Modeling Structure with Blocks in SysML

Critical Embedded Systems

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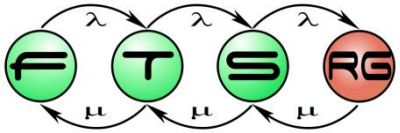

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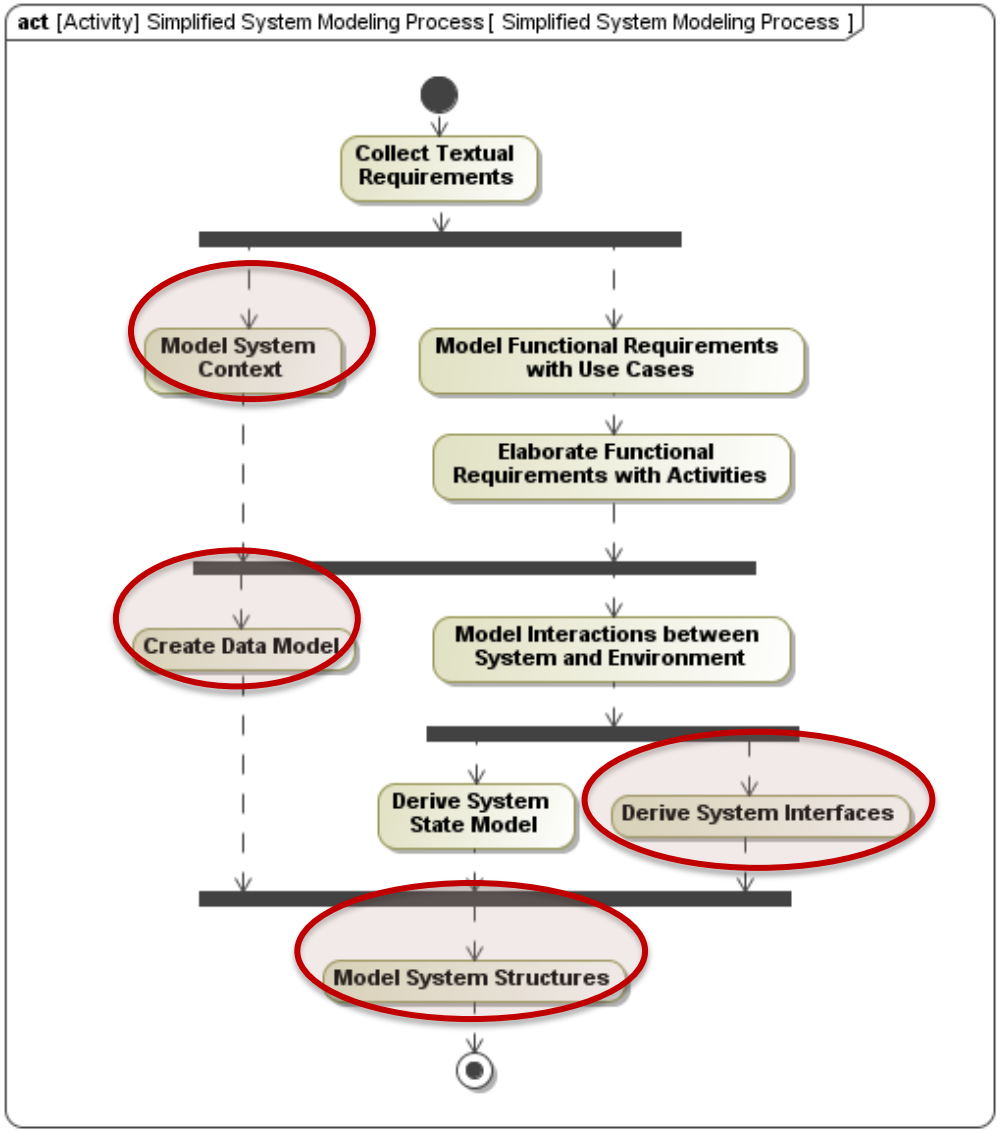
System Modeling Process



Block Definitions

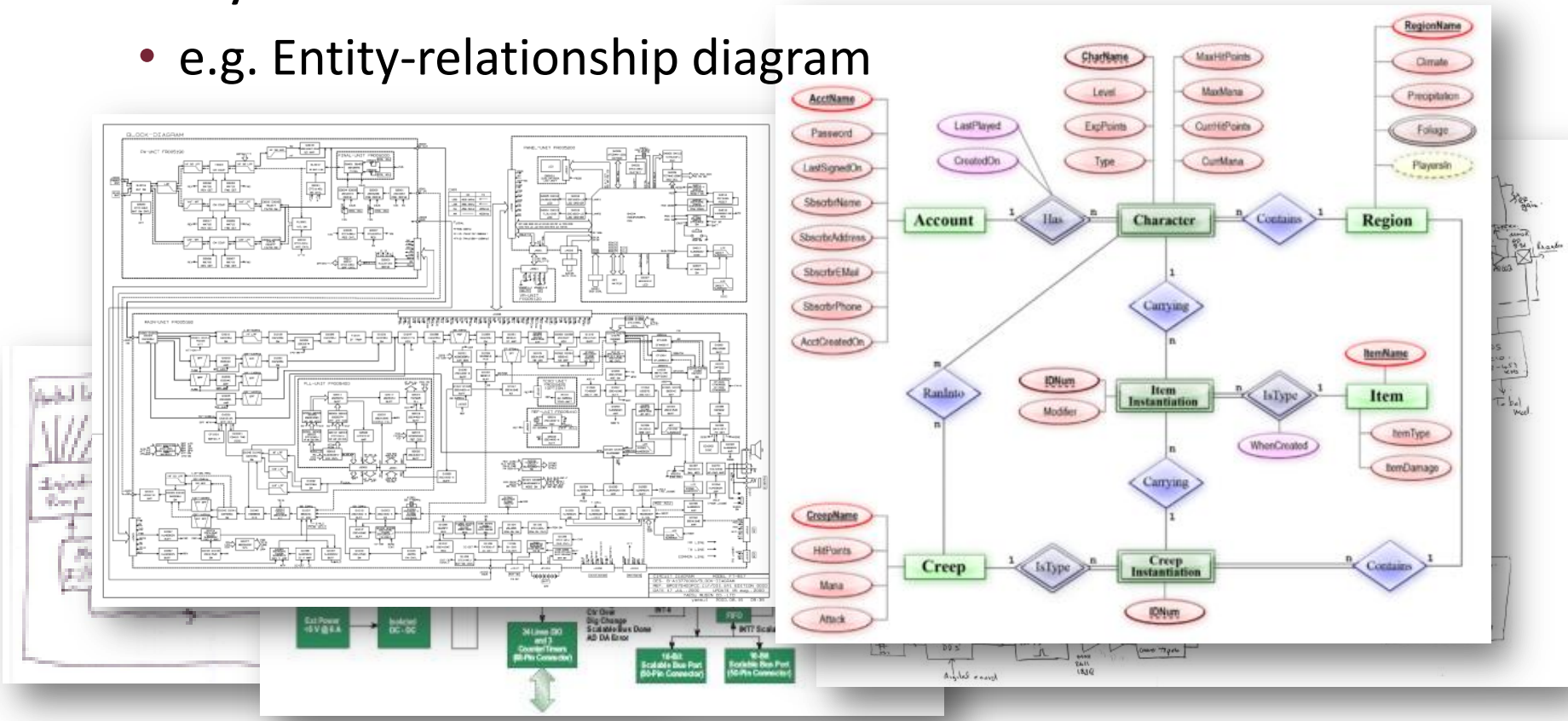
Block Definition Diagrams

What is it about?

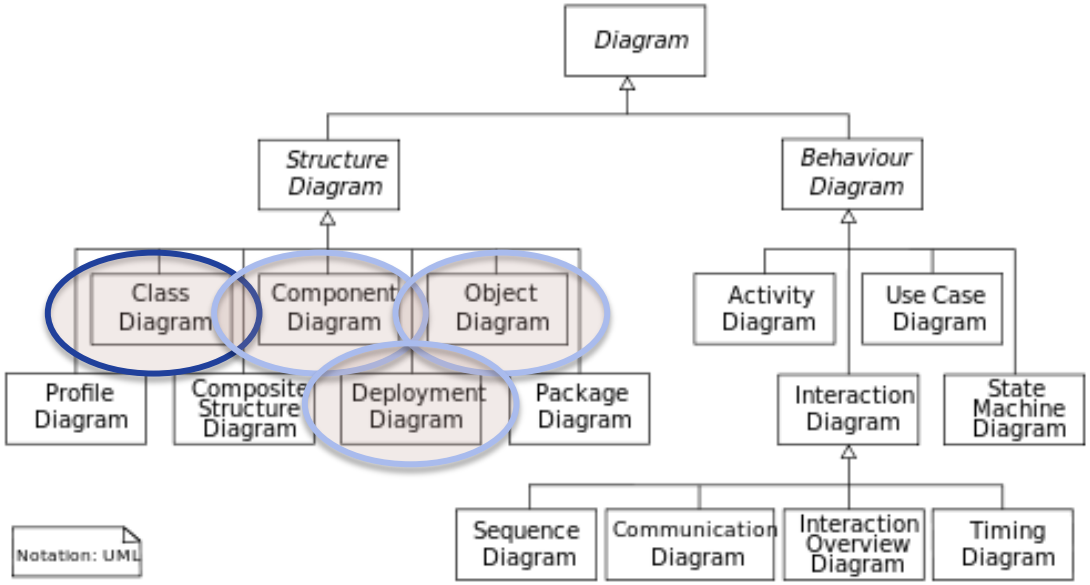
Context of the Modeling Aspect

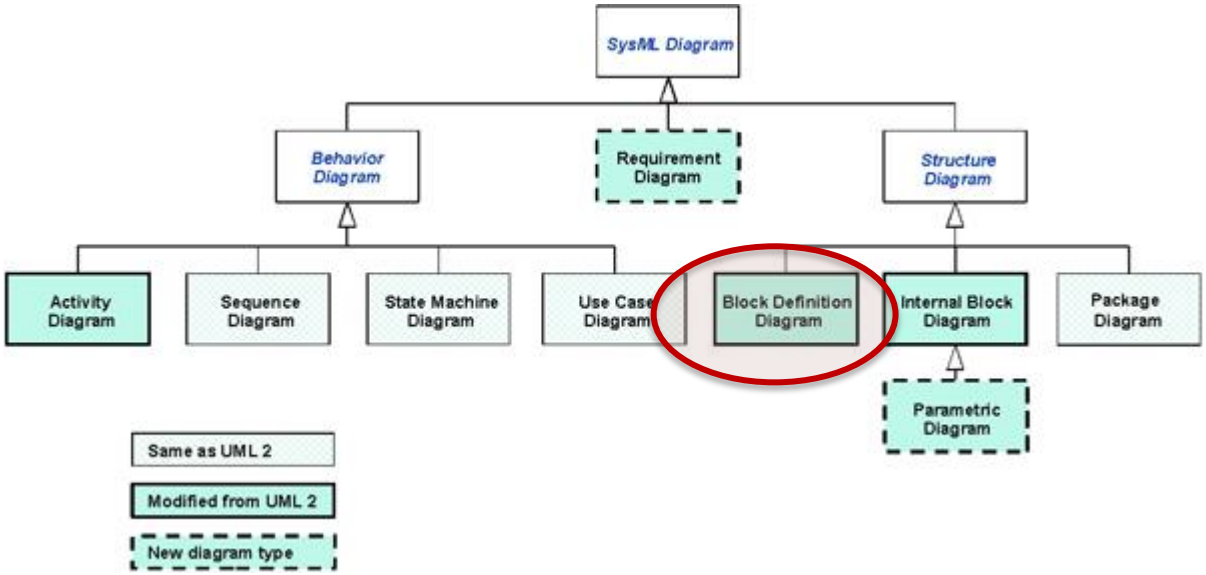
Roots & Relations

- Engineers draws blocks from the beginning
  - By hand or with CAD tools
  - Many formats
    - e.g. Entity-relationship diagram



Block Definition Diagram

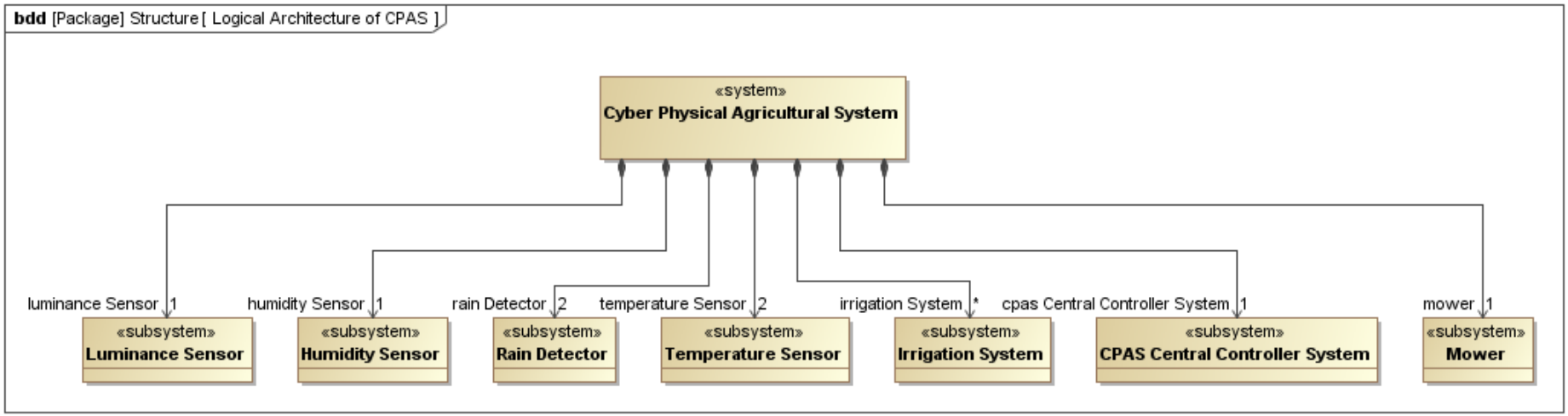




Modeling Aspect

What are the building blocks?

