Streamlining development processes through an automotive architecture framework

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Vehicle complexity has increased dramatically over the past two decades. New “smarter” vehicles are evolving with intelligent, built-in safety and comfort functions; green technologies such as hybrid and fully electric engines; and interconnected systems of systems that link occupants to the outside world. These advances are based on the increasing use of electronics and embedded software. Today’s luxury cars use approximately 100 million lines of code running on several dozens Electronic Control Units (ECUs). This complexity translates to higher manufacturing costs, expressed in longer development times and a greater risk of development failure.

As a result, original equipment manufacturers (OEMs) are trying to reduce the number of ECUs needed by integrating more powerful processors, such as multi-core technologies. But ECU consolidation requires advanced systems engineering and architecture management to enable OEMs to make optimum decisions. With the goal of helping turn complexity into product innovation, IBM and the Technical University of Munich conducted a systematic study on automotive architecture and laid out foundational concepts for an automotive architecture framework (AAF).

An architecture designed for a complex ecosystem
The multifaceted network of highly interdependent organizations, which defines the automotive industry, must collaborate in all phases of the vehicle lifecycle. Efficient collaboration requires all members of this ecosystem -- OEMs, suppliers, tool vendors, research institutes -- to agree on common structures and descriptions. An architecture framework provides a consistent way to structure, decompose, and describe a system across a specific industry or value chain, which is the objective of the AAF.

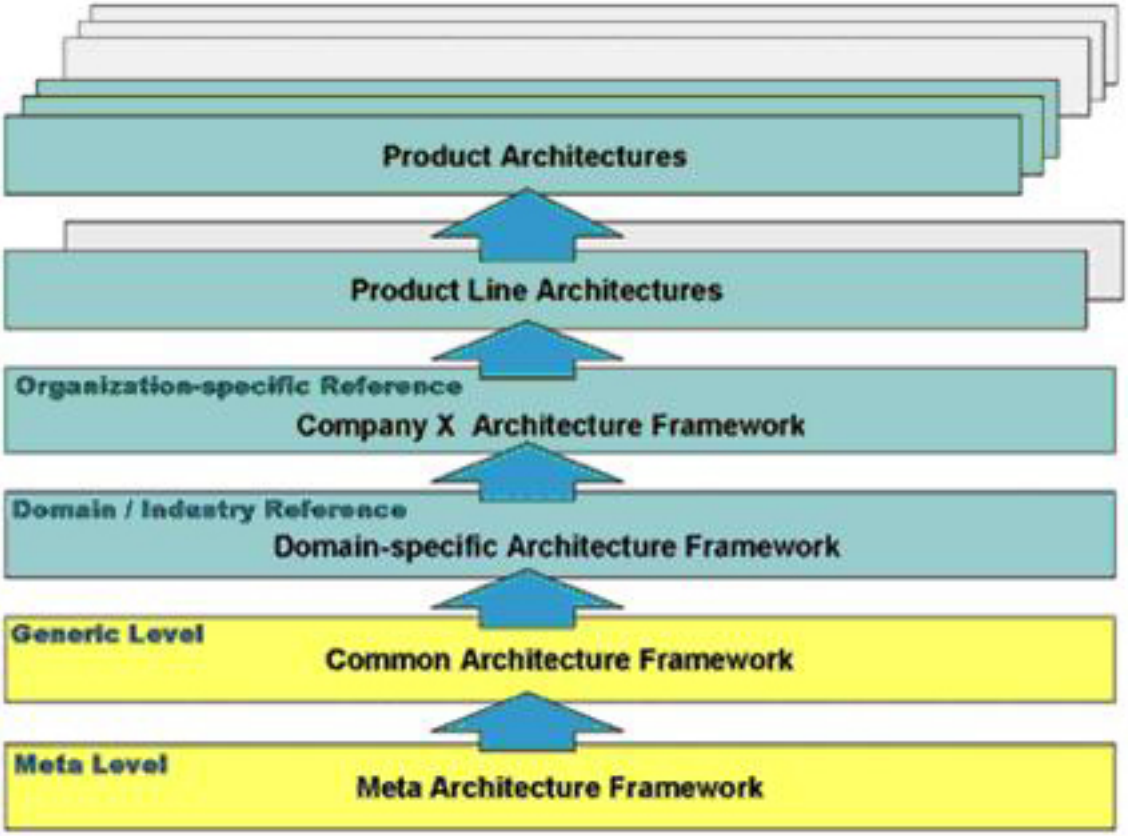

Fig. 1

Some of the methods of structuring and decomposing are more generic and others are very specific to the modeled system. A system can be described generically in terms of its user functions (black box view) or its components (white box view). On the other hand, decomposing a system into body, interior, chassis, and engine is very specific to the automotive industry.

