

Tools for Making Better Architecture Decisions

Ian Gorton
Computational and Information Sciences
Pacific Northwest National Lab

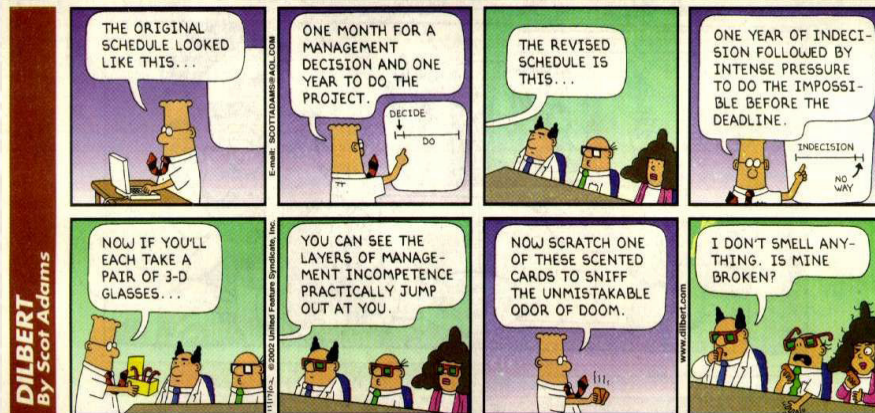
Outline

- ▶ Why is architecture difficult?
- ▶ ArchDesigner
- ▶ BRedB
- ▶ Model-driven performance engineering
- ▶ Middleware for data intensive computing

Why is architecture hard?

"..The life of a software architect is a long (and sometimes painful) succession of sub-optimal decisions made partly in the dark..."

(Philippe Krutchen)



Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy

3

Why is architecture hard?

- ▶ Architecture design typically takes place at an early stage of the project
 - hard, often impossible, to thoroughly reason about the consequences of many design decisions
- ▶ Involves making design decisions that are difficult/costly to change downstream if they are discovered to be flawed
- ▶ Complex design trade-offs needed to meet competing architectural requirements
- ▶ Put very simply – architecture aims to address any issues that will be expensive/impossible to change once the project progresses

Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy

4

Specific issues

► Design

- Multiple (conflicting) stakeholder requirements
- Large number of design options
- Complex technical issues, design trade-offs, technology selections

► Analysis and Documentation

- Support easier/cheaper downstream modification
- Capture design rationale behind design decisions
- Survive changes in staff or outsourced development

► Risk mitigation

- Will system perform/scale to meet requirements?
- How much hardware needed?
- Avoid expensive rework required late in project

Architecture Design



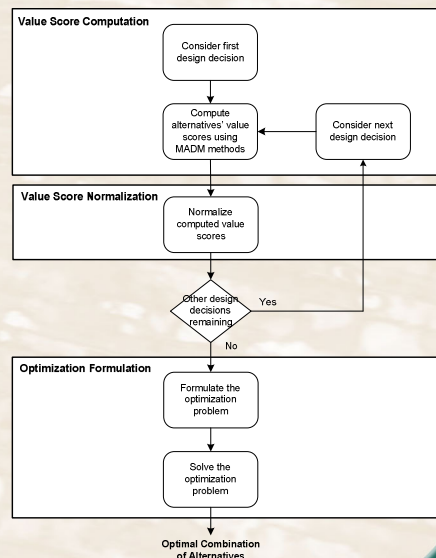
Architecture Design Issues

- ▶ Typical architecture design scenario
 - numerous design decisions with multiple design alternatives
 - Each decision requires evaluation and selection from among a the alternatives
 - Many design alternatives conflict
 - Multiple stakeholders with competing priorities
 - Designs constrained by project cost and schedule
 - Project costs in multi-million \$\$\$ range
- ▶ We've created ArchDesigner to address such scenarios.

ArchDesigner Approach

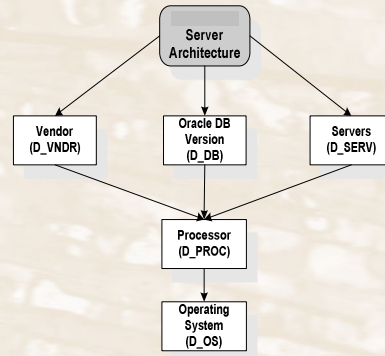
- ▶ Help architects select optimal design alternatives given:
 - Constraints
 - Dependencies
 - Stakeholder priorities

- ▶ Exploits management science and operational research techniques:
 - Integer Programming
 - AHP



ArchDesigner Case Study

- ▶ Upgrading a major packaged business system (CRM)
- ▶ Package can run on:
 - Different operating systems
 - Operating systems runs on different servers/processors
 - Oracle required, only certified on certain OS/CPU/server alternatives
 - 4 vendors, different costs/solutions/support
- ▶ 3 key stakeholders



Stakeholder Participation



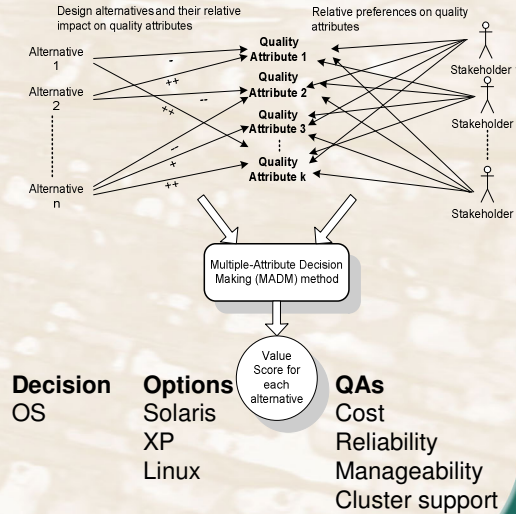
Copyright © 2003 United Feature Syndicate, Inc.

