

Grid Computing in the Enterprise with the UD MetaProcessor

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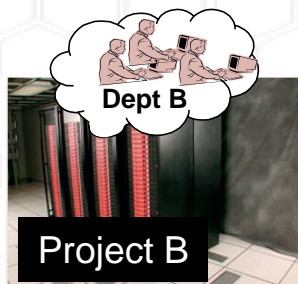
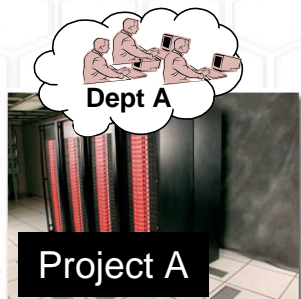
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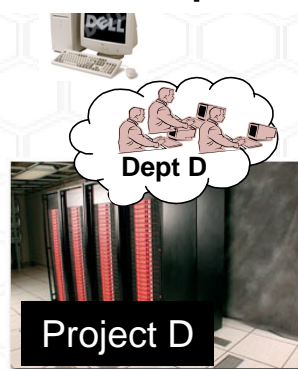
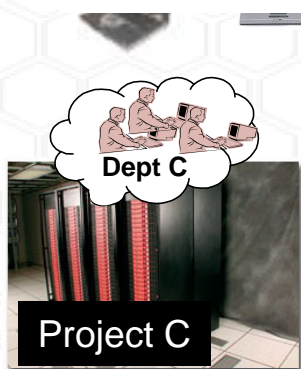
Outline

- **The High Performance Computing landscape today**
- **A compelling alternative opportunity – Enterprise Grid**
- **Some of the key challenges to overcome**
- **The MetaProcessor Architecture**
- **Solution Case Studies**
- **The future and a final summary**

High-Performance Computing Today



1000s of underutilized resources across the enterprise



- Departmental usage in industry; more sharing in universities
- Low utilization and duplication of compute and data resources
- Expensive resources: Supercomputers, SMP, Linux cluster
- Are the applications appropriate?
- Obsolete in 2-3 years

Massive amount of under-utilized capacity – mostly PCs

Relative processing capacity



**1989 Cray
Y-MP8/4128**



**Intel® Pentium™
4 Processor**

CPUs

4 166MHz

1 P4 1.5GHz

Max RAM

1 GB

1 GB+

MFLOPS

~1333

~1800

Cost

~ \$14,000,000

Under \$300

3/20/89
Electronic News

11/00
www.hardwarecentral.com

... and interconnect bandwidth, storage



**1000s of underutilized
resources across the enterprise**

- All PC's are now connected
 - Bandwidth at 10, 100 and rapidly evolving to 1000 Mb/sec
- PC hard drive sizes at 20+ GB
 - Large amounts of disk space go unused
 - Nearly 50% unused – per MS study

