Toward Platform Architectures for Modular Cognitive Cockpits

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Objectives and Challenges

Objectives

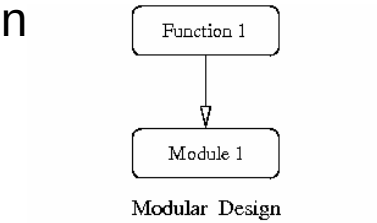
- To develop a much closer relationship between the human and computer, leading to computer systems that can automatically sense when a human operator is overloaded, and then provide cues that will enable the operator to process information more efficiently (Boeing, 2004).

Challenges – Basic Tenets

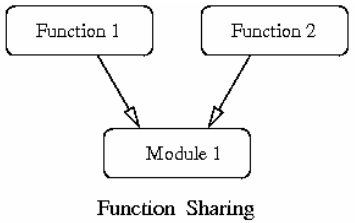
- Solutions will require integration of neurophysiology, bioengineering, and computing technology with experimental psychology.
- Technologies will evolve rapidly. Applications will be adapted to new scenarios … therefore, architectures for augmented cognition systems should be modular.

Challenges

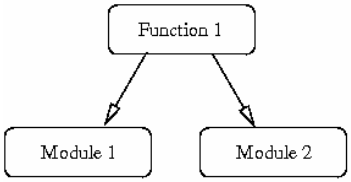
- In a modular design, one function is supported by one module.
- In an integrated design, functionality is implemented by multiple sub-systems.
- Modularity promotes simplicity of implementation and improved economics and quality via reuse.
- Integration focuses on achievement of superior performance by sharing the implementation across modules.
- Augmented cognition systems need to find a way of extracting the best from these competing objectives.



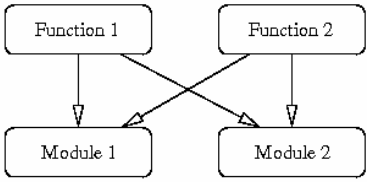
Modular Design



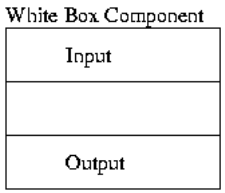
Function Sharing

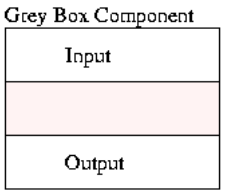


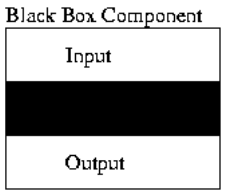
Function Distribution



Integrated Design





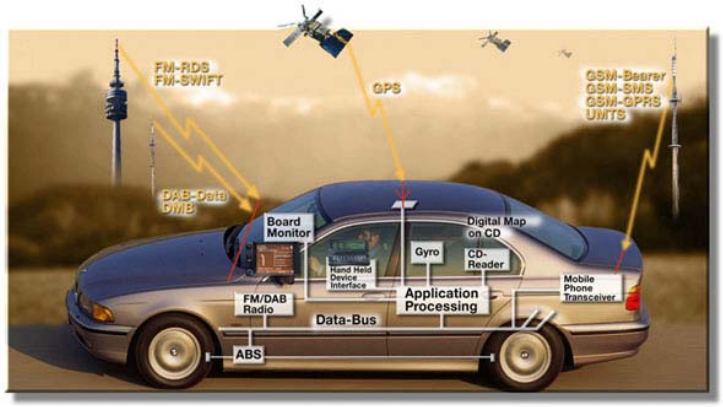


Appeal of Integration

A system will function better when the subsystems work together as a team rather than independently.

Example: Luxury Automobile

Electronics and communication systems provide drivers with new forms of functionality (e.g., GPS) and now account for 30% of overall cost.



Electronics and communications in a modern car. (Source: A.S. Sangiovanni-Vincentelli, UC Berkeley, Fall 2002.)

Key Point: Integration requires concurrent consideration of subsystem functions and performance, together with models of connection and communication among subsystems.

