GSAW2005

Ground System Architectures Workshop

Development of Generic Ground Systems by the Use of a Standard Modeling Method

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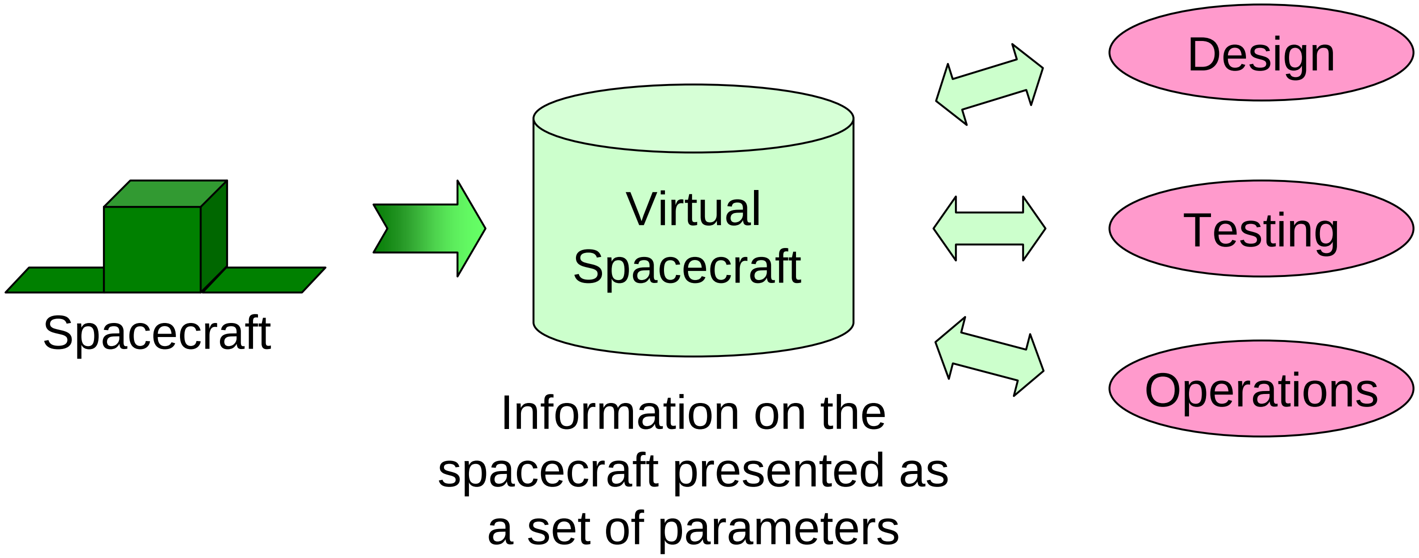
Purpose of This Presentation

- To explain how spacecraft can be virtualized by using a standard modeling method;
- To introduce the basic concept of modeling spacecraft as a set of Objects;
- To explain how virtual spacecraft can be manipulated using the standard spacecraft model;
- To explain how monitor & control of spacecraft can be performed in a standard way and what role the standard spacecraft model plays in this; and
- To present the basic architecture of a generic system used for testing and operations of spacecraft.

