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Customer Success Is Our Mission

Architecture Decisions and Risk Management

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Architecture Decisions and Risk Management

Agenda

- Design Heuristics and Principles
- Evaluating an Architecture
- Evaluating an Architecture with DFSS

Design Heuristics and Principles

Common Challenges in Architecture

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- Architecture is a long-term investment, while projects often have aggressive short-term goals
- Projects that suffer from schedule compression implicitly prioritize functional requirements over the non-functional requirements
  - We often under-spend on architecture to meet delivery commitments

Common Challenges in Architecture

Reuse is a worthy goal, but cultural and organizational barriers keep it from achieving its potential

- Cultural barriers:
  - "Not-invented-here" syndrome
  - Perceived long-term risks of open-source
- Organizational barriers:
  - Need a product-line architecture approach built into the organizational structure to succeed

Common Pitfalls in Architecture

- Performance
  - Not understanding the relative priorities between performance and other quality attributes
- Security
  - Not being up to speed on modern techniques
  - Not having an architecture roadmap for a product
  - Not thinking from hacker's perspective
- Usability
  - Allowing for some customer configuration with excessive parameterization
  - Lack of backwards compatibility
- Availability
  - Creating single points of failure
  - Artificially tight constraints
- Modifiability
  - Excessive reliance on third party products
  - Overshooting on reusability
  - Not thinking enough about reusability
  - Not investing in refactoring
  - Excessive reliance on experts instead of documentation
- Testability
  - Too many fault messages results in information overload
  - Not considering the cost of defect characterization

What Do Good Architects Do?

Good architects can satisfy the functional requirements while meeting non-functional requirements (i.e. quality attributes). How do they achieve that?

By applying design heuristics and principles such as:

Separation

- Isolates a portion of a system's functionality into a component

Abstraction

- Is the operation of creating a virtual machine and hiding its underlying implementation

Compression :

- Removing layers or interfaces (i.e. the opposite of Separation)

Resource sharing

- Encapsulation of either data or services
- Sharing among multiple independent consumers

Replication

- Operation of replicating a component.

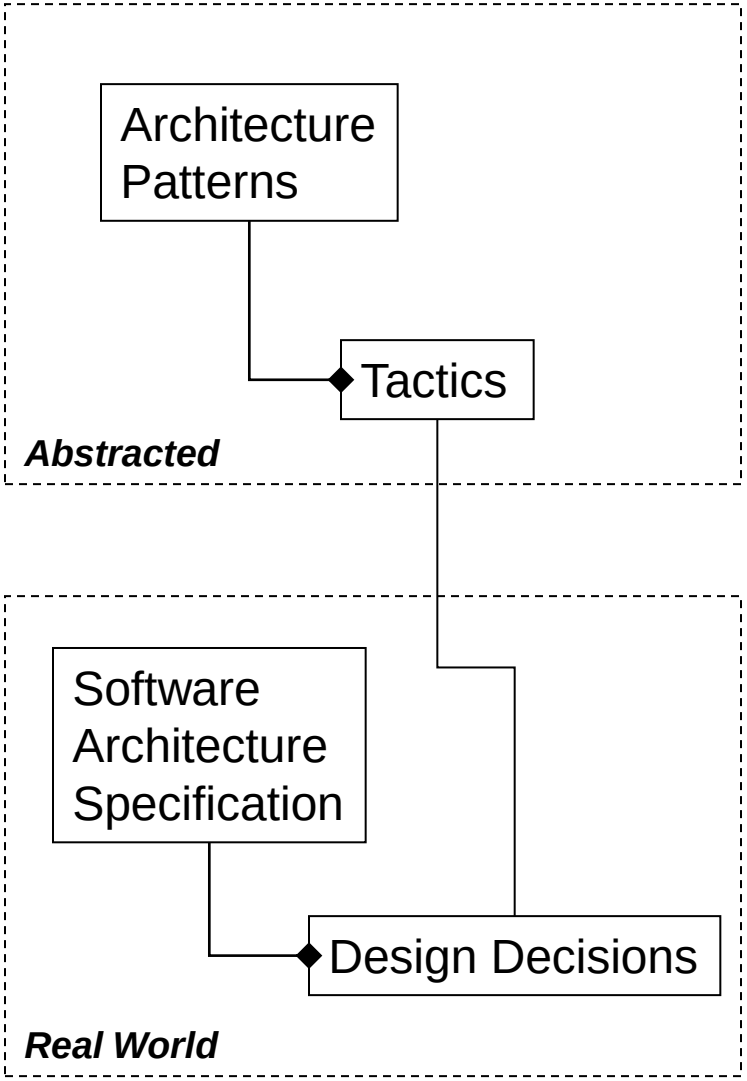
Decomposition

- Separating a large system into smaller components
- Part-Whole : each subcomponent represents non overlapping portions of the functionality
- Is-a : Each subcomponent represents a specialization of its parent's functionality

What Do Good Architects Use?

- The SEI has started collecting a catalog of proven solutions that help address the quality attributes – they call these proven approaches “tactics”.

