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Architecture Tradeoff Analysis Method® (ATAM®) Evaluator Training

SKAO/SDP Version

DM18-0699

Introductions

Instructor Introductions

Participant Introductions

- Name
- Position
- Background
- Architecture/Design Experience
- Role in Architecture Activities
- Architecture Evaluation Experience

Course Objectives

To understand:

- How to organize and execute TM-tailored version of the ATAM evaluation
  - The steps of the ATAM
  - The roles and responsibilities of the various participants during an ATAM evaluation
  - Artifacts created during an ATAM evaluation

What constitutes a Software Architecture?

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

Why Analyze an Architecture?

All design involves tradeoffs.

A software architecture is the earliest life-cycle artifact that embodies significant design decisions: *choices and tradeoffs*.

We can predict a system's quality attributes by studying it's architecture.

- Since architecture influences quality attributes in known ways, it follows that we can use architecture to predict how well quality attributes will be achieved.
- We can analyze an architecture for achievement of quality attributes.

Purpose of the ATAM - 1

The purpose of the Architecture Tradeoff Analysis Method® (ATAM®) is to assess the consequences of architectural decisions in light of quality attribute requirements and business goals.

The ATAM process is a short, facilitated interaction between multiple stakeholders, leading to the identification of risks, non-risks, sensitivities, and tradeoffs.

Purpose of the ATAM - 2

ATAM is a method in which the right questions are asked to discover:

- Risks – potentially problematic architectural decisions.
- Non-Risks – good architectural decisions that are frequently implicit in the architecture.
- Tradeoffs – is a property that affects more than one attribute and is a sensitivity point for more than one attribute.
- Sensitivity Points – a property of one or more components (and/or component relationships) that is critical for achieving a particular quality attribute response. In practice, sensitivity points are often trivial, and we won't record every one.

Purpose of the ATAM - 3

The purpose of an ATAM evaluation is NOT to provide precise analyses . . . the purpose IS to discover the risks created by architectural decisions.

We want to find *trends* - correlations between architectural decisions and predictions of system properties.

Discovered risks can then be made the focus of mitigation activities.

Surfaced tradeoffs and sensitivities can be explicitly identified and documented.

ATAM Steps

Step 1: Present the ATAM (Pre-Evaluation)

Step 2: Present Business Drivers (Pre-Evaluation)

Step 3: Present Architecture (Abbreviated)

Step 4: Identify Architectural Approaches

Step 5: ~~Generate~~ Complete Quality Attribute Utility Tree

Step 6: Analyze Architectural Approaches

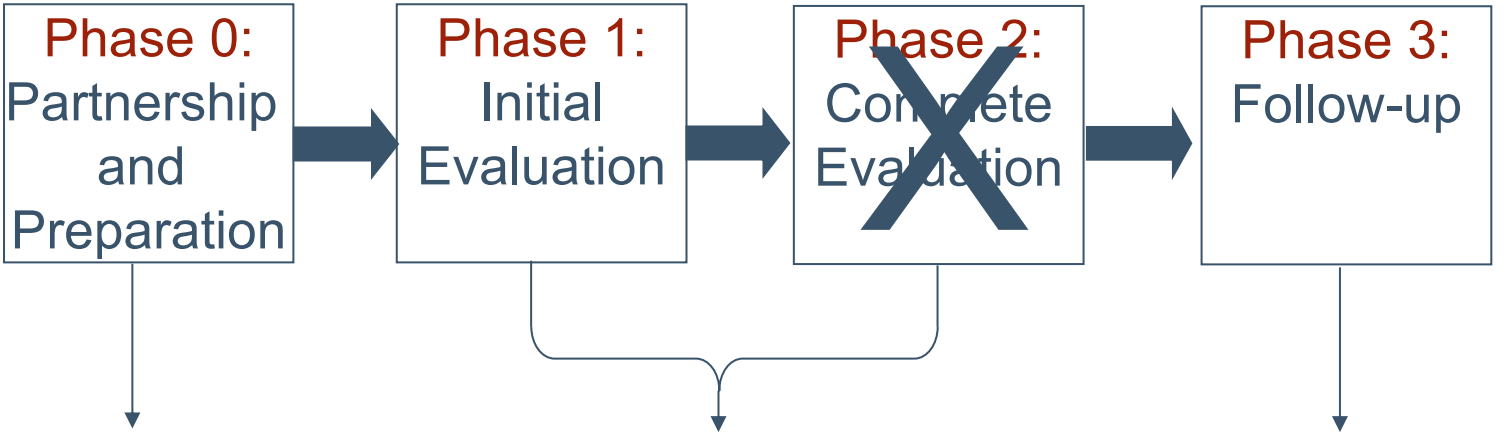
~~Step 7: Brainstorm and Prioritize Scenarios~~

~~Step 8: Analyze Architectural Approaches~~

Step 9: Present Results

Nominal ATAM Phases

ATAM evaluations are conducted in ~~four~~ **three** phases.



ATAM Phase 0

Phase 0: This phase precedes the technical evaluation.

- The customer and a subset of the evaluation team exchange understanding about the method and the system whose architecture is to be evaluated.
- An agreement to perform the evaluation is worked out.
- A core evaluation team is fielded.

ATAM Phase 1

Phase 1: involves a small group of predominantly technically-oriented stakeholders

- architecture and technology centric
- focused on eliciting detailed architectural information and analyzing it
- top down analysis

ATAM Phase 2

Phase 2: involves a larger group of diverse stakeholders

- stakeholder centric
- focused on eliciting diverse stakeholder points of view and on verification of the Phase 1 results
- bottom-up analysis

In this case, there is not a clear distinction between Phase 1 and Phase 2 stakeholders – the system builders are also the system operators and users. This was the rationale for collapsing Phase 1 and Phase 2 into a single working meeting.

ATAM Phase 3

Phase 3: primarily involves producing a final report for the customer as well as reflecting upon the quality of the evaluation and the ATAM materials.

- The report is nominally written by the evaluation team.
- Key stakeholders are given a chance to provide feedback on the report (language, emphasis, but not to change findings)
- A postmortem is conducted by the evaluation team
  - What went well?
  - Did we deviate from the method? Why?
  - What could we do better?

ATAM Principles

Create ownership of evaluation findings

Transparency

- Live scribing of proceedings
- All findings are created and documented during the working sessions

