Product Line Systems Program

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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.

Strategic Relevance

This work directly enables

- predictable product qualities during design, evolution, and construction
- dramatically reduced cost for software-intensive systems through reduced test and integration time and economies of scale

Our Portfolio of Work

Software Architecture

(Software Architecture Technology Initiative)

Predictable Software Construction

(Predictable Assembly from Certifiable Code Initiative)

Software Product Lines

(Product Line Practice Initiative)

Ultra-Large-Scale Systems

Program Technical Themes

Product-centric

Quality attribute focus

Architecture importance

Predictability

Efficiency

Business and mission goals

Stakeholder involvement

Automated support

Our Customers and Collaborators

ABB
Boeing
Daimler Chrysler
Caterpillar
Federal Express
Foliage
General Dynamics Viz
Gereral Motors
Intuit
NCR
Northrop Grumman
Ortho Clinical Diagnostics
Pitney Bowes
Raytheon
RIM
Robert Bosch Co.
Siemens
Unisys
Visteon
LLNL
FAA
NASA: JSC, KSC, JPL
NASA: Goddard
NRO: CCT
JNIC
DMSO

US Army: ASA(ALT), Aviation, TAPO, BC, FBCB2, CECOM, ATSC, FCS, AMTS, WinT, IBS,
US Navy: Navair, DDX, OAET, CLIP
US Air Force: F-22, JMPS, ESC

Philips
Lucent
AT&T
Hewlett Packard
Thomson-CSF
Ericsson
Schlumberger
Nokia
Telesoft S.p.A.
Boeing
CelsiusTech
Avaya
Fraunhofer
IBM
Microsoft
Motorola
Cummins, Inc.
General Motors
Lockheed Martin
Salion, Inc.
MarketMaker
Argon Engineering
Agilent

Today's Presentation

Software Architecture

(Software Architecture Technology Initiative)

Predictable Software Construction

(Predictable Assembly from Certifiable Code Initiative)

Software Product Lines

(Product Line Practice Initiative)

Ultra-Large-Scale Systems

Universal Business Goals

High quality

Quick time to market

Market agility

Product alignment

Low cost production

Low cost maintenance

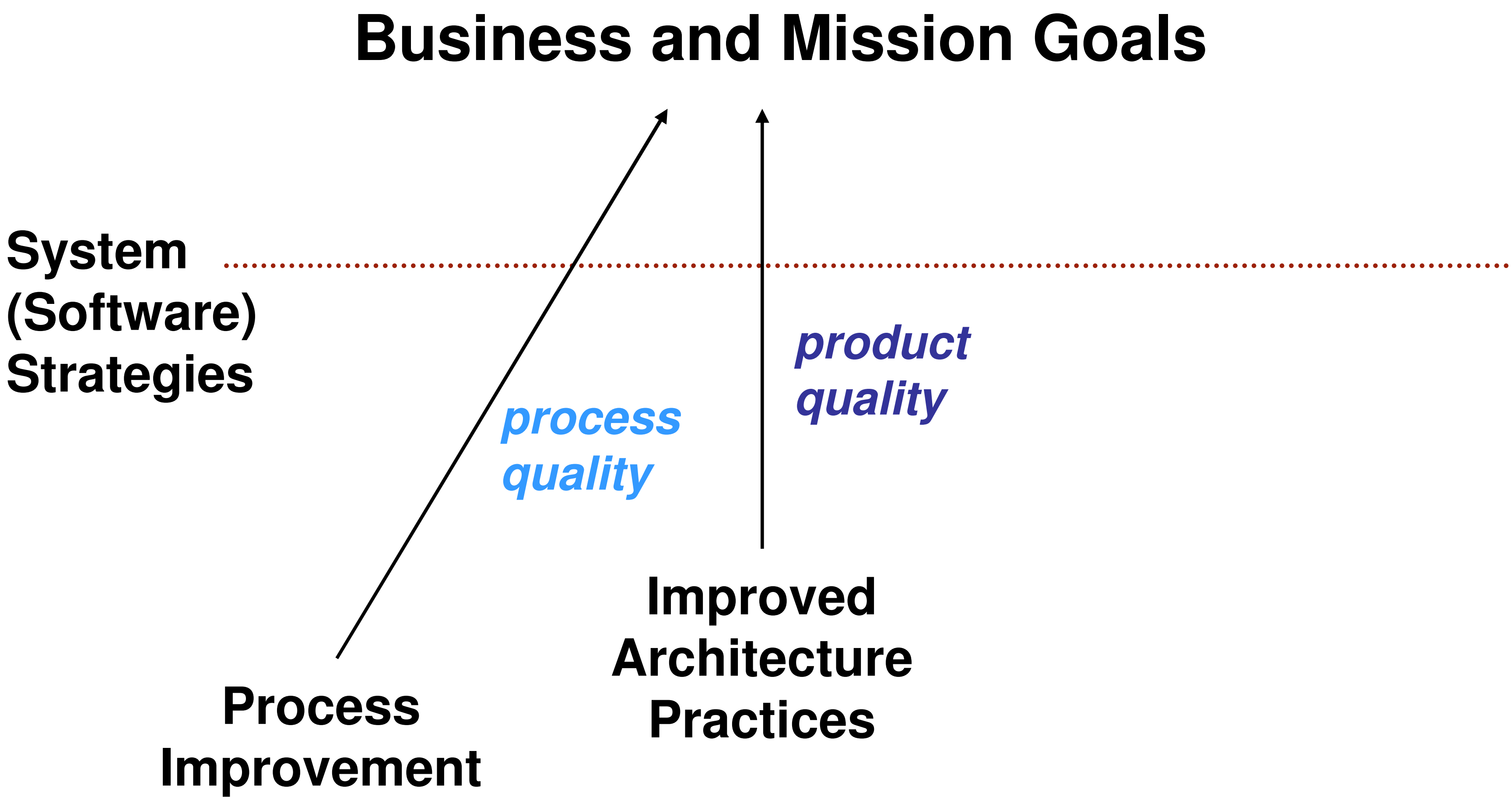
Mass customization

Mind share

require

IMPROVED EFFICIENCY AND PRODUCTIVITY

Software Strategies Are Needed



Focus: Software Architecture

From our experience:

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

Risk mitigation early in the life cycle is key.

- Mid-course correction is possible before great investment.
- Risks don't become problems that have to be addressed during integration and test.

Software Architecture Value Proposition

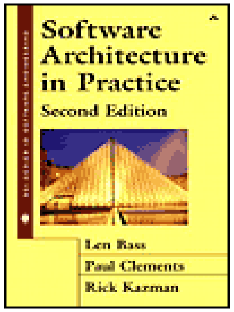
Using architecture-centric practices throughout the software development lifecycle and throughout the lifetime of a software-intensive product leads to

- 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.*”[1]

[1] 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

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

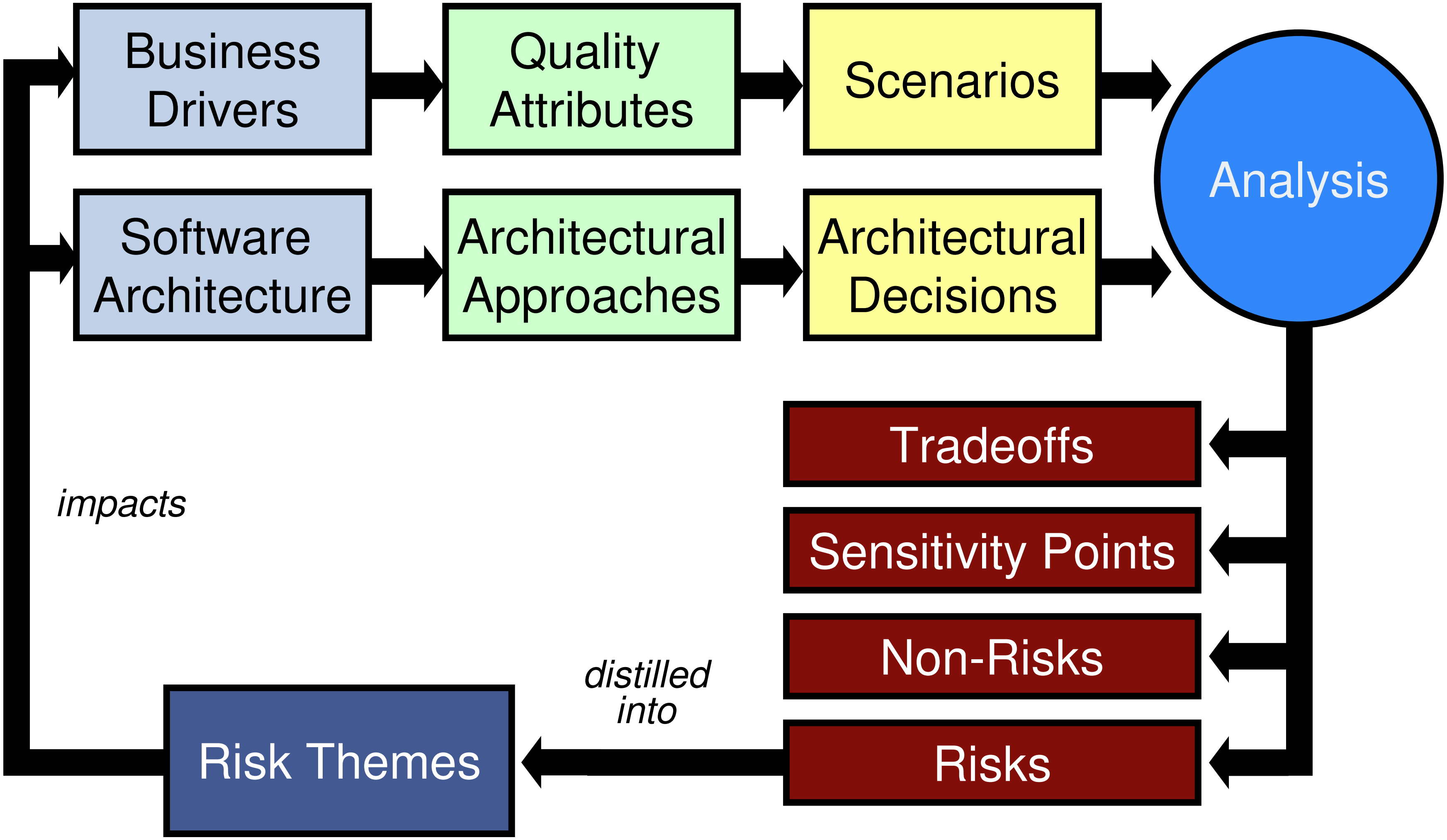
Ensure that business and mission goals are predictably achieved by using effective software architecture practices throughout the development lifecycle.