  Tactics = Fundamental design decisions employed to achieve the quality attributes



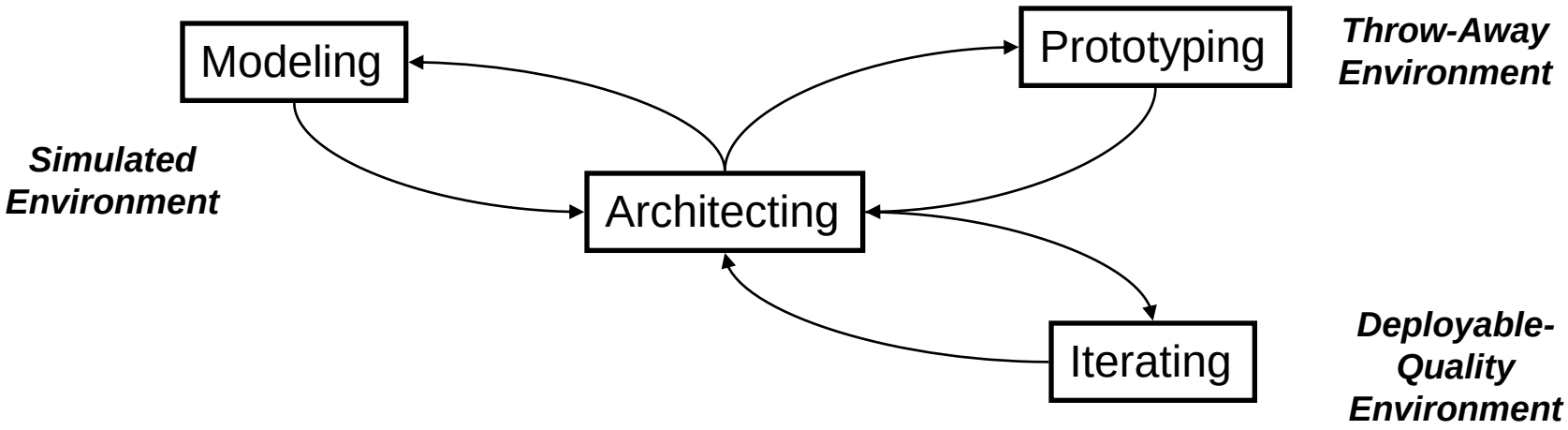
Good Architects Never Stop Learning

- Good architects are continuously learning
- Good architects stay on top of industry trends
- Good architects balance the risk of change against the value of the new ideas they may apply to a product
- Good architects maintain the architecture documentation to help the next generation of architects to learn
- Good architects strive to optimize the system behavior, not the product behavior
  - Or, similarly, optimize the product more than the component…

Evaluating an Architecture

Evaluating an Architecture

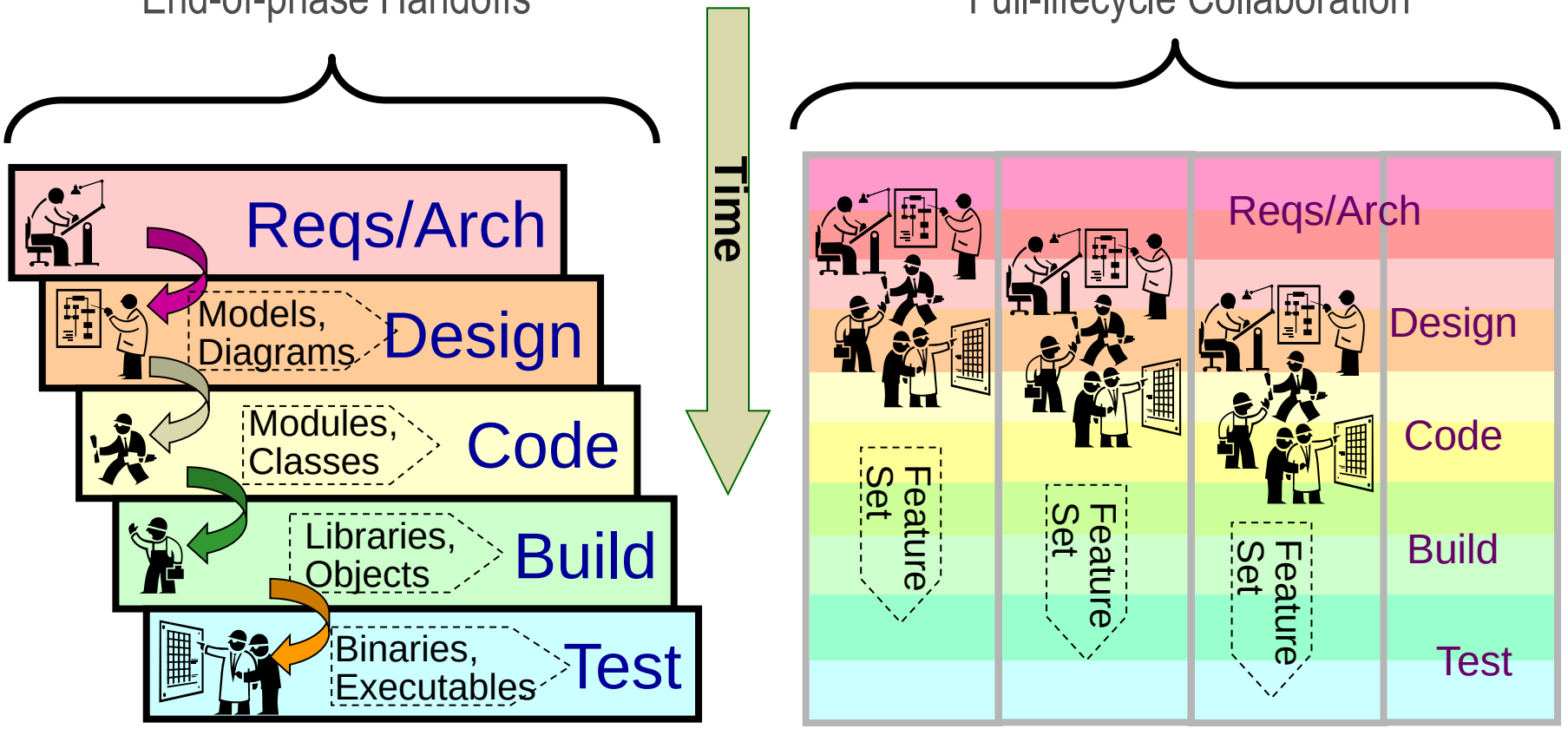
- How do you know whether the application of the tactics will really pull the critical parameters within spec?
  - Create executable models of your architecture specification
  - Leverage an iterative development lifecycle
  - Develop prototypes that implement parts of the architecture
- Somehow, you'll want to get some measurable feedback on the effectiveness of your architecture…



