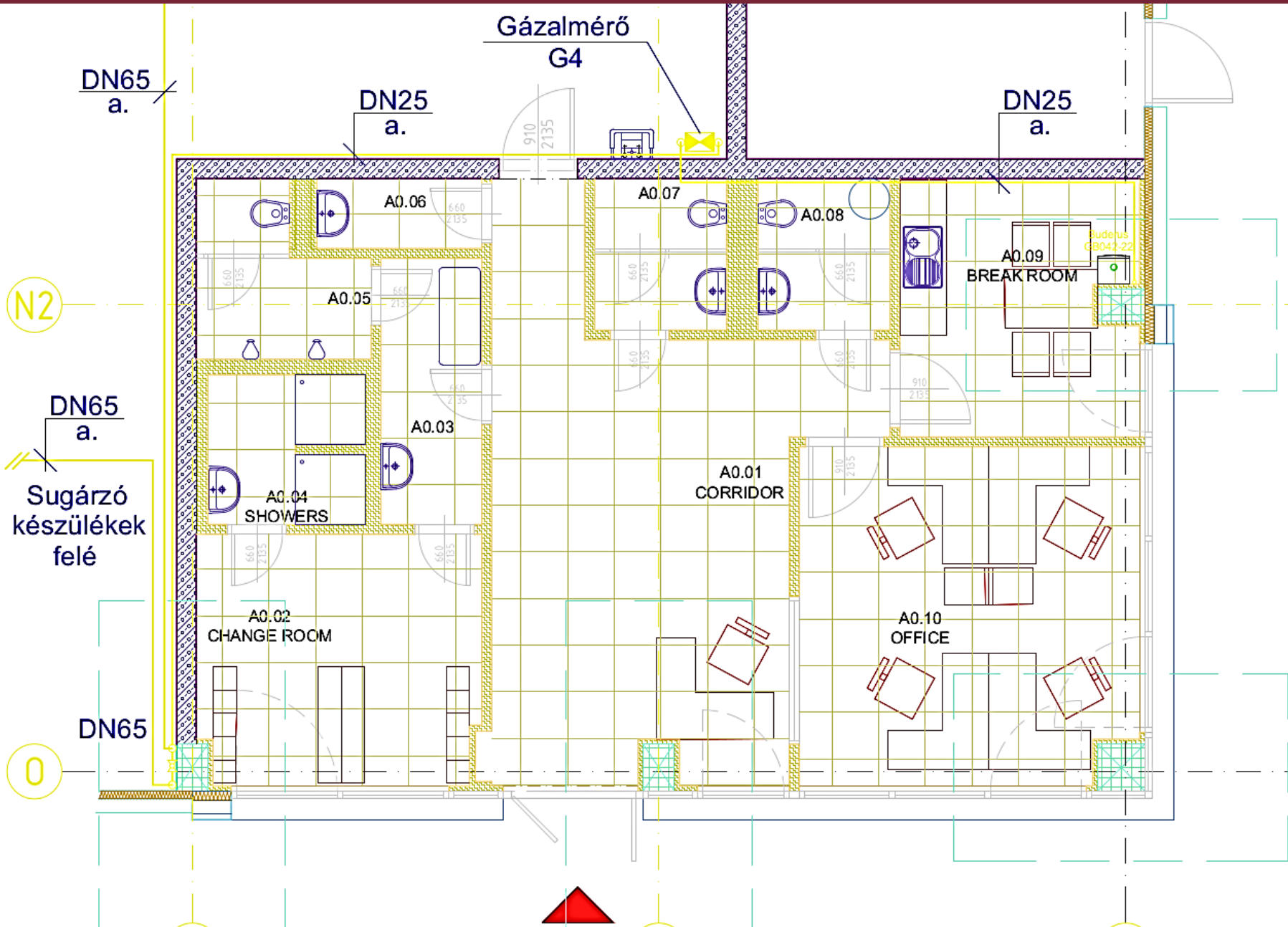
Example: Architecture Models

- BIM (Building Information Model)
- Modelling the whole building in a single model
- Views
 - Gas pipe system
 - Isolation
 - Water pipe and sewerage system
 - Electric installation plan
 - etc.

