Overview of Object-Process Methodology (OPM)

Lecture 30, v02

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BSEE

MSSE

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About This Courseware

- This courseware is presented as a brief overview of the Object-Process Methodology (OPM) developed by Dr. Dov Dori
- The majority of the material presented in this lecture is sourced from the book "*Object-Process Methodology, A Holistic Systems Paradigm*" by Dr. Dov Dori
- I, John Artus, make no claim of ownership of the material sourced from this textbook
- I, John Artus, am using the material sourced from this textbook, and other indicated sources, as content for this courseware for educational purposes only
- For further information and details on OPM, the reader is directed to the following two textbooks
  - *Object-Process Methodology, A Holistic Systems Paradigm,* by Dr. Dov Dori
  - *Model-Based Systems Engineering with OPM and SysML,* by Dr. Dov Dori
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Objects, Processes, and States

- OPM is built on top of three types of entities
  - An object is a thing that exists or has the potential of existence, physically or mentally
  - A process transforms objects by, consuming, producing, or affecting them
  - A state is a situation within which an object can exist at a given moment in time
- States are used to describe (stateful) objects, and are not standalone things
  - Stateful means that the object has memory of a past state of existence
  - Previous transactions are remembered and may affect the current transaction
  - Stateful objects are those that have memory of more than one defined state of existence
  - Stateful objects therefore have the ability to change state based on the memory of the conditions that define the state
    - I declare that I am now in State X, because my current conditions are consistent with my memory of the definition of that state
- At any point in time, each stateful object exists in one of its defined states

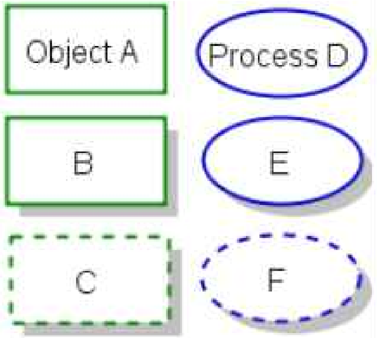
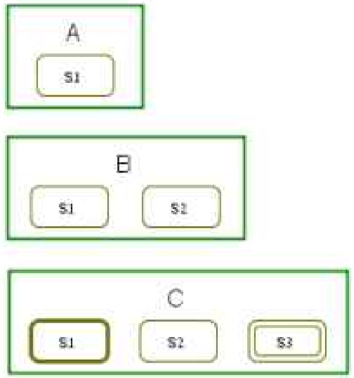
Premise of OPM

- The premise of OPM is that everything in the universe (and everything inherent in a system) is ultimately either an object or a process
  - Objects (form) — things that exist in one or more states
  - Processes (function) — things that happen and transform objects by creating or consuming them or by changing their states
- OPM explicitly shows the connections between objects and processes
- OPM is a formal paradigm to systems development, lifecycle support, and evolution
- In OPM, a system is represented simultaneously in formal graphics and in a natural language
  - Object-Process Diagrams (OPDs) – formal yet simple visual models
    - Every OPD construct is expressed by a semantically equivalent OPL sentence or part of a sentence and vice versa
  - Object-Process Language (OPL) - constrained natural language sentences
    - OPL is a dual-purpose language, oriented towards humans as well as machines

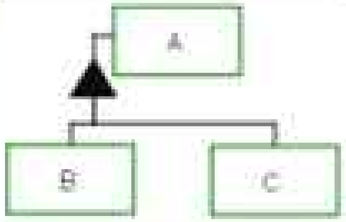
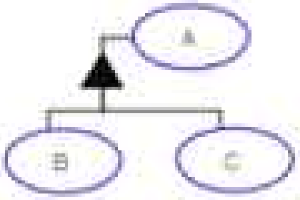
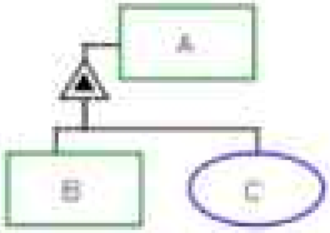
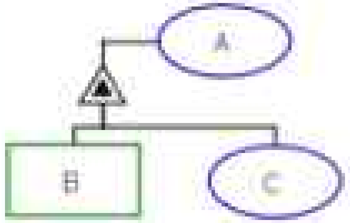
OPM Conventions and Syntax Summary