Evaluating with Iterative Development

Waterfall Lifecycle
Breadth-First Delivery
Phase-based Development
End-of-phase Handoffs

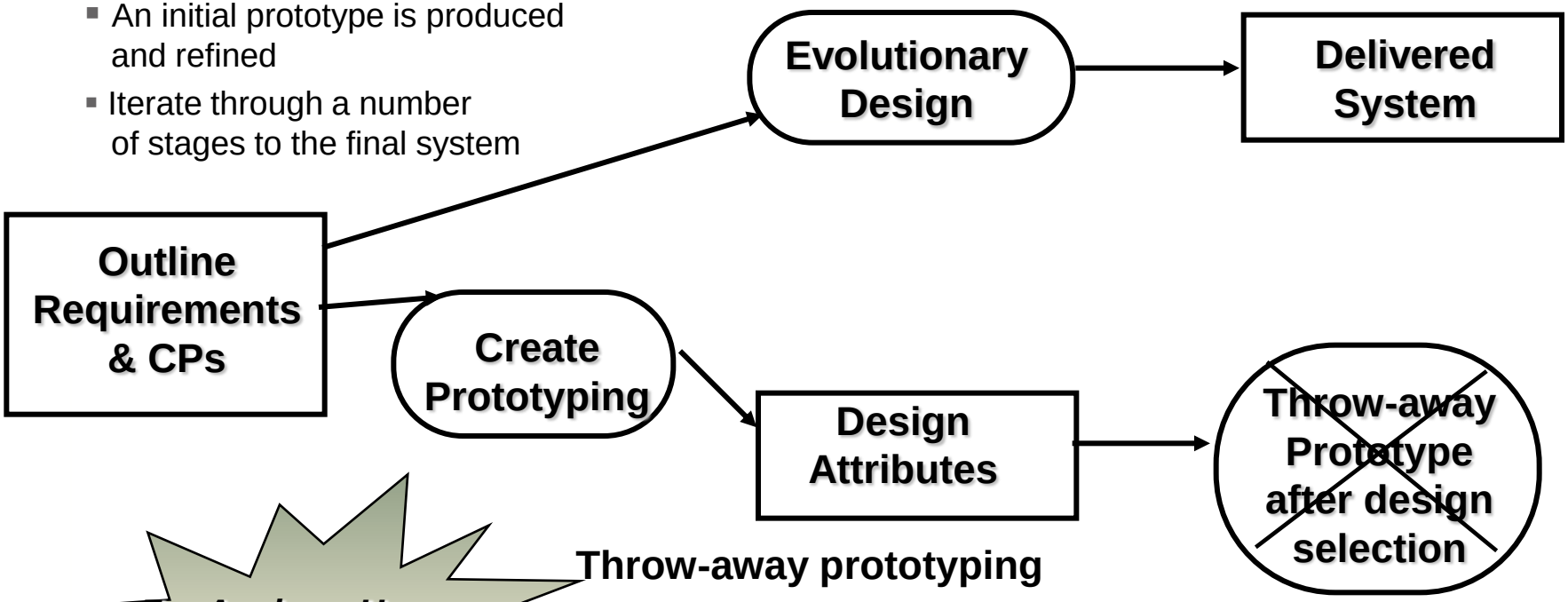
Iterative Lifecycle
Depth-First Delivery
Feature-Set-based Development
Full-lifecycle Collaboration



Evaluating with Prototyping

Evolutionary Design

- An initial prototype is produced and refined
- Iterate through a number of stages to the final system



For Analyze, Use Throw-away techniques

Throw-away prototyping

- A prototype is produced to help discover attributes associated with a concept
- The results are discarded when design selection is completed.
- Resist management's tendency to use/release the throw away prototype

Never change a Throw-away prototype to an Evolutionary Design

Prototyping Techniques & Tools

- Prototypes are created as models presented in a format that is immediately recognizable to the users
- Normally a mock-up is a user interface model that may or may not be skeletal in terms of functional capability
- Prototypes are created through the use of specification languages that are directly machine-interpretable. (Flash)
- Prototypes are developed by using a high-level language that is application oriented;

Evaluating using Risk Analysis

What is a Risk

- According to the Defense Acquisition University:

"Risk is a measure of the potential inability to achieve overall program objectives within defined cost, schedule and technical constraints"

- ISO Defines Risk as the:

"combination of the probability of an event and its consequence"

The Risk Management Process

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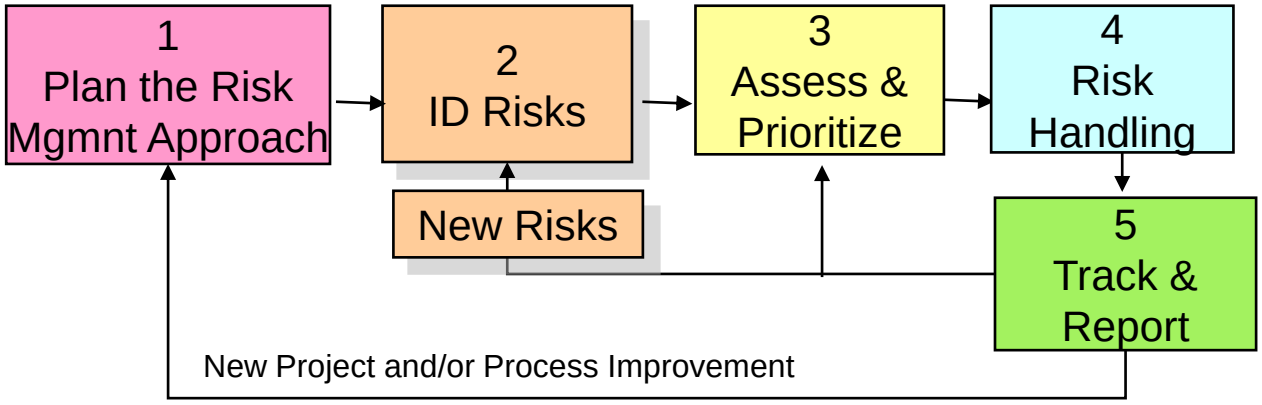
- Risk Management is a continuous closed loop process that captures new risks as they emerge, tracks the status of already identified risks, retires risks through successful actions, or realizes risks through unsuccessful actions