**Data from Microsoft SIGMetrics Paper ('98-'00)*

Availability, Utilization



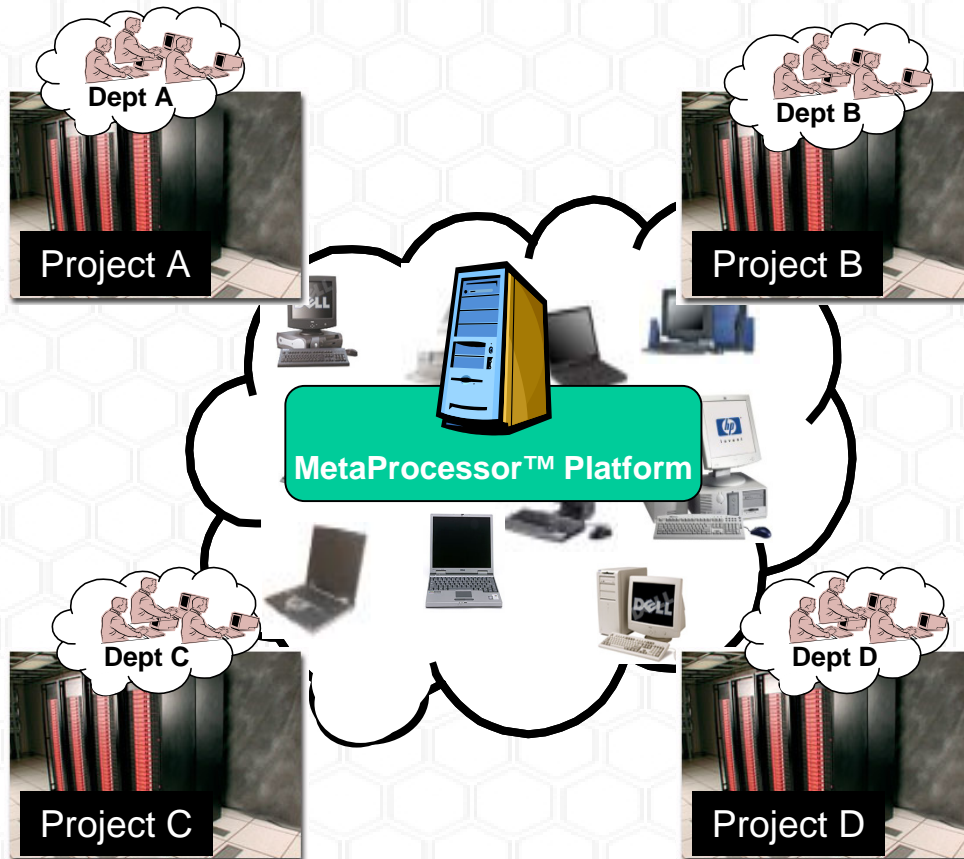
1000s of underutilized
resources across the enterprise

- 50% of all PCs available nearly 95% of the time
- 9% of PCs utilized nearly 100%
- Remaining 91% at or near idle
 - Median load is at 1-2%

**Data from Microsoft SIGMetrics Paper ('98-'00)*

Harness it! The MetaProcessor

Extending the Grid



- 10x to 70x reduction in cost – millions of dollars in savings
- Nearly 100% resource utilization
- Enterprise-wide use for appropriate applications
- Preserve departmental control of policies and access controls
- Single virtual system view for application developers, administrators, users
- Asset appreciates over time – Moore's Law

The Challenges

➤ Security

- Providing controlled access to resources, applications, and data
- Preserving the integrity of applications and data
- Securing applications
- Securing the application execution environment

➤ Unobtrusiveness

- Will this be unobtrusive to the primary user of the PC?
- How will this impact other users of the network infrastructure?

➤ Scalability

- Will the resource scale to tens of thousands of devices? How?
- What about application scalability?

➤ Manageability

- How will this virtual system be administered and maintained?
- How are reliability and availability addressed?

➤ Dealing with non-dedicated resources

- Resources are not always available, connected, reliable

The Challenges

➤ Application Feasibility

- This is feasible only for a small subset of embarrassingly parallel applications
- How do we determine application feasibility?

➤ Application Migration

- What is required to migrate applications to this grid?
- Are source code modifications necessary?
- How long does it take to migrate applications? What is involved?

➤ Application Management

- How are applications updated as new versions become available

➤ Data Management

- How are application datasets managed in the system?

