


**Software Architecture
Technology Initiative**

SATURN 2008

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

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April 2008


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Presentation Outline

Getting (Re)acquainted

Transition

Current Work and Challenges

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Report Documentation Page

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Product Line Systems Program

Our mission:

- create, mature, apply, and transition technology and practices
- to effect widespread, **architecture-centric development and evolution, verifiable and predictable software construction, and product line practice**
- on systems at all scales throughout the global software community.

Portfolio of work:

- **Software Architecture Technology (SAT) Initiative**
- Product Line Practice Initiative
- Predictable Assembly from Certifiable Code Initiative
- Ultra-Large-Scale Systems



Value Proposition for Architecture

The quality and longevity of a software-intensive system is largely determined by its architecture.

Many large system and software failures point to

- inadequate software architecture education and practices
- the lack of any real software architecture evaluation early in the life cycle

Using architecture-centric practices throughout the software development lifecycle and throughout the lifetime of a software-intensive product leads to

- early identification of important product qualities resulting in higher contract win rates
- early identification and mitigation of design risks resulting in fewer downstream, costly problems
- cost savings in integration and test
- predictable product quality supporting the achievement of business and mission goals, which translates into competitive advantage
- cost-effective product evolution



What Is a Software Architecture?

“The **software architecture** of a program or computing system is the structure or **structures of the system**, which comprise the software elements, the **externally visible properties** of those elements, and the **relationships among** them.”

Bass, L.; Clements, P. & Kazman, R. *Software Architecture in Practice, Second Edition*. Boston, MA: Addison-Wesley, 2003.



Why Is Software Architecture Important?

Represents **earliest**
design decisions



- hardest to change
- most critical to get right
- communication vehicle among stakeholders

First design artifact
addressing



- performance
- modifiability
- reliability
- security

Key to systematic **reuse**



- transferable, reusable abstraction

Key to system **evolution**



- manage future uncertainty
- assure cost-effective agility

The **right architecture** paves the way for system **success**.

The **wrong architecture** usually spells some form of **disaster**.



SEI Software Architecture Technology (SAT) Initiative's Focus

Ensure that business and mission goals are predictably achieved throughout a system's lifetime by using effective architecture practices for systems of all scale.

"Axioms" Guiding Our Work

- Software architecture is the bridge between business and mission goals and a software-intensive system.
- Quality attribute requirements drive software architecture design.
- Software architecture drives software development throughout the life cycle.

Earliest work focused on the second axiom leading to the Architecture Tradeoff Analysis Method® (ATAM®)

