

System Architecture

Tutorial on Object Process Modeling

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January 11, 2007
Rev 2.0

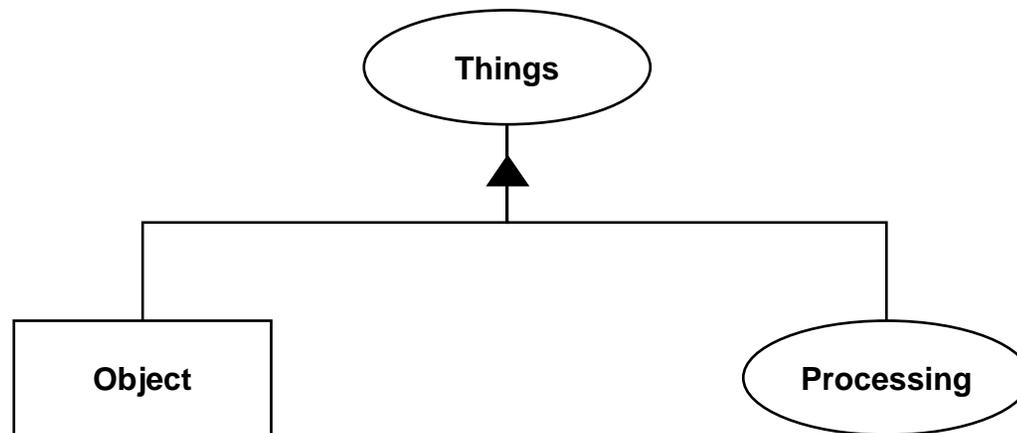
Outline

- **Objects, processes and their links**
- **Objects and their links**
- **Processes**

A Tutorial: Object-Process Methodology (OPM)

- **OPM is a system development methodology that integrates many system attributes in one model**
- **In particular, explicitly represents objects, processes and their links**
- **Gives us a framework for rigorous *qualitative* system thinking, and perhaps quantitative modeling and analysis**
- **Developed by Dr. Dov Dori, modified for System Architecture**
- **A way to think, not **the** way to think**

Things



- **The world is composed of things (physical/informational) which consist of objects and processes**

Objects



- **Defined: An object is that which has the potential of stable, unconditional existence for some positive duration of time**
- **Can be physical: visible or tangible and stable in form**
- **Can be informational: anything that can be apprehended intellectually**
- **Objects have states (which can be changed by processes)**
- **Objects are linked to nouns**

Processes



Processing

- **Defined: A process is the pattern of transformation applied to one or more objects**
- **Cannot hold or touch a process - it is fleeting**
- **Generally creation, change, or destruction**
- **A process relies on at least one object in the pre-process set**
- **A process transforms at least one object in the pre-process set**
- **A process takes place along a time line**
- **A process is associated with a verb**

Object and its States

- **State** is a situation at which the object can exist for some positive duration of time (and implicitly can change).
- Processes change the state of a particular object(s), the operand(s)
- For simple objects, the state can be represented by a rounded rectangle within the rectangle representing the object

- **Examples:**

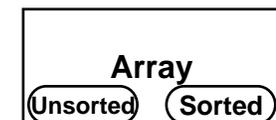
- When thinking about transportation, a person:



- When thinking about heating, a home



- When thinking about assigning, an array



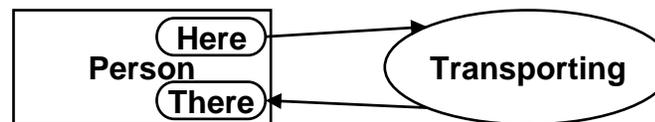
Thought Exercise

- **Look at things and decide if they are objects or processes - have states or change states**

Process and its Links



- A process is associated with a verb and stateless
- There are a family of about 5 types of links from process to object
- A process changes the states of its operand(s) through input and output links

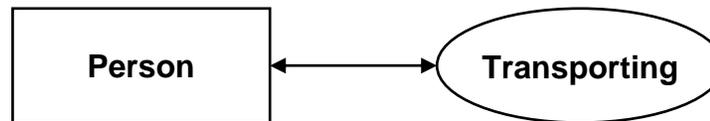


Transporting changes a person from here to there

Effect Links



- **The input, output and states can be suppressed for simplification to an effect link**



Transporting affects person

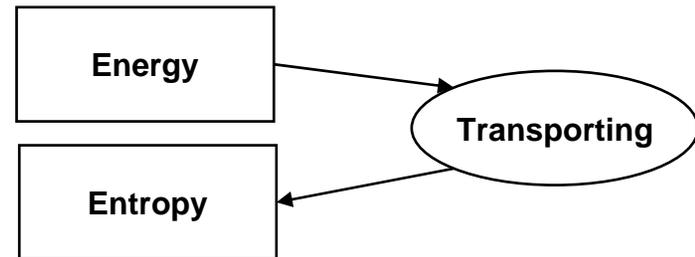
Consumption and Result Links



- **Special cases of input and output links are consumption and result**
- **Consumption links connects a process with an object which is consumed**
 - **A whole and its parts**
- **Result link connects a process with an object which results**

Transporting consumes energy

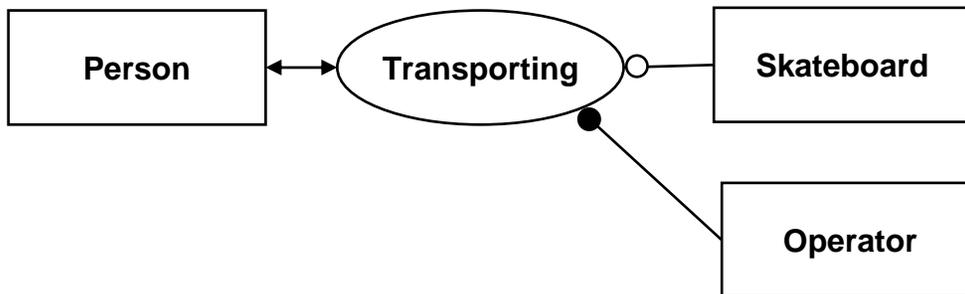
Transporting yields entropy



Enablers



- **Defined: Enablers of a process is an object that must be present for that process to occur, but does not change as a result of the occurrence of the process**
- **Defined: Agent is an intelligent enabler** —●
 - A human or organization of humans
 - Autonomous devices (animals, real-time computing services)
- **Defined: Instruments is a non-agent enabler** —○

