TSP[SM] on an Architecture-Driven Project

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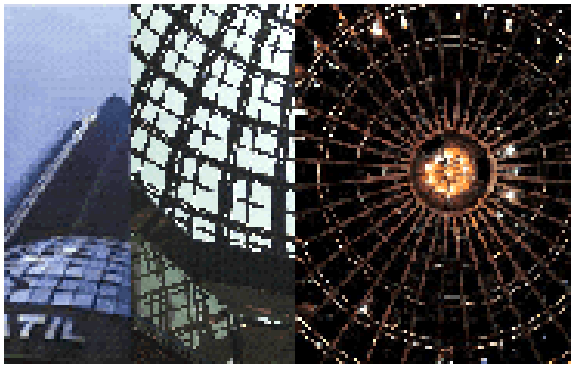
The Opportunity

Background:

- Bolsa Mexicana de Valores (BMV) operates the Mexican financial markets under license from the federal government.
- Bursatec is the technology arm of the BMV.
- BMV desired a new trading engine to replace the existing stock market engine and integrate the options and futures markets.
- The BMV performed a build vs. buy analysis, and decided to replace their three existing trading engines with one in-house developed system.

The Project -1



Bursatec committed to deliver a trading engine in 8-10 quarters:

- High performance (as fast or faster than anything out there)
- Reliable and of high quality (the market **cannot** go down)
- Scalable (able to handle both spikes and long-term growth in trading volume)

Bursatec approached the SEI for support during design & development.

SEI's role—provide methods, techniques, and guidance to improve Bursatec's software delivery capability:

- Training and coaching for the system architects
- Training and coaching for the development team

The Project -2

Architecture Decisions:

- Development in Java (lower TCO)
- Low Latency Communication Multicast Network
- In memory data storage during trading session.
- Hot-Hot High Availability configuration.
- Parallel processing in JVM
- Horizontal scalability

Functional Requirements:

- Order routing with FIX protocol.
- Interconnect to current legacy systems.
- Combined Cash and Derivatives markets with a single Control Workstation.
- Separate Market Data and Index calculation system.

Architecture Principles

ARCHITECTURE

An architecture of a system consists of structures (elements and relationships) and content (responsibilities of the elements).

The structures determine the ***quality attribute*** properties of the system and those properties either support or hinder the achievement of the business goals.

The content of the elements determines the functions the system can provide.

Architecting a system means designing the structures and elements of that system in such a way that the quality attribute properties as well as the functions exhibited by the system support the business goals.

