INCOSE/OMG MBSE Initiative
PBSE Patterns Challenge Team

Meeting: June 16, 2015

Team web site: http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

(Schedule adjustable as needed)

Meeting Agenda: INCOSE PBSE Patterns Challenge Team of MBSE Initiative (Web conferenced)

Tuesday, June 16, 2015, 4:00 – 5:00 PM Eastern Time

Pre-reading and Background: Team web site: http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

Materials of meeting of May 19, 2015: http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns_challenge_team_mtg_05.19.15

	4:00 – 5:00 PM EST
Meeting start up: • Review of meeting objectives and agenda • Introduction of participants • Why the Patterns Challenge Team exists: Goals and approach	4:00 – 4:05
Announcements and updates: • Our team will meet twice during IS2015, on site in Seattle and on line: ○ Sunday, July 12 (15:00-17:00 Pacific Time) and Monday, July 13 (13:30 - 15:00 Pacific Time) • INCOSE Great Lakes Regional Conference (GLRC9) 2015: Cleveland, October 23-25, 2015: https://www.incose.org/newsevents/currentevents/2015/01/14/incose-great-lakes-9th-regional-conference-2015-(glrc9) • Look for five or our team's papers at IS2015, Seattle, July: Pickard (best paper award); Cook; Peterson; Sanyal; Schindel • Agile SE Life Cycle Model (ASELCM) Project (joint w/Agile WG) host enterprise workshops to begin August; five orgs in pipeline • Other announcements or updates?	4:05 – 4:15
PBSE technical subjects—discussion of: • Attribute parametric couplings: Stakeholder Feature Attribute – Technical Role / Requirements Attribute Couplings • Attribute parametric couplings: Technical Role / Requirements Attribute – Physical Component Attribute Couplings • The System Phenomenon *(For those interested in catching up on past PBSE material, refer to the May 19 team meeting materials on:* *"PBSE Methodology Summary" document, plus meeting slides on:* • *Brief review of HLR (high level requirements framework) portion of S*Metamodel* • *Criticality of Interactions to the heart of MBSE and PBSE, science and engineering* • *Viewing Requirements Statements as non-linear Transfer Functions* • *Gestalt Rules in PBSE – and their connections to the above and applications in understanding system patterns* *Those materials may be found at:* http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns_challenge_team_mtg_05.19.15)	4:15 – 4:50
Planning discussion: • Discussion of candidates for focus of Patterns Challenge Team meeting at IS2015 in July; meeting schedule for same • Future (Third Wave) Projects Pipeline Candidates: • Future meetings schedule: Pace, rate, calendar • Outreach: Who else should be involved? Example—other INCOSE WGs that are natural Patterns applications. Ideas?	4:50 – 5:00

Mapping PBSE to COTS Tools and Information Systems	Example SOS Pattern (Joint with SoS WG)
Mapping to ISO 15288; Processes vs. Data (Maps vs. Itineraries)	Supporting INCOSE objective for SE model-based; Case for Stronger Model Semantics
PBSE Implementation Strategies	Other interests from team members
Example Product Line Engineering (PLE) Pattern (Joint w/PLE WG)	

For more information, contact-- Bill Schindel schindel@ictt.com Troy Peterson peterson_troy@bah.com

The MBSE Initiative Patterns Challenge Team: *Who are we?*

- Our most active members come from across diverse domains:
  - Automotive
  - Advanced Manufacturing
  - Aerospace
  - Consumer Products
  - Defense
  - Health Care, Medical Devices, Pharmaceuticals
  - Others
  - Today's attendees?

- During the last 18 months, over 100 colleagues have participated in Patterns Challenge Team activities:
  - Team meetings, work sessions, and tutorials
  - Construction of system patterns
  - Writing related papers for IS, IW, and regional INCOSE conferences
  - Invited presentations of our team's work to INCOSE chapter meetings

What does the Patterns Challenge Team *do*?

- **This Challenge Team is concerned with *configurable, re-usable system models*, called "S*Patterns":**
  1. Models containing a certain minimal set of elements are called S*Models (S is short for "Systematica")
  2. Those underlying elements are called the S*Metamodel, which was inspired by the physical sciences
  3. S*Models using those elements may be expressed in any modeling language (e.g., SysML, or other languages)
  4. S*Models can be created and managed in many different COTS modeling tools.
  5. Re-usable, configurable S*Models are called S*Patterns
  6. By "Pattern-Based Systems Engineering" (PBSE) we mean MBSE enhanced by these generalized assets
  7. These are system-level patterns (models of whole managed platforms), not just smaller-scale component design patterns

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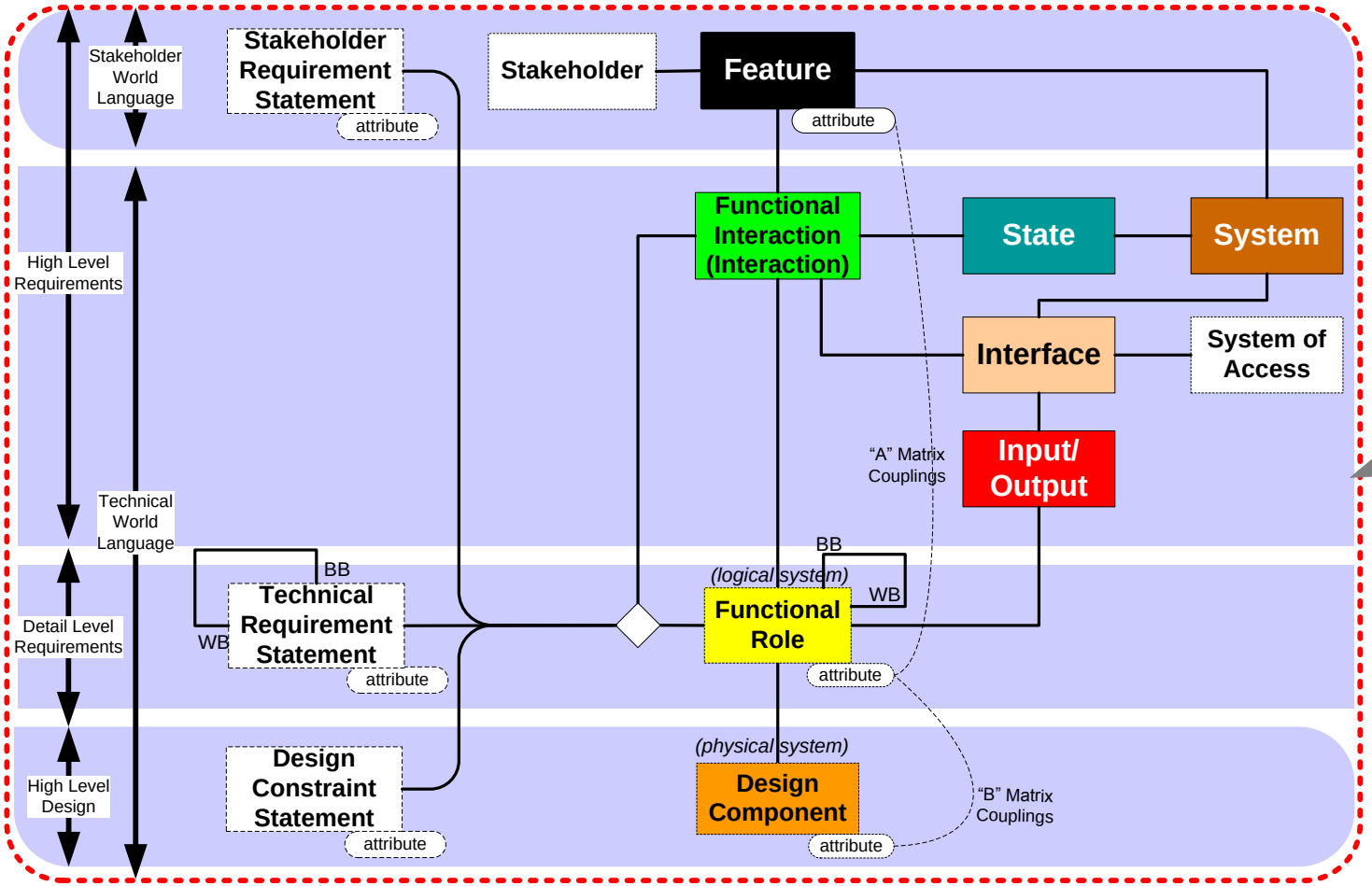
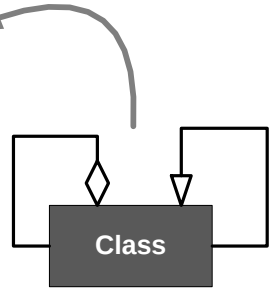
Summary of some major S*Metamodel classes and relationships—the underlying semantics of all S*Models (Refer to S*Glossary for definitions)