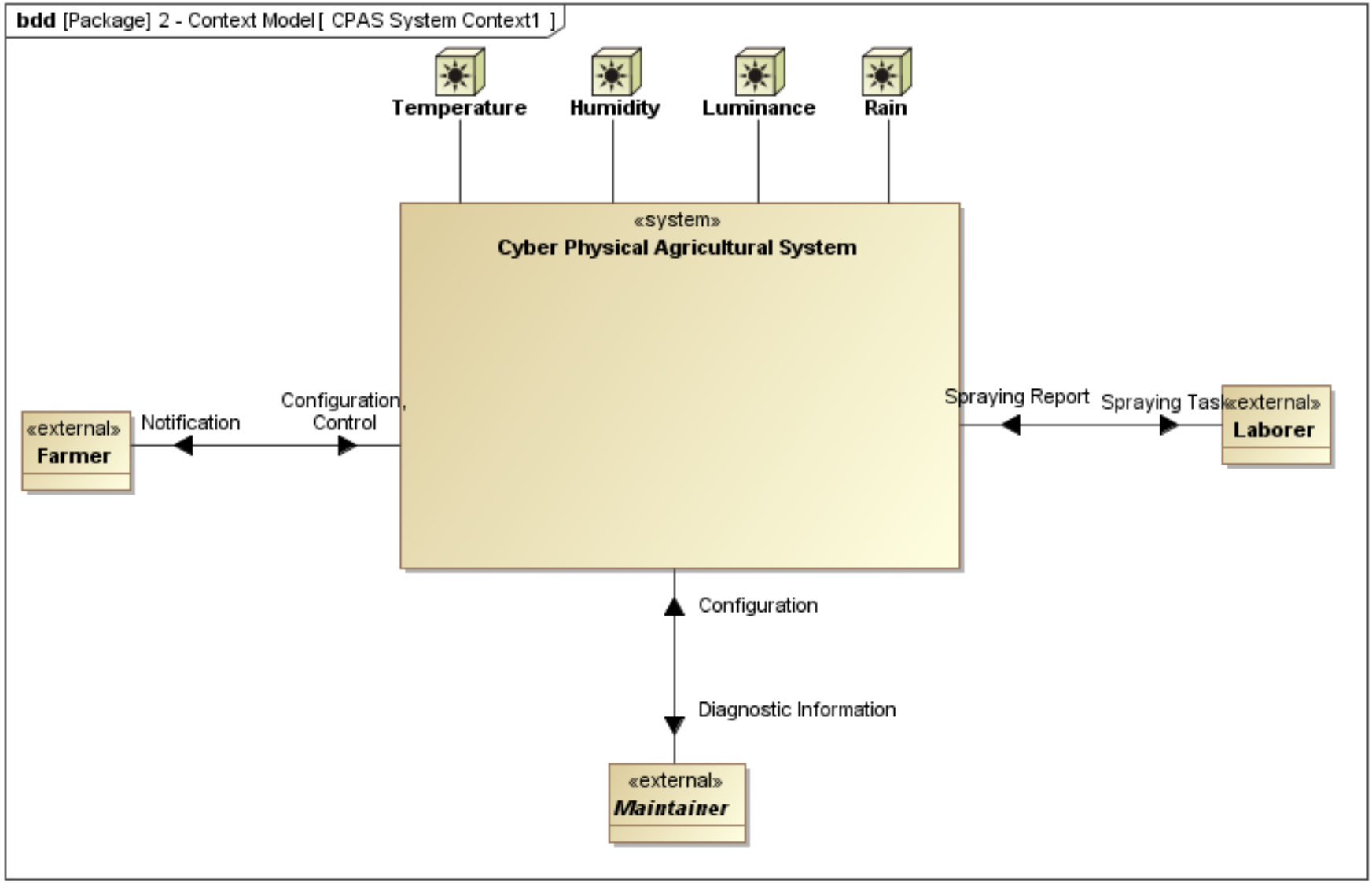
What are their relations in general?



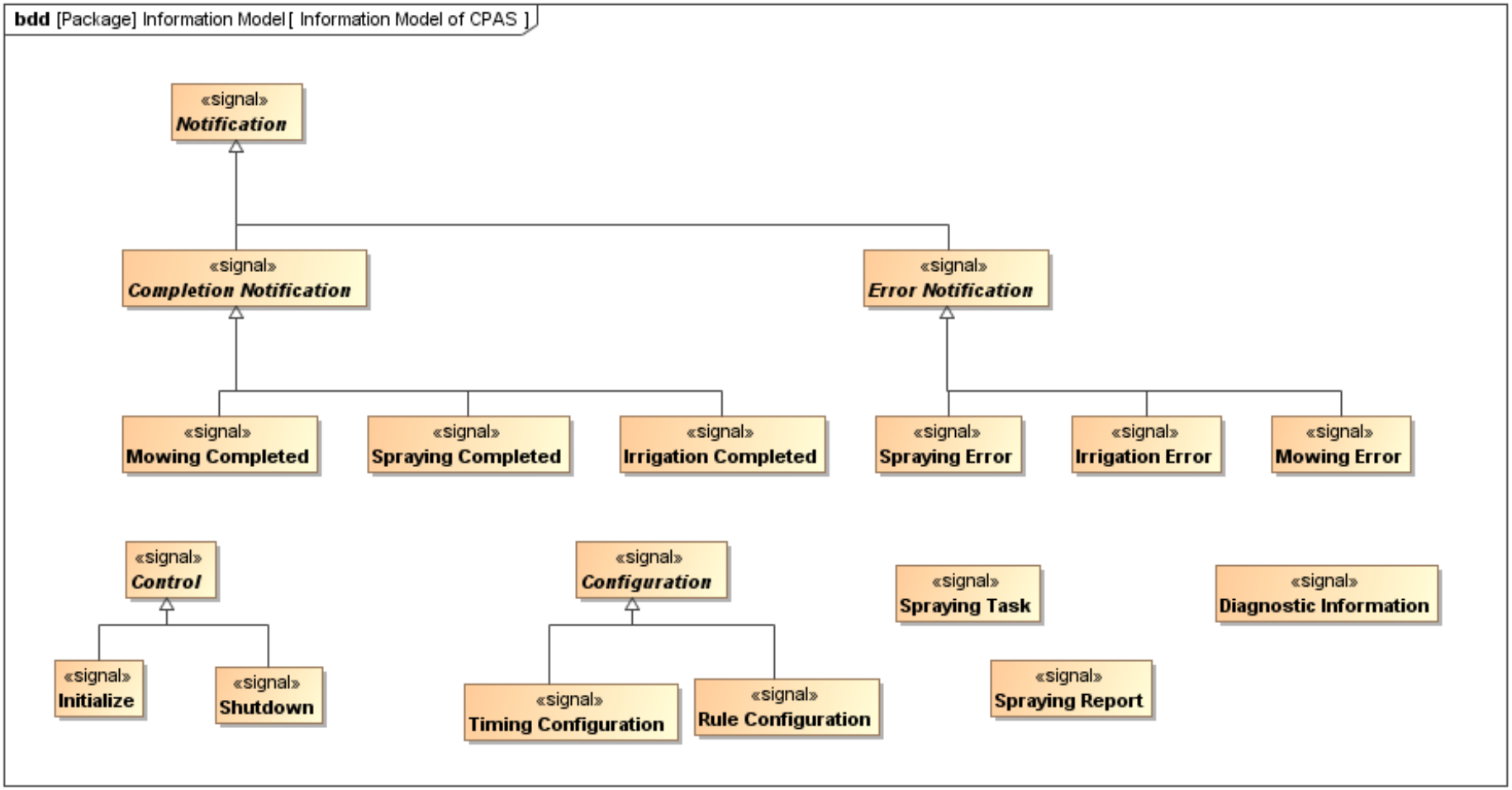
Objectives

- Define component types
  - Support organization into taxonomy (generalization)
- Define data model
- Define system decomposition
- Define interfaces and ports