- 5 steps - derived from a process developed by the Defense Acquisition University, and other sources such as Carnegie Mellon's Software Engineering Institute and the Open Systems Initiative.
  1. Plan
  2. Identify Risks
  3. Assess and Prioritize Risks
  4. Develop and Implement Risk Handling Approaches
  5. Track and Report



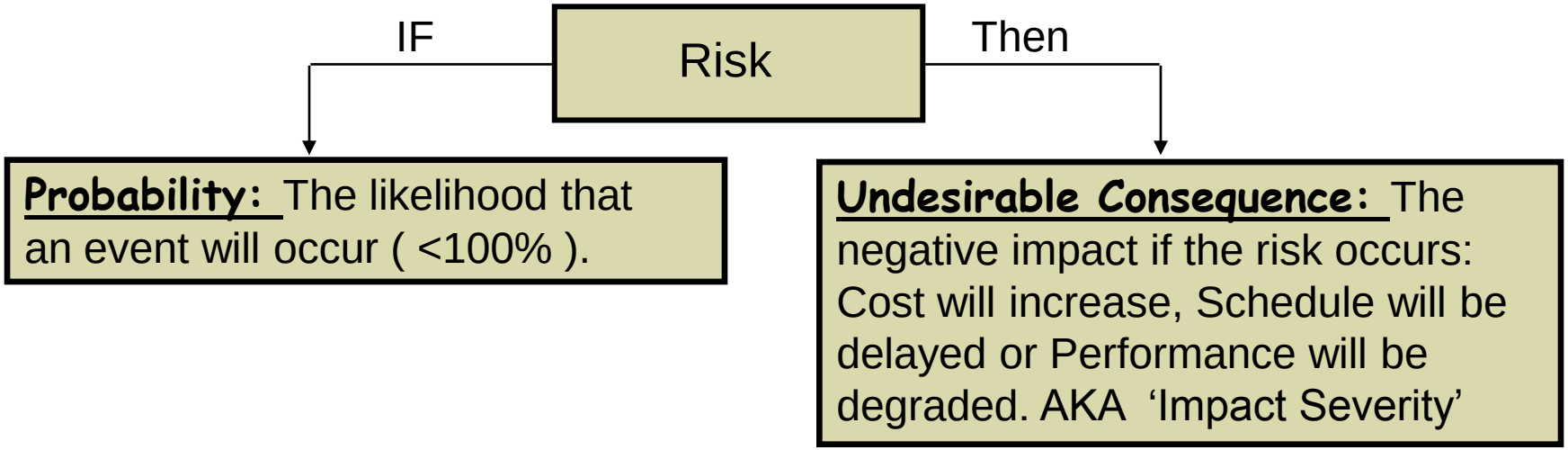
Risk Management is an ongoing process, not an event

Evaluating using Risk Analysis

Risk is …the *Possibility* Of Suffering A *Loss,* the uncertainty of attaining a future goal – it hasn't happened yet.

Every Risk has Two Elements

- Probability: the chance that an event will occur. If it's a sure thing, then it's a problem (not a risk)
- Consequence: A negative impact on Cost, Schedule, Performance or a combination of all three…"then"



Risk Assessment

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- Risk Factor is an evaluation of a Risk's probability of occurrence (Pf) and severity of consequence (Cf) to determine its seriousness

(Pf * Cf) = Rf

- Risk Factor is used to prioritize the list of risks
  - High, Med, Low

RISK FACTOR (Rf)

High (R_f >0.50)

Moderate (.25 ≤ R_f ≤ 0.5)

Low (R_f <0.25)

HIGH **(RED)**	Likely to cause significant serious disruption of schedule, increase in cost, or degradation of performance even with special contractor emphasis and close government monitoring.
MODERATE **(YELLOW)**	Can potentially cause some disruption of schedule, increase in cost, or degradation of performance. However, special contractor emphasis and close government monitoring will probably be able to overcome difficulties.
LOW **(GREEN)**	Has little potential to cause disruption of schedule, increase in cost, or disruption of performance. Normal contractor effort and normal government monitoring will probably be able to overcome difficulties.

Rf Action Guidelines Table

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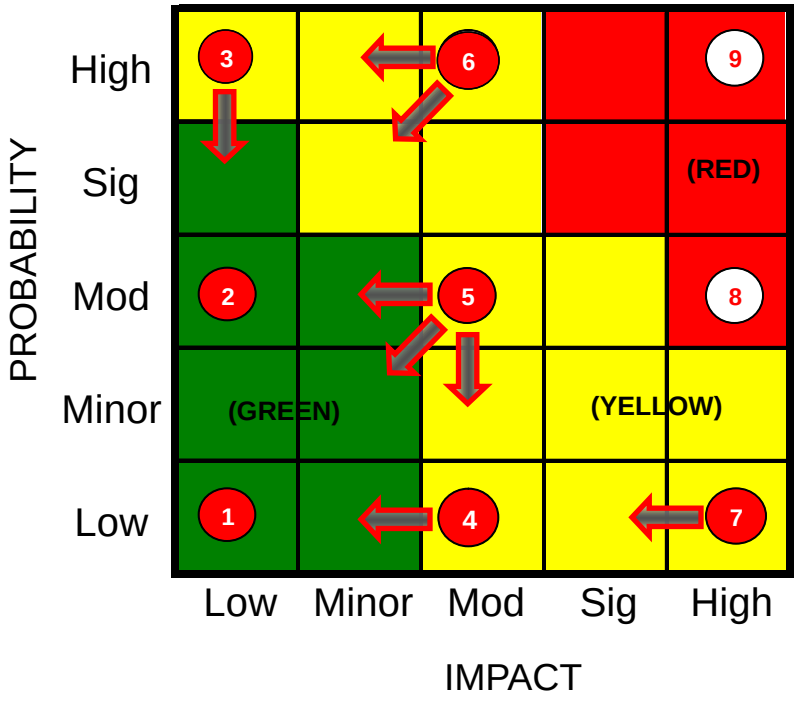
#	P_f	C_f	R_f	Recommendation
1	Low	Low	Low	Do Nothing
2	Medium	Low	Low	Do Nothing
3	High	Low	Medium	Reduce likelihood or establish contingency
4	Low	Medium	Medium	Monitor, take action if needed
5	Medium	Medium	Medium	Take action if needed
6	High	Medium	Medium	Take action to reduce likelihood
7	Low	High	Medium	Develop cost effective mitigation plan
8	Medium	High	High	Take action
9	High	High	High	Take action