Consequences of these Challenges

New Types of Architectures

Achieving modularity, high performance, and broad functionality will require new architectures that are part-modular/part-integrated and can dynamically adapt – multi-modal architectures -- to the needs of a scenario.

New Analysis Methods and Design Tools

Formal methods for the synthesis and assessment of modular/integrated system-level architectures.

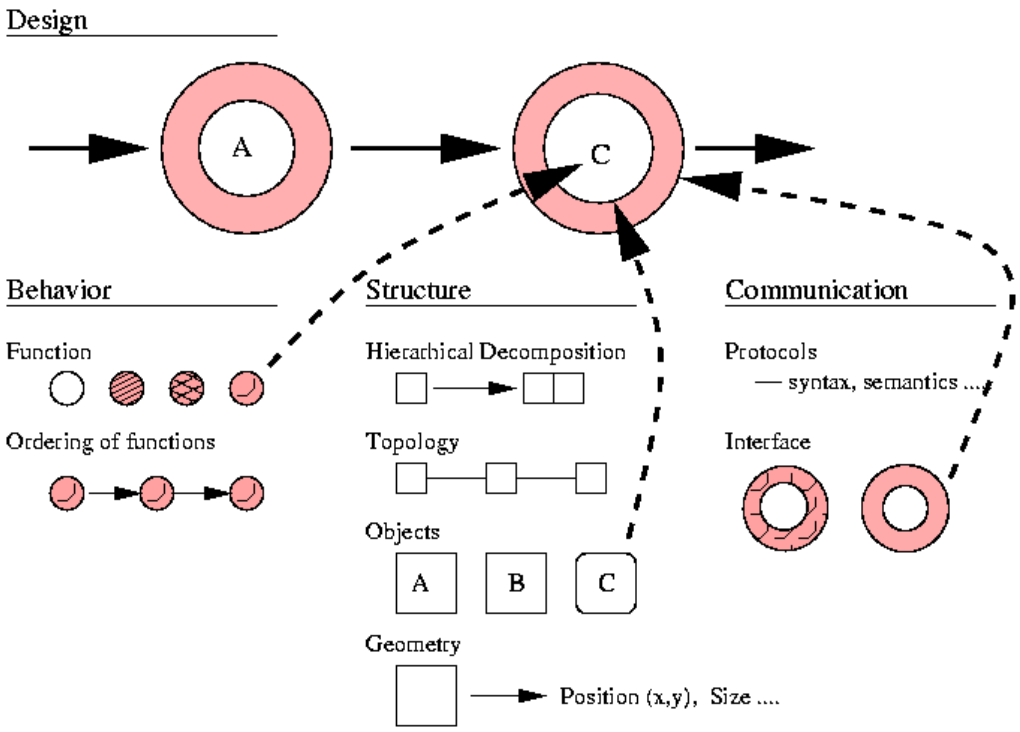
Platforms to support synthesis and evaluation of modular systems from components.

