IT Consolidation Technical Design Considerations

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Agenda

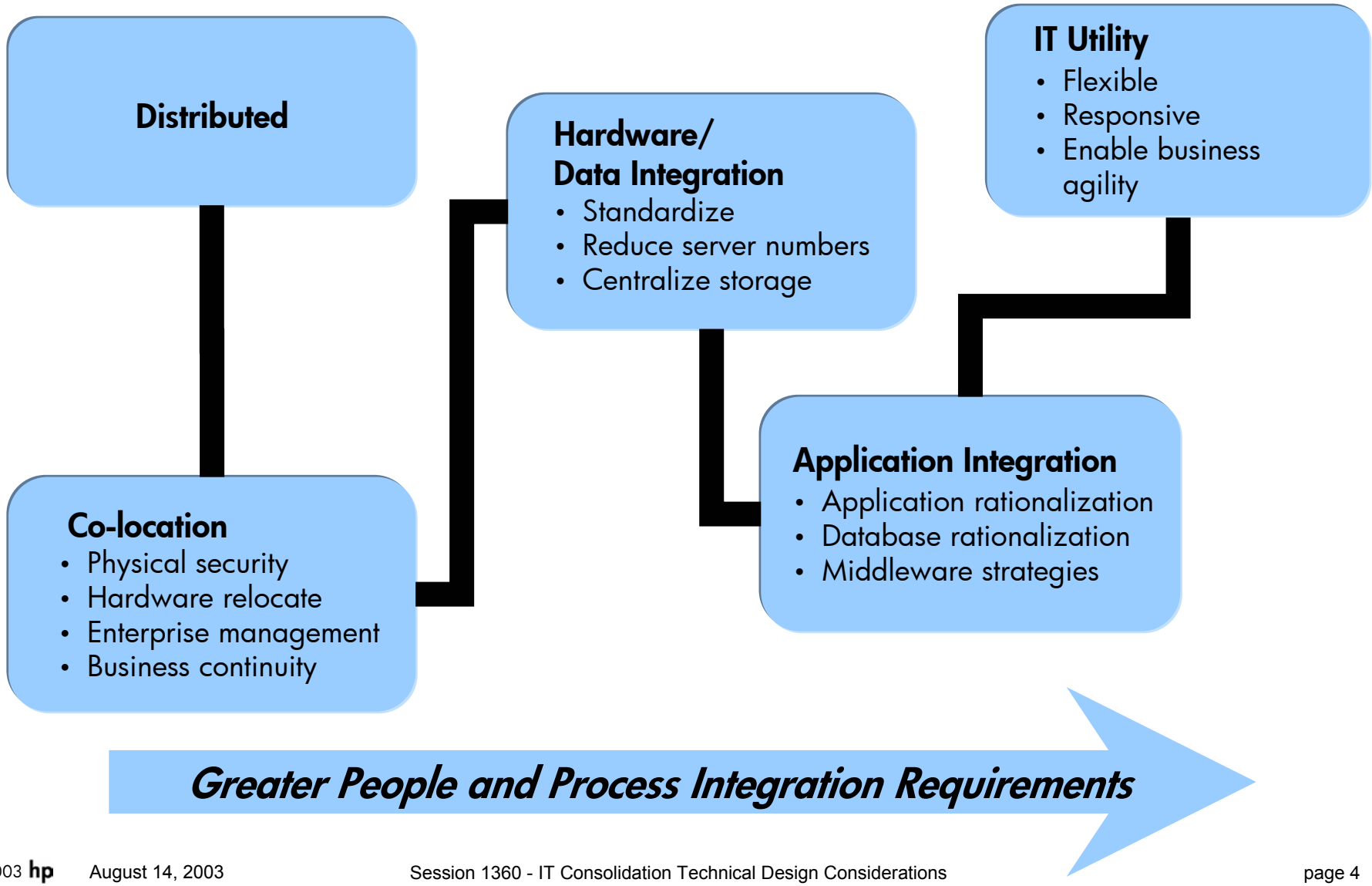
- IT Consolidation Overview
  - Definition
  - What Can Be Consolidated?
  - Consolidation Strategies
  - Consolidation Methodology
- Detailed Design
  - Document
  - Project Team
  - Components
- Summary

What is IT Consolidation?