Evaluating using Risk Analysis

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- **Risk analysis should clarify the possible outcomes and assign values to the probabilities and impacts**

Risk area	Risk	Prob†		Impact†		Risk
Rqmt Stability	If requirements change, then architecture design will slip; fixed need date prevents meeting users' need	High	X	Med	=	Med
Design Perform	If throughput rqmts are not achievable with COTS S/W; then schedule will slip	Low	X	Med	=	Med
Rqmt Scale	If effort is larger than expected, then will not be able to staff causing extensive slips	Med	X	Low	=	Low

Risk list

Ranked risk list

†Prob – High: 1>P>0.7, Med: 0.7>P>0.4, Low: 0.4>P>0.1, None: 0.1>P
Impact – High: >$1M or slip>3 months, Med: ...

Using Tactics To Reduce Risk

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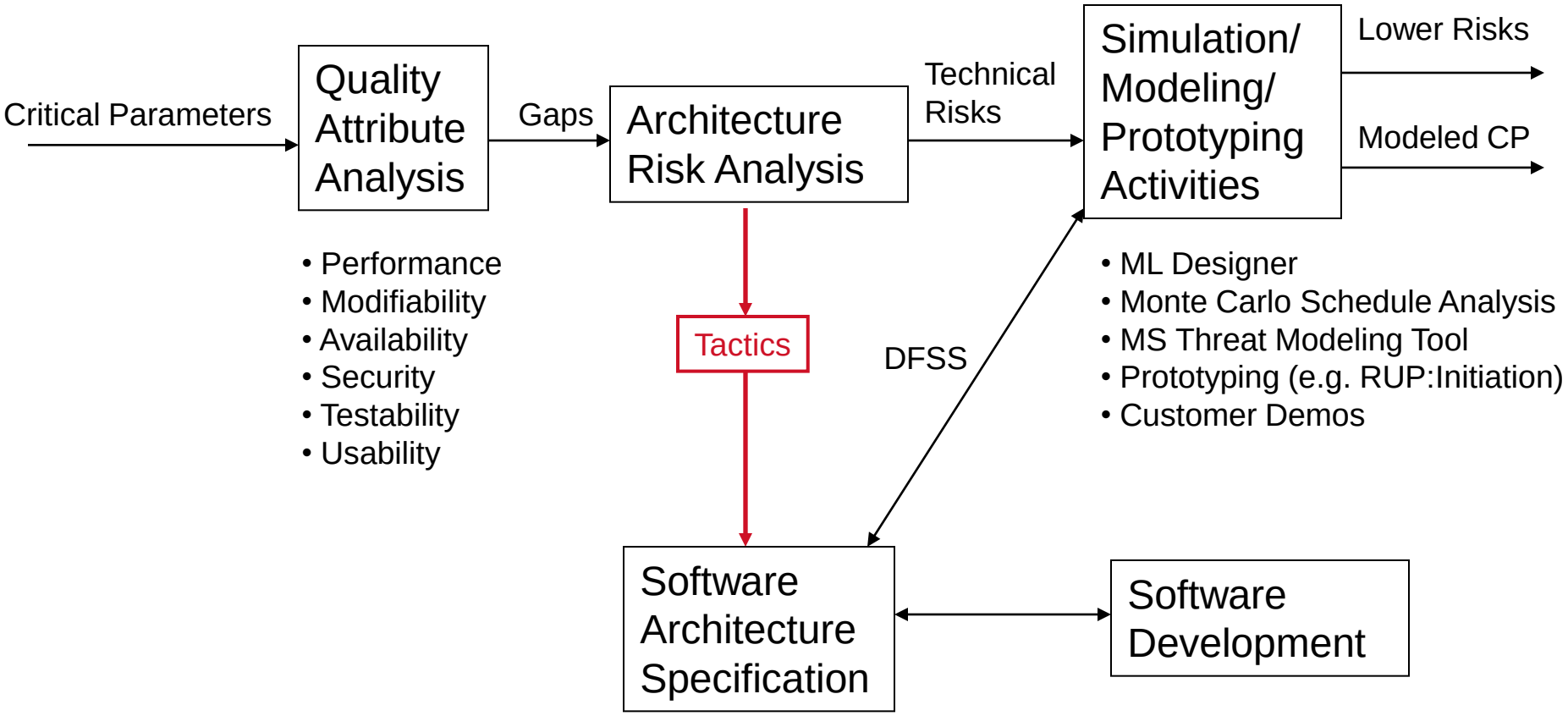

Kinds of Tactics

- Performance
  - Resource Demand
  - Resource Management
  - Resource Arbitration
- Security
  - Resisting Attacks
  - Detecting Attacks
  - Recovering from an Attack
- Usability
  - Separate User Interface
  - Support User Initiative
  - Support System Initiative
- Availability
  - Fault Detection
  - Recovery: Preparation and Repair
  - Recovery: Reintroduction
  - Prevention
- Modifiability
  - Localize Changes
  - Prevention of Ripple Effect
  - Defer Binding Time
- Testability
  - Manage Input/Output
  - Internal Monitoring