Trading Engine Quality and Other Attributes

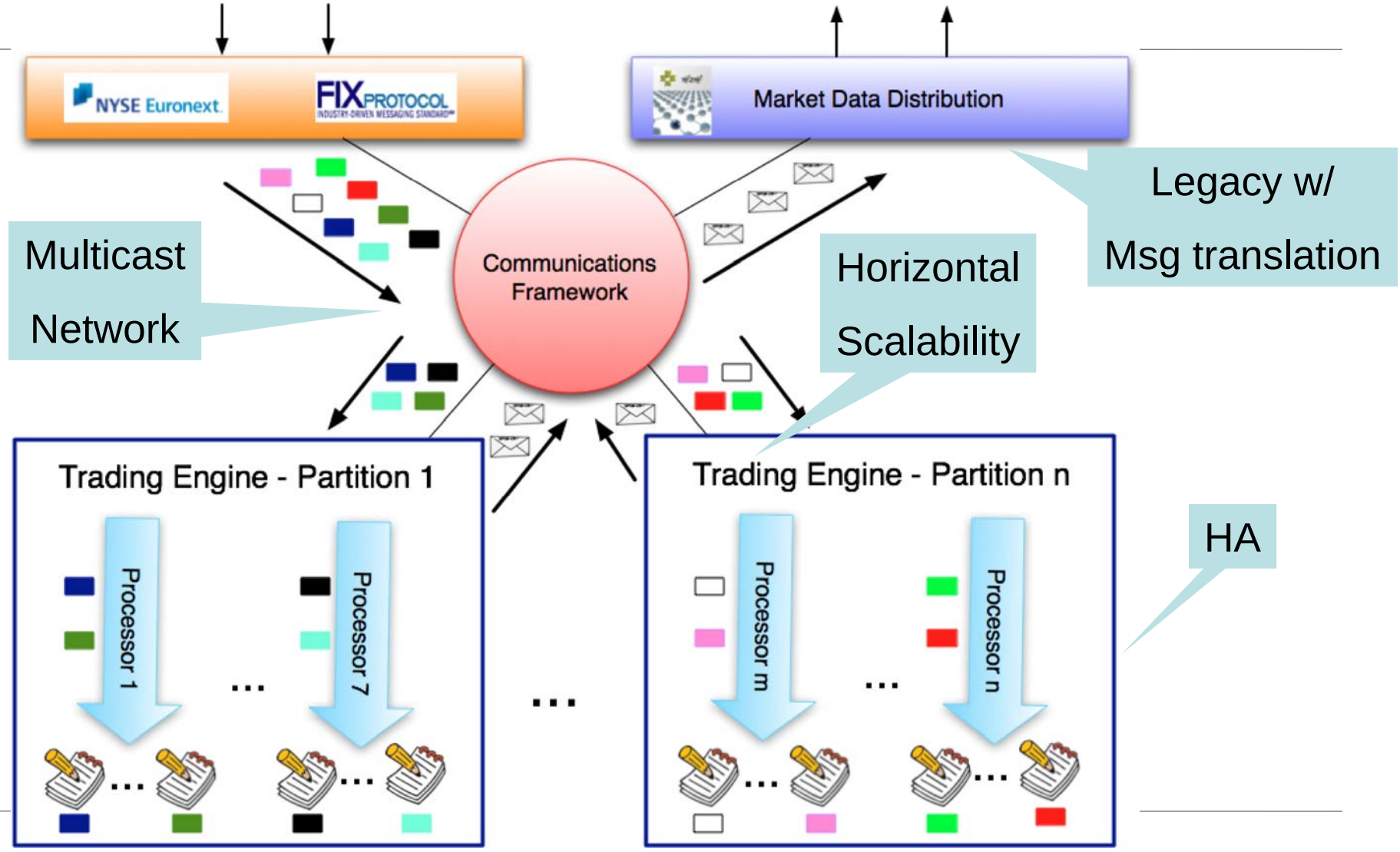
Quality Attributes

- Under 1ms processing latency
- Horizontal scalability
- Redundant HA system
- Warm DR system
- Automatic testing framework (one day turnaround attribute)
- Localize business rules changes in specific modules

Other Attributes

- Backward compatible with current systems
- Combined platform for both markets
- Run on Commodity hardware
- 86 order type/attribute combinations (30 in current system)
- Real time updates to status of system via Control Workstation.

