Software Design and Architecture

[Architecture and Design Evaluation] – Chapter 08, L01

Lecture Outlines

- **Previously- Design Patterns**
- Architecture Evaluation
- Benefits of Architecture Evaluation
- Methods of Architecture Evaluation
- ATAM Evaluation

Software Architecture Evaluation*

- The **architecture** design is the **foundation** of any software system.
- It defines the structure of the system through its underlying components and their relationship as well as the properties and behavior that are exposed to the external world.
- The software architecture is basically shaped by the following drivers: **functional requirements**, **non-functional requirements** and **business constraints**.

*Source: https://johnolamendy.wordpress.com/2011/08/12/evaluate-the-software-architecture-using-atam/

Software Architecture Evaluation

- In order to run a successful project with a high quality software product, it is important to validate the architectural design in advance
- The earlier we find a problem in the design phase, the better (less cost to fix an error)
- Software architecture (*architectural decisions*) should be evaluated before the construction phase begins .

Benefits of Architecture Evaluation

- Results in prioritization of conflicting goals
- Forces clear explanation of architecture
- Improves quality of architecture documentation
- Uncovers opportunities for cross-project reuse
- Results in improved architecture practices

Major Architectural Evaluation Methods

- Today, we have several methods to evaluate the software architecture :
  - ✓**ATAM**: Architecture Tradeoff Analysis Method
  - ✓**SAAM**: Software Architecture Analysis Method
  - ✓**ARID**: Active Reviews for Intermediate Designs
- These methods, have in common, the use of scenarios and quality attribute in the evaluation process

ATAM Evaluation Method

- The Architecture Tradeoff Analysis Method (**ATAM**), is one of the most used architectural decision method.
- The purpose of **ATAM** is to assess the consequences of architectural decisions in light of quality attribute requirements and business goals.
- This means discovering risks where a quality attribute of interest is affected by architectural decisions (a trade-off between the quality attributes).

ATAM Evaluation Method – Quality attributes Re-visited

- One important concept related to any architecture evaluation method is the **quality attribute**.
- In complex systems, quality attributes can never be achieved in isolation.
- In order to achieve one quality, other quality is affected (sometimes negative and sometimes positive).
- So … the architectural decisions are really **a trade-off** between the quality attributes in order to support the business goals.

ATAM Evaluation Method - Quality attributes Re-visited

- We can group the quality attributes into three main categories:
  - ✓ **End-user perspective**: performance, availability, usability and security
  - ✓ **Technical perspective**: modifiability, portability, reusability, testability, interoperability
  - ✓ **Business community perspective**: time to market, cost and benefits, projected life time, project budget
- In order to evaluate the software architecture using quality attributes, we need to characterize them in a proper way using quality attribute **scenario**. (see Chapter 3 slides for details about attribute scenarios)
- Then, a quality attribute scenario can be used to prioritize the quality attributes.

ATAM Evaluation Method – Participants

- In order to execute the ATAM process correctly, we need three groups cooperating each other:
  - ✓ **Evaluation team:** A group of experienced architects (three to five people)
  - ✓ **Project decision makers:** People with the authority to make changes in the project (project manager, customer, manager)
  - ✓ **Architecture stakeholders:** People interested in a good architecture for doing correctly there job (developers, testers, integrators, maintainers, performance engineering and users)

ATAM Evaluation - Team Roles

Role	Responsibilities
Team leader	Sets up the evaluation; coordinates with client, making sure client's needs are met; establishes evaluation contract; forms evaluation team; sees that final report is produced and delivered (although the writing may be delegated)
Evaluation leader	Runs evaluation; facilitates elicitation of scenarios; administers scenario selection/prioritization process; facilitates evaluation of scenarios against architecture; facilitates on-site analysis
Scenario scribe	Writes scenarios on flipchart or whiteboard during scenario elicitation; captures agreed-on wording of each scenario, halting discussion until exact wording is captured
Proceedings scribe	Captures proceedings in electronic form on laptop or workstation: raw scenarios, issue(s) that motivate each scenario (often lost in the wording of the scenario itself), and resolution of each scenario when applied to architecture(s); also generates a printed list of adopted scenarios for handout to all participants
Questioner	Raises issues of architectural interest, usually related to the quality attributes in which he or she has expertise

ATAM Evaluation Method – Steps

- The ATAM evaluation process consist of 9 steps:
  1. Present the ATAM method
  2. Present the business drivers
  3. Present the architecture
  4. Identify architectural approaches
  5. Generate quality attribute utility tree
  6. Analyze architectural approaches

ATAM Evaluation Method – Steps (cont.)