Figure 1 presents levels of architecture frameworks ordered by generality, beginning with the most concrete one. On the generic Level, on the common architecture framework, general concepts are laid out such as the distinction between the functional, the logical, and the technical architecture, as shown in Figure 2.

These concepts are then applied to the development of more detailed architectures such as the domain-specific architecture framework.

The proposed automotive architecture framework, as suggested in the joint study, is the automotive-specific instantiation of the domain-specific architecture framework.

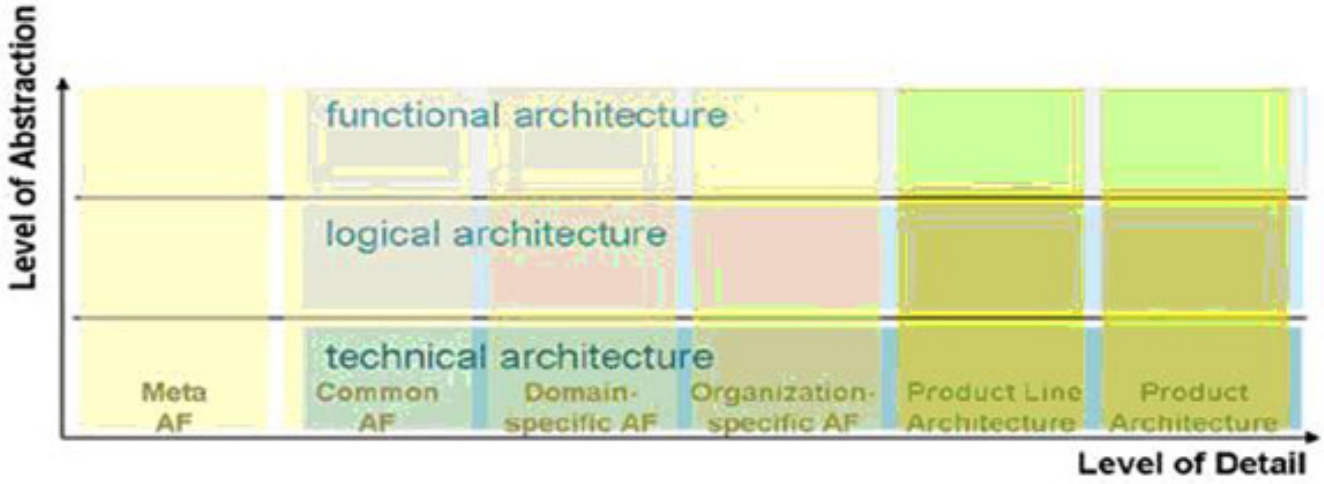

Fig. 2

The joint study depicts proposed elements of an AAF by describing various viewpoints. Unlike AUTOSAR, AAF goes beyond a focus on a given technology platform and the related methodology and instead spans a wider range of concerns, including the interrelation between mechanical, electrical, electronic, and software components.

An automotive architecture framework can contribute to improvements in all areas of product development, from initial reasoning about a new product, to communication between stakeholders within the value and supply chain, to a more integrated development environment. The proposed AAF will help collaboration by providing guidance and rules for modeling, documenting, developing, understanding, analyzing, using, and comparing architectures based on a common denominator across a virtual development organization.

The AAF can also:

• Provide insight for external stakeholders into how a specific lead organization develops products.
• Help ensure that descriptions of vehicle architectures can be compared and related across different vehicle programs, development units, and organizations.
• Support traceability, increase quality and innovation, and reduce costs while mitigating risk.