"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 ®) for architecture evaluation.

Conceptual Flow of the ATAM®



Architecture-Centric 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
- setting up the appropriate **tests and measures** against the architecture
- **implementing** the system based on the architecture
- ensuring that the implementation **conforms** to the architecture
- evolving the architecture so that it **continues to meet business and product goals**

ATAM® Led to the Development of Other Methods and Techniques

What if the quality requirements are not well-understood?

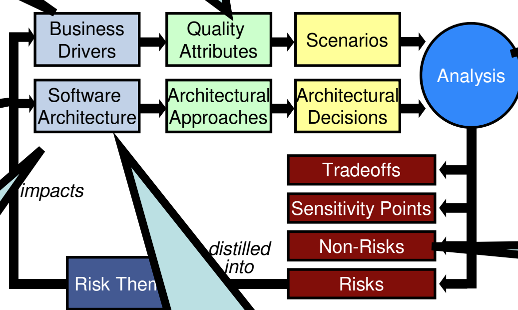
Quality Attribute Workshop (QAW)

Our scenarios tend to be incomplete or ambiguous.

Quality Attribute General Scenarios

What are some of the most important questions to ask?

Quality Attribute Tactics



What if there's no architecture?

Attribute Driven Design (ADD)

Which risks should I work on first?

Cost Benefit Analysis Method (CBAM)

What if I don't know my system's architecture?

Architecture Reconstruction using ARMIN

What information should be included in my architecture documentation?

Views and Beyond Approach (VaB)

Characteristics of SEI Methods

QAW

ADD

Views and Beyond

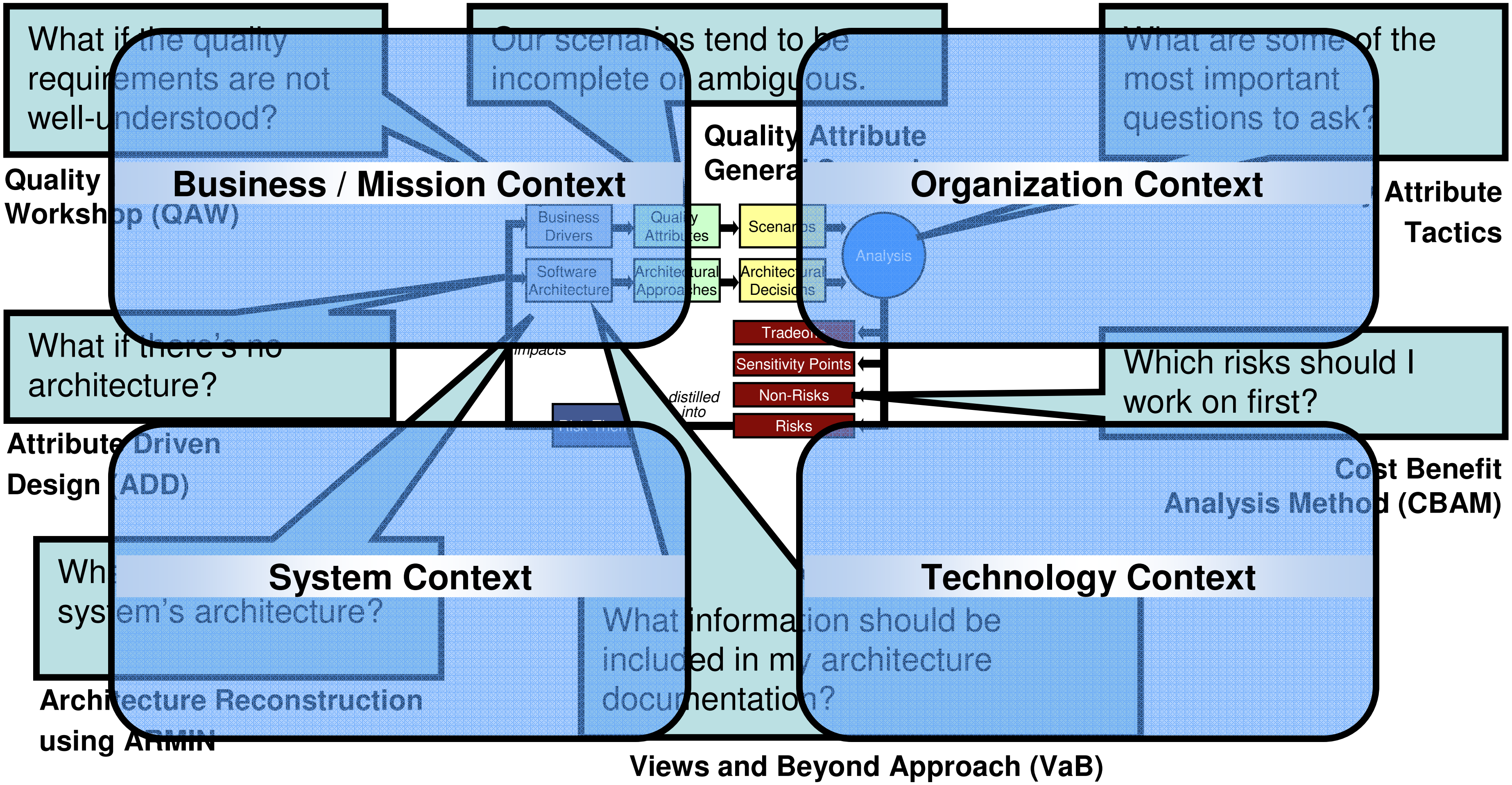
ATAM

CBAM

ARMIN

- are explicitly focused on quality attributes
- directly link to business and mission goals
- explicitly involve system stakeholders
- are grounded in state-of-the-art quality attribute models and reasoning frameworks
- are documented for practitioner consumption
- are applicable to DoD challenges and DoD systems

ATAM® Led to the Development of Other Methods and Techniques



Architecture Evolution

Problem

- The architecture of a software intensive system must continually evolve to ensure consistency between the system and its ***mission and business goals.***
  - "Tactical evolution" focuses on change over a ***short time horizon*** to ensure system consistency with ***current*** goals.
  - "Strategic evolution" focuses on change over a ***long time horizon*** to manage ***uncertainty*** in future goals, exploit future opportunities, and defend against future risks.

Approach

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

Architecture Competence

Problem

- Organizations need help in measuring and improving the architecture competence of their individuals and teams in order to effectively use and benefit from architecture-centric software engineering practices.

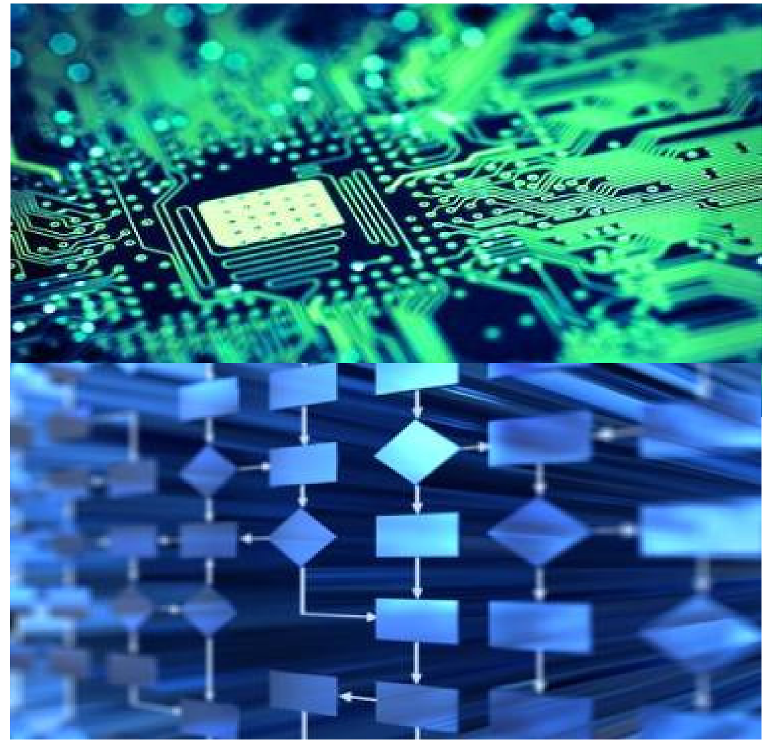
Approach

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

System ATAM

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 a System of Systems (SoS) context where major system and software elements are developed concurrently.



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.

Architecture-Related Technology

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

Transition


Enable others
• Course licensing
• Certificate Programs
• ATAM Lead Evaluator Certification
• ArchE
Foster widespread awareness
• Books
• Reports
• Presentations
• SATURN, ATAM Lead, DoD, and Educators Workshops
Transition Products and Services
Ensure practicability
• Methods
• Case studies
• Acquisition guidelines
• Technology investigation
Assist others
• Teaching
• Applying methods and techniques
• Providing expertise

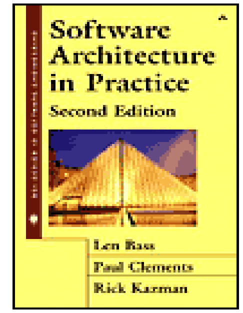
Certificate Program Course Matrix

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

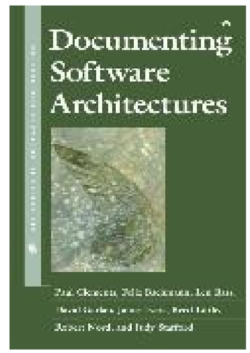
Architecture Tradeoff Analysis Method ® (ATAM ®)

Associated Texts

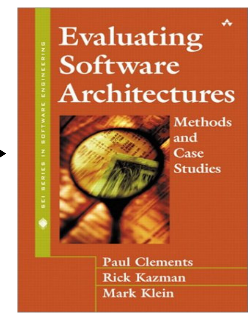
Software Architecture in Practice, 2nd Edition



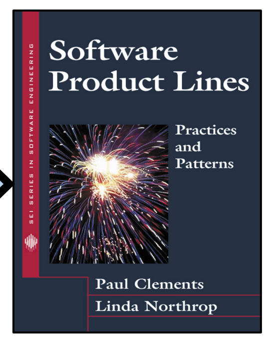
Documenting Software Architectures: Views and Beyond



Evaluating Software Architectures: Methods and Case Studies



Software Product Lines: Practices and Patterns



SAT Accomplishments

- Individuals from more than 400 different companies have taken courses in the SEI Software Architecture Curriculum.
- The SEI ATAM® was used to uncover risks in major DoD systems; for example, Win-T, ABCS, DDX, FBCB2, and FCS
- Teams at Raytheon, Boeing, and Robert Bosch GmbH are routinely conducting architecture evaluations using the ATAM.
- Representatives from ten U.S. Army programs reported that ATAM® evaluations resulted in reduced risk in schedule and cost, improved documentation and communication, and a higher quality product for the warfighter.
- The SEI books on software architecture have sold over 110,000 copies.