Step 1: Value Score Computation

► **Value Score** of design alternative X is the degree to which alternative X satisfies desired quality attributes

► **Example:**

- if Performance (P) is "moderately more important" than Modifiability (M) then we have $(P,M)=3$ and $(M,P)=1/3$

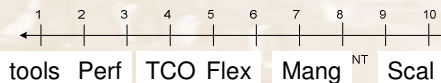


Step 2 and 3

► **Normalize and weight decisions**

► **Use integer programming to select optimal set of design alternatives subject to**

- Cost
- Schedule
- dependencies

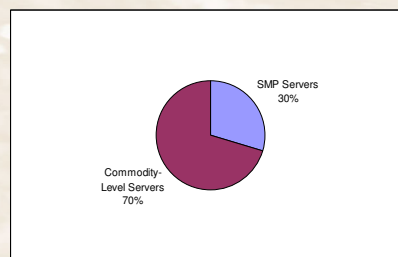
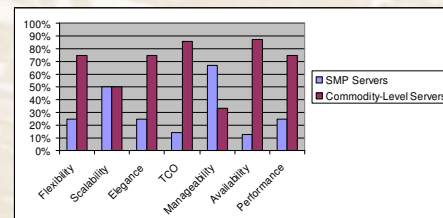
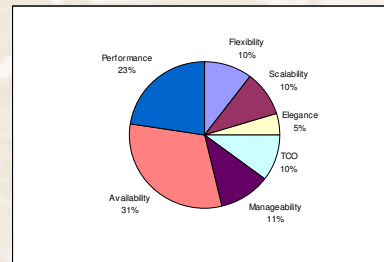
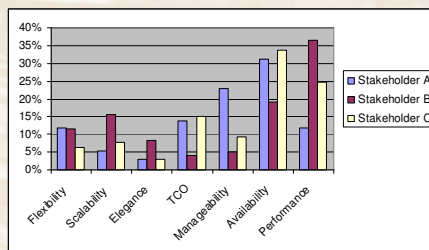


$$\sum_{j=1}^m \sum_{i=1}^{n_j} X_{ij} V_{ij}'$$

Scoring examples

Architectural Decision		Alternative		Value Score	Normalized Value Score
No	Name	No	Name		
1	D_SERV	1	SMP-Based	0.296	1.776
		2	Commodity-Level	0.704	4.224
2	D_OS	1	Solaris	0.321	2.568
		2	HPUX	0.285	2.28
		3	Windows	0.096	0.768
		4	SUSE	0.154	1.232
		5	RHE	0.144	1.152
3	D_PROC	1	AMD-32	0.312	2.184
		2	AMD-64	0.323	2.261
		3	Intel-32	0.078	0.546
		4	Itanium-64	0.170	1.19
		5	Ultrasparc-64	0.117	0.819
4	D_DB	1	Oracle 9i RAC	0.197	1.379
		2	Oracle 9i	0.166	1.162
		3	Oracle 10g	0.637	4.459
5	D_VNDR	1	Vendor-1	0.447	2.235
		2	Vendor-2	0.190	0.95
		3	Vendor-3	0.064	0.32
		4	Vendor-4	0.299	1.495

Decision-centric analysis



Combination-centric analysis



*select best 10
for all stakeholders
for all quality attributes*

Rank	Server	Oracle DB	Vendor	Processor	OS	Score
1	Commodity	10g	Vendor-1	AMD-64	SUSE	14.411
2	Commodity	10g	Vendor-1	Itanium-64	HPUX	14.388
3	Commodity	10g	Vendor-1	AMD-32	SUSE	14.334
4	Commodity	10g	Vendor-1	AMD-64	RHE	14.331
5	Commodity	10g	Vendor-1	AMD-32	RHE	14.254
6	Commodity	10g	Vendor-1	AMD-64	Windows	13.947
7	Commodity	10g	Vendor-1	AMD-32	Windows	13.870
8	Commodity	10g	Vendor-4	AMD-64	SUSE	13.671
9	Commodity	10g	Vendor-4	AMD-32	SUSE	13.594
10	Commodity	10g	Vendor-4	AMD-64	RHE	13.591

What-If analysis




► ArchDesigner makes it easy to do what-if analysis:

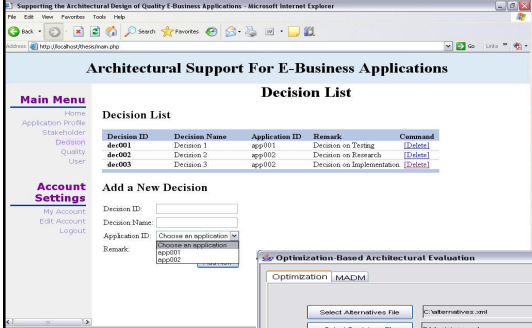
- assume all vendors rated equal, are design decisions same/similar?
- ignore cost constraints to find best technical choice
- Reduce budget to find best/cheaper technical choice
- Remove low-weight design decisions (sensitivity analysis)

► Eventually 5 viable alternatives emerged:

1. Vendor1 – Itanium-64 – HPUX.
2. Vendor4 – AMD-64 – SUSE.
3. Vendor2 – AMD-64 – SUSE.
4. Vendor1 – AMD-64 – SUSE.
5. Vendor2 – Ultrasparc-64 – Solaris.



ArchDesigner



Architectural Support For E-Business Applications

Decision List

Decision ID	Decision Name	Application ID	Remark	Command
dec001	Decision 1	app001	Decision on Testing	[Delete]
dec002	Decision 2	app002	Decision on Research	[Delete]
dec003	Decision 3	app002	Decision on Implementation	[Delete]

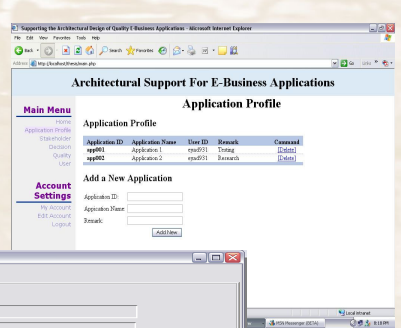
Add a New Decision

Decision ID:

Decision Name:

Application ID:

Remark:



Architectural Support For E-Business Applications

Application Profile

Application ID	Application Name	User ID	Remark	Command
app001	Application 1	epa001	Testing	[Delete]
app002	Application 2	epa001	Research	[Delete]

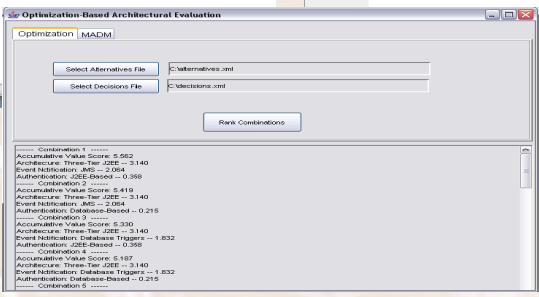
Add a New Application

Application ID:

Application Name:

User ID:

Remark:



Optimization-Based Architectural Evaluation


Optimization: MADM

Select Alternatives File:

Select Decisions File:


```

===== Combination 1 =====
Accumulative Value Score: 5.552
Architecture Times Tier (2005) -- 3.140
Event Notification_AMS -- 2.054
Authentication_C2C-Shared -- 0.369
===== Combination 2 =====
Accumulative Value Score: 5.415
Architecture Times Tier (2005) -- 3.140
Event Notification_AMS -- 2.054
Authentication_Database-Based -- 0.215
===== Combination 3 =====
Accumulative Value Score: 5.330
Architecture Times Tier (2005) -- 3.140
Event Notification_Database Triggers -- 1.532
Authentication_C2C-Shared -- 0.359
===== Combination 4 =====
Accumulative Value Score: 5.187
Architecture Times Tier (2005) -- 3.140
Event Notification_Database Triggers -- 1.532
Authentication_Database-Based -- 0.215
===== Combination 5 =====
  
```




Pacific Northwest National Laboratory
 U.S. Department of Energy

17



Benefits

- ▶ A design decision aid
 - With web-based tool support and query language
- ▶ Enables architects to:
 - systematically evaluate design alternative combinations
 - consider all possible options by identifying and quantifying all possible permutations
 - conduct what-if and sensitivity analysis
 - explicitly capture design decisions and rationale
 - visibility of decisions to stakeholders/management
- ▶ If you have a nasty tender to evaluate, challenging stakeholders, complex designs trade-offs