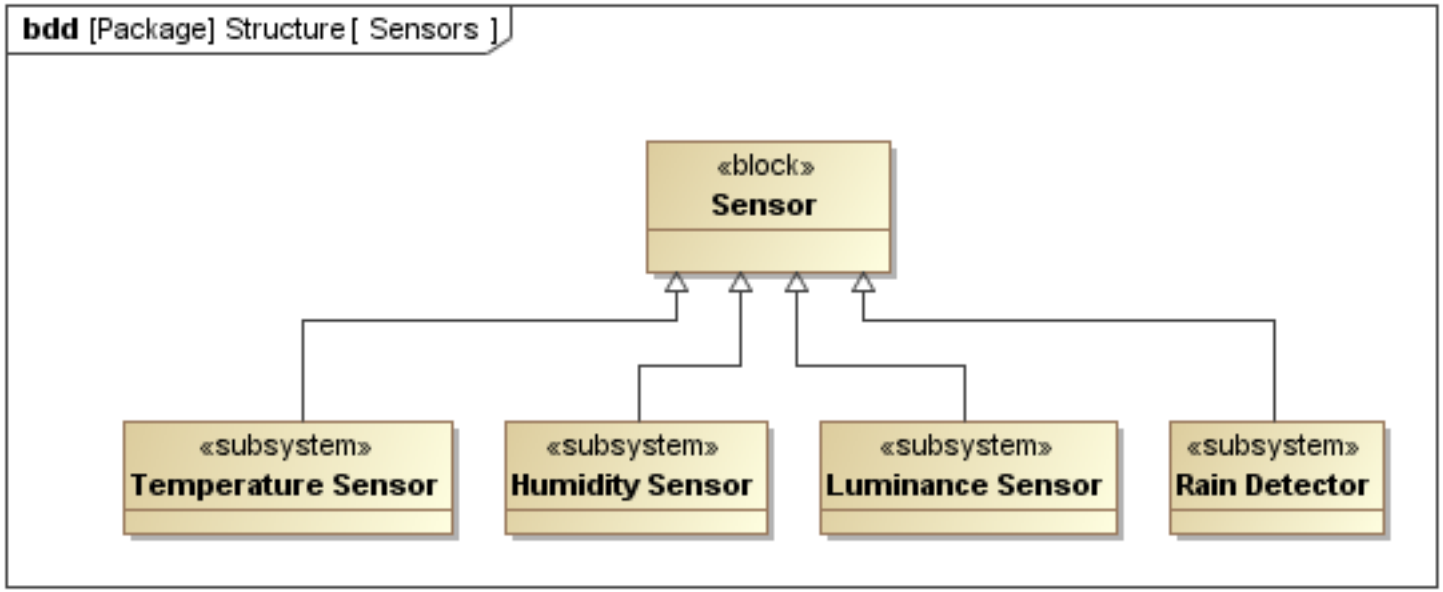
Example – System Context



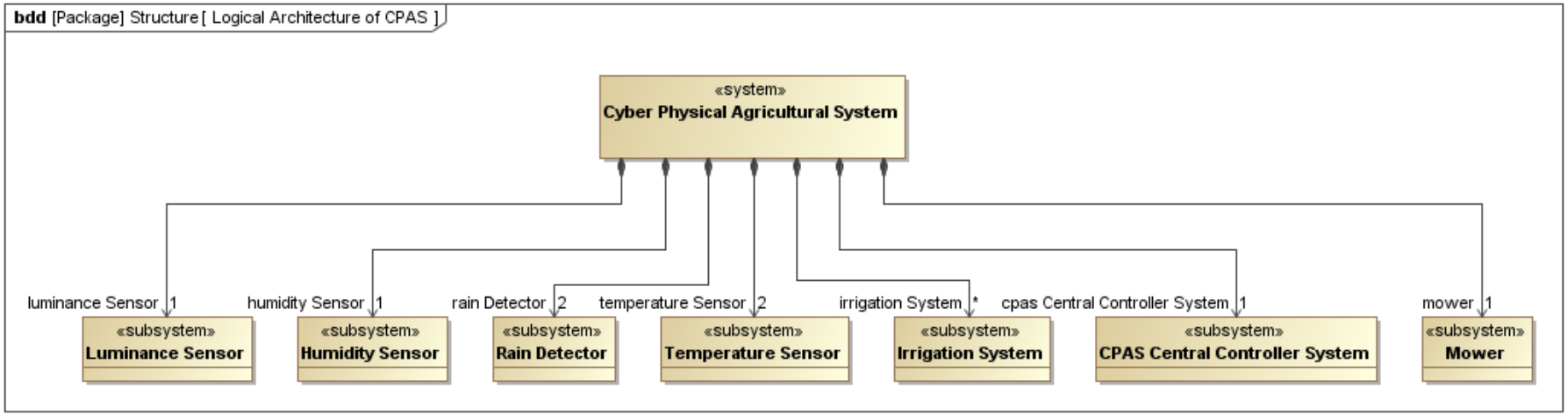
Example - Signals



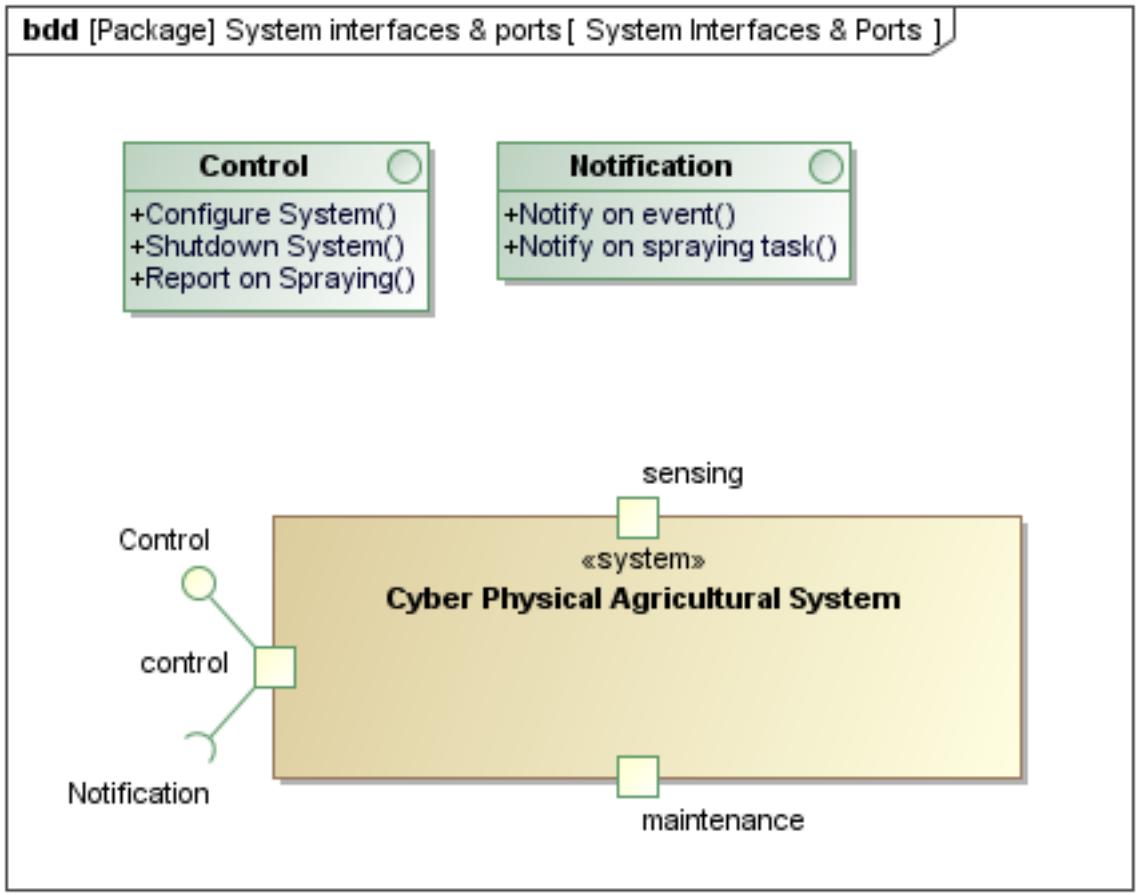
Example – Component definition



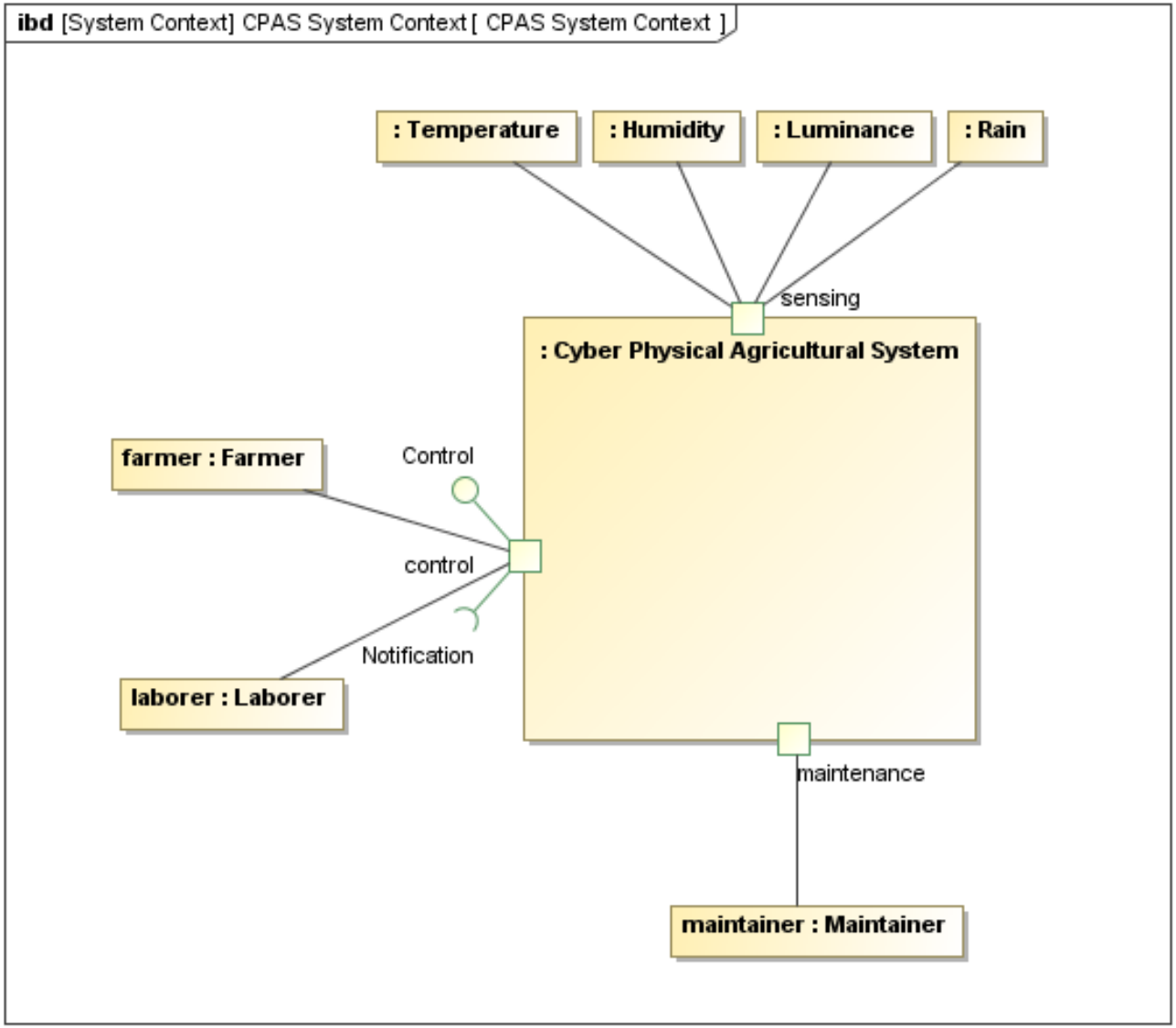
Example – System Decomposition



Example – Interfaces and Ports



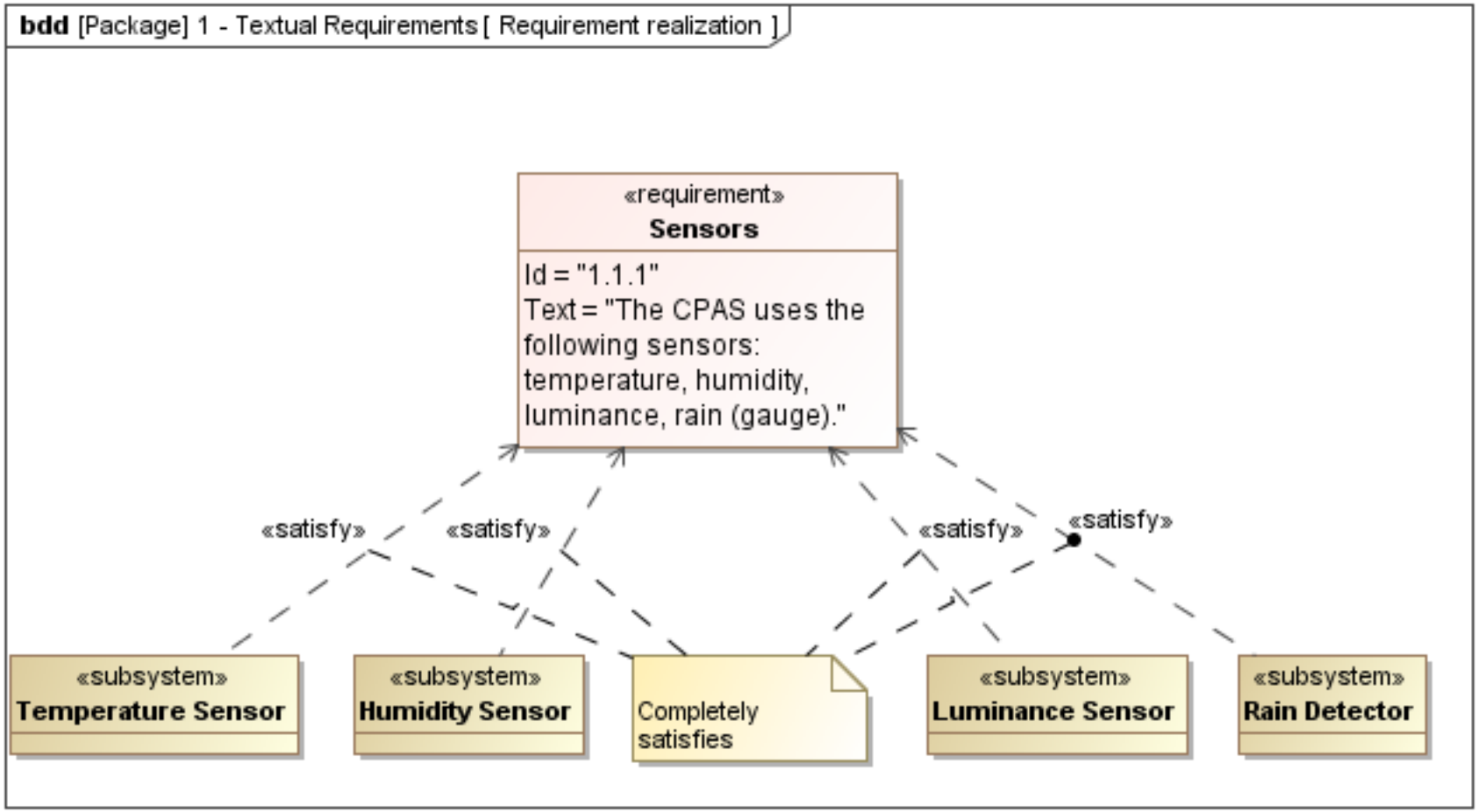
Example – System Context with Ports



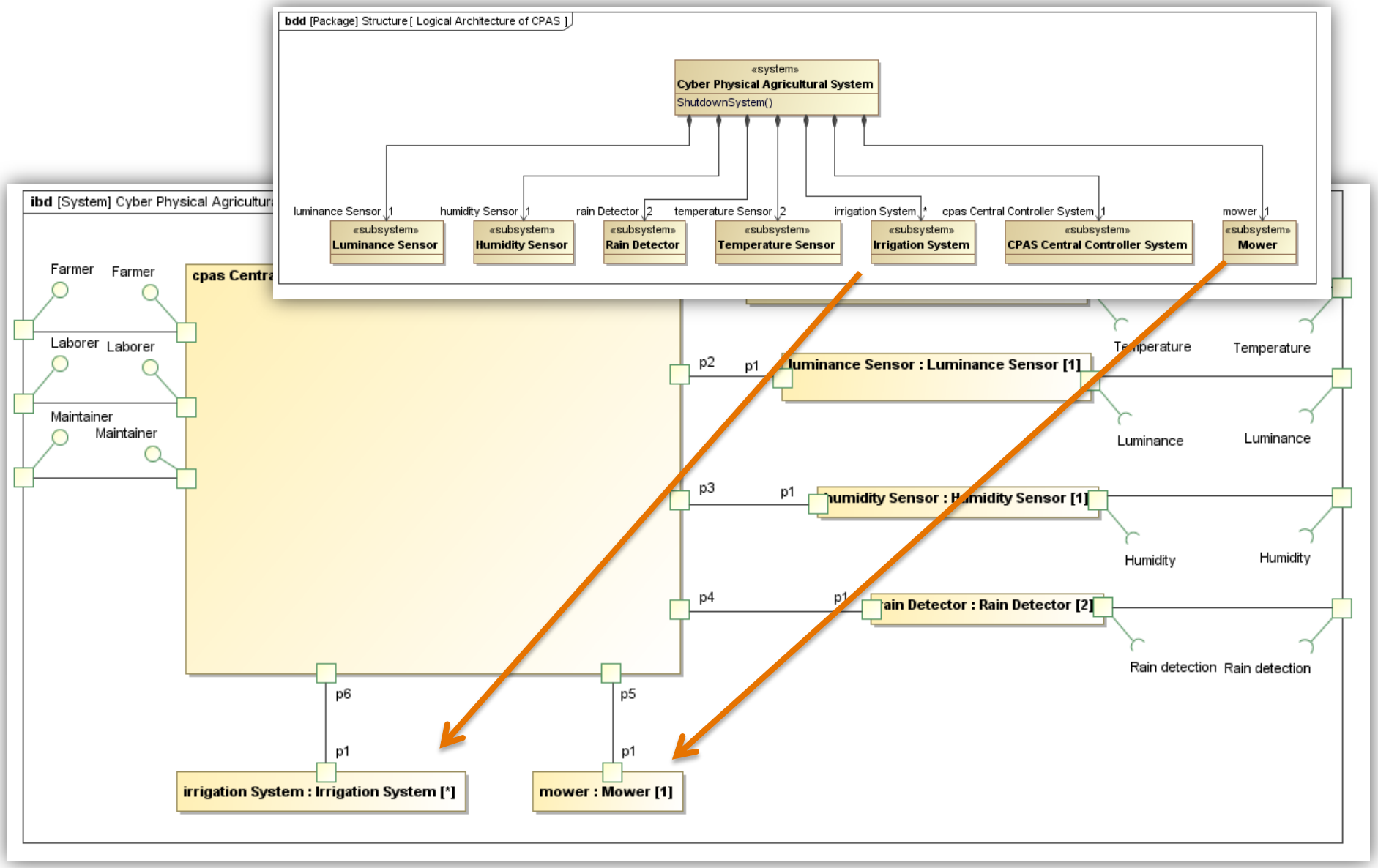
Relations to other aspects

- Realizes requirements