New Challenges

Challenge: Developing empirical and theoretical foundations for our competence assessment and improvement instruments.

Our Research: Applying the foundations of organizational learning and organizational coordination to the field of software architecture.

Challenge: Developing techniques to manage the uncertainty associated with strategic architecture evolution.

Our Research: Applying models and techniques from economics (such as real options and utility theory), release planning and product marketing (such as conjoint analysis) to the field of software architecture.

Challenge: Extend the concepts of software architecture to ultra-large-scale systems.

Our Research: Potentially develop new notions of architecture based on ideas from mechanism design and emergent behavior in complex (biological) systems.

Today's Presentation

Software Architecture

(Software Architecture Technology Initiative)

Predictable Software Construction

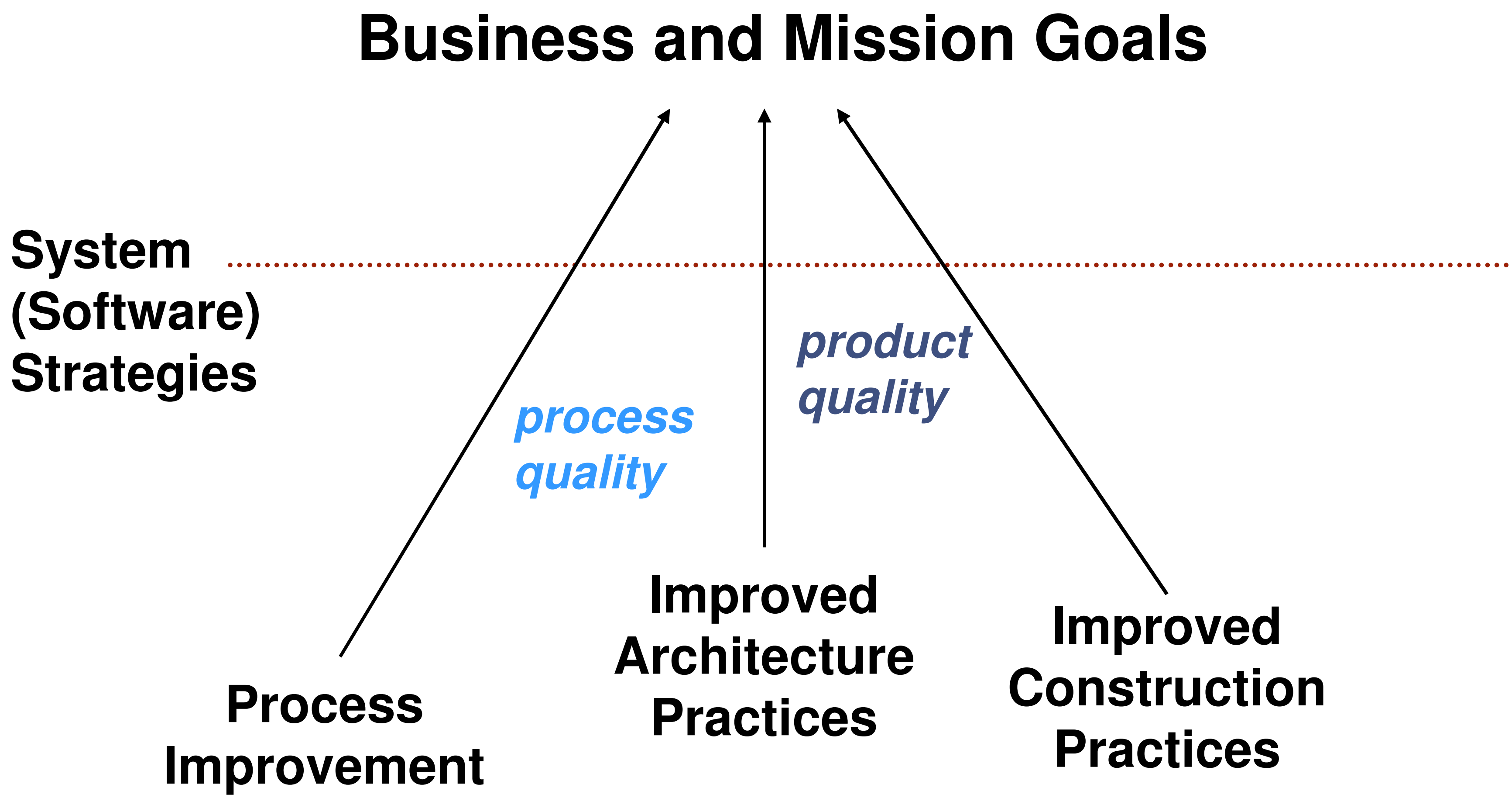
(Predictable Assembly from Certifiable Code Initiative)

Software Product Lines

(Product Line Practice Initiative)

Ultra-Large-Scale Systems

Software Strategies are Needed



The PACC Initiative

Predictable: runtime properties of an assembly

Assembly: easy but controlled integration

Certifiable: runtime properties of software

Code: executable code

PACC Focus and Axioms

Focus:

To introduce into routine practice the use of programming techniques that result in systems that exhibit quantifiably predictable runtime qualities.

Axioms:

- Runtime quality attributes are ultimately implemented in code, and code is ground truth for which qualities are implemented.
- Smart constraints improve the scale, confidence, and automation of quality attribute analysis of software.
- Automation is key to reducing the cost and increasing confidence that programs verifiably meet quality requirements

PACC Value Proposition

There is **economic value in objective evidence** that code implementations satisfy quality attribute requirements

- This value can be realized in several ways, including: reduced quality assurance cost, reduced acquisition risk, optimized system designs.
- Evidence becomes stronger, and yields greater value, as it moves nearer to code implementation.

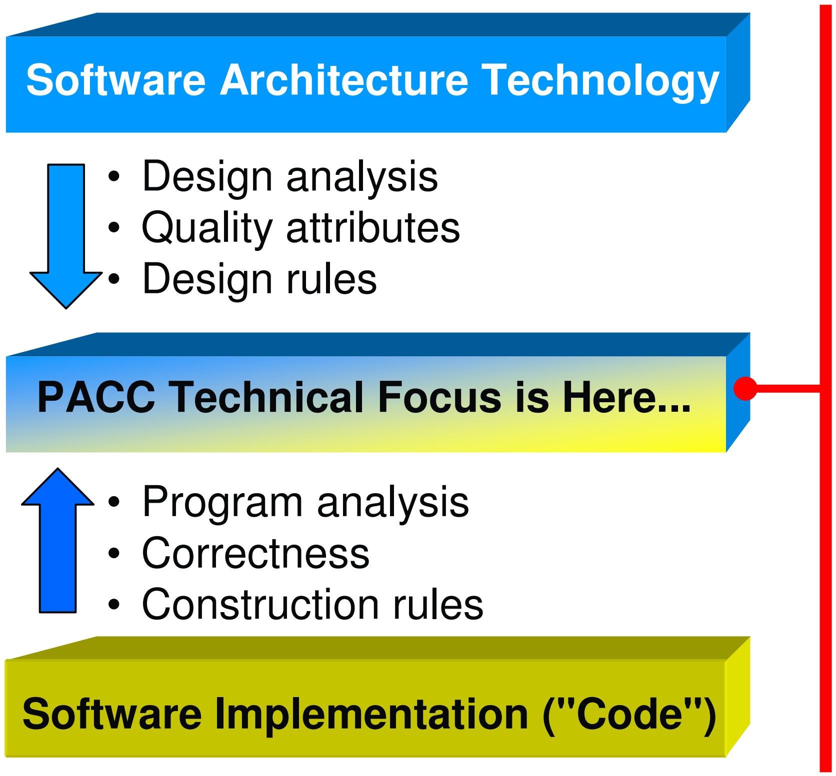
Independent of economic value propositions, there is a **pressing need** to establish a **sound basis for trusted software**

- DoD and US Industry increasingly depends on code with unknown provenance, from the global market, and from open source code.

The **cost of quality and its evidence** can be substantially **reduced through automation**

- Automation magnifies the impact of analysis theory: how much economic value has accrued from Java's strong type system?

Working the Architecture/Code Seam



PACC will enable organizations to

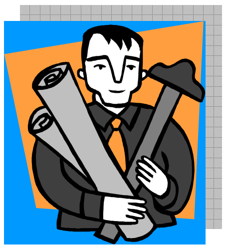
- develop classes of systems
- that predictably satisfy
- with objective evidence
- quality attribute requirements

PACC links architecture and code.