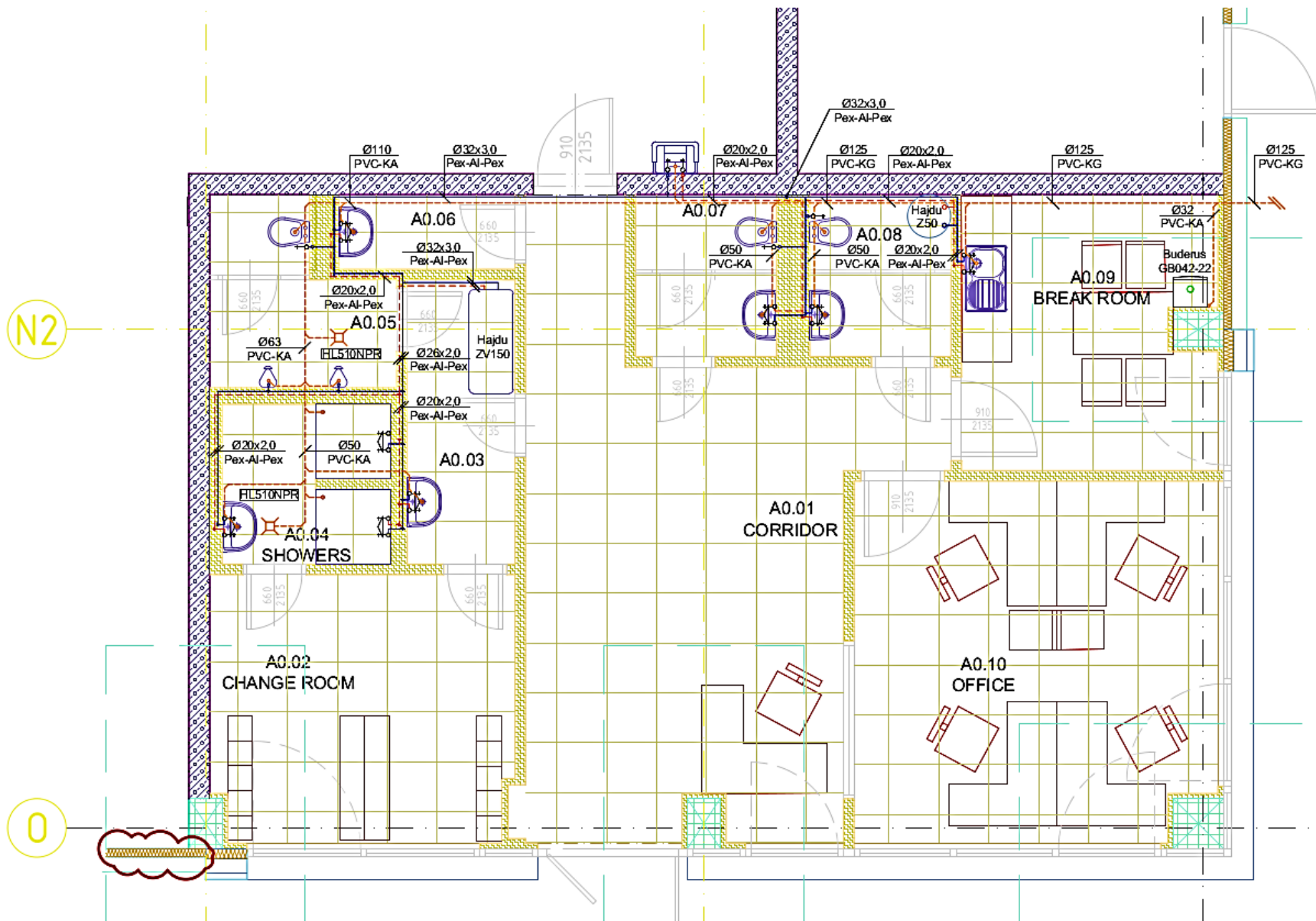
Office in a Production Hall



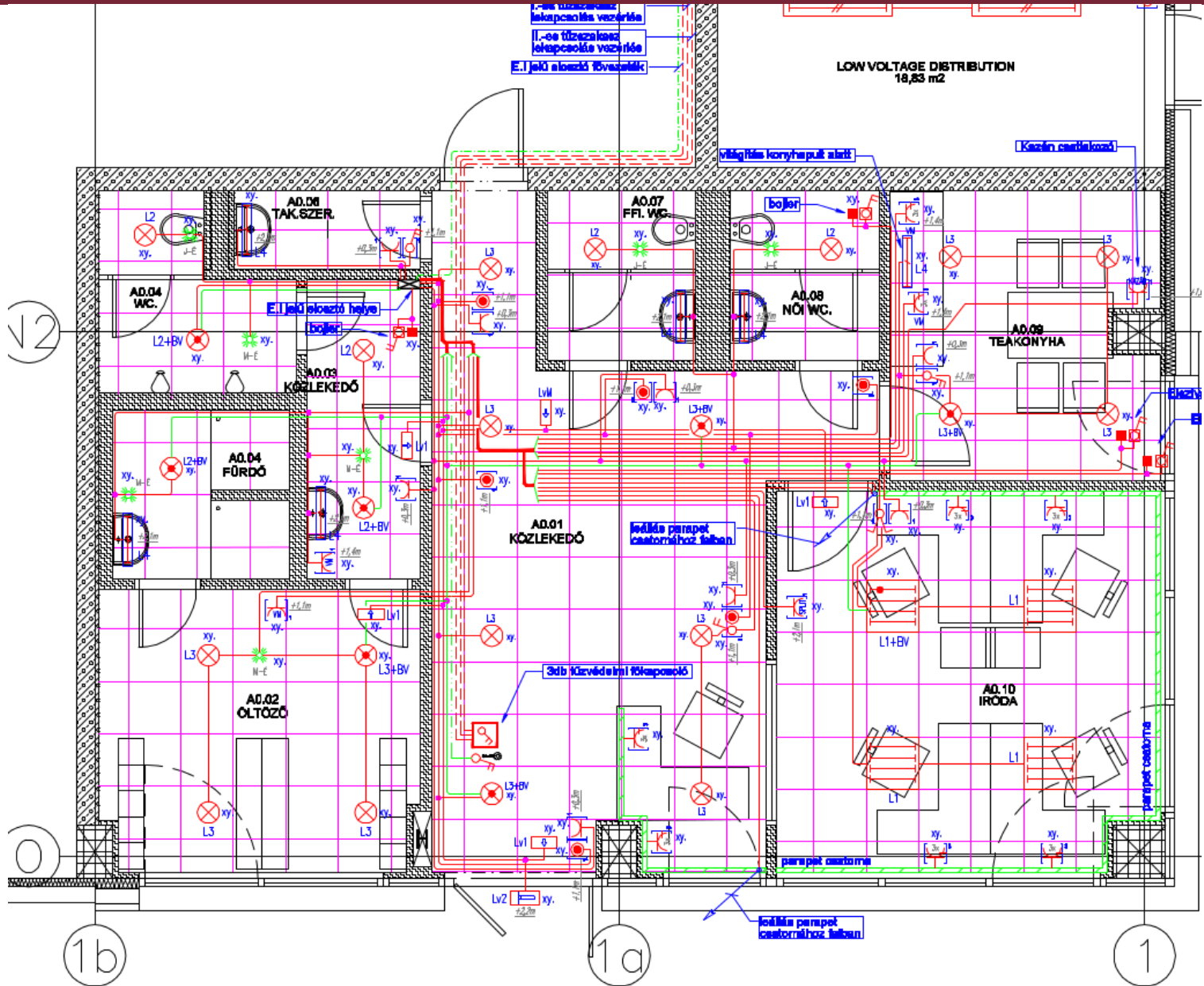
Gas Pipe System



Water and Sewerage System



Electric Installation Plan

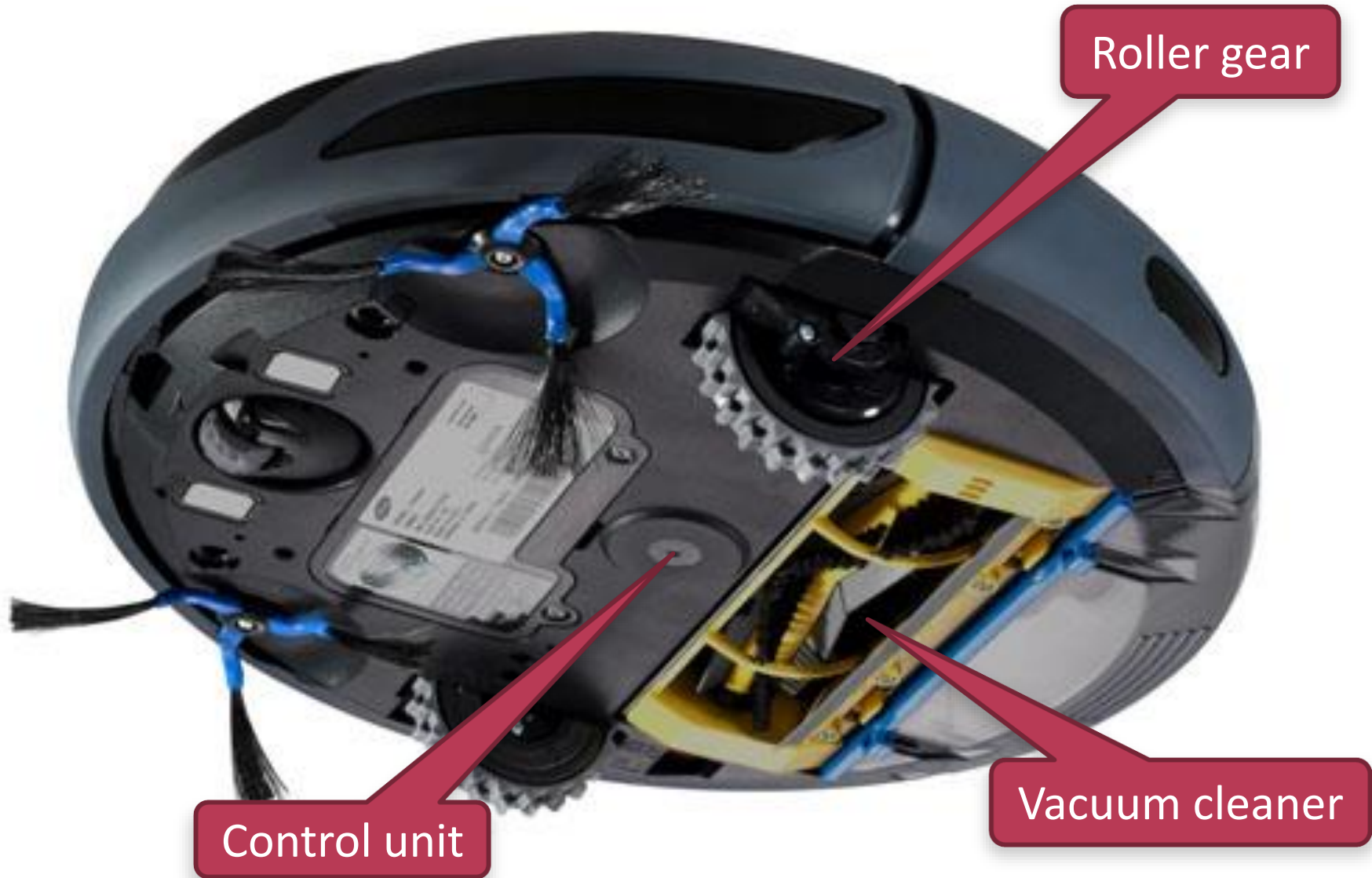


Goal of Structural Modelling

- Dividing a system
 - It is simpler to design smaller units
 - Usage of already existing parts
 - Usage of commercial components (COTS - Commercial off-the-shelf)
- Documentation of an existing system
 - „System overview”
- Defining data structures
 - What pieces of information should be there?
 - Relationships of the pieces



Example: Robot Vacuum Cleaner



Structural and Behavioural Modelling

■ Structural

- static
- whole and part, components
- connections

The main components of the robot vacuum cleaner are the control unit, the roller gear and the vacuum cleaner.

■ Behavioural

- dynamic
- timeliness
- states, processes
- reactions to the environment (context)

For the command „to right” changes the roller gear its operational mode to „turn”.

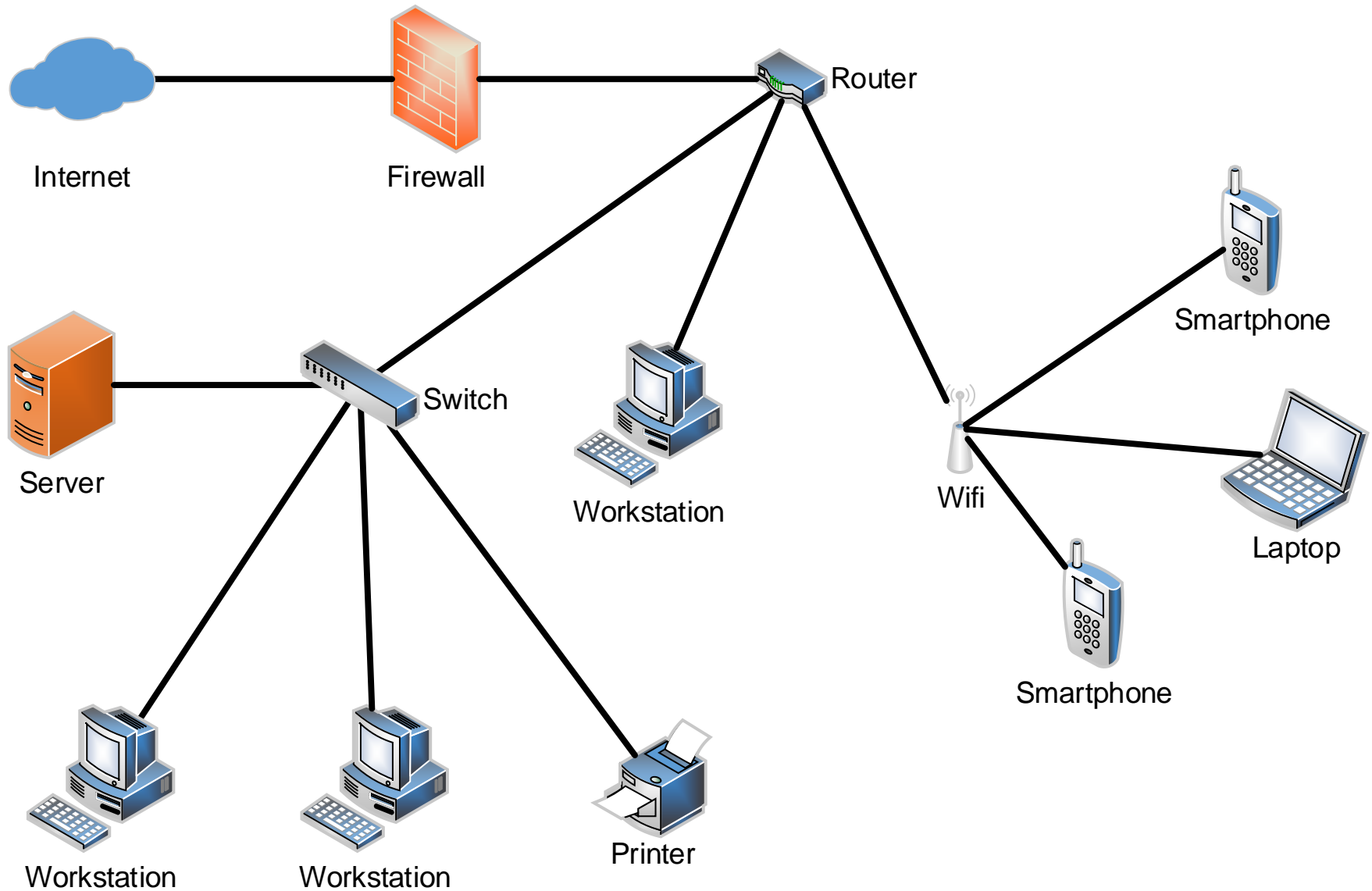
The roller gear of the robot intervenes when signals of the sensors are received.
(When, how?)

- This categorization is neither full nor disjoint ...

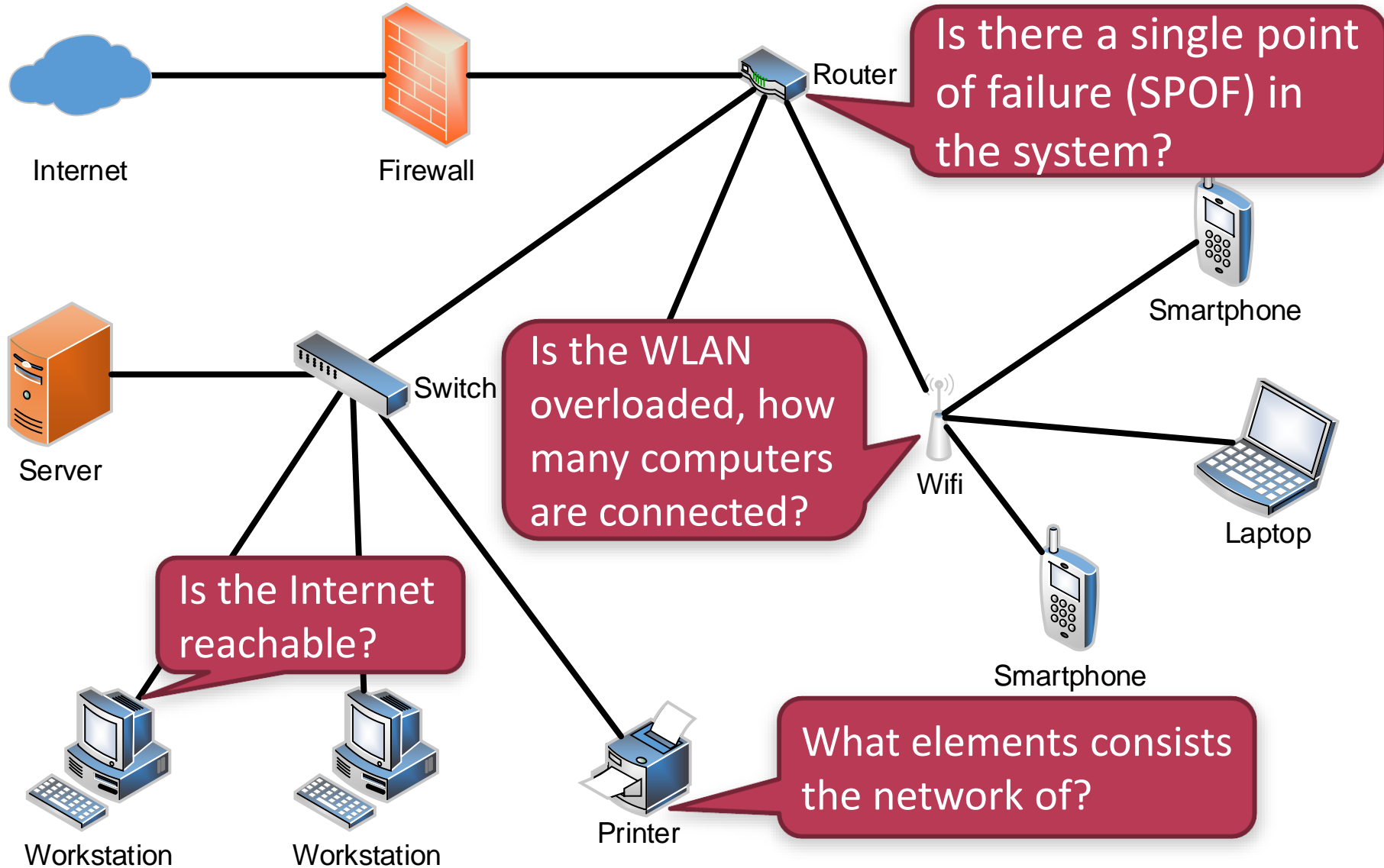
Structural Model

- The knowledge about the structure of the system
 - What parts consists the system of?
 - How are they connected?
 - What kind of properties do the elements have?

Example: Corporate Network



Example: Corporate Network



Goals,
Applications

Decomposition

Graphs

Properties

STRUCTURAL DECOMPOSITION

What containedness relationships are there among the subsystems?

Examples:

- Robot vacuum cleaner
- Registration office

Definition: Decomposition

„**Structural models** are static. Their basis are (sub-)systems that are divided into their ingredients by the relation „**Part of**”.

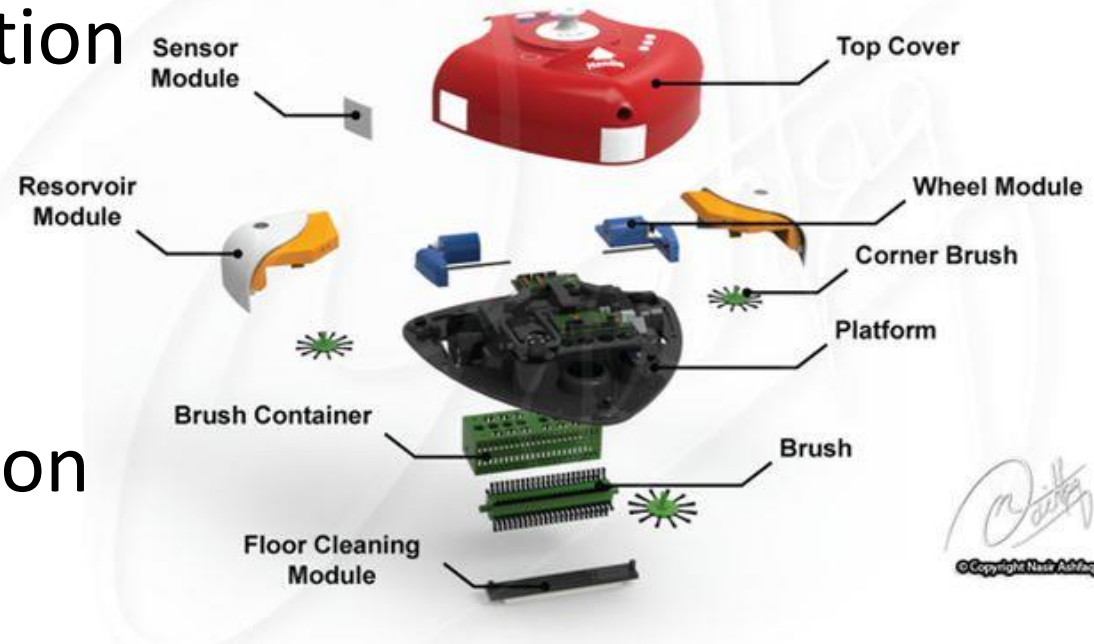
Decomposition („faktoring”) is the division of a complex problem or system into smaller parts that are easier to conceive, understand, design, implement/program and maintain.