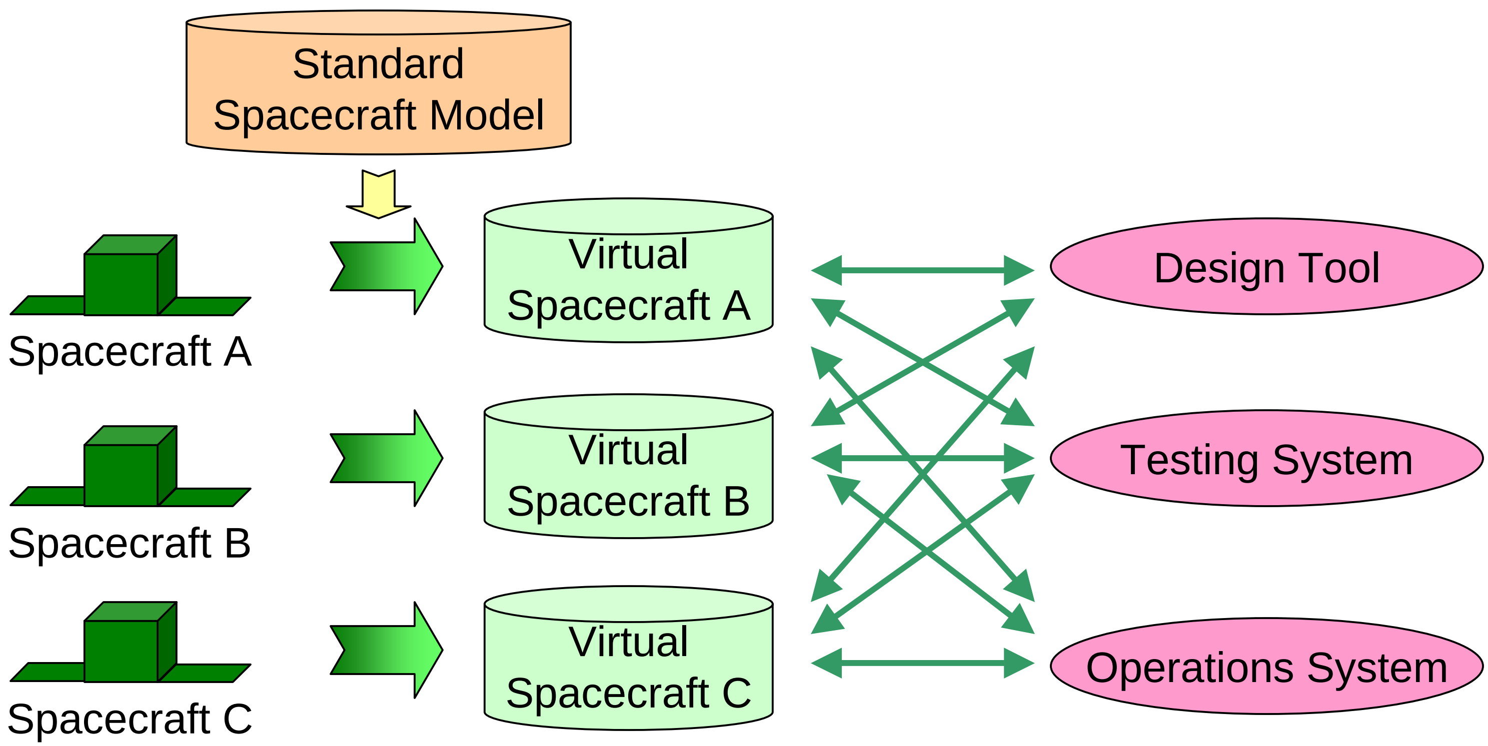
Virtualization of Spacecraft

- Virtualization of spacecraft is to present the information on spacecraft as a set of parameters so that the information can be commonly used for the design, testing, and operations of spacecraft.
- The virtual spacecraft can also serve as an online version of the specification and the operations manual of the spacecraft.



Standard Method for Virtualizing Spacecraft

- If there is a standard model for describing spacecraft as a set of parameters, any spacecraft can be virtualized in the same way.
- If any spacecraft is virtualized in the same way, we can develop tools applicable to any virtual spacecraft and save the cost of developing tools.