- using construction rules that
- are automatically enforced
- and are informed by theories
- that are sound and effective
- and provide confirmable results

PACC and Component Technology

Architect



Quality by design

- component and connector view
- analyzable design patterns

Prediction Enabled Component Technology

Quality by construction

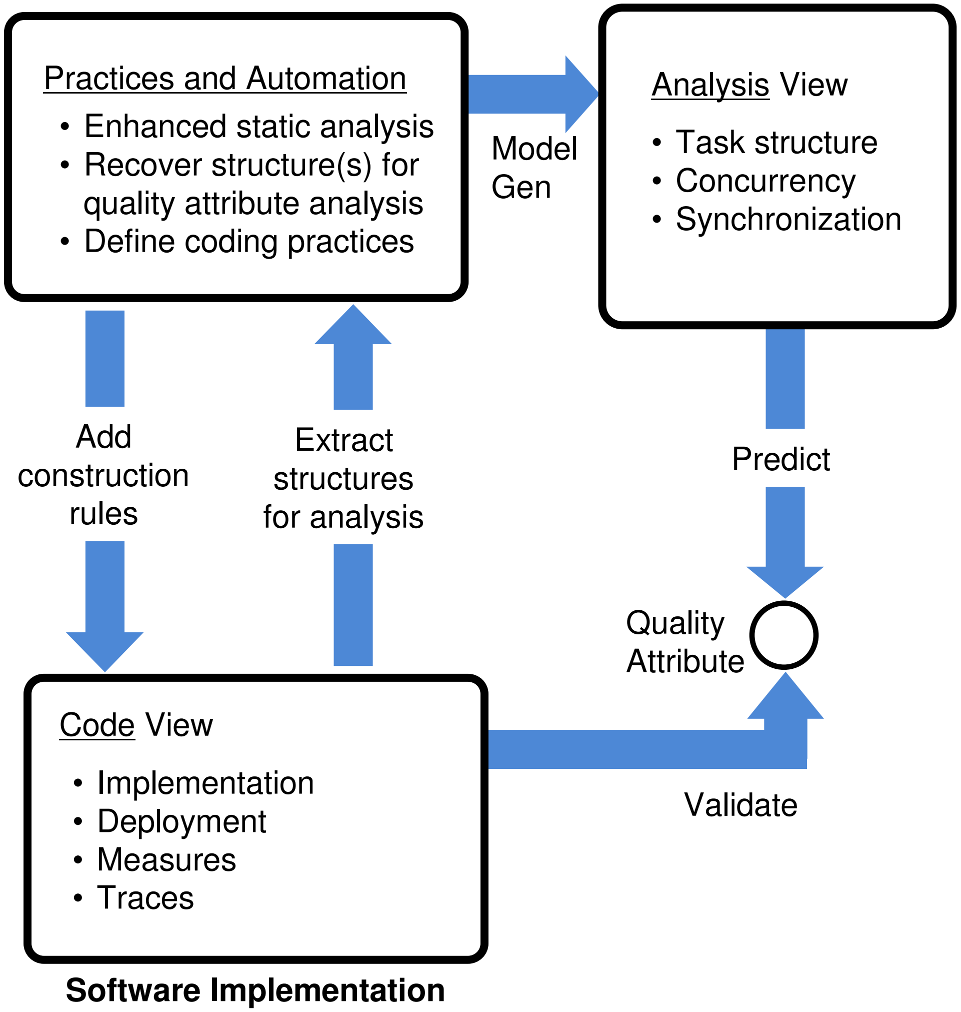
- strict code abstractions
- automated checking

Developer

PACC 2002-2007 exploited strong assumptions about programming models based on "components"

Beginning in 2008 we begin relaxing these assumptions to reach a broader audience

Today: Verifiable and Predictable Code



Component model + Software Architecture is effective, but:

- Assuming use of component technology is a strong a priori constraint on PACC customers.

Relaxing the assumption of a strong component model in code

- continues emphasis on programming technology
- preserves emphasis on objective evidence of code behavior
- opens new avenues for PACC to deal with legacy software

Producing Trusted Binaries

Problem:

- Obtaining justifiable trust in the behavior of code without having to trust code suppliers or their development processes.

Approach:

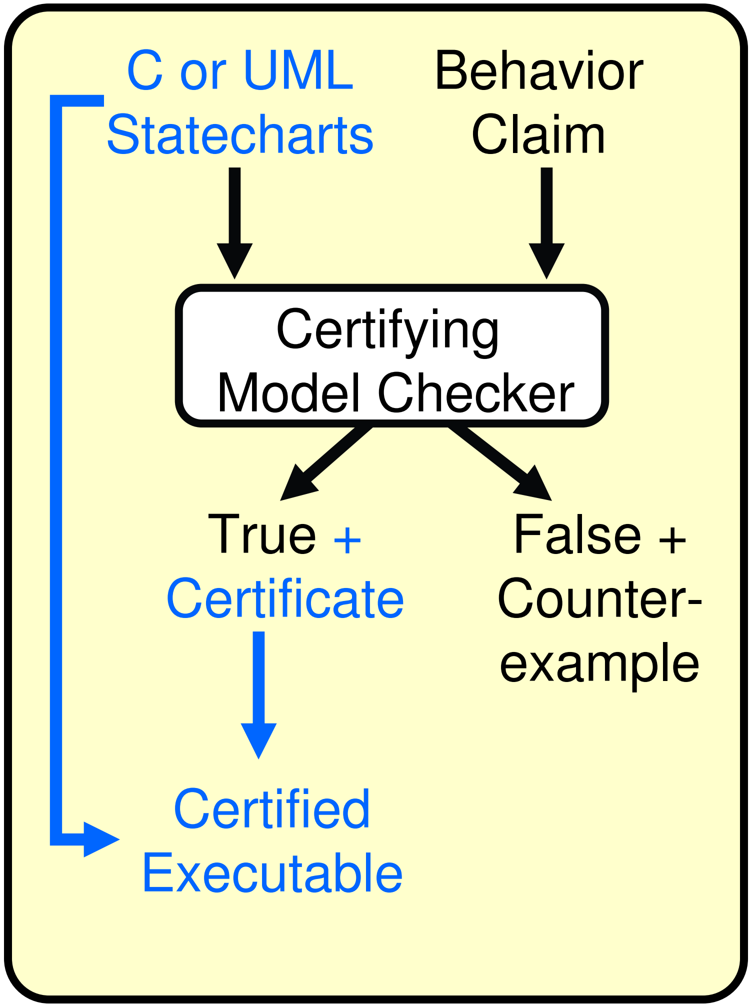
- Automated program verification with software model checking

Foundations

- Automated predicate abstraction, abstraction refinement, SAT solvers, L*, ...
- Proof-carrying code and certifying model checking

Contributions

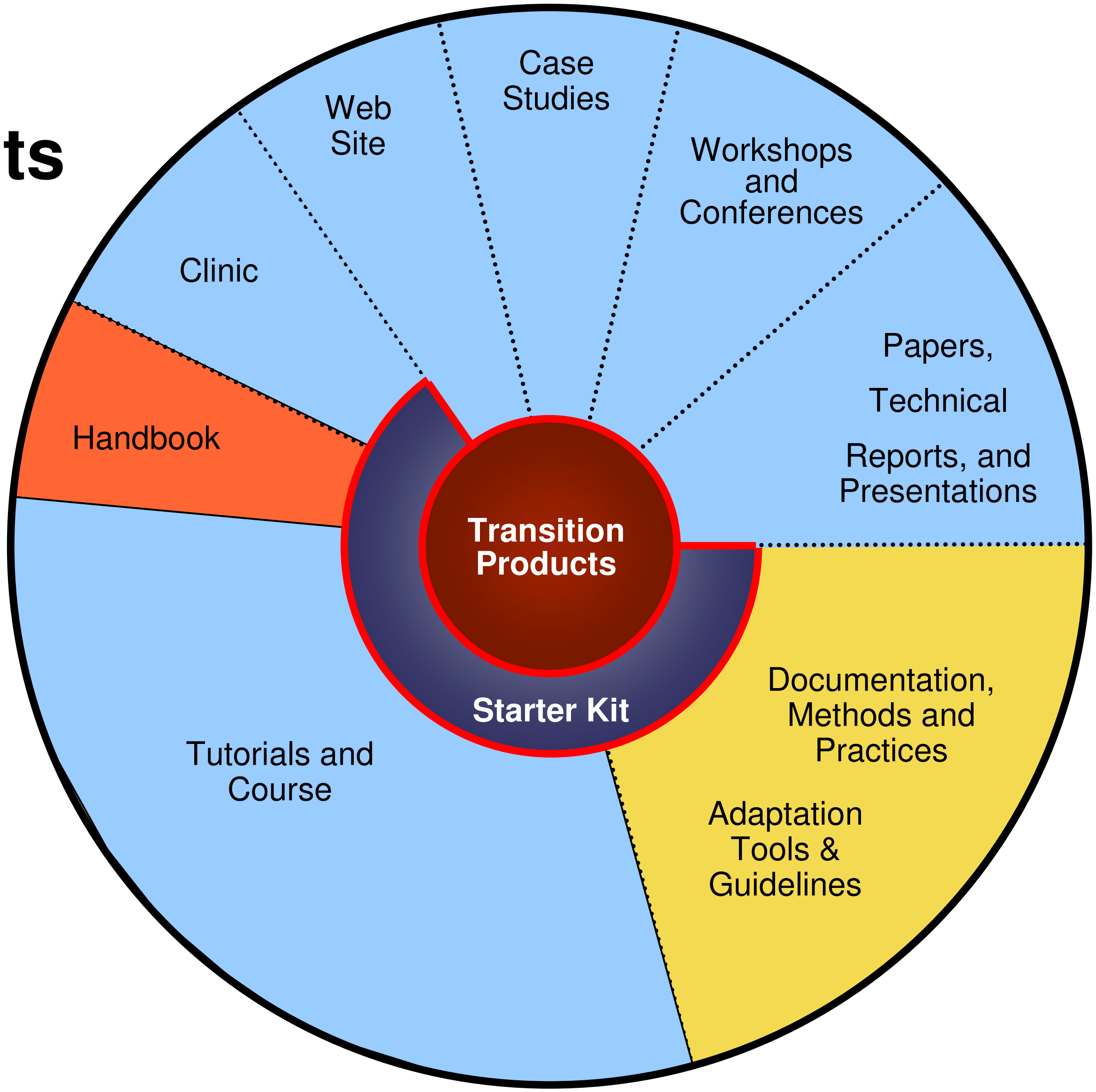
- Carry proof from design to executable
- Reduce trusted computing base: model checker, code generator, and compiler



PACC
Transition Products

KEY:

Ongoing
Early Stages
Not Yet Started



Transition: PACC Starter Kit and Testbed

Problem

- Getting the power of PACC into the hands of practicing software developers.