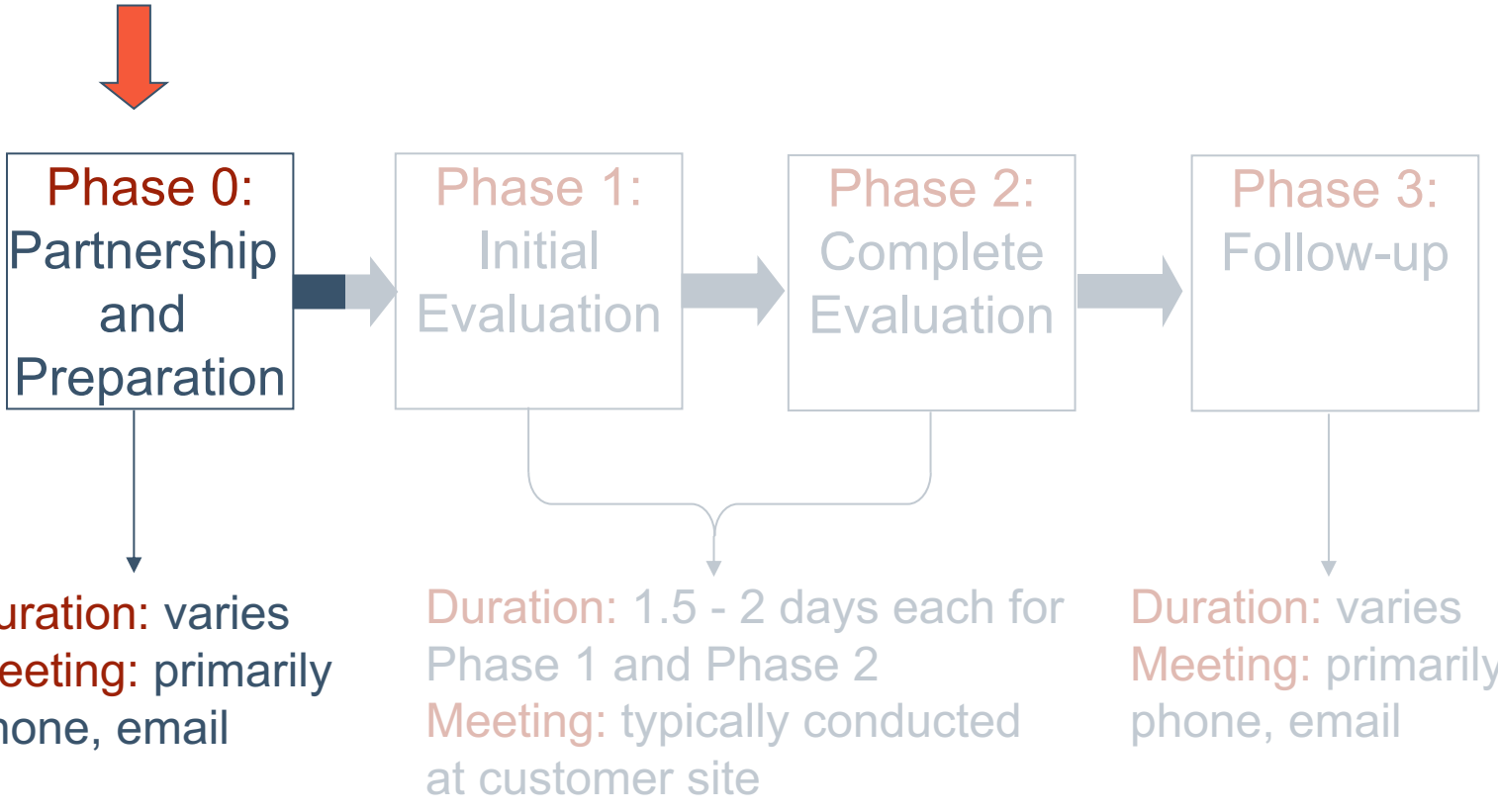
Evidence-based findings, not subjective

Stakeholder-centric

- Quality attributes
- Scenarios
- Prioritization

Reasoning chain:
qualities→scenarios→decisions→findings

We Are Here



Phase 0 – Partnership and Preparation

Phase 0 is a preparation phase preceding the technical part of the evaluation.

The client and a subset of the evaluation team exchange information on

- the ATAM
- the system whose architecture is to be evaluated

~~At the conclusion of Phase 0, an agreement to perform the evaluation is agreed to, and a core evaluation team is fielded.~~

Phase 0 – Steps

Step 1: Present the ATAM

~~Step 2: Describe candidate system~~

~~Step 3: Make a Go/No-Go Decision~~

~~Step 4: Negotiate the statement of work~~

Step 5: Form the core evaluation team

Step 6: Hold evaluation team kick-off meeting

Step 7: Prepare for Phase 1

Step 8: Review architecture

Phase 0 – Step 1

Purpose: To ensure that the client understands the mechanics of the evaluation method.

- Make a presentation about the method using the standard ATAM presentation.
- ~~Provide the client with product/service descriptions.~~
- ~~Refer the client to any of the published papers on the ATAM.~~
- ~~Make sure that the client understands the costs and benefits of an architecture evaluation.~~
- ~~Record questions for possible inclusion in the ATAM FAQ list.~~

Phase 0 – Step 5

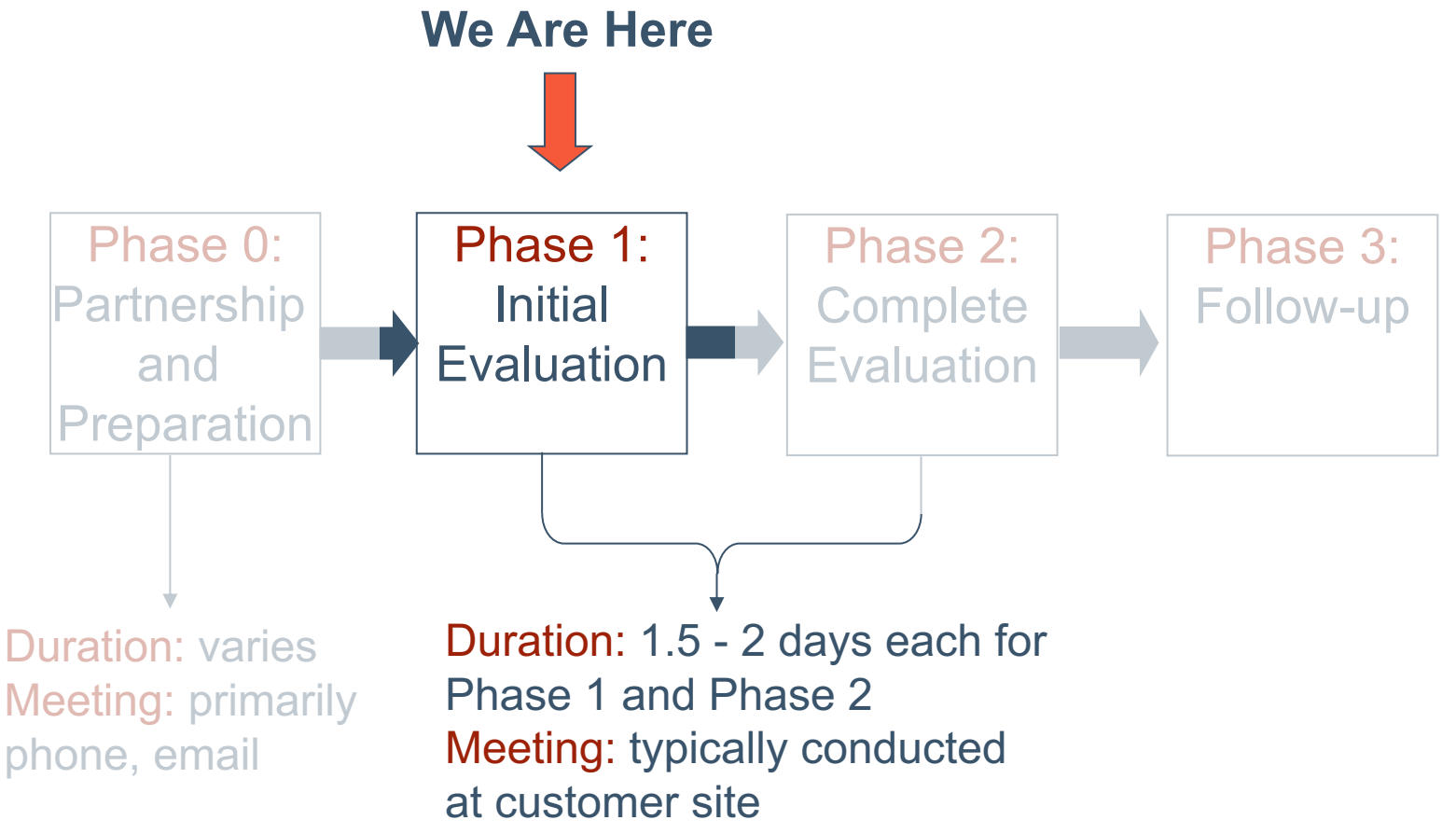
Purpose: To form the core evaluation team.