- This section includes a very brief overview of the OPM graphical syntax
  - This is intended as a reference guide, not a tutorial on how to use the OPM graphical syntax
  - It is recommended that students access the references listed in this presentation for more information and specific examples of OPM graphical syntax usage
- The symbol for objects and processes are rectangles and ellipses, respectively
- The first letter of object and process names is always capitalized
- Process names are expressed as gerunds (ends in "-ing") indicating they are active, dynamic things
- The symbol for state is a "roundangle" (rounded-corner rectangle)
- State names start with a lower-case letter

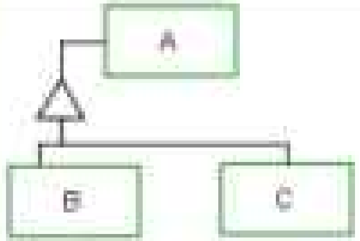
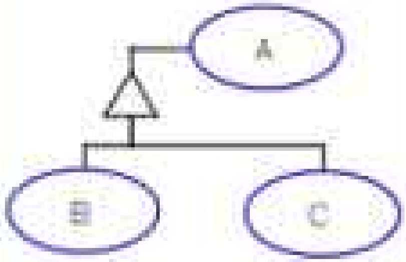
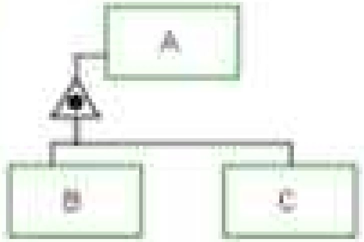
OPM Entities

Name	Symbol	OPL	Definition
Things: **Object**, **Process**		**B** is physical. (shaded rectangle) **C** is physical and environmental. (shaded dashed rectangle) **E** is physical. (shaded ellipse) **F** is physical and environmental. (shaded dashed ellipse)	An **object** is a thing that exists. A **process** is a thing that transforms at least one object. Transformation is object generation or consumption, or effect—a change in the state of an object.
State		**A** is **s1**. **B** can be **s1** or **s2**. **C** can be **s1**, **s2**, or **s3**. **s1** is initial. **s3** is final.	A **state** is situation an object can be at or a value it can assume. States are always within an object. States can be initial or final.

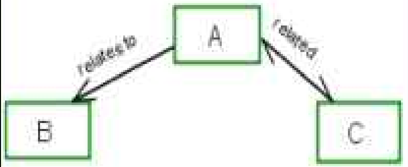
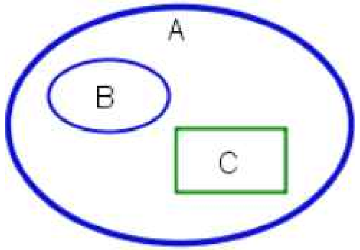
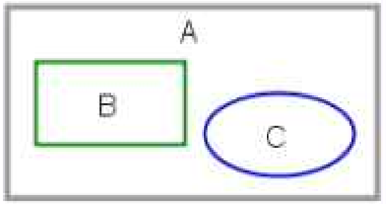
OPM Fundamental Structural Relations

	Name	Symbol	OPL	Semantics
Fundamental Structural Relations	Aggregation-Participation		A consists of B and C.	A is the whole, B and C are parts.
			A consists of B and C.	
	Exhibition-Characterization		A exhibits B, as well as C.	Object B is an attribute of A and process C is its operation (method). A can be an object or a process.
			A exhibits B, as well as C.	

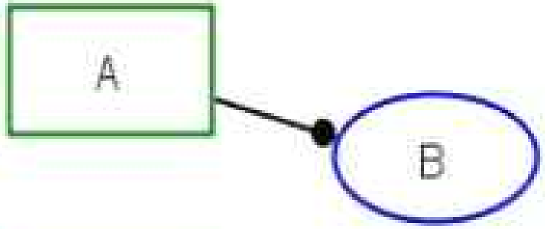
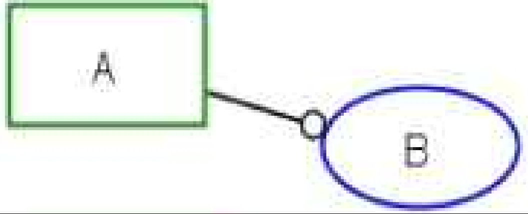
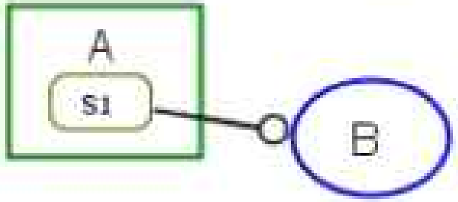
OPM Fundamental Structural Relations (continued)

