The Relevance of Grid Computing to the Auto and Aerospace Industries

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What is a Grid?
Key Grid Characteristics

- *Heterogeneous, Flexible and Reliable*
- Distributed Control
  - not centralized like clusters, not laissez-faire like P2P
- Dynamic configuration
- Adaptive discovery - problems find resources; Grids are not built for a specific configuration
- QoS Maintenance - workloads are balanced, attention to task priority, not just best effort rules
- Bandwidth Diversity - processing intensive apps tolerate lower speed data movement
GRID: FLEXIBLE, HIGH-PERFORMANCE ACCESS TO ALL SIGNIFICANT RESOURCES

On-demand creation of powerful virtual computing systems

Source: Dietmar Erwin, “UNICORE and EUROGRID: Grid Computing in Europe,” EUROGRID and UNICORE
Cost drives Users from Supercomputers to Clusters

- Supercomputers - “peak processor performance regardless of cost.” Built for specific configuration.

- Clusters - let users pursue “lowest possible ratio of price to performance”
  - Google - 2002- 15,000 commodity PC cluster
  - 1 query - tens of billions of CPU cycles examine hundreds of megabytes of data
  - Today $1/CPU/hour
  - 1996 $15,000/CPU/hour
How does a Cluster differ from a Grid?

**Cluster**
- Uses affordable building blocks
- does so in a known and typically homogeneous configuration of identical or at least quite similar units
- under a **single controlling authority**.

**Grid**
- a more dynamic and usually heterogeneous system
- **“virtualizing resources** that may be quite different in character and capabilities and that may even come and go without warning as their availability changes over time.”
- **distributed control**.

Globus Toolkit® History

- DARPA, NSF, and DOE begin funding Grid work.
- NASA begins funding Grid work, DOE adds support.
- GT 1.0.0 Released.
- Early Application Successes Reported.

- NSF & European Commission initiate many new Grid projects.
- Physiology of the Grid Paper Released.
- Significant commercial interest in Grids.

- GT 2.0 Released.

Does not include downloads from: NMI, UK eScience, EU Datagrid, IBM, Platform, etc.
Grids are Moving to Become a Services Platform
Grids are Evolving

- **Stage 1 - Parallel Compute Grids**
  - Big jobs, can be large clusters

- **Stage 2 - Transactional Grids**
  - Grids with File Sharing and Coordinated Messaging

- **Stage 3 - Services Grids**
  - Application integration efficiencies
  - Business process coordination
  - Grid as Virtualization
    - Accelerates application migration/development
    - Far greater IT efficiency
Grid Services Platform Evolution - Japan

- Platform for Grid Use is evolving, moving to
  - Grids between design centers in a single firm (autos)
  - Grids to insure that Supply Chain partners run the same simulations that are run by the OEM
    - Partner Grids now used in autos and heavy equipment
      - Tier 1 and 2 suppliers are linked in autos
      - Mitsubishi Heavy Industry ties to suppliers to insure that 6 Sigma quality is maintained across the chain
        - Economic driver -- 25% of profits go to repair mistakes with 4 Sigma, only 1% with 6 Sigma
        - Move to “Zero design time”

- Next step is to integrate separate centers more closely -- virtualization of resources is underway
Services Oriented Infrastructure as the Next Phase in the Evolution of Grids

Infrastructure is Globus that is “completely” Web Service-ized

The SOI links to applications using Grid Services, Applications are linked by Web Services.

Source: Rich Miller, Univa
Three Stages of Grids

1. Big Job Efficiency
   - Scientific, Batch: Yes

2. Data Transaction Efficiency
   - IT Efficiency: Yes
   - For Supply Chains: Yes

3. Coordinates Business Efficiency
   - Supply Chains and CRM: Yes
Key Findings Regarding Grid Adoption and Evolution - Japan

- **A Grid Services platform is taking shape**
  - Supercomputer focus evolves to much cheaper servers, accompanied by computer center and data center consolidation

- **Vendors see Grid development linked to Services Development**
  - Result is a “collaborative environment” within and between firms [Supply chain partners]

- **One Telco (NTT Data) is offering Grid Services on-demand**
Future Prospects and Breakthroughs

Source: NEC. Slide used with permission of NEC.
Grids in Industry
Key Subjects in Industries

SPEED: Cycle Reduction in Research/Development/Design/Manufacturing
--- *Time to Market*

COST: Cost Reduction in Research/Development/Materials/Manufacturing/Resource/Logistics/Maintenance
--- *Operation Efficiency, Competitiveness*

QUALITY: Improvement in Quality/Functionality/Performance/Safety
--- *Customer Satisfaction, SPEED, COST*
Why Design Process Improvement?

