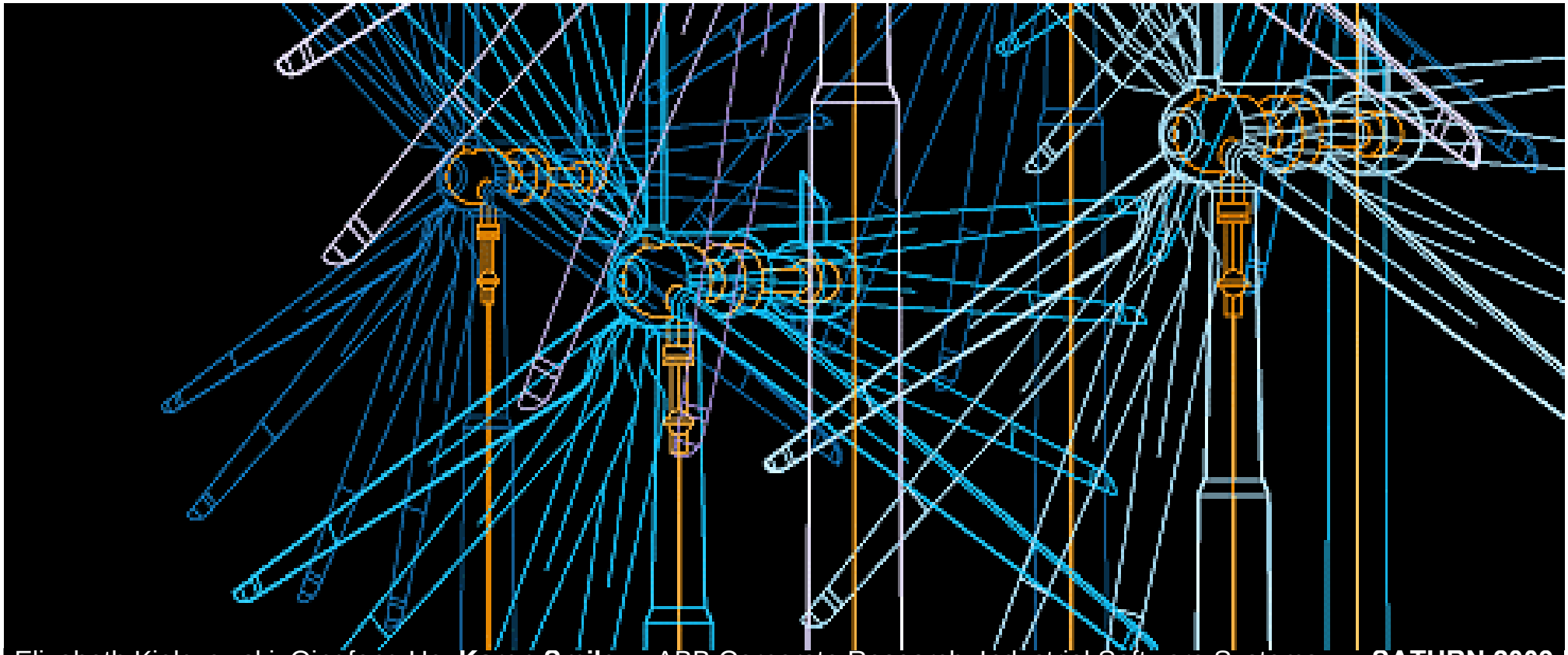


Elizabeth Kielczewski, Qingfeng He, **Karen Smiley -** ABB Corporate Research, Industrial Software Systems **SATURN 2009**

Leveraging ADD for Objective Technology Evaluation and Decision Analysis

AHEAD method and case study

Leveraging ADD for Objective Technology Evaluation and Decision Analysis
AHEAD method and case study

Topics in this presentation:

1. Software technology evaluation challenges
2. Initial approach using ADD with prototyping
3. Requirements: scope, criteria, alternatives
4. Architecture and design of technology prototypes
5. Adjustment of approach (AHP) / emergence of AHEAD
6. Evaluation results and decision analysis
7. Lessons learned
8. Conclusions

Why Use ADD for Software Technology Evaluations?
Key Principle

Meaningful evaluations of software technologies

require that

technology alternatives

must be assessed

within the context of corresponding

software system architectures.