Examples of Tactics

- Performance
  - FIFO
  - Leaky Bucket
- Security
  - Trusted Computing Base
  - Authenticate Users
  - Authorize Users
- Usability
  - Parameter Hiding
  - Undo
  - Clearly Marked Exits
- Availability
  - Trusted Computing Base
  - FIFO
  - Leaky Bucket
  - Garbage Collection
- Modifiability
  - Abstract Common Services
  - Anticipate Expected Changes
  - Runtime Registration
- Testability
  - Record/Playback
  - Built-in Monitors

Example: Trusted Computing Base

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- Let's say we're developing an architecture for a phone.
- The gap analysis of the quality attributes revealed that the security response of the phone is a critical parameter
  - Desired Response: Keep Mean-Time-To-Detect within 5 minutes (i.e. to detect an attack)
- What design decisions can we make to achieve this?
  - Leverage a tactic called "Trusted Computing Base"
- Design decision:
  - Choose an architectural boundary, within which, the data is trusted.
  - Note that this decision could result in a degradation of performance response. Tactics will often support one attribute, but at the expense of another.

Example: FIFO

- Let's say we're developing an architecture for an infrastructure product that handles call processing.
- The gap analysis of the quality attributes revealed that the performance response is a critical parameter
  - Desired Response: Maintain response/turnaround time of 5 ms for 95% of inbound events.
- What design decisions can we make to achieve this?
  - Leverage a tactic called "First In, First Out (FIFO)"
- Design decision:
  - Queue events for service in First-in, first-served manner.
  - Note that this decision could result in a degradation of availability, since an individual user that gets buried in the queue will perceive a fault…

Example: Anticipate Expected Changes

- The gap analysis of the quality attributes revealed that the modifiability response is a critical parameter.
  - Desired Response: Changing the audio transport model from circuit-switch to packet-based routing some time in the future should cost no more than 5 SM (Staff Months).
- What design decisions can we make to achieve this?
  - Leverage tactics called “Anticipate Expected Changes”
- Design decision:
  - Keep the transport-specific details isolated in an audio programming layer, distinct from the call processing control logic.

Example: Parameter Hiding

- The gap analysis of the quality attributes revealed that the usability response is a critical parameter
  - Desired Response: Keep the number of configurable parameters below a threshold value (e.g. 20 fields).

- What design decisions can we make to achieve this?
  - Leverage a tactic called “Parameter Hiding”
- Design decision:
  - Make a wider set of configurable parameters available to a select user base (e.g. beta/field personnel) for performance tuning, but not to the general users.

Risk Assessment Summary

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- **Disciplined risk management can be applied to all business aspects**
- **Use the process correctly.**
  - Don’t skip steps in an ill-founded attempt to speed up the process.
- **Train key business personnel as coaches/facilitators**
- **Hold regular risk reviews**
  - Work the process through the program, not just at the Risk Assessment Session.
- **Manage available information to:**
  - Use what we know
  - Understand what we don’t know
  - Minimize what we don’t know we don’t know!
- **Share lessons learned across businesses**

Evaluating Architecture Using DFSS Techniques

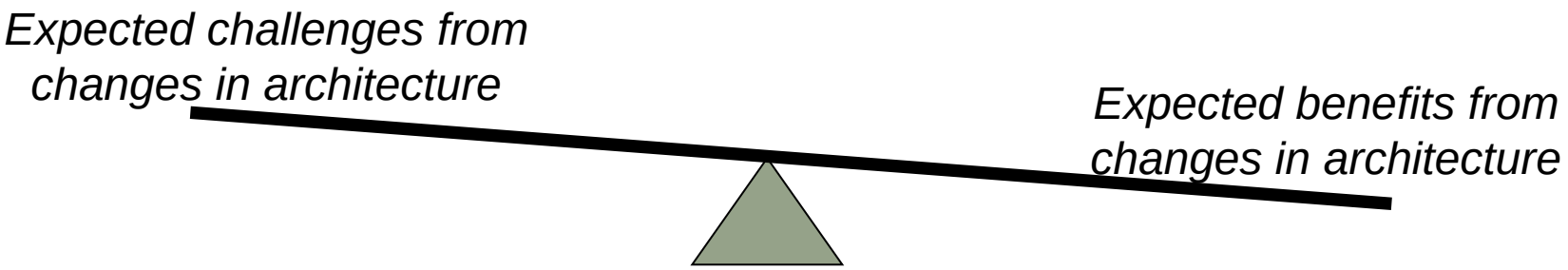
Design Trade Off Analysis Overview

1. Quality Tradeoffs
   - Changing an existing product's architecture is risky…
2. Design* Tradeoffs
   - Prioritization Matrix
   - Pugh Matrix
   - Monte Carlo analysis
3. Economic Tradeoffs
   - Cost Benefit Analysis Model (CBAM)
   - Developing architecture roadmaps for a product

** In this context, "Design" refers to making choices when architecting…*

Quality Tradeoffs

- Changing a legacy architecture is one of the riskiest development activities that a team can undertake.
- The keys are to:
  - Keep the effort under control by making changes in small steps
  - Understand the risks that derive from how well you know your architecture, requirements, and current implementation:
    - Risk of insufficient documentation of legacy products
    - Risk of insufficient domain experience/understanding
    - Risk of insufficient architecture skills on team
  - Make the investment that is needed (i.e. long term architecture phase)



Introduction to Design Trade-off Analysis

- The ability to make decisions is a vital skill, both in our personal and our professional lives.
  - What am I going to have for lunch?
  - What kind of computer should I buy next?
  - What display and keypad should Motorola use to meet a customer's need for a robust design?
- To make a decision you need to know:
  - What are the possible choices?
  - What criteria distinguish the choices?
- If only one criteria is important, the decision is easy:
  - I want the quickest lunch.
  - I want the cheapest computer.