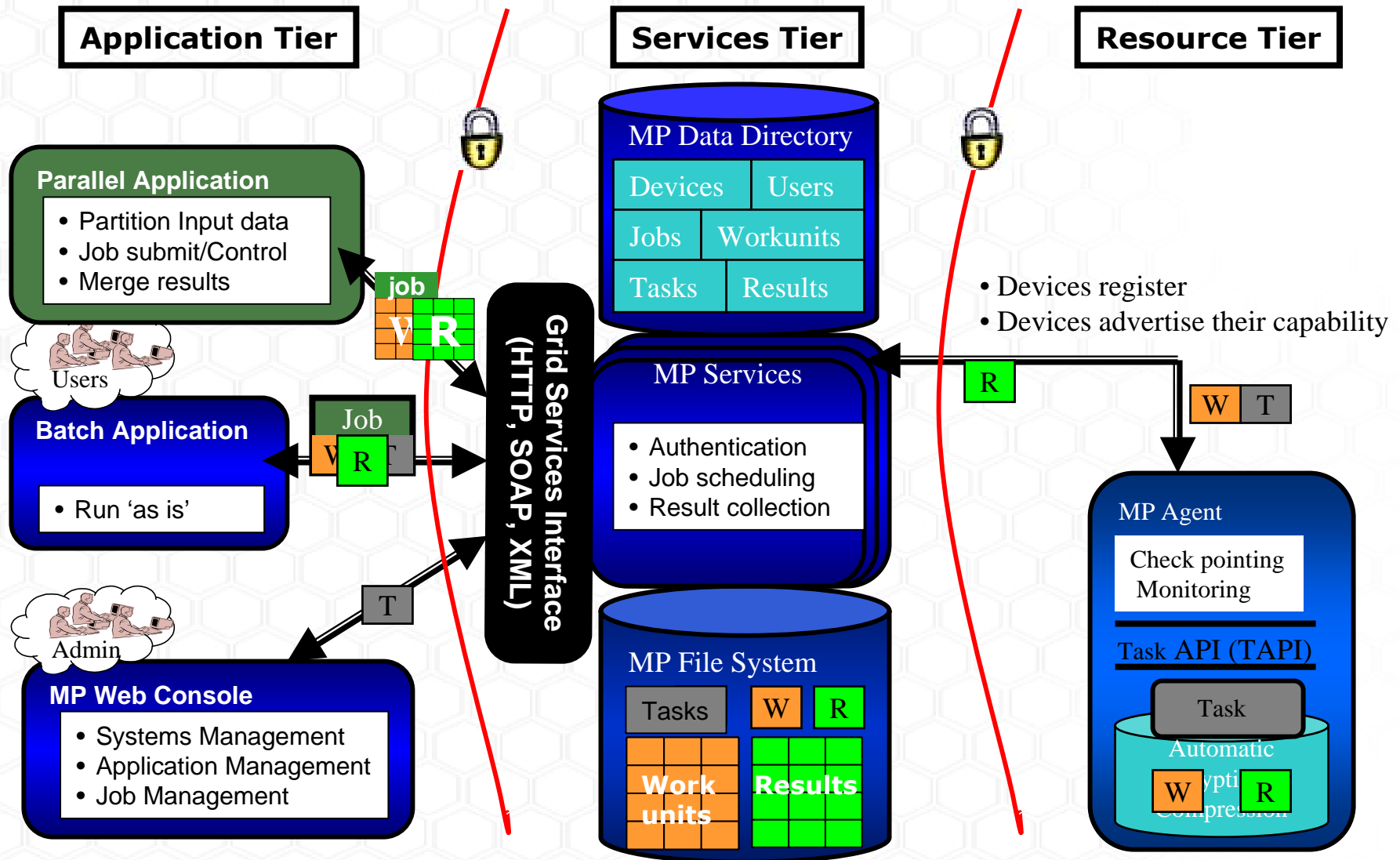
➤ Resource and Workload management

- Controlling and balancing workloads across a very large resource set

➤ Application user interface

- Are application users aware of the grid?