- Aim for an overall team size of 4-6 evaluators.
- Establish and coordinate schedules.
- Assign as many of the roles as practical during this step.
- Assign questioners based on their experience with various quality attributes and early indications of what the system's driving quality attributes are.
- Make travel arrangements as necessary.

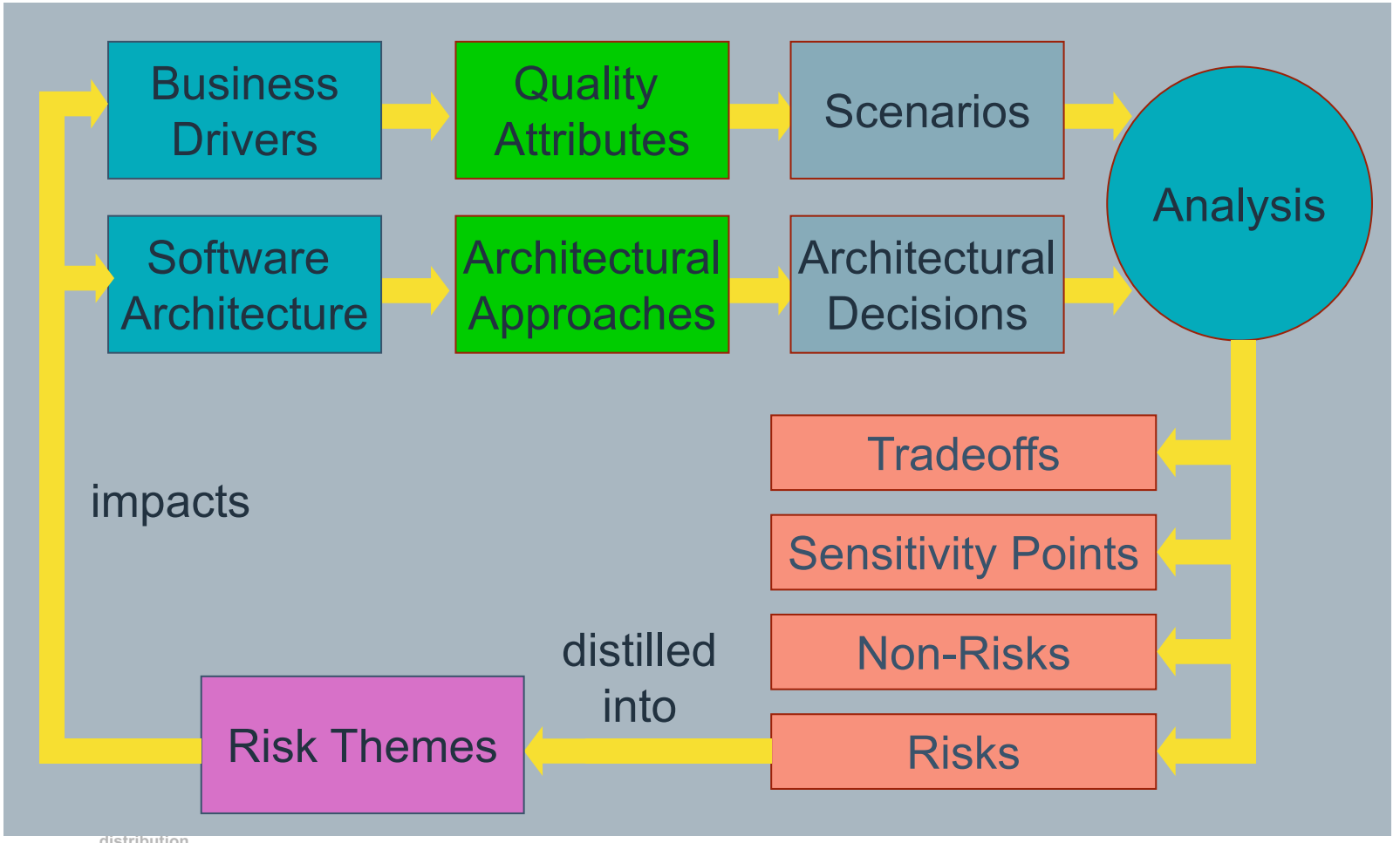
Phase 0 – Step 6

Purpose: Conduct evaluation team kick-off meeting.

- The team leader:
  - establishes the time and place for the meeting
  - ensures team members are trained ATAM evaluators, reviews roles, and ensures team members are comfortable with their roles.
  - distributes documents received from the client
  - makes plans with team to meet and confer continuously throughout the ATAM exercise