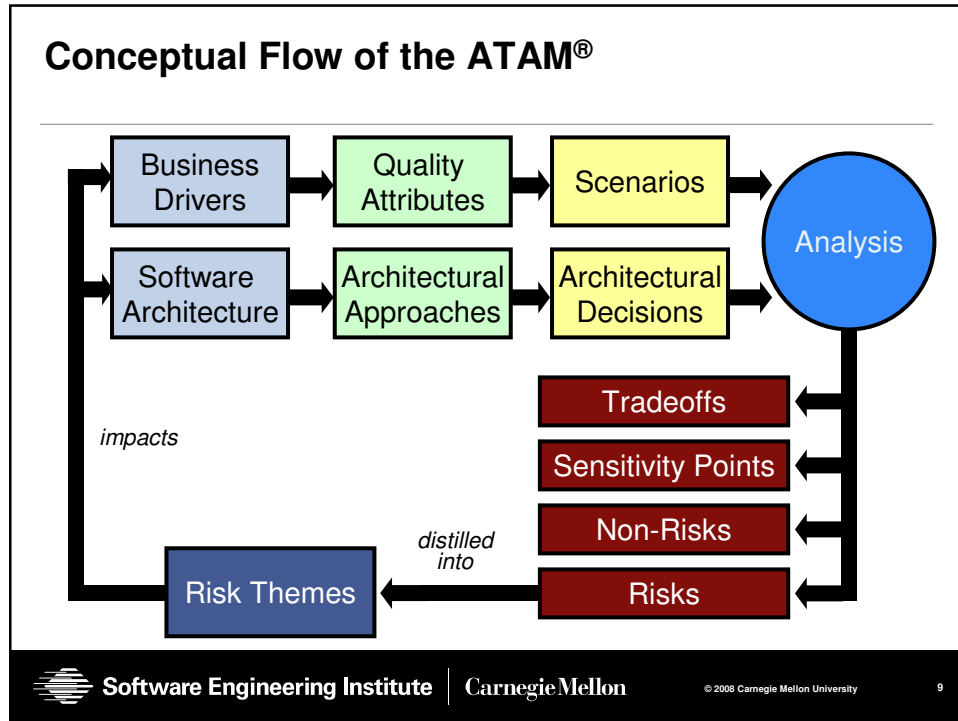


SEI's Architecture Tradeoff Analysis Method® (ATAM®)

The ATAM is an architecture evaluation method that focuses on multiple quality attributes

- illuminates points in the architecture where quality attribute tradeoffs occur
- generates a context for ongoing quantitative analysis
- utilizes an architecture's vested stakeholders as authorities on the quality attribute goals

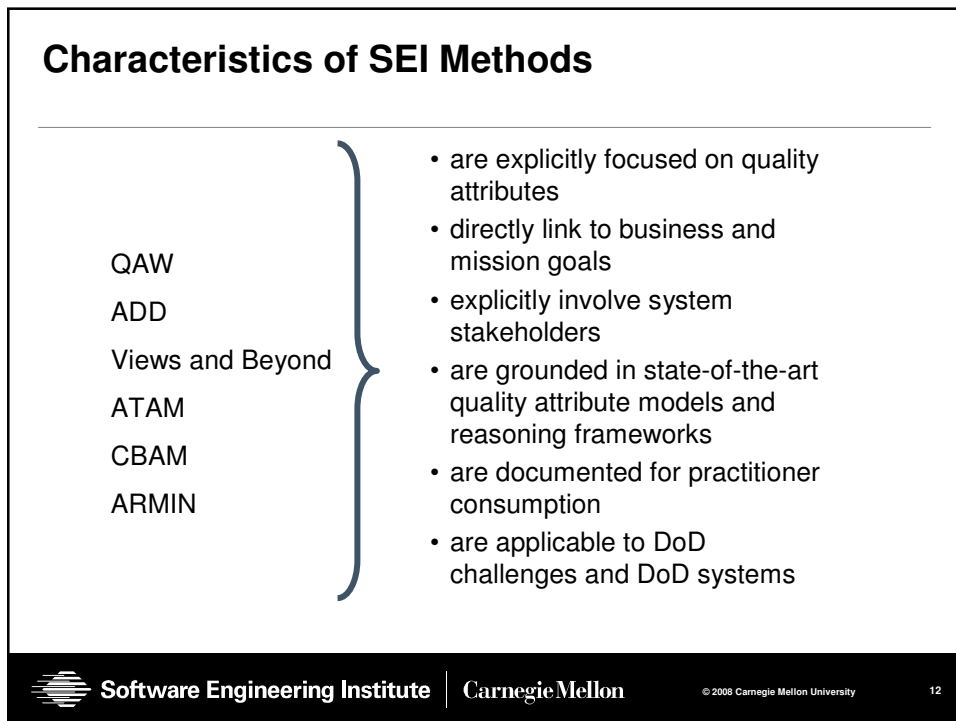
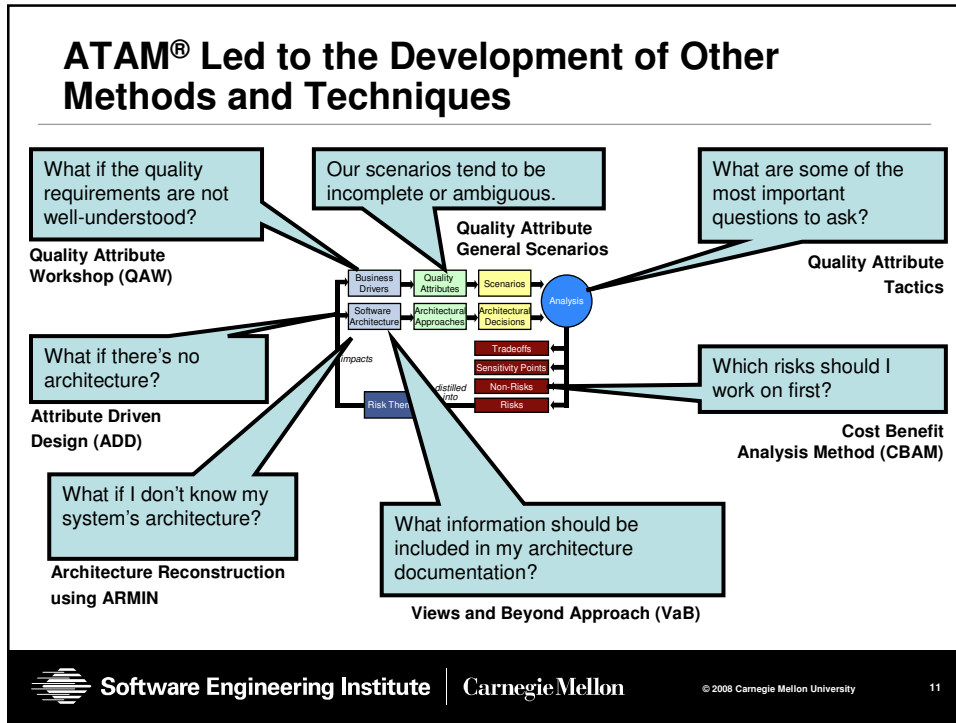