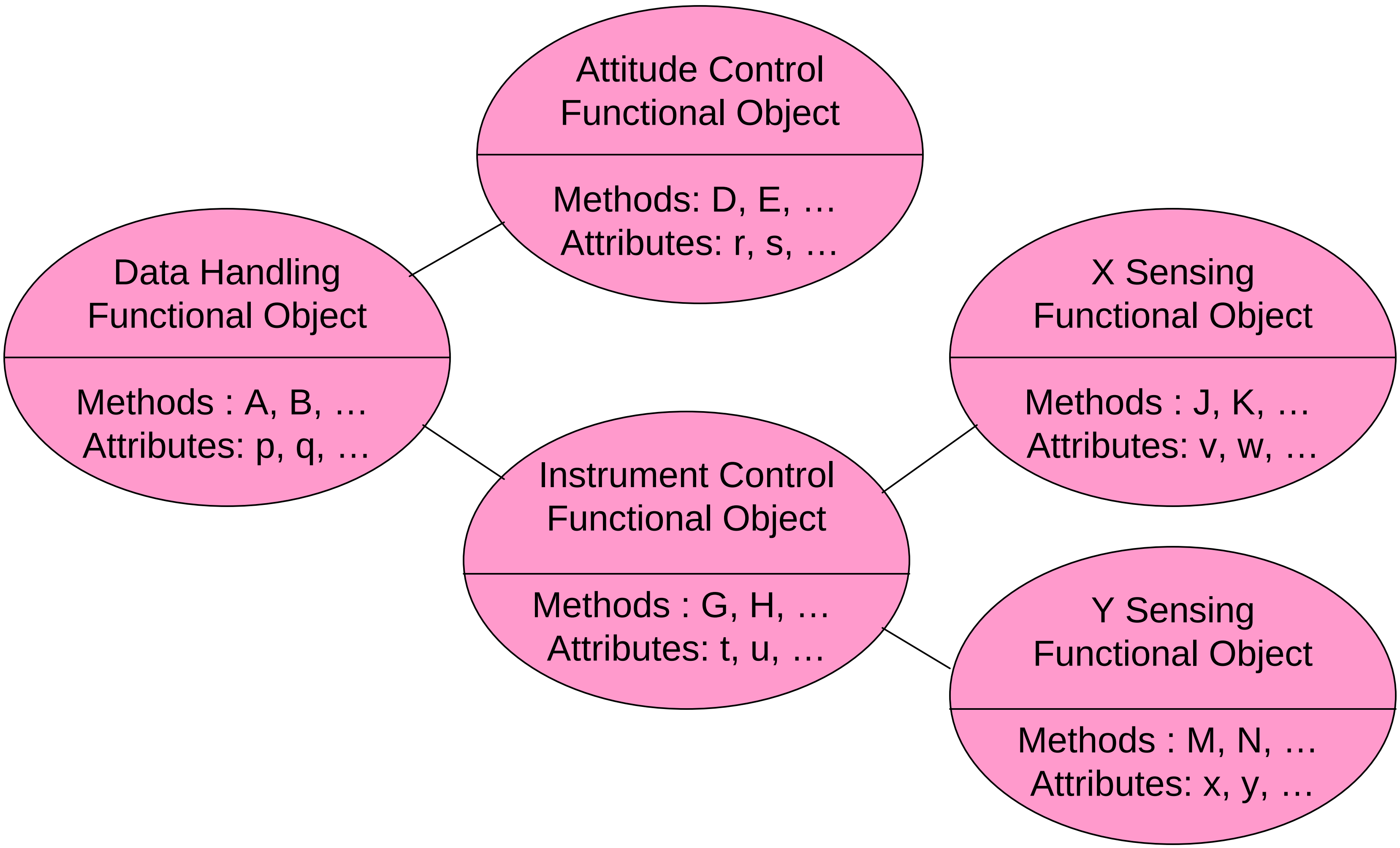
Standard Spacecraft Model

- The standard spacecraft model provides a common framework for describing the characteristics and internal organization of spacecraft.
- The model specifies a standard set of
  - elements (or objects),
  - relationships between elements,
  - attributes of elements, and
  - attributes of relationships.
- *In the first stage of this project, only the functional aspect (i.e., the functions performed by spacecraft) and the informational aspect (i.e., the information exchanged with and within spacecraft) will be modeled.*
- *Other aspects (structural, thermal, etc.) will be treated at a later stage by extending the method described here.*

Functional Model

- The functions performed by spacecraft are described as Functional Objects.
- Each onboard subsystem or instrument has one or more Functional Objects.
  - *Note: There are Functional Objects on the ground, too, for testing and operating spacecraft.*
- Functional Objects are characterized by their methods (operations) and attributes (parameters).
- Methods are actions performed by Functional Objects started with requests by other Functional Objects.
- Attributes are parameters that represent the status of some parts of Functional Objects. Each attribute may have a discrete value, an analog value, or a complex value like an array or a table.
- Methods and attributes are defined in terms of their functionality, not in terms of how they are implemented.