Available Technologies



Pacific Northwest National Laboratory
 U.S. Department of Energy

18

Architecture Knowledge Management

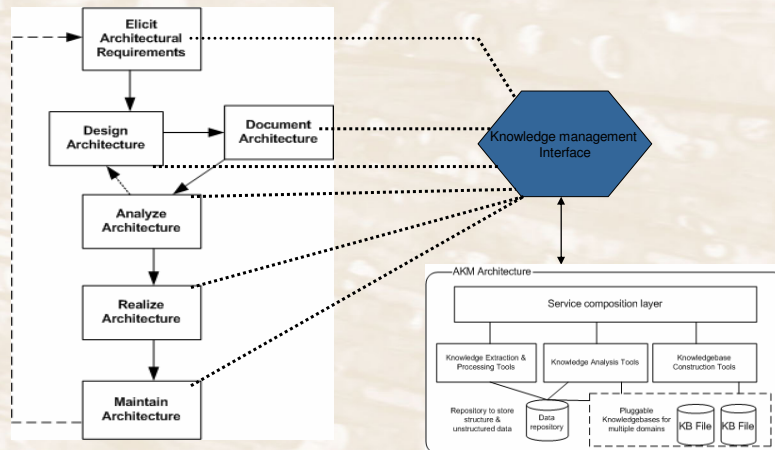


Capturing architecture knowledge

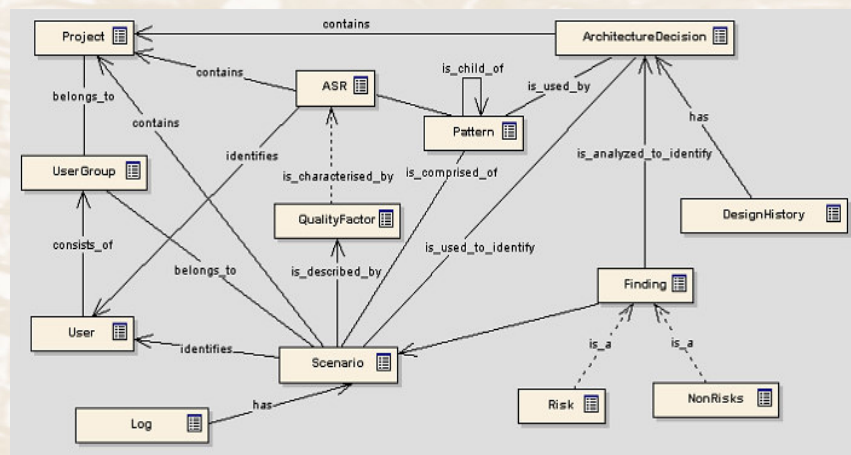
- ▶ An architecture embodies crucial design decisions
 - Rarely captured in architecture docs (if they exist!)
- ▶ If rationale behind design decisions is lost:
 - System evolution becomes hard
 - Difficult to identify design errors
- ▶ We did a survey:
 - 80% can't understand designs without adequate docs
 - 73% forget why they designed something!
 - Impediments to capturing design info:
 - 61% have no time/budget/tools
- ▶ And built an architecture knowledge management tool
 - BRedB




Architecture knowledge capture



Modeling Architecture Knowledge



BRedB



Start
Collaborative Tools
Contact Management
Project Management
Content Production
Corporate Library
Project Collaboration
Configuration

Home
Knowledge-Based
Project-Based
Search

Project Collaboration

Knowledge-Based

The knowledge-based involves capturing various experience artefacts that users may *create, modify, delete and search*. These artefacts include the following:

- General Scenarios
- Patterns
- Analysis Model
- Architecturally Significant Requirement

Project-Based


The project-based involves building database of artefacts for specific projects to support their software architecture evaluation. This can be achieved through creating new artefacts and/or extracting them from the knowledge-based. All newly created artefacts will be added to the knowledge repository. The project-based artefacts include:

- General Scenario
- Concrete Scenario
- Architecturally Significant Requirement
- Quality Factor
- Architecture Decision
- Alternative Decision
- Finding

Search

Search provides essential functionalities to allow users to seek for their desired artefacts. The two different types of search are:


- Field-based
- Keyword-based




Pacific Northwest National Laboratory
 U.S. Department of Energy


23

BRedB Case Study



- ▶ Australian Defense Science Technology Organization (DSTO)
 - Avionics architecture assessment
 - Long lived, high cost projects
- ▶ BRedB used for avionic architecture evaluation
 - Quality attributes
 - Evaluation framework
 - Risk management





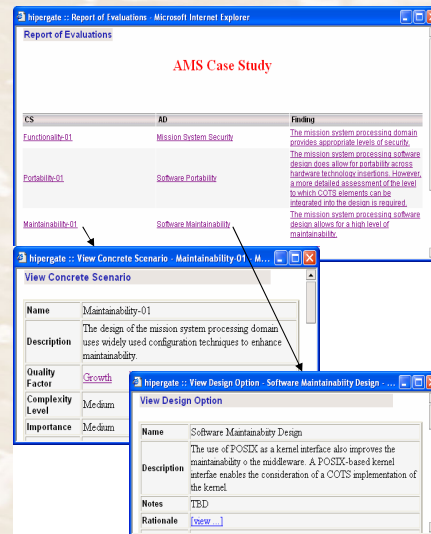
Pacific Northwest National Laboratory
 U.S. Department of Energy

24

- 26

Reporting

- Automatically generate evaluation reports
 - Shows how architectural decisions satisfy a concrete scenario



Initial Findings

- BRedB added considerable rigour to the DSTO evaluation process
 - Repository of expert knowledge in general scenarios
 - Archive of past project experience valuable over time
 - effective mechanism to organise and query large amounts of architecture knowledge
- BRedB should be useful if you:
 - are outsourcing/off-shoring/purchasing your systems?
 - have superhero architects prone to sudden departure or large pay increase demands
- More studies and R&D needed
 - We're keen to work with interested partners ...