- Hierarchical Decomposition:
 - Multi-level whole-part relationship
- Meaning of the relation Part of:
 - Physical Decomposition: Part of = spatial division
 - Logical Decomposition: Part of = functional division

Types of Decomposition

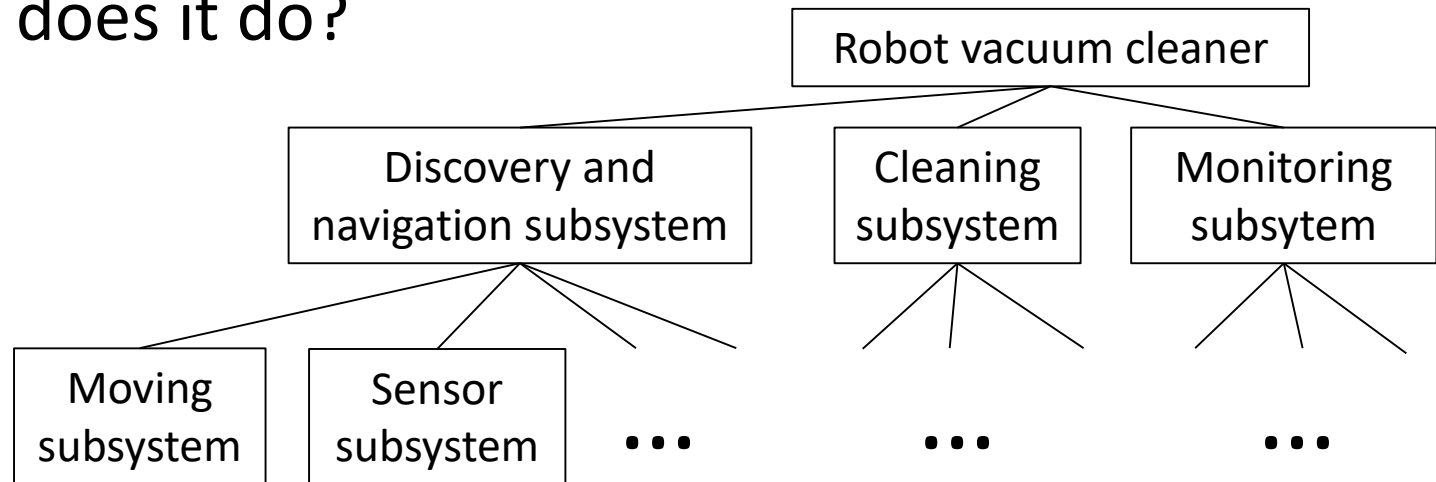
- Physical decomposition

- What pieces does it consists of?



- Logical decomposition by functions

- What does it do?



Definition: Correctness of Decomposition

A decomposition is **correct**, if

- each element of the system resulting from the decomposition corresponds to an element of the original system, and
- each element of the original system corresponds to some elements of the system resulting from the decomposition.

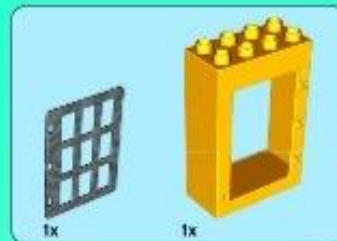
Example of a Correct (De)Composition

The whole system

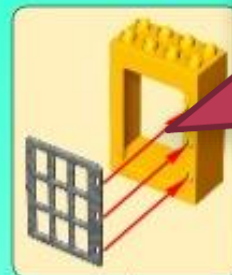


Further not detailed building blocks (in practice: Do we know all of them?)

IT example: service catalogue



2



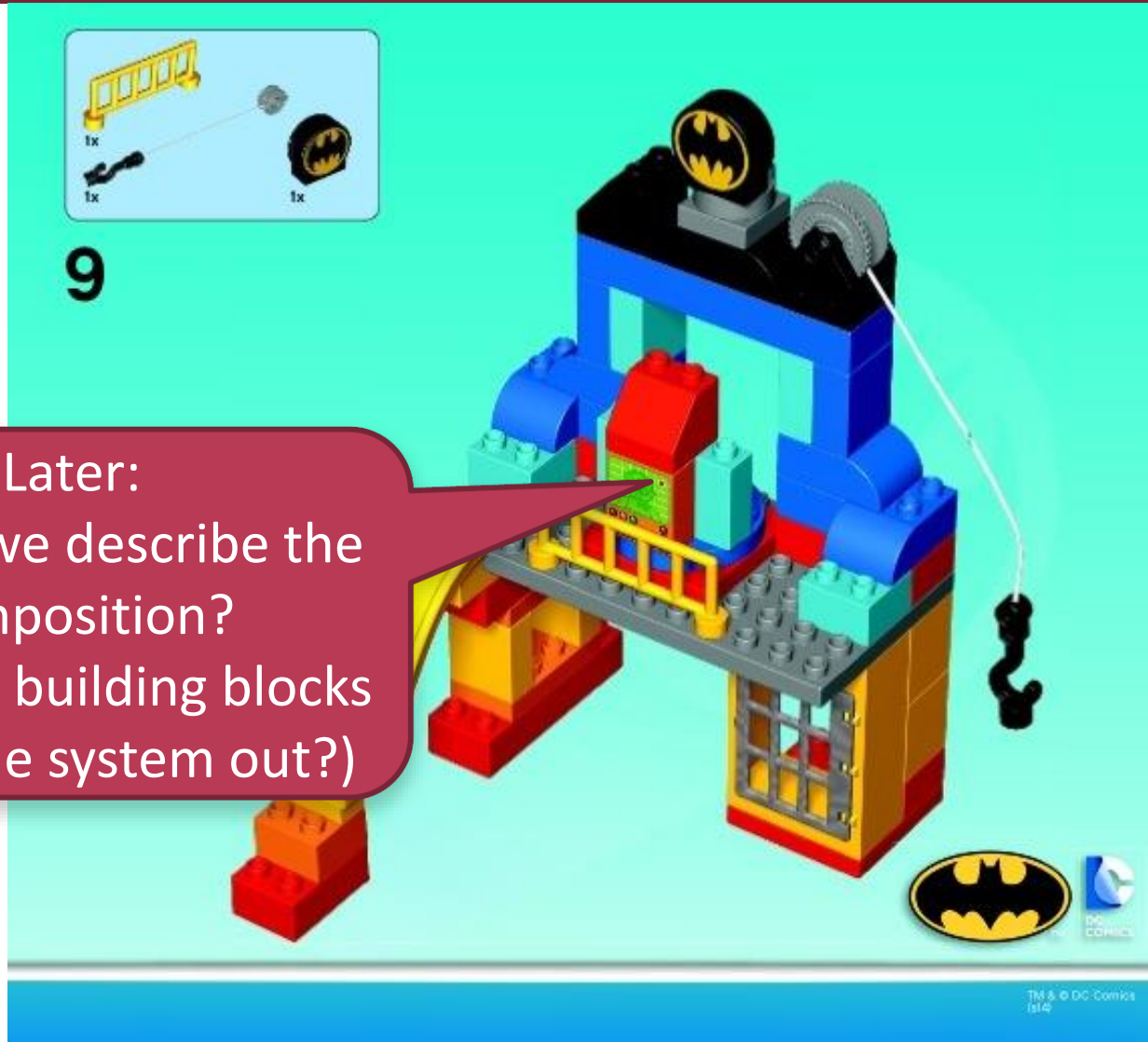
Interface definition (within a subsystem)



Interface to the outer world

http://lego.brickinstructions.com/en/lego_instructions/set/10545/batcave_adventure

Example of a Correct (De)Composition



Later:

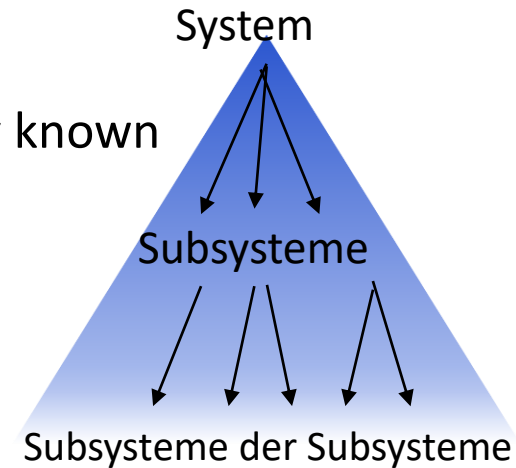
How do we describe the composition?
(from the building blocks
/ from the system out?)

http://lego.brickinstructions.com/en/lego_instructions/set/10545/batcave_adventure

Top-down and Bottom-up

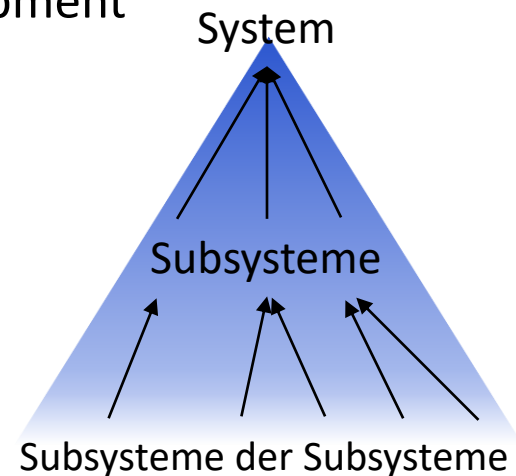
■ Top-down

- ☺ Roles of the subsystems are during development already known
- ☹ There are no functioning parts during development
- ☹ Problems/Reqs of the subsystems are revealed late



■ Bottom-up

- ☺ Subsystems can be tested step-by-step
- ☺ There are always some functioning parts during development
- ☹ Exact roles of the subsystems are revealed late



- Not only in structural modelling
- Mixed approaches, iterative Development

Goals,
Applications

Decomposition

Graphs

Properties

STRUCTURAL MODELS

What kind of relationships are there among the subsystems?

Examples

- Transport network
- File system

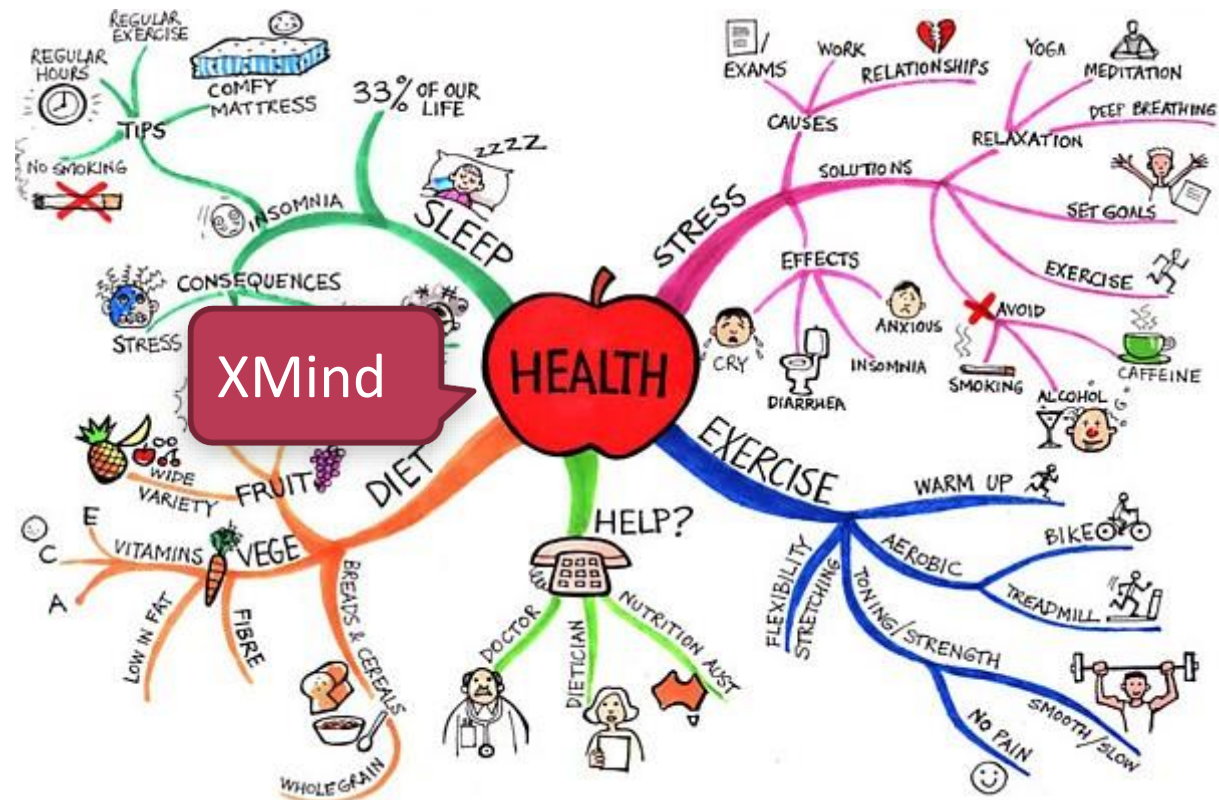
Graph Representation

- Human way of thinking: „Connections of Things”

- **Things:** persons, airports, areas
- **Connections:** dependency, acquaintance, flights, containment