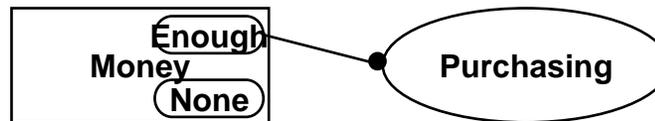


Transporting requires skateboard

Skateboard is handled by operator

Conditional Link

- **Defined: Conditions are state that must be achieved before a process will execute**
- **Could be agent or instrument** 

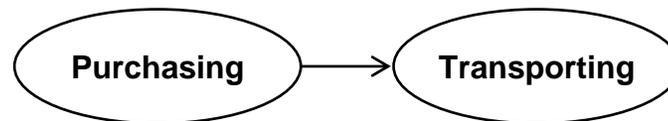


Purchasing occurs if Money is enough

Invocation Links



- While almost all process produce outputs that lead to other processes (i.e. there is an object between processes), sometimes it is more convenient to represent a direct causal link from one process to another
- This is called an invocation link
- Can occur between physical processes (skidding invokes spinning) or informational (if command invokes contained instructions) ▪

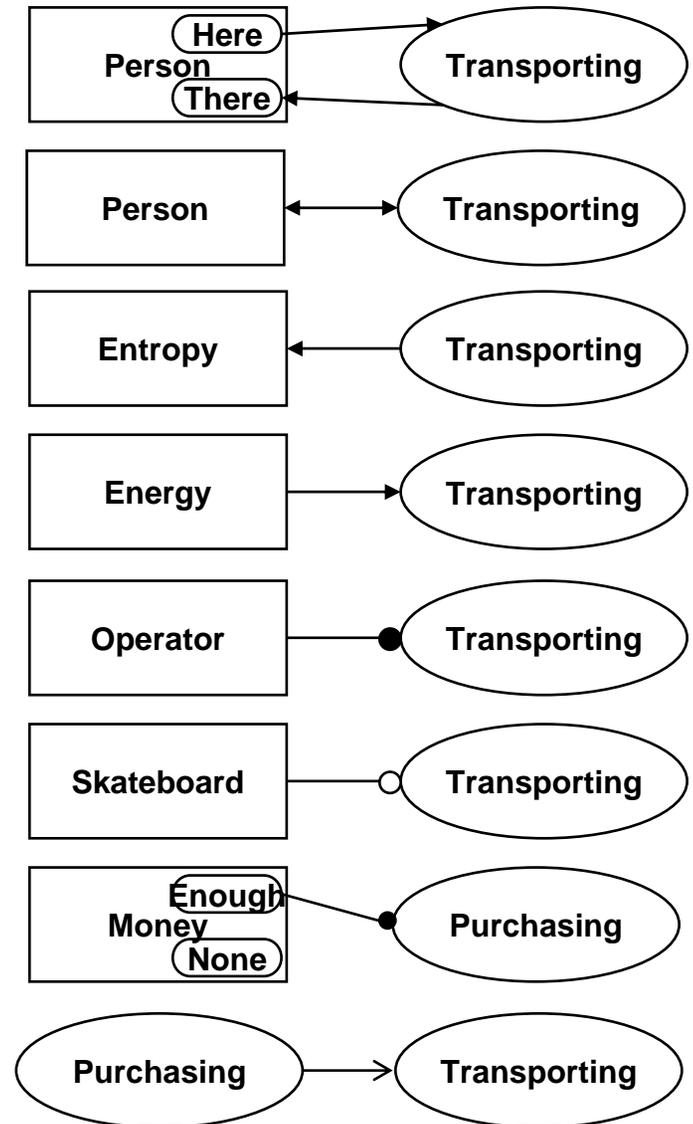


Sometimes a double headed arrow



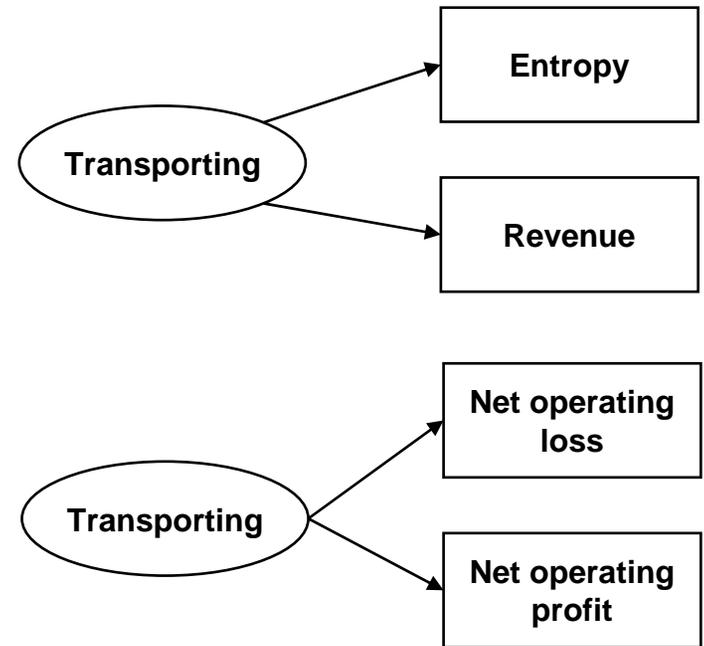
OPM Process Links

- **P changes O** (from state A to B).
- **P affects O**
- **P yields or creates O**
- **P consumes or destroys O**
- **O is an agent of P (agent)**
- **O is and instrument of P**
- **P occurs if O is in state A**
- **P1 invokes P2 directly**