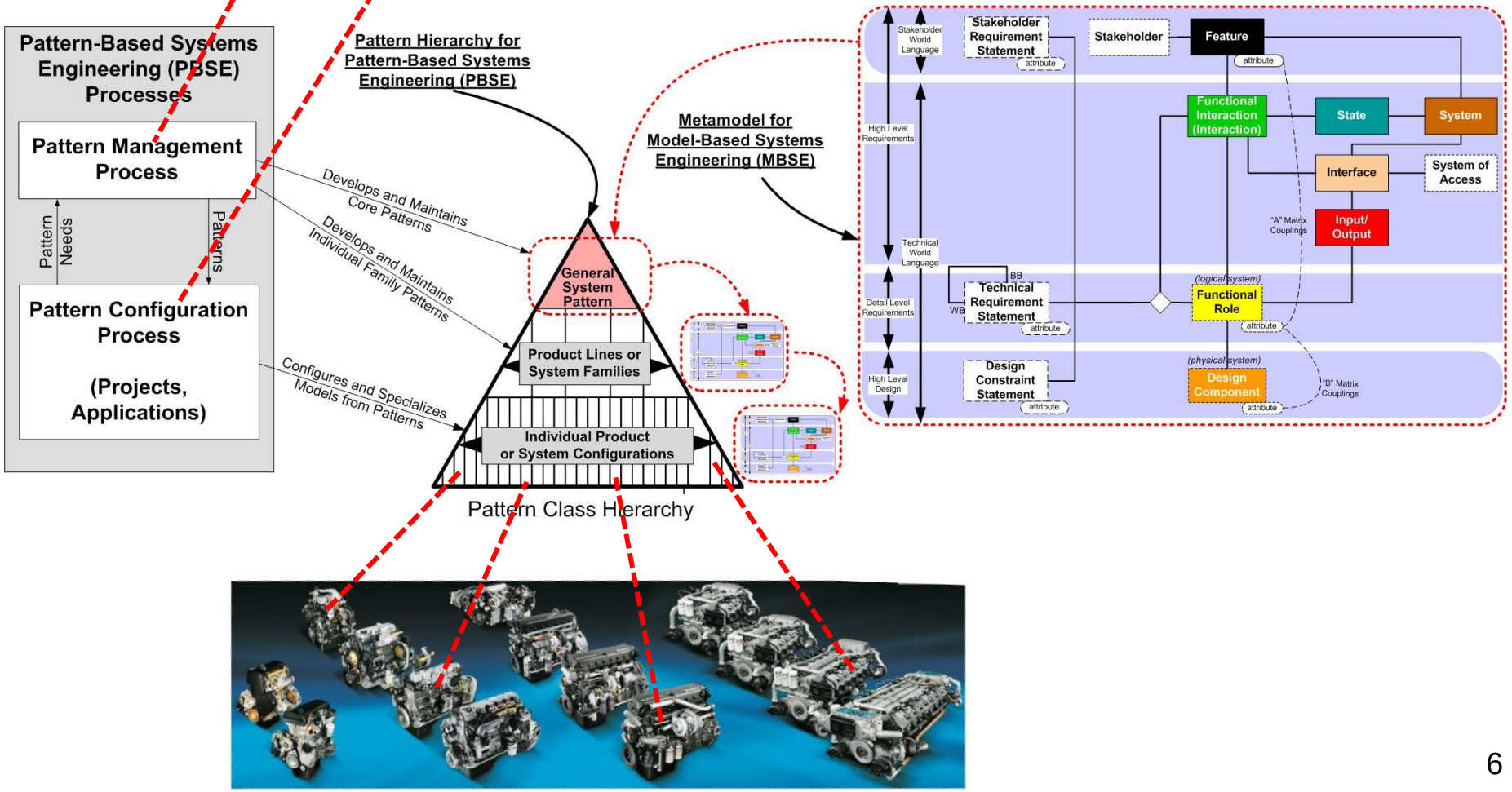




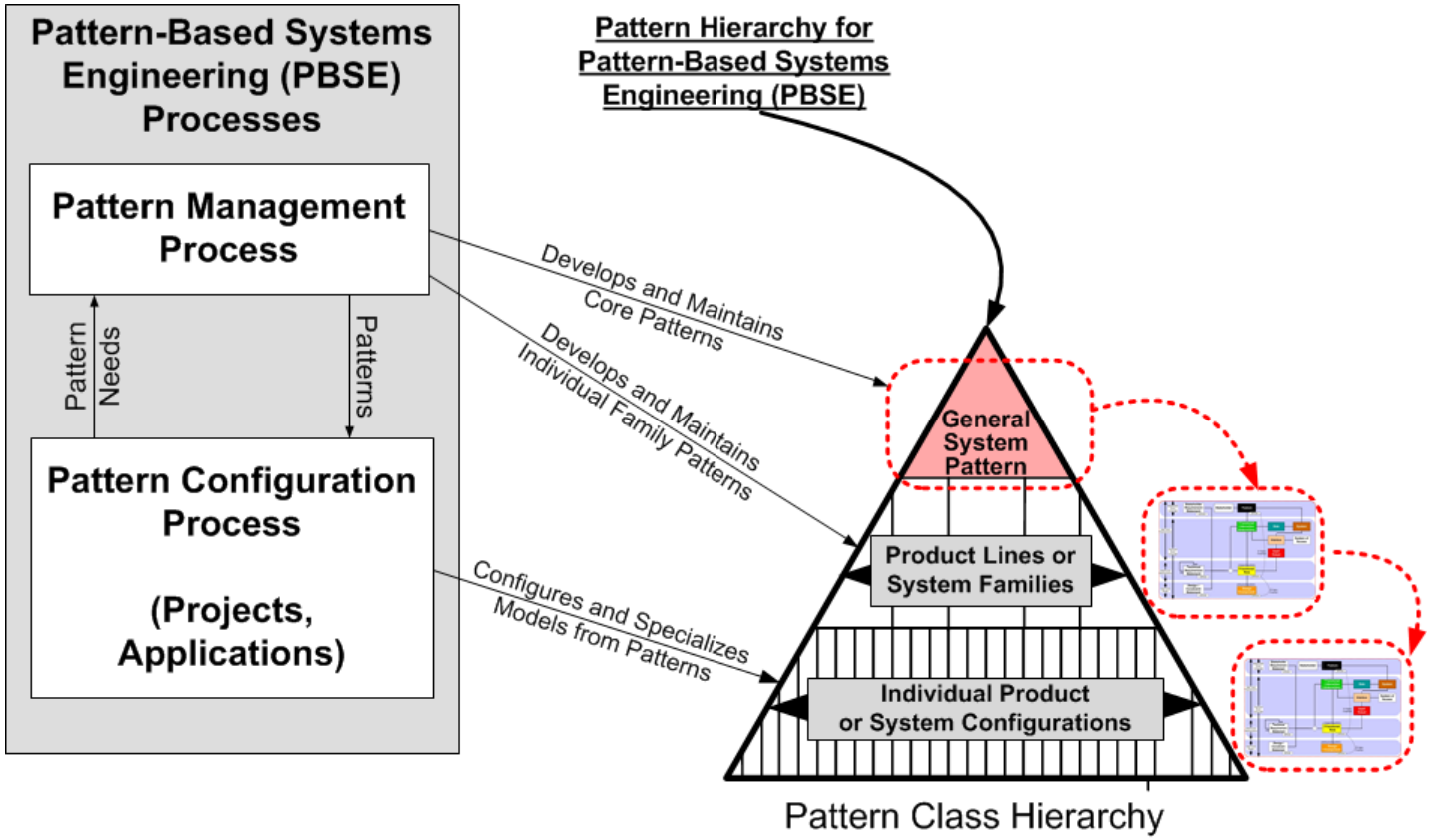
Every S*Metaclass shown is embedded in both an aggregation (whole-part) hierarchy and an abstraction (general-special) hierarchy, connected by the relationship types shown.

Summary of S*Metamodel

- Pattern-Based Systems Engineering (PBSE) has two overall processes:
  - **Pattern Management Process**: Generates the general pattern, and periodically updates it based on application project discovery and learning;
  - **Pattern Configuration Process**: Configures the pattern into a specific model for application in a project.



Business process optimized for PBSE fulfill a different vision:



Why do most representations of the systems engineering process appear to assume starting from no formal knowledge about the system of interest & its domain?

