Architecture Evaluation

Qualitative and Quantitative
When we say ‘Architectural evaluation’

“For a large system, its architecture often is described by a hierarchy of related architectures. An architecture hierarchy is a linear sequence of two or more individual architectures that may differ with respect to the number and kind of components and connections among them.” …

The utility of an architecture hierarchy is severely limited by the current level of informality. Individual architectures may be ambiguous, allowing multiple and perhaps unintended interpretations. The mapping between architectures in the hierarchy is partially specified, if at all, making it impossible to accurately trace the lineage of implementation decisions.

The analysis of architecture is limited to syntactic checks. It is not possible to check semantic properties of an architecture, such as the safety and fairness of its connections, or to check the relative correctness of two architectures in the hierarchy. Consequently, a concrete architecture may erroneously be seen as an implementation of a more abstract architecture.”
(Moriconi, Qian & Riemenschneider, 1995, p. 356)

- What exactly are we evaluating?
  - Small group discussion…. 
Architecture Management & Planning

Enterprise Architectures

Professor Truex
Two Techniques

- Architecture Tradeoff Analysis Method (ATAM)
  - Qualitative approach to prioritizing requirements

- Cost Benefit Analysis Method (CBAM)
  - Takes the output of the ATAM and adds economic analysis in the form of cost benefit tradeoffs
ATAM

- Multiple stakeholders and participants
  - Evaluation team
  - Project managers
  - Architecture stakeholders

- What characteristics do you want in the team?
  - Roles and attributes (Bass et al, c.f. pg 273)
ATM outputs/deliverables

- Rank ordered priorities in the following forms:
  1. Concise architecture model
  2. Clear business goals of the architecture (system)
  3. Quality requirement scenarios (QRSs)
  4. Mapping of architectural decisions to QRSs
  5. Sensitivity analysis and tradeoff points
     - How important is it and at what tradeoff?
       E.g., back up database important to reliability, problem for security
  6. Risk analysis and risk theme clustering
# Example tabular ATAM output

<table>
<thead>
<tr>
<th>Quality Attribute</th>
<th>Attribute refinement</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>Transaction Response time</td>
<td>User updates patient acct. in less than .75 second</td>
</tr>
<tr>
<td></td>
<td>Throughput</td>
<td>Patient acct under peak load in response to chg of add notification &lt; 4 secs.</td>
</tr>
<tr>
<td></td>
<td>Generating reports</td>
<td>Batch by midday</td>
</tr>
<tr>
<td>Usability</td>
<td>Proficiency training</td>
<td>Experienced new hires up to speed in &lt; 2wks</td>
</tr>
<tr>
<td></td>
<td>Normal operation</td>
<td>Set payment plan real time with patient w/out delays</td>
</tr>
<tr>
<td>Configurability</td>
<td></td>
<td>No source code changes to change fee structures; &lt;1 day</td>
</tr>
<tr>
<td>Maintainability</td>
<td></td>
<td>…Change, update, maintenance scenarios…</td>
</tr>
</tbody>
</table>
CBAM -- Cost Benefit

- If each architectural decision has costs and tradeoffs (risks)
- How do we evaluate economic value and necessity?
CBAM (Benefits) vs. ATAM (tradeoffs)

- ATAM identifies sets of key architectural decisions
- BAM quantifies them as to cost
- Scenarios
  - Utility curves
    - Best case and worst case scenarios compared to current and desired states
  - Prioritizing scenarios via voting
A model of Security Design

What are each of these elements?
A model of Security Design

- Threats
  - Destruction
  - Modification
  - Disclosure

- Control
  - Avoidance
  - Tolerance
  - Mitigation

- Targets
  - Physical (Hardware, people...)
  - Data
  - Data Communications
Intranet Security: instance example

- Intranet security is vital especially if connected to the Internet

- Security can be
  - threatened (someone tries to break in)
  - compromised (someone knows how to break in)
  - breached (actually breaks in or infiltrates)

- Security threats can
  - come from inside and outside
  - be deliberate or accidental
Types of Threats

- Threats to hardware
  - Theft of equipment
  - Tampering by disgruntled employees
  - Destruction by natural accidents (fire, flood etc.)
  - Ordinary wear and tear

- Threats to software
  - Deletion - accidental or deliberate
  - Theft by user
  - Corruption by virus or hardware malfunction

- Threats to information
  - Corruption, theft or deletion of files
Planning Intranet Security

- Defining security goals
  - Protect what? (hardware? network? data?)
  - Protect from whom? (users? outsiders?)
  - Protect from what? (fire? natural disasters?)
  - Cost effectiveness of measures

- Typical security goals include
  - Preventing malicious damage to files and system
  - Preventing accidental damage
  - Protecting data integrity and confidentiality
  - Preventing unauthorized access
  - Providing appropriate disaster recovery
Use the model to assess and plan...