List Architecture Needs

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Architecture Needs	QA	Type
User needs a response to an inbound call request within 400 ms.	Performance	Use Case/AR
Denial of service attacks must be identified and thwarted in 95% of the cases.	Security	Use Case/AR
The system must deliver a mean-time-to-failure of 24 hours or better.	Availability	Use Case/AR
The cost to add new system objects to the NM interface must be less than 5 SM.	Modifiability	Use Case/AR
User must be able to configure a new site subsystem within 5 commands.	Usability	Use Case/AR
System will need to be able to add Phase 2 security standards within 18 months.	Security	Change/Growth
System must remain operational with traffic bursts of up to 4M users per hour.	Performance	Extreme/Stress

Prioritize Needs

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Architecture Needs	QA	Type	Weight
User needs a response to an inbound call request within 400 ms.	Performance	Use Case/AR	90
Denial of service attacks must be identified and thwarted in 95% of the cases.	Security	Use Case/AR	60
The system must deliver a mean-time-to-failure of 24 hours or better.	Availability	Use Case/AR	70
The cost to add new system objects to the NM interface must be less than 5 SM.	Modifiability	Use Case/AR	30
User must be able to configure a new site subsystem within 5 commands.	Usability	Use Case/AR	40
System will need to be able to add Phase 2 security standards within 18 months.	Security	Change/ Growth	10
System must remain operational with traffic bursts of up to 4M users per hour.	Performance	Extreme/ Stress	80

Introduction to Design Tradeoff Analysis

- Usually, there are many choices and many selection criteria. To select a restaurant for lunch, you might consider:

*distance	*price	*variety of entrees
*cuisine	*service	*previous experience

- For a computer, price would seldom be the only criteria:

*display	*package deal	*amount of RAM
*intended use	*size	*mobile technology

- Note that selection criteria seldom point to a perfect choice, because the perfect fit may not exist. To get the perfect cuisine, for example, you might have to drive further.

Design Tradeoff Analysis Tools & Methods

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- Common steps in Design Tradeoff Tools
  1. List the choices, options, or alternatives.
  2. List the selection criteria (e.g. critical parameters).
  3. Score each choice against each criteria.
  4. Score the choices against each other.
  5. Document which choice scores the highest.
- Design Tradeoff Tools & Methods to be presented:
  - Prioritization Matrix
  - Pugh Matrix
  - Cost Benefit Analysis Method (CBAM)

Design Tradeoff tools help you select & document the best choice.

DFSS Tradeoff Tools

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- What do we need in a tradeoff tool to help us make architecture decisions?
  - Analysis support to help us sort through the many choices and conflicting criteria
  - A disciplined approach that helps remove emotion and politics from the decision-making process
- Consider these examples of architecture decision-making:
  1. Choosing between a few alternatives when designing the primary components (architecture elements) in the product architecture
  2. Selecting one among many 3rd party products
  3. Choosing between two algorithms for a queuing model
  4. Creating an architecture roadmap for a product that prioritizes a set of architecture changes by economic value

Tradeoff Example 1

- Choosing between a few design alternatives:
  - Captured as an open issue
    - with a few alternative solutions
    - with pros and cons for each alternative

- Use a Prioritization Matrix when you need to:
  - *accommodate both qualitative and quantitative data*
  - *apply criteria weighting*

Prioritization Matrix

- Prioritization Matrix = a weighted, subjective analysis
  - Multiple alternatives
  - Success criteria
  - Subjective weightings of the criteria

Criteria					
Criteria Weightings					
Alternatives	*Positive correlation of alternative to criteria*				**Score**

Prioritization Matrix

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1. List the alternatives
2. Establish the criteria
3. Weight the criteria (on a 1-10 scale)

Criteria	Performance	Development Cost	Future Modifiability	Security	
Criteria Weightings	7	5	9	4	
Alternatives	*Positive correlation of alternative to criteria*				**Score**
Create a new mobility handler					
Extend the current mobility tracker					
Use classes in ACE framework					
Reuse the iDEN mobility handler					

Prioritization Matrix

4. Rate each alternative against each criteria (1-10 scale)
5. Rank the alternatives by score
6. If no clear winner emerges, consider adding criteria

Criteria	Performance	Development Cost	Future Modifiability	Security	
Criteria Weightings	7	5	9	4	
Alternatives	*Positive correlation of alternative to criteria*				**Score**
Create a new mobility handler	8	2	6	8	152
Extend the current mobility tracker	5	6	3	3	104
Use classes in ACE framework	3	4	7	9	140
Reuse the iDEN mobility handler	6	5	3	2	102

DFSS Tradeoff Example 2

- Selecting one among many 3rd party products:
  - Captured as a list of 3rd party offerings
    - with costs and benefits for each offering

- Use a Pugh Matrix when you need to:
  - do a quick qualitative assessment
  - determine if there is an obvious winning concept
  - get a quick feel for concept comparison
  - down-select from many concepts to the most promising few

Pugh Concept Selection

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Summary: compares and selects best ideas & concepts using a simple system of "better than", "worse than", and "same" scoring. Identifies best features from each concept and creates hybridized solutions.