Trading Engine



The Proposed Solution –
Integrates High-Value Architecture and Team Practices

Architecture-Centric Engineering

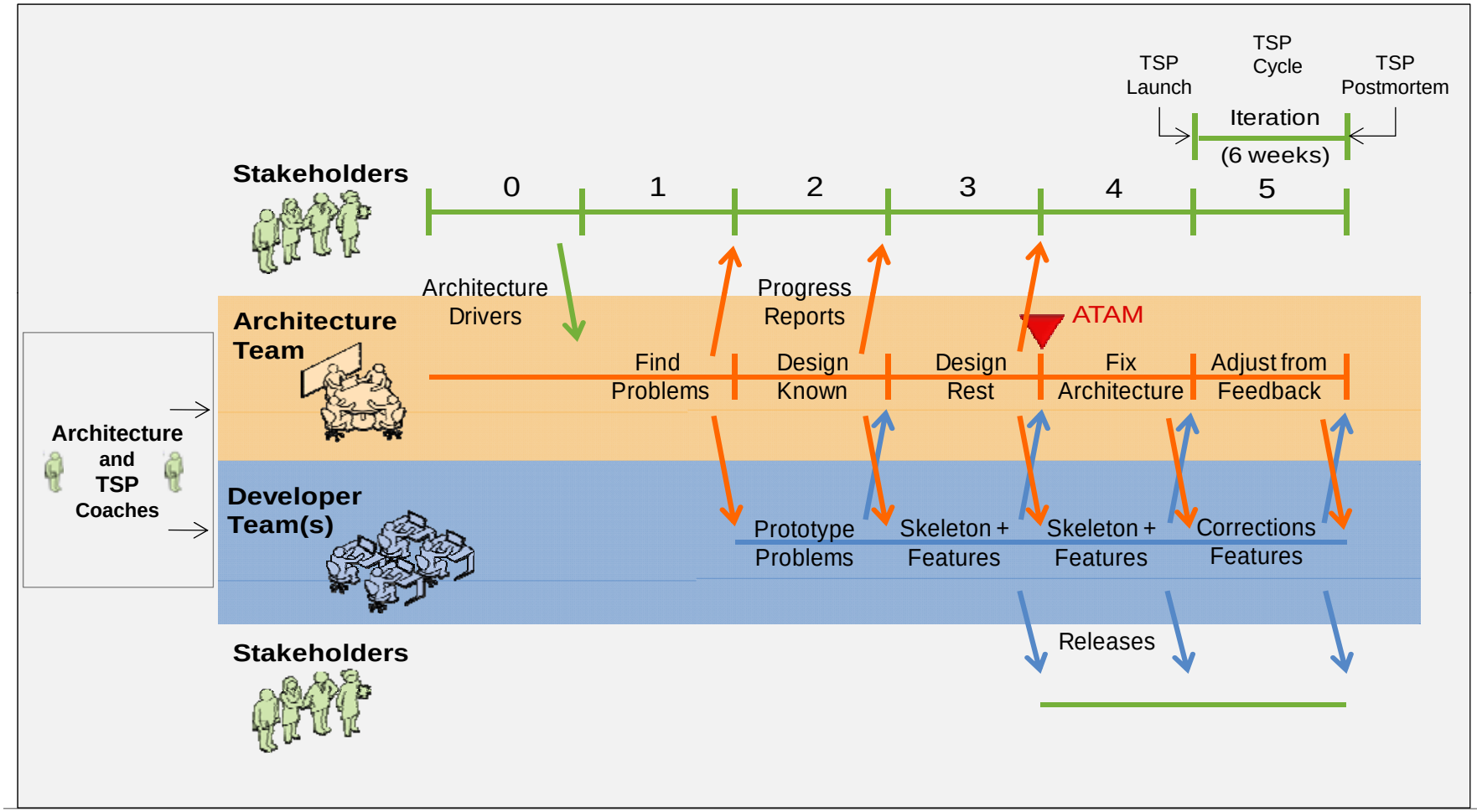
- Proven technology.
- Strongly addresses critical technical aspects of the early project lifecycle activities.
- Specific focus on architecting to meet business objectives.
- Key managers familiar with technology via training courses.

Team Software Process

- Proven technology.
- Strongly addresses management and measurement across the project lifecycle.
- Specific focus on building high-performance teams.
- Key managers familiar with technology only through word-of-mouth and literature.