PSK provides real and compelling examples:

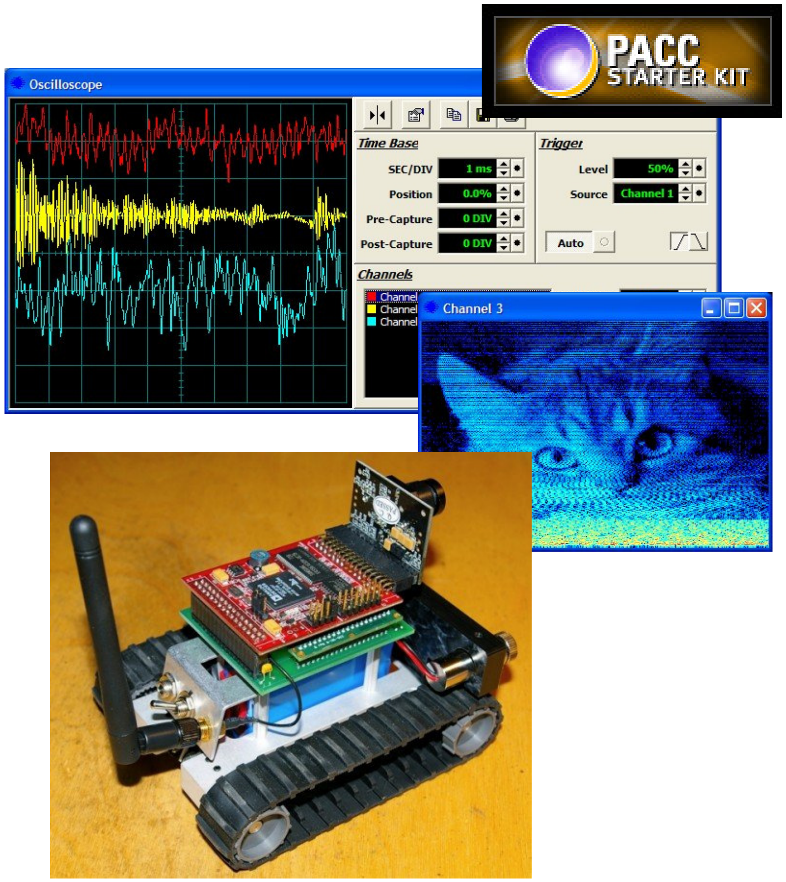
- Robot Command and Control
- Multichannel Audio Mixing

PSK demonstrates integrated concepts:

- Prediction with objective evidence (real time analysis, model checking)
- Pin component technology, real-time threads, event queues, statecharts, code generation, reasoning frameworks, Eclipse

Reduces learning curve

- Hands-on Tutorial at 2008 International Conference on Software Engineering
- PACC Educators' Workshop, Summer 08



Examples from PACC Testbed & Starter Kit

Industrial Cases from 2002-2006

Industrial Robotics

1. Safe 3rd-party software extension of hard real-time robot controller

2. Using model checking to find deep bugs in robot controller middleware

Substation Automation

3. Component-level assembly of substation controllers with predictable performance

4. Evolving a legacy substation controller to safe, predictable 3rd party configuration

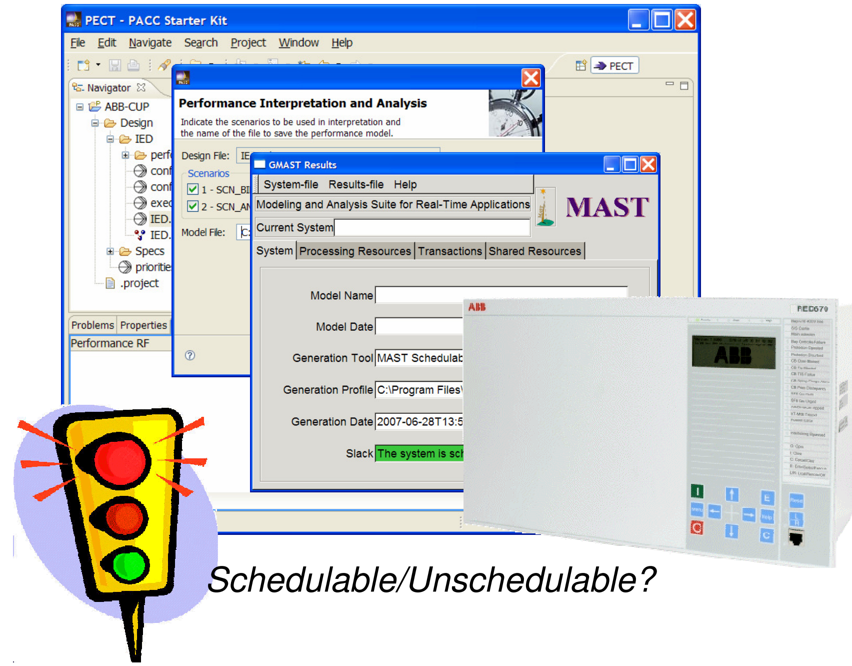
Recent Results: Predictable Assembly in Legacy Grid Code

Problem

- Highly configurable controller to support safe 3rd party configuration
- Legacy code not designed for predictability
- *Millions of lines of code*

Results

- Used the PACC Starter Kit to predict latency for specific configurations
- Identified architecture and coding changes to improve predictability
- Showed how performance models can be extracted from code
- Developed confidence intervals to provide evidence of system performance



Schedulable/Unschedulable?

Thread	Pop (ρ)	Con (γ)	Ub (MRE)	Con (γ)	Ub (MRE)
tApp1	99%	95	8.75%	99%	9.42%
tApp2	99%	95	6.03%	99%	6.44%

Confidence Intervals

New Challenges

Challenge: Developing practical and theoretical foundations for predicting the behavior of legacy software and potential modifications.

Our Research: Creating and applying program analysis technologies and best practices (e.g., static analysis, model checking, and run-time monitoring) to existing code.

Challenge: Developing an objective basis for trusting code developed by third-parties.

Our Research: Linking the theories needed to reason about program behavior to implementation constructs and providing objective evidence of program behavior (e.g., statistical measures or proof objects).

Challenge: Developing scalable technologies for reasoning about program behavior.

Our Research: Identifying "smart constraints" that simplify automated analyses and developing a technique for integrating static analysis and model checking technologies.

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Software Product Lines

(Product Line Practice Initiative)

Ultra-Large-Scale Systems

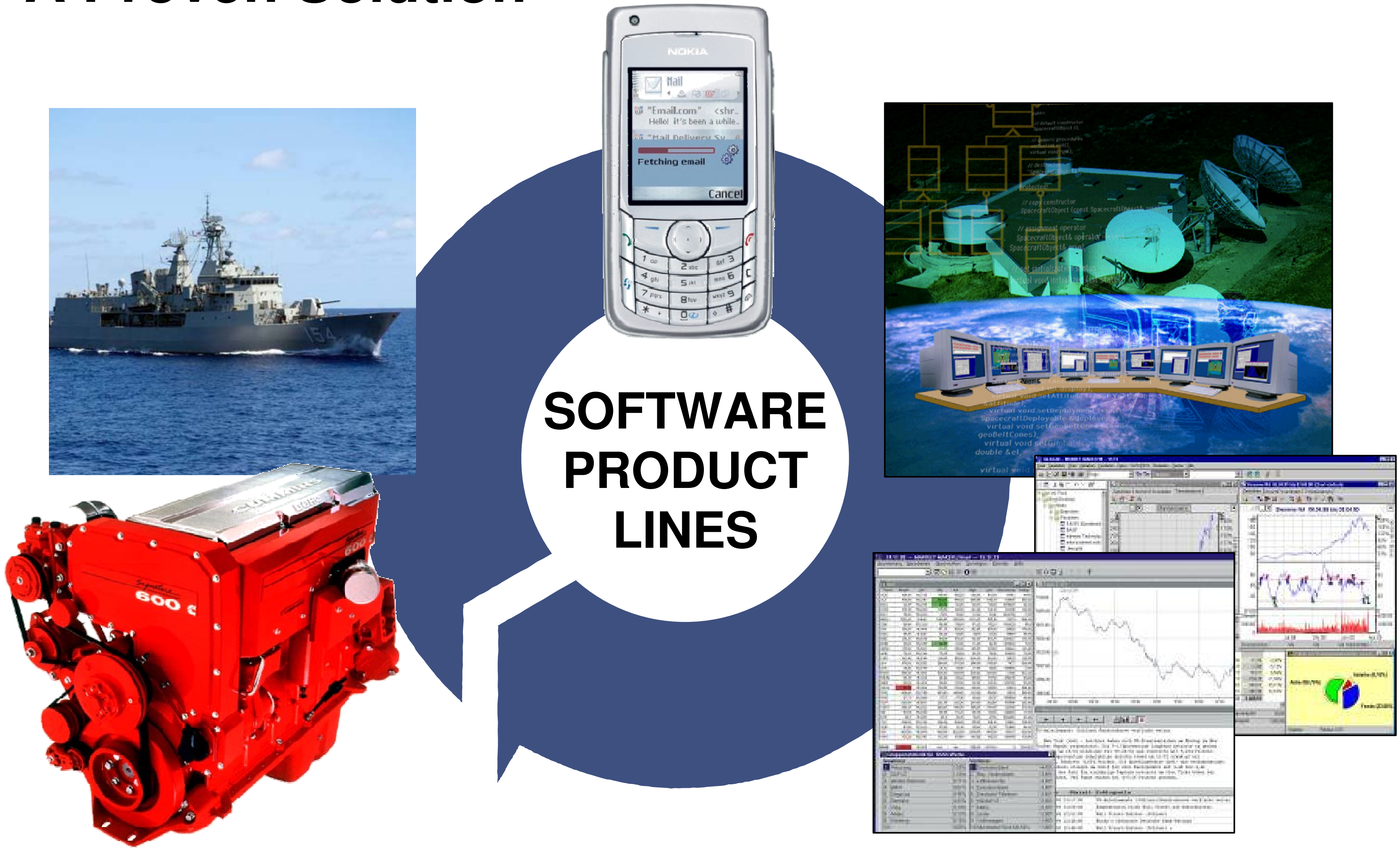
Few Systems Are Unique

Most organizations produce families of similar systems, differentiated by features.

A reuse strategy makes sense.

Traditional reuse strategies have had little economic benefit.