Architecture-Centric Development Activities

Architecture-centric activities include the following:

- creating the business case for the system
- understanding the requirements
- creating and/or selecting the architecture
- documenting and communicating the architecture
- analyzing or evaluating the architecture
- implementing the system based on the architecture
- ensuring that the implementation conforms to the architecture



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SAT Transition



Certificate Program Course Matrix

	Three Certificate Programs		
	Software Architecture Professional	ATAM® Evaluator	ATAM® Lead Evaluator
<i>Requirements</i>			
Software Architecture: Principles and Practice	✓	✓	✓
Documenting Software Architectures	✓		✓
Software Architecture Design and Analysis	✓		✓
Software Product Lines	✓		
ATAM® Evaluator Training		✓	✓
ATAM® Leader Training			✓
ATAM® Observation			✓

Architecture Tradeoff Analysis Method® (ATAM®)



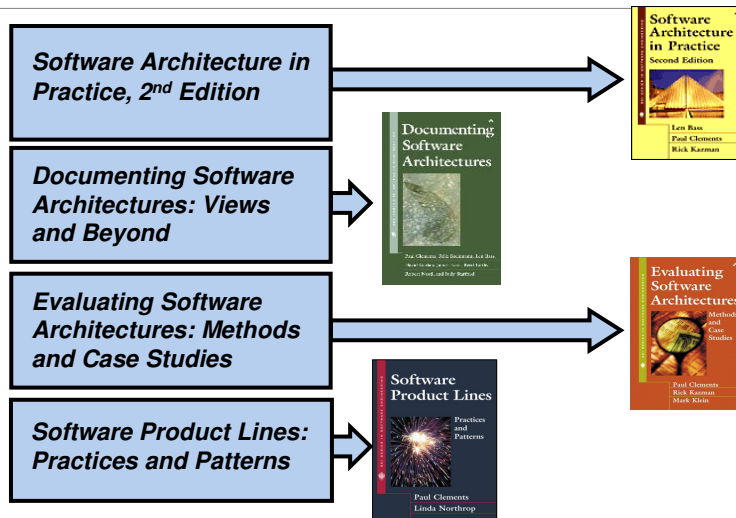
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Associated Texts