Architecture Risk Mitigation



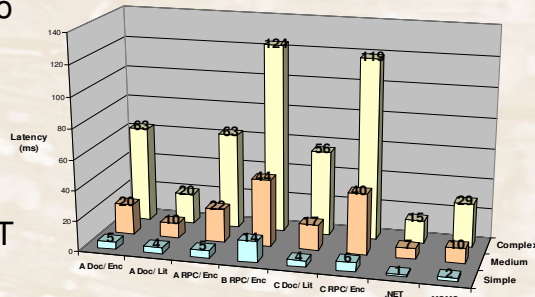
SOA Performance Engineering

- ▶ Service-Oriented Architecture (SOA) being widely adopted
 - SOAs built using J2EE/.NET/Web Services technologies
 - Need to be scalable and reliable
- ▶ Performance/scalability issues are complex
 - Application code accounts for small percentage of execution time
 - Middleware, databases, Web servers, etc
- ▶ Many applications fail disastrously due to lack of attention to performance

Web Services Performance



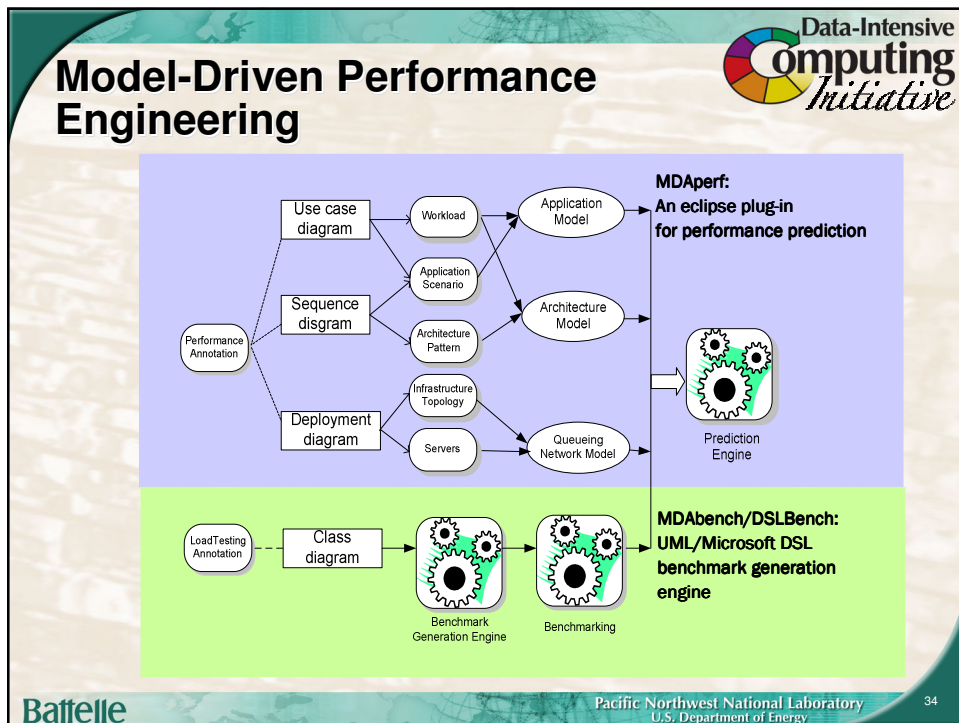
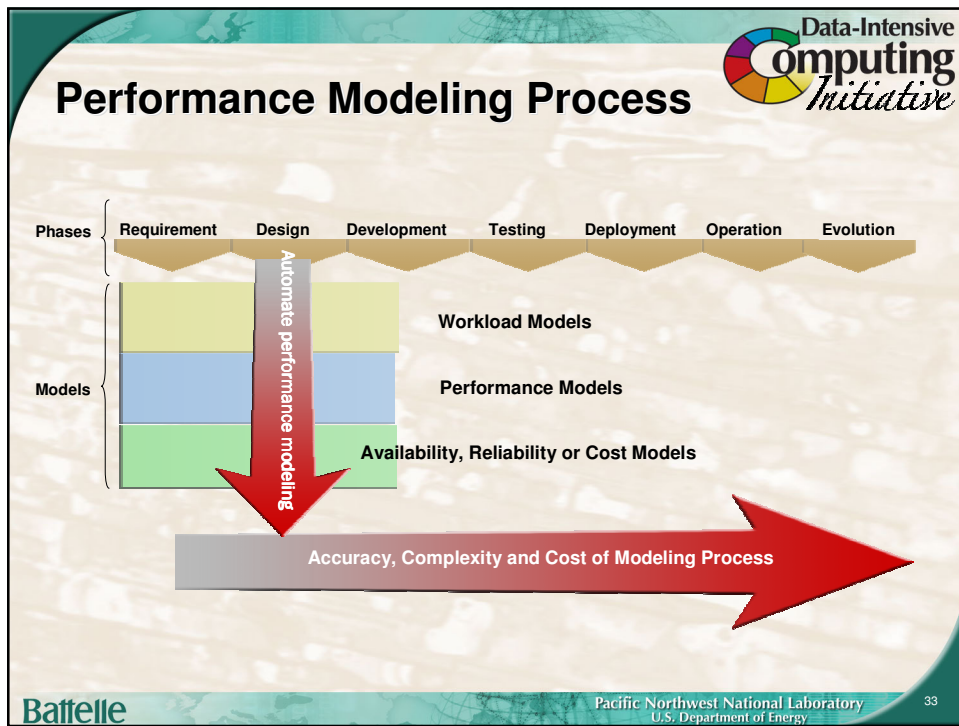
- ▶ A common concern due to XML
 - Verbosity
 - Processing overheads
- ▶ What's the reality?
- ▶ Some experiments performed at CSIRO's ICT Centre in 2005