Conceptual Flow of ATAM

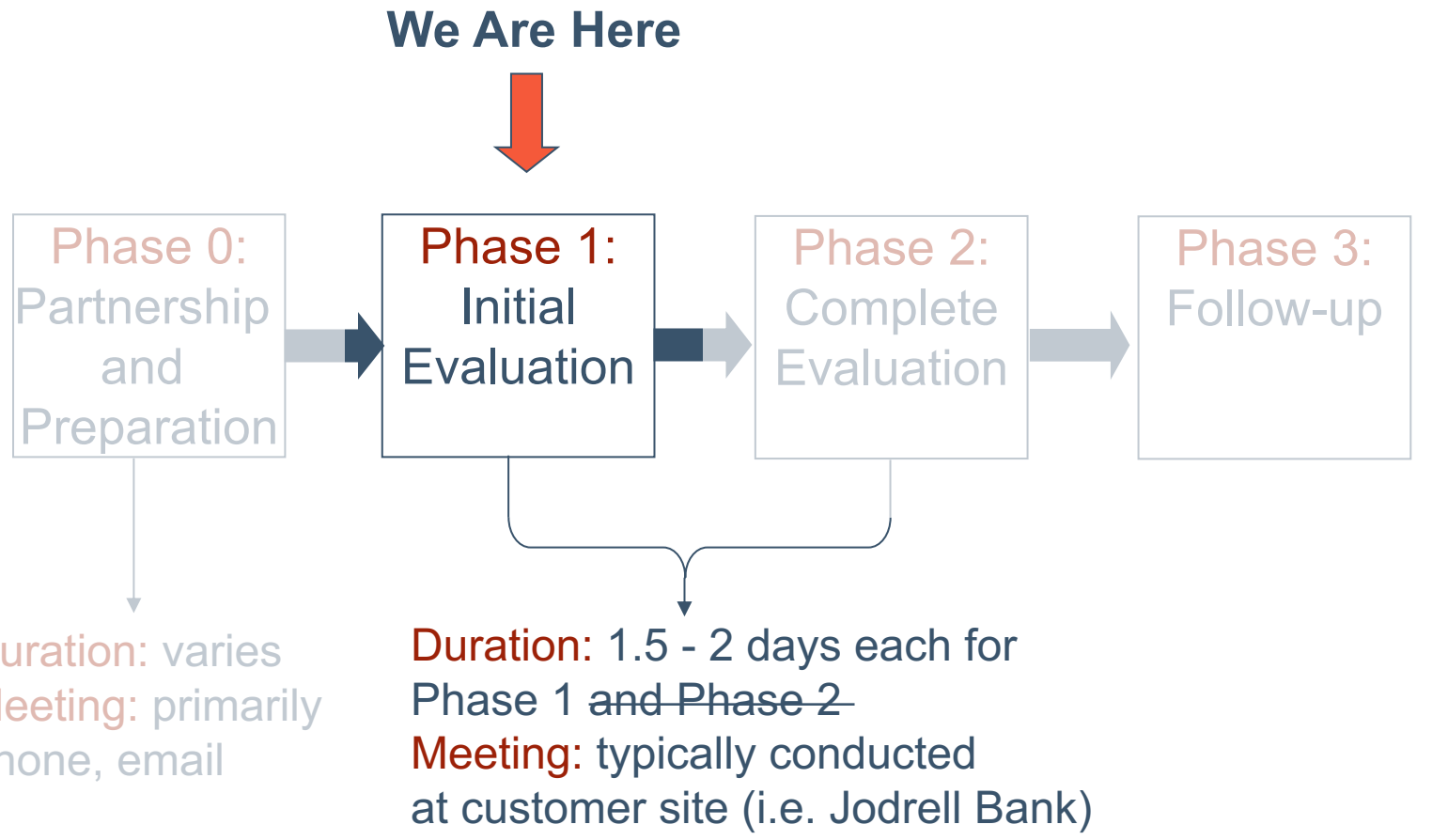


Evaluation Team Roles - 1

- Team Leader — Sets up the evaluation, coordinates with client, forms the evaluation team. In charge of seeing that final report is produced and delivered (Nick)
- Evaluation Leader — runs evaluation, facilitates discussions, brainstorming, and analysis. (Mary and John)
- ~~Scenario scribe —~~ **The Scribe (Marco) -** writes utility tree, raw scenarios, risks, sensitivities, and tradeoffs on flipcharts, whiteboards, or laptop using a projector.
- ~~Proceedings scribe —~~ Record issues that motivated each scenario, the resolution of each scenario when applied to architecture. Used in the final report to provide context

Evaluation Team Roles - 2

- Questioner(s) — raise issues that the stakeholders have not thought of; asks questions based on how the quality attributes of interest relate to architectural styles. (You)
- Process enforcer/observer — monitors the process steps and takes notes about the process, and how it could be improved. Helps evaluation leader to carry out the process as defined. Uses the Process Observer Report Template (Mary/John)
- Data gatherer — makes sure Participants complete End-of-Exercise Survey, collects names and contact information (Mary/John)
- Timekeeper — informs the evaluation leader when the time allocated for a step has expired. (Mary/John)



Phase 1 Steps

Step 1: Present the ATAM

Step 2: Present Business Drivers

Step 3: Present Architecture

Presentation

Step 4: Identify Architectural Approaches

Step 5: Generate Quality Attribute Utility Tree

Step 6: Analyze Architectural Approaches

Investigation and Analysis

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Investigation and Analysis

Agenda for SDP Evaluation - 1

Assumes that the following tasks been completed before the evaluation:

- Evaluation team group training session (remote meeting with SEI)
- Evaluation process and practices
- Roles assigned, responsibilities understood, execution logistics
- Discuss evaluation execution concerns, areas where there may be challenges, team norms, and approaches

Draft utility tree has been developed

- Quality attributes and concerns
- Many 3-part scenarios
- Gaps in coverage identified (to be addressed during evaluation)
- Shared with architecture team

Evaluation team – individual preparation

- Templates prepared and pre-populated
- Team members begin “Private list” of architecture issues

Agenda for SDP Evaluation

See agenda slides

Phase 1 Steps

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Investigation and Analysis

Phase 1 Step 2: Present Business Drivers - SDP

Propose that we handle this offline:

- Nick will identify or circulate summary of key SKAO drivers that are most relevant for SDP
- This should be already well-understood by everyone at this point in the project

We will use the business/mission drivers:

- To identify quality attributes
- Prioritize scenarios
- Ground and focus scenario analysis questions

Phase 1 Steps

Step 1: Present the ATAM

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Investigation and Analysis

Present the Architecture - SDP

We would like to minimize the time spent on this step – we will review architecture documents prior to the June pre-CDR meeting

We will allow the architecture team to “tell the story in their own words” and summarize key ideas

We will limit questions to ”clarifying questions”, e.g.,

- Architecture scope
- Confirm presence or absence or quantity of a component

Defer questions covering your concerns about the solution until the scenario analysis that follows.

Phase 1 Steps

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Presentation

Step 4: Identify Architectural Approaches

Step 5: Generate Quality Attribute Utility Tree

Step 6: Analyze Architectural Approaches

Investigation and Analysis

Phase 1 Step 4: Identify Architectural Approaches - 1

Purpose: Identify places in the architecture that are key to realizing quality attribute goals.

- This information comes from the architectural presentation.

Identify predominant architectural approaches and the reason(s) for selecting them:

- Client-server – *ability to accommodate many users; maintain central control of data*
- Publish-subscribe – *decouple producers from consumers of data; maintain separation of concerns*
- Redundant hardware – *to ensure that the system will not crash due to hardware failure*

Phase 1 Step 4: Identify Architectural Approaches - 2

Architecture approaches lead to basic quality attribute questions:

- Client Server:
  - Scalability: Is there a limit on the number of clients? Mechanism for load balancing across servers? How do clients locate a server?
  - Availability: What happens when a server fails? When a client fails?
- Pipe and Filter:
  - Modifiability: Are filters versioned? How are filters updated?
  - Performance: Can instances of a filter run in parallel?

Phase 1 Step 4: Identify Architectural Approaches – SDP

We will do this as we read the architecture documentation.

We will collect these and review as a team prior to the evaluation.

We can adjust the list when we hear the architecture presentations.

Phase 1 Steps

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Step 2: Present Business Drivers

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Step 5: Generate Quality Attribute Utility Tree

Step 6: Analyze Architectural Approaches

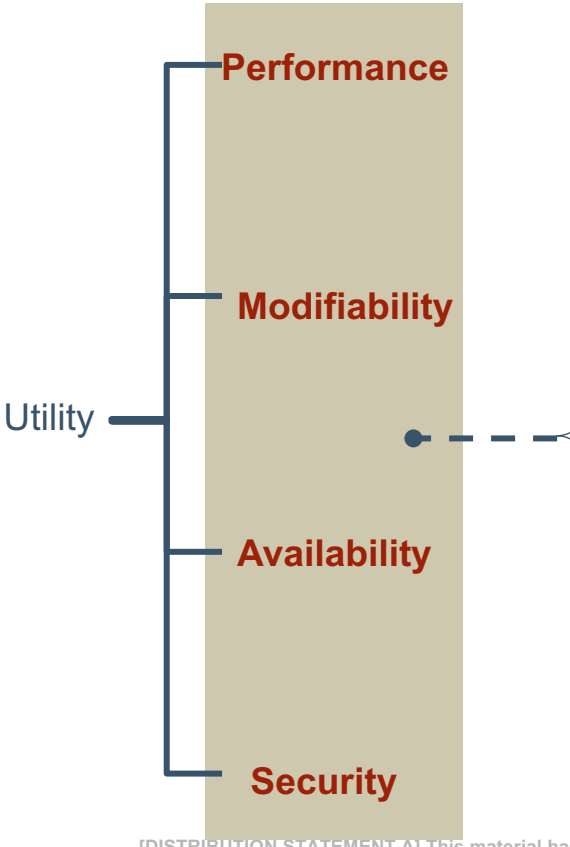
Investigation and Analysis

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 1

Purpose: Prioritize and refine the most important quality attribute goals by building a *utility tree*.