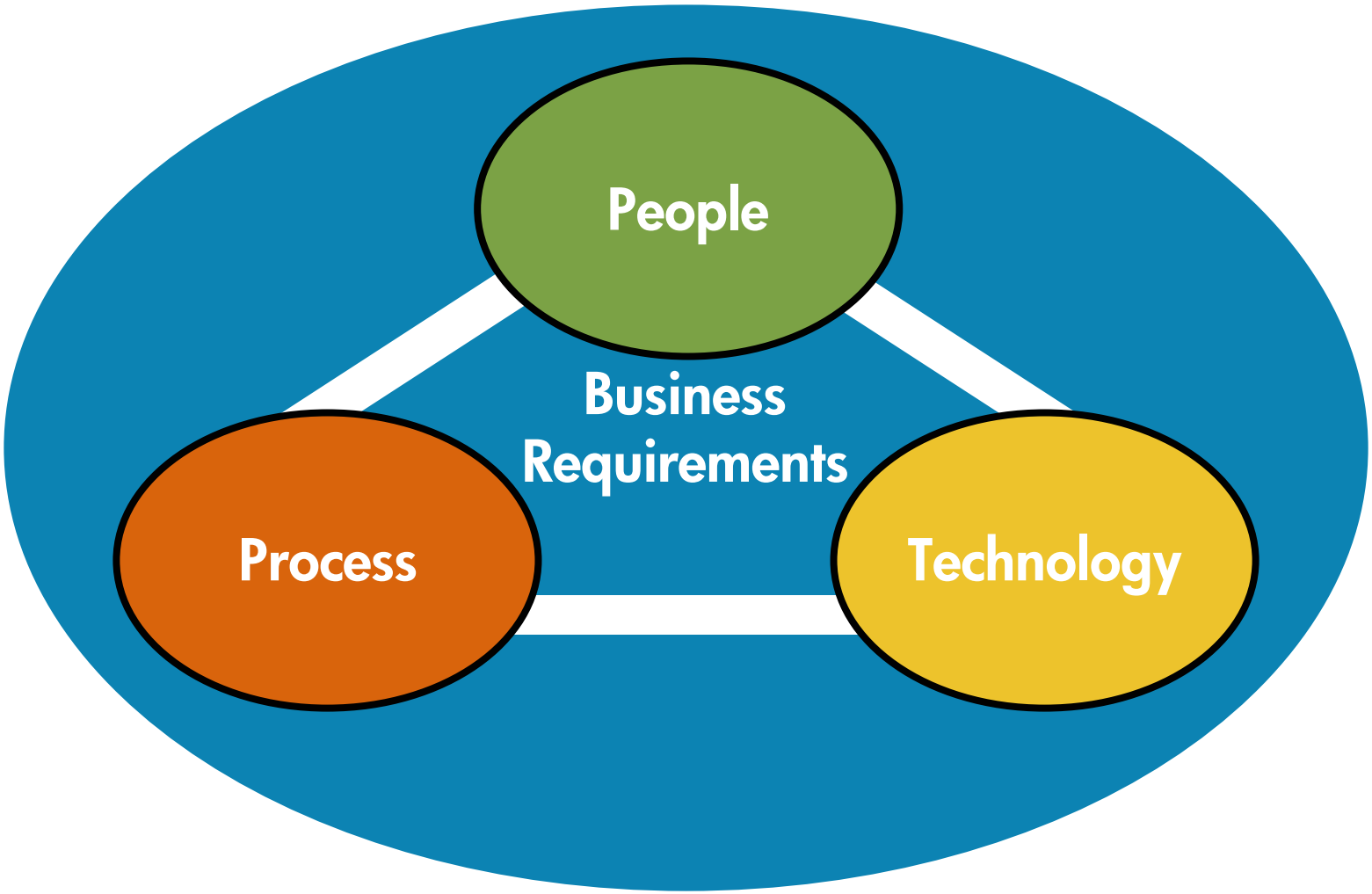
One Definition -

"IT Consolidation is an iterative process that optimizes services, people, skills, infrastructure, applications, IT processes, and management that supports an organizations business while at the same time simplifying the operational environment, increasing service levels to the business, and creating greater adaptability to meet evolving business requirements."

IT Consolidation Journey

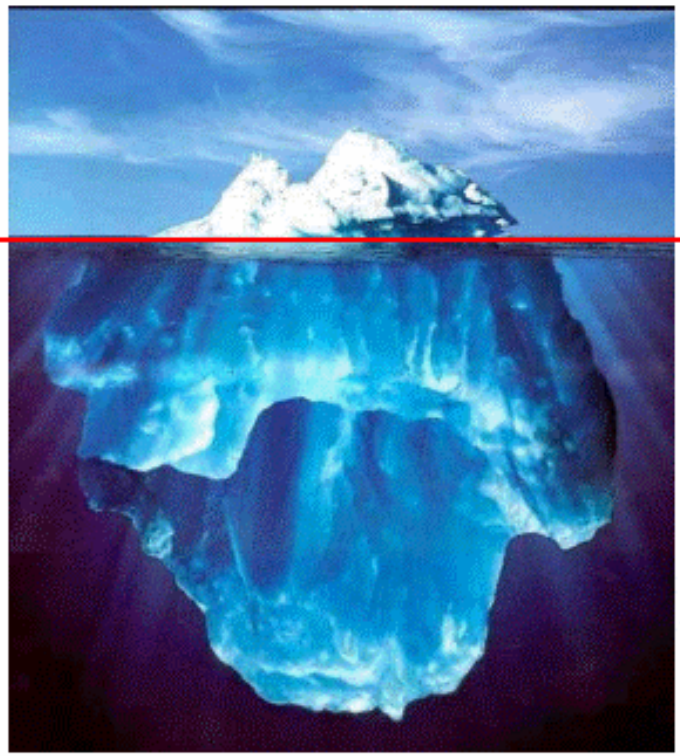


Successful IT Consolidation Requires a Balanced Approach



The Big Picture

During an IT Consolidation Project, many IT Organizations focus too heavily on tools and technology. Moving to a more consolidated IT environment typically requires change across many aspects of the organization.