Team Announcements and Updates

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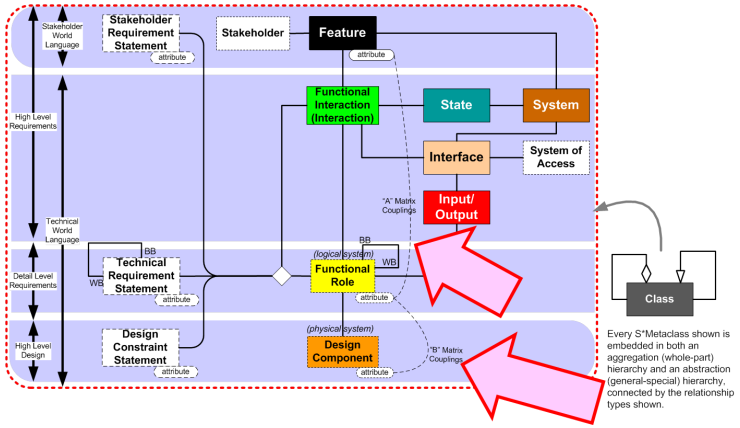
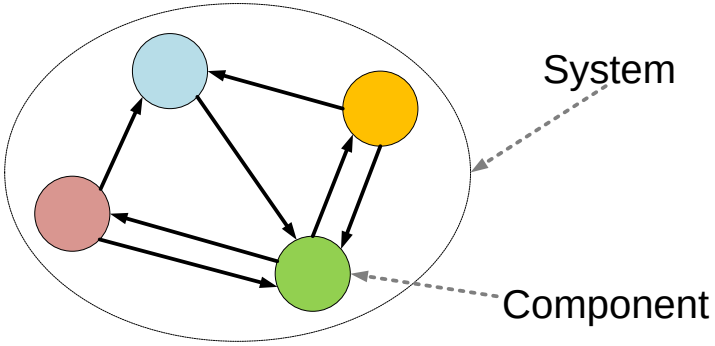
  - Sunday, July 12 (15:00-17:00 Pacific Time) and
  - Monday, July 13 (13:30 - 15:00 Pacific Time)
- Our team's co-chair, Troy Peterson, named INCOSE Asst. Director for SE Transformation to MBSE
- INCOSE Great Lakes Regional Conference (GLRC9) 2015: Cleveland, October 23-25, 2015: https://www.incose.org/newsevents/currentevents/2015/01/14/incose-great-lakes-9th-regional-conference-2015-(glrc9)
- Look for five or our team's papers at IS2015, Seattle, July: Pickard (best paper award); Cook; Peterson; Sanyal; Schindel
- Agile SE Life Cycle Model (ASELCM) Project (joint w/Agile WG) host enterprise workshops to begin August; five orgs in pipeline
- Other announcements or updates?