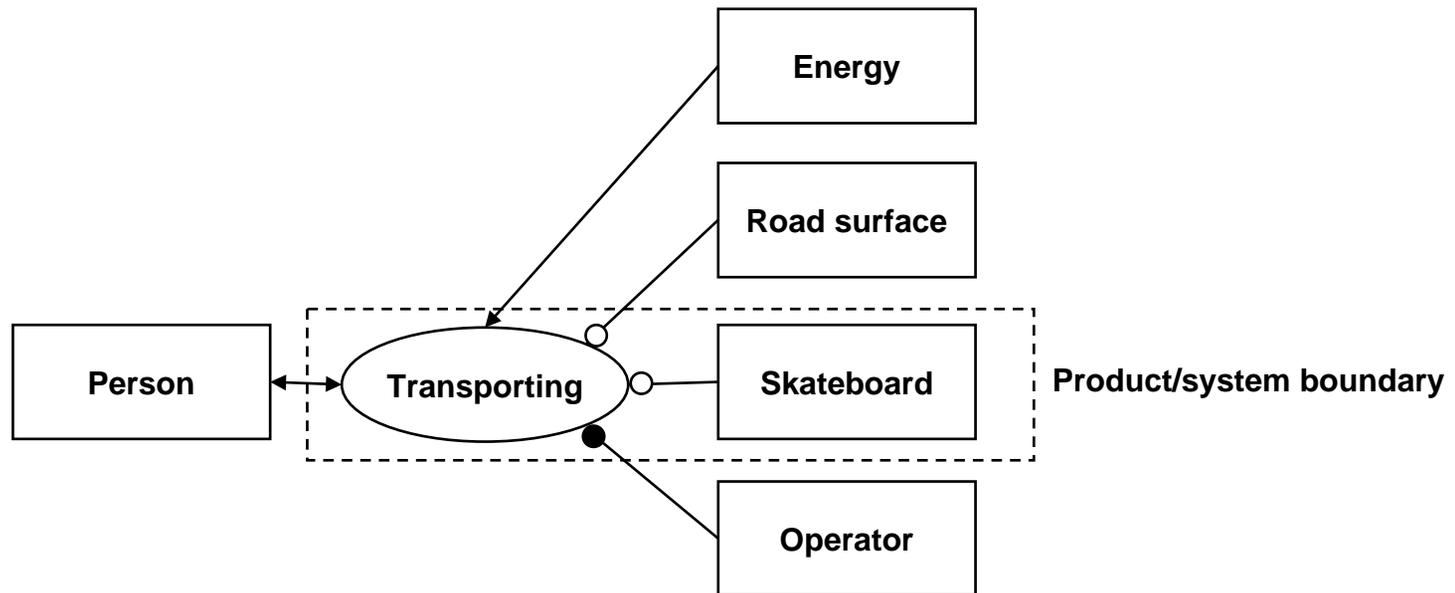
Forks in Object Process Links

- If two links leave from different point on a process, it implies that both paths occur
- If two links leave from the same path on the process oval, it implies an exclusive or, one or the other path occurs
- Similarly for inputs and instruments of processes

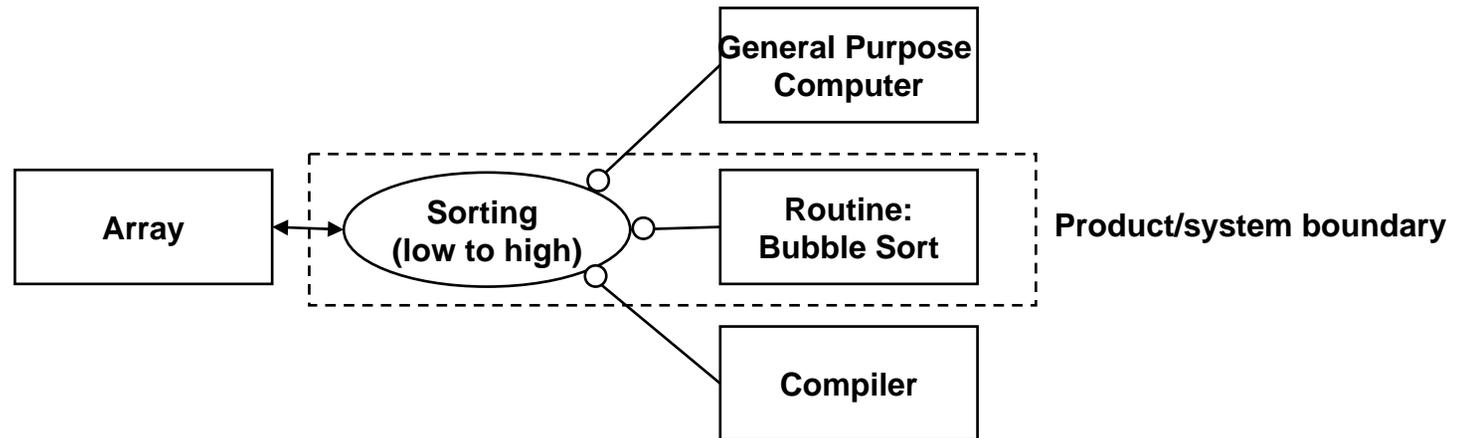


OPM of a Whole Product System (Mechanical - Skateboard)