	Name	Symbol	OPL	Semantics
Fundamental Structural Relations	Generalization - Specialization		B is an A. C is an A.	A specializes into B and C. A, B, and C can be either all objects or all processes.
			B is A. C is A.	
	Classification-Instantiation		B is an instance of A. C is an instance of A.	Object A is the class, for which B and C are instances. Applicable to processes too.

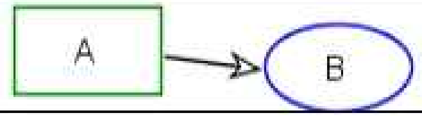
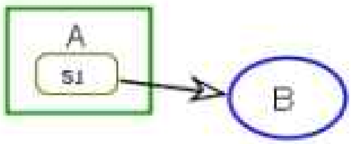
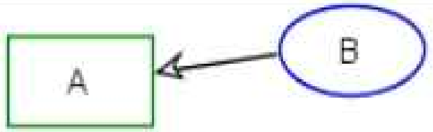
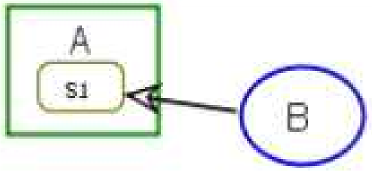
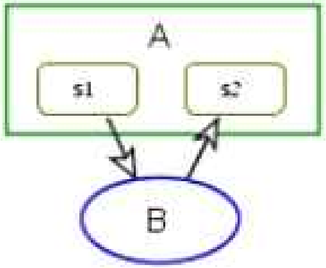
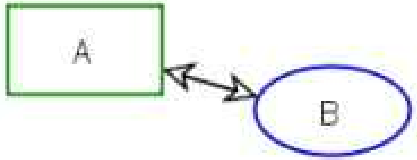
OPM Complexity Management

Unidirectional & bidirectional tagged structural links		**A** relates to **B**. (for unidirectional) **A** and **C** are related. (for bidirectional)	A user-defined textual tag describes any structural relation between two objects or between two processes.
In-zooming		**A** exhibits **C**. **A** consists of **B** **A** zooms into **B**, as well as **C**.	Zooming into process A, B is its part and C is its attribute.
		**A** exhibits **C**. **A** consists of **B**. **A** zooms into **B**, as well as **C**.	Zooming into object A, B is its part and C is its operation.

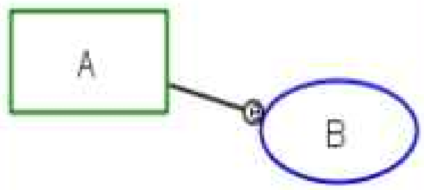
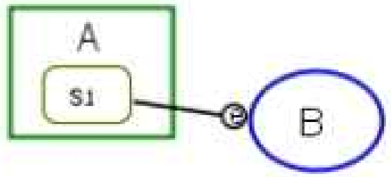
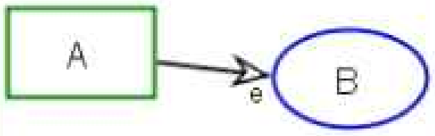
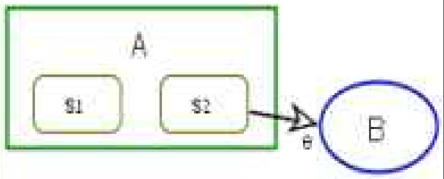
OPM Enabling Procedural Links

Name		Symbol	OPL	Semantics
Enabling links	Agent Link		**A** handles **B**.	Denotes that the object is a human operator.
	Instrument Link		**B** requires **A**.	"Wait until" semantics: Process B cannot happen if object A does not exist.
	State-Specified Instrument Link		**B** requires **s1** **A**.	"Wait until" semantics: Process B cannot happen if object A is not at state s1.