MetaProcessor Architecture



Enterprise Grid / Public Grid / Partner Grid

Enterprise - MP



Public Grid UD GMP



Firewall

Aggregated Resources



Public
Internet
Resources

Firewall

Partner Grid



Firewall

Internet
For Coms
Only

Firewall

Aggregated Resources

Enterprise
Resources



- **Authentication**
 - User access to MetaProcessor requires an identifier and password
 - SSL-like protocol for authentication and network encryption key generation
 - Unique device identifiers and network session keys for authenticating devices
- **Encryption and Checksum**
 - Network communications encrypted using triple-DES network key
 - All data stored on devices is encrypted using triple-DES device key
 - All files stored on the devices are tamper-proofed using checksum validation
- **Organizations and Roles**
 - Users and applications allocated into organizations
 - User roles based on four levels of access control to the system
- **Digital Signature**
 - Application executable modules may be signed and validated on devices
 - DSA signature keys can be modified for each customer
- **Constrained execution environment**
 - MP Agent executes tasks in a sandbox with limited access to device resources

Unobtrusiveness

- **Preference profiles**
 - Control computation and communication time windows
 - Control disk space usage on devices
 - Control tasks that can execute on devices
- **Agent deployment**
 - Installation does not require a machine reboot
 - Deployed silently using enterprise software distribution tools
 - Run as a protected process such as, 'WinNT Service' or a user level application
- **Optimal usage of resources**
 - MP agent has a negligible memory foot-print
 - Lowest priority supported by the operating system
 - Limit disk usage based on device preference settings
 - Optionally configured to run in 'screen saver only' mode
- **Network unobtrusiveness**
 - Network communication only after task completion
 - All data transmitted on the network is automatically compressed
- **Optional User control**
 - User can snooze the task on non-dedicated devices
 - User can shutdown MP agent

Product Scalability



<u>Devices</u>	<u>Connections per hour, Data-In/hour</u>	<u>MP Dispatch Service</u>	<u>Management Service</u>	<u>Application Service</u>	<u>MP Database</u>
<u>500</u>	83 conn/hr, 4 MB/hr	1 Server – 1CPU, 1GB RAM, 50 GB disk, Linux			
<u>1,000</u>	167 conn/hr 8 MB/hr	1 Server – 1 CPU, 1GB RAM, 20 GB disk, Linux			1 Server-1cpu, 1GB RAM, 50 GB disk, Linux
<u>10,000</u>	1,667 conn/hr 83 MB/hr	1 Server-1cpu, 1 GB RAM, Linux	1 Server-1 cpu, 512 MB RAM, 30 GB disk (shared w/UD servers), Linux		1 Server-2cpu, 4 GB RAM, 100 GB disk, Linux
<u>25,000</u>	4,167 conn/hr 208 MB/hr	1 Server- 2 cpu, 1 GB RAM, Linux	1 Server-1cpu 512 MB RAM 100 GB shared disk, Linux	1 Server-1cpu 1 GB RAM, 20 GB disk, Linux	1 Server-2cpu 8 GB RAM, 150 GB disk. Linux + Warehousing
<u>150,000</u>	25,000 conn/hr 1,250 MB/hr	3 Servers-2 cpu, 1 GB RAM, Linux	1 Server-2 cpu 512 MB RAM, 500 GB shared disk, Linux	1 Server-1cpu, 1GB RAM, 20 GB disk, Linux	1 Server-4cpu, 8 GB RAM, 150 GB disk, AIX + Failover + Warehousing

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Manageability

- **Web-based administration Console**
 - Remote administration of users, devices, applications and jobs
 - Features accessible based on role and access control policies
 - System management functions to control core services
- **Self-updating infrastructure**
 - Automatic update of MP Agent and tasks
 - Phases and versioning enable smooth transition to new code base
- **Automated systems management**
 - Periodic review and cleanup of stale data in the database and file system
 - Manager process restarts failed slave service processes
- **Rapid installation and upgrades**
 - Single command installation of MetaProcessor services in most environments
 - MP Agent compatible with most software distribution tools
 - Average time for MetaProcessor deployment is less than a day
 - Customized migration scripts to enable smooth upgrades

Dealing with non-dedicated resources



- **Optional redundancy parameters**
 - Each unit of work can be scheduled more than once
 - System can be set to wait for a minimum number of results to assure result integrity