- Mathematical Formalism:
Graph

- Nodes
- Edges
- (Properties)







Definitions in Computer Engineering

- In the computer engineering everything has several, often contradicting definitions
 - System = ?
 - Model = ?
- The same term is often named with different names
 - node, vertex, object, concept
 - edge, link, arc, connection, relationship

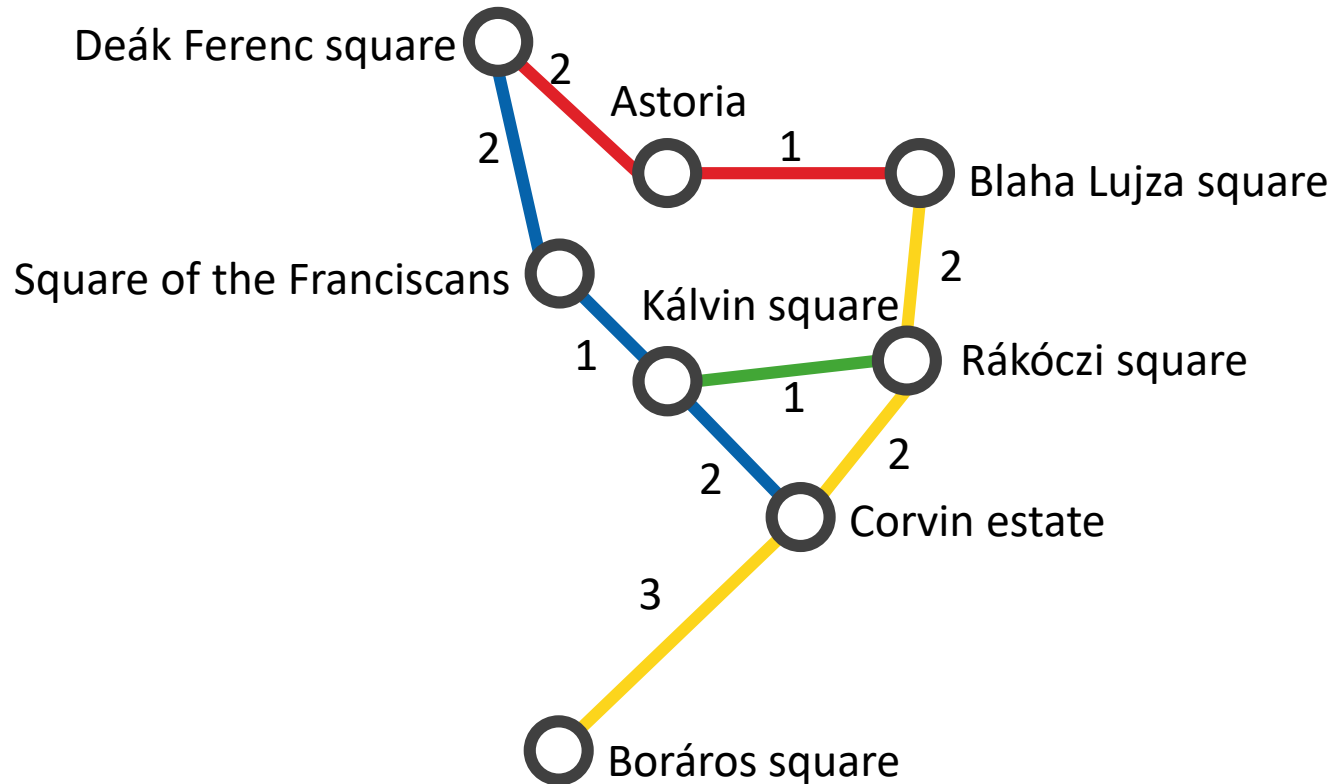
Always pick one!

Budapest – Rail-bound Transport Network



-  M2
-  M3
-  M4
-  4-6

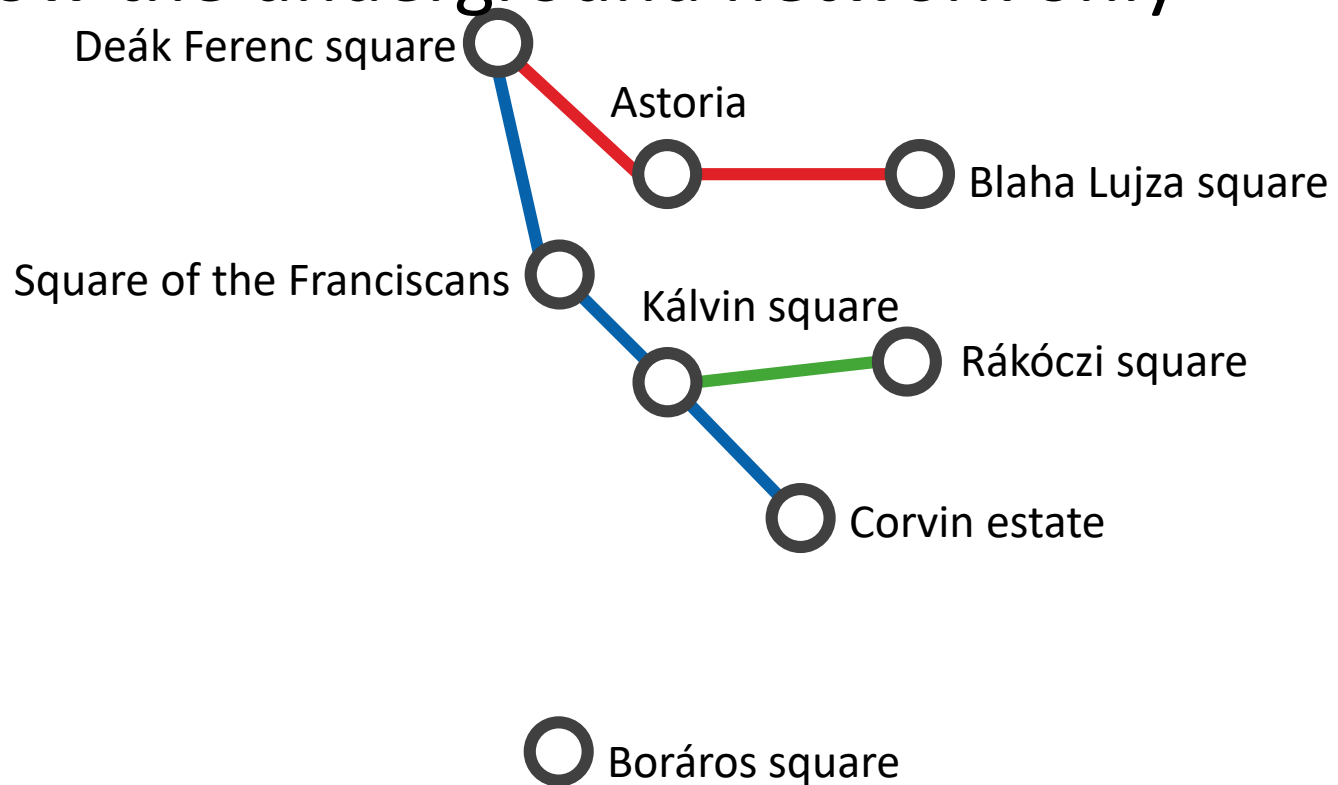
Budapest – Rail-bound Transport Network



Shortest path?

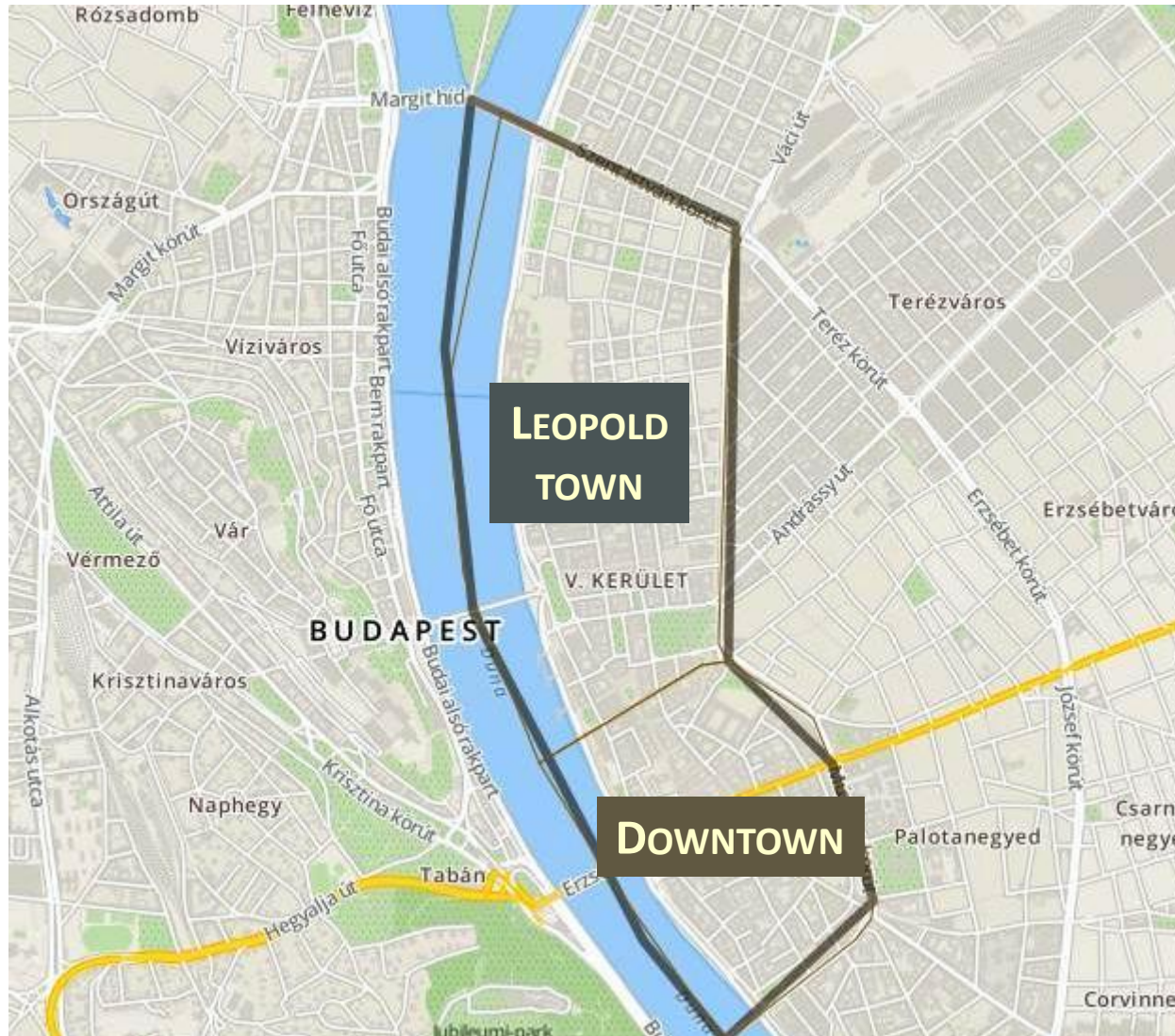
Filtering: by edge labels (Subgraphs)

- E.g. show the underground network only

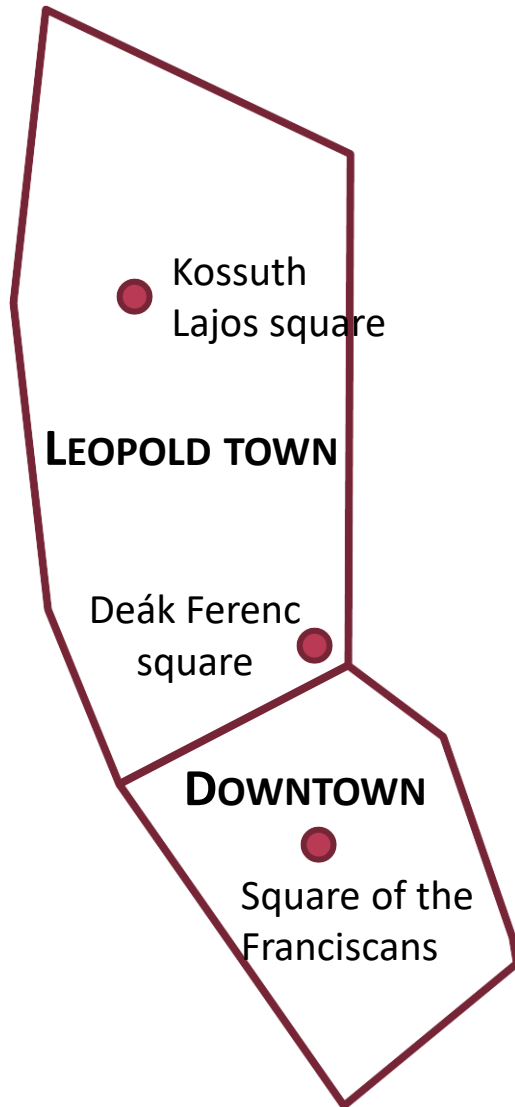


- What is reachable by the underground only?