Separation of Design Concerns

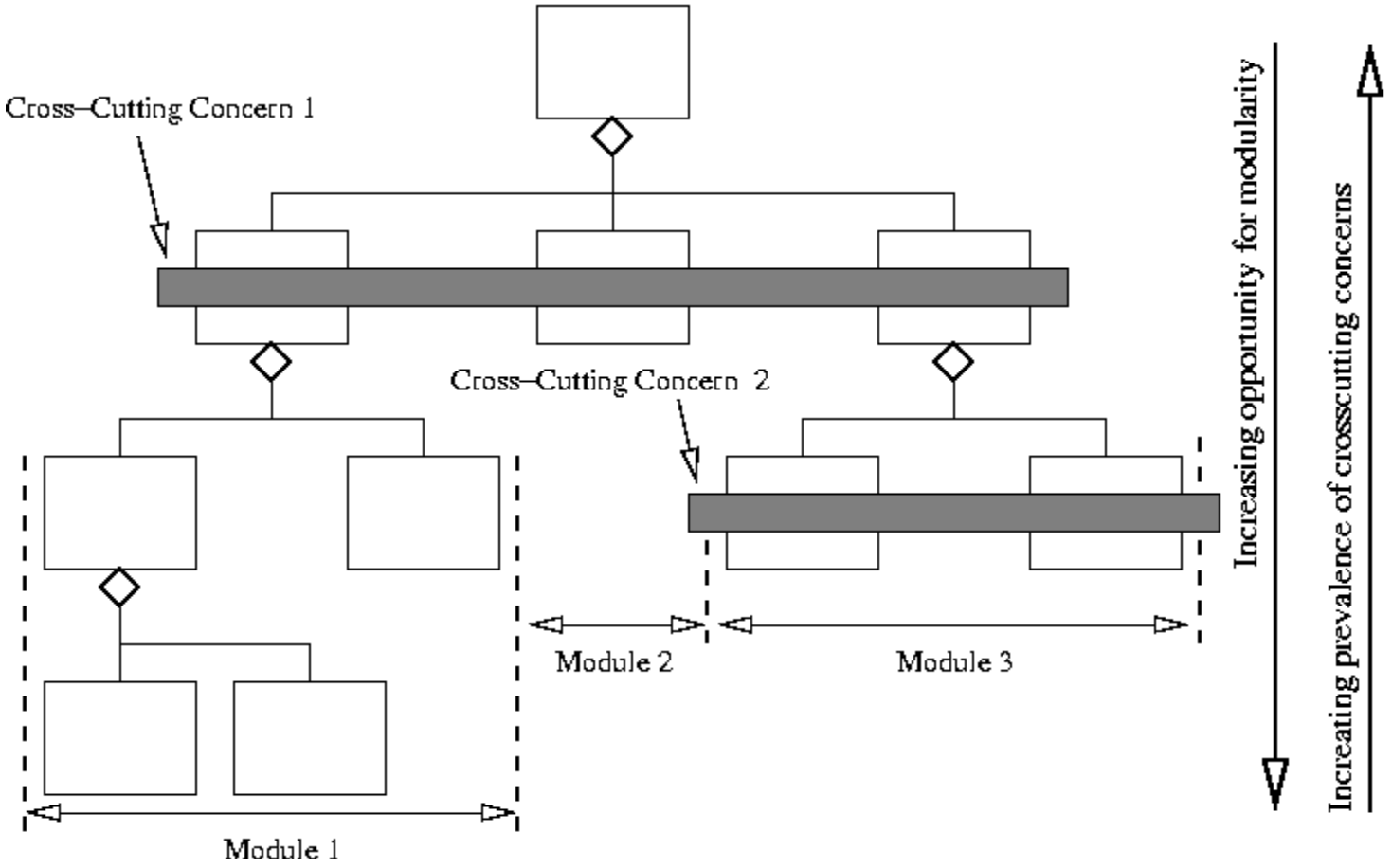
Separation of design concerns simplifies: (1) The understanding of design issues in complex systems, and (2) The exploration of options in the space of design alternatives.

Goal: Pull design apart and examine it from perspectives that are almost orthogonal.

Question: What are the key concerns facing the implementation of adaptable augmented cognition systems?