- **Optional application-level checkpointing**
 - Provides features to enable applications to checkpoint their state periodically
 - System automatically resumes application execution from last saved state

Application Feasibility

- **Running many, many instances of the same application**
- **Coarse-grain data parallelism**
 - Data can be partitioned into independent chunks for executions
 - Large computation to communication ratios
 - Static data dependencies can be resolved
- **Coarse-grain control parallelism, pipelined execution**
 - The application itself can be partitioned into independent pieces
 - Output of one stage feeds the input of the next stage
- **Number of applications with this criteria**
 - Virtual screening of small molecules to develop drug leads
 - Genetic sequence analysis algorithms
 - Monte Carlo simulations
 - Decryption, key-breaking applications
 - Text mining applications
- **Windows executable exists**
 - Tools available to enable rapid migration – cygwin is an example

Application Management

- **Registration**
 - Programs are registered as tasks in the system
 - Registered tasks may be shared by one or more applications
 - Tasks have platform-specific executables called task modules
- **Versioning**
 - Tasks and task modules have versions
 - Versions enable tasks to be centrally upgraded and managed
- **Phases**
 - Tasks can be released in test, pilot and production phases
 - Phases enable developers & administrators to unobtrusively release tasks

Application Migration

➤ **MetaProcessor Task Wrapper**

- packages executable programs without source code modifications. Runs 'as is'
- Transparent encryption and compression without source code modifications
- Monitors and controls programs when executing on device

➤ **MetaProcessor Grid Services Interface (MGSI)**

- Programmatic Web services interface based on HTTP, SOAP and XML
- Support for 22 different programming languages
- Minimal effort to develop Application services, tools and utilities

➤ **MetaProcessor Application Services**

- Application services pre processes data, submit jobs and post processes results
- Uses MGSI to interface with the MetaProcessor. Optionally can use batch utilities

➤ **MetaProcessor Task API**

- Optional source code modifications for task check-pointing and monitoring

➤ **MetaProcessor SDK**

- Detailed documentation for all components
- Reference implementation and value-added modules for rapid development

Data Management

➤ Registration

- Data is registered as work data and resident data using MGSI
- Data is uniquely named to avoid name collision
- Data can be grouped as work data set and resident data set