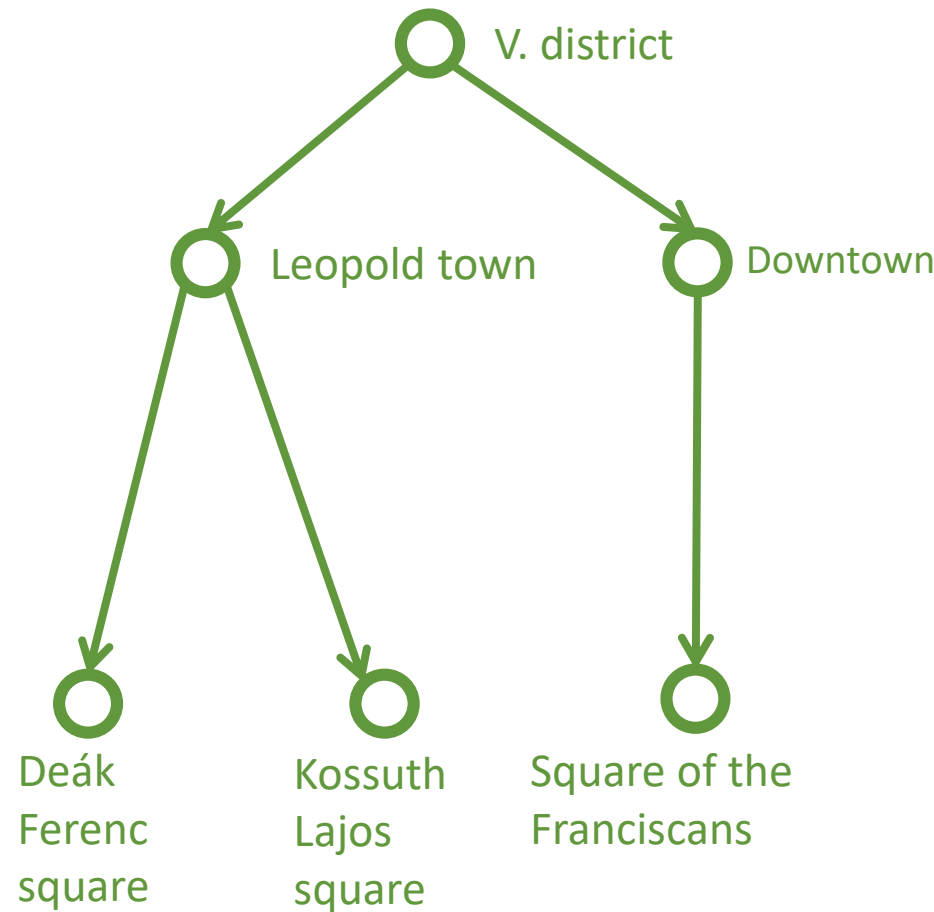
Budapest V. district



Budapest V. district – Hierarchical Model



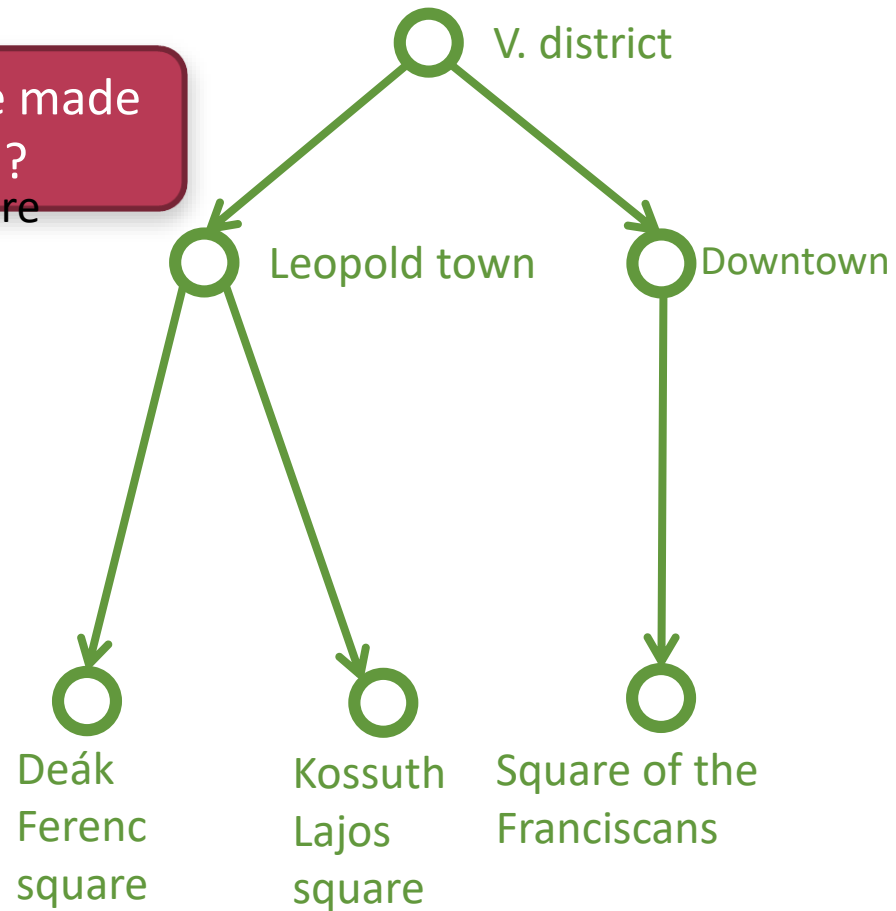
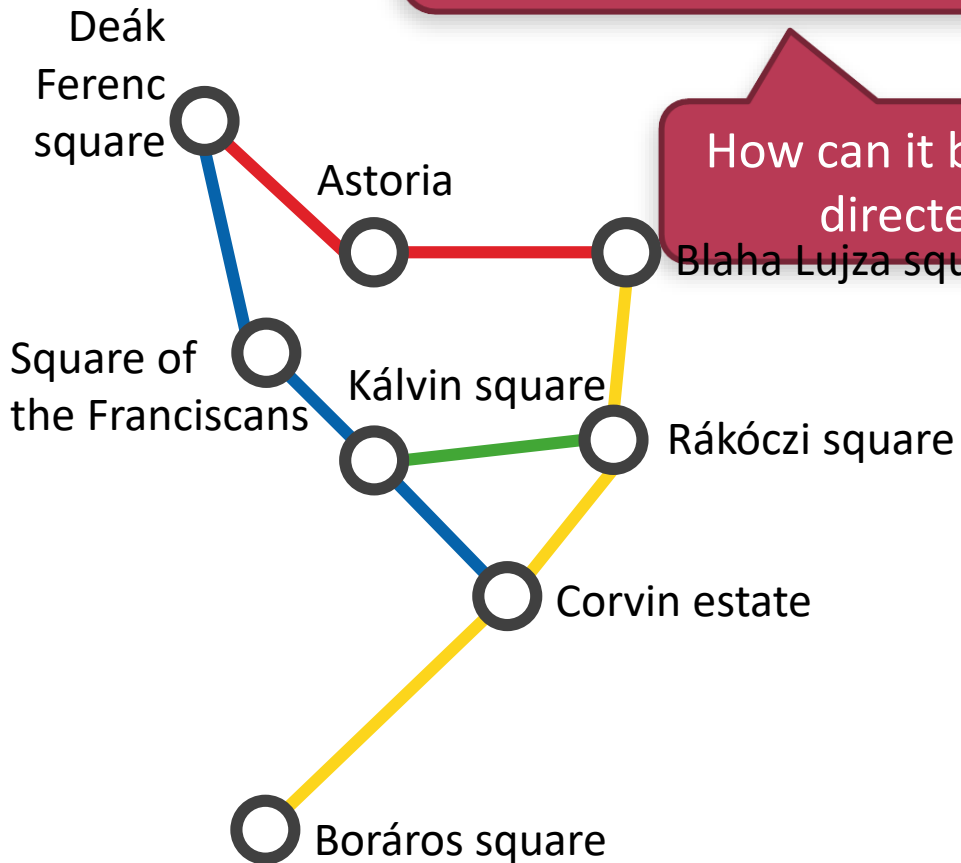
≡



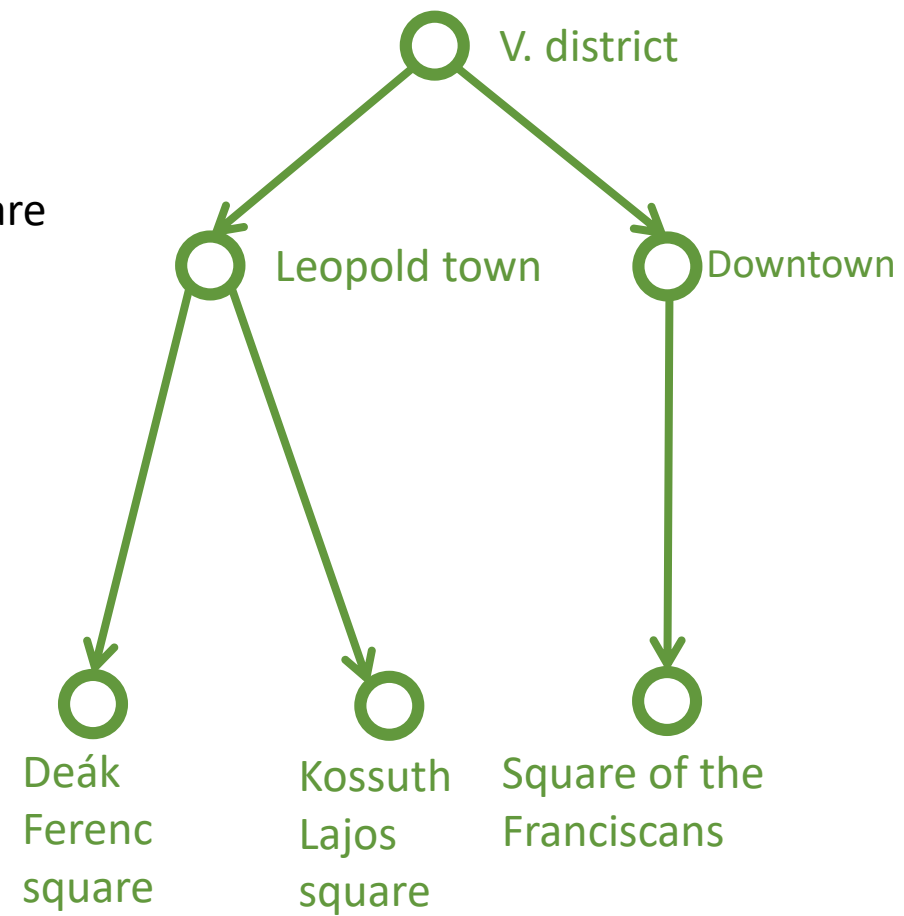
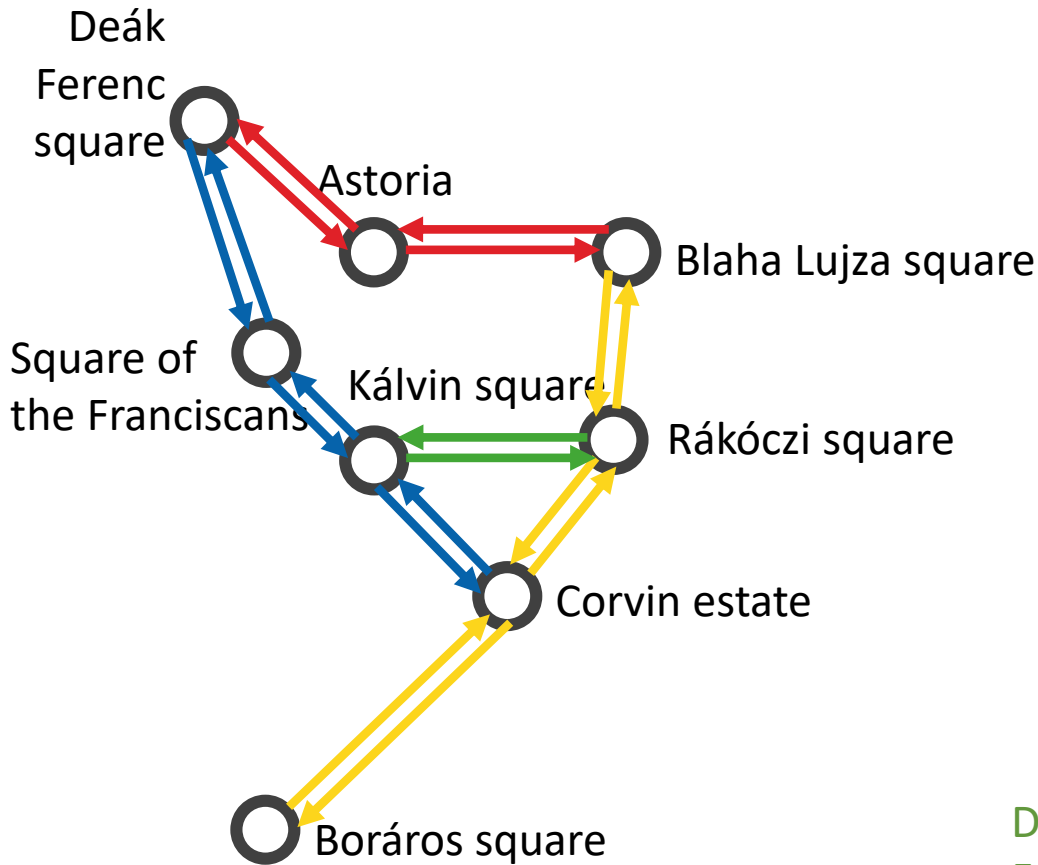
Simple Graphs