Example of Functional Objects



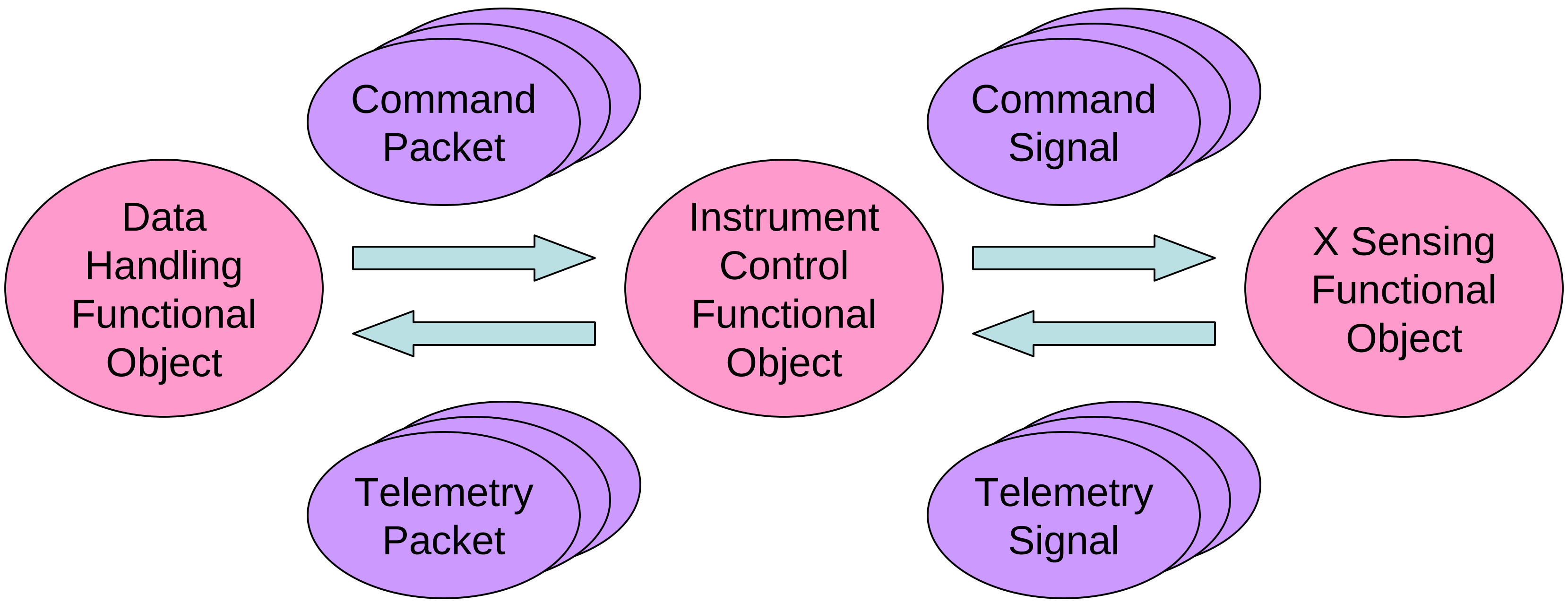
Behavior of Functional Objects

- The behavior of Functional Objects can be described as rules on how the values of attributes should change and how they should be interrelated with each other.
- The values of some discrete attributes can only change according to some rules
  - Example: from Off to Standby to On, but not directly from Off to On
  - Such rules can be specified by state transition rules and how to specify such rules should be part of the standard spacecraft model.
- There may be constraints on the values of a group of attributes.
  - Such constraints can be specified with a formal language and how to specify such constraints should also be part of the standard spacecraft model.