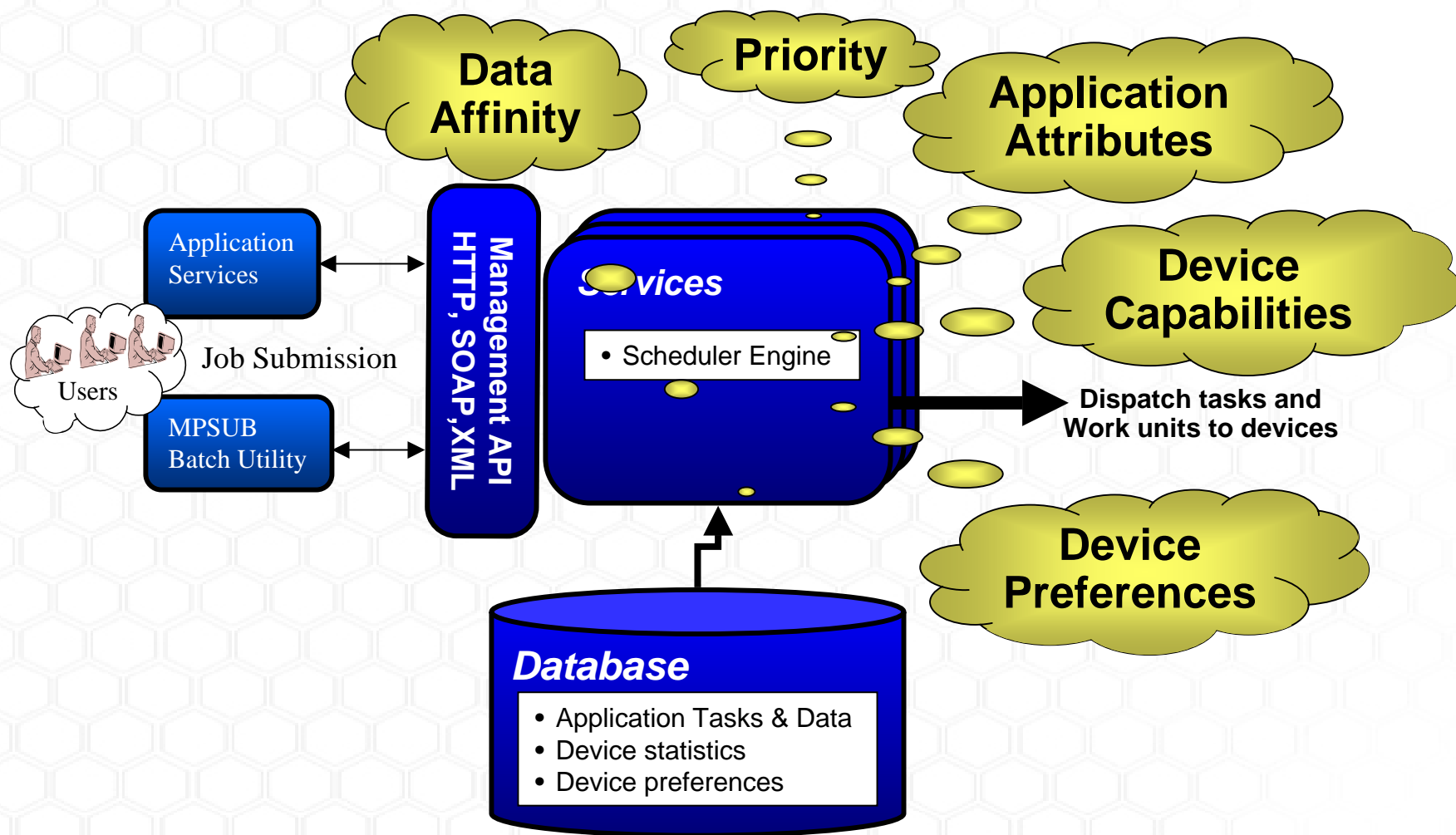
➤ Resident Data

- Data is always cached on devices to reduce network traffic
- Data once registered may be shared by many jobs and users
- Enables scheduling based on resident data affinity