- The utility tree is a top-down vehicle for characterizing the "driving" attribute-specific requirements.
- Quality attributes are derived from the business goals and are the high-level nodes of the tree.
- Scenarios are the leaves of the utility tree.

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 2



Qualities are derived from business goals:

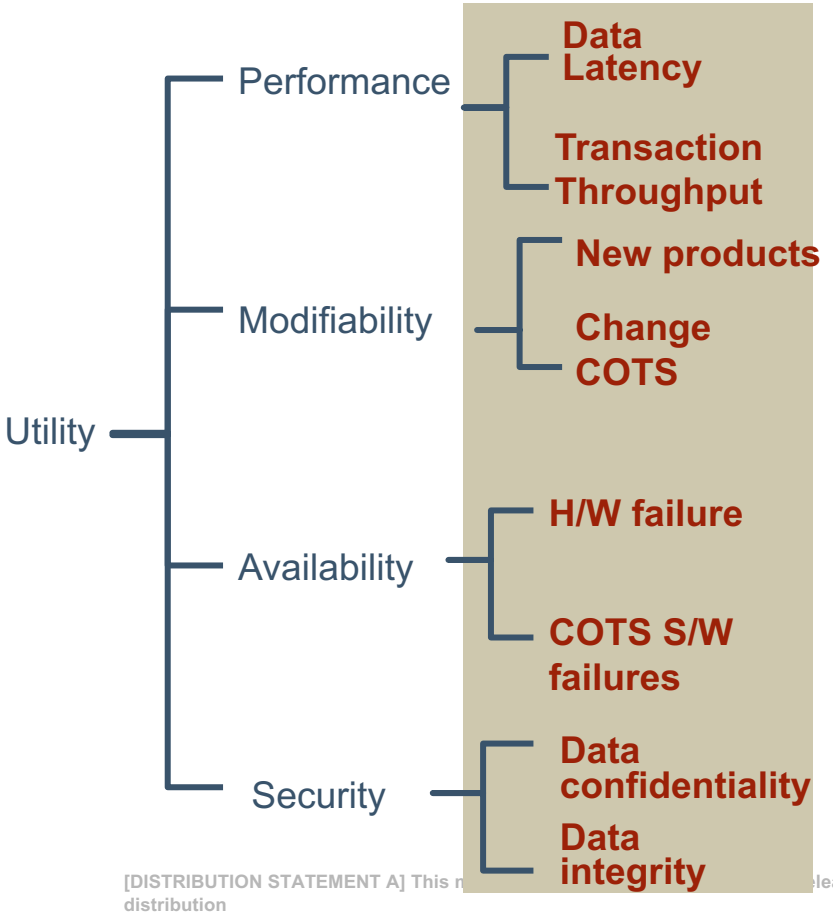
"The system must be available 24/7."

"User Data must never be compromised."

"The system must have faster response time than all of our competitors."

"Deliver version 1 by 1Q2017 and version 2 by 4Q2017."

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 3

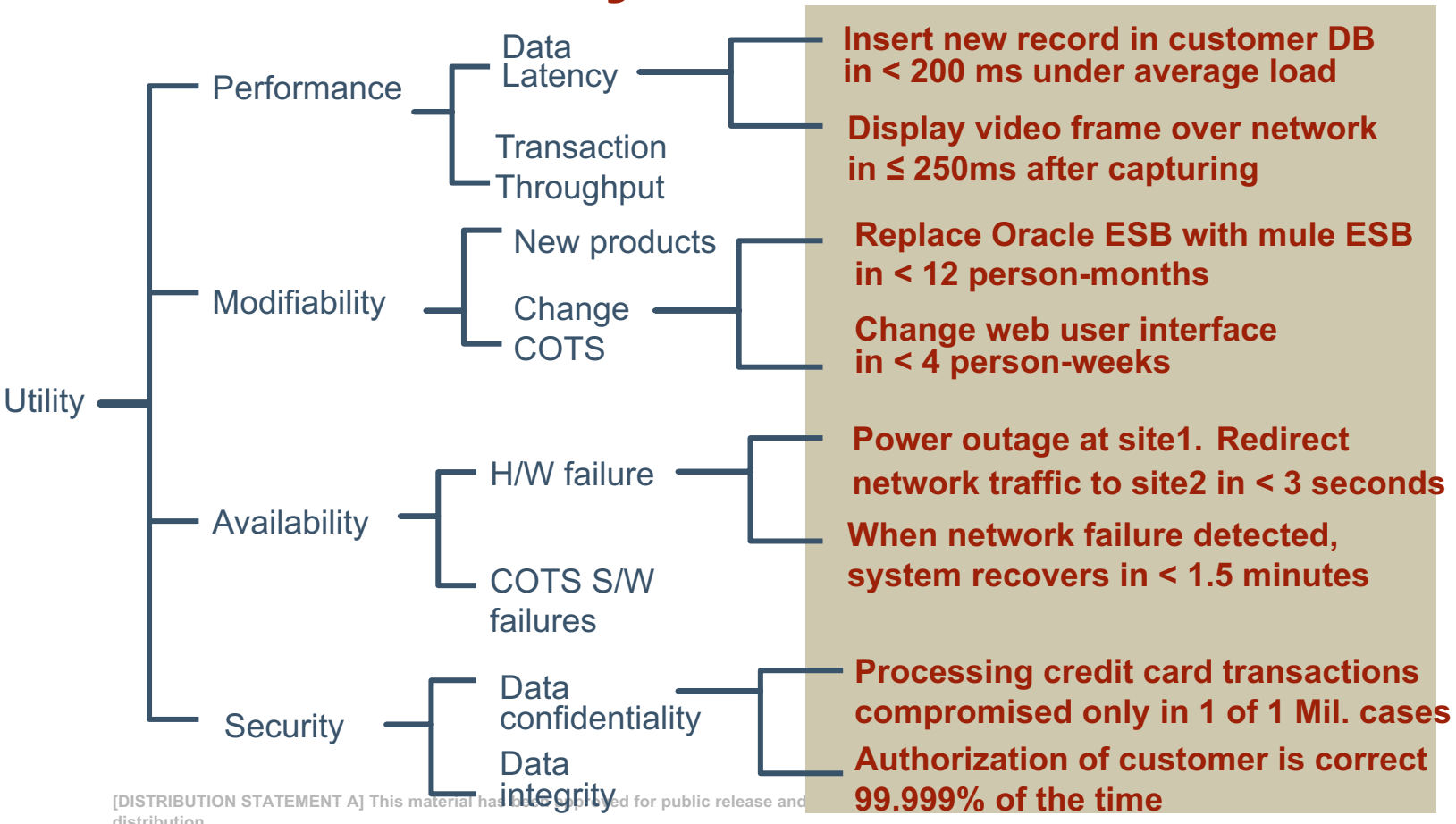


This level of the tree is called the “quality concerns”.

This level better characterizes each quality.

For example, “Performance” can mean many things. Here it is characterized as “performance” with respect to “data latency.”