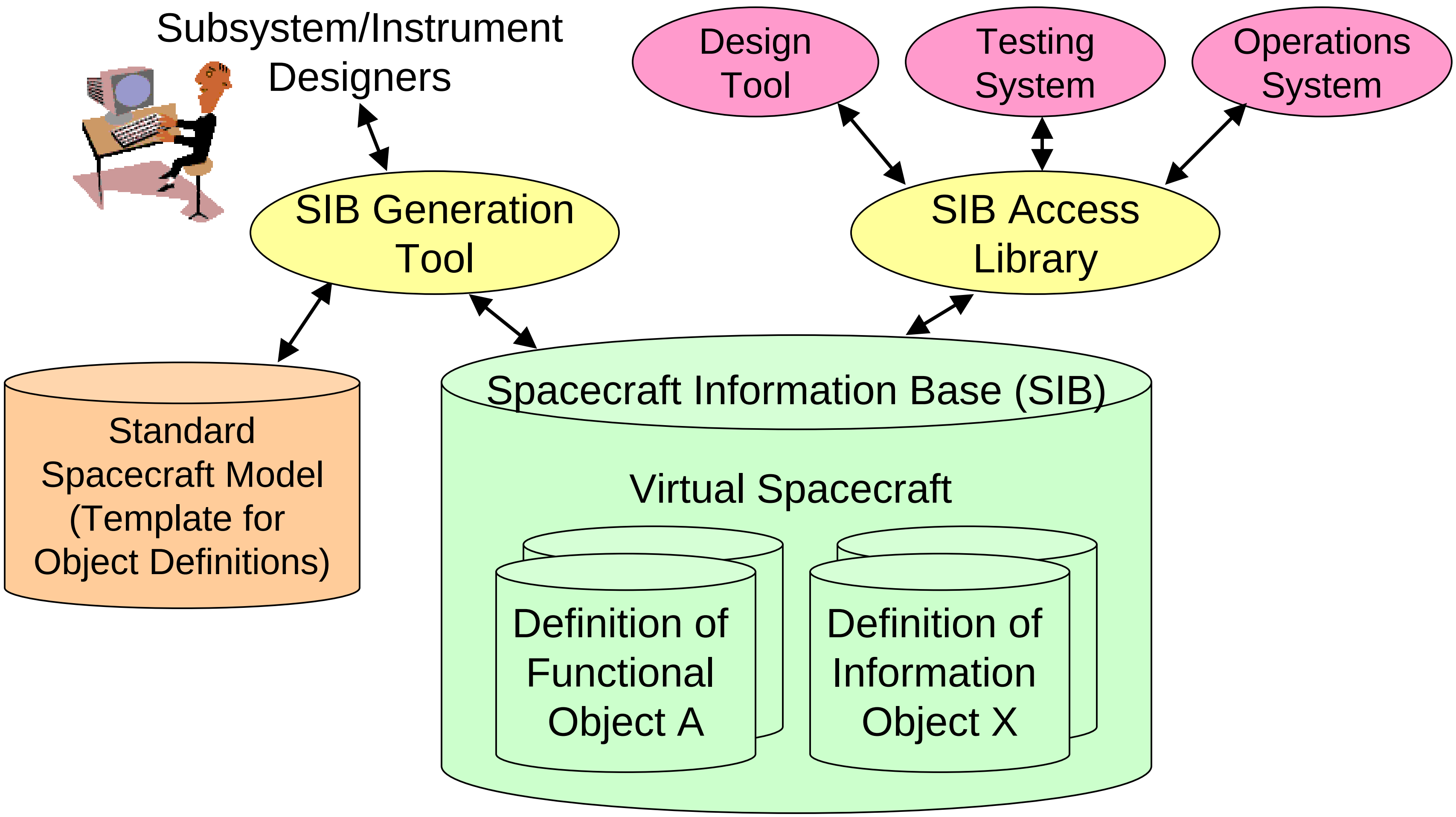
Informational Model

- The information exchanged between Functional Objects is described as Information Objects.
- Information Objects are characterized by their semantics (what they mean) and syntax (how they are realized).
- The semantics of an Information Object can be specified based on the definition of the Functional Object that generates or consumes the Information Object.
- The syntax of an Information Object can be specified by showing how the semantic elements of the Information Object are expressed and organized as binary data or physical signals.