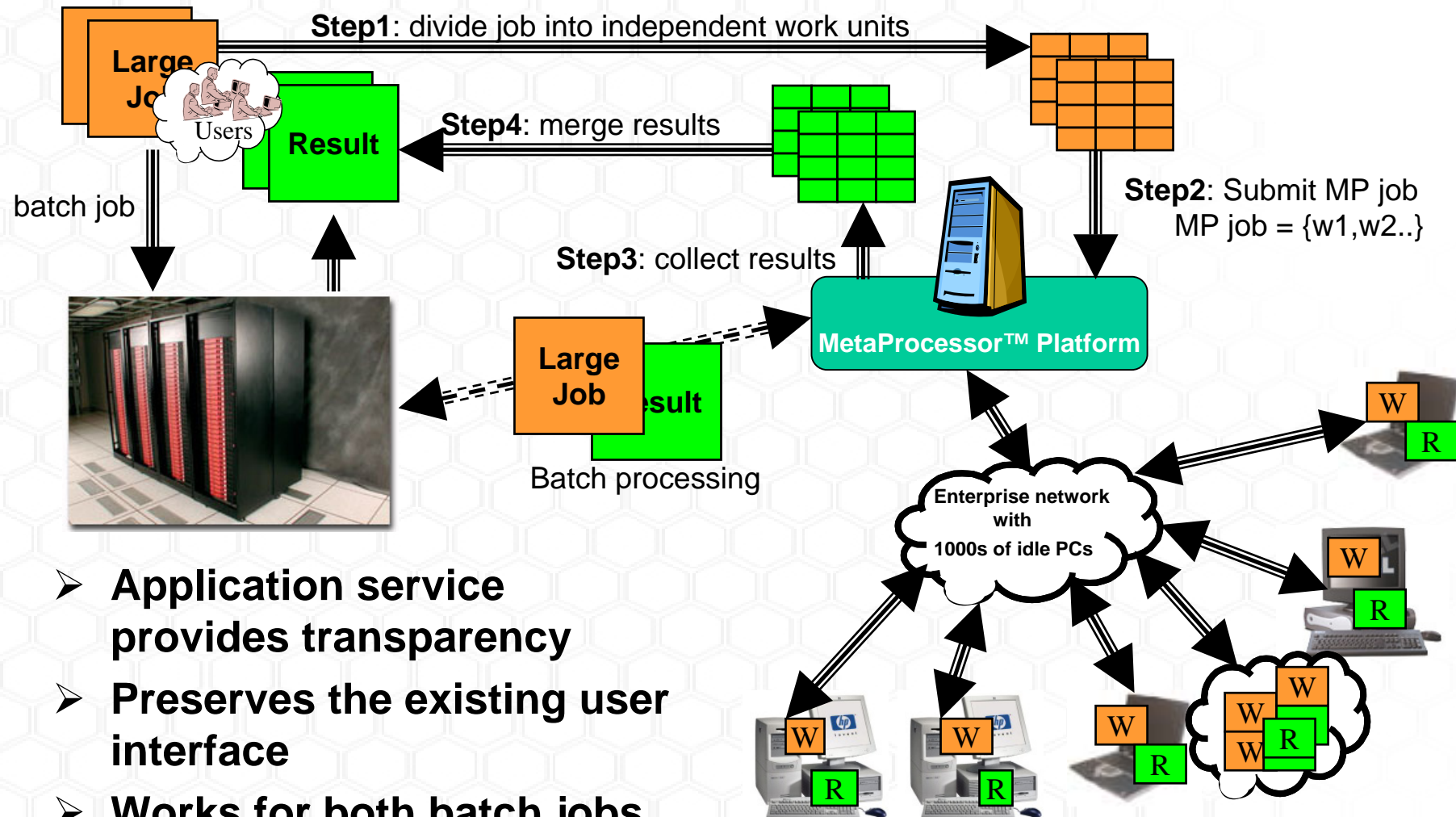
➤ Annotation

- Enables application services to store information such as, a data index

Workload and Resource Management



End-user Transparency



- Application service provides transparency
- Preserves the existing user interface
- Works for both batch jobs and data parallel jobs

Case Studies

The Novartis Grid

➤ Goal

- Accelerate lead identification and profiling 10X within one year
- Find a way to accomplish the goal without raising costs 10X

➤ Solution

- Adopt a PC-based Grid solution

➤ Pilot Highlights

- Rapid deployment across 600+ Windows desktops
- Exceeded expectations on all pilot criteria
- Aggregated 3.18 years of processing time in first 7 days
- Migrated proprietary application during the pilot

➤ Results

- Currently running a 1000 device Grid
- Response time on virtual screening reduced from days to hours
- Network bandwidth usage increased by less than 2.5%
- Investigating text mining application as well

Oxford University – A Global Grid

➤ Goal

- Be able to screen a public database of small molecules against 12 protein targets identified in several cancers