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 4



Phase 1 Step 5: Generate Quality Attribute Utility Tree – 5

Scenarios are used to represent stakeholders' interests and to understand quality attribute requirements.

Scenarios should cover a range of:

- anticipated uses of the system (use case scenarios)
- anticipated changes to the system (growth scenarios)
- unanticipated stresses on the system (exploratory scenarios)

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 6

Scenarios should be as specific as possible.

A good scenario makes clear what the stimulus is and what the desired responses of the system are.

A fully specified quality attribute scenario consists of six parts:

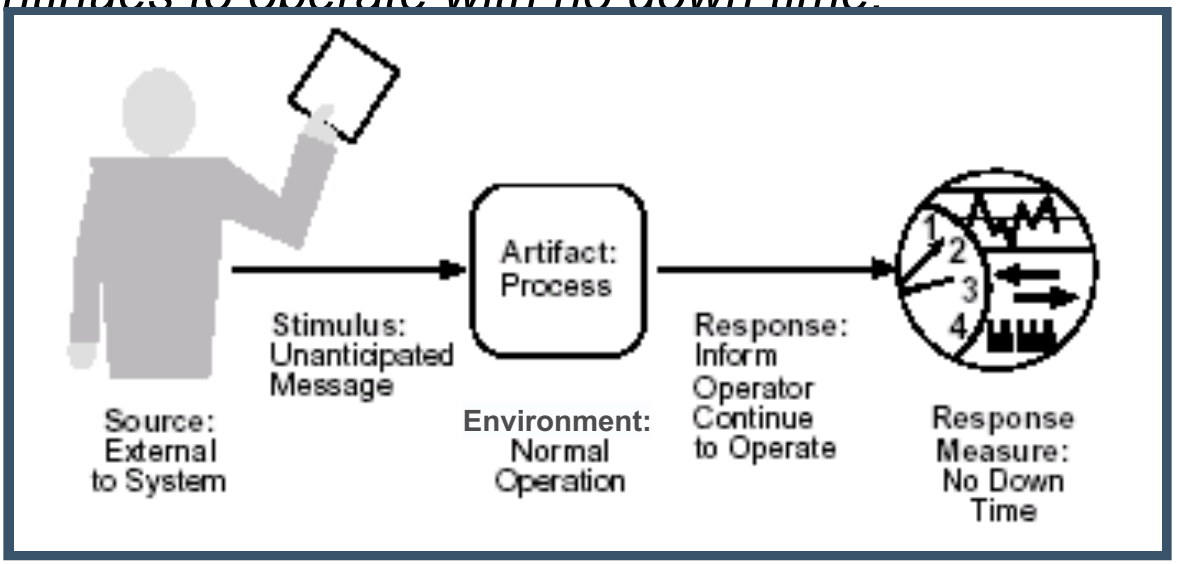
- Stimulus – condition that effecting the system
- Response – activity as a result of the stimulus
- Source of stimulus – The entity that generated the stimulus
- Environment – the condition under which the stimulus occurred
- Artifact stimulated – the artifact that was stimulated
- Response measure – the measure by which the system's response will be evaluated

Initial statement: Stimulus/Response/Environment

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 7

Example Availability Scenario:

An unanticipated external message is received by a process during normal operation. The process informs the operator of the receipt of the message and the system continues to operate with no down time.



Phase 1 Step 5: Generate Quality Attribute Utility Tree – 8

Stimuli, Environment, **Responses**

Use Case Scenario:

Remote user requests a database report via the Web **during peak period** and receives it within 5 seconds.

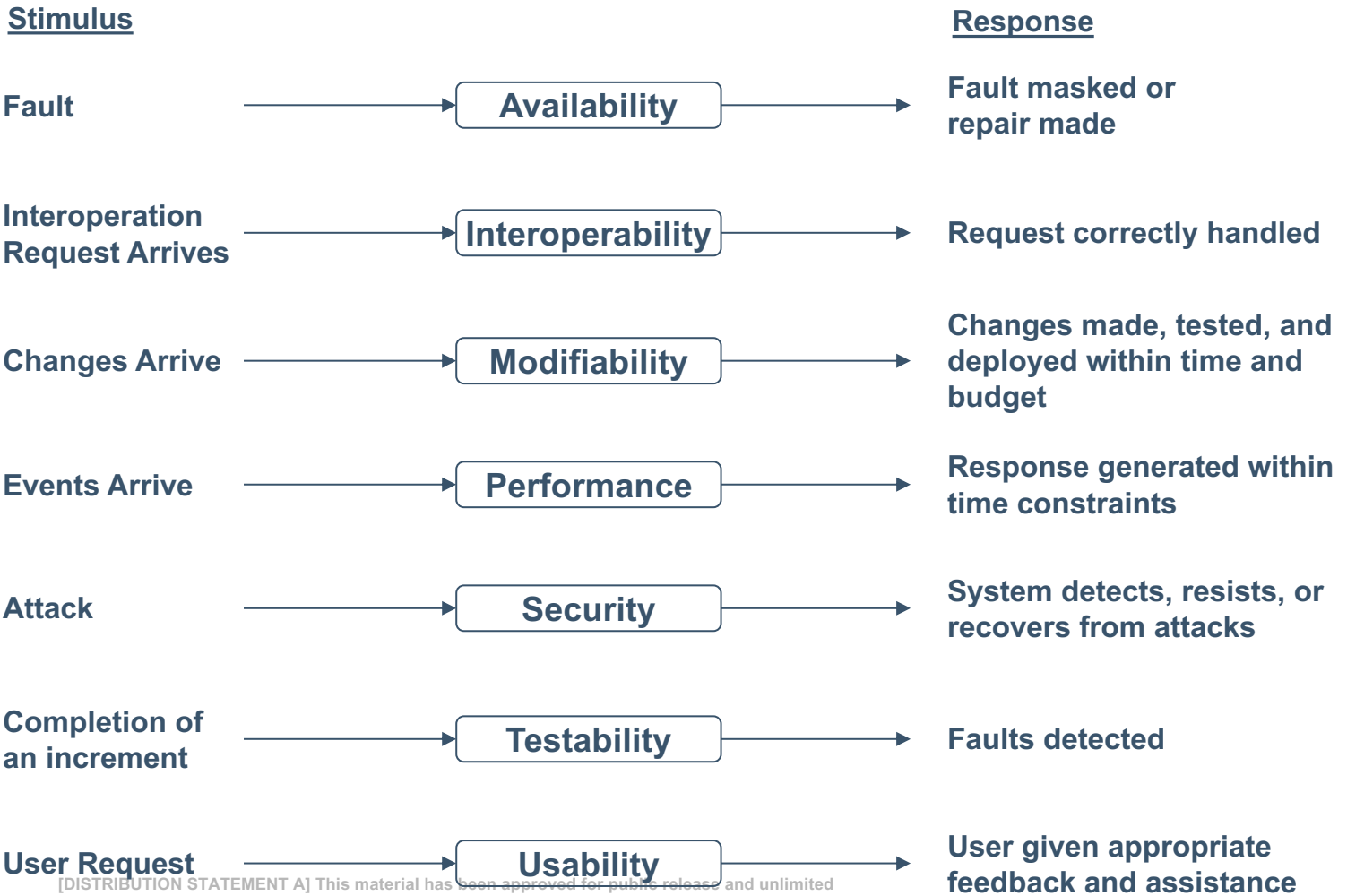
Growth Scenario:

Add a new data server to reduce latency in scenario one to 2.5 seconds within 1 person-week.