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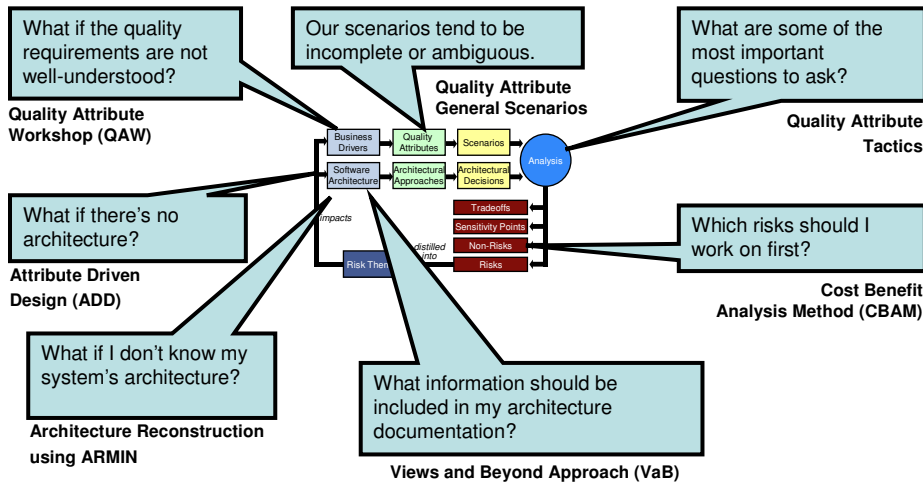
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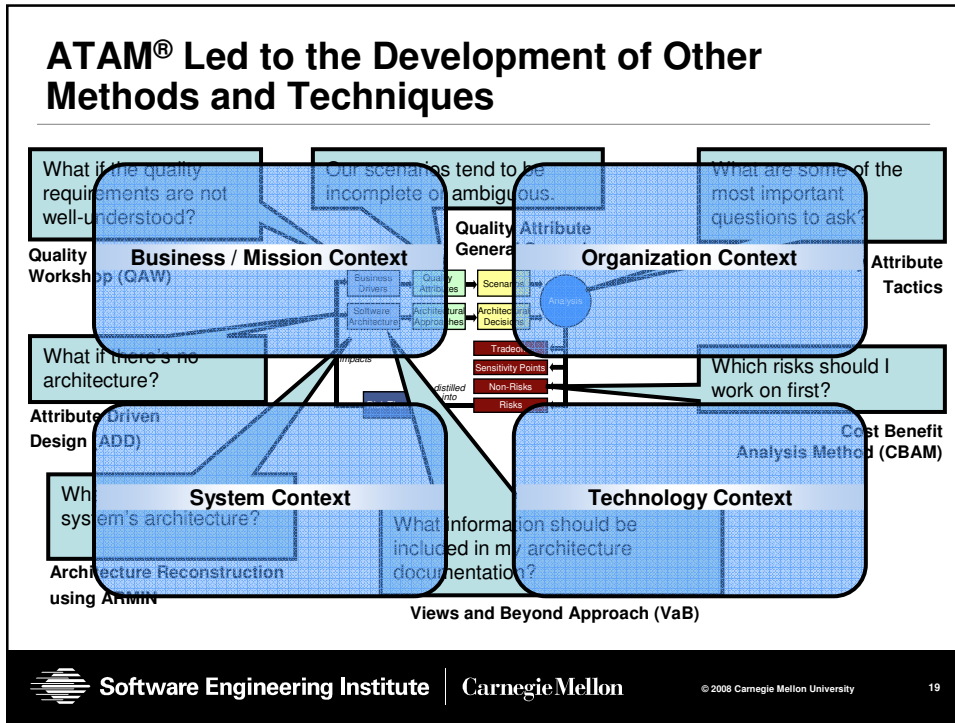
Transition

Current Work and Challenges



ATAM® Led to the Development of Other Methods and Techniques





Architecture Evolution₁

Problem

- *Systems evolve* to satisfy mission and business goals that change over time.
- Systems must evolve without compromising quality while being constrained by time and resource constraints.
- A sound practicable approach for architecture-based system evolution is needed. Approach should:
 - enable value-based architectural design and analysis
 - allow for tradeoffs between near- and long-term goals
 - foster communication between management and architects

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Architecture Evolution₂

Approach

- Explore design space using quality attribute tactics, patterns, and tradeoff analysis.
- Use ideas from economics such as real options, utility theory, combinatorial optimization, release planning, portfolio analysis, and decision markets.

Progress

- Developed a method for value-based architecture evolution
- Developed and delivered Economics-Driven Design tutorial
- Started applying evolution techniques to actual evolution problems
- Investigating architecture-based cost and benefit analysis
- Creating prototype tool to support architecture-based cost / benefit analysis



Architecture Competence₁

Problem

- Effective architecture-centric practice requires architecture competence at the individual, team, and organizational levels.
- DoD and commercial organizations have difficulty assessing architecture competence.
- Instruments and approaches for measuring and improving architecture competence are needed.