A Proven Solution



Software Product Lines Value Proposition

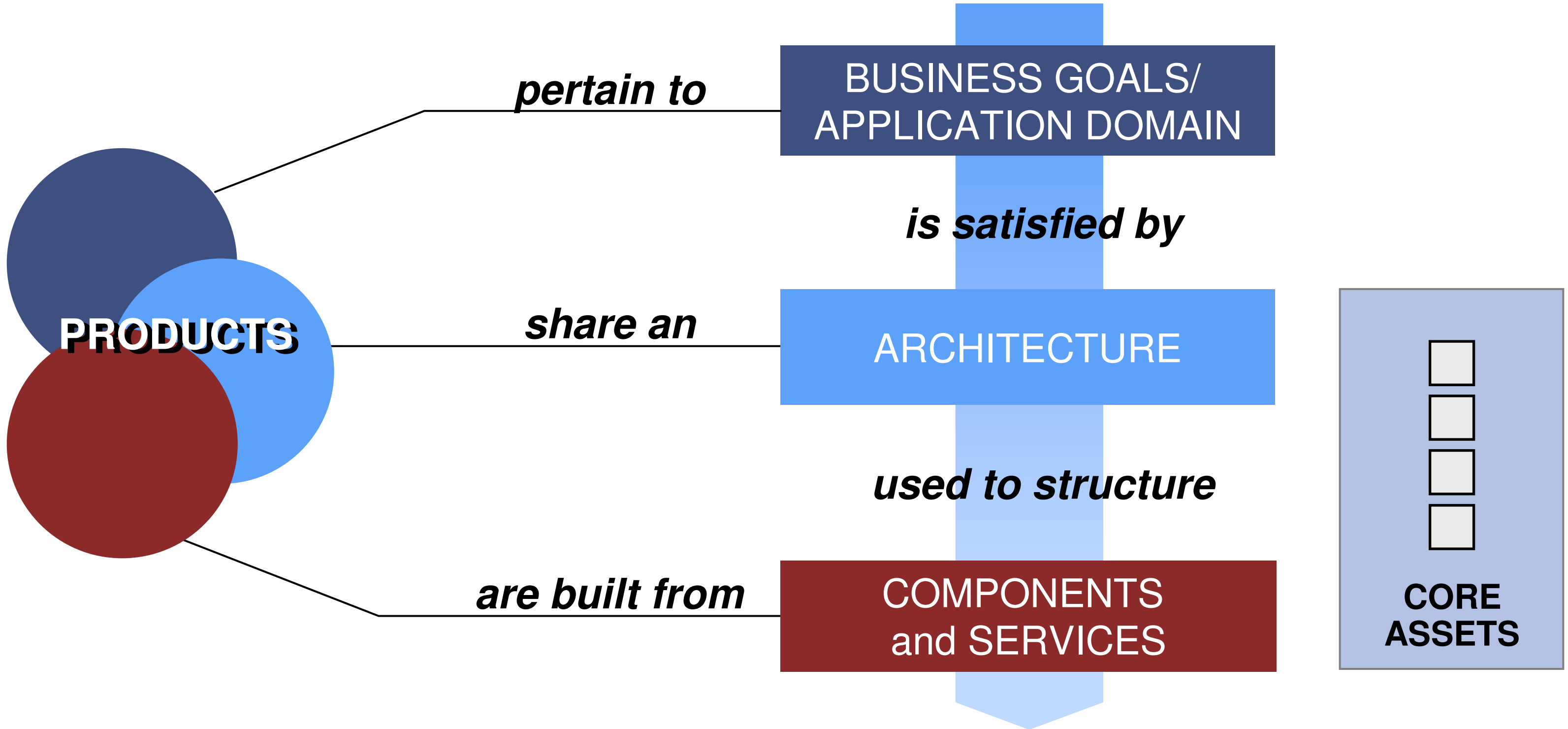
The systematic use of software product line practices results in significant organizational benefits including

- increased quality
  - by as much as 10x
- decreased cost
  - by as much as 60%
- decreased labor needs
  - by as much as 87%
- decreased time to market (to field, to launch...)
  - by as much as 98%
- ability to move into new markets
  - in months, not years

What Is A Software Product Line?

A software product line is a **set** of software-intensive systems sharing a **common, managed set of features** that satisfy the specific needs of a **particular market segment or mission** and that are **developed from a common set of core assets in a prescribed way.**

Software Product Lines

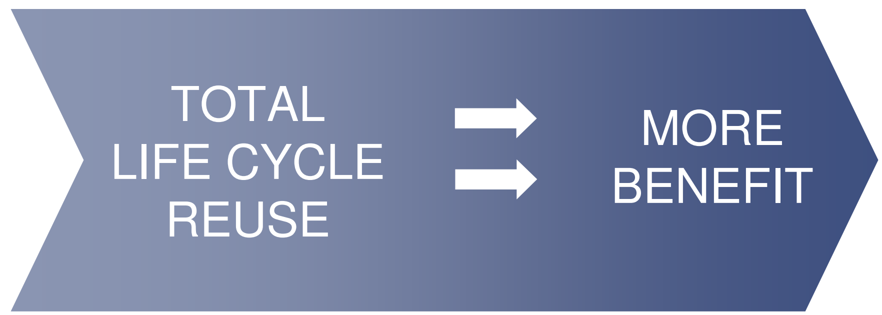


Product lines
- take economic advantage of commonality
- bound variation

How Do Product Lines Help?

Product lines amortize the investment
in these and other core assets:

- requirements and requirements analysis
- domain model
- software architecture and design
- performance engineering
- documentation
- test plans, test cases, and test data
- people: their knowledge and skills
- processes, methods, and tools
- budgets, schedules, and work plans
- components and services



PRODUCT LINES = STRATEGIC REUSE

Widespread Application - 1

akvasmart

Feed control and farm management software

BOEING

Bold Stroke Avionics

E-COM Technology Ltd.

Medical imaging workstations

hp invent

Firmware for computer peripherals

Lucent Technologies
Bell Labs Innovations

5ESS telecommunications switch

ABB **Asea Brown Boveri**

Gas turbines, train control, semantic graphics framework

Dialect

Internet payment gateway infrastructure products

ERICSSON

AXE family of telecommunications switches

LG

Elevator control systems

NOKIA

Mobile phones, mobile browsers, telecom products for public, private and cellular networks

AXIS COMMUNICATIONS

Computer printer servers, storage servers, network camera and scanner servers

DNV

Customized solutions for transportation industries

GM

Software for engines, transmissions and controllers

LSI LOGIC

RAID controller firmware for disk storage units

NASA

Interferometer product line

Widespread Application - 2

PHILIPS

High-end televisions,
PKI telecommunications switching system,
diagnostic imaging equipment

RICOH

Office appliances

BOSCH

Automotive gasoline systems

SALION TARGET. WIN. DELIVER.

Revenue acquisition management systems

SIEMENS

Software for viewing and quantifying radiological images

Rockwell Collins

Commercial flight control system avionics,
Common Army Avionics System (CAAS),
U.S. Army helicopters

TELVENT

Industrial supervisory control and business process management systems

testo

Climate and flue gas measurement devices

symbian

EPOC operating system

alltel FIDELITY NATIONAL FINANCIAL

Support software

NAVSEA WARFARE CENTERS

Test range facilities

U.S. ARMY

Command and control simulator for Army fire support

MOTOROLA

Pagers product line

SEI Product Line Practice (PLP) Initiative's Focus

Capitalize on the commonality across scores of families of similar systems to predictably and efficiently achieve business and mission goals by using effective software product line practices.

"Axioms" Guiding Our Work

- A product line approach is a proven strategy for exploiting the commonality among similar systems and achieving significant cost, schedule, agility, and quality benefits.
- Software product lines require specific technical and management practices.
- An architecture-centric approach is pivotal to software product lines.

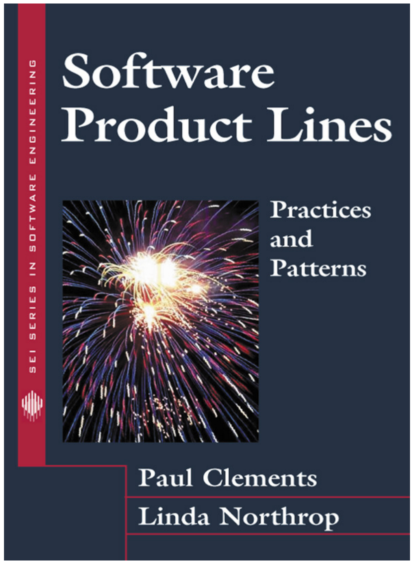
The SEI Framework For Software Product Line Practice℠

The SEI Framework for Software Product Line Practice is a conceptual framework that describes the essential activities and twenty-nine practice areas necessary for successful software product lines.

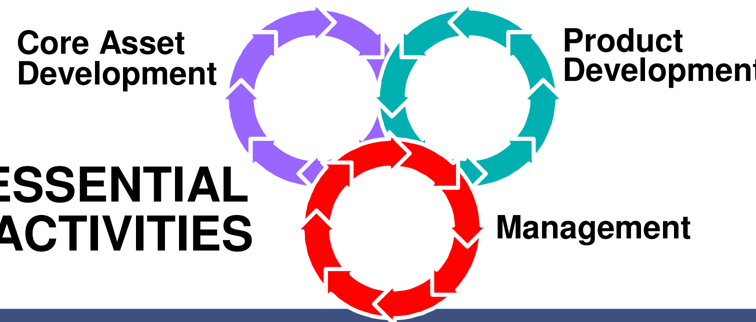
The Framework, originally conceived in 1998, is evolving based on the experience and information provided by the community.