- Provides types for parts & ports
- Executes actions
- Defines participants in collaborations
- Provides context for state machines

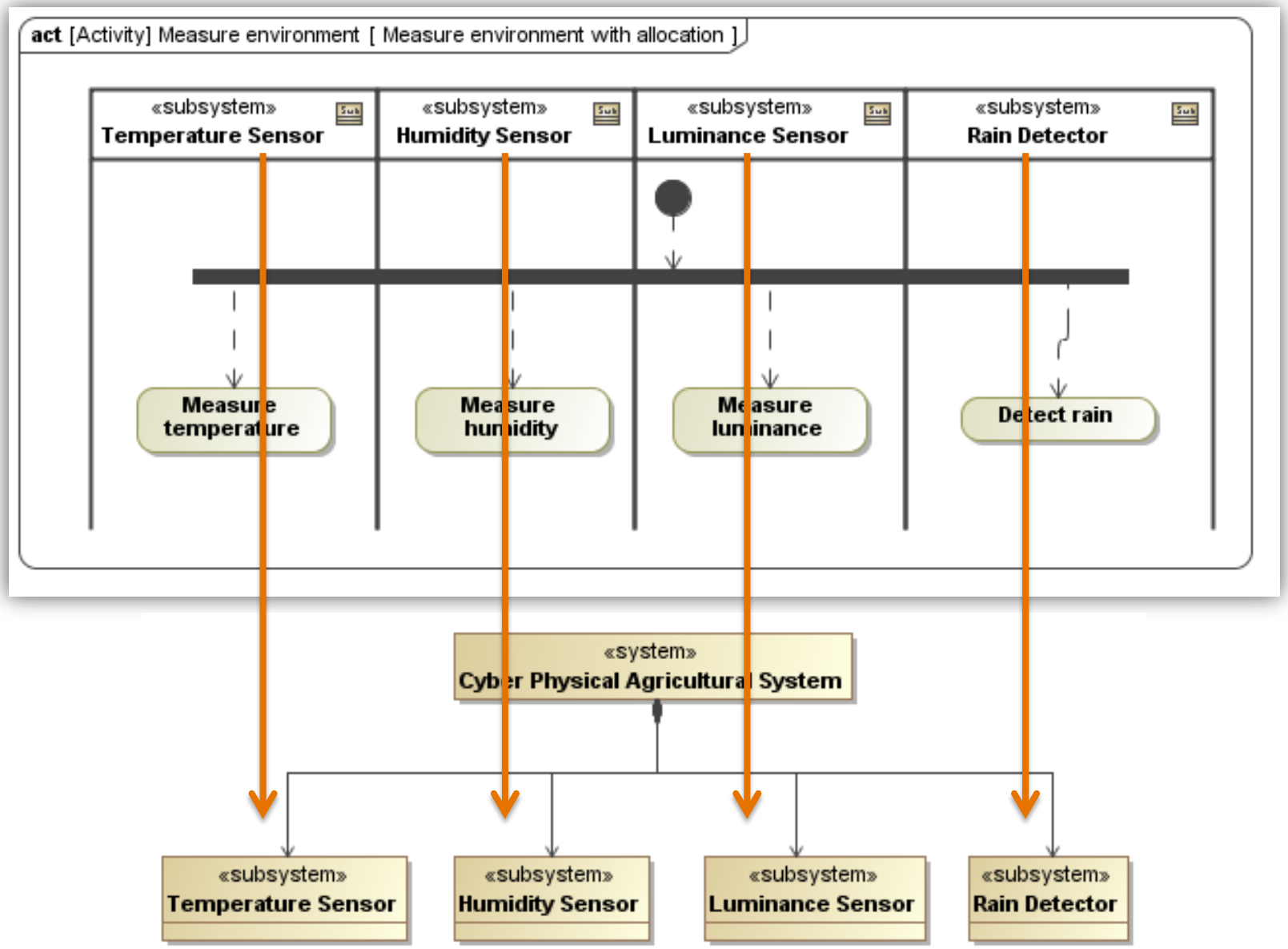
Realizes requirements



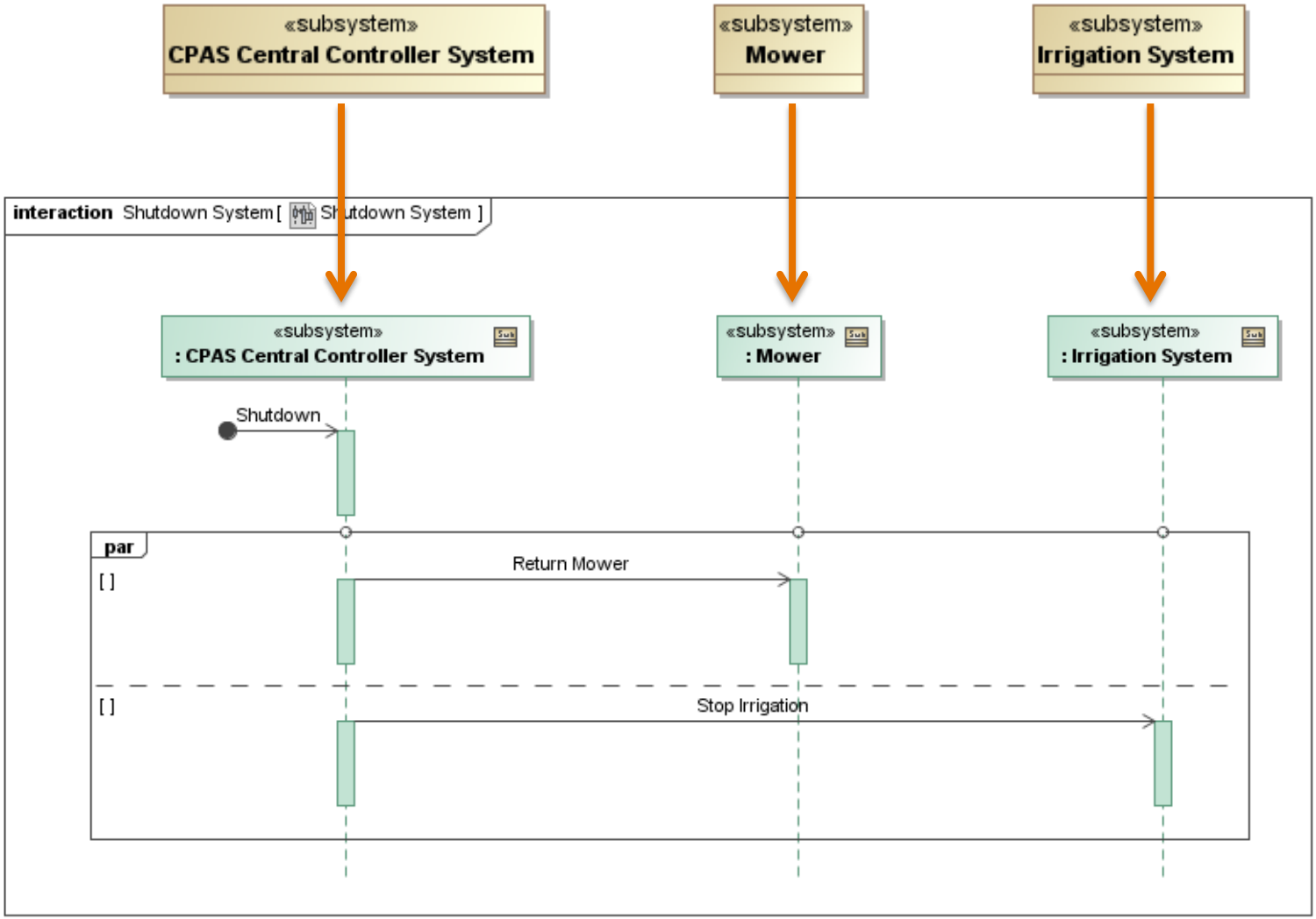
Provides types for parts & ports



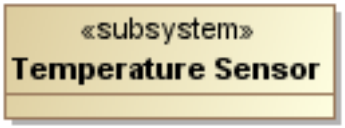
Executes actions

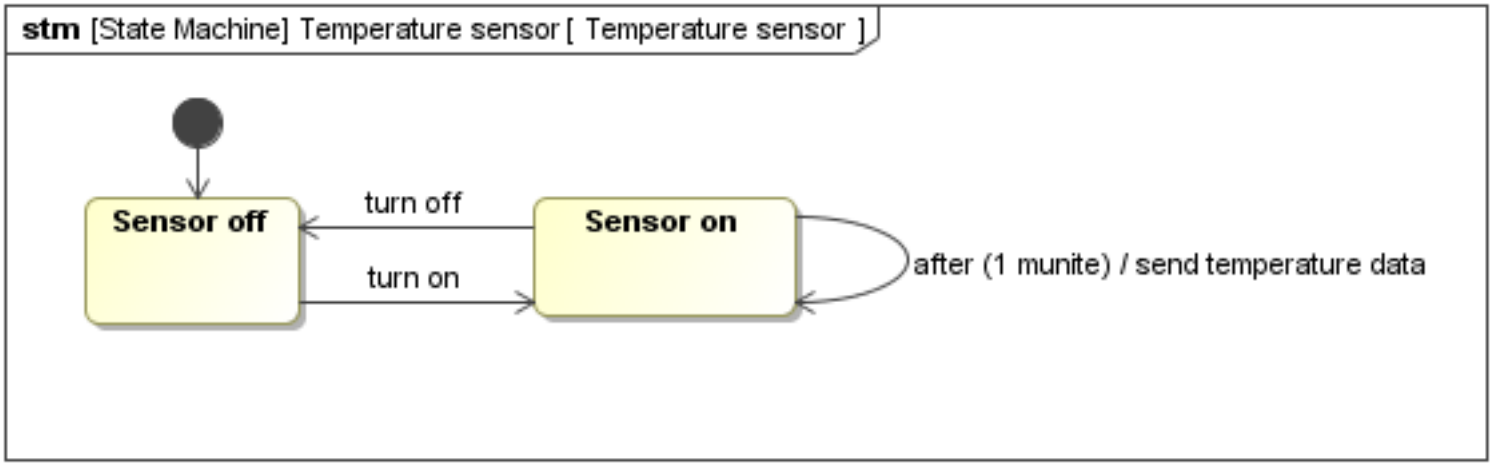


Defines participants in collaborations



Provides context for state machines





What are the building blocks?