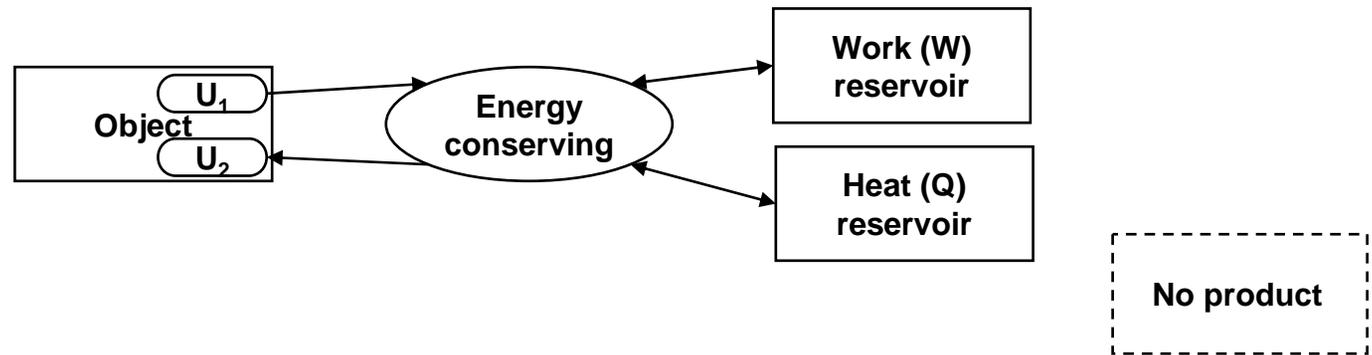
- **OPM Def:** The whole system is the array of objects necessary to deliver the externally delivered process to the operand(s).



OPM of an Information System (Bubble Sort)

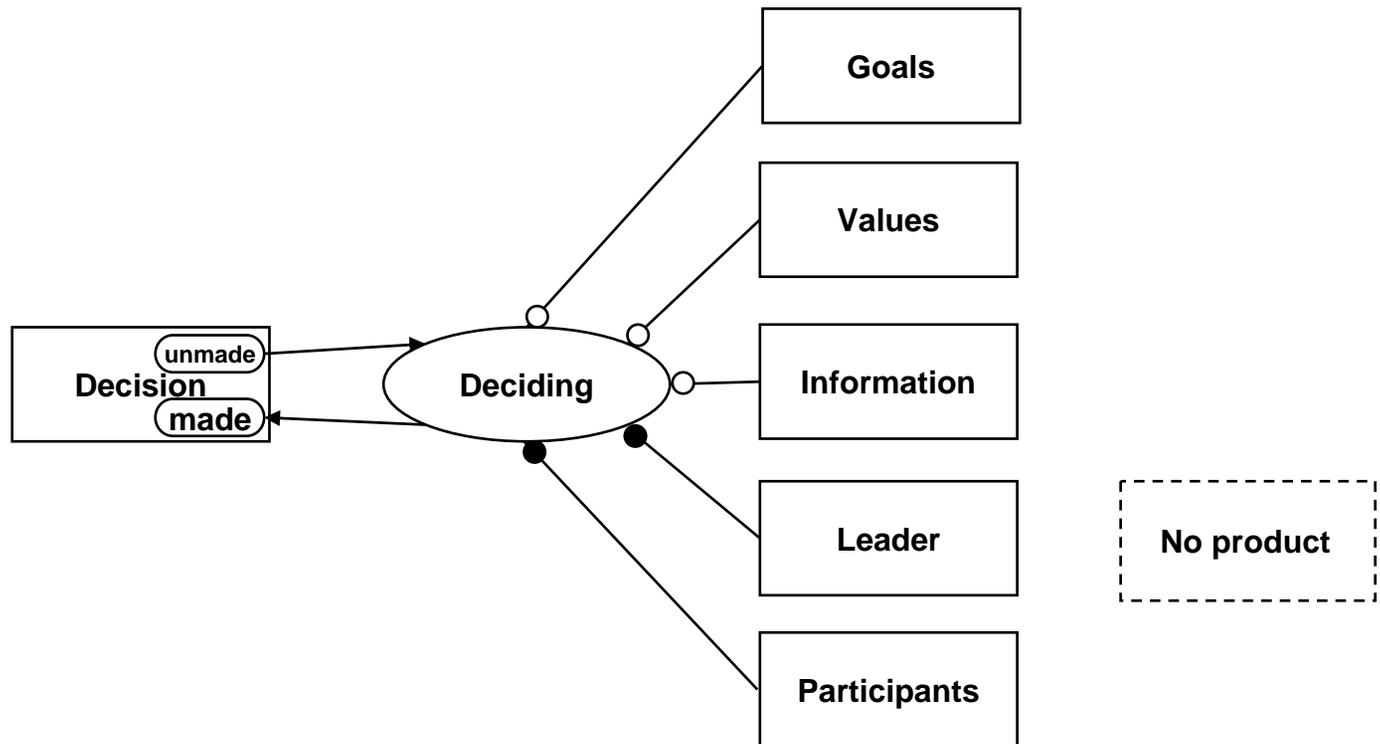


OPM of a Fundamental Physical Process



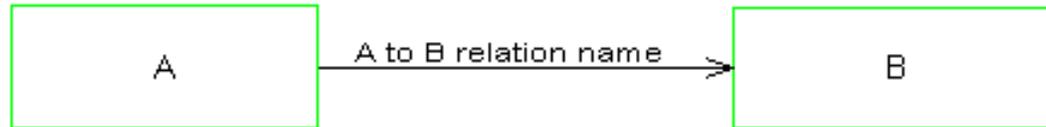
Generally, in detailed technical systems, equations represent processes, and variable represent the state of the objects

OPM of a Social System

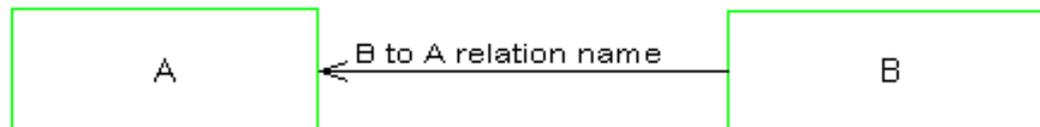


OPM Object-Object Structural Links

- **Defined:** A structural link is the symbol that represents a binary relationship between two objects.