Exploratory Scenario:

Half of the servers go down **during normal operation** without affecting overall system availability.

Scenario Templates



Phase 1 Step 5: Generate Quality Attribute Utility Tree – 10

In practice, the utility tree never looks like the example utility tree shown earlier.

- Utility trees are usually too large to fit on document pages and presentation slides.
- Currently there are no tools for drawing utility trees.
- Hard to view the utility trees drawn this way in real time.

In practice we use ~~tables~~ outlines to represent utility trees.

Representing concerns as scenarios

Opinion: “This architecture will never scale”

Why: “Bottlenecks in the middle tier – the singleton XYZ component holds global state”

Scenario:

- (Stimulus) Workload increases – the request rate increases by 25% for 24 hours.
- (Response) System continues to produce outputs with no increase in latency.
- (Environment) Normal operation.

During analysis, ask questions that focus on XYZ component throughput.

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 12

Once all of the scenarios have been generated, they need to be prioritized by the stakeholders.

In Phase 1, the scenarios are prioritized according to two dimensions:

- how important the scenario is
- how difficult it will be to implement in the system

Each dimension is rated high, medium, or low.

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 13

The *importance dimension* is rated high, medium, or low

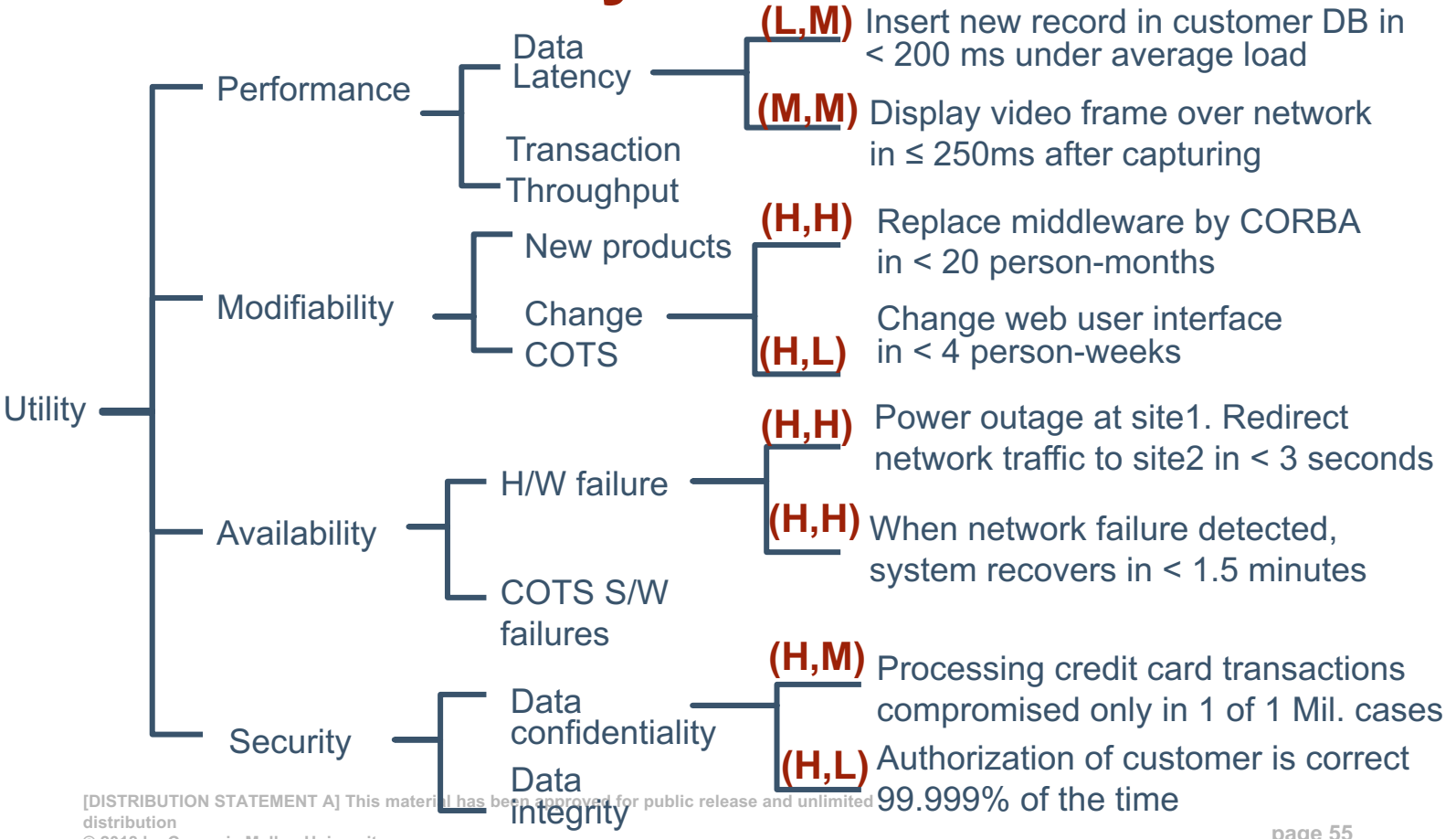
- High – If this scenario can't be satisfied the system will be useless.
- Medium – It would be highly desirable for the system to satisfy this scenario.
- Low – Satisfying this scenario would be a "nice-to-have" feature.

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 14

The *difficulty dimension* is rated high, medium, or low

- High – The architect and technical team are very concerned about satisfying this scenario.
  - You are joking, right?
  - lack experience, lack expertise, have no idea how to satisfy the scenario
- Medium – The architect and technical team are concerned about satisfying this scenario.
  - difficult, time consuming, but generally understand how to satisfy the scenario
- Low – Satisfying this scenario is relatively easy.

Phase 1 Step 5: Generate Quality Attribute Utility Tree – 15



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Step 6: Analyze Architectural Approaches

Investigation and Analysis

Phase 1 Step 6: Analyze Architectural Approaches - 1

Purpose: To analyze the highest priority scenarios.

- Begin by reading the highest priority scenarios.
  - Typically you will only have time to analyze the top five or so scenarios.
- Spend some time to refine the scenario into its six parts. This will produce better understanding of the scenario.
- Ask the architect(s) to explain how the architecture responds to the stimuli.
  - Architects should use existing pictures and/or they may draw new pictures as necessary.
- **Evaluators will ask quality-attribute-specific questions to uncover risks, non-risks, sensitivity points, and tradeoffs.**

Phase 1 Step 6: Analyze Architectural Approaches - 2

Risks, Non-Risks, Sensitivity Point, and Tradeoffs:

- A *Risk* is a potentially problematic architectural decision.
- *Non-Risks* are good architectural decisions that are frequently implicit in the architecture.
- A *Tradeoff Point* is a property that effects more than one attribute and is a sensitivity point for more than one attribute.
- A *Sensitivity Point* is a property of one or more components (and/or component relationships) that is critical for achieving a particular quality attribute response.