➤ Solution

- Adopt a Global Grid solution and use volunteered PCs

➤ Project Highlights

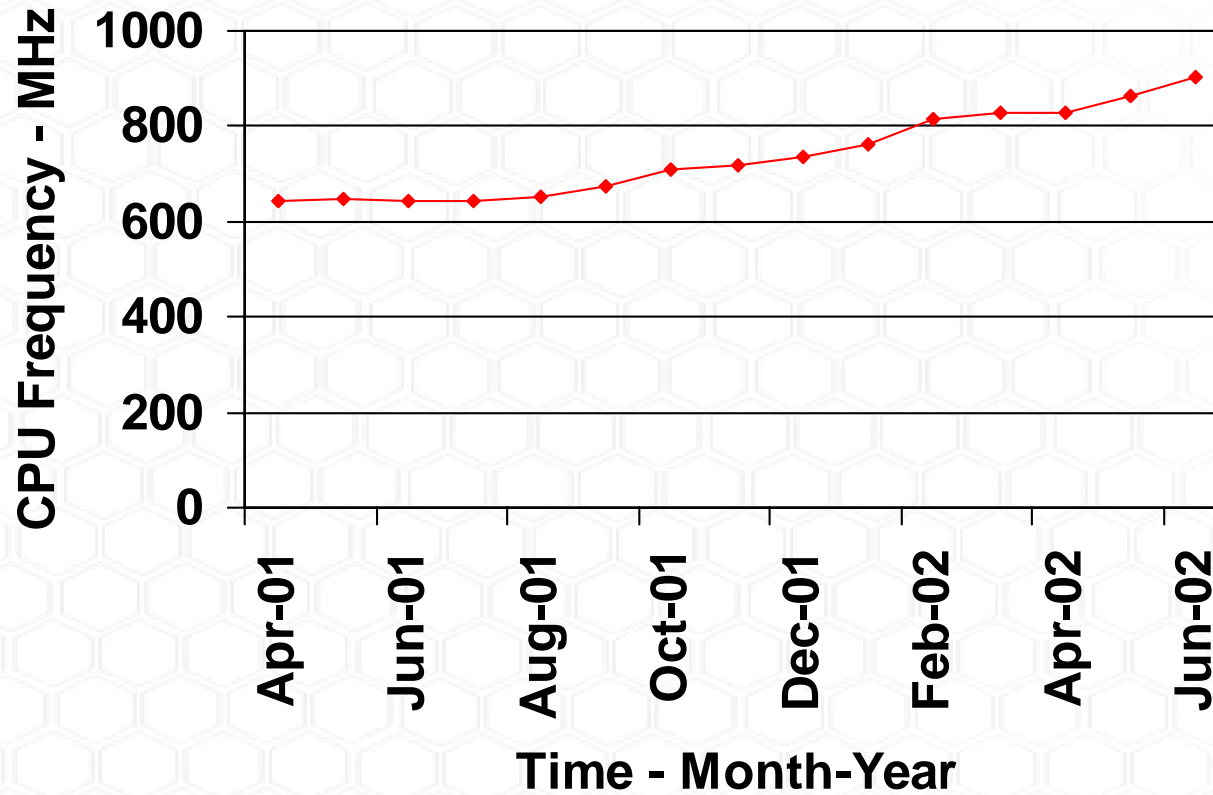
- A total of over 1.6M PCs from around the world – 220 countries represented, including the Vatican
- Unprecedented scope – project scope was increased 70-fold based on the available compute power
- Total CPU time is over 126,000 years; 200+ years every day!

➤ Results

- Other related projects completed: Anthrax screen in 24 days!
- “Hits” will undergo the next stage of analysis
- Largest, general-purpose, public compute Grid



The Global MetaProcessor Grid



**Performance improved 50% in 14 months.
The asset appreciates over time!**

Summary and the Future

- **The opportunity with enterprise grid computing (or P2P) is REAL**
- **There are some challenges but they can be overcome**
 - Applications and end-user transparency
 - Administration and manageability
- **The benefits are compelling and it is happening TODAY**
 - Novartis and Oxford University are example projects
- **The Future**
 - Every device is “plugged” into this type of grid
 - It becomes ubiquitous – you don’t have to think about it anymore
 - True peer-to-peer features enable less loosely-coupled applications