Leveraging to reduce cost, cycle time, and time-to-market AND improve quality.
Parameter Studies by Parallel Distributed Computing System

- Automatic Execution of Tasks
- Load Balancing and Resource Management
- Automatic Gathering of Computed Results
- Automatic Statistic Analysis

Parallel Task Submission

Heterogeneous HPC Network
(Supercomputers, Servers, Clusters, Grids)
Grid Solutions for Collaboration

Centralized product development and optimization environment that enables design collaboration with globally dispersed design teams, organizations, and suppliers

Source: Takehiko Kato, Presentation at GridWorld 2005
Central Design Hub Collaboration (Engine)

Virtual Enterprise Concept

Collaboration Hub

Company E

Company D

Company C

SME Company B

OEM Company A

Services
- Extended enterprise PDM
- Document management
- Virtual meeting
- Content translation
- Media exchange
- Others …

Extended Enterprise PDM
- Will provide product data management services for all enterprise partners
- Standalone Web-based access and direct integration with partner PDM

Key Industrial Participants:
Rolls-Royce, Volvo, MTU, Avio
GM, FORD AND THE SERVICE GRID

- ADVANTAGE: GOING BEYOND ENTERPRISE GRIDS TO CONNECT TO SUPPLIERS & CUSTOMERS
  - GM, FORD USED BIG CLUSTERS, GRIDS FOR CRASH SIMULATIONS, COMPLEX DESIGN NEEDS
  - SERVICE GRID WILL GET SOFTWARE FIXES TO CUSTOMERS WITH “HIGHLY ELECTRONIC” CARS & INFORMATION TO DEALERS
  - NEW ISSUE: CORRUPTION OF SOFTWARE FOR ENGINE CONTROLS; IMPOSSIBLE TO FIX WITHOUT SERVICE GRID
  - SERVICE GRID SENDS OUT FIX AFTER THE GLITCH IS ANALYZED. DEALERS, CUSTOMERS GET FIX OVER HIGH SPEED CONNECTIONS FOR THE SERVICE GRID
Comparisons of Auto Grid Adoption

Figure 4: Penetration of Grids in the Auto Industry

- Cluster Computing
- Enterprise Grids
- Partner Grids

Penetration of Grids in the Auto Industry, 2002-2010

- 85% Penetration in 2010 — Saturation
- 60% Penetration in 2007-08
- Data Grids may grow slowly
- Web Services grow with cluster computing
- Cluster computing grows rapidly to about 85% adoption by 2005 — about the same as pharmaceuticals

Percent Penetration in Industry

2002 2005 2010
<table>
<thead>
<tr>
<th>Change</th>
<th>Auto Industry</th>
<th>Financial Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity Gain – Grids &amp; Web Services</td>
<td>25%</td>
<td>26%</td>
</tr>
<tr>
<td>Output Increase</td>
<td>18%</td>
<td>10%</td>
</tr>
<tr>
<td>Price change</td>
<td>-15%</td>
<td>-12%</td>
</tr>
<tr>
<td>Increase in Spending on Communications Services</td>
<td>437%</td>
<td>97%</td>
</tr>
</tbody>
</table>
GRIDs RAISE PRODUCTIVITY IN AUTOS AND FINANCE

Labor productivity - Autos
Comparing Adoption of Grids (Blue) and Baseline Forecast to 2010

Labor productivity - Financial Services
Comparing Adoption of Grids (Blue) and Baseline Forecast to 2010
AEROSPACE AND HOSPITALS HAVE LOWER PRICES

Prices - Aerospace
Comparison of baseline and Adoption of Grids

Prices - Hospitals
Comparison of baseline and Adoption of Grids
BANK OF AMERICA, JPMorgan Chase AND RISK ANALYSIS

- ADVANTAGE: TREMENDOUS COST SAVINGS ACROSS A BANK. CLUSTERS AND GRIDS EMPLOYED TO ESTIMATE A BANK’S RISK EXPOSURE EVERY DAY. LOWERING RISK RESERVES CAN SAVE BILLIONS
  - BANKS INITIALLY USED CLUSTERS & GRIDS TO RUN RISK SIMULATION MODELS FOR TRADING GROUPS.
  - ANALYZING OVERALL RISK PERMITS ONLY THE TOP 10 US BANKS TO REDUCE THEIR CAPITAL ALLOCATION FOR RISK.
  - US, INTERNATIONAL REGULATORS PERMIT USE OF SOPHISTICATED MATHEMATICAL MODELS TO DO SOPHISTICATED RISK ANALYSIS ACROSS ALL PARTS OF BANKS. THIS WOULD NOT BE POSSIBLE WITHOUT VERY LARGE CLUSTERS & PARALLEL PROCESSING
  - REDUCING THESE COSTS CUTS OVERALL OPERATING COSTS
  - SYSTEMS DIFFICULT TO REPLICATE: NEED ANALYTIC SKILLS & SOPHISTICATED COMPUTER SYSTEMS
CADENCE/ SYNOPSYS: GREATER INSIGHT INTO THE DETAILS OF CHIP DEVELOPMENT

- KEY COMPETITIVE ADVANTAGE: VAST COMPUTE POWER CREATES ABILITY TO EXAMINE DESIGN AT FORMERLY IMPOSSIBLE LEVELS
  - ALSO, PUTTING DISPARATE DESIGN GROUPS IN SEVERAL LOCATIONS IN A SINGLE DESIGN TEAM REDUCES TIME TO MARKET, EXTENDS ANALYTIC CAPABILITIES TO ALL PARTS OF FIRM.