Modeling Elements & Notation

Essential Elements of Block Definition Diagrams

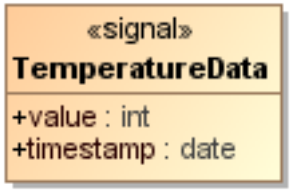
- Nodes
  - Block nodes
  - Signals
  - Value Type, Quantity Kind and Unit
  - Enumeration nodes
  - Actor nodes
- Paths
- Ports and Flows
- Constraint blocks

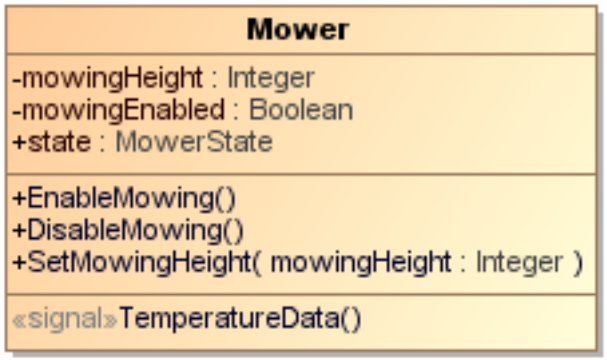
Block nodes

- Basic structural elements, that describe the structure of the system
- Compartments
  - Property types (e.g. parts, properties, references, values)
  - Behavioral (operations, receptions)
  - Constraints
- Describe
  - (Sub)Systems – Hardware / Software / Data
  - Person

Signal

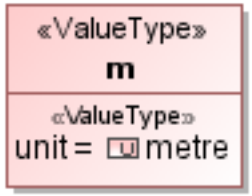
- A signal is a *specification of send request instances* communicated between objects.
- The receiving object handles the received request instances as specified by its *receptions*.
- The data carried by a send request (which was passed to it by the send invocation occurrence that caused that request) are represented as *attributes of the signal*.
- A signal is defined independently of the classifiers handling the signal occurrence.

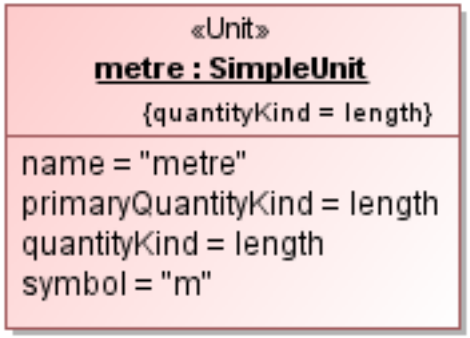


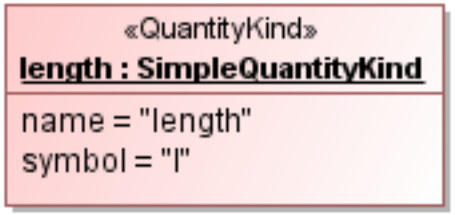


Value Type, Quantity Kind and Unit

- Uniform definition of a quantity
- Value Type
  - Data type, that can have Unit and QuantityKind nodes
  - Type for value properties in blocks
- Quantity Kind
  - Identifies a physical quantity
- Unit
  - Describes the structure of a physical unit – the unit of measure
  - Must be related to a Quantity Kind

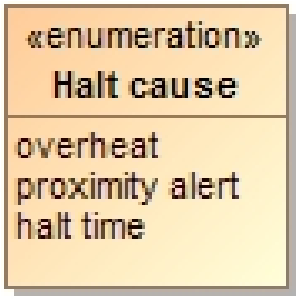






Enumeration and Actor nodes

- Enumeration
  - Defines a type, the value range of which is a limited set of named values, called literals.



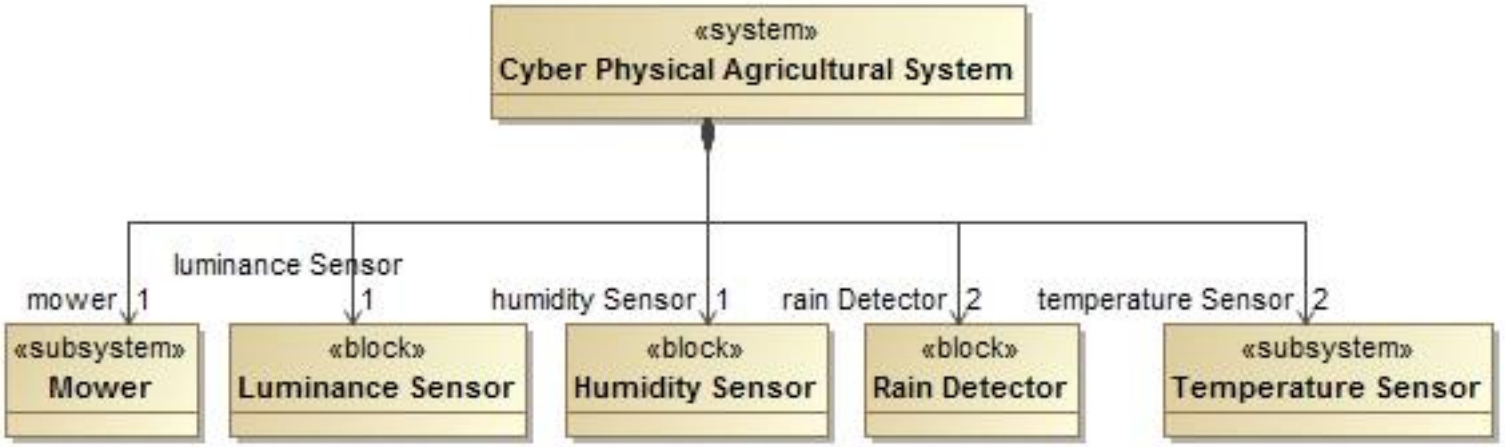
- Actor
  - Represents any stakeholder (human, organisation or external system) that participates in the use of the system

Defining Paths between Blocks

- Paths
  - Part Association
  - Shared Association
  - Reference Association
  - Association Class
  - Generalization
  - Dependency

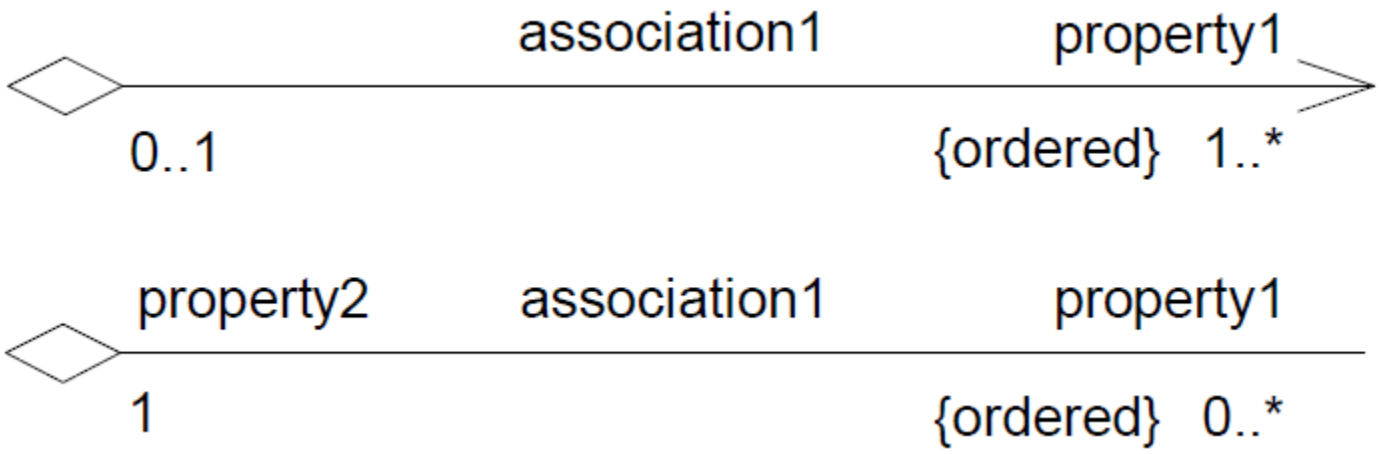
Part Association

- Specifies a strong whole-part hierarchy
  - From a *composite*
  - To a *composite part*
- Denoted with a black diamond on the whole end
- Role name on the part end
- Can be directed or undirected



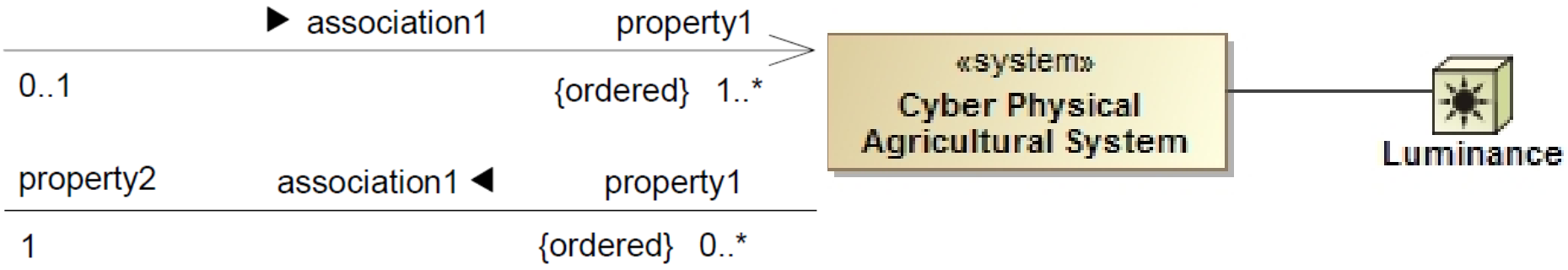
Shared Association

- Specifies a weaker whole-part hierarchy
  - "Shared" indicates, that the whole part is not the only one, it can be more of it
  - The parts are not owned by the whole part
- Denoted with an empty diamond



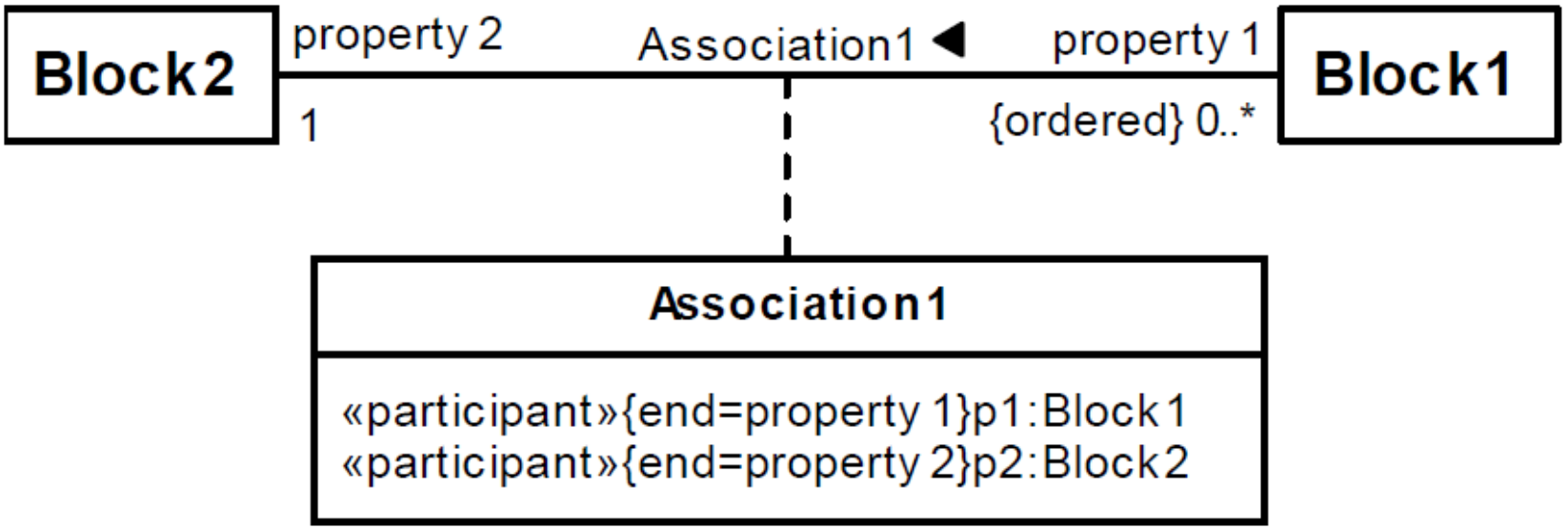
Reference Association

- Represents a relationship between two blocks
  - Undirected: reference in both blocks
  - Directed: reference only in one block
- Can have properties
  - Multiplicity
  - Name
  - Reference on both sides