Threats

Destruction
Modification
Disclosure

Avoidance
Tolerance
Mitigation

Physical (Hardware, people...)
Data
Data Communications

Control

Targets

Enterprise Architectures

Professor Truex
## Security Planning and Design Grid

<table>
<thead>
<tr>
<th></th>
<th>Physical</th>
<th>Data</th>
<th>Data Comm.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Destruction</strong></td>
<td>Intentional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accidental</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disclosure</strong></td>
<td>Intentional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accidental</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Modification</strong></td>
<td>Intentional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accidental</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risk (Cost) benefit analysis

- \( E_C = P_i \times C_i \)
- \( E_v = B_i - E_C \)

Overall utility of scenarios
- Where \( B_i = \sum_j (b_{i,j} \times W_j) \)
  - Where \( b_{i,j} \) is the benefit assigned to a strategy \( I \) given its effect on scenario \( j \) and where \( W_j \) is the weighting given to scenario \( j \)

- What is an inherent weakness in this formulation?
- Are traditional investment decision metrics adequate?
Design benefits, costs and Return on Investment

- Question: How good is good enough?
- Once decided and costs are assigned then we compute the expected return on investment. That metric is, in turn, compared to organizational standards.
- ROI $\Rightarrow R_i = B_i / C_i$
CBAM steps

1. Gather and group (Collate) scenarios
2. Refine scenarios
3. Prioritize scenarios
4. Assign a utility to each
5. Develop architectural strategies for each and assess expected quality attribute levels
6. Determine utility value for each
7. Derive expected benefit
8. Choose strategies based on ROI
9. Check choices with your intuition (common sense)
c.f., pgs. 318-323

- Collected scenarios
- Response goals
- Refined Scenarios
- Assign utility
Financial Analysis of Projects

- Financial considerations are often an important consideration in selecting projects.
- Three primary methods for determining the projected financial value of projects:
  - Net present value (NPV) analysis
  - Return on investment (ROI)
  - Payback analysis
Net Present Value Analysis

- Net present value (NPV) analysis is a method of calculating the expected net monetary gain or loss from a project by discounting all expected future cash inflows and outflows to the present point in time.
- Projects with a positive NPV should be considered if financial value is a key criterion.
- The higher the NPV, the better.
# Net Present Value Example

## Excel file

### PROJECT 1

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AN. INT. RATE --&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROJECT 1</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>YEAR 4</th>
<th>YEAR 5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVENUES</td>
<td>$0</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$5,000</td>
<td>$14,000</td>
</tr>
<tr>
<td>COSTS</td>
<td>$5,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$9,000</td>
</tr>
<tr>
<td>CASH FLOW</td>
<td>($5,000)</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

| NPV | $2,316 |

**Formula** = npv(b3:b8)

### PROJECT 2

<table>
<thead>
<tr>
<th>PROJECT 2</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>YEAR 4</th>
<th>YEAR 5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVENUES</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$4,000</td>
<td>$4,000</td>
<td>$4,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>COSTS</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>CASH FLOW</td>
<td>($1,000)</td>
<td>$0</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

| NPV | $3,201 |

**Formula** = npv(b3:b15)

---

Notice that cash flow totals are the same, but NPVs are different.

RECOMMEND PROJECT 2 BECAUSE IT HAS THE HIGHER NPV.

IF STATEMENT --> =IF(B9>B16,A5,A12)

RESULT --> PROJECT 2
Return on Investment

- Return on investment (ROI)
  - or income divided by investment
    
    \[ \text{ROI} = \frac{\text{total discounted benefits} - \text{total discounted costs}}{\text{discounted costs}} \]
  - The higher the ROI, the better

- Many organizations have a required rate of return or minimum acceptable rate of return on investment for projects
Payback Analysis

- Another important financial consideration is payback analysis.
- The payback period is the amount of time it will take to recoup, in the form of net cash inflows, the net dollars invested in a project.
- Payback occurs when the cumulative discounted benefits and costs are greater than zero.
- Many organizations want IT projects to have a fairly short payback period.
### NPV, ROI, and Payback Analysis for Project 1