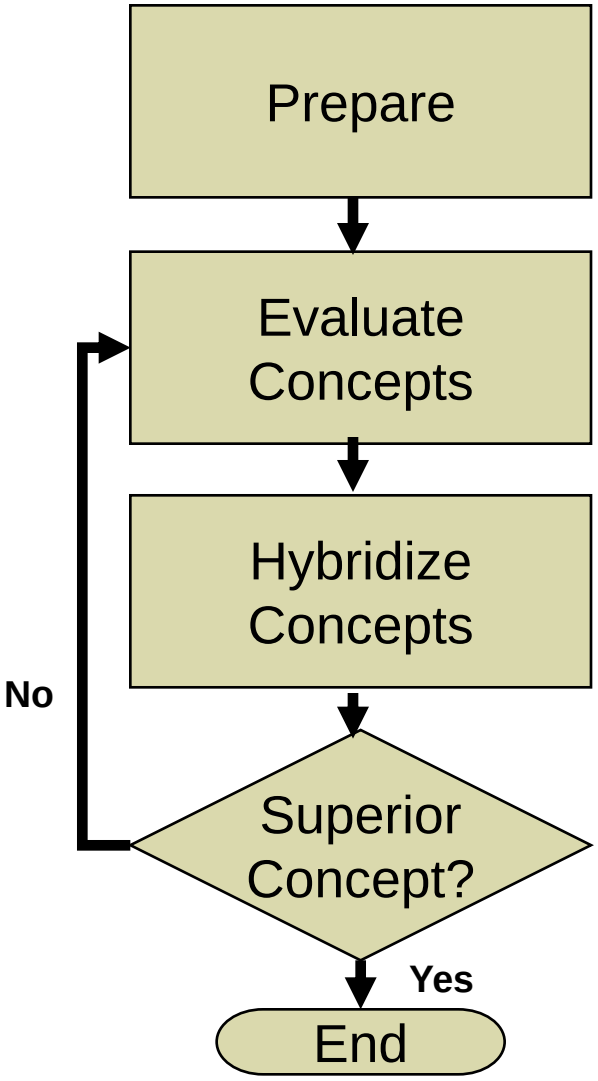
Criteria / Concept	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ease of achieving 105-125 DbA		S	-		+	-	+	+	-	-	-	-	S	+
Ease of achieving 2000-5000Hz		S	S	N	+	S	S	+	S	-	-	-	S	+
Resistance to corrosion, erosion & water		-	-	O	S	-	-	S	-	+	-	-	-	S
Resistance to vibration, shock & acceleration	D													
Resistance to temperature	A													
Rsponse time	T													
Complexity: number of stages	U	-	+	E	S	+	+	-	-	-	+	+	-	-
Power consumption	M	-	-	V	+	-	-	+	-	-	-	-	S	+
Ease of maintenance		S	+	A	+	+	+	-	-	S	+	+	S	-
Weight		-	-	L	+	-	-	-	S	-	-	-	-	+
Size		-	-	U	S	-	-	-	-	-	-	-	-	-
Number of parts		S	S	A	+	S	S	-	-	+	-	-	S	-
Life in service		S	-	T	+	-	S	-	-	-	-	-	-	-
Manufacturing cost		-	S	E	-	+	+	-	-	S	-	-	-	-
Ease of installation		S	S	D	S	S	+	-	S	-	-	-	S	-
Shelf life		S	S		S	S		-	S	S	S	S	S	S
Σ+		0	2		8	3	5	3	0	2	2	2	0	4
Σ-		6	9		1	9	7	12	11	8	13	13	8	9
ΣS		10	5		7	4	4	1	5	6	1	1	8	3

Pugh Concept Selection Matrix

Benefit:

- Identifies the superior concepts
- Aids in hybridization of concepts by identifying strengths & weakness of each concept

Pugh Concept Evaluation Process



1. Prepare all concepts to similar level of detail
2. Define concept evaluation criteria
3. Construct evaluation matrix

4. Select datum to evaluate concepts against
5. Compare each concept against the datum

6. Analyze concepts and create new superior hybrid concepts
7. Eliminate weak concepts from evaluation matrix

8. Confirm superior concept

Select the Datum – Step 1

1. Choose one of the alternatives to be the straw man, or "datum"
   - Rather than comparing each concept against the others, all concepts are compared against the datum
     - The datum "takes the heat" thus rendering a focus for all other concepts to beat
   - Datum for Initial Evaluation
     - Benchmarked best-in-class design in the context of your product requirements and competitive environment
     - If no best-in-class design exists, the datum is the concept that the team believes is the strongest among the alternatives
   - Datum for Subsequent Evaluation Iterations
     - Select the strongest concept that is present in the matrix (either the initial datum or a concept that has emerged as stronger)

Select the Datum – Step 2 & 3

2. Systematically compare each concept against the datum
   - For each evaluation criteria, rate the concept as:
     - \+ Better than, less than, less prone to, easier than, etc., relative to the datum
     - \- Worst than, more expensive than, more complex than, more prone to than, etc., relative to the datum
     - S Same as the datum
3. For each concept, sum the +, - and s ratings

Compare Each Concept Against The Datum

Product Concepts →

	1	2	3	4	5				N
Evaluation Criteria #1		s	-	+	s				
Evaluation Criteria #2		+	-	-	s				
Evaluation Criteria #3	D	+	+	+	s				
	A	-	-	s	-				
	T	-	-	s	-				
	U	+	-	+	+				
Evaluation Criteria #N	M	+	-	+	+				
∑+		4	2	4	2				
∑-		2	6	1	2				
∑s		1	0	2	3				

DFSS Tradeoff Example 3

- Choosing between two algorithms for a queuing model:
  - Two alternative approaches to handling inter-process communications within the product's concurrency model
    - each algorithm has different advantages and weaknesses
    - there is variability on the traffic patterns
    - the requirements are stated as a range of acceptable utilization %
- Use Monte Carlo Analysis* when you need to:
  - handle variability in the inputs
  - do sophisticated statistical modeling
  - determine whether the results fall within acceptable ranges

*[Refer to "Applying DFSS to Software and Hardware Systems, Maass & McNair, Prentice-Hall, 2009]

Summary of Architecture Evaluation Techniques

- A comprehensive set of scenarios was presented to assist in a complete evaluation of the architecture.

- Methods were defined to help measure the architecture so an evaluation could be performed. Using capability flow up, flow down along with simulation or models provides a very powerful metrics based evaluation technique.

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