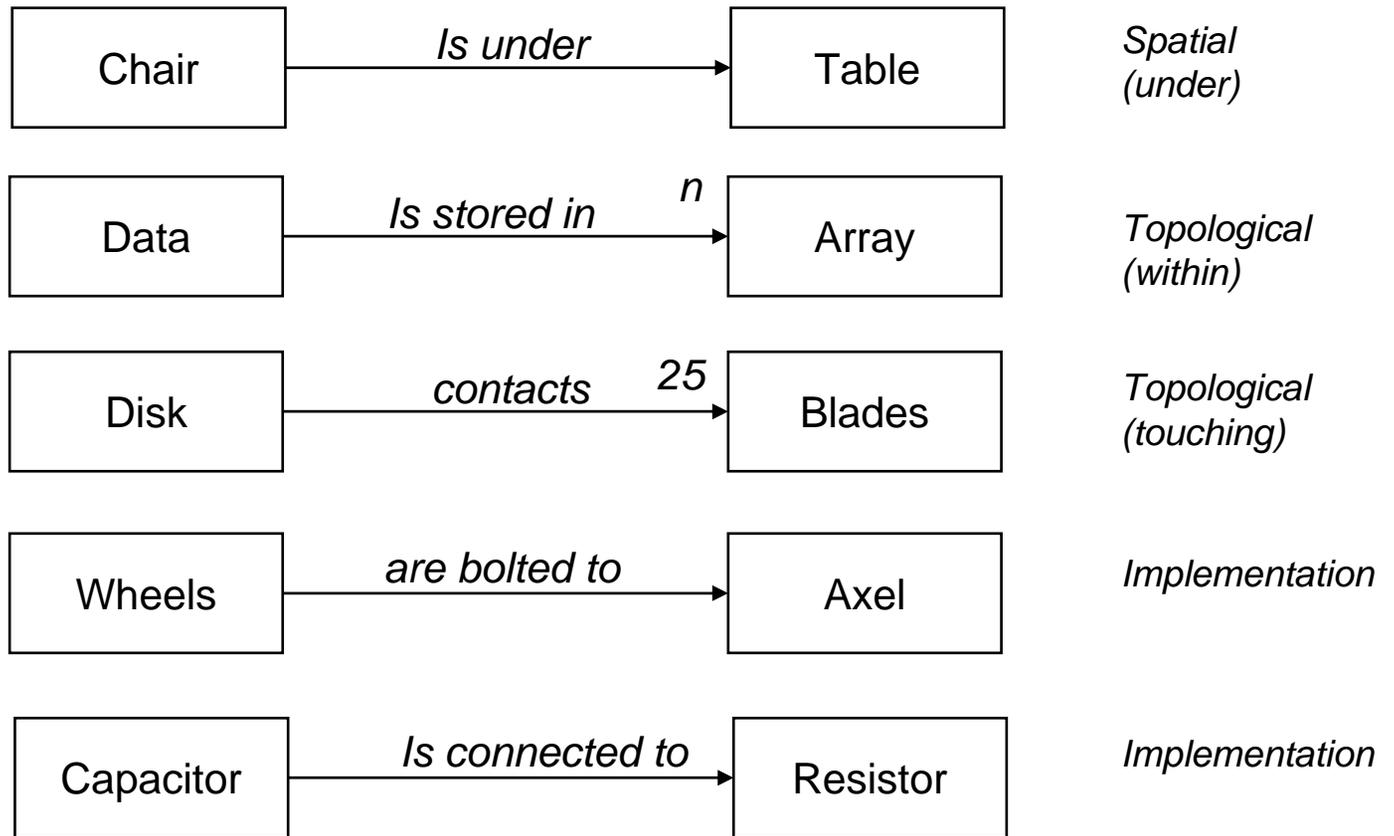


- **There is also a backward direction relation.**



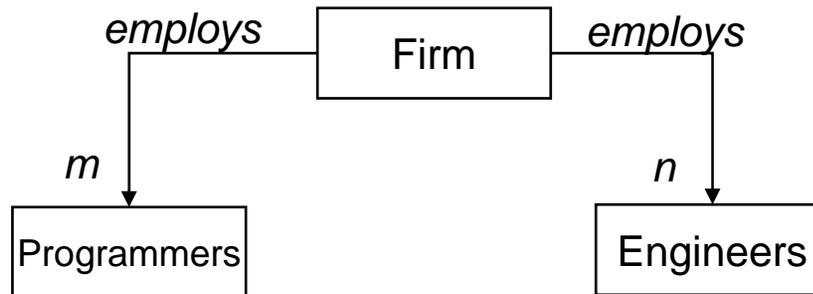
- **Usually it is only necessary to show one, and the other is implicit.**

Structural Link Examples

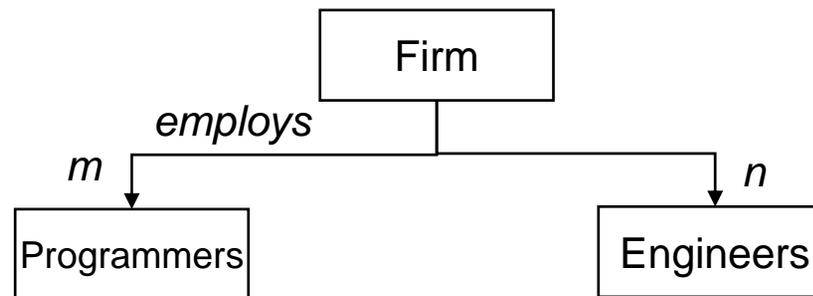


Forks

- **Some times there are two or more structural links with the same label, and one common end point**