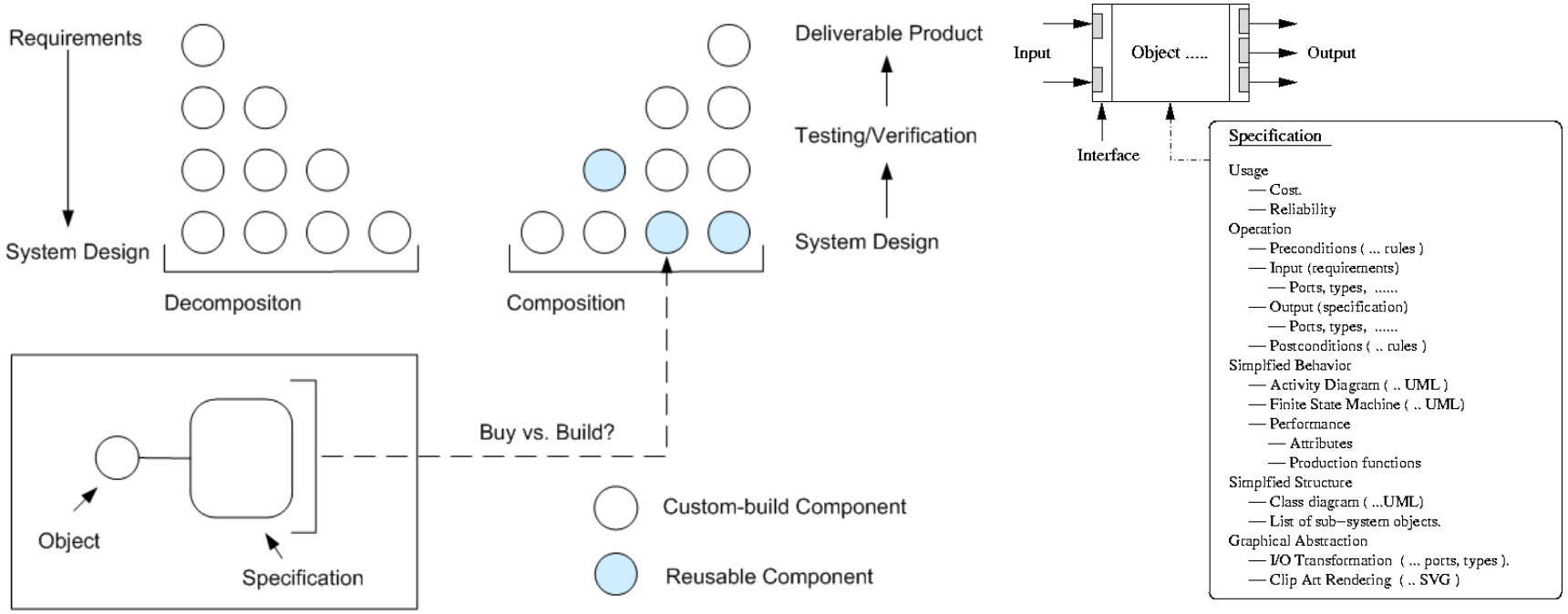


Strategy of Development



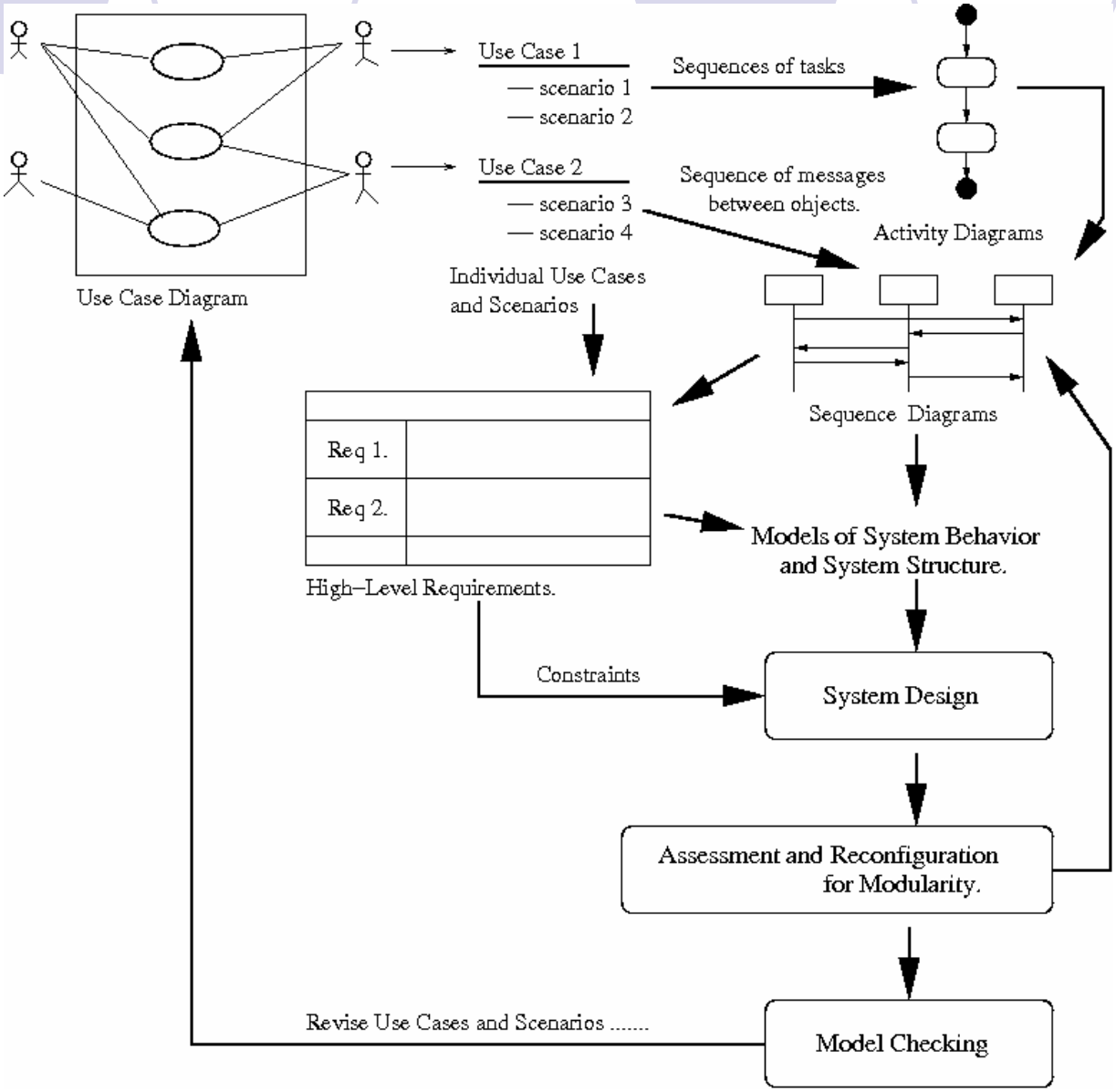
Synthesis from Components

Modular Systems will be synthesized from modular object-specification pairs.



How to specify functionality of modules without revealing IP?

Strategy of System-Level Development

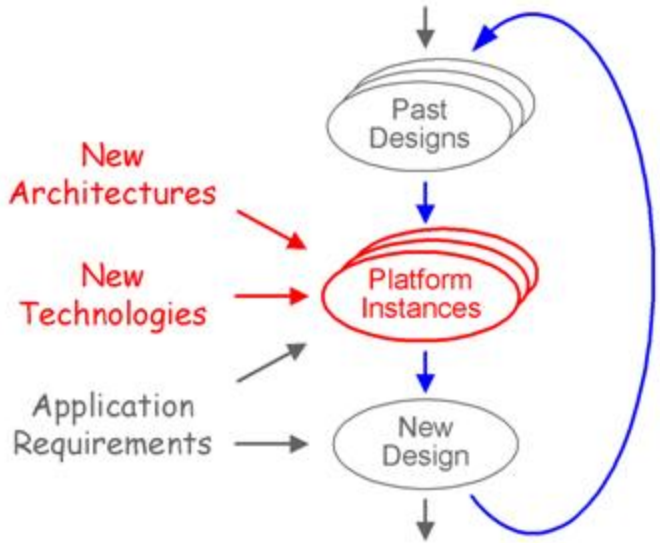


Design Platform Architectures

Design Platforms are defined as:

The creation of a stable architecture that can be rapidly extended, customized for a range of applications, and delivered to customers for quick deployment.

Tenet: Platform success is achieved through a set of “well-defined design modules and interfaces” that can be easily customized (configured) to a variety of customer requirements.