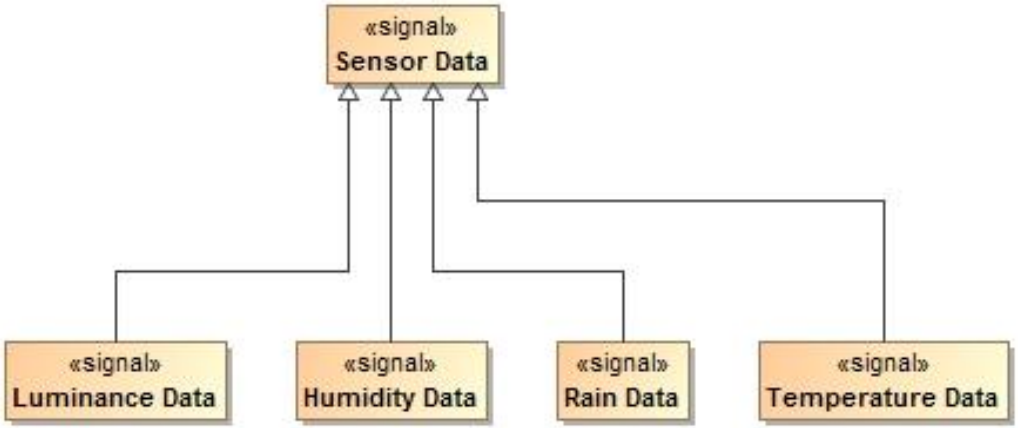
Association Class

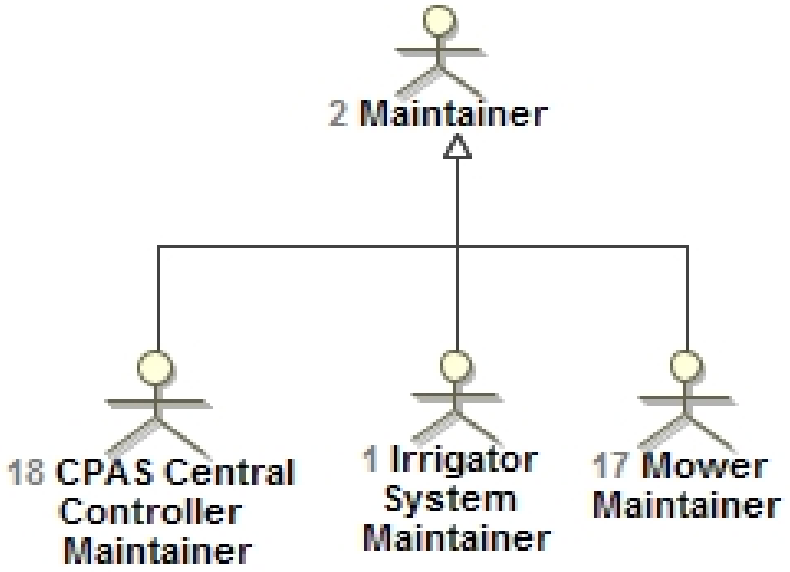
- Describes the structural properties of an association
- Combination of
  - Association
  - Block



Generalization

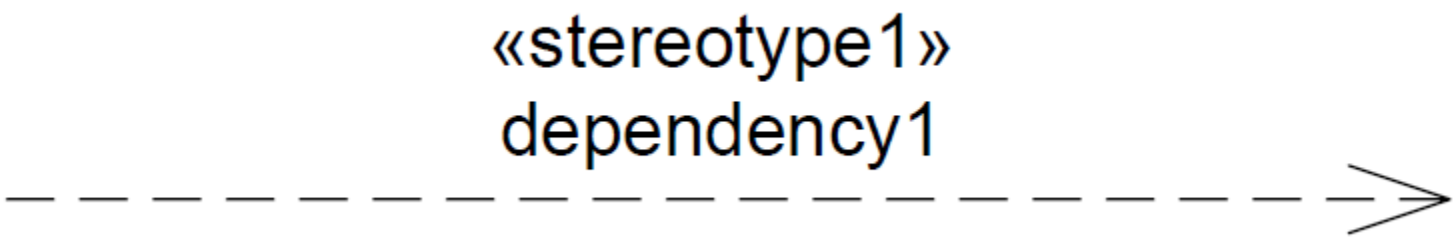
- Specifies an object oriented relationship between a more general block and a more specific one (ISA relationship)
- Denoted with a closed arrowhead from the specific block to the general one





Dependency

- Between two elements
- One element needs the other element for its
  - Specification
  - Implementation
- Almost between any model elements

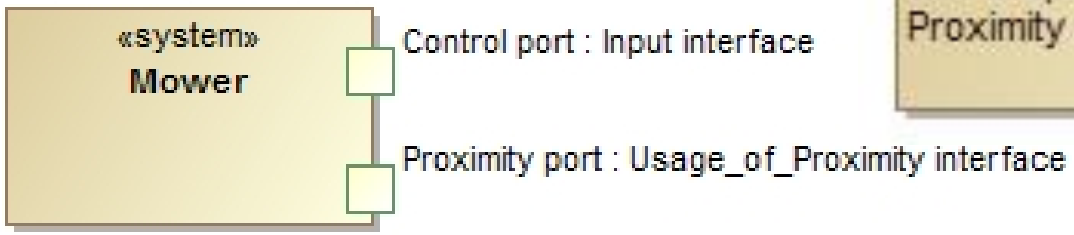


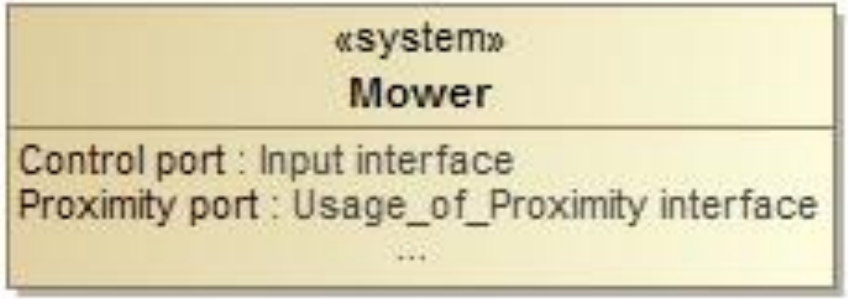
Defining Ports and Flows

- Port
- Flow Property
- Interface

Port

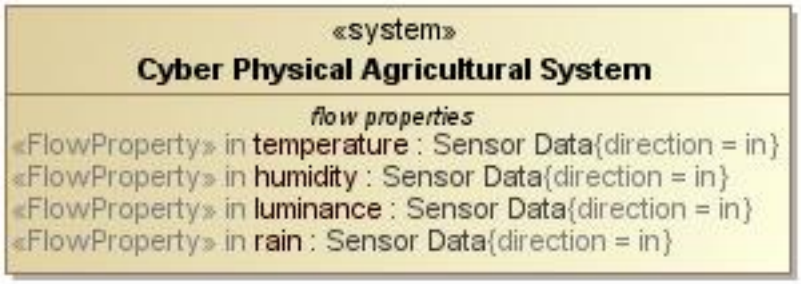
- Port
  - Interaction points at which external entities can be connected
  - Limits and differentiates the possible connection types
  - Defines the available features (e.g. properties, operations)
  - More denotation alternative





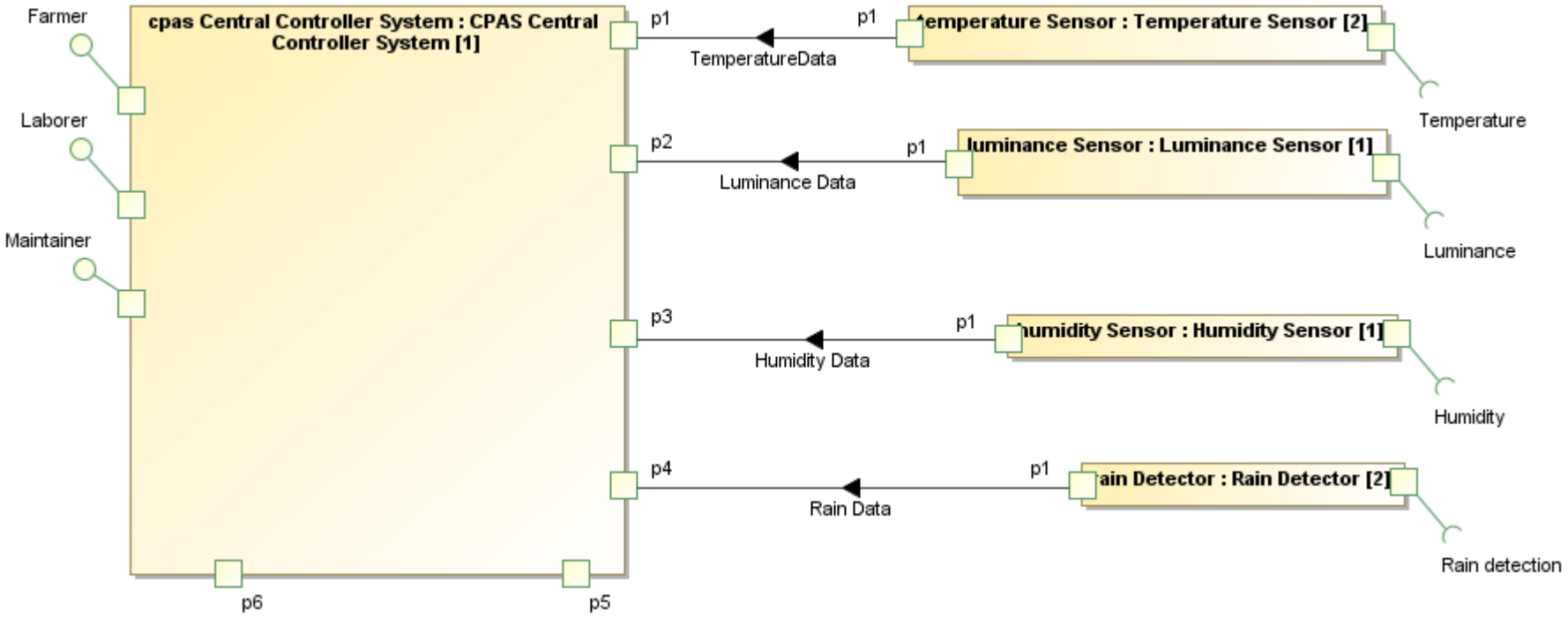
Flow Property

- Specifies the possible types of flowing items on a port
  - Part of flow specification
  - *What "can" flow?*
    - Data
    - Material
    - Energy
    - …



Flow Item

- Specifies what flows between the blocks
  - *What "does" flow?*

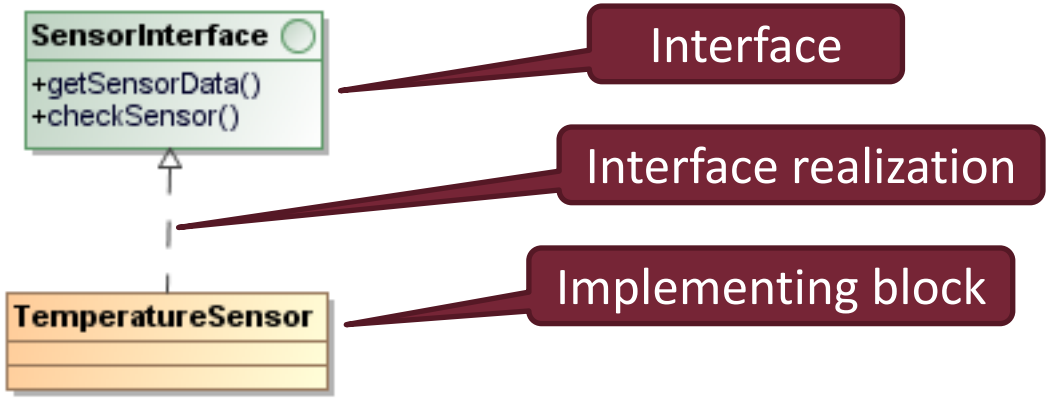


Interfaces

Definition

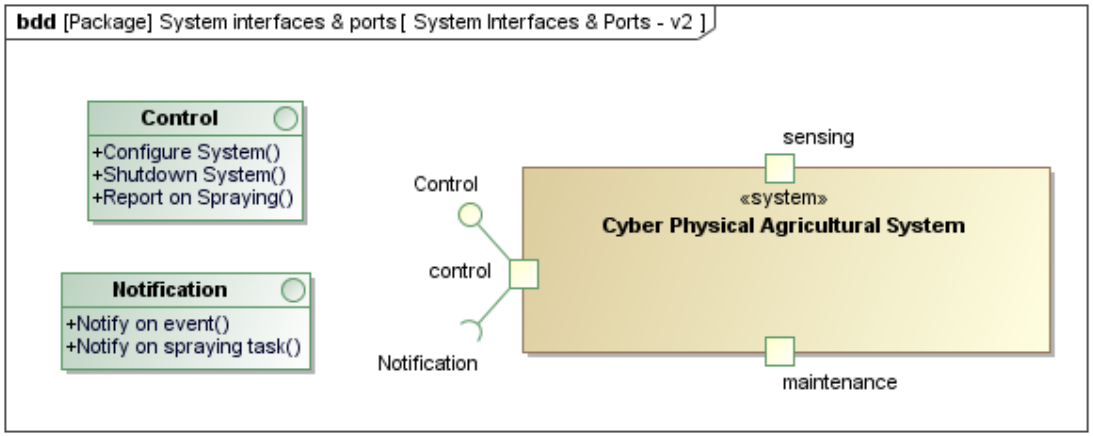
An interface declares a set of public features and obligations that constitute a coherent service offered by a classifier.