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DISCOUNT RATE</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TOTAL</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
<td>($9,000)</td>
</tr>
<tr>
<td>4</td>
<td>COSTS</td>
<td>($5,000)</td>
<td>($1,000)</td>
<td>($1,000)</td>
<td>($1,000)</td>
<td>($1,000)</td>
<td></td>
<td>-9,000</td>
</tr>
<tr>
<td>5</td>
<td>DISCOUNT FACTOR</td>
<td>0.91</td>
<td>0.83</td>
<td>0.75</td>
<td>0.68</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DISCOUNTED COSTS</td>
<td>-4,545</td>
<td>-826</td>
<td>-751</td>
<td>-683</td>
<td>-621</td>
<td></td>
<td>-7,427</td>
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<tr>
<td>8</td>
<td>BENEFITS</td>
<td>$0</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$5,000</td>
<td></td>
<td>14,000</td>
</tr>
<tr>
<td>9</td>
<td>DISCOUNT FACTOR</td>
<td>0.91</td>
<td>0.83</td>
<td>0.75</td>
<td>0.68</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>DISCOUNTED BENEFITS</td>
<td>0</td>
<td>1,653</td>
<td>2,254</td>
<td>2,732</td>
<td>3,105</td>
<td></td>
<td>9,743</td>
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<td>12</td>
<td>DISCOUNTED BENEFITS + COSTS</td>
<td>-4,545</td>
<td>826</td>
<td>1,503</td>
<td>2,049</td>
<td>2,484</td>
<td></td>
<td>2,316 ← NPV</td>
</tr>
<tr>
<td>13</td>
<td>CUMULATIVE BENEFITS + COSTS</td>
<td>-4,545</td>
<td>-3,719</td>
<td>-2,216</td>
<td>-167</td>
<td>2,316</td>
<td></td>
<td>4,633</td>
</tr>
<tr>
<td>15</td>
<td>ROI</td>
<td>Excel file</td>
<td>31%</td>
<td></td>
<td></td>
<td></td>
<td>Payback in this year</td>
<td></td>
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</table>
## NPV, ROI, and Payback Analysis for Project 2

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DISCOUNT RATE</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>COSTS</td>
<td>($2,000)</td>
<td>($2,000)</td>
<td>($2,000)</td>
<td>($2,000)</td>
<td>($2,000)</td>
<td>-10,000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DISCOUNT FACTOR</td>
<td>0.91</td>
<td>0.83</td>
<td>0.75</td>
<td>0.68</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DISCOUNTED COSTS</td>
<td>-1,818</td>
<td>-1,653</td>
<td>-1,503</td>
<td>-1,366</td>
<td>-1,242</td>
<td>-7,582</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>8</td>
<td>BENEFITS</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$4,000</td>
<td>$4,000</td>
<td>$4,000</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>DISCOUNT FACTOR</td>
<td>0.91</td>
<td>0.83</td>
<td>0.75</td>
<td>0.68</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>DISCOUNTED BENEFITS</td>
<td>909</td>
<td>1,653</td>
<td>3,005</td>
<td>2,732</td>
<td>2,484</td>
<td>10,783</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>DISCOUNTED BENEFITS + COSTS</td>
<td>-909</td>
<td>0</td>
<td>1,503</td>
<td>1,366</td>
<td>1,242</td>
<td>3,201</td>
<td><strong>NPV</strong></td>
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<tr>
<td>13</td>
<td>CUMULATIVE BENEFITS + COSTS</td>
<td>-909</td>
<td>-909</td>
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<td>1,960</td>
<td>3,201</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td>ROI</td>
<td>42%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Excel file

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Weighted Scoring Model

- A weighted scoring model is a tool that provides a systematic process for selecting projects based on many criteria
  - First identify criteria important to the project selection process
  - Then assign weights (percentages) to each criterion so they add up to 100%
  - Then assign scores to each criterion for each project
  - Multiply the scores by the weights and get the total weighted scores

- The higher the weighted score, the better
Sample Weighted Scoring Model for Project Selection

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
<th>Project 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports key business objectives</td>
<td>25%</td>
<td>90</td>
<td>90</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Has strong internal sponsor</td>
<td>15%</td>
<td>70</td>
<td>90</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Has strong customer support</td>
<td>15%</td>
<td>50</td>
<td>90</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Realistic level of technology</td>
<td>10%</td>
<td>25</td>
<td>90</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Can be implemented in one year or less</td>
<td>5%</td>
<td>20</td>
<td>20</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>Provides positive NPV</td>
<td>20%</td>
<td>50</td>
<td>70</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Has low risk in meeting scope, time, and cost goals</td>
<td>10%</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>Weighted Project Scores</td>
<td>100%</td>
<td>56</td>
<td>78.5</td>
<td>50</td>
<td>41.5</td>
</tr>
</tbody>
</table>

Weighted Score by Project

![Weighted Score by Project Diagram]

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