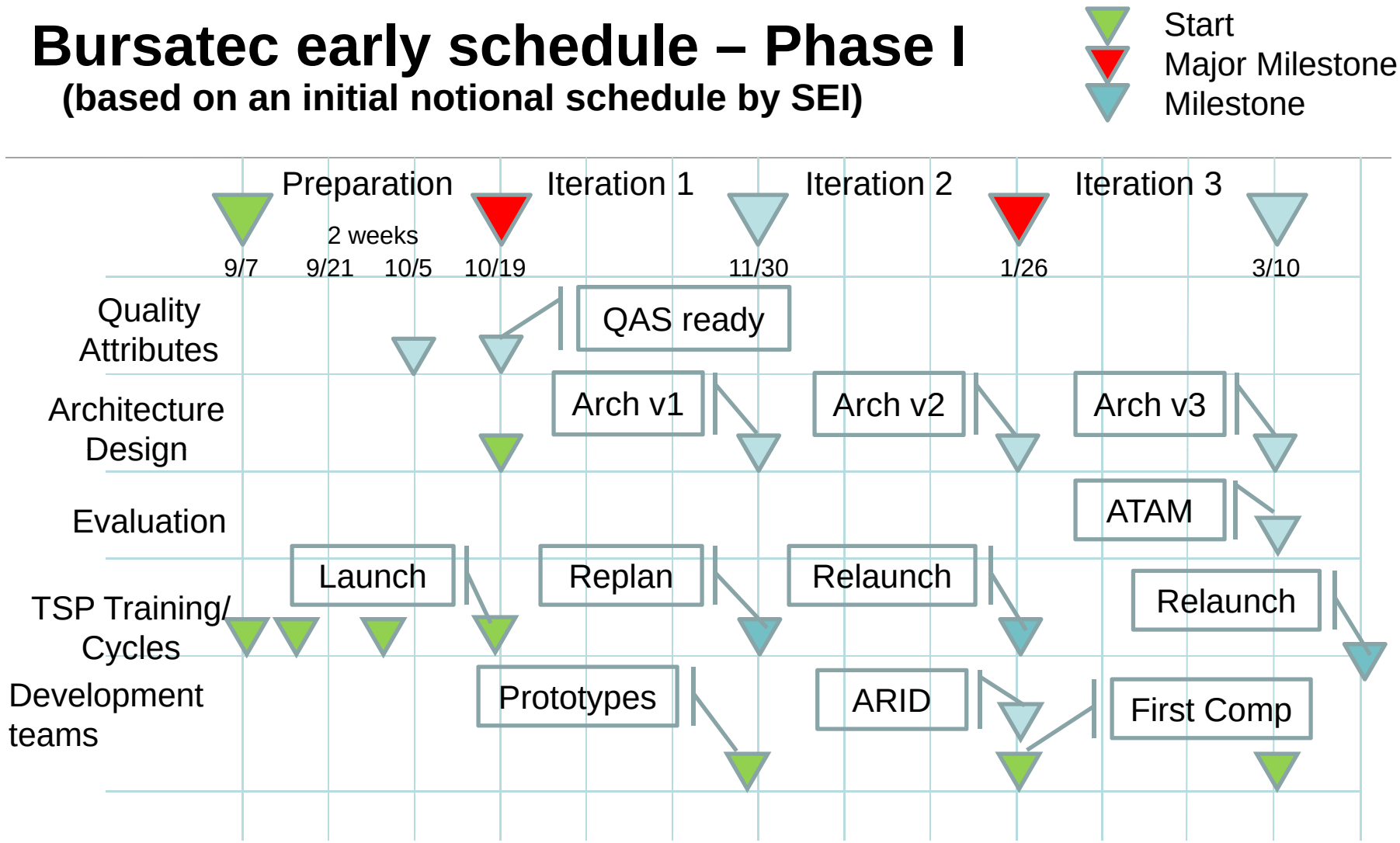
Architecure drove the work breakdown structure (WBS) and provided a robust framework for requirements management.