Example of Information Objects

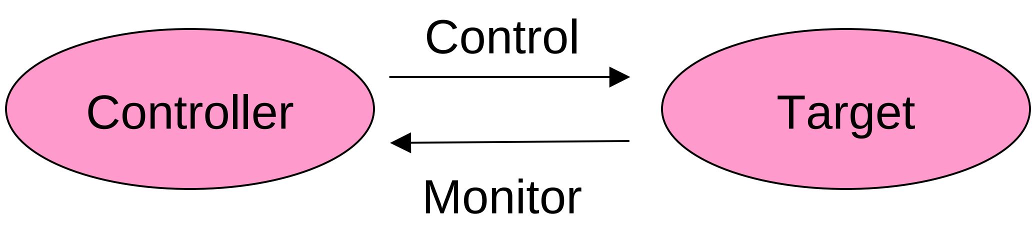


How to Manipulate Virtual Spacecraft

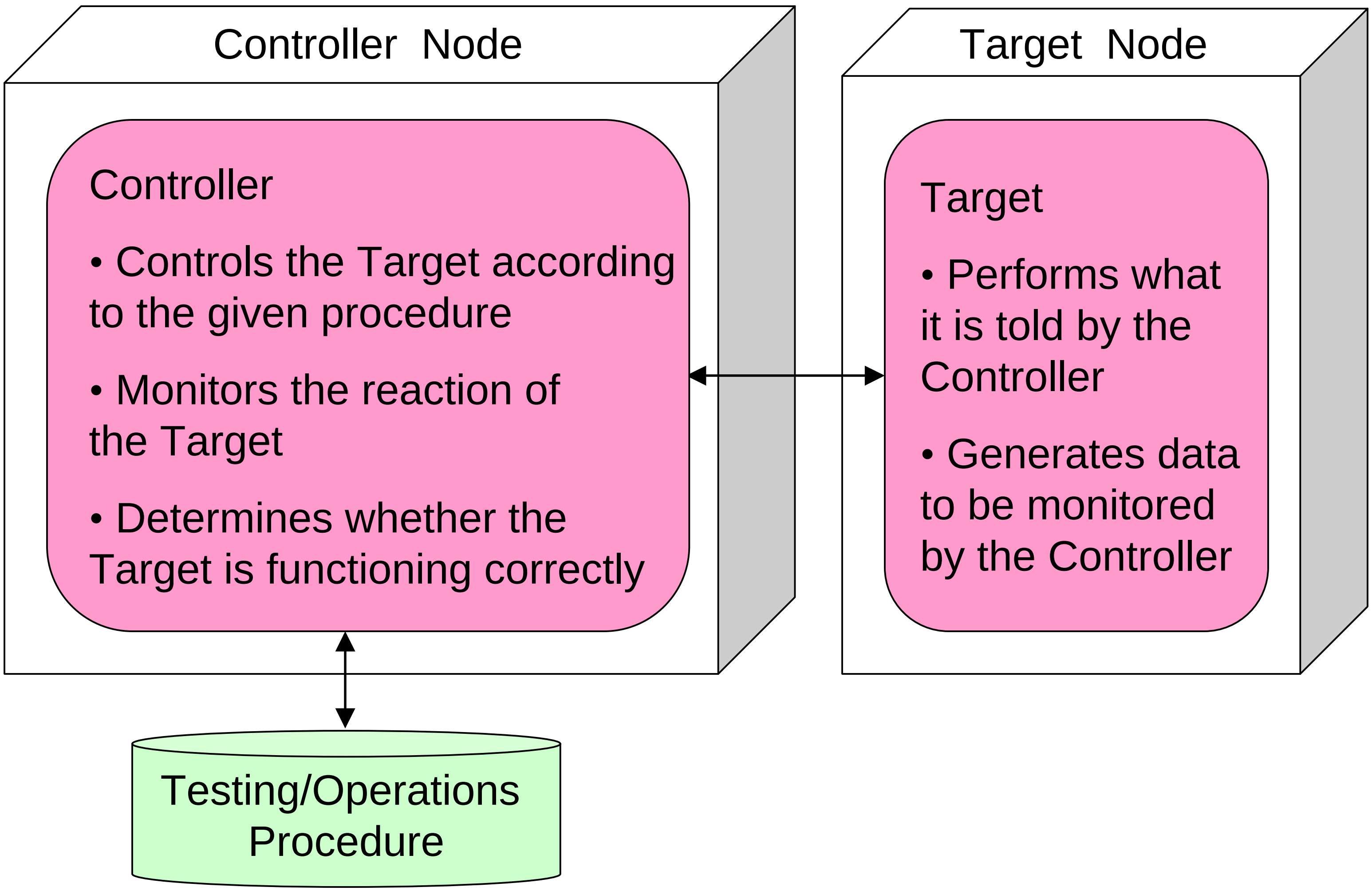


Interactions Between Functional Objects

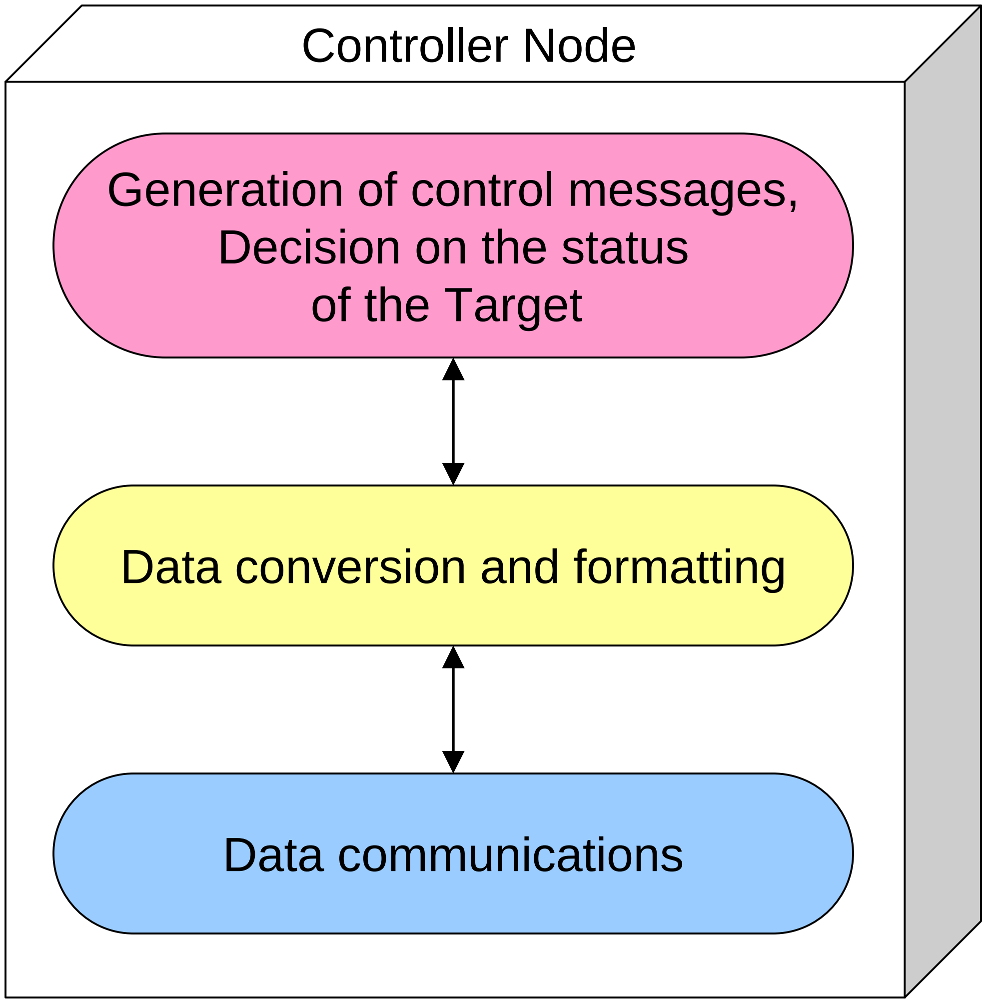
- Most interactions between Functional Objects can be modeled in such a way that one Functional Object (Controller) monitors and controls the other Functional Object (Target).
- The Controller
  - Reads the values of attributes of the Target (either by explicit requests or according to a predefined schedule),
  - Changes the values of attributes of the Target, and
  - Invokes methods of the Target.
- The Target
  - Notifies the Controller of changes in the values of attributes.



Monitor & Control, In Essence



Layered Implementation of Controller



Application Layer:

Performs functions that require knowledge of the behavior of the Target

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Middle Layer:

Performs functions that do not depend on the behavior of the Target but depend on the structure of the data