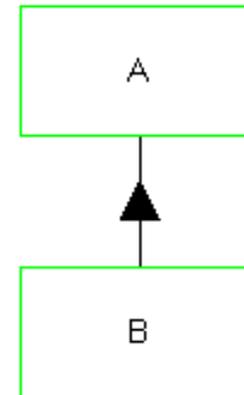
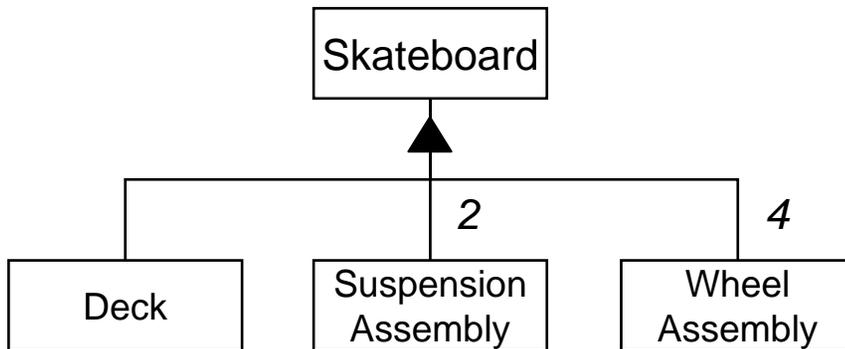
- **Can be replaced with a Fork**



Logical/Relational Structural Links

Decomposition

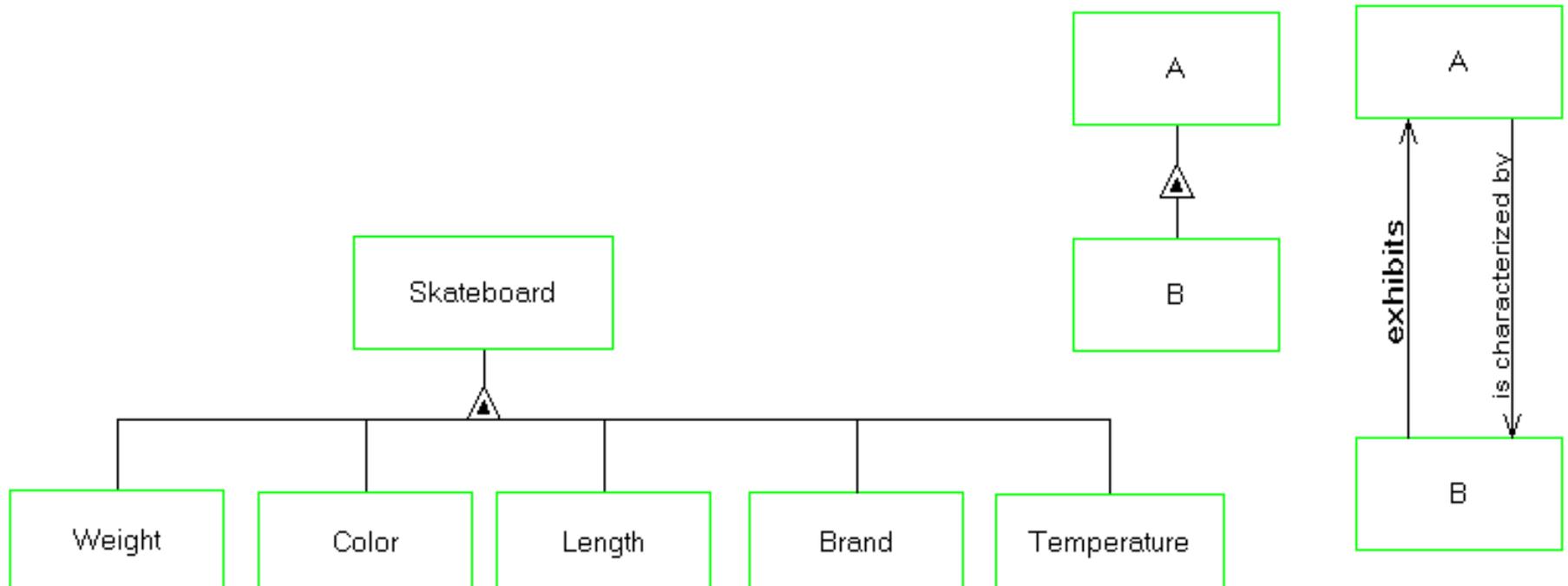
- These 4 are a set of very commonly used logical/relational links, and therefore have special symbols.
- **Decomposition/Aggregation**
 - A whole and its parts



Characterization

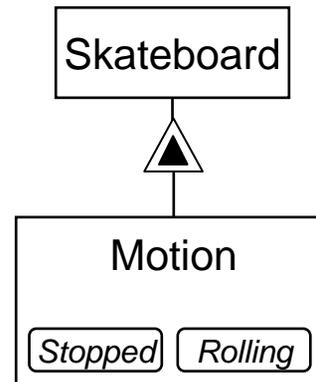
- Characterization/Exhibition

- The relation between an object and its features or *attributes*
- Some attributes are states (which ones?)