Phase 1 Step 6: Analyze Architectural Approaches - 3

Example Risk:

- *"Rules for writing business logic modules in the second tier of your 3-tier architecture are not clearly articulated. This could result in replication of functionality thereby compromising modifiability of the third tier."*

Risk Statement Template

<Architecture Decision or Gap>

<Result or implication>

<Quality attribute impact>

<If possible, connection to mission goal impacts>

Phase 1 Step 6: Analyze Architectural Approaches - 4

Example Tradeoff:

- *"Changing the level of encryption could have a significant impact on both security and performance."*

Example Non-Risk:

- *"Assuming message arrival rates of once per second, a processing time of less than 30 ms, and the existence of one higher priority process, a 1 second soft deadline seems reasonable."*

Phase 1 Step 6: Analyze Architectural Approaches - 5

Example Sensitivity:

- *"The average number of person-days of effort it takes to maintain a system might be sensitive to the degree of encapsulation of its communication protocols and file formats."*

In practice, we don't focus on Sensitivities. They are usually trivial and obvious.

Phase 1 Step 6: Analyze Architectural Approaches - 5

Evaluators must be attentive and listen for cues indicating risks, sensitivities, tradeoffs and non-risks may be present

- "*Not sure how we address that*" – potential risk
- "*I don't think we considered that*" – potential risk
- "*We could have written stuff to disk, but we chose not to, to speed up the system*" - potential tradeoff
- "*That would be an easy change, but it would impact lots of other tasks*" - potential sensitivity
- "*We have lots of margin in bandwidth since we can add more event generators*" - potential non-risk
- "*That requirement isn't clear*" – potential risk

Analysis – Ask questions to lead the architect to the conclusion

Be a questioner, not a pointer-outer

Don't say things like

- "that will never work" or
- "that is a strange approach"

Instead, think about

- Why won't it work? What is missing? Then ask a question about that, like "what happens if the observation is manually terminated?"
- What is strange – what is a more typical approach? What does the typical approach achieve that is missing here? Then ask a question about that.

Types of questions

Probing– open-ended questions:

- Why did you make that decision?
- What tradeoffs does that decision make?
- What analysis/data/evidence do you have to back up that assertion? (about throughput, scale, latency, availability, …)
- How does the architecture respond when X happens?
- How does that affect <quality>?

Close and conclude:

- Is that a problem?
- Is that a risk?
- That looks like a non-risk.

Analysis is a team sport

We have to support and help each other

Let a team member finish a line of questioning

- Help, if needed, to move things forward
- Don't take things in another direction – the facilitator will come back to you
- Make it clear when you are finished, especially if you decide that there is no risk/non-risk at the end

A line of questioning can identify multiple risks

- If the scenario was about quality X, it is OK to identify risks related to quality Y
- Try to first focus on the original quality – negotiate with team members to maintain as much continuity of the questioning as possible – e.g., "Before we go in that direction, I'd like to probe a little more on the last issue"

Phase 1 Step 6: Analyze Architectural Approaches - 6

Evaluators should refer often to:

- business goals
- quality attributes and quality concerns
- architectural approaches
- various architectural artifacts

Often, these artifacts can help evaluators probe the architecture further.

Phase 1 Step 6: Analyze Architectural Approaches - 7

The scenario scribe will use the scenario analysis template provided with your course materials to record the analysis.

This is best done projected in front of everyone:

- Cut and paste the scenario into the template.
- Type the quality attribute and quality concern in the appropriate rows.
- Capture any decisions, risks, tradeoff, sensitivities, and non-risks during analysis.

Please review this template.

Scope and duration of a scenario analysis

The scenario was created to focus on a particular quality attribute – we should be sure to cover that QA

Other QAs may arise

- Cover these if the QA or concern was highly rated, otherwise note that it is applicable but move on
- Try to cover the primary QA first
- E.g., we are tracing a performance path, OK to ask about availability (what if there is a failure?) or modifiability (what if the logic needs to change?)

Completion criteria:

- Architect has traced from stimulus to response, or we identify a risk that the response will not be achieved
- No more questions or re-tracing covered ground

Analysis ≠ Fixing Problems

We want to avoid discussing solutions during the evaluation

Until we understand ALL of the issues, we can't decide on the best solution

Some problems may be solved without changing the architecture

- E.g., accept higher cost, carry the risk forward, accept reduced capability, …

SDP Scenario Analysis

Scenario analysis will begin on Day 2 and continue through afternoon of Day 3.

I hope to analyze 9-10 scenarios. This may be ambitious.

The first scenario analysis takes more time (60-90 minutes)

- “Teaching” the audience about the architecture
- Learning the process
- Identify the most risks

Subsequent scenarios usually go faster – (30-60 minutes)

Risk Themes – 1

A risk theme is a summarization of multiple similar risks discovered during the analysis of quality attribute scenarios.

They point out “bigger” issues in the architecture and are:

- Either multiple questionable decisions made in the architecture (commission)
- Or decisions NOT made or requirements not included in the architecture (omission)

Risk Themes – 2

Risk: *"No timing budgets established – difficult to predict response time"*

Risk: *"System memory requirements can't be predicted until all tasks are integrated"*

Risk: *"There is no disciplined approach to scheduling tasks – tweaked until it works"*

Risk Theme: *"There is no holistic approach to resource management…"*

Impacts Business Goal: "*Cost, time-to-market, ability to compete with competitors"*

Risk: *"Small changes in timing impact other tasks in unpredictable ways"*

Risk: *"System resource allocation is not part of the architecture, and required resources can't be estimated or budgeted"*

Building the risk themes

We will meet after Day 2

- Discuss risks found so far
- Start clustering into candidate risk themes
- Assess coverage and plan Day 3

We will meet for about 2 hours after last scenario analysis on Day 3 (late afternoon)

- Finalize risk themes and risk mapping
- Build final presentation
  - Skim
    - Utility tree and prioritization
    - List of scenarios analyzed
    - List of risks, non-risks, tradeoffs found
  - Present and discuss risk themes

Present Results – 3

Typically the evaluation leader makes the final presentation:

- There is never time to cover each slide in detail.
- Focus on the high level issues, review
  - the ATAM
  - business goals
  - system architecture
  - utility tree
  - risks, sensitivities, tradeoffs, non-risks

Phase 0 Tasks

Laying the groundwork to identify risks – 1

In reading the architecture documentation, you see something that looks <odd | unusual | wrong | …>

Be a questioner, not a pointer-outer

Why is it odd? Is there a tradeoff being made? Project forward to how you think the end of your line of questioning will play out.

Now, back up. What is the relevant quality attribute? What would be a good scenario that would allow you to ask your questions?

How does this tie back to mission goals?

Laying the groundwork to identify risks – 2

We want to start now to lay the groundwork so that we will get the chance to ask our questions.

- Be sure that the mission goals are on our list
- Put the qualities on the utility tree
- See if stakeholders propose something close to your scenarios. If not, propose the scenario and see how stakeholders react.

Remember that our issue may not impact the system's ability to achieve the mission goals. Be willing to drop your concern if the proposed architecture is good enough.

Slack, Google Docs, etc.

Please limit use of the Panel Slack Channel during the evaluation

- Nick and John can't monitor the channel when we are leading the evaluation
- Scribes can't copy messages from Slack into the proceedings
- If you have a question or concern then say it, don't Slack it ☺

If you see something in the proceedings that you want to correct or extend, interrupt and tell the facilitator. We will focus the discussion to address your concern. Don't edit the proceedings directly – this is distracting for the scribe, and if you make a change off-screen then nobody sees it.

Capturing Risks

In the TM Evaluation, we could have done a better job on risk wording.

Risk statement template:

- <Architecture Decision or Gap>
- <Result or implication>
- <Quality attribute impact>
- <If possible, connection to mission goal impacts>

Capture enough context so that the risk can be understood later or by another reader.