Technology Evaluation
Goals in This Case Study

Customer's goal:

To improve architectural aspects *(maintainability, performance, scalability, usability, and configurability)* of a component of a well-established product suite

Evaluation project goals:

- Objectively evaluate candidate software technologies
- Recommend software system architecture for implementing the preferred technology

Technology Evaluation Challenges – 1
Architectural Design

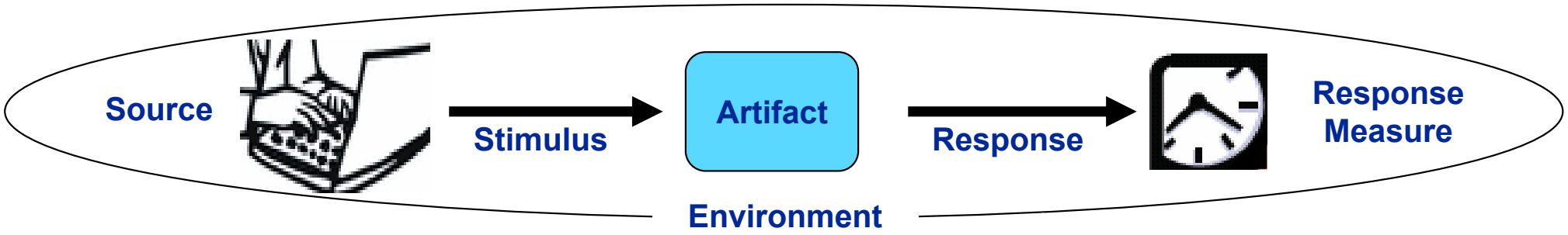
- Scope: What (part of the) system are we designing?
  - Client application interacting with other parts of the system, and other systems in the product family
  - Long-term strategic technology plans
  - Organizational constraints and stakeholder selection
- Which non-functional qualities of this system are most critical to its design?
- What technologies are available?
- Which design options are relevant to these technologies?
- Is a technology-agnostic architecture possible?

Technology Evaluation Challenges – 2
Evaluation Method

- How can we *efficiently* evaluate technologies?
  - Balancing cost and schedule vs. the risk of a ‘bad’ decision
- How to *objectively* compare the technology alternatives?
  - “Apples vs. oranges”
  - Minimizing impact of acknowledged or latent biases

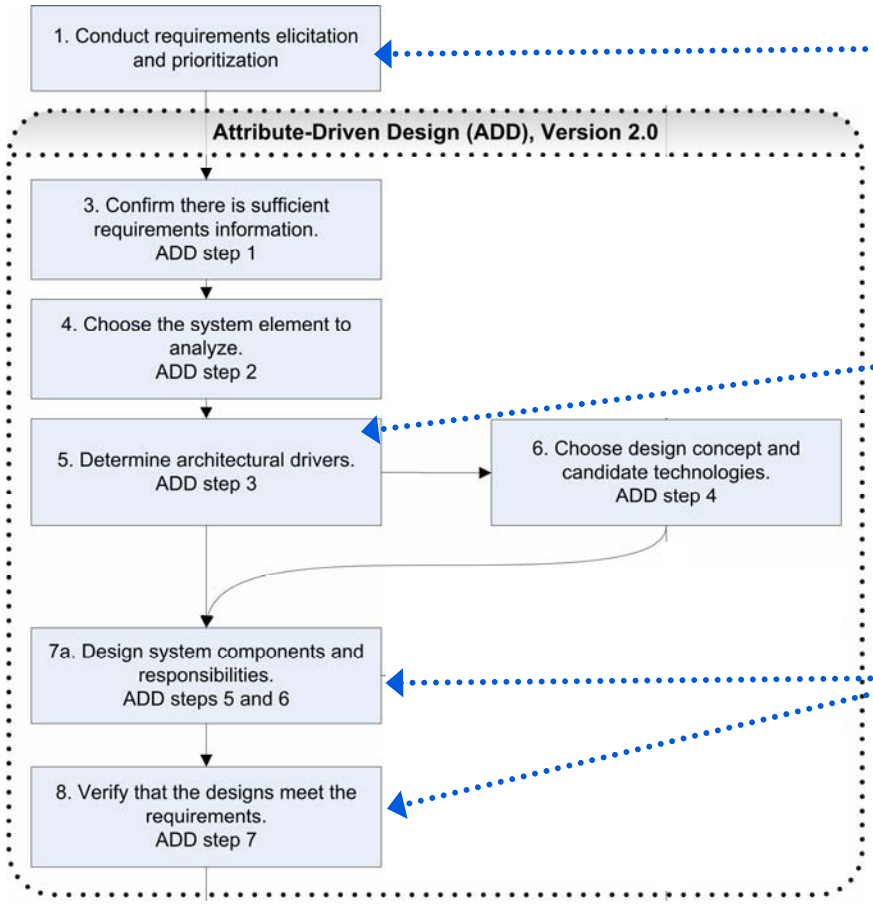
Technology Evaluation – Leveraging ADD
Initial approach