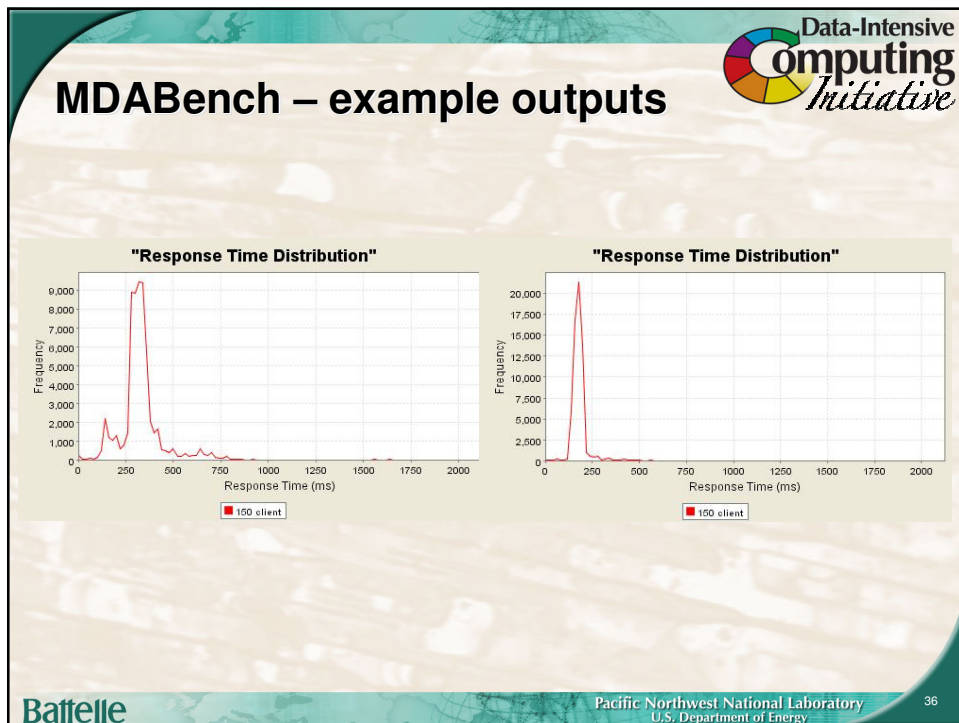
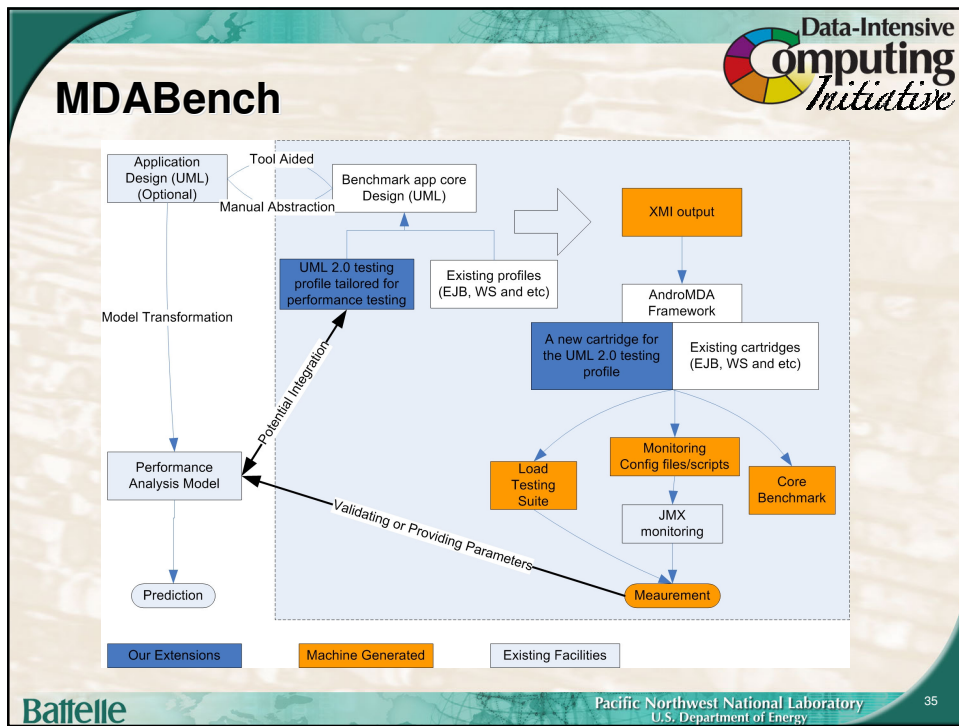


Performance Prototyping



- ▶ Performance prototyping is time-consuming and tricky
 - Build server prototype (if no existing system)
 - Configure server/database, test prototype
 - Load test data
 - Build test client
 - Multithreaded
 - Generate variable loads and test data
 - Instrument client and server to capture performance
 - Capture/process/analyze results
 - Fix the stuff you got wrong and run tests again ... and again
- ▶ We're trying to make this easy ...