Transport network:
undirected graph

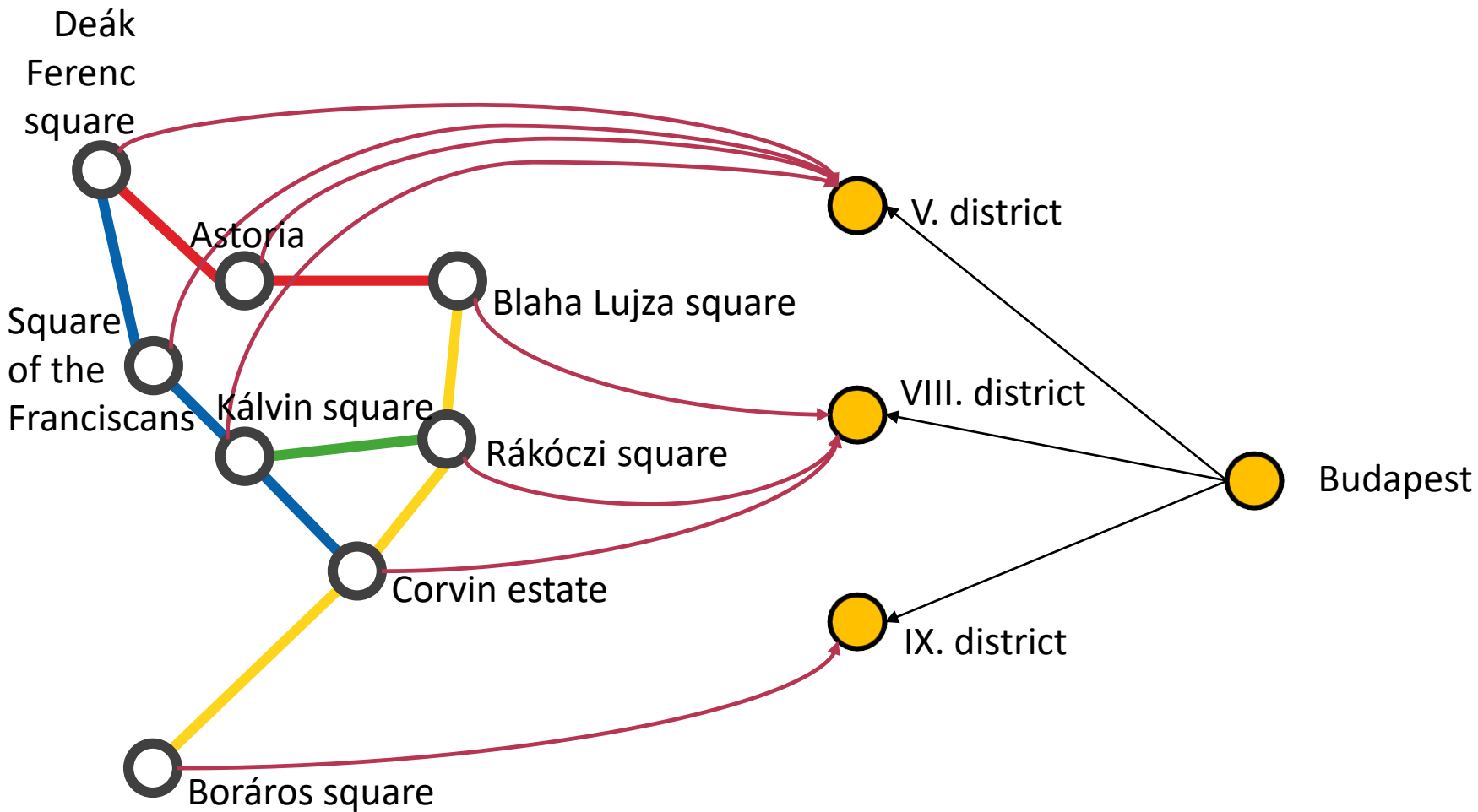
Areas:
directed graph



Simple Graphs

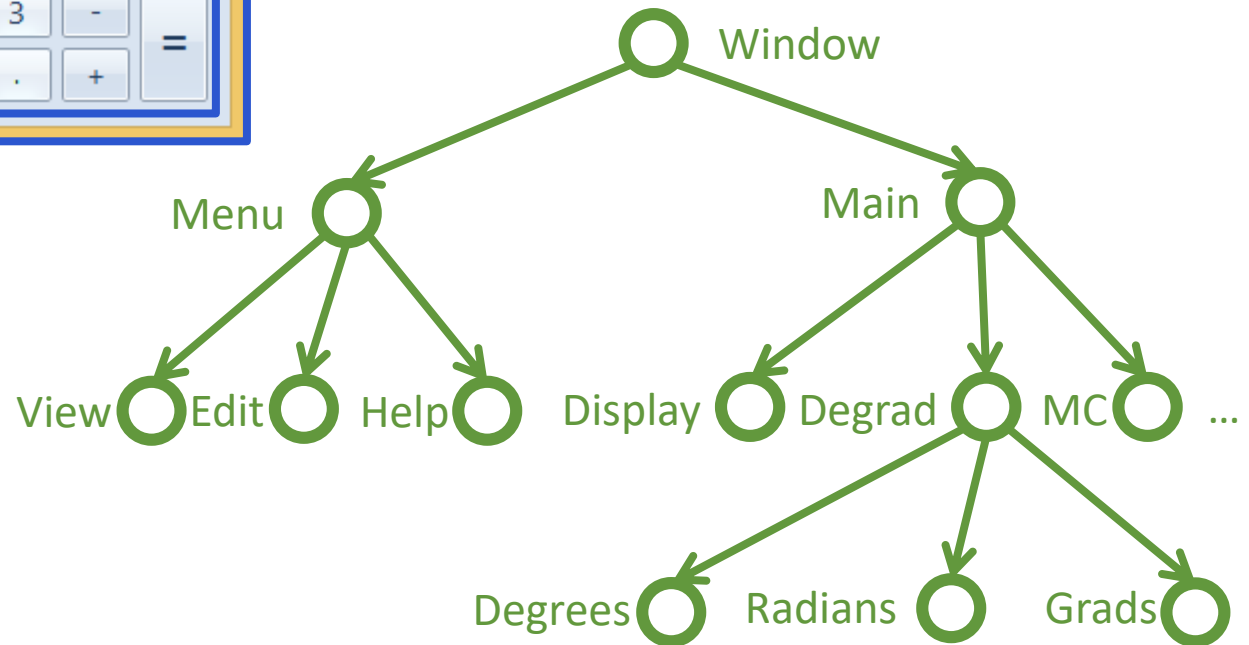
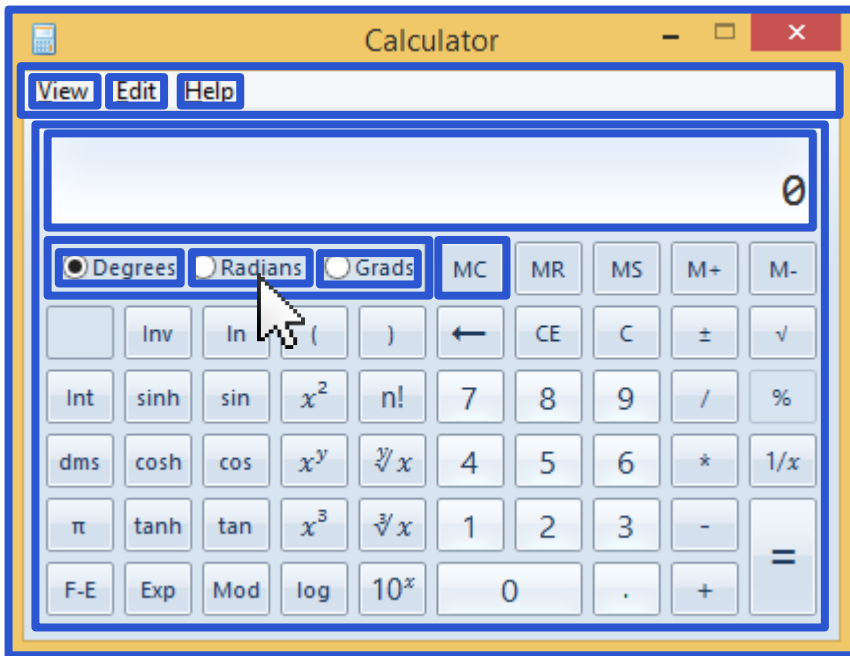


Typed Graph



Graphical User Interface

- Representation of a tree structure
 - as graph
 - as containment relation



Representation of a Tree Structure

File system

C:

\Documents

\Pictures

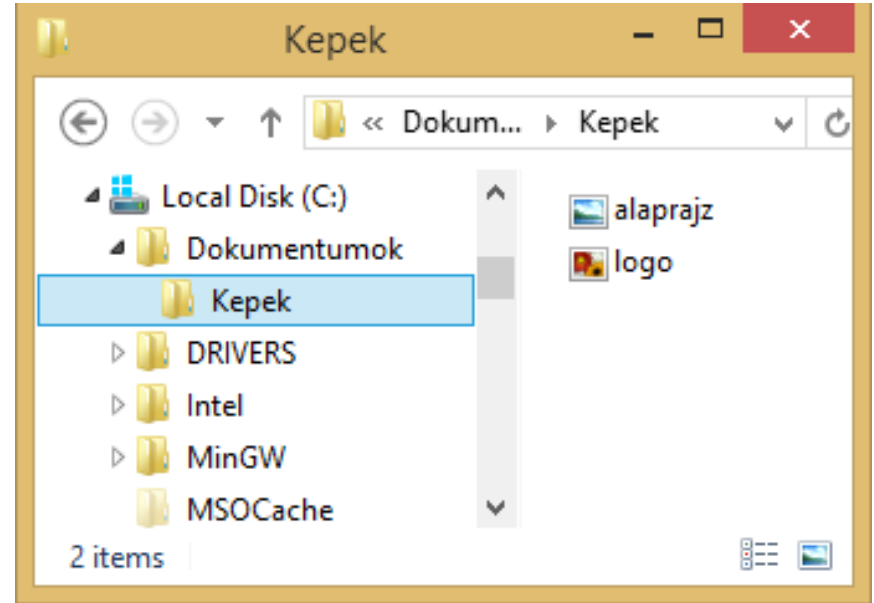
\logo.png

\groundplot.jpg

\contracts.pdf

\Drivers

...



How much storage capacity can be gained by deleting the directory „Documents”?

Characteristics of a File System

- How much storage capacity can be gained by deleting the directory „Documents”?
- Some further Parameter are required

Name	Type	Size (kB)	Last modified
Documents	directory		2016.02.02
Contracts.pdf	file	569	2015.11.09
Pictures	directory		2016.02.02
Logo.png	file	92	2015.03.06
Groundplot.jpg	file	1226	2016.02.02

- Knowing these pieces of information and the file hierarchy, the question can be answered.

Goals,
Applications

Decomposition

Graphs

Properties

MODELLING THE PROPERTIES

What properties do have the individual components?

Examples

- Tables
- Databases

Definition: Property

- Properties of the elements of a model can also be described.

A **property** is a **function** that is

- defined **over the elements of a model** and
- **partial** (values may be undefined), and
- the **value set** of which is the set of the possible values of the given property.

Tabular Representation

- **Rows of the table** = Model elements
- **Columns of the table** = Properties

Name ▾	Type ▾	Size (kB) ▾	Last modified ▾
Documents	directory		2016.02.02
Contracts.pdf	file	569	2015.11.09
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Logo.png	file	92	2015.03.06
Groundplot.jpg	file	1226	2016.02.02

NULL / NA
Attributes

Definition: Filtering

- During **filtering** a **filtering condition** is **evaluated** over the elements of the model, and
- the **submodel** is kept that consists exactly of the elements **satisfying the condition**.

○ Type = „file“

Name ▾	Type ▾	Size (kB) ▾	Last modified ▾
Contracts.pdf	file	569	2015.11.09
Logo.png	file	92	2015.03.06
Groundplot.jpg	file	1226	2016.02.02

○ Size > 1000 kB

Name ▾	Type ▾	Size (kB) ▾	Last modified ▾
Groundplot.jpg	file	1226	2016.02.02

Definition: Projection

During **projection** some **parameters** of the model are chosen, others are omitted.