- Identify and prioritize business goals and technical criteria
- Survey software technologies and frameworks
- Design candidate solutions using SEI Attribute-Driven Design (ADD) method
- Prototype and evaluate candidate solutions
- Recommend the best (technology + architecture) to meet the requirements



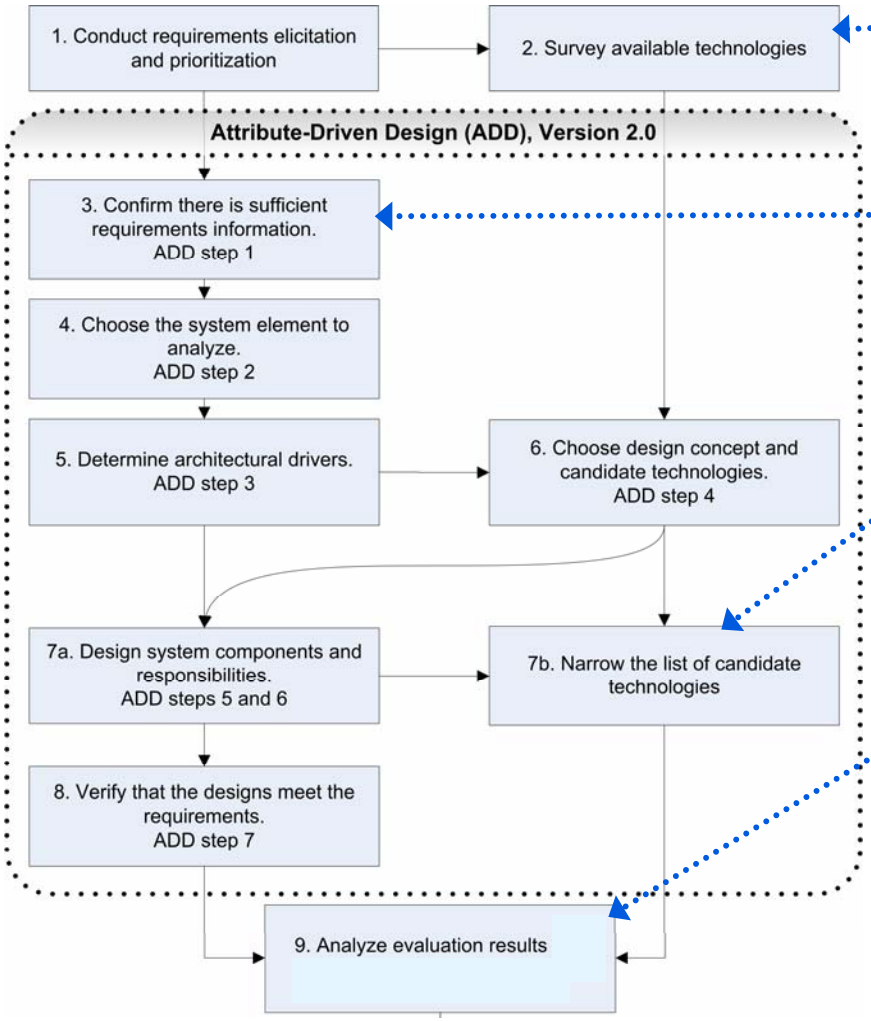
Technology Evaluation – Leveraging ADD

Adapting ADD for **Evaluating** A Software Technology



- Elicitation precedes ADD; technology evaluations require both functional and non-functional criteria.
- Tradeoff analyses can focus on the top N criteria; an evaluation typically requires more exhaustive consideration.
- Prototyping can provide insight.