- The rest of the ATAM evaluation process steps:
  7. Brainstorm and prioritize scenarios
  8. Analyze architectural approaches
  9. Present results

ATAM Evaluation – Phases

Phase	Activity	Participants	Typical duration
0	Partnership and preparation: Logistics, planning, stakeholder recruitment, team formation	Evaluation team leadership and key project decision-makers	Proceeds informally as required, perhaps over a few weeks
1	Evaluation: Steps 1-6	Evaluation team and project decision-makers	1-2 days followed by a hiatus of 2-3 weeks
2	Evaluation: Steps 7-9	Evaluation team, project decision makers, stakeholders	2 days
3	Follow-up: Report generation and delivery, process improvement	Evaluation team and evaluation client	1 week

ATAM Evaluation Method – Output

- The **output** of the ATAM method must include at least the following artifacts:
  - ✓ **The documentation of the selected architecture**: the key artifact to specify the architecture is the SAD (Software Architecture Document)
  - ✓ **An evaluation report that**:
    - Recaps the ATAM process
    - Captures the scenario analysis (quality requirements captured in the form of scenarios).
    - Explains the candidate architectures and the underlying rationale in the architectural decision process to select the right architecture and a summary of all the work done.

ATAM Steps .. In more details …

Step 1. Present the ATAM method

- The evaluation team presents an overview of the ATAM process such as:
  - ✓ The **key steps**, techniques (e.g. utility tree generation, architecture elicitation and analysis, scenario brainstorming).
  - ✓ The expected **output** (architectural approaches, utility tree, scenarios, risks, sensitivity points).

Step 2. Present the business drivers

- The project decision maker presents the system from the business point of view including the following information:
  - ✓ Business **goals** and context
  - ✓ Major **stakeholders**
  - ✓ High-level **functional requirements** (described as use cases or user stories) that impact on the system architecture
  - ✓ Most important **quality attributes** (described as quality scenarios) that impact on the system architecture
  - ✓ **Constraints** such as technical, managerial, economic and political

Step 3. Present architecture

- The lead architect makes a presentation describing the **architectural** approach used to meet the requirements and the constraints.
- In order to describe the architecture, it's very useful to use the **4+1** architectural view model (see Chapter 02, L03)
- This view model describes the contextual view (e.g. relationship with humans and other systems), the logical view (module, layers, relationship), process view (e.g. process, threads, data flow, events) and deployment view (CPU, storage, devices, network).
- And finally, describe **risks** associated in order to meet the architectural requirements.