Today's Session:
Selected PBSE Technical Subjects

- Attribute parametric couplings



- The System Phenomenon



For those catching up on past PBSE material

- Refer to the May 19 team meeting materials on:
  - "PBSE Methodology Summary" document
- Plus May 19 meeting slides on:
  - Brief review of HLR (high level requirements framework) portion of S*Metamodel
  - Criticality of Interactions to the heart of MBSE and PBSE, science and engineering
  - Viewing Requirements Statements as non-linear Transfer Functions
  - Gestalt Rules in PBSE – and their connections to the above and applications in understanding system patterns
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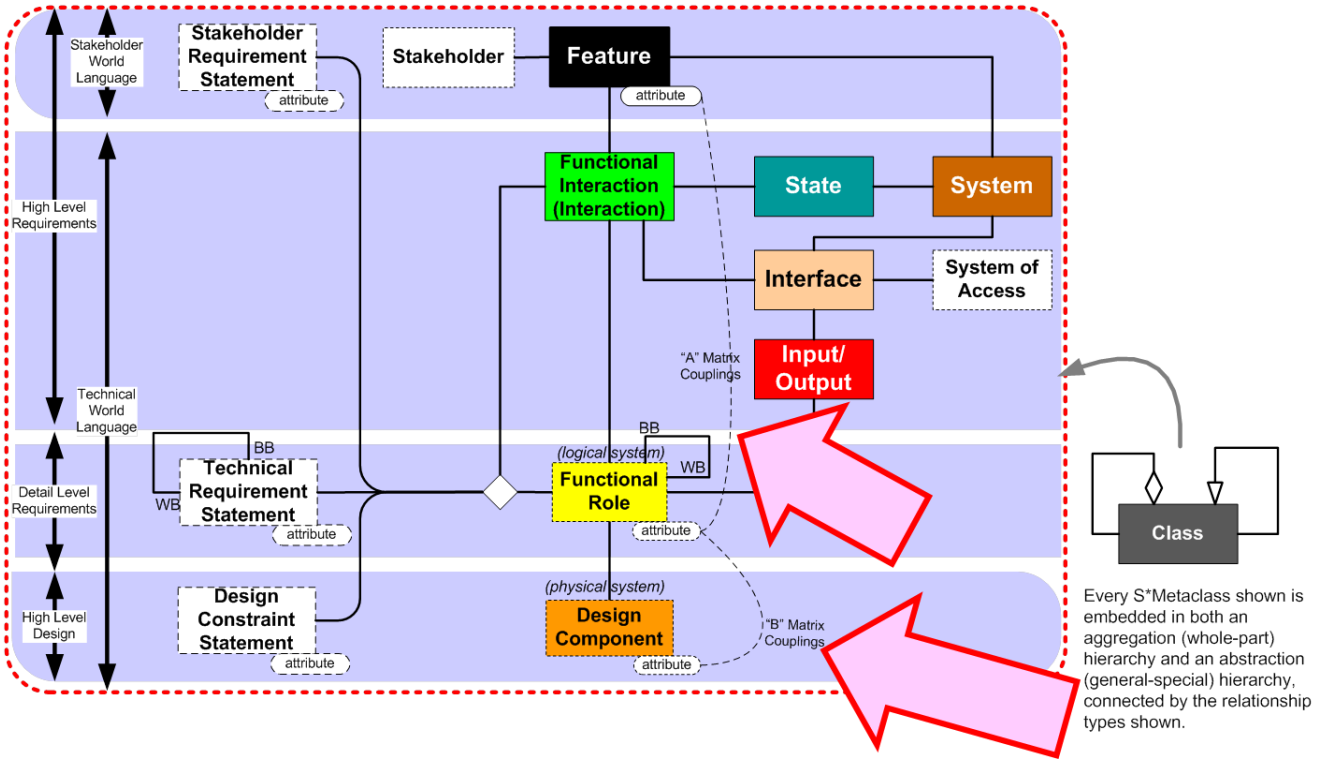
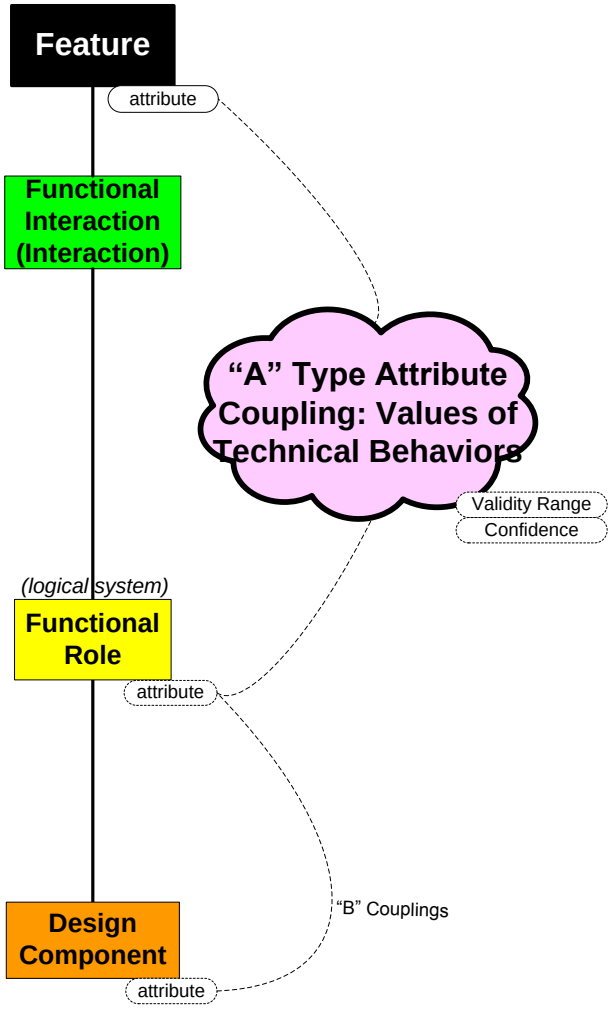
Attribute parametric couplings

- Stakeholder Feature Attribute – to – Technical Roles & Requirements Attribute Couplings
- Technical Roles & Requirements Attribute – to – Physical Component Attribute Couplings



Stakeholder Feature Attribute – to – Technical Roles & Requirements Attribute Couplings