Version 4.0 –
in *Software Product Lines: Practices and Patterns*

Version 5.0 –
www.sei.cmu.edu/productlines/framework.html



Framework Version 5.0



PRACTICE AREAS

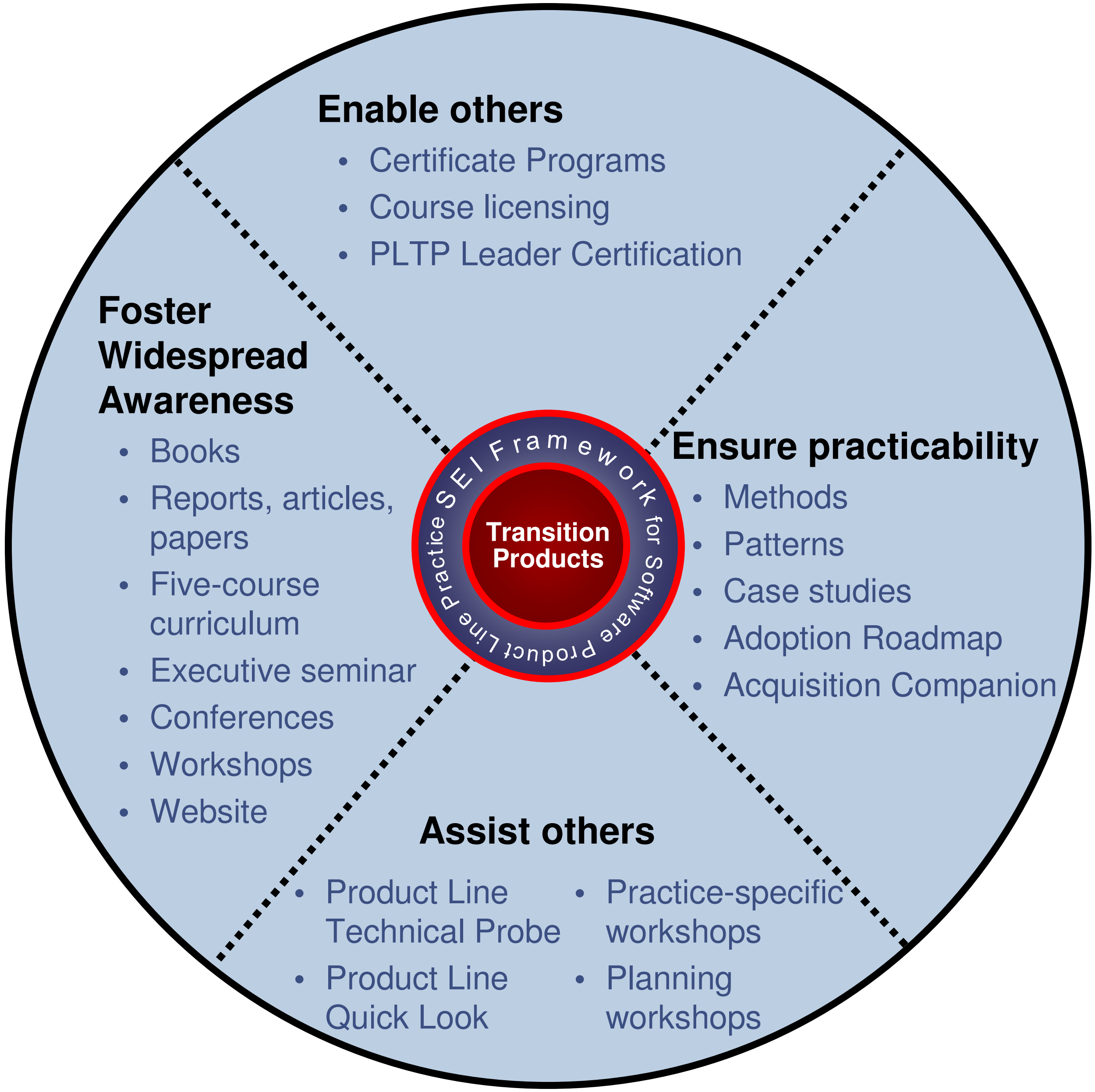
Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	Make/Buy/Mine/Commission Analysis	Customer Interface Management
Component Development	*Measurement and Tracking*	Developing an Acquisition Strategy
Mining Existing Assets	*Process Discipline*	Funding
Requirements Engineering	Scoping	Launching and Institutionalizing
Software System Integration	Technical Planning	Market Analysis
Testing	Technical Risk Management	Operations
Understanding Relevant Domains	Tool Support	Organizational Planning
Using Externally Available Software		Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training

Key:

New Name and Substantial Change

Substantial Change

PLP: Transition



Certificate Program Course Matrix

Requirements	*Three Certificate Programs* **Software Product Line Professional**	**PLTP Team Member**	**PLTP Leader**
Software Product Lines	✓	✓	✓
Adopting Software Product Lines	✓	✓	✓
Developing Software Product Lines	✓	✓	✓
PLTP Team Training		✓	✓
PLTP Leader Training			✓
PLTP Lead Observation			✓

Summary of SEI Contributions

Models and Guidance

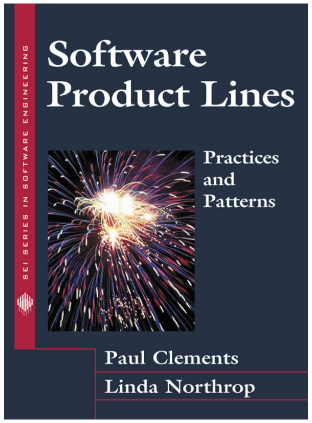
- *A Framework for Software Product Line Practice℠*
- *Software Product Line Acquisition: A Companion to A Framework for Software Product Line Practice*
- Product line practice patterns
- Product line adoption roadmap
- Pedagogical product line

Methods and Technology

- product line analysis
- architecture definition, documentation, evaluation (ATAM®), and recovery
- mining assets
- production planning
- Structured Intuitive Model for Product Line Economics (SIMPLE)
- Product Line Technical Probe℠ (PLTP℠)
- Product Line Quick Look (PLQL)
- Interactive workshops in product line measurement, variability management, product line management
- Prediction-enabled component technology

Book

Software Product Lines: Practices and Patterns



Curriculum and Certificate Programs

- Five courses and three certificate programs
- Product Line Executive Seminar

Conferences and Workshops

- SPLC 1, SPLC2, SPLC 2004; SPLC 2006; Workshops 1997 - 2005; Army Product Line Workshop 2007

Technical Reports, publications, and Web site

New Challenges

Challenge: Automating all or part of the product line production process.

Our Research:

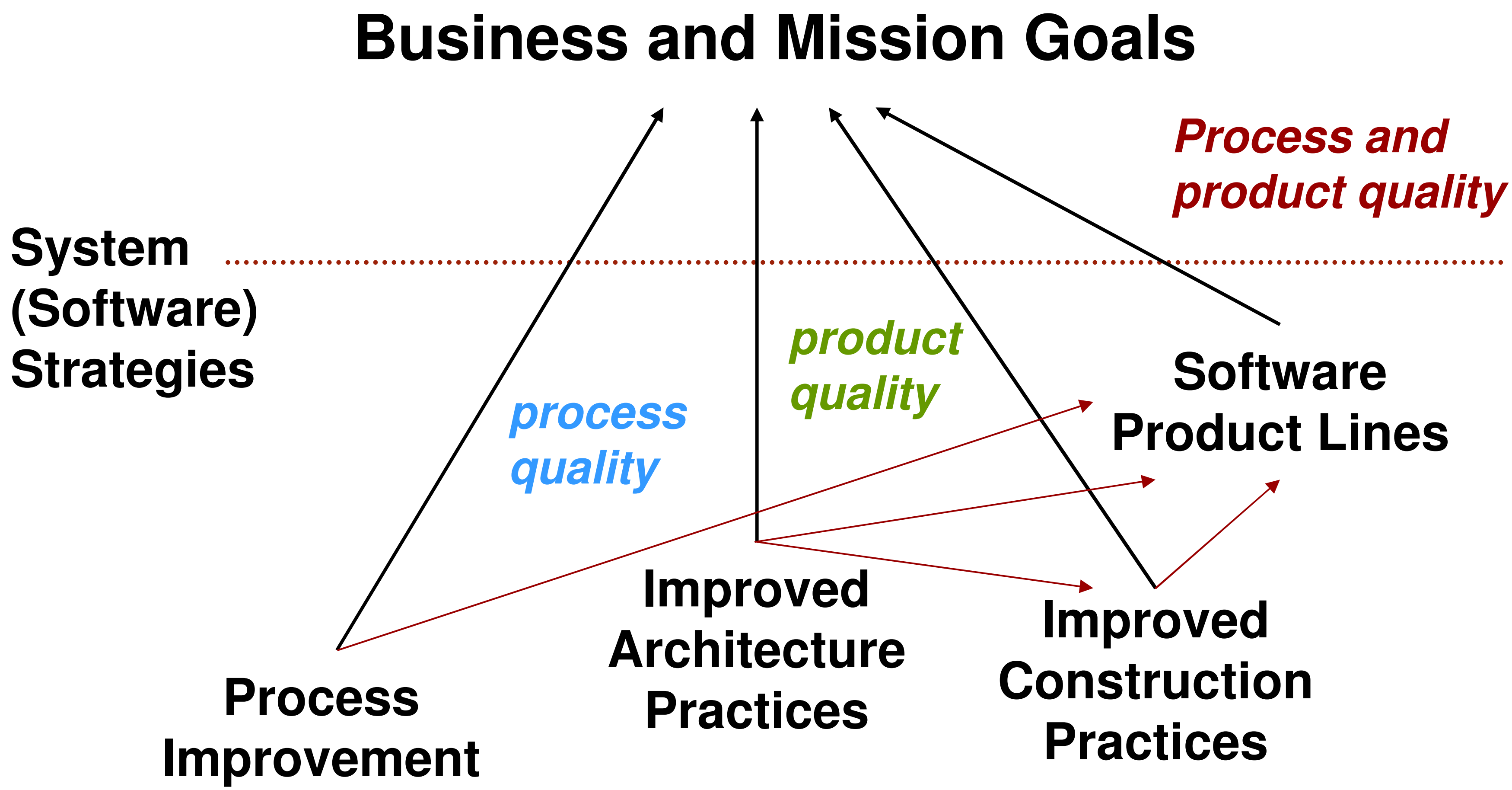
- Use of aspect-oriented programming to support product lines
- Product line production, including automated derivation

Challenge: Combining a software product line approach with new technologies and contexts

- System of systems
- Service-oriented architectures
- Open source
- Globalization
- Predictable assembly
- Ultra-large scale systems

Our Research: adapting software product line concepts to exploit new technologies and serve new contexts

The Total Picture



Today's Presentation

Software Architecture

(Software Architecture Technology Initiative)

Predictable Software Construction

(Predictable Assembly from Certifiable Code Initiative)

Software Product Lines

(Product Line Practice Initiative)

Ultra-Large-Scale Systems

Trend Toward Increasing Scale-1

- Enormous web service and computing infrastructure
- Supply chain systems
- Software-based engineering systems