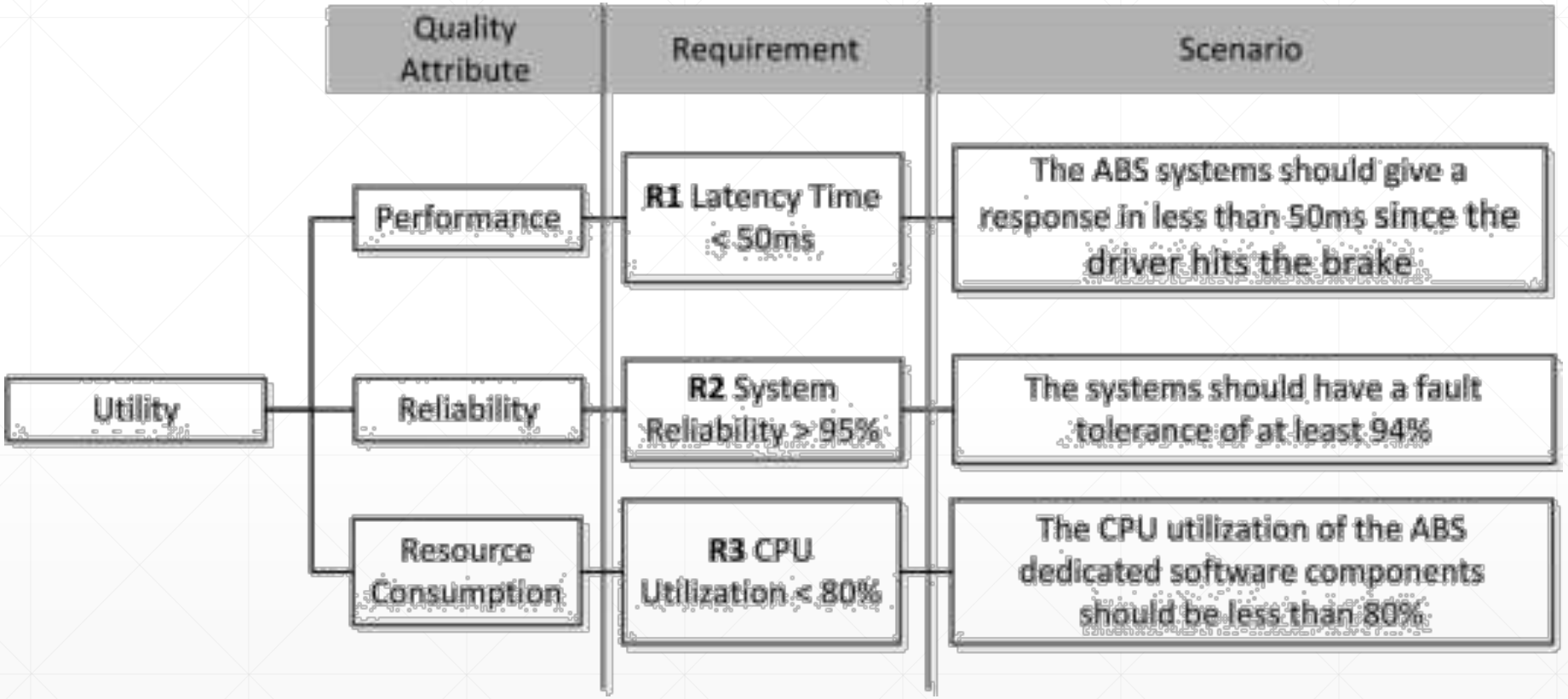
Step 4. Identify architectural approaches

- The evaluation team tries to identify what key architectural approaches (**patterns**) are used for realizing the requirements and constraints.
- Possible architectural approaches like: client-server, multi-layer application, pipes-filters, etc.
- In this step, the evaluation team **analyzes** deeply the **architecture** presented in the step 3, and then it has a good idea of what patterns and approaches the architect used at designing the system.