State

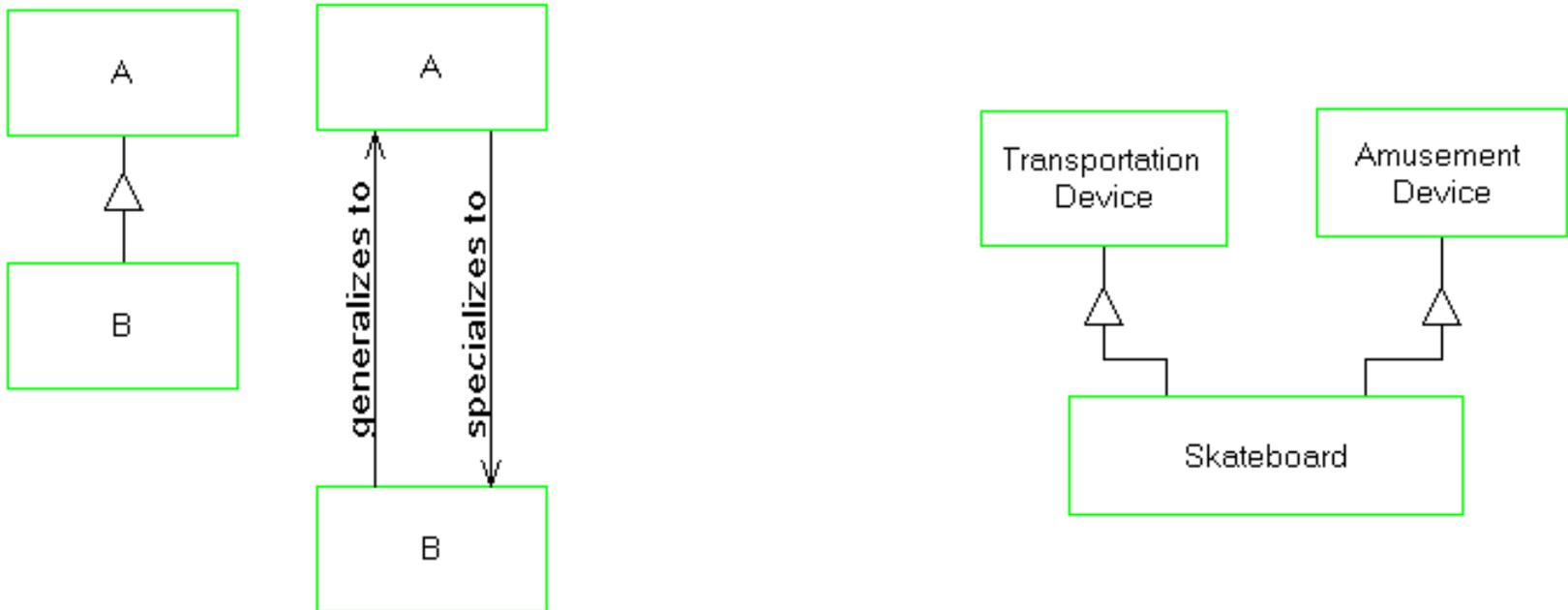
- **Defined: State is a situation in which the object can exist for some positive duration of time.**
- **The combination of all the states describes the possible configuration of the system throughout the operational time.**
- **The states can be shown with the object, or alternatively within an attribute object.**



Specialization

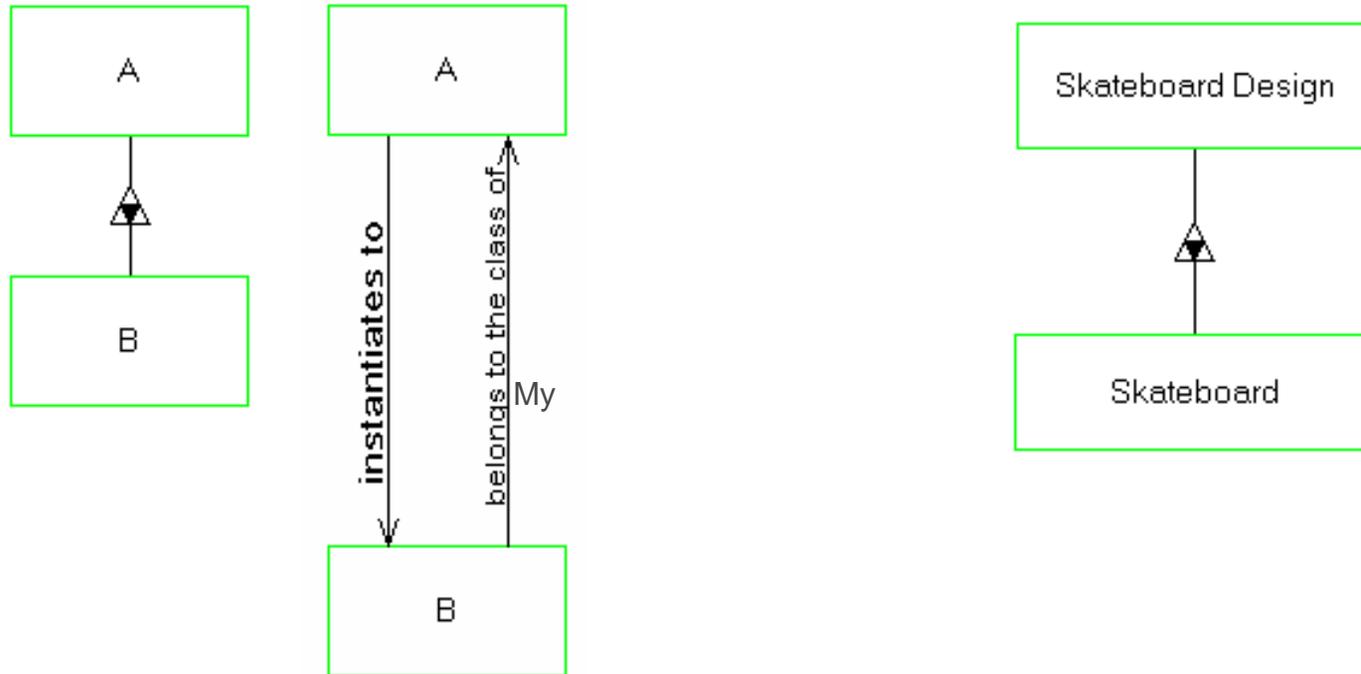
- Specialization/Generalization

- The relationship between a general object and its specialized forms



Instantiation

- The relationship between a class of things and instances of the class



Relational Structural Links- Summary

- **Logical/Relational links**

→ – “Is a” , is the same as

→ – A code, surrogate, address of symbol for

▲ –Decomposes to, aggregates to

△ –Is characterized by, exhibits

△ –Specializes to, generalizes to

△ –Instantiated to, belongs to the class of

Summary- OPM Objects

- **An object is that which has the potential stable circumstantial existence for some period**
- **An object has states, which can change**
- **An object can be linked to another object**
- **Objects are often linked to other objects special by logical/relational links:**
 - **Equivalence,**
 - **Decomposition,**
 - **Characterization,**
 - **Specialization and**
 - **Instantiation**