- An interface specifies a contract; any instance of a classifier that realizes the interface must fulfill that contract.



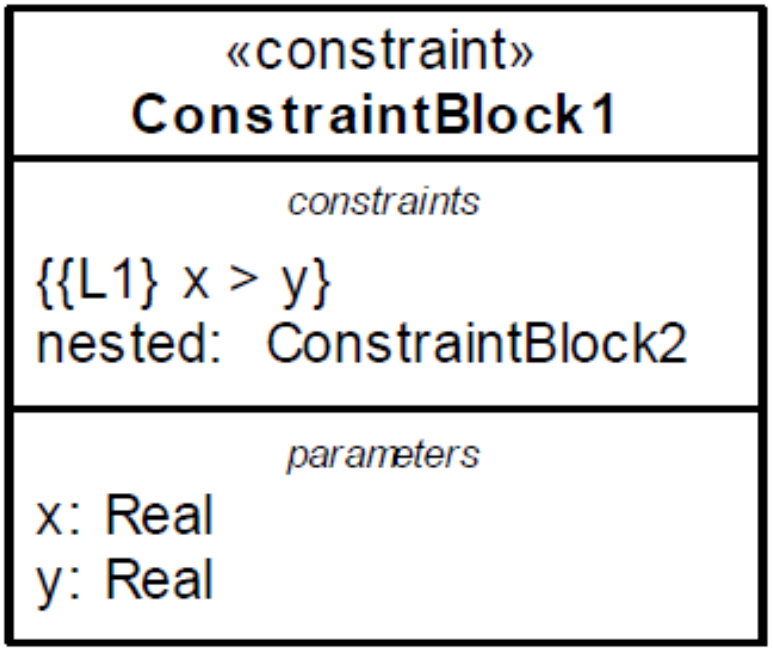
Interface

- Specifies the behavioral features of a block
  - Provided interface
    - A service is provided by the block for its environment
    - Denoted with a lollipop / ball symbol
  - Required interface
    - The set of the operations is required by the block for its operation.
    - Denoted with a socket symbol



Defining Constraint Blocks

- Constraint Block node
  - Specify a network of constraints to
    - Constrain the physical properties of the system
    - Identify critical performance paramaters
  - Constraints represent mathematical expressions
    - F = m*a
    - a = dv / dt



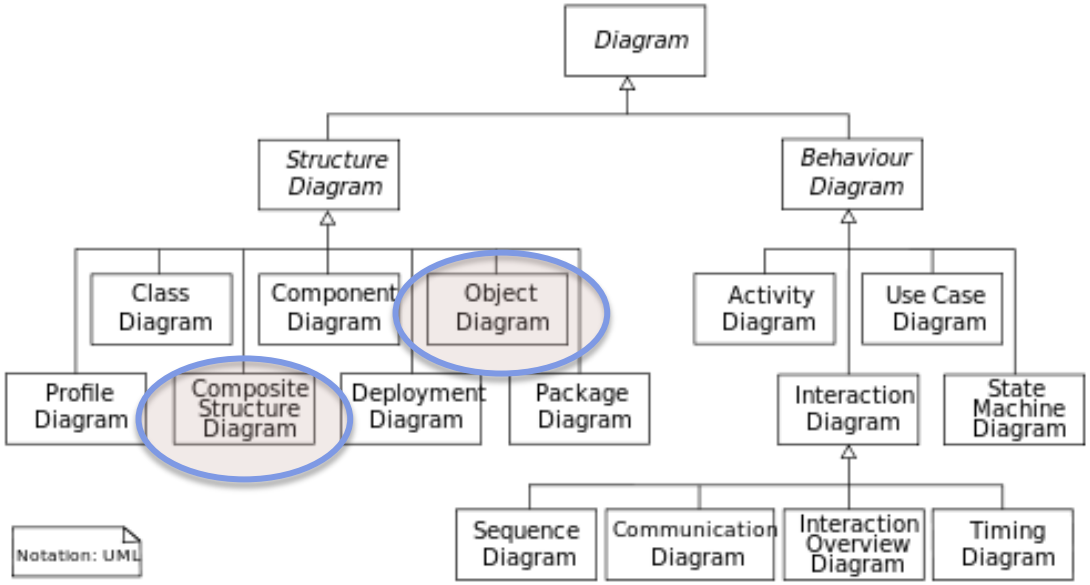
Block Usage

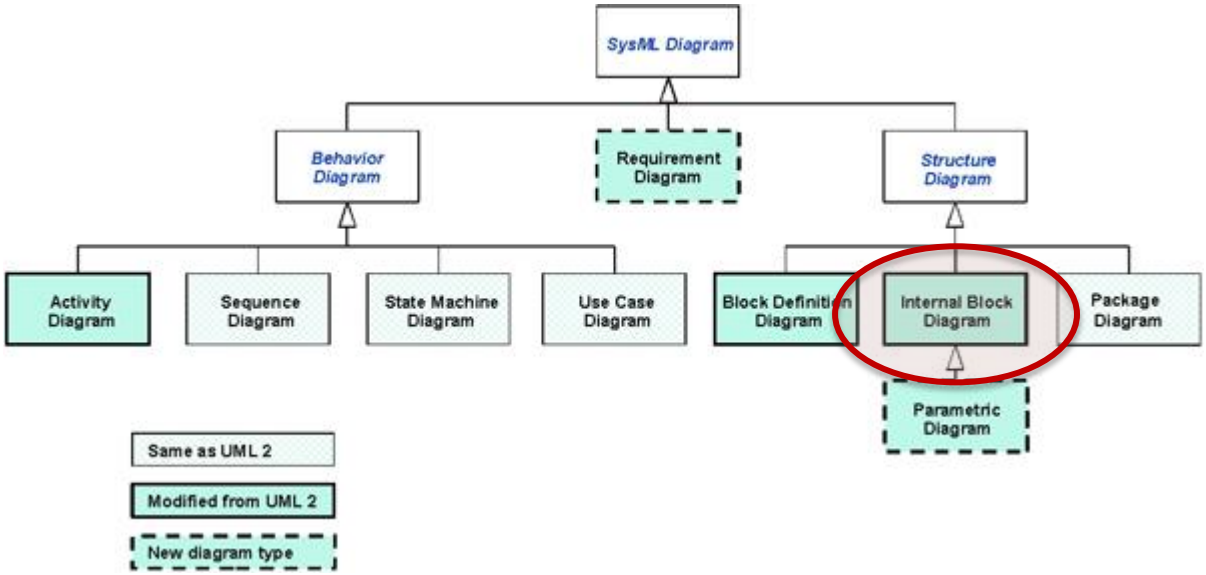
Internal Block Diagrams

What is it about?

Context of the Modeling Aspect

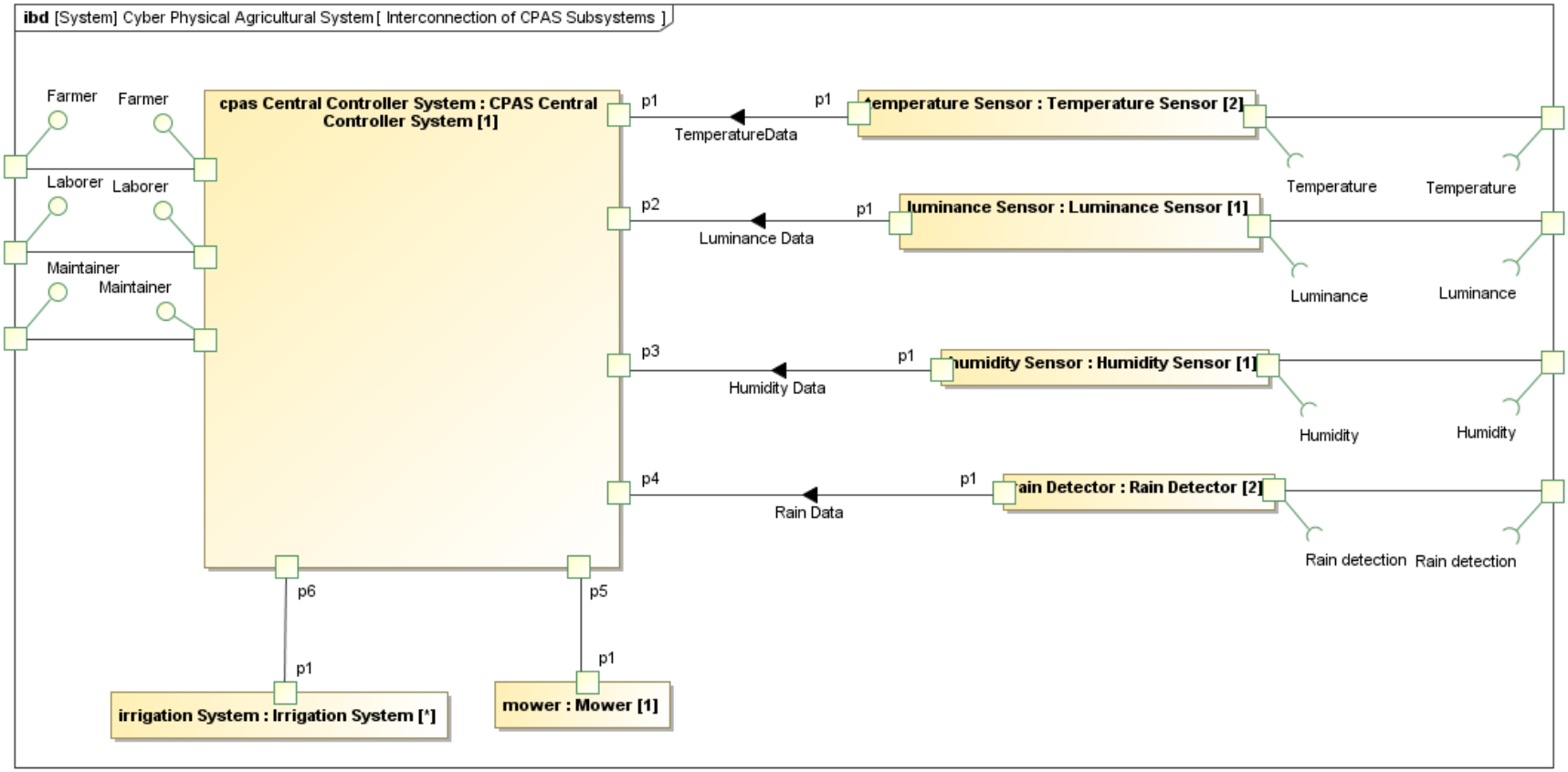
Internal Block Diagram





Modeling Aspect

How are components used in a given context or system?