Name ▾	Type ▾	Size (kB) ▾	Last modified ▾
Documents	directory		2016.02.02
Contracts.pdf	file	569	2015.11.09
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Logo.png	file	92	2015.03.06
Groundplot.jpg	file	1226	2016.02.02

Projection:

{Name, Size}

Name	Size (kB)
Documents	
Contracts.pdf	569
Pictures	
Logo.png	92
Groundplot.jpg	1226

Example: Filtering and Projection

- SELECT „Name”, „Size” 
- FROM „Dataset” 
- WHERE „Type = file” AND „ Size > 1000 kB” 
- SQL: Structured Query Language
 - Data query (and manipulation)
 - Basics of relational databases
 - Here: Description lang. (Filtering, Projection, Derivation)
 - In more details: Databases

<https://portal.vik.bme.hu/kepzes/targyak/VITMAB04/>

MODELLING TYPES

Tabular Representation

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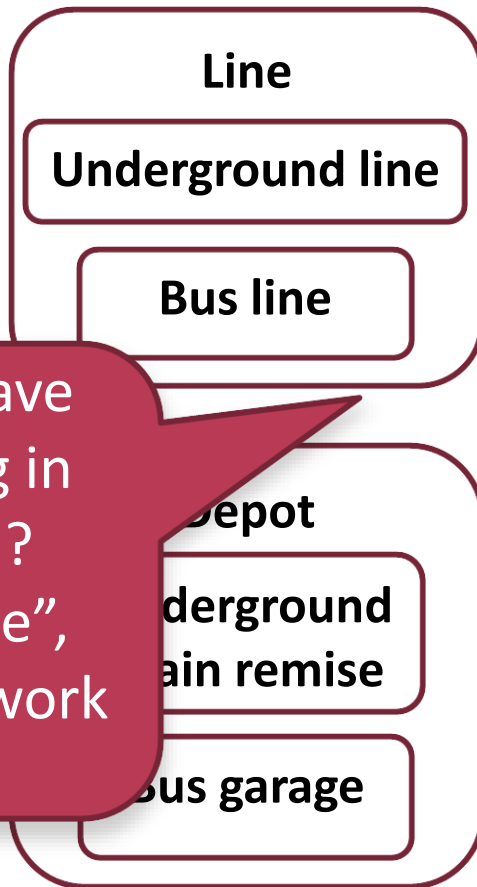
Type and Attributes

- Type is a part of the knowledge, implicitly expressed in the label
 - *Type* is a special property
 - Other properties: *attributes*

- Widely used Convention:
 - Attributes may sometimes change (but they do not have to)
 - Type is permanent (forever)

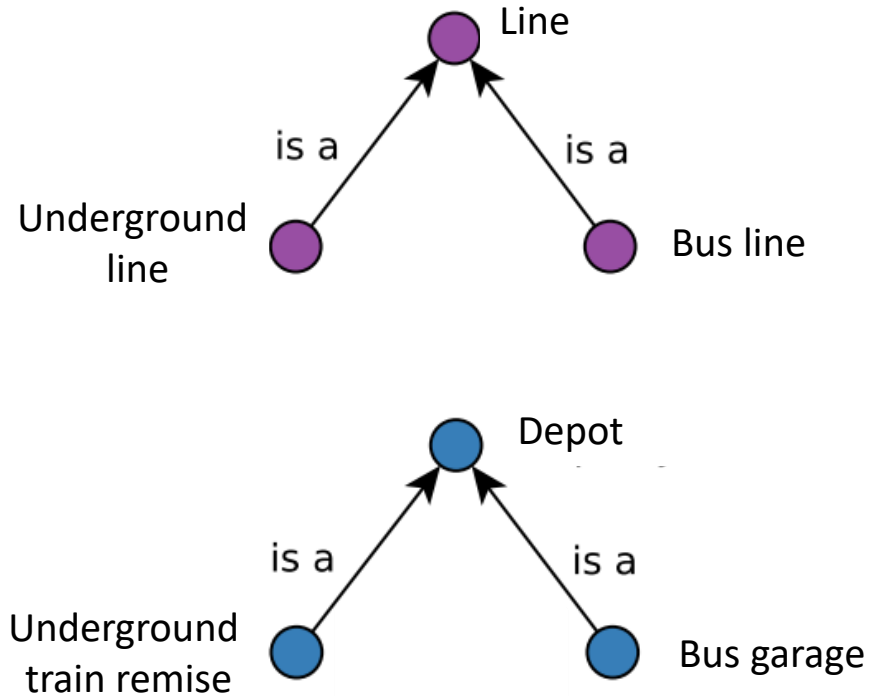
Type Graph

- A *type node* for each node type
- A *type edge* for each edge type
- ...



Do they have something in common?
(e.g. „place”, „traffic network node”)

} Metamodell



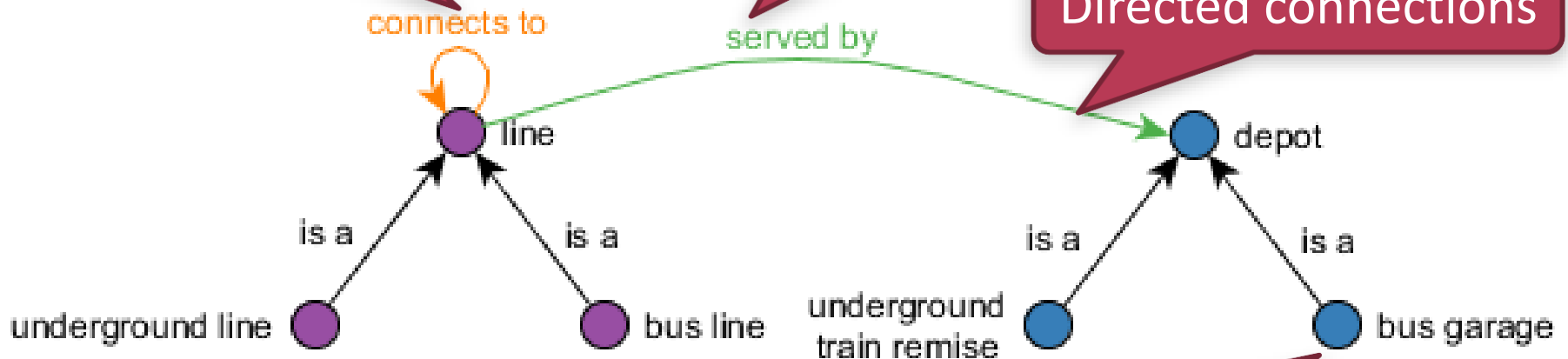
Type Graph

- Labelled (typed) relations among type nodes

Loops are possible

How to do that, if the data come from different sources?

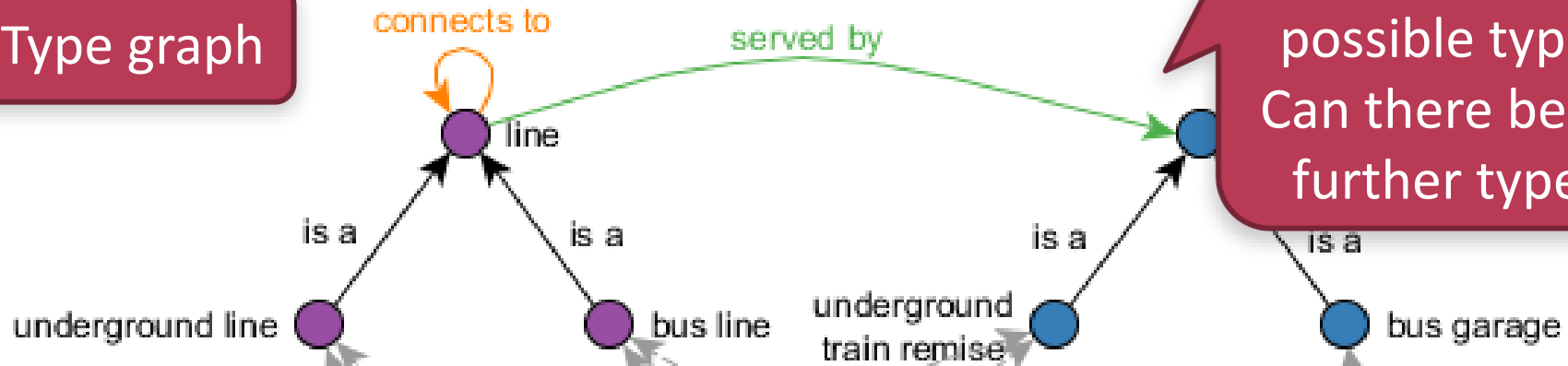
Directed connections



Missing?
„Bus lines can only be served by bus garages”

Type Graph and Instance Graph

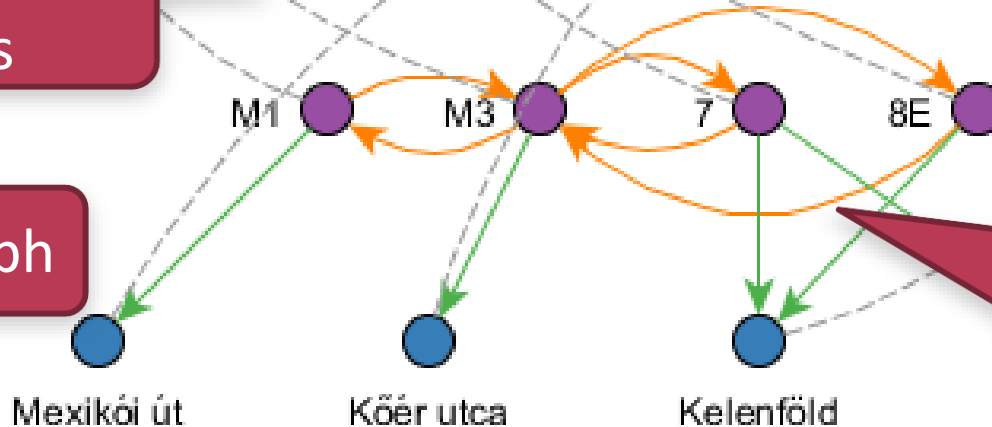
Type graph



What are the possible types?
Can there be any further types?

„instance of” relations

Instance graph



Do the instances correspond to the types? (e.g. „connects to”)

SUMMARY

Definition: Structural Model

Structural models are static. Their basis are (sub-)systems that are divided into their ingredients by the relation „**Part of**”.

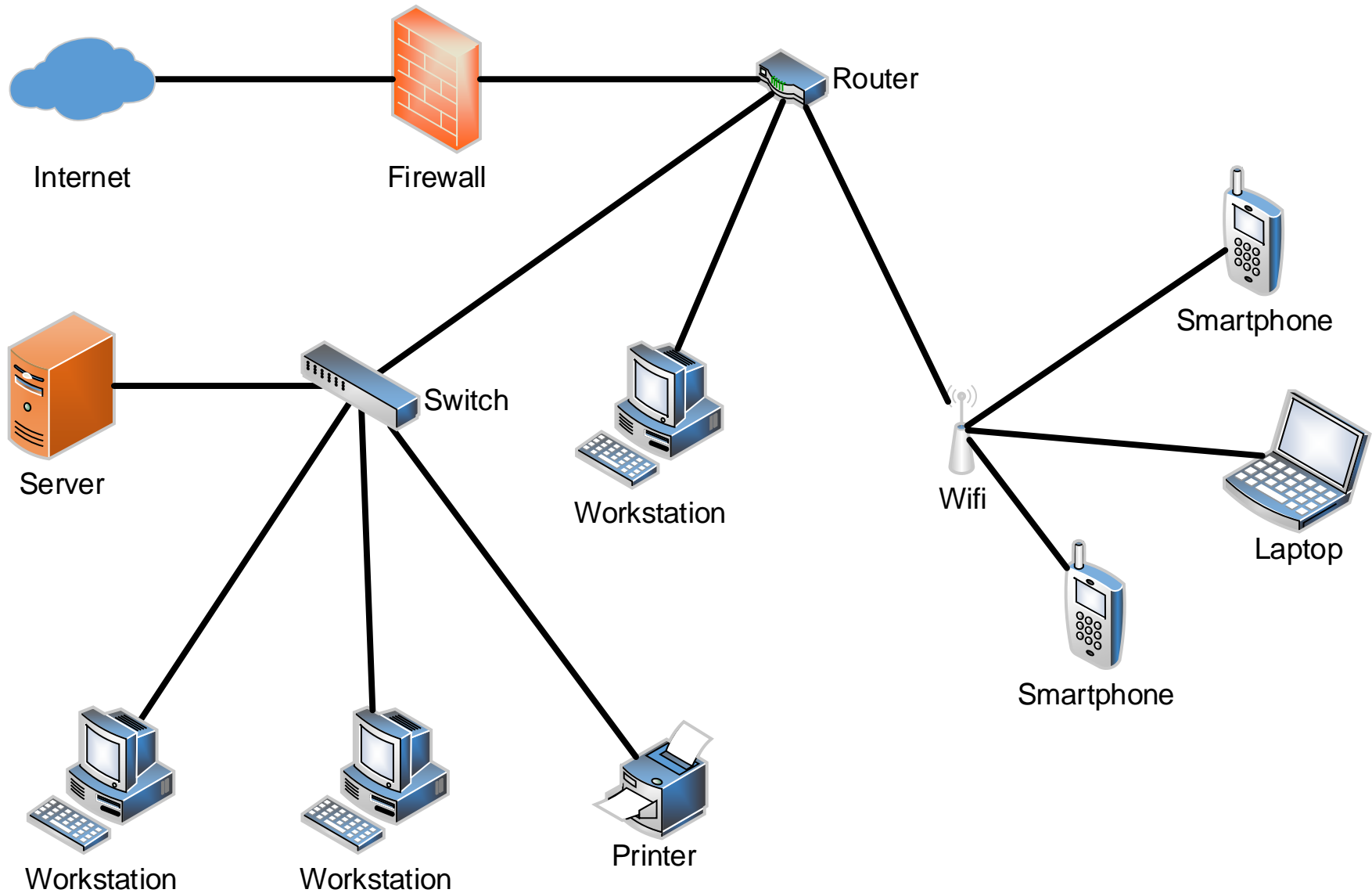
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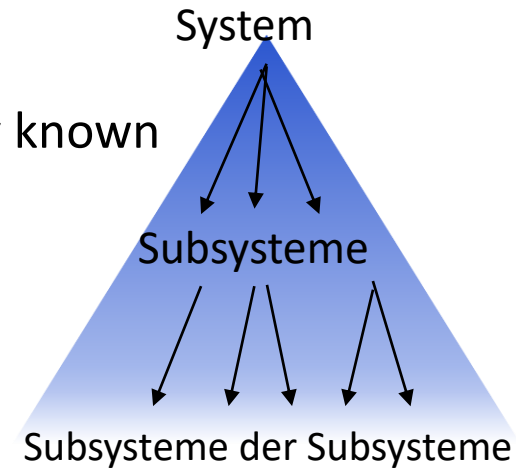
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- Meaning of the relation Part of:
 - Physical Decomposition: Part of = spatial division
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Top-down and Bottom-up