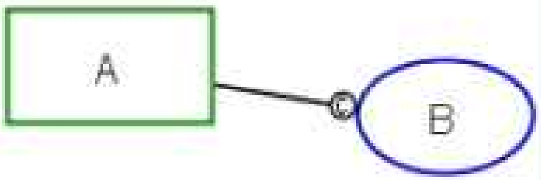
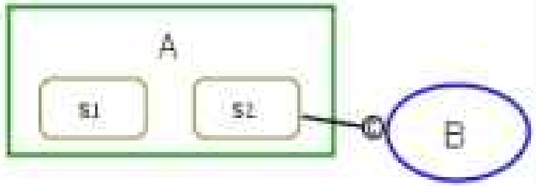
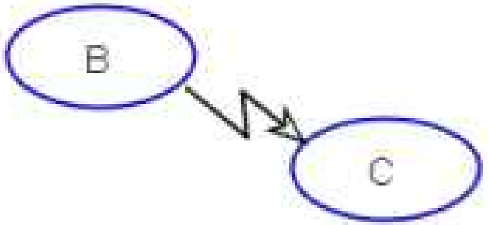
Transforming Procedural Links

Transforming links	Consumption Link		**B** consumes **A.**	Process B consumes Object A.
	State-Specified Consumption Link		**B** consumes **s1 A.**	Process B consumes Object A when it is at State s1.
	Result Link		**B** yields **A.**	Process B creates Object A.
	State-Specified Result Link		**B** yields **s1 A.**	Process B creates Object A at State s1.
	Input-Output Link Pair		**B** changes **A** from **s1** to **s2.**	Process B changes the state of Object A from State s1 to State s2.
	Effect Link		**B** affects **A.**	Process B changes the state of Object A; the details of the effect may be added at a lower level.

OPM Event Procedural Links

Name	Symbol	OPL	Semantics
Instrument Event Link		**A** triggers **B**. **B** triggers **A**.	Existence or generation of object A will attempt to trigger process B once. Execution will proceed if the triggering failed.
State-Specified Instrument Event Link		A triggers **B**. when it enters **s1**. **B** requires **s1** **A**.	Entering state s1 will attempt to trigger the process once. Execution will proceed if the triggering failed.
Consumption Event Link		**A** triggers **B**. **B** consumes **A**.	Existence or generation of object A will attempt to trigger process B once. If B is triggered, it will consume A. Execution will proceed if the triggering failed.
State-Specified Consumption Event Link		**A** triggers **B** when it enters **s2**. **B** consumes **s2** **A**.	Entering state s2 will attempt to trigger the process once. If B is triggered, it will consume A. Execution will proceed if the triggering failed.

OPM Condition and Invocation Procedural Links

Name	Symbol	OPL	Semantics
Condition Link		B occurs if A exists.	Existence of object A is a condition to the execution of B. If object A does not exist, then process B is skipped and regular system flow continues.
State-Specified Condition Link		B occurs if A is s1.	Existence of object A at state s2 is a condition to the execution of B. If object A does not exist, then process B is skipped and regular system flow continues.
Invocation Link		B invokes C.	Execution will proceed if the triggering failed (due to failure to fulfill one or more of the conditions in the precondition set).

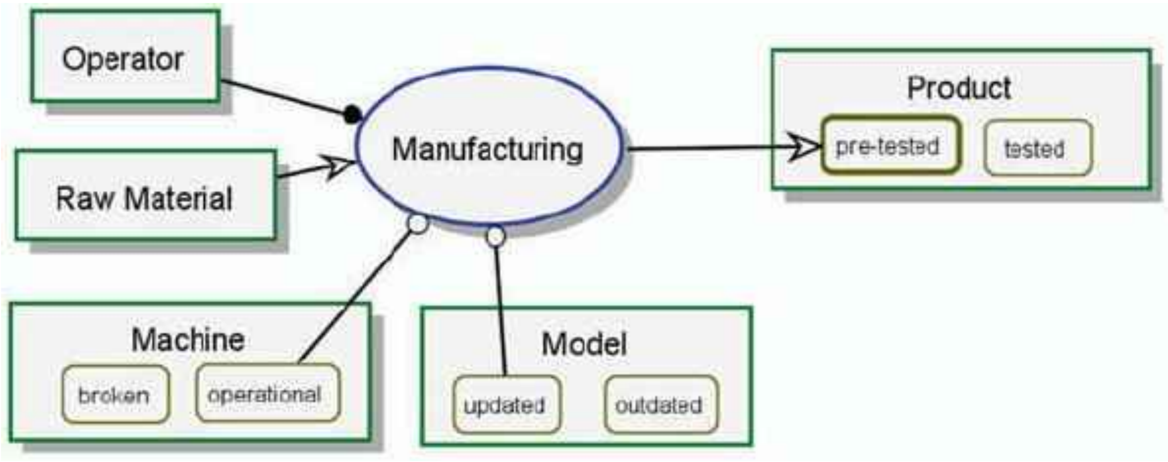
Object Process Language (OPL)