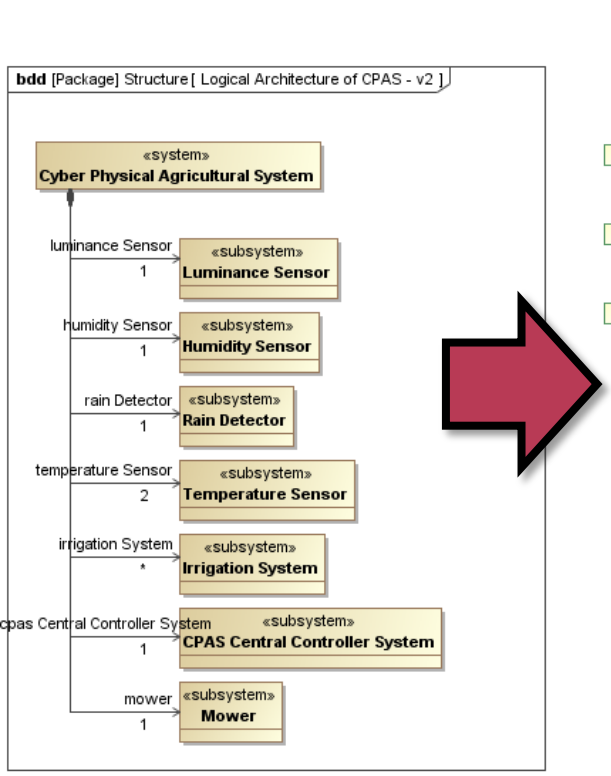


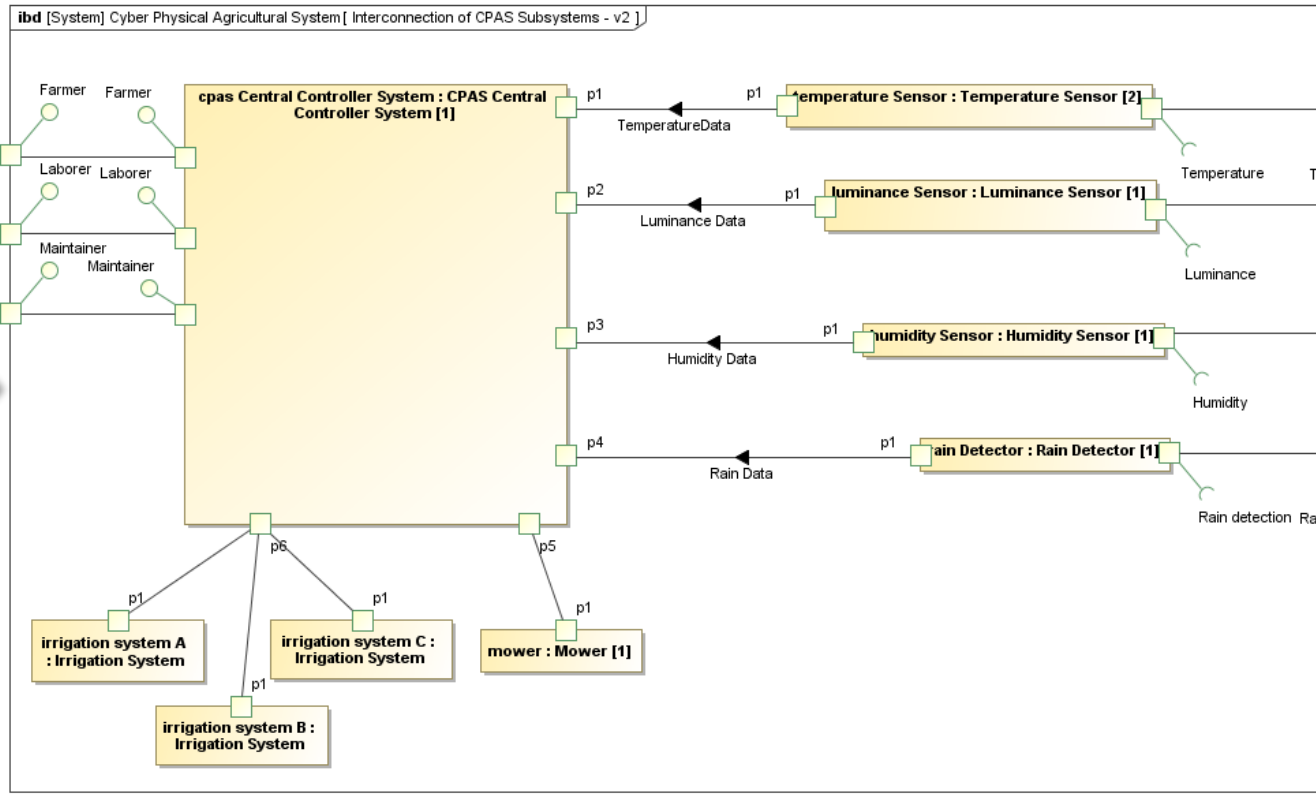
Objectives

- Define how components are interacting with each other within a given system
  - Define relations
  - Define data flow
  - Define interfaces

BDD vs. IBD

- Block Definition vs. Usage
  - Block diagram → Definition of the structure
  - Internal block diagram → Usage of this structure in different contexts





Relations to other aspects

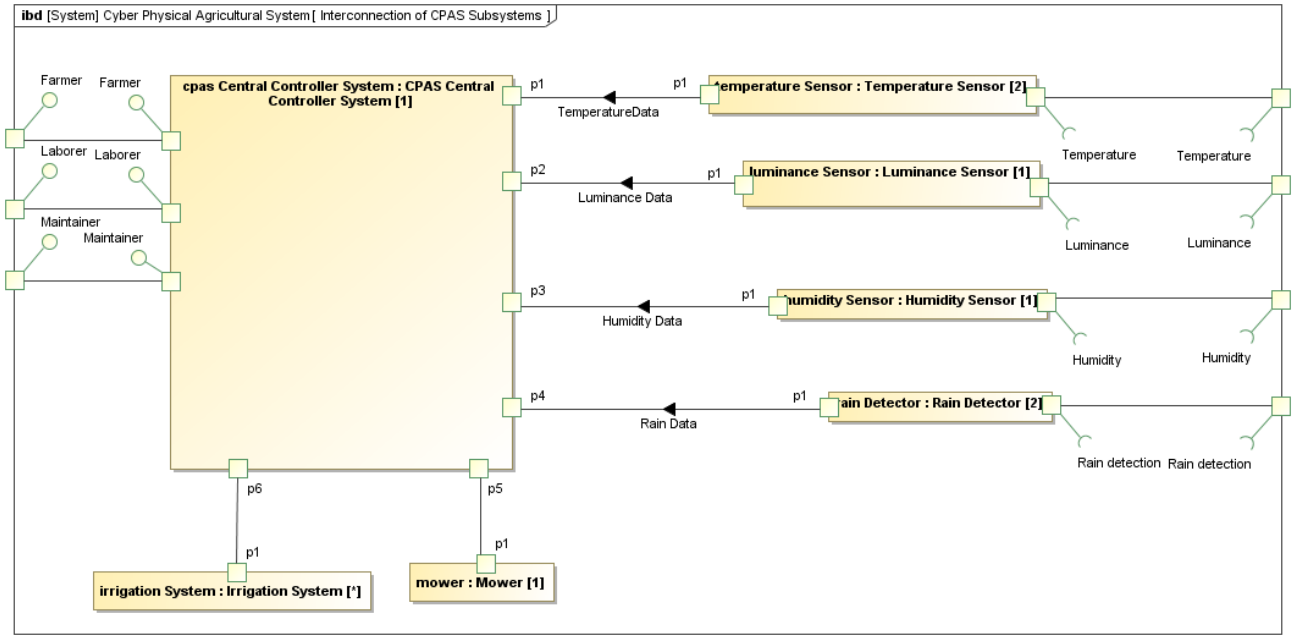
- Interpreted in the context of a block
- Defines usage of blocks
- Item flows can be mapped to object flows in activities

What are the building blocks?

Modeling Elements & Notation

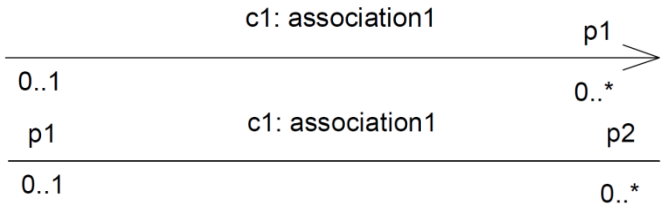
Defining Blocks - 1

- Nodes
  - The instances of the nodes from the related block diagram (Part properties)
  - Can have a unique name with type indication
  - Can also be nested into more levels

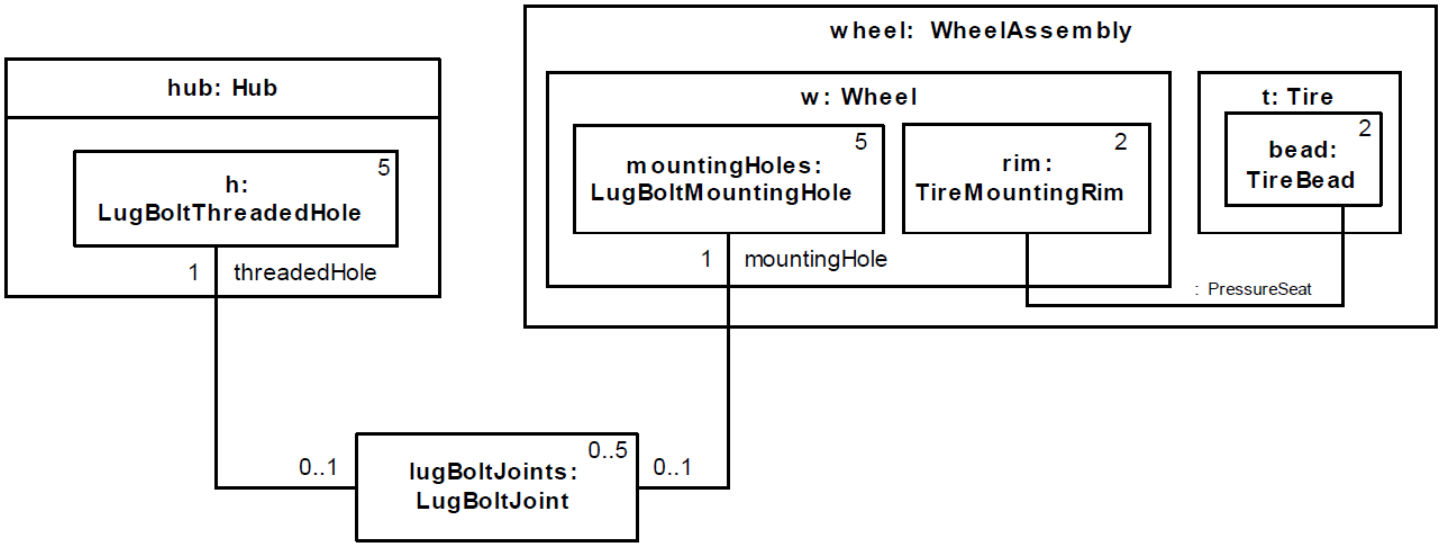


Defining Blocks - 2

- Paths
  - The properties can be connected to each other with
    - Unidirectional Connector
    - Bidirectional Connector

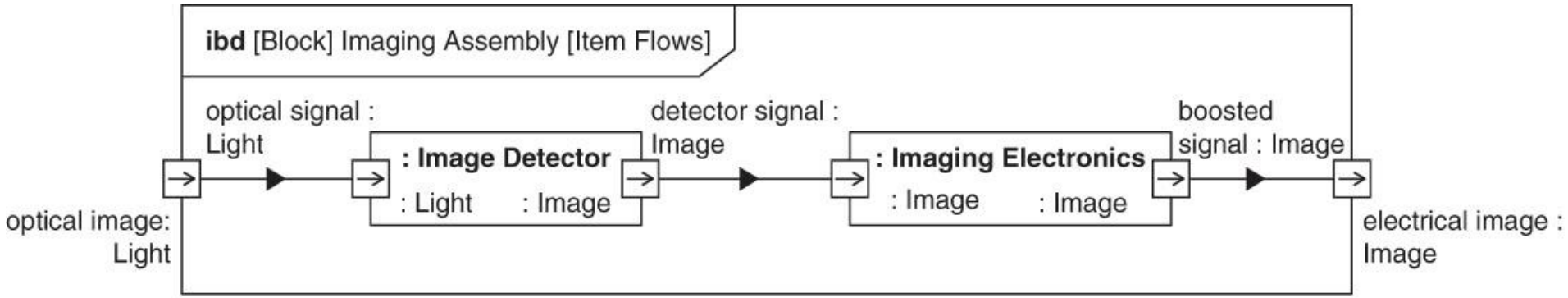


  - Connectors are the instances of the associations
  - Can have multiplicity on both ends



Defining Ports and Flows

- Ports are to define the interaction points of the part property
- Flows are to specify the items that flow across a connector
- Both are understanded in a particular context



Summary

- Block Definition Diagram
  - *What are the elements of the system?*
- Internal Block Diagram
  - *How are elements within a system relates to each other?*