Trend Toward Increasing Scale-2

Healthcare Infrastructure

Trend Toward Increasing Scale-3

Homeland Security

Trend Toward Increasing Scale-4

Networked Automobiles

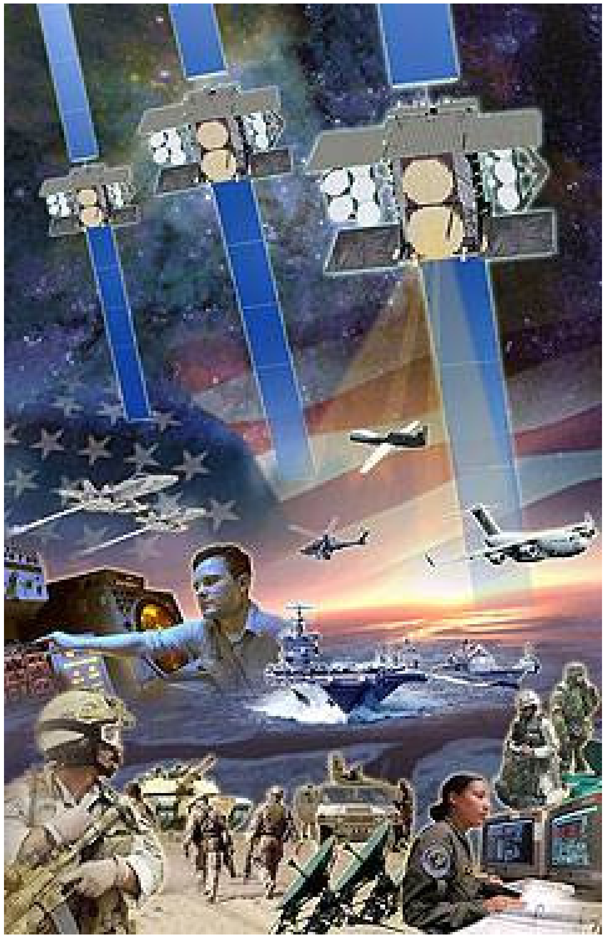
Trend Toward Increasing Scale-5

Saving the Environment

Increasing Scale In Military Systems

Increasingly Complex Systems

- ultra-large, network-centric, real-time, cyber-physical-social systems
  - thousands of platforms, sensors, decision nodes, weapons, and warfighters
  - connected through heterogeneous wired and wireless networks



Goal: *Information Superiority*

- *Transient and enduring resource constraints and failures*
- *Continuous adaptation*
  - changes in mission requirements
  - changes in operating environments
  - changes in force structure
  - perpetual systems' evolution
  - addition of new systems
- *Sustainable - legally, technically, politically*

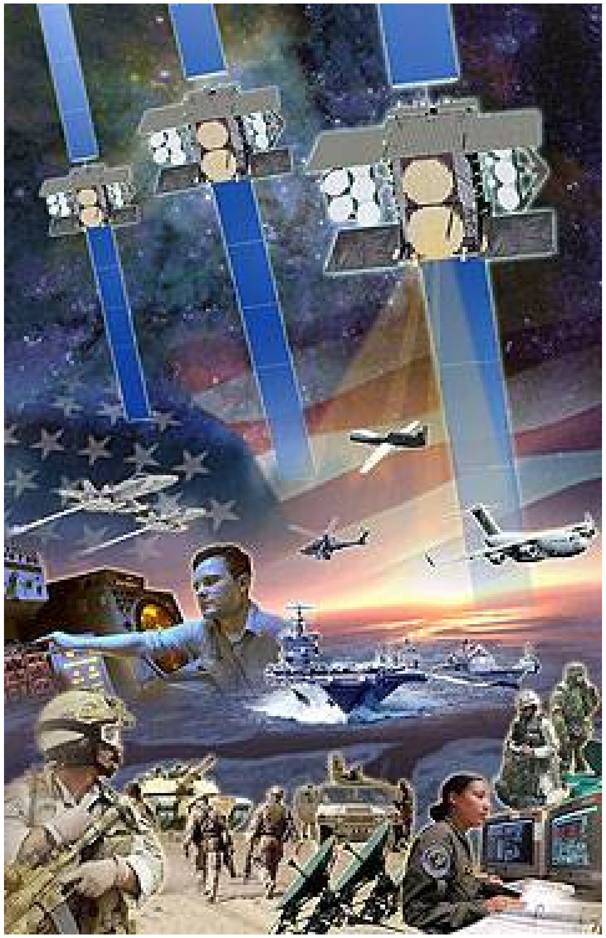
Ultra-Large-Scale (ULS) Systems Study

Gather leading experts to study:

- characteristics of ULS systems
- challenges and breakthroughs required
- promising research and approaches

Intended outcomes:

- ULS System Research Agenda
- program proposal
- collaborative research network



About the Effort

Funded by the Army (ASA ALT)

Staffing: 9 member SEI team
13 member expert panel

Duration: one year (04/05 -- 05/06)

ULS Systems Research Study Report

Acknowledgements

Executive Summary

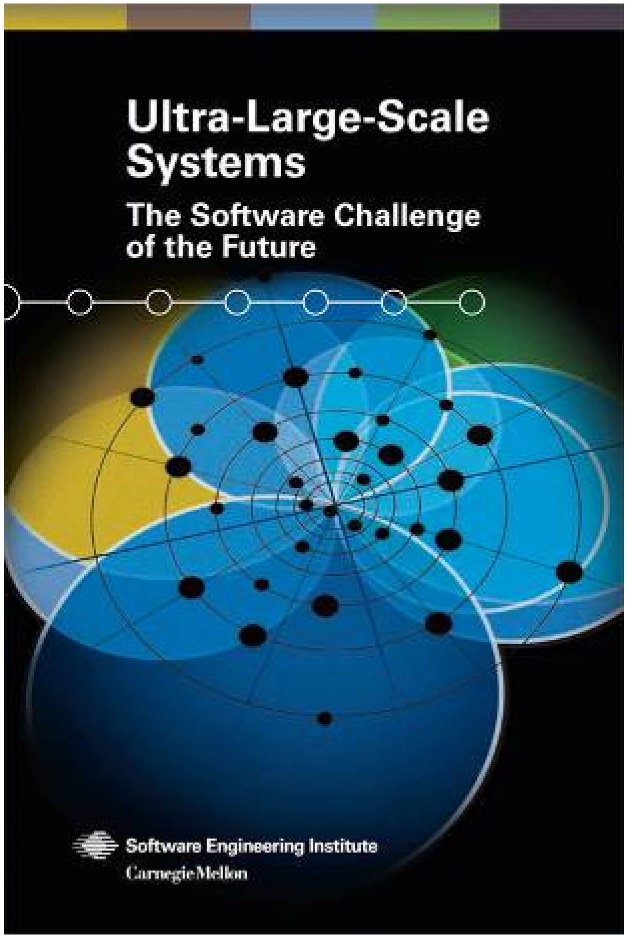
Part I

1. Introduction
2. Characteristics of ULS Systems
3. Challenges
4. Overview of Research Areas
5. Summary and Recommendations

Part 2

6 Detailed Description of Research Areas
- Glossary

http://www.sei.cmu.edu/uls/



How is This Study Different

It presents an overall research agenda -- not just for new tools or a new software method or modest improvements in today's approaches.

It is based on the challenges associated with ultra-large scale.

It focuses on the future.

It involves an interdisciplinary base.

It takes a fresh perspective on the development, deployment, operation, and evolution of software-intensive systems.

Germs of these ideas are present today in small research pockets; these efforts are currently too small to have much impact on next-generation ULS systems.

Study Conclusions

There are fundamental gaps in our current understanding of software development at the scale of ULS systems.

These gaps

- present profound impediments to the technically and economically effective achievement of the DoD goals* based on information superiority and to effective solutions for many of society's vexing problems
- require a broad, fresh perspective and interdisciplinary, breakthrough research

We recommend

- a ULS Systems Research Agenda that includes research areas based on a fresh perspective aimed at challenges arising from increasing scale

** As stated in the Quadrennial Defense Review (QDR) Report, Feb 2006*

Activity Since Report Published in May 06

There is growing community interest and research starts.

Since July 06

- more than 95,000 downloads of the report
- more than 3,000 copies of the report distributed
- more than 14 keynotes and more than 25 presentations by author team
- three press and one industry analyst interviews
- research workshops at OOPSLA 2006 and ICSE 2007
- NSF center established

New SEI Research Activities

- Mechanism design
- Implications of ULS on software architecture

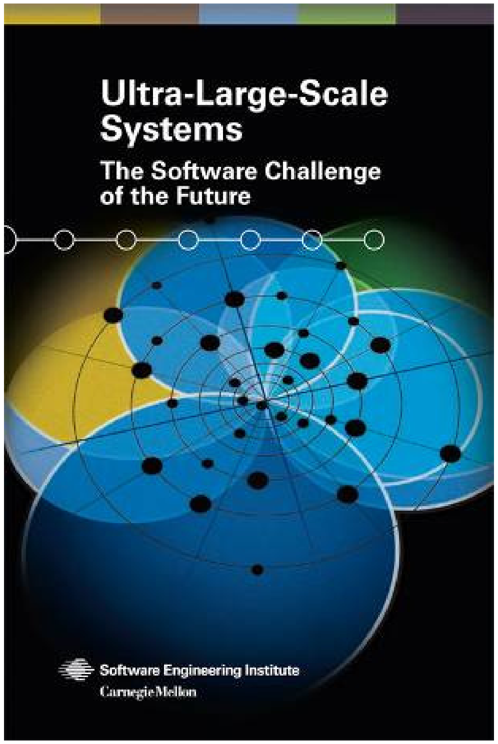
Roadmap Exercise funded by Army organization (CERDEC)

New book from a non-military perspective is underway.

SMART Event

Upcoming event:

- ICSE 2008 Workshop



http://www.sei.cmu.edu/uls

Redesign of SEI ULS Systems Website

New site features include

- Podcasts and video presentations
- ULS Systems news & events
  - RSS feed
- ULS Systems library
- Online Glossary

http://www.sei.cmu.edu/uls/

What We Learned That We Want to Share

- There is an unstoppable trend toward increasing scale in many systems important to our society.
- Scale changes everything.
- Manifestations of scale and its attendant complexity arise in many disciplines, and can be understood as a phenomenon in its own right.
- New, interdisciplinary perspective and new research in building ultra-large-scale systems is long overdue.

Working With The Product Line Systems Program

In the areas of software architecture, predictable construction, and/or software product lines, we can

- Help you solve specific problems
- Help you launch initiatives
- Help you improve your capabilities
- Conduct applied research that meets your needs
- Partner with you to create leading edge techniques, methods, and tools

In the area of ultra-large-scale systems, we would welcome your involvement as sponsors and/or as research partners.

For More Information

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Director

Product Line Systems Program

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