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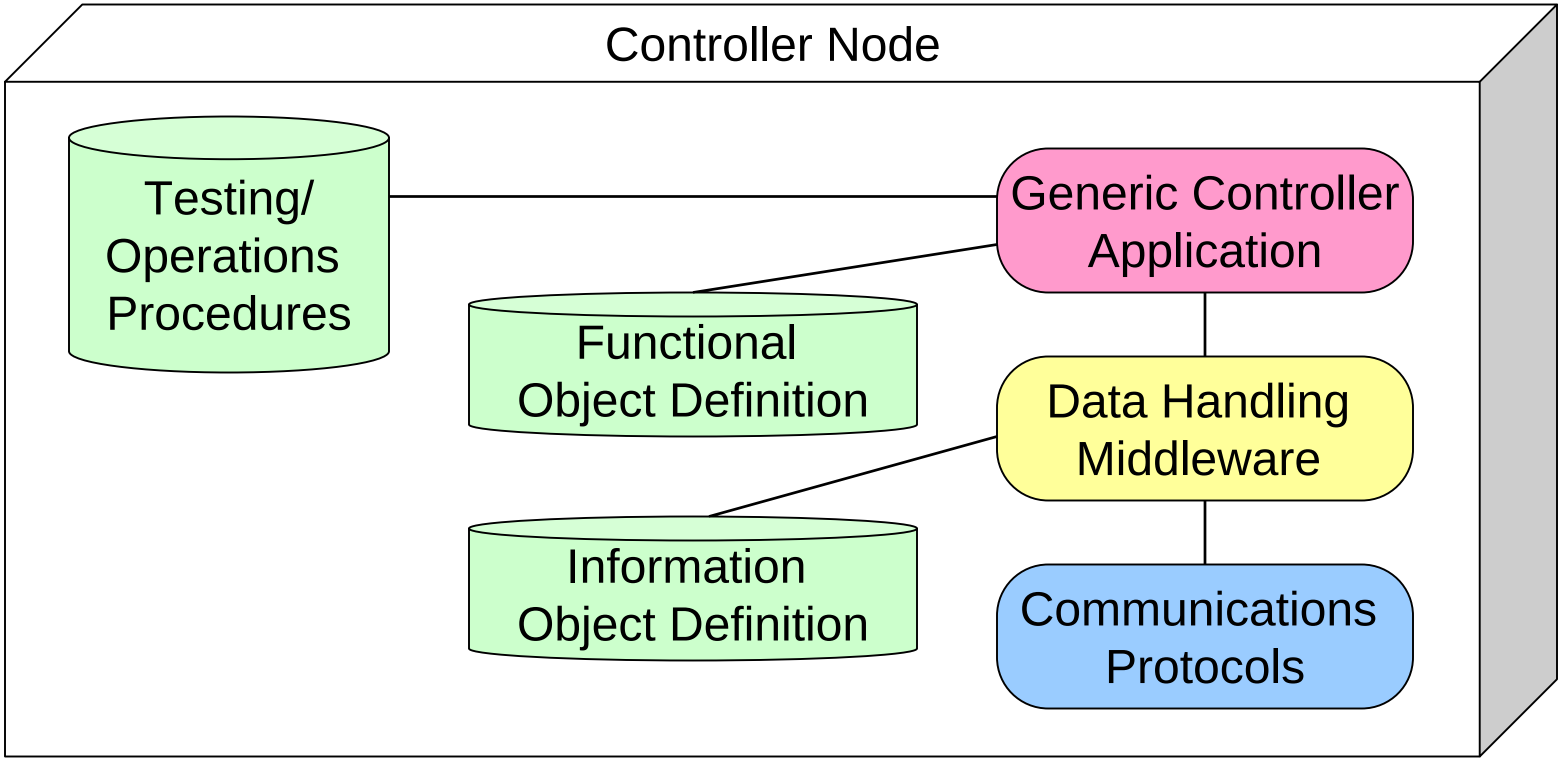
Communications Layer:

Performs communications

Generic Controller



- In order for a Controller to be used for any Target, the definition of the Target as Functional Objects and the definition of the Information Objects that the Target generates and consumes must be supplied as a database.

Applications of the Generic Controller

- The generic Controller can be used for
  - Testing of onboard subsystems,
  - Testing of integrated spacecraft, and
  - Flight operations of spacecraft in orbit.
- The generic Controller can be used for ANY subsystem or spacecraft by supplying
  - The definition of the Target as Functional Objects,
  - The definition of the Information Objects that Target generates and consumes, and
  - The communications protocols used for communications with the Target.

Implementation Plans

- ISAS is planning to prototype a SIB this year.
- Next year, a generic controller (with limited functionality) to be used for testing of instruments will be developed.
- By extending the functionality of the generic controller used for testing of instruments, a generic controller to be used for testing of integrated spacecraft will be developed.
- By augmenting the functionality of the generic controller used for testing of spacecraft, a generic controller to be used for flight operations of spacecraft will be developed.