Example Design and Implementation Strategy

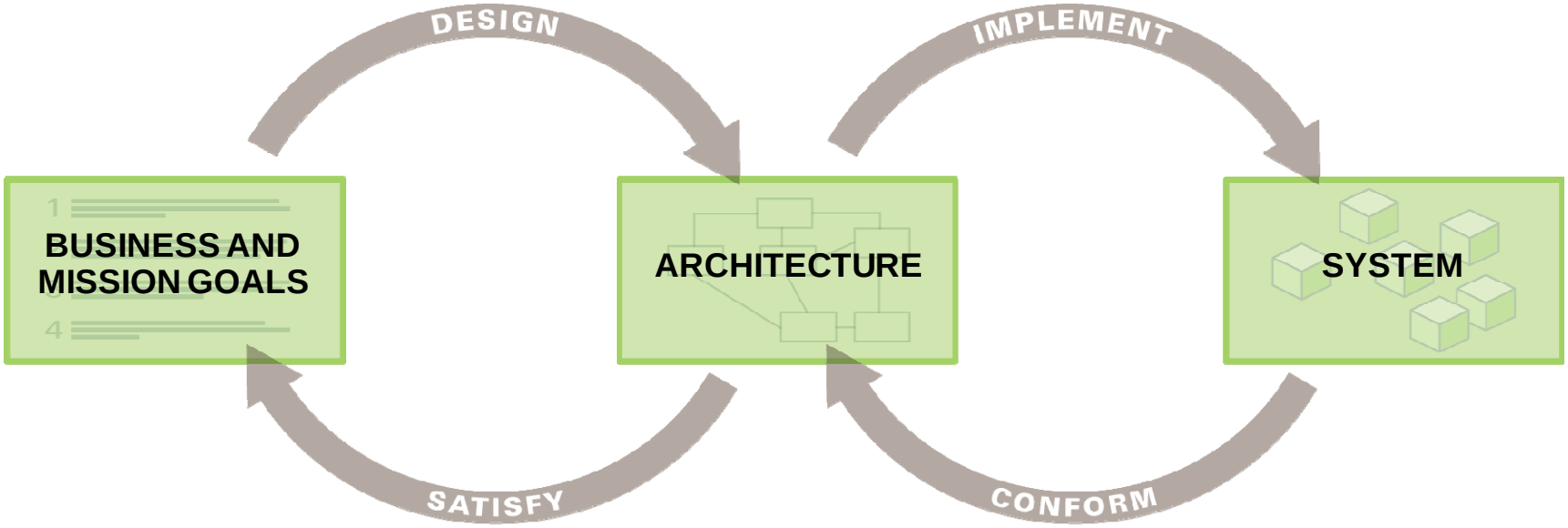


Bursatec early schedule – Phase I

(based on an initial notional schedule by SEI)