Step 5. Generate quality attribute utility tree

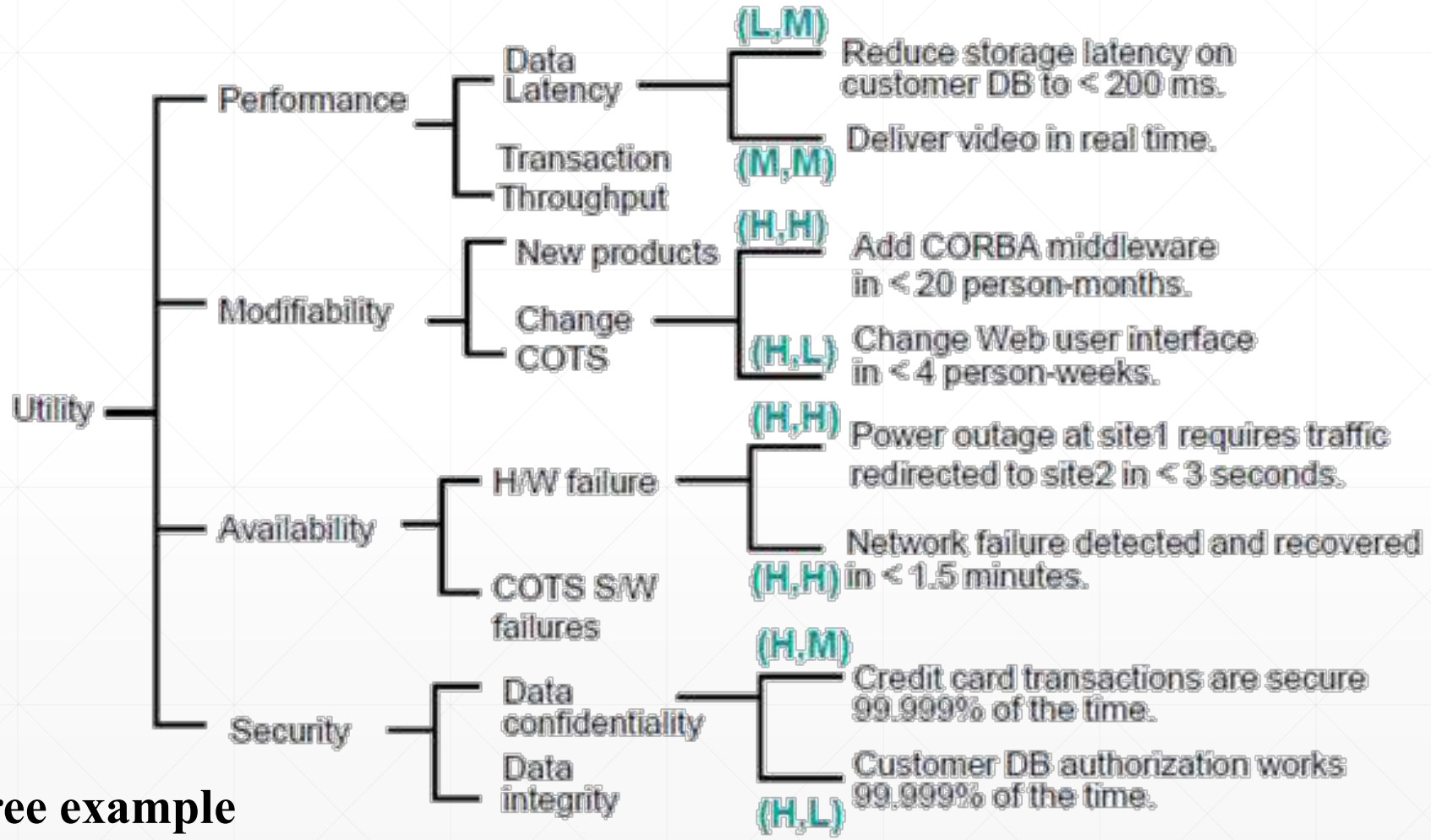
- In this step, the evaluation team (along with the project decision maker) identifies, prioritizes and refines the most important quality attribute goals (expressed by quality scenario) by building a utility tree.
- **A utility tree** is top-down approach for characterizing the quality attribute requirements, selecting the most important quality goals to be the high-level nodes (*performance, security, availability, modifiability, maintainability*) and the leaves of the tree are quality scenarios evaluated by important (success of the system) and difficulty (architect's assessment).

Step 5. Generate quality attribute utility tree (cont.)



Utility tree example

Step 5. Generate quality attribute utility tree (cont.)

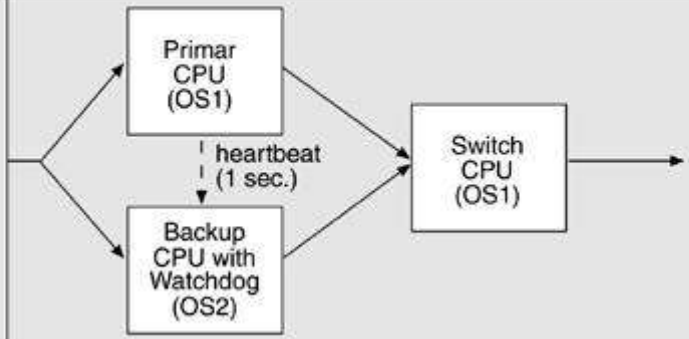


Utility tree example

Step 6 – Analyze Architectural Approaches

- In this step, the evaluation team examines the highest-ranked scenarios one at time in order to understand how the proposed architecture supports each one.
- The team also identify and document the architecture decisions and its rationale, risks, non-risks, sensitivity points and tradeoffs with regards to quality attributes.
- This information can be recorded using the form shown in the next slide, where the analysis of the architecture approach for a scenario is captured.

Step 6 – Analyze Architectural Approaches (cont.)