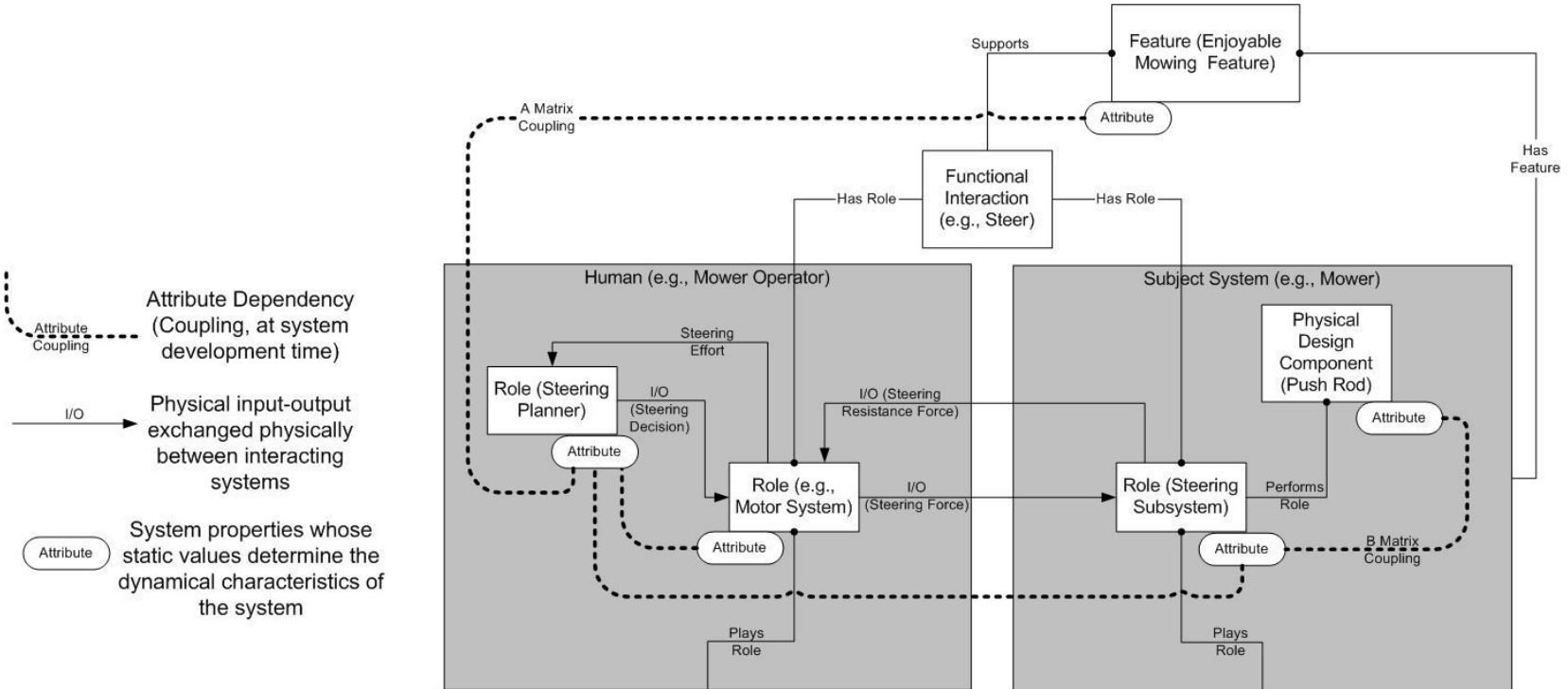


These "A" type parametric couplings describe how parameter value changes in technical behavior (the attributes of Roles / Requirements) bear on changes in Stakeholder-perceived value (the attributes of Stakeholder Features).

A simple example

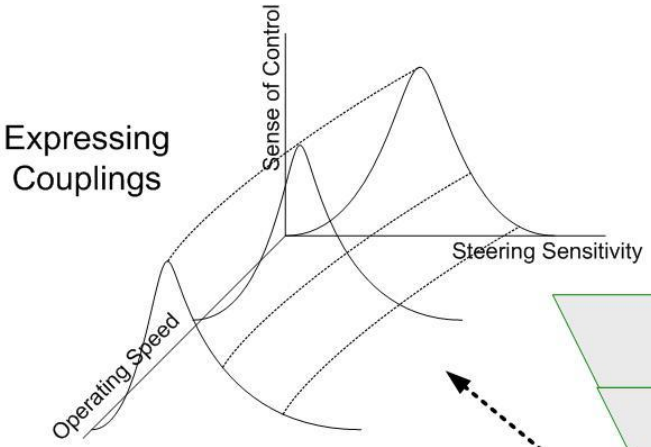
Operator fatigue, sense of control, coupled to technical steering gain, mower speed:

- "Enjoyable Mowing Feature" attributes
  are coupled to attributes of . . .
- "Operator Steering Planner" role
- "Operator Motor System" role
- "Mower Steering Subsystem" role
  which are coupled to attributes of . . .
- "Mower Steering Push Rod" component



A simple example

- Expressing these couplings as tables, charts, graphs, or otherwise captures our best currently available knowledge of human behavior as well as mechanics.
- Creates integrated view contributed to & shared across a team of specialists in humans versus machine design.



Features

Feature Attributes

Functional Roles

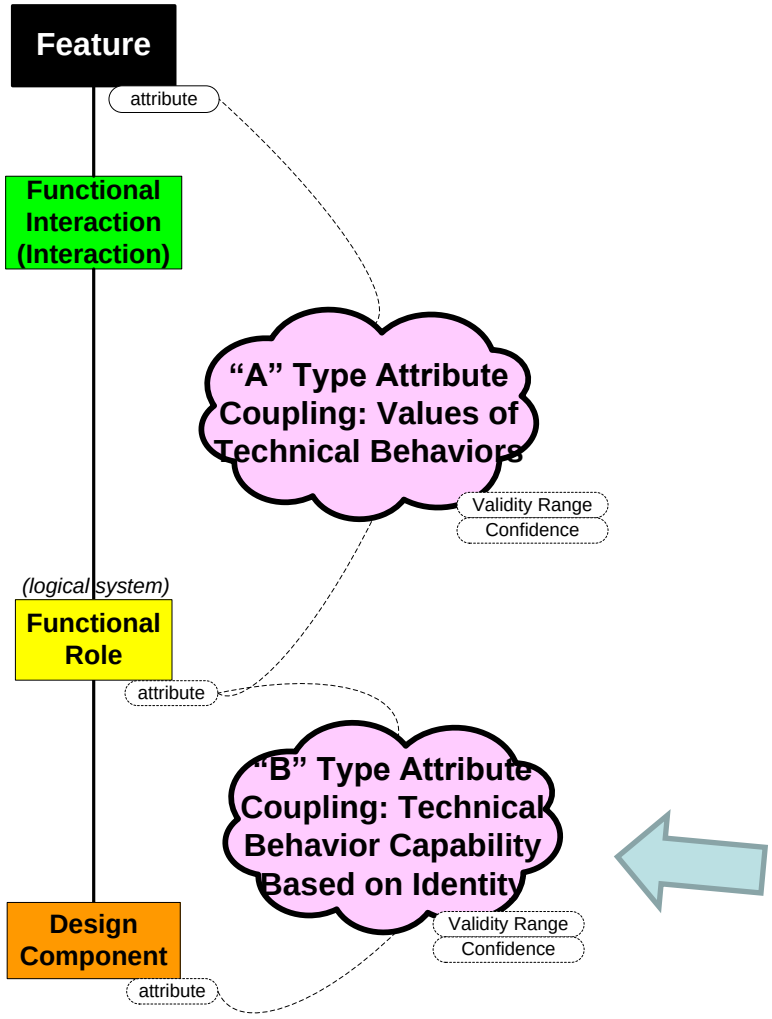
Role Attributes

Attribute Couplings

		Enjoyable Mowing Feature		Market Segment Fit Feature		
		Sense of Control	Operator Fatigue	Operator Comfort	Application Positioning	Purchase Price
Application Environment	Terrain Roughness			X	X	
Steering Subsystem	Steering Tactile	X				
	Steering Sensitivity	X	X		X	
	Cost					X
Seating System	Shock Absorbence		X	X	X	
	Seat Cushioning		X	X	X	
	Cost					X
Propulsion System	Max Acceleration	X	X		X	
	Max Mowing Speed	X	X		X	
	Braking	X			X	
	Cost					X