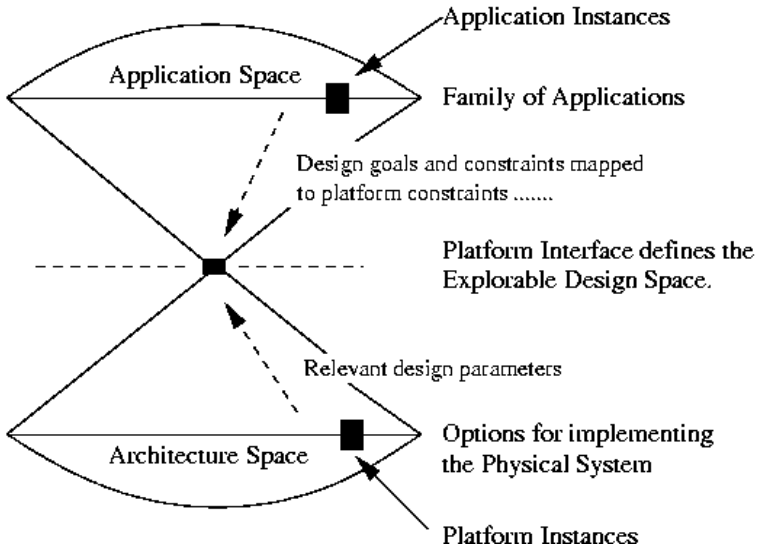
Design Platform Architectures

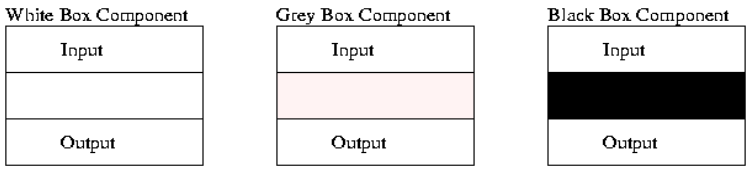
Meet-me-in-the-middle: Top-down refinements meet bottom up design options.

Two-part definition:

Decomposition of the overall functionality of a product into a set of well-defined functions and the component parts that are going to provide that functionality.

Specification of the interface between components.





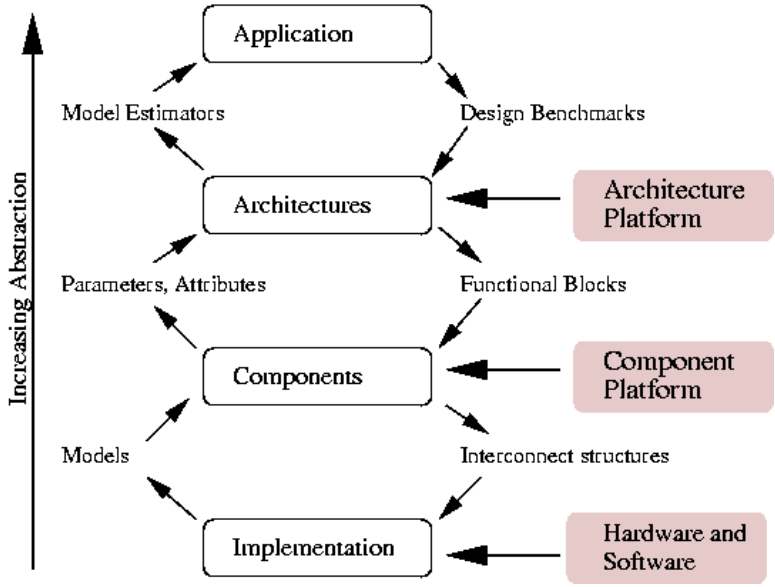
Design Platform Architectures

Platform is an "abstraction layer" in the design flow that facilitates refinements into subsequent abstractions.

Platform stacks are simply a stack of abstraction layers.

Upper layers are an abstraction of lower layers.

Lower layers provide the set of rules allowing for classification of components that can be part of the platform.



Question: What rules and abstractions are needed to cover augmented cognition systems? What representations (mathematical, graphical) are appropriate?

Conclusions

Multi-Modal Architectures

Achieving modularity, high performance, and broad functionality will require new architectures that are part-modular/part-integrated and can dynamically adapt – multi-modal architectures -- to the needs of a scenario.

Analysis Methods and Design Tools

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