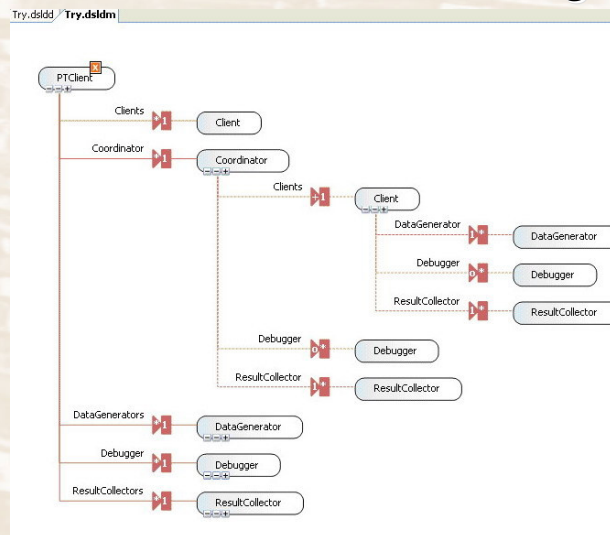




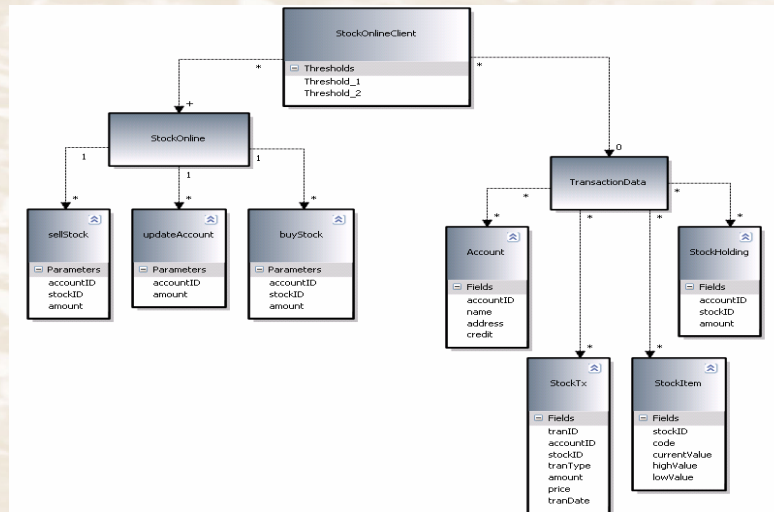
DSL v MDA

- ▶ MDA is an OMG driven initiative for model-driven development
 - Based on UML models and tools
- ▶ DSL is Microsoft's model-driven development initiative
 - If you don't like/need UML, roll your own modeling language