Processes

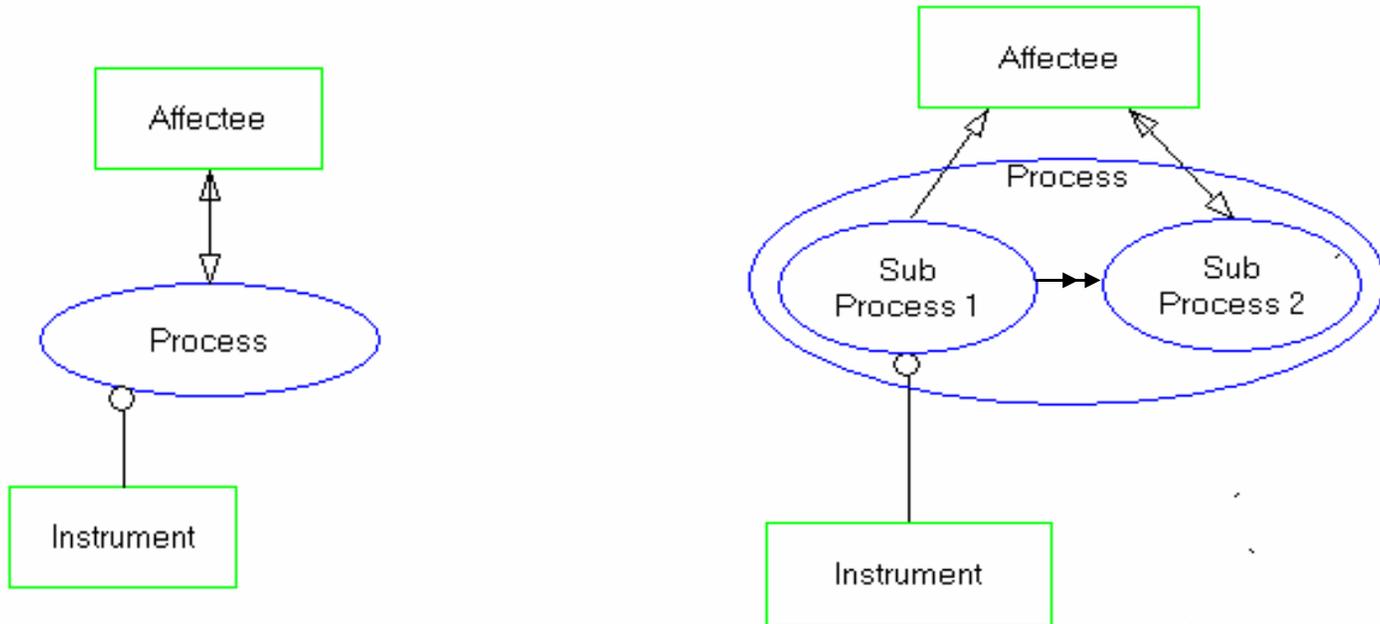


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Zooming

- **Process zooms into sub-processes**



- Process zooms to sub-process#1 and sub-process #2**
- Process emerges from sub-process#1 and sub-process #2**
- Object-process arrows can move to sub-processes**
- Sub-process #1 invokes Sub-process #2 (a rarely used symbol that suppresses the intermediate object between processes)**

Emergence

- A process can be zoomed into sub-processes
- A process emerges from sub-processes
- The process and sub-processes are not linked in any explicit manner, as the object decomposes into parts
- Emergence is a powerful feature of systems - parts and sub-processes can come together to cause a process to emerge
- Emergence sometimes yields the anticipated processes, sometimes *does not* yield the anticipated process and sometimes *unanticipated* processes

Some OPM Process Notes

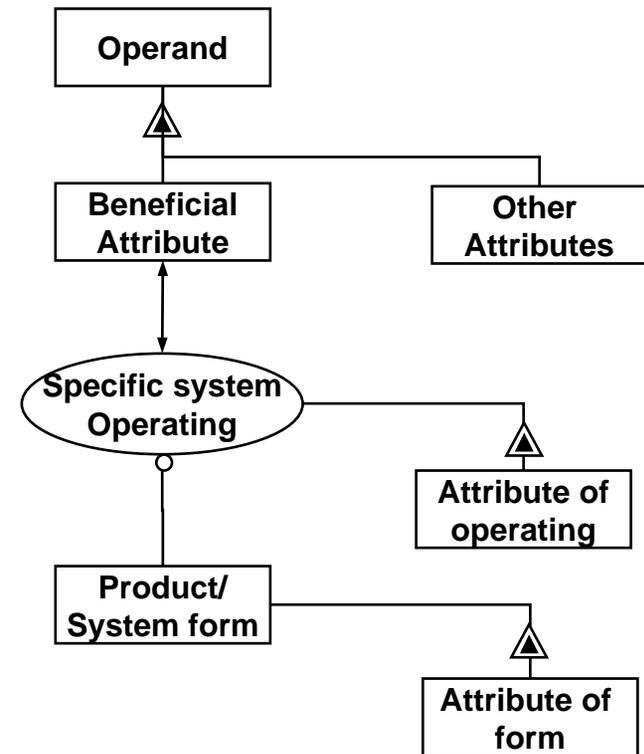
- When a process is zoomed, affect, instrument and agent links move from the boundary of the process to the boundary of the sub-process they are actually connected to (it could be more than one sub-process)
- If one sub-process is followed by a second without any explicit object between, the invocation link is used (only from process to process)



- In reverse engineering, objects may “dangle”. This indicates all functions have not yet been identified.
- Sometimes it is more convenient in an OPM to use the decomposition symbol rather than the zooming “Venn diagram” but if you do so, remember that this is just a convenience - processes don’t decompose in any linear manner

Objects and Processes in Natural Language

- **Objects are nouns: subjects (agents and instruments) and predicates (operands)**
- **Processes are verbs**
- **All human languages are in one of two patterns: NNV or NVN**
- **Read down for passive voice, up for active**



Engineers tend to focus on product/systems objects, and neglect the associated processes and operands, and hence the link to value

Summary - OPM

- OPM is **a** means (not **the** means) of representing systems. It is conceptually able to represent a wide range of system nature and complexity
- OPM represents in one graphical model the objects, the processes and their interrelationships
- Objects sum to form, and have interrelationships - structure
- Processes, together with operand objects, yield function, and have interrelationships - emergence
- Objects are related to processes through a small number of types of links