The Development Process

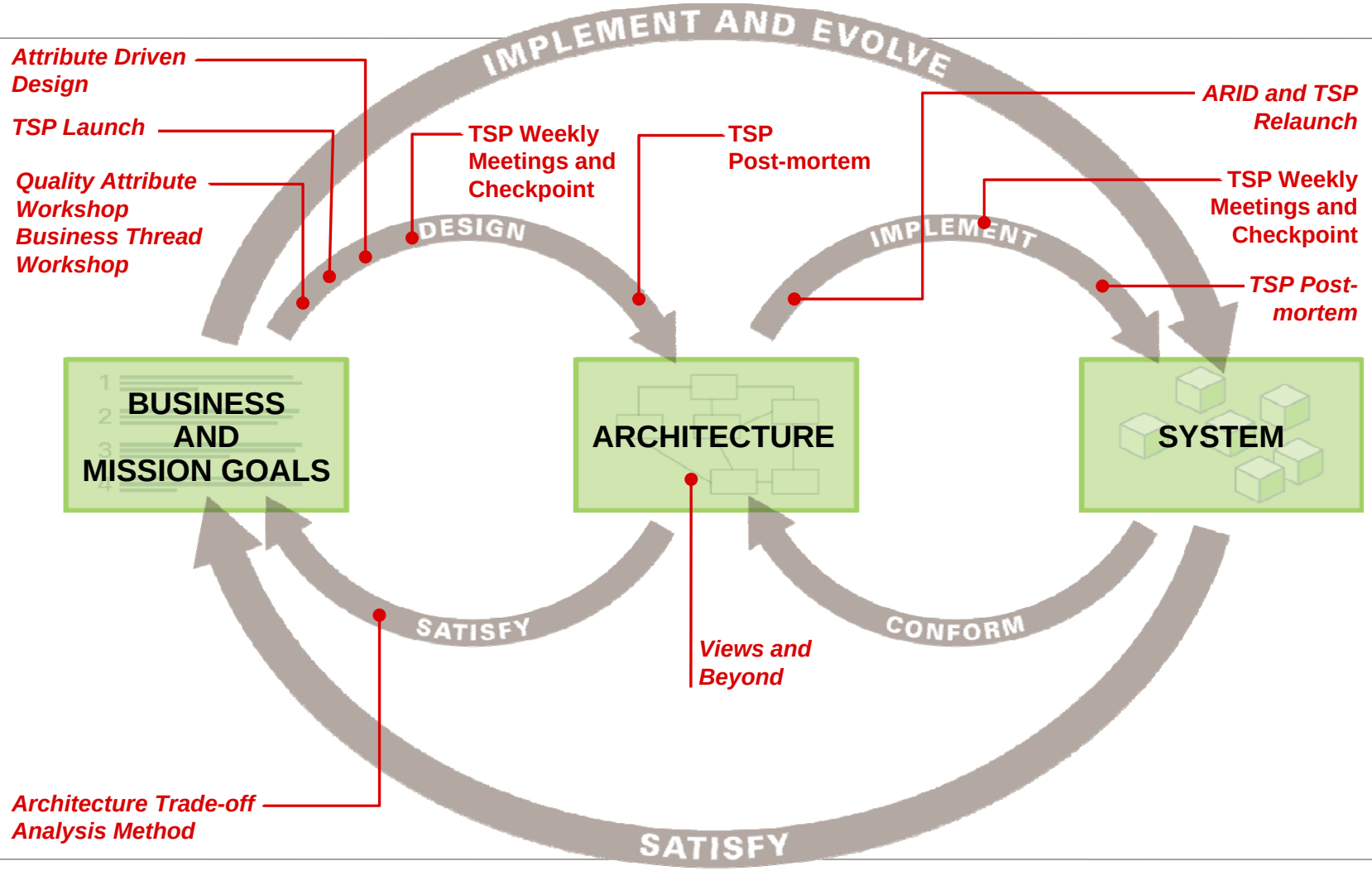


Two iterative processes based on the architecture of the system:

Design cycles (1, 2)
The goal is to design a system that ensures business success.

Implementation cycles (3, 5, 6)
The goal is to implement the system according to the design.

ACE / TSP Design, Analysis, and Implementation



Project History

Cycle 1 (Architecture) – Completed Jan. 2010 (on time), demonstrated architecture coaching for the first time, evaluation of comm. packages, built test framework

Cycle 2 (Infrastructure implementation) – Completed Apr. 2010 (on time), included successful ATAM in Mar. 2010 (documentation noticeably thorough, no significant new architectural risks discovered)

Cycle 3 (Basic functions and main performance loop) – Completed July 2010 (on time), good (not great) quality, performance exceeding requirements by more than a factor of 5

Cycle 4 (Non-TSP cycle, outside evaluation by world-class experts) – Completed Aug. 2010, JVM & high-speed redundant communications

Cycle 5 (Full normal operations, complete performance loop) – Completed Jan. 2011 (on time)

Cycle 6 (Full functionality incl. startup, shutdown, & maintenance modes) – Completed July 2011 (additional scope extended scheduled June finish)

Current Project Status – cont.