■ Top-down

- ☺ Roles of the subsystems are during development already known
- ☹ There are no functioning parts during development
- ☹ Problems/Reqs of the subsystems are revealed late

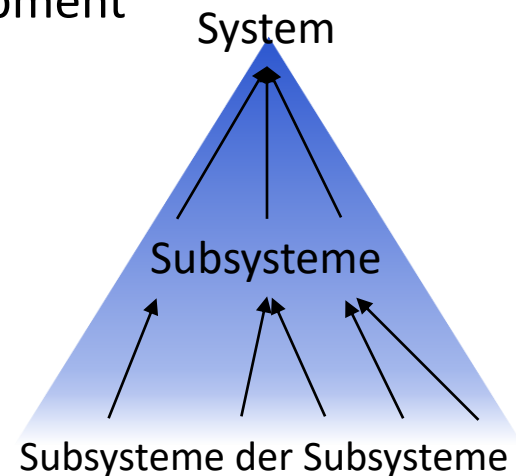


■ Bottom-up

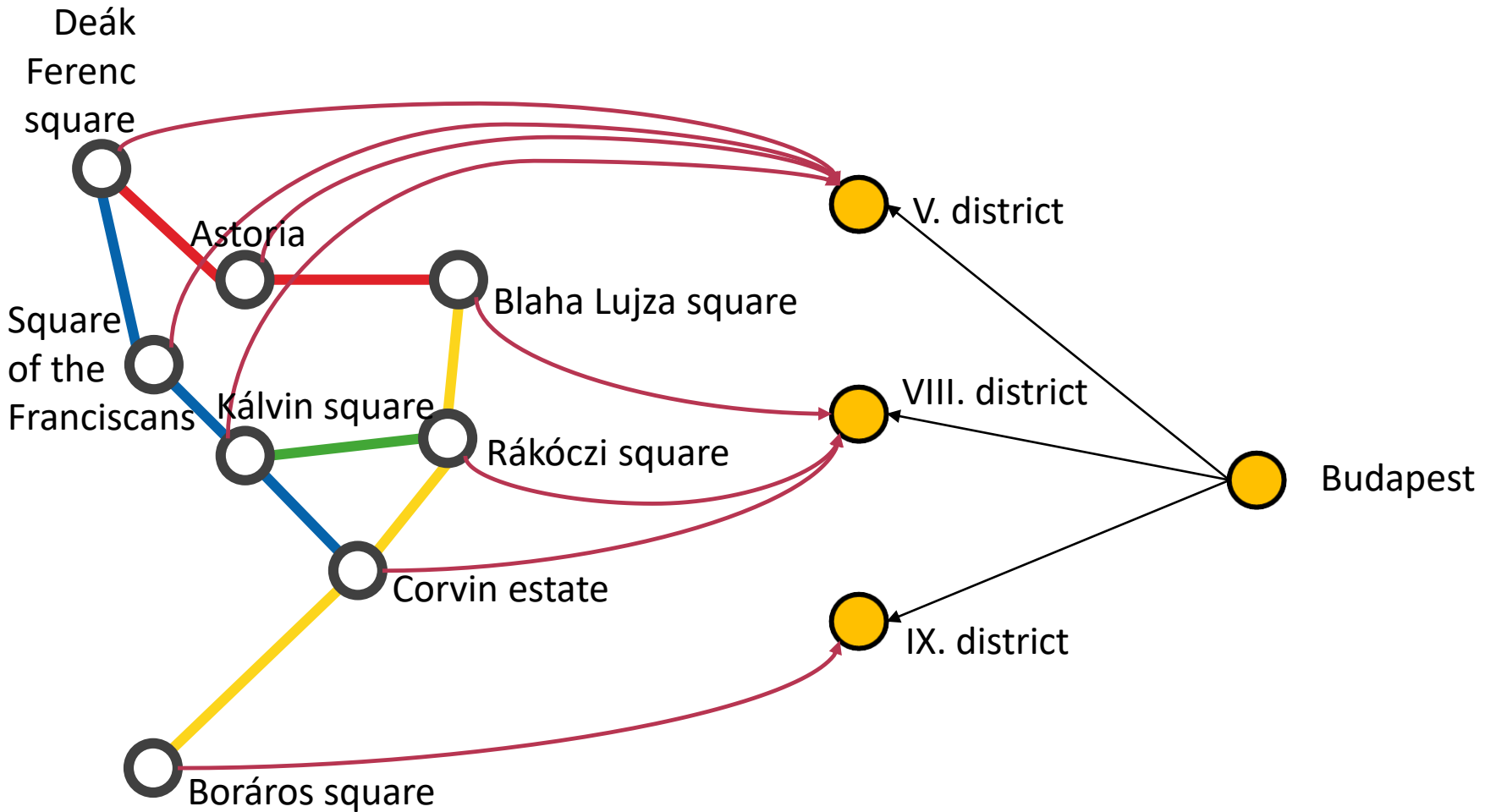
- ☺ Subsystems can be tested step-by-step
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■ Not only in structural modelling

■ Mixed approaches, iterative Development



Typed Graph



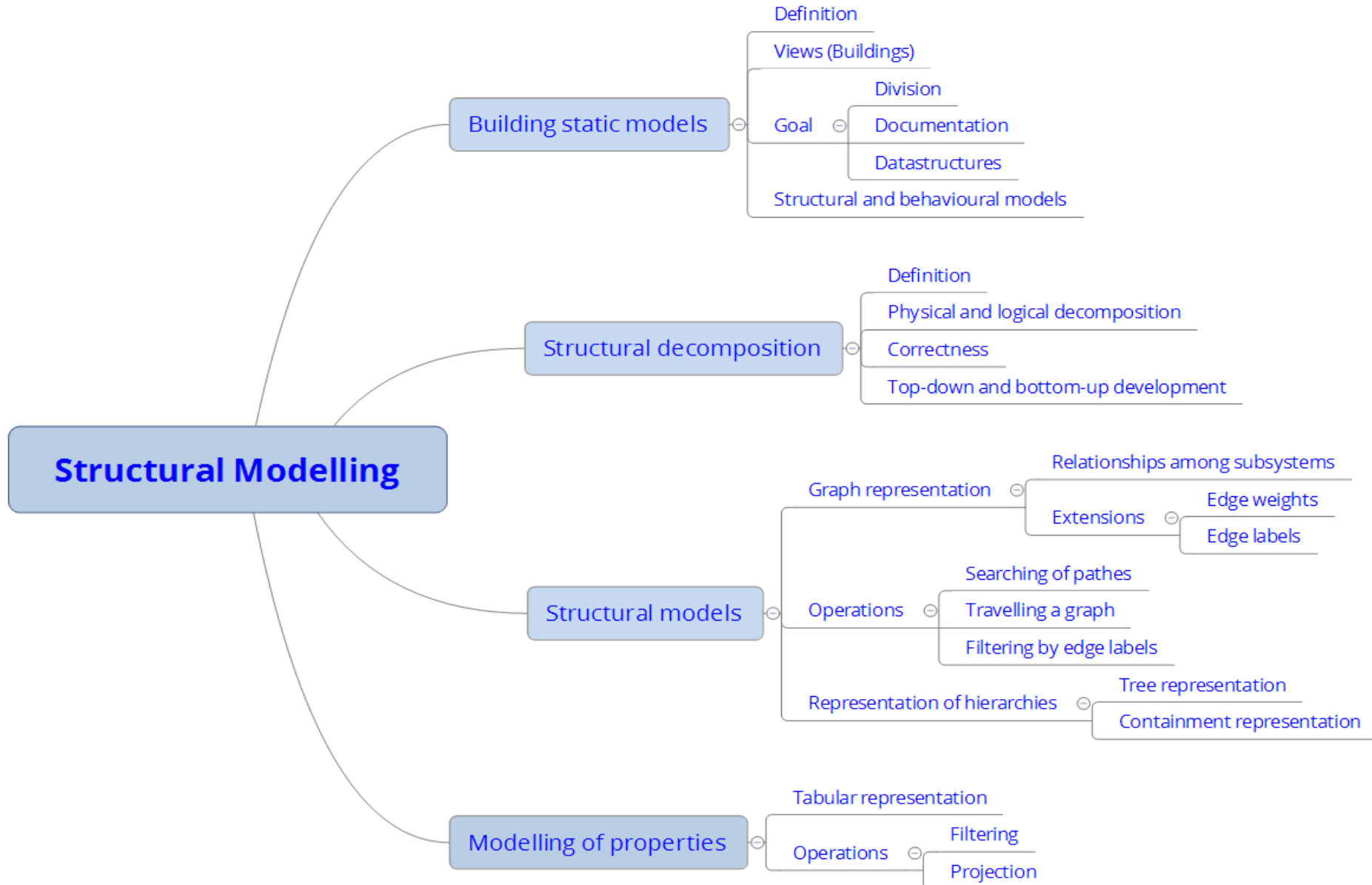
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NULL / NA
Attributes

Summary



FURTHER ILLUSTRATIVE EXAMPLES

Illustration – Structural Models

Nested representation

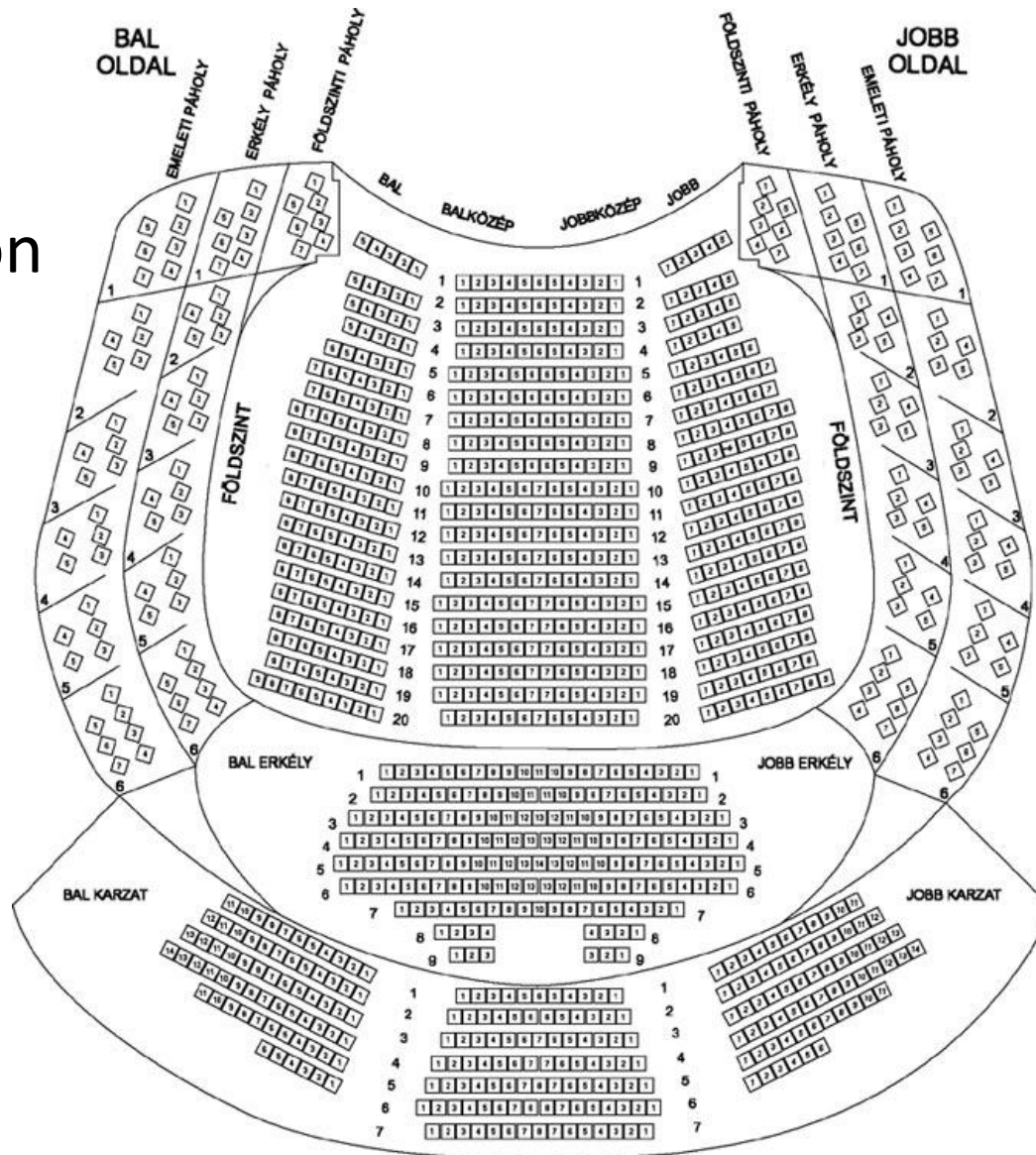


Illustration – Structural Models

Frame structure