Scenario #: A12	Scenario: Detect and recover from HW failure of main switch.			
Attribute(s)	Availability			
Environment	Normal operations			
Stimulus	One of the CPUs fails			
Response	0.999999 availability of switch			
Architectural decisions	Sensitivity	Tradeoff	Risk	Nonrisk
Backup CPU(s)	S2		R8	
No backup data channel	S3	T3	R9	
Watchdog	S4			N12
Heartbeat	S5			N13
Failover routing	S6			N14
Reasoning	Ensures no common mode failure by using different hardware and operating system (see Risk 8) Worst-case rollover is accomplished in 4 seconds as computing state takes that long at worst Guaranteed to detect failure within 2 seconds based on rates of heartbeat and watchdog Watchdog is simple and has proved reliable Availability requirement might be at risk due to lack of backup data channel ... (see Risk 9)			
Architecture diagram				

Step 7 – Brainstorm and prioritize scenarios

- In this step, the stakeholders brainstorm scenarios that are operationally meaningful with respect to the stakeholders' individual roles.
- The purpose of scenario brainstorming is to take the pulse of the larger stakeholder community: to understand what system success means for them.
- Once the scenarios have been collected, they are prioritized by voting.
- The list of prioritized scenarios is compared with those from the utility tree exercise:
  - ✓ If they agree, it indicates good alignment between what the architect had in mind and what the stakeholders actually wanted.
  - ✓ If additional driving scenarios are discovered—and they usually are—this may itself be a risk, if the conflict is large. This would indicate that there was some disagreement in the system's important goals between the stakeholders and the architect.

Step 8 – Analyze Architectural Approaches

- In this step, the evaluation team guides the architect in the process of carrying out the highest ranked scenarios from step 7.
- The architect identifies how the architectural approaches are impacted by the scenarios generated in the previous step.
- Risks, non-risks, sensitivity points and tradeoffs continue to be identified and architectural decisions are specified.

Step 9 – Present Results

- And finally, the information generated by the ATAM process needs to be presented to stakeholders.
- The evaluation team can write a report and present the ideas with slides.
- The lead architect must report the business context and drivers, requirements and constraints.
- As well as the documentation of the selected architecture, the set of prioritized scenarios, the utility tree and the discovered risks, non-risks, sensitivity points and tradeoffs.

A Lightweight ATAM

- A Lightweight Architecture Evaluation method have been developed which is based on the ATAM, for smaller, less risky projects.
  - ✓ May take place in a single day, or even a half-day meeting.
  - ✓ May be carried out entirely by members internal to the organization.
  - ✓ However, this lower level of scrutiny and objectivity may not probe the architecture as deeply.
- Because the participants are all internal to the organization and fewer in number than for the ATAM, giving everyone their say and achieving a shared understanding takes much less time.
- The steps and phases of a Lightweight Architecture Evaluation can be carried out more quickly.

A Lightweight ATAM - Agenda

Step	Time	Notes
1. Present the ATAM	0 hours	Participants already familiar with process.
2. Present business drivers	0.25 hours	The participants are expected to understand the system and its business goals and their priorities. A brief review ensures that these are fresh in everyone's mind and that there are no surprises.
3. Present architecture	0.5 hours	All participants are expected to be familiar with the system. A brief overview of the architecture, using at least module and C&C views, is presented. 1-2 scenarios are traced through these views.
4. Identify architectural approaches	0.25 hours	The architecture approaches for specific quality attribute concerns are identified by the architect. This may be done as a portion of step 3.
5. Generate QA utility tree	0.5- 1.5 hours	Scenarios might exist: part of previous evaluations, part of design, part of requirements elicitation. Put these in a tree. Or, a utility tree may already exist.
6. Analyze architectural approaches	2-3 hours	This step—mapping the highly ranked scenarios onto the architecture—consumes the bulk of the time and can be expanded or contracted as needed.
7. Brainstorm scenarios	0 hours	This step can be omitted as the assembled (internal) stakeholders are expected to contribute scenarios expressing their concerns in step 5.
8. Analyze architectural approaches	0 hours	This step is also omitted, since all analysis is done in step 6.
9. Present results	0.5 hours	At the end of an evaluation, the team reviews the existing and newly discovered risks, nonrisks, sensitivities, and tradeoffs and discusses whether any new risk themes have arisen.

Summary

- In this session, we presented:
  - ✓ Architecture Evaluation
  - ✓ Benefits of Architecture Evaluation
  - ✓ Methods of Architecture Evaluation
  - ✓ ATAM Evaluation