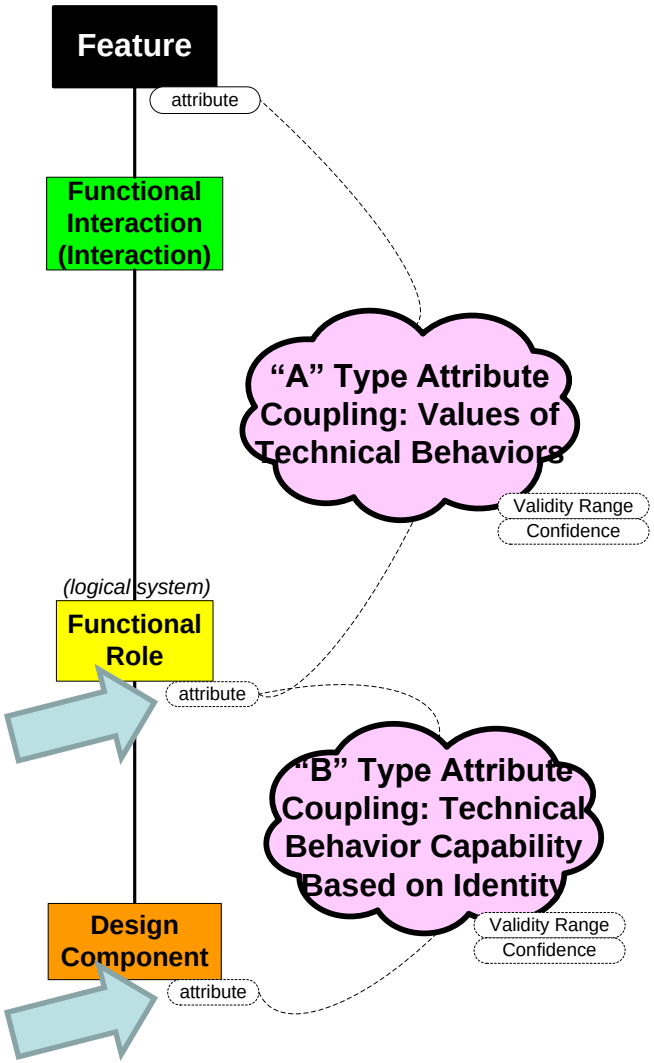
"A" Matrix: Expresses Feature-Role Attribute Couplings

Technical Roles & Requirements Attribute – to – Physical Component Attribute Couplings



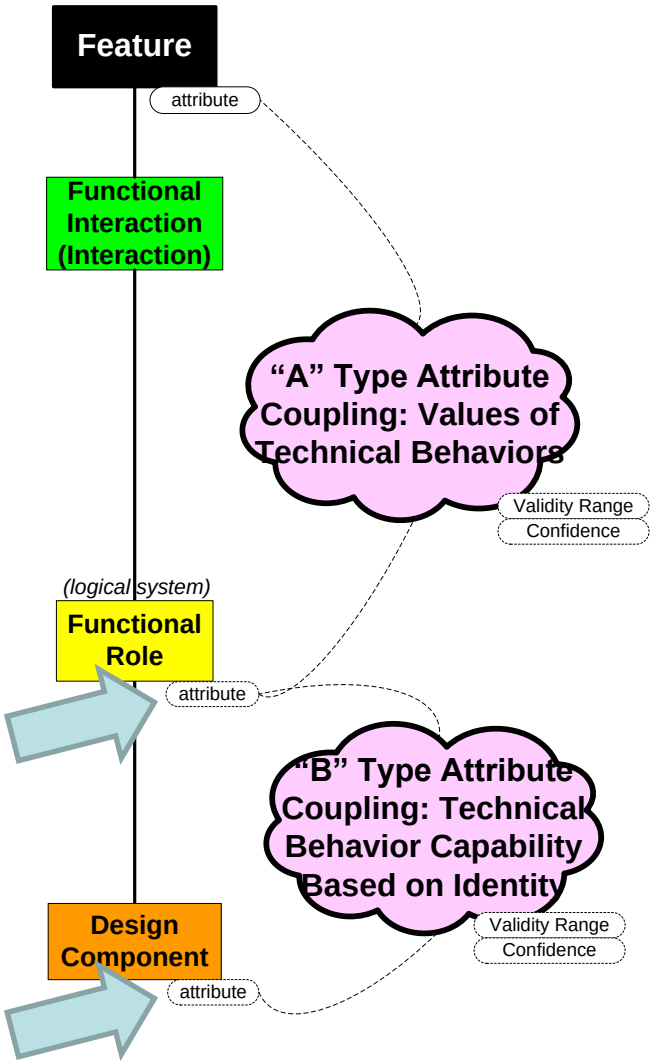
The "B" type parametric couplings describe how parameter value changes in design components (the attributes of Design Components) bear on changes in technical behavior (the attributes of Roles / Requirements)

Key methodology point:



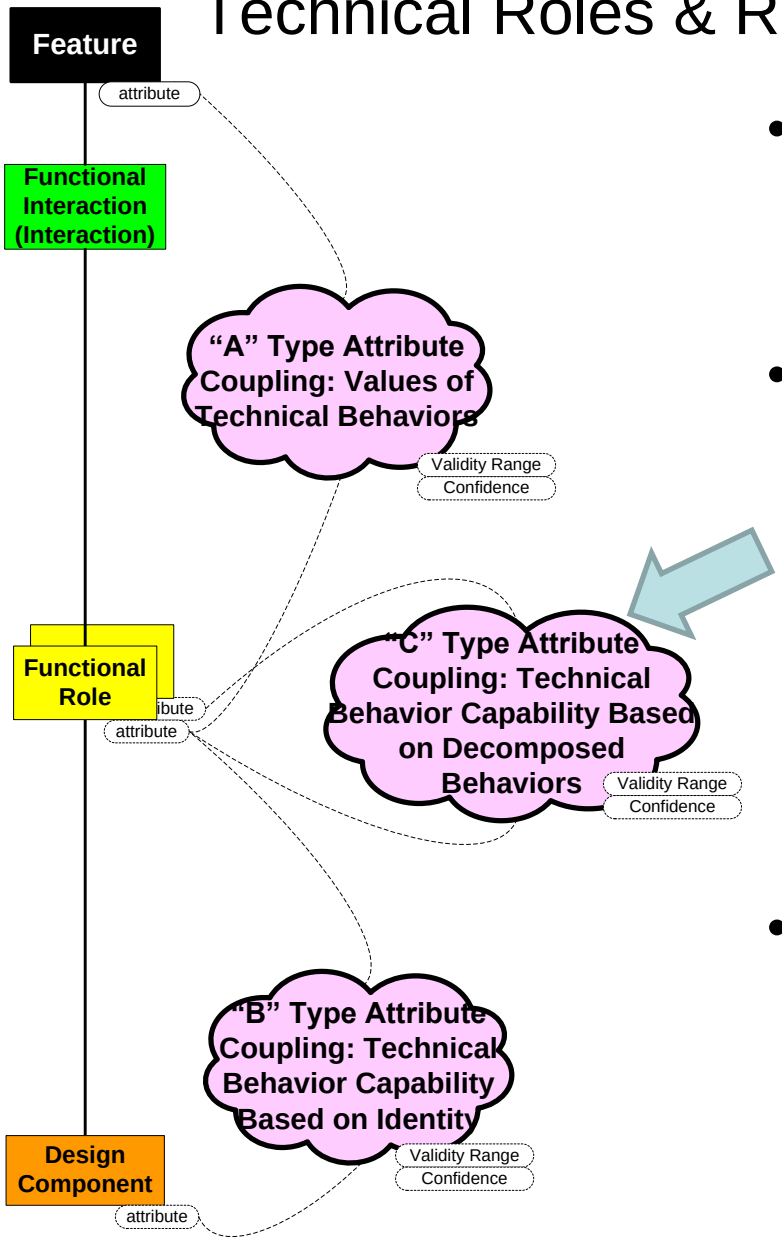
- Modeled technical behavior (including its parameterization) is focused in the Functional Roles (including their parameterization by Role Attributes, which are identical reappearances of the technical Requirements Attributes).
- So, the attributes of Design Components are not used to describe behavior! (After all, Design Components are characterized by their identity, not their behavior – their behavior comes entirely from allocations of Functional Roles to them.)
- The attributes of Design Components therefore describe identity or existence, not behavior.
- Examples include: Part Number, Department Name, Material of Construction, Chemical Element, Person, etc.