Technology Evaluation – Leveraging ADD
Adapting ADD for **Comparing** Software Technologies



- Comparative evaluations require a list of alternatives.
- With many evaluation criteria, H-M-L or H-HM-M-ML-L priority scales may not suffice.
- Eliminate technology options when it is determined that they cannot satisfy the criteria.
- Choosing the best technology alternative requires careful weighting and assessment of prioritized criteria and how well the candidates satisfy them.

Technology Evaluation – Leveraging ADD
Identification of criteria and technology alternatives

Requirements elicitation and prioritization were performed in parallel with surveying the current market of technologies and frameworks relevant for development of complex, data-intensive applications.

This yielded 50 criteria and 11 technology alternatives for further evaluation.

These 50 criteria were ranked for importance:

- by 3 stakeholders
- with a 5-level nominal scale (H, HM, M, ML, L)

Later, they were also ranked for architectural impact:

- with a similar 5-level scale (H, HM, M, ML, L)
- by 4 researchers

Technology Evaluation – Leveraging ADD
Using ADD steps 2, 3 & 4

In ADD, the criteria are stratified using dual rankings of importance and architectural impact. Rather than limit our evaluation to the top 5-6, we chose all criteria ranked:

- H in importance, Any architectural impact
- HM in importance, H, HM, or M architectural impact

This yielded 25 key criteria (candidate architectural drivers).

- Measurable quality scenarios were defined for the 25 criteria, and combined into use cases to form the basis for prototyping
- We agreed with stakeholders to focus on one functional area
- The design concept of implementing our exploratory prototypes as browser-based applications (RIA) was chosen
- 3 technologies were selected from the 11 candidates, for further investigation.

Technology Evaluation – Leveraging ADD
Why and how the AHEAD method emerged

Identified Concerns:

- Desire for better objectivity
  - Stakeholders can have very different priorities
  - Researchers can have varying technology biases
- Measurable, comparable, traceable results
- Need to handle 25 important criteria
  - *Nominal scale does not 'prioritize' among the 25*
  - *Significant prototyping effort foreseen to examine them all*

Technology Evaluation – Leveraging ADD
Adjustment of approach / how AHEAD emerged

Identified solutions:

- Use **AHP** (**A**nalytic **H**ierarchy **P**rocess) for:
  - rigorous prioritization of criteria
  - quantitatively evaluating ('scoring') candidate solutions vs. the criteria
  - calculating overall evaluation result from priorities and scores

But not yet … first:

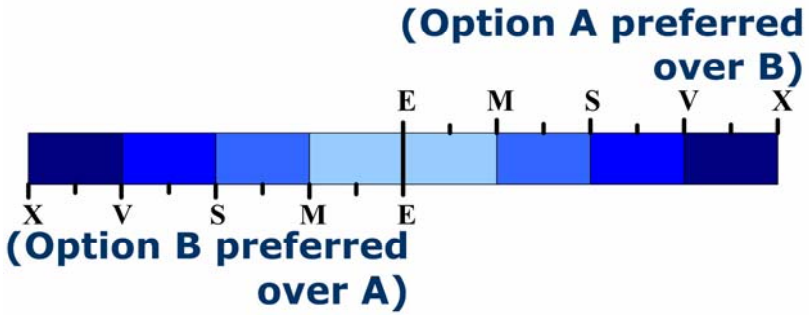
- Eliminate 'equivalent' criteria from further evaluation (identify "discerning criteria")
- Perform additional prototyping and evaluation for specific scenarios to assess "discerning criteria"

➔ **AHEAD** method – "Attribute Hierarchy-based Evaluation of Architectural Designs"

Technology Evaluation – Leveraging ADD
Using AHP – Why?

AHP (Analytic Hierarchy Process) is a well-established **multi-criteria decision making (MCDM)** technique which:

- Leverages hierarchies to manage complexity
- Uses pair-wise comparisons to bring mathematical rigor and greater accuracy to human judgments
- Enables easy aggregation of conflicting opinions of multiple stakeholders and evaluators
- Provides an "inconsistency ratio" calculation to assess whether the ratings make sense overall.