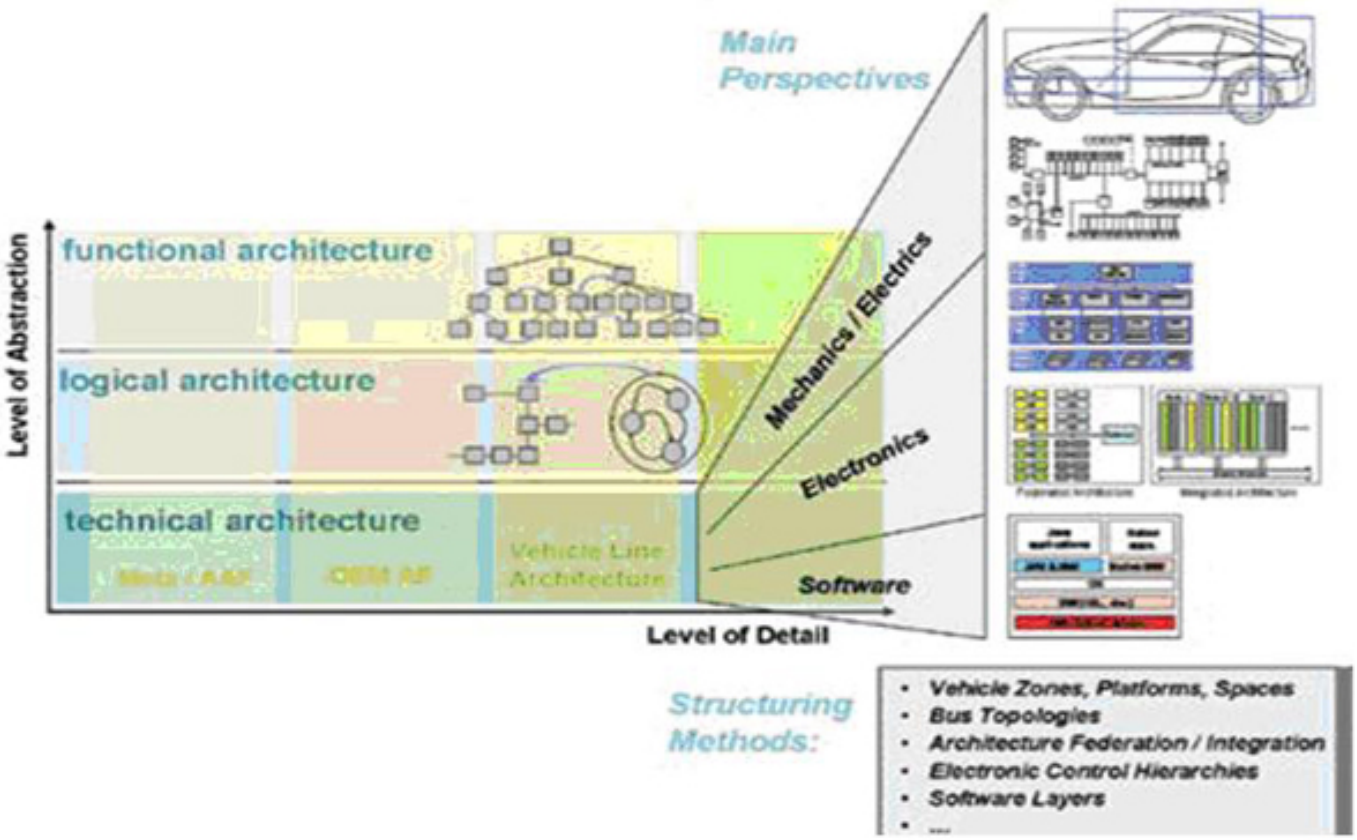

Fig. 3

A model-driven approach

The most efficient way to implement the architectural development concept within the relationship space of methodology, process and artifacts, is in an integrated fashion, by an iterative, model-driven approach.

The classical, mostly document-driven, product development approach has several drawbacks, including (often) the decomposition of requirements into specifications rather than decomposing systems to subsystems and deriving requirements for each substructure. By contrast, a model-driven system development approach uses several abstract layers which map closely to the architecture layers, as shown in Figure 4. This allows the various layers in the system decomposition to be supported and fed via components from an architecture framework.