Cycle 7 – System Test / Integration Test

- On Time
- Integration Test with Legacy systems

Cycle 8 – Acceptance Test / Parallel Test

- Internal user testing / certification
- Scheduled to start in 4Q’2011

Cycle 9 – User Test / Deployment

- Brokerage firms testing , including functional, HA, throughput and DRP tests
- Scheduled to start late 2011

Go-Live Scheduled 2Q’2012

Select Process Data

Measured size through cycle 7 (actual)

- ~208 eKLOC in 24 months

Effort distribution through cycle 6 (% of task hours)

Cycle 1	Cycle 2	Cycle 3	Cycle 5	Cycle 6
14.4	4.9	19.4	32.5	28.8

Effort distribution through cycle 6 (% by “block activities”)

Mgt	Req	Arch	DLD	Code	Test	Other
3.7	17.5	12.0	18.5	32.2	14.5	1.5

25.3 % of all recorded task hours through cycle 6 were some form of review or inspection

Current Project - tools

- Unit Test in place
- Daily continuous integration – junit and TF
- Static analysis tools for Inspections and Architecture Integrity
  - Findbugs, Checkstyle and others
  - Code reviews – IDE plugins
  - Component dependency metrics,
  - Cyclomatic complexity
  - Coverage analysis
  - Performance analysis (Performance Manager)
  - GC analysis (GC Manager)
  - Security analysis

Current Project Status

- Very low defect count in System Test
- Defects encountered have not modified the Architecture
- Unit Test in place with high code coverage
- Testing Framework allowed a smooth continuous integration
- Regression tests done within the same day (except for multiday orders)
- Static analysis tools for Inspections and Architecture Integrity
- Latency and throughput metrics exceeded initial expectations

Key Takeaways

- Architecture and TSP were focused on core of the System: Matching Engine
- Other key components would have benefitted with TSP such as:
  - Message Format translator
  - Trading Terminal
- Most of the issues encountered have been with the interaction with legacy systems: Reporting, Billing, Market monitoring due to legacy fields.
- Requirements / Inspections could be done better (including DLD interfaces with Legacy systems) to have a better defect yield.

TSP Guidelines for Architecture Methods -1

Training (SEI courses – SAPP, DSA, SADA, ESA)

- *Software Architecture Principles & Practices (2 days or 11 hrs. online)*
- *Documenting Software Architectures (2 days – some concepts overlap with PSP design templates)*
- *Software Architecture Design and Analysis (2 days)*
- *Evaluating Software Architecture (2 days – can be replaced by an architecture coach; recommended for TSP coaches)*

TSP Guidelines for Architecture Methods -2

For first projects:

- An architecture coach is essential for inexperienced teams, replacing ESA training.
- ESA may be sufficient for experienced teams, especially if there is architecture expertise elsewhere in the organization.
- Expertise in defining and capturing quality attributes (QAW) and evaluating architectures (ATAM) is worth the price.

Architectural Process Assets

- Views & Beyond (taught in DSA) informs design standards.
- ADD (a subject in SADA) is the basic architecture design process.
- Lead Architect is more than a design manager.

Future Potential for TSP & Architecture

This is not a complete set of possible TSP adaptations of architecture processes.

Applying architecture methods to a large legacy system that requires significant enhancements demands different adaptations of the underlying principles.

Questions?

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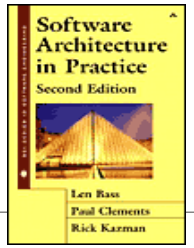
Intellectual Property

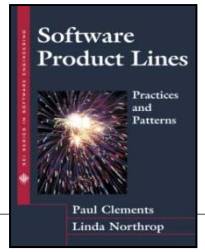
Personal Software Process, PSP, Team Software Process, and TSP are service marks of Carnegie Mellon University.