Approach

- Determine factors contributing to architecture competence based on surveys, exemplar practices, and SEI experience
- Develop assessment and improvement instruments based on those factors and relevant models such as those from
 - Organizational coordination mechanisms
 - Human performance model
 - Organization learning



Architecture Competence₂

Progress

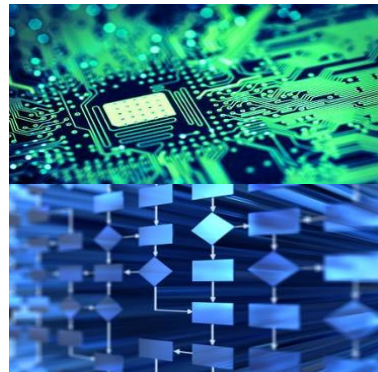
- Codified the results of an informal survey of architecture duties, skills, and knowledge
- Started developing an architecture assessment instrument
- Planning to pilot architecture assessment
- Applying organizational learning theories to architecture competence



System / SoS Architecture Practices₁

Problem

- Severe integration and runtime problems arise due to inconsistencies in how quality attributes are addressed in *system and software architectures*.
- This is further exacerbated in an *SoS* context where major system and software elements are developed concurrently.
- A uniform approach for specifying quality attribute requirements and analyzing SoS, system, and software architectures against such requirements is needed.



System / SoS Architecture Practices₂

Approach

- Make minor enhancements to the ATAM for use on system architectures.
- Develop a method to perform a "first pass" identification of inconsistencies between constituent systems of SoSs by using mission threads augmented with quality attribute concerns.

Progress

- Defined "ATAM for Systems"
- Developed Mission Thread Workshop and outlined SoS architecture evaluation method
- Plans underway to pilot ATAM for Systems, Mission Thread Workshop, and SoS architecture evaluation on two DoD systems



Architecture-Related Technology₁

Problem

- Prevailing technology and technology trends can both enable and be inimical to sound architecture practices.
- Guidance is needed.
- Architecture practices are often labor intensive and error prone.
- Automated support can help.

Approach

- Scrutinize technology and technology trends through the lens of architecture-centric development and provide guidance and support
 - SOA, from a quality attribute point of view
 - impact of open source on architecture and vice versa
- Identify technology gaps related to architecture practices and provide guidance and build prototype tools
 - reconstruction and conformance technology (with PACC)
 - ArchE, an architectural design assistant



Architecture-Related Technology₂

Progress

- Completed an analysis of how to evaluate the architecture of SOA-based systems using the ATAM. Documented results in a technical report and tutorial. Received positive feedback on approach from SOA practitioners.
 - quality attribute perspective beyond interoperability
 - vendor-neutrality
- ArchE was enhanced to support adding external reasoning frameworks, was made available to the community via the web, and was downloaded more than 500 times with positive feedback received.
- Completed an analysis of the use of AOP for architecture conformance.
- Have begun an investigation of the relationship between open source and architecture practices.



Future Directions

Ultra-Large-Scale Systems Research

Obvious trends toward systems of increasing scale lead to architecture-related research questions that we will pursue as part of our future research agenda.

- How do architecture concepts and practices apply or need to be extended for ULS systems?
- How can the principles of game theory, computational mechanism design, and computational emergence inform ULS system structure?
- How can the principles of game theory and mechanism design influence “designing in the human elements” of a ULS system?
- How can we apply lessons from open source and global development to ULS systems?



Future Directions**Enterprise Architecture and Transition**

Given the increased attention paid to enterprise architecture and our belief that SEI architecture principles are directly applicable, the SEI will develop a set of unifying principles for software, system, SoS, and enterprise architectures.

To increase impact, we will ramp up transition efforts

- create a partner network for licensing SAT architectures courses
- capitalize on the Army Software Architecture Initiative to develop a sustaining infrastructure for sound architecture practices within the Army

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We want your input!

Our ongoing goals are to

- Respond to the needs of the world
- Increase our level of impact
- Base techniques and methods on theoretically sound foundations

We are very much looking forward to getting your thoughts!

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