Key methodology point:



- In managing complex patterns and their multiple configurations, that aspect of the S*Model approach has tremendous utility.
- Among other things, it greatly simplifies parameter space complexity and proliferation of variables / namespace size.
- When systems are configured, all behavior parameter values (whether required, or achieved capability, or best in class, or competitor product), become "shadow values" of the same Functional Role attributes, for differently configured systems, including their Design Components.
- It also means that things like vendor data sheets, materials specifications, and similar information fit neatly into "B" coupling matrices or tables that show the values of Role Attributes for different Components, Materials, Compounds, etc.

Technical Roles & Requirements – to – Decomposed Technical Roles & Requirements Attribute Couplings

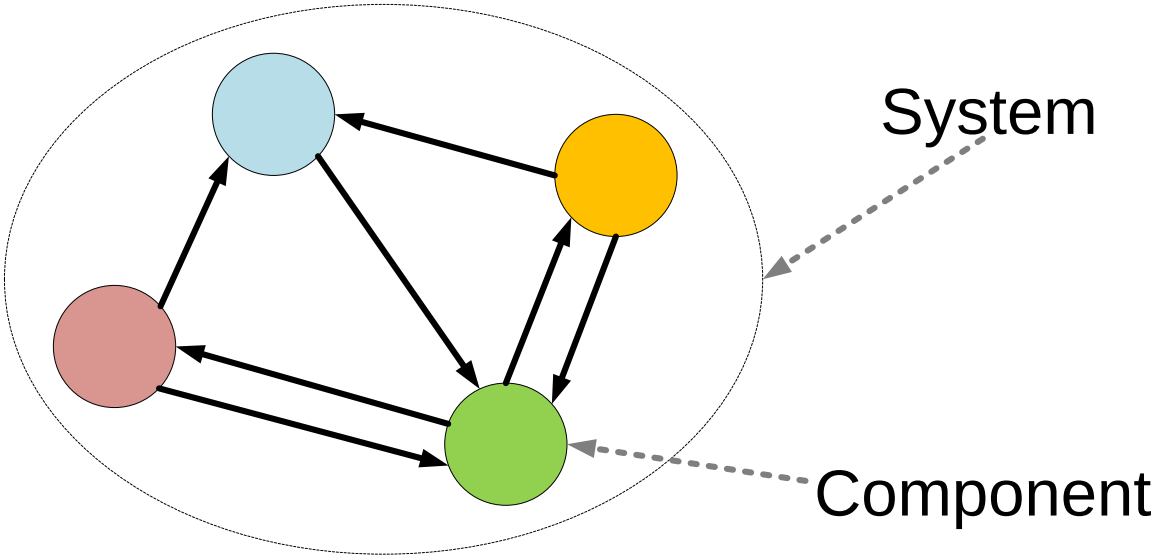


- When decomposing multi-level logical architectures, a third kind of attribute coupling appears.
- This "C" coupling describes how values of parameters of behavior (Functional Role attributes) are impacted by changes in values of parameters of subsystem behavior (Functional Role attributes).
- This is where mathematically expressed emergent phenomena of physics, chemistry, and larger scales are expressed.
- Leading to . . .

The System Phenomenon

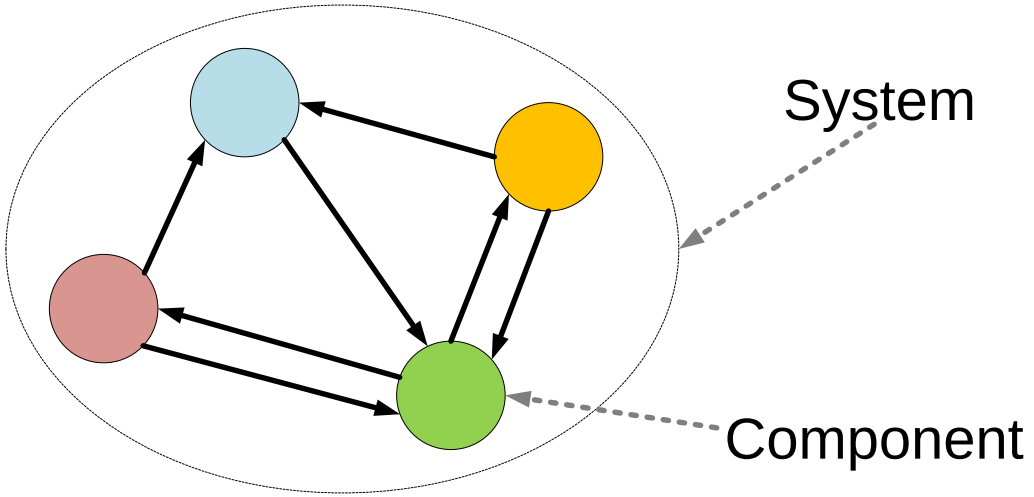
S*PBSE Definition: “A System is a set of interacting components.”

- By interact, we mean that one component exchanges energy, forces, mass flow, or information with another component, resulting in component changes of state.
- By state of a component, we mean the condition of the component that determines its input-output behavior during interactions.