DSL Bench: Meta-level Modeling



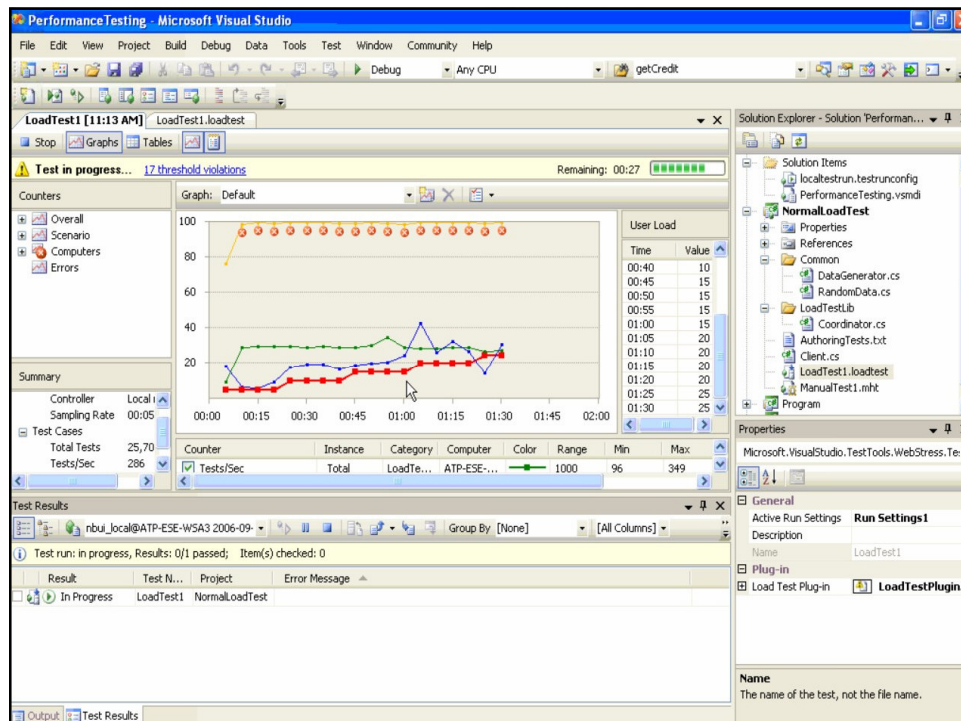
Examples



Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy

39

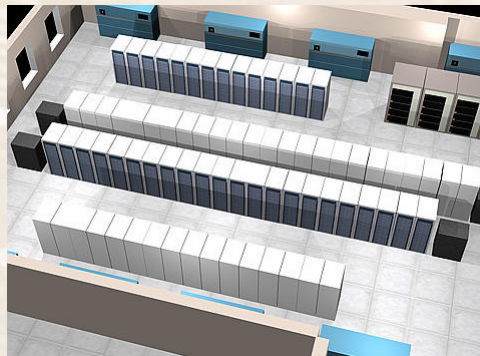


Current Status

- ▶ Prototype tools deployed in a major case studies
 - Australian Tax Office and Medicare SOA integration
 - SOA for home mortgage process integration
- ▶ If you have gnarly, risky SOAs whose performance you don't quite understand



Middleware for Data Intensive Computing



Data Intensive Computing

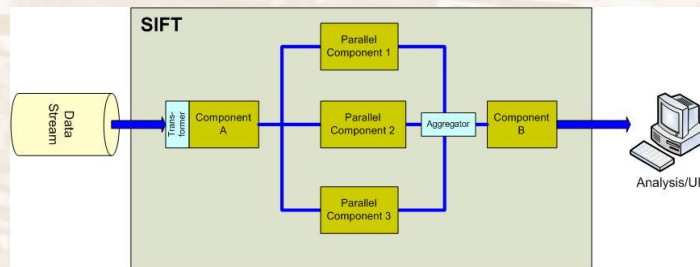


Data-intensive computing is managing, analyzing, and understanding data at volumes and rates that push the frontier of current technologies.

- Gb/s –Tb/s data streams
- Heterogeneous data
- Distributed resources for data, computing
- Terabyte to petabyte data volumes
- Complex non-linear analysis



Analytical Processing Pipelines

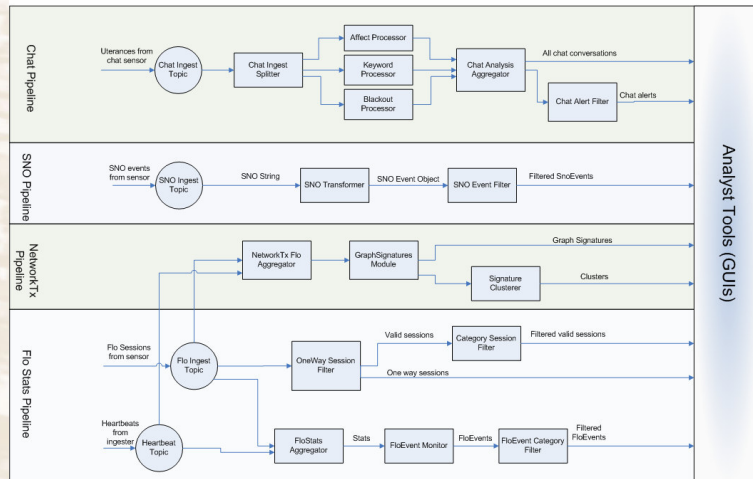


- Common design pattern requires:
- Flexible integration
 - Ability to process massive data volumes
 - High performance and scalability

Analytical Processing Pipelines



Combined SC06 Pipeline

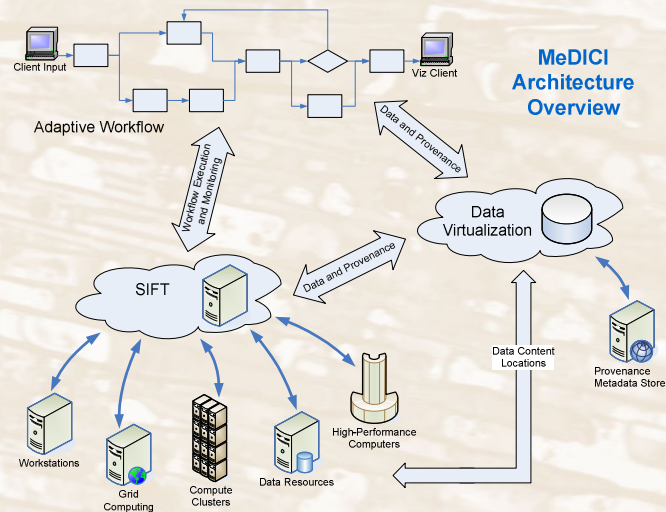


Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy

45

MeDICI



Battelle

Pacific Northwest National Laboratory
U.S. Department of Energy

46

MeDICI Status

- ▶ Using MeDICI to design/build several large scale data intensive applications:
 - Cyber-security
 - Bio-informatics
 - Proteomics
- ▶ Initial API and programming guide coming this summer ...
- ▶ Open source release is in the plans for later in 2007



That's it ...

- ▶ Paying attention to your architecture will provide large returns on investments
- ▶ Upfront effort is needed
 - “no free lunch”, but methods and tools will help
 - remember, you pay now or later, just a lot less now!!
- ▶ Advanced technologies can make a difference
 - We're keen to work with organizations to trial and deploy



Questions?

Some answers ...