- ADDITIONAL INNOVATIONS & SAVINGS:
  - INITIAL SURGE IN PRODUCTIVITY (UP 70-90%) DUE TO FAR MORE EFFICIENT BATCH PROCESSING OF COMPLEX JOBS; ROI: 1 MONTH
  - GREATLY REDUCED TIME TO FINAL PRODUCT, TIME TO RETRIEVE AND USE INFORMATION, COST OF DESIGNER TIME
  - MORE SOPHISTICATED MANAGEMENT OF EXPENSIVE LICENSES
  - ABILITY TO PACKAGE GRID CAPABILITIES WITH LICENSES AS PART OF A NEW SOFTWARE-SERVICE PRODUCT
Pharma Grid Adoption

- Initial use in research analysis and design
  - Do more 3-D modeling, sophisticated chemical and genomics analysis of potential drug designs

- Grid Use in Next 2-3 Years
  - Closely tied to the product development cycle
    - to reduce time and costs
    - to sharpen focus on likely successful drug targets
    - to Integrate genomics with bioinformatics
  - Create personalized drugs using genotypes
Pharma Adoption - Japan and US

Japan

U.S.

Figure 1: Grids and Web Services in the Pharmaceutical Industry, 2002-2010

Figure 8: Penetration of Grids in the Pharmaceutical Industry

- Cluster Computing
- Enterprise Grids
- Data Grids: Data Grids grow rapidly to 2004
- Web Services: 65–70% Penetration
- Partner Grids: 20–25% Penetration
- Enterprise Grids Forecast 2
- Accelerated deployment of Enterprise Grids starting in about 2007
- Likely delay in deployment of Partner Grids to 2011-2012
- Partner Grids: 25% Penetration
Why Six Sigma Robust Design?

- Cost of Poor Quality
  - Internal – Scrap, Inspection, Rework, Increased Cycle Time
  - External – Customer Satisfaction, Warranty, Competitive

Cost: (4σ  25% of Revenue  6σ  1% of Revenue)

- Cost of Change
  - Apply Six Sigma Early in the Design Phase

Quality should be “designed, not inspected” – Taguchi
What is Design for Six Sigma?

Wider Meaning
Redesigning of Total Operation Process in order to realize Six Sigma Level Management Quality

Narrower Meaning
Innovative Product Design Process in order to realize Six Sigma Level Product Quality

A Structured, Disciplined, Repeatable Process That Will Deliver Near Perfect Products and Performance
Will Enable Zero Design Cycle Time

Customer Needs

Understand the Future
Create Technology
Improve Models
Re-formulate Problem
Upgrade Computer Based Design “Machine”

Engineers

Computer Based Design

Run 24/7 365 Days A Year
Continuous Detailed Design
Solve All Possible Applications @ Technology Readiness Level

Customer Req. Exceed Technology

Zero Design Cycle Time

Design is always ready and waiting to “best” meet customers needs

J. Brent Staubach
Impacts on Industry and the Economy
<table>
<thead>
<tr>
<th>Contribution of Grids and Web Services to National Economic Change</th>
<th>Increase due to Grids and Web Services</th>
<th>Percentage Increase by 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross domestic product in $ Billions</td>
<td>756.7</td>
<td>6.13%</td>
</tr>
<tr>
<td>Real Disposable Income $ Billions</td>
<td>495.8</td>
<td>5.42%</td>
</tr>
<tr>
<td>Personal Consumption $ Billions</td>
<td>275.9</td>
<td>3.21%</td>
</tr>
<tr>
<td>Aggregate Price Level</td>
<td>-0.084</td>
<td>-6.32%</td>
</tr>
<tr>
<td>Total Civilian Employment 000s of Jobs</td>
<td>433.7</td>
<td>0.29%</td>
</tr>
<tr>
<td>Unemployment Rate - Percentage</td>
<td>-0.28</td>
<td>-5.25%</td>
</tr>
<tr>
<td>Aggregate Private Sector Productivity</td>
<td>1.67</td>
<td>4.73%</td>
</tr>
</tbody>
</table>

Note: Dollar amounts are in 1996 Dollars
Figure 13. Japanese Industries' Estimated Productivity Gains in 2010 as a Result of the Adoption of Grids
Changes in U.S. Industry Productivity Due to the Adoption of Grids and Web Services, 2002-2010

- Computers
- Elec. Components
- Pharmaceuticals
- Autos
- Aerospace
- Financial Services
- Hospitals
- Communications Services

Percentage Change over Forecast Level in 2010

0% 5% 10% 15% 20% 25% 30%
Percentage Change in US Industries' Sales due to the Adoption of Grids and Web Services, 2002-2010

Changes due to the Adoption of Web Services

Changes due to the Adoption of Grids and Web Services

Percentage Change over Forecast for 2010
Conclusions

- Grids will change the way firms do business, not just provide compute cycles!
- Merged with Web Services, Semantic Grids become a way to develop applications rapidly and to enhance CRM
- The Economic Impact of Grids and Web Services will be tremendous -- an incremental increase of 6% GDP growth by 2010