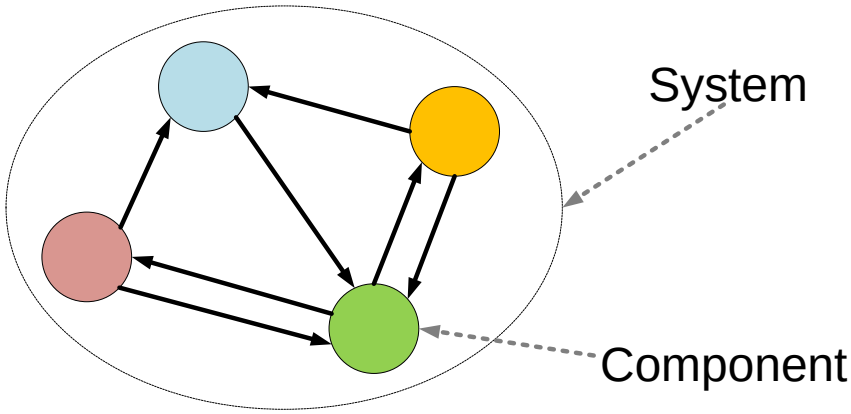


The System Phenomenon

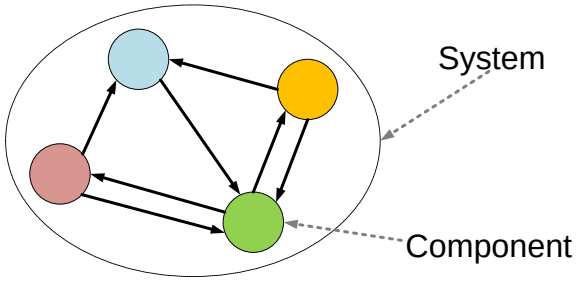
- One goal of S*Patterns is to more strongly ground Systems Engineering in the scientific/mathematical “phenomena” of systems, just as Electrical Engineering is grounded in electromagnetic phenomena.
- Although it is not immediately obvious what “system phenomena” might mean here, this turns out to be answerable.
- It is the reason for the definition: “A System is a set of interacting components.”



- When the behaviors of isolated individual components are integrated (and constrained) by an overall Interaction, the emergent behavior of the resulting System may be quite different than simply listing all the behaviors of the individual components in isolation.



- This well-known fact is the “phenomenon” of systems, and is the basis of both (1) the power and value of engineered systems, but also (2) many of the challenges of engineered systems.



- It is traditionally analyzed by the Principle of Least Action, expressed in models through the Calculus of Variations by the minimization of the Action Integral, the Euler-Lagrange Equations, and Hamiltonian and Lagrangian mathematical models (Levi, 2011).
- It is one of the traditional paths for textbook derivation of the equations of motion or other forms of physical laws of the more specific “fundamental” physical phenomena of mechanics and the rest of physics, electromagnetics, and other discipline-specific phenomena.
- It is one traditional means by which Newtonian models of individual component attributes and behaviors is replaced by Lagrangian descriptions of system level attributes and system state space trajectory behaviors.

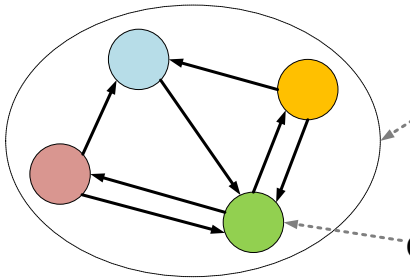
- Specialists in individual engineering disciplines sometimes argue their fields have “real” physical phenomena, physical laws, and first principles, claiming generalized systems do not:
  - However, the above can be used to demonstrate that the opposite is true!
- For each of the specialized disciplines, the emergent models and laws of their physical phenomena have been found to be derivable through the above approach, applied to Interactions of System Components from one phenomena level lower:
  - Thus, the laws and phenomena of Chemistry are seen to emerge from those of underlying Physics, beginning at and just below the interaction of element atoms and molecules, behavior of bonds, etc.
  - *So, it can be seen that the System Phenomenon is the basis for the “fundamental” laws of each of the specialized disciplines, and that those phenomena are less fundamental than the (recurring at each emergent system level) System Phenomenon.*

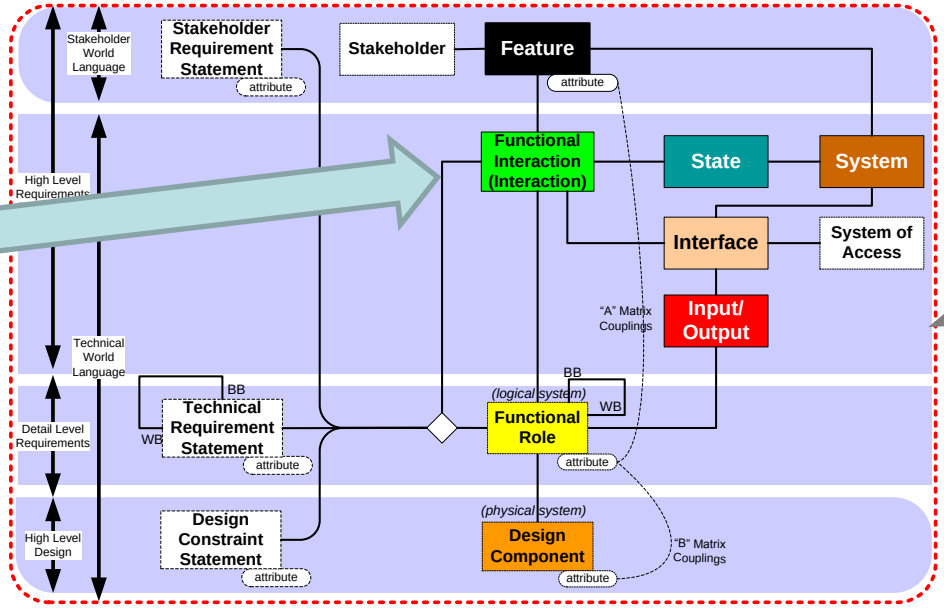
The System Phenomenon

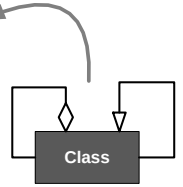
- The importance of this perspective is not just philosophical or a rivalry between disciplines.
- Rather, it reminds us that there are ever-higher levels of systems that have their own emergent “phenomena”, “first principles”, and “physical laws”.
- At one time, those of interest were whole vehicles, aircraft, or marine vessels, now better understood.
- Among those of critical future interest to systems engineers and system scientists are biological systems (whose behavior emerges from underlying chemistry and physics) as well as market systems and economies, health care delivery or other societal service systems, military conflict systems, Internet-mediated systems, and other social systems.

The System Phenomenon

- Systems Engineering requires a strong enough underlying Metamodel and Systems Science to equip it for the challenges and opportunities of these higher level systems.
- The S*Interaction model is at the center of that framework.







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Summary of S*Metamodel

Planning Discussion: Next and Future Activities

- Agenda item of candidates for focus of Patterns Challenge Team meeting at IS2015 in July
- Future (Third Wave) Projects Pipeline Candidates:

Mapping PBSE to COTS Tools and Information Systems	Example SOS Pattern (Joint with SoS WG)
Mapping to ISO 15288; Processes vs. Data (Maps vs. Itineraries)	Supporting INCOSE objective for SE model-based; Case for Stronger Model Semantics
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