Key:
E – Equally preferred
M – Moderately preferred
S – Strongly preferred
V – Very strongly preferred
X – Extremely preferred

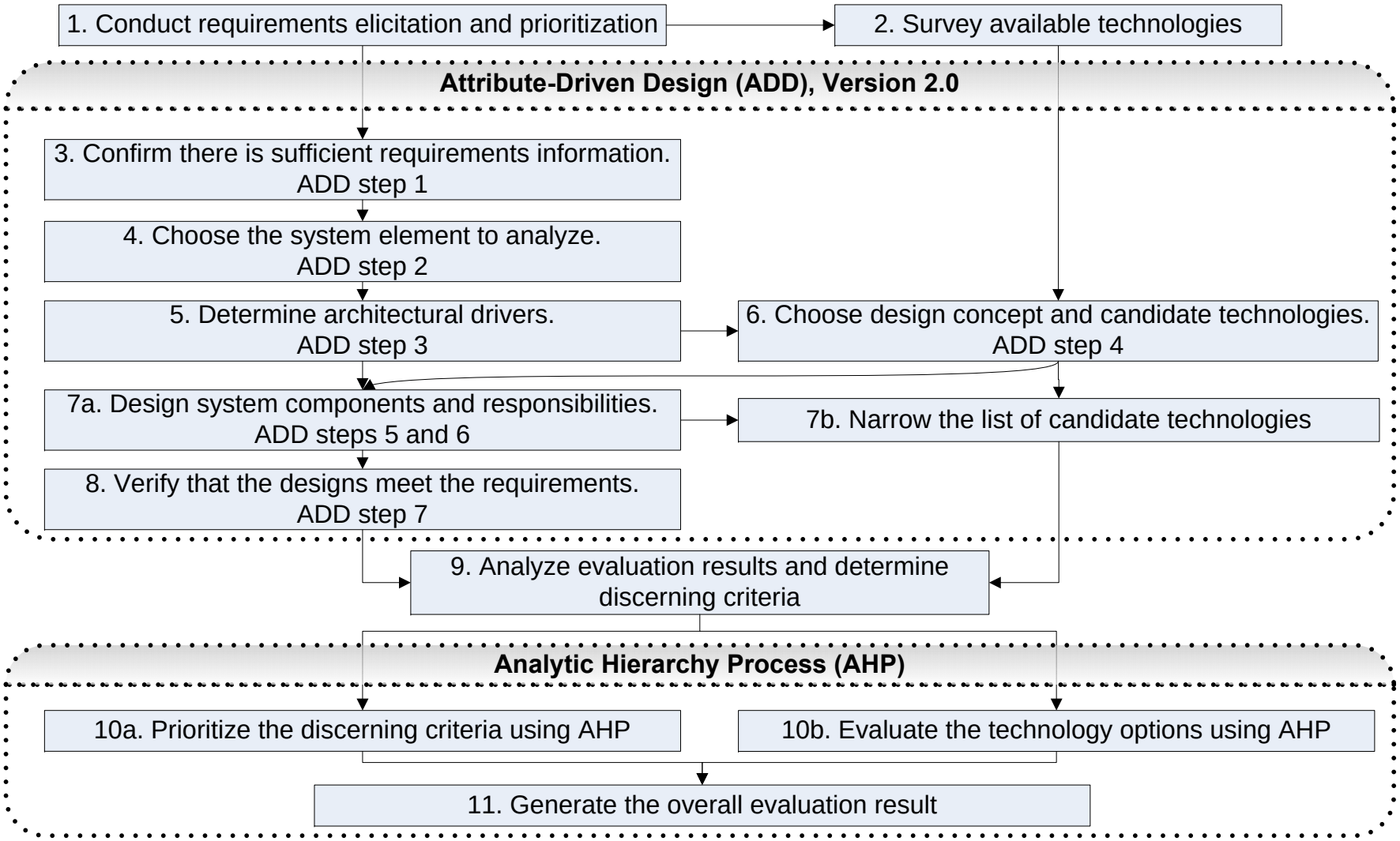
Technology Evaluation – Leveraging ADD
Using AHP – Why 'not yet'?

+ AHP delivers an accurate, robust set of judgment ratings which are mathematically valid ratio-scale numbers.

- AHP scalability is a concern:
  - 7 criteria require 21 comparisons (6+5+4+3+2+1)
  - 25 criteria would require (24+23+22+…) = 300 comparisons, if not structured into a hierarchy
  - Creating an AHP hierarchy (using KJ Method, or affinity process) reduces the comparisons, but the effort can still be significant.