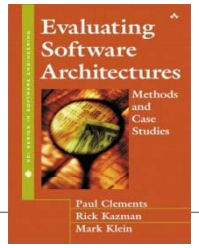
Architecture Tradeoff Analysis Method and ATAM are registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

Backup Slides

ACE Training







	CERTIFICATE PROGRAMS		CERTIFICATION
Requirements	**Software Architecture Professional**	**ATAM Evaluator**	**ATAM Leader**
Software Architecture: Principles and Practices course	●	●	●
Documenting Software Architectures course	●		●
Software Architecture Design and Analysis course	●		●
Software Product Lines course	●		
Software Architecture: Principles and Practices Exam	●	●	●
ATAM Evaluator Training course		●	●
ATAM Leader Training course			●
ATAM Observation			●

QAW/BTW – Building Quality Attribute Scenarios

The Quality Attribute Workshop (QAW) and Business Thread Workshop (BTW)

- bring together important internal and external stakeholders
- develop and validate key quality attribute scenarios that ***quantitatively*** define the most important ***non-functional*** requirements
- QAW focuses on developing quality attribute scenarios
- BTW focuses on business context to validate scenarios

Attribute-Driven Design (ADD) Method

ADD uses quality attribute scenarios to drive architectural design.

The process was time-boxed two ways.

- Six-week boxes to focus on
  - initial architectural (v1) while training architect team
  - refined architecture (v2) for early review or ATAM[1]
  - "complete" (not final) architecture (v3) for use by developers[2]
- Two-week boxes that focused on
  - developing the architecture
  - preparing for and performing ATAM-based peer-reviews with the "architecture coach"

1. ***Development team was launched at this point***
2. ***ATAM actually occurred at this point***

Views and Beyond for Architecture Documentation

"View and Beyond is not a method, but a collection of techniques:

1. Find out what architecture information stakeholders need.
2. Provide that information to satisfy the needs.
3. Capture the information in views, plus beyond-view information.
4. Package the information in a useful form to its stakeholders.
5. Review the result to see if it satisfied stakeholders' needs."

From the SEI class *Documenting Software Architectures,*
http://www.sei.cmu.edu/training/p33.cfm.

Active Review of Intermediate Designs (ARID)

An ARID was held in conjunction with a TSP relaunch.

The purpose of ARID is to

- put the architectural documents into the hands of developers
- ensure that the documents are fit for development use (right information recorded at sufficient level of detail)
- provide early “live” feedback to the architecture team

Architecture Trade-off Analysis Method (ATAM)

ATAM

- brings together a system's stakeholders
- evaluates the existing architecture with respect to the quality attribute scenarios
- focuses on surfacing architectural risks
- promotes & requires adequate documentation of the architecture

As mentioned previously, two-day ATAM-based peer-reviews were used by the architecture coach during development.

- on-the-job training for architecture team
- forced adequate documentation from the start
- fewer risks surfaced at formal ATAM than expected for size/scope of project

The Work

Type	Duration	Purpose	Tasks
I. Architectural Design and Analysis	During architecture development Months 1-6 of project	Launch the project team Build architecture and development skills	•Architecture Coaching including Launch •Quality Attribute Requirement Refinement •Architectural Design (iterative) •Quality Attribute Modeling •Documentation Support •Architecture Review •PSP / TSP Introductory Training
II Implementation Support	During software development Months 6-18 of project	Keep the project on track and develop a quality trading engine, on-time.	•Architecture Coaching, Focusing on Review of Development Infrastructure •TSP Team Launches (2 teams) •Weekly TSP Development Team Coaching •Architectural Conformance Verification •Quality Attribute Modeling •TSP Cycle End / Team Re-Launch (2 teams)
III Architecture support, development support, and self-sustainment support	Remaining life of project Months 18-30 of project	Provide architectural support s needed and develop TSP self-reliance.	•Architectural Support (as necessary) •Continued TSP Team Coaching •PSP Advanced Programming Course •TSP Coach Development •TSP Instructor Development