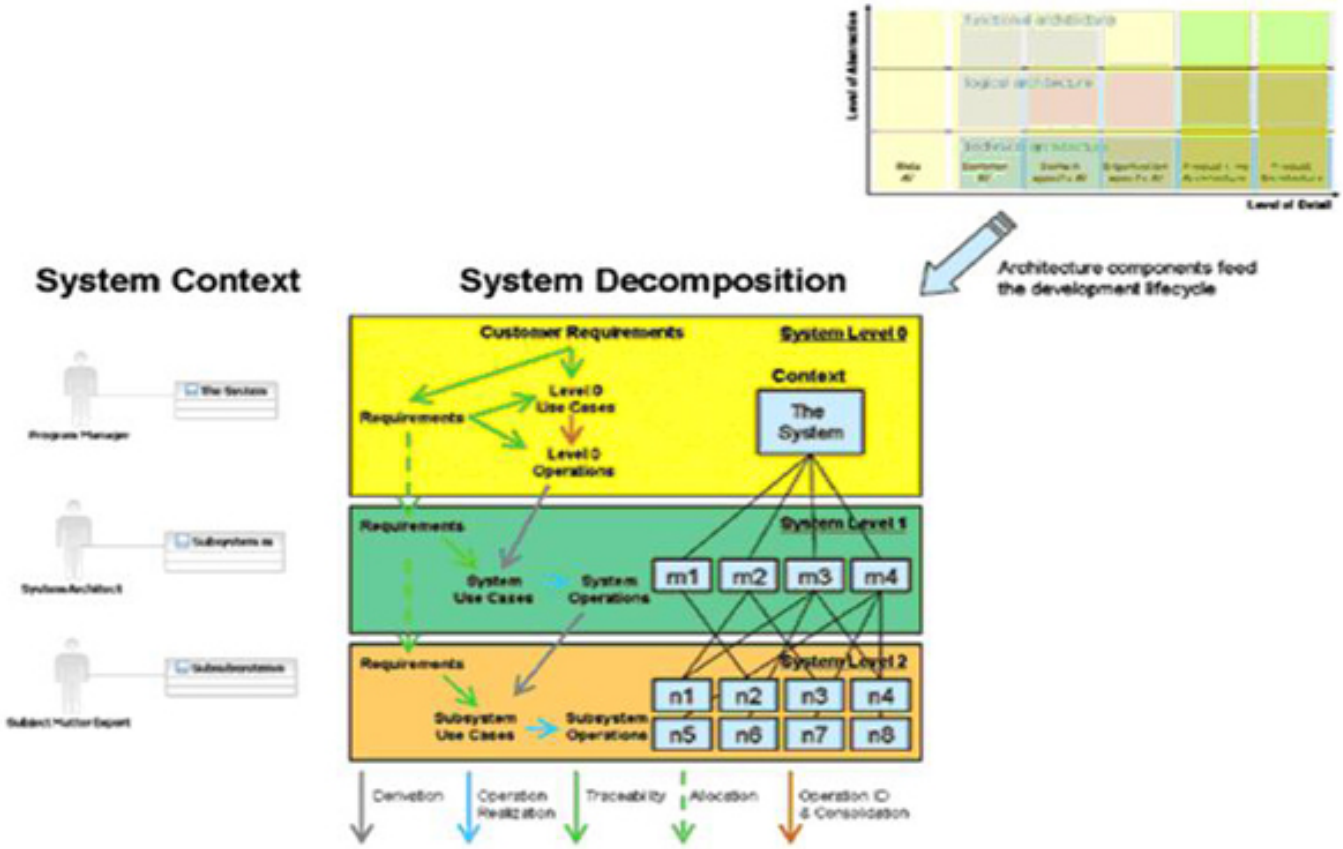

Fig. 4

Implementing an automotive architecture framework
The long and largely successful track record maintained by vendors such as IBM in developing and managing architectures for complex systems underlines significant value in the proposed AAF. The framework should assist stakeholders in the vast automotive supply chain to improve the way they architect their products -- whether mechanical, electronic, or embedded software components.

Implemented in concert with automated tool suites, the AAF should help automotive manufacturers to:

• Leverage proven process frameworks: Support iterative elements within the “automotive-typical” V-model.

• Manage product portfolios effectively: Build the right product at the right time for the right market.

• Manage requirements: Capture, define, analyze and manage requirements across the supply chain.

• Develop systems and software: Visually develop complex systems using a structured approach in a model-driven way.

• Adapt modern approaches: Elevate software engineering to a strategic business

process.

• Manage change: Synchronize changes across different disciplines and across the supply chain.

• Manage quality: Make quality management a continuous lifecycle activity from beginning to end.

Leveraged appropriately, the automotive architecture framework can help the automotive industry manage complexity, manage product lines, maintain a strong competitive edge, and become state-of-the-art innovation leaders as the future brings more advanced electronics and integrated driver interfaces.

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