Technology Evaluation – Leveraging ADD

Steps of the AHEAD method



Technology Evaluation – Leveraging ADD
Prototyping + preliminary evaluation

As we created 3 proposed architectures and prototypes, by following ADD steps 5 & 6:

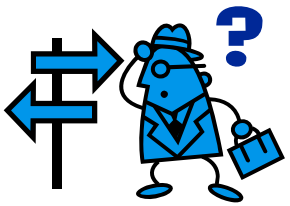
- 1 technology alternative was disqualified
- Prototypes and further research were completed for the top 2 technologies

Per ADD step 7, we verified the two designs/prototypes:

- 10 criteria could not be judged effectively within the constraints of the evaluation;
- the candidate technologies were considered equally preferred for 33 criteria;
- distinct differences were noted on 7 ‘discerning criteria’, but without team consensus on which technology was better

Additional evaluation effort was needed to assess the options.

Technology Evaluation – Leveraging ADD
Quantitative evaluation of alternatives



After **additional prototyping and research** to better examine satisfaction of the 7 discerning criteria, numerical priorities and technical scores were obtained with AHP:

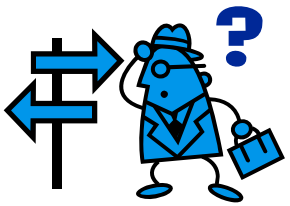
- 21 pair-wise comparisons of importance priorities were collected from the 3 stakeholders, and their ratings aggregated.
- 4 researchers pair-wise-compared the 2 final prototypes, and their technical judgments were combined.

Inconsistency ratios were low, confirming validity of judgments.

The AHP-derived priority and judgment vectors were aggregated to yield overall scores for both final technology alternatives.

Sensitivity analyses examined robustness.

Technology Evaluation – Leveraging ADD
Results and decision analysis



- Both final technologies could meet the needs for improving the identified architectural qualities of this product.
- Based on the sensitivity analyses and scores, technology (A) would better satisfy the prioritized evaluation criteria.

✓ The team uniformly accepted the overall evaluation result.

✓ Stakeholders understood the basis for the recommendation.

Discerning Criteria		BU Priority	Technical Evaluation		Weighted Result	
			A	B	A	B
C1	Dialog response time	***12.4%***	0.50	0.50	0.062	0.062
C2	Integration with product portfolio	***5.1%***	0.13	0.87	0.007	0.044
C3	Ease of migration to new development env.	***23.0%***	0.79	0.21	0.181	0.049
C4	Maximum reuse of existing code	***17.9%***	0.75	0.25	0.134	0.045
C5	Minimum thin client installation effort	***9.9%***	0.88	0.12	0.087	0.012
C6	UI widget features	***15.0%***	0.77	0.23	0.116	0.034
C7	Minimum overall deployment cost	***16.8%***	0.57	0.43	0.095	0.072
OVERALL		***100%***			**0.68**	**0.32**

Technology Evaluation – Leveraging ADD
Lessons Learned

1. **Analysis of evaluation scope is critical**
   - Interdependence of components in product suite
   - Strategies for surrounding sub-systems
   - Choice of stakeholders and weight attributed to each
2. **Practice makes perfect**
   - Hands-on experience in methodology to conduct evaluation
   - Detailed design of prototypes to provide results which can be meaningfully compared
   - Unambiguous and measurable criteria to minimize subjectivity
3. **Evaluation result ≠ automatic decision**
   - Technical aspects vs. other decision factors
   - Both priorities and technologies evolve, over time

Technology Evaluation – Leveraging ADD
Conclusions

Combining ADD with incremental prototyping and AHP delivered an overall evaluation result accurately reflecting the stakeholders' stated priorities.

Benefits of using ADD and the AHEAD method:

- Guidance for all phases of the comparative evaluation project
- **Technologies evaluated in software system architecture context**
- Balance efficiency, accuracy, completeness, cost, schedule
- Mitigation of subjective decision factors
- Traceable evaluation which delivers quantitative results
- Ease of performing sensitivity analysis

Future work:

- Improved elicitation of architectural requirements
- Examination of the full set of requirements
- Applicability towards functional requirements
- Reusability of evaluations

Technology Evaluation – Leveraging ADD
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QUESTIONS, COMMENTS…

Technology Evaluation – Leveraging ADD
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See: www.agileteams.com/AHEAD.html for further information.

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