- The Object–Process Methodology includes a native language associated with the OPM graphical syntax, known as the Object Process Language (OPL)
- OPL serves two goals
  - One goal is to convert the set of Object-Process Diagrams (OPDs) into a natural language script
    - For communicating analysis and design results back to the prospective users and customers and getting their feedback and approval
  - The other goal of OPL, which is attained by its formality, is to provide the infrastructure needed for automated application generation
    - Including code, database scheme, and user interface generation
- To enhance OPM's expressive power, we associate with each OPD a collection of sentences in OPL as a textual, natural interpretation of the OPD's graphic representation
  - Each graphic symbol has a textual OPL equivalent
- The syntax of OPL is designed such that the resulting text constitutes plain natural, albeit syntactically restricted, English sentences

Object Process Language (OPL) (continued)

- The OPD-OPL pair follow the graphics-text equivalence principle
  - The OPD and its OPL paragraph contain the same information and are therefore reconstructible from each other
- Shown below is a simple example of the OPL for the given OPD
- Refer to the references listed in this presentation for more information on the OPL

Object Process Diagram (OPD)



Object Process Language (OPL)

Machine can be **operational** or **broken**.
Model can be **updated** or **outdated**.
Operator handles **Manufacturing**.
Manufacturing requires **operational Machine** and **updated Model**.
Manufacturing consumes **Raw Material**.
Manufacturing yields **pre-tested Product**.

An OPL paragraph of an OPD is a collection of sentences that express the content of the OPD

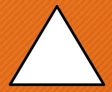
Recognition of OPM

- International Recognition
  - Formal international recognition of OPM as a modeling language has been established through the publication of ISO 19450:2024 Object-Process Methodology
  - While not a textbook for learning OPM, nor a manual for using OPM, it does precisely define the elements of the language
  - For learning the language, there are an extensive number of alternative resources available, such as the ones mentioned in the slide References
- Commercially-Available Modeling Tool
  - A commercially available modeling tool called OPCAT has been developed to support the modeling of systems with OPM
  - OPCAT is available in two executable formats:
    - Cloud execution (https://www.opcloud.tech/)
    - Standalone installation (https://esml.technion.ac.il/opm/opcat-installation/)

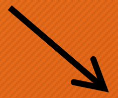
OPM Drawing Elements

 Aggregation – Participation

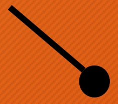
 Exhibition – Characterization

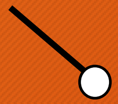
 Generalization – Specialization

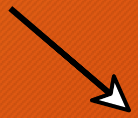
 Classification – Instantiation

 Uni-directional Structural Link

 Bi-directional Structural Link

 Enabling Link (Agent)

 Enabling Link (Instrument)

 Transforming Link

For use in drawing OPM diagrams using MS PowerPoint

References

1. Dori, Dov (2002). *Object-Process Methodology, A Holistic Systems Paradigm*, Springer-Verlag Berlin Heidelberg, New York, NY
2. Dori, Dov (2016). *Model-Based Systems Engineering with OPM and SysML*, Springer-Verlag Berlin Heidelberg, New York, NY
3. Crawley, Edward; Cameron, Bruce; Selva, Daniel (2016). *System Architecture: Strategy and Product Development for Complex Systems*, Pearson Higher Education Inc, Hoboken, NJ
4. OPCAT Version 3.0 Getting Started Guide. Retrieved from https://web.mit.edu/deweck/Public/opcat/OPCAT_Manual_3.0.pdf
5. ISO 19450:2024 https://www.iso.org/standard/84612.html