Technology: Tools and Infrastructure

Process: Definition/Design, Compliance and Continuous Improvement

People: Roles & Responsibilities, Management, Skills Development & Discipline

Culture: Values, Unspoken norms, Often experienced and not seen

IT Consolidation
People & Process Considerations

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IT Governance Model

IT Processes

IT Organization

Human Impact

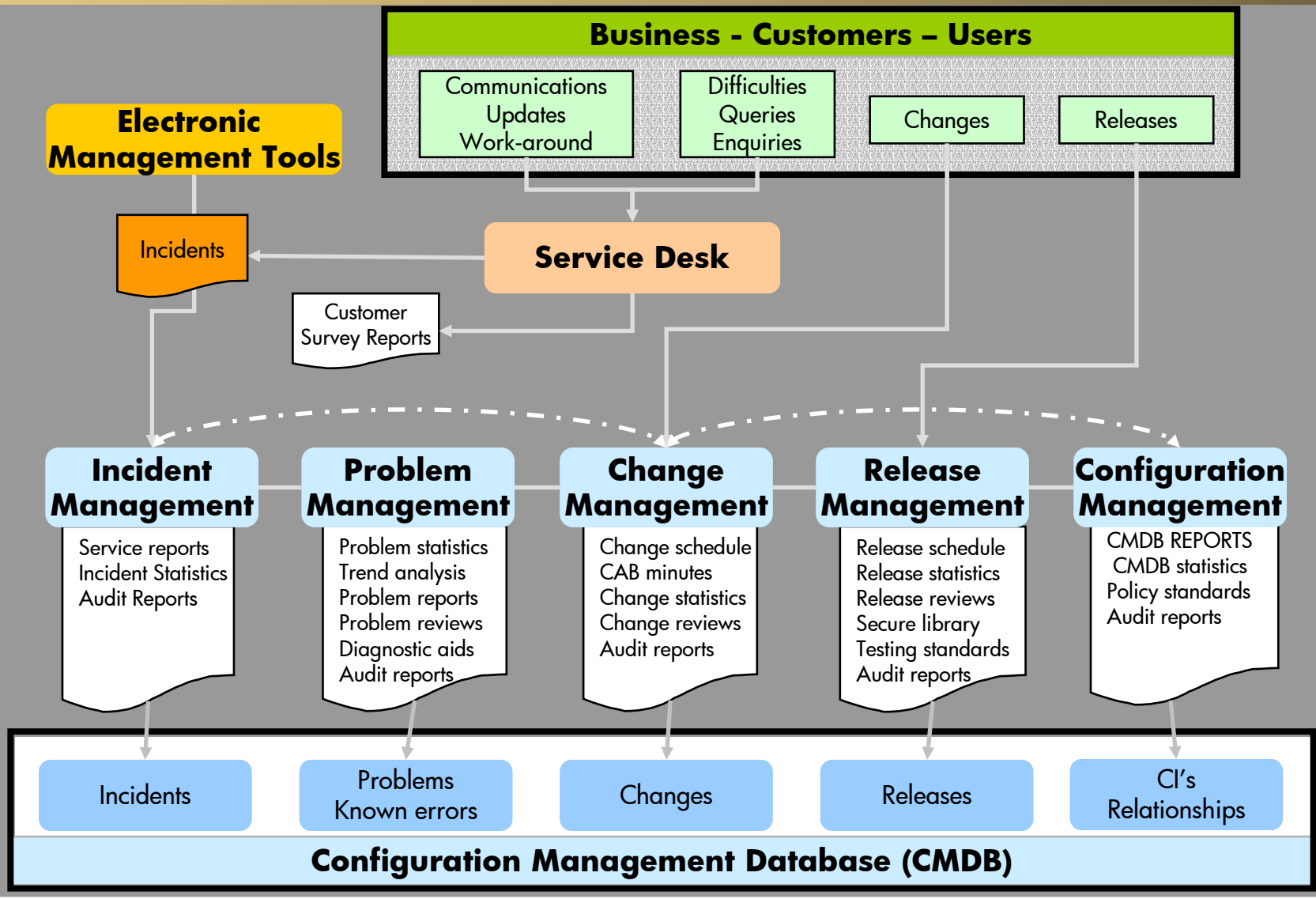
IT Governance Model
- Ensure business alignment
- Proper balance of cost, service levels, risk and agility for the business
- Must support standards and shared infrastructure

IT Processes
- Many processes will need to change because of shared infrastructure, and to maintain the efficiencies from consolidation

IT Organization
- Reorganization may be warranted given other changes, especially with collocation

Human Impact
- Consolidation means change for your staff
- May mean role change, retooling, relocation or redeployment
- Retention and buy-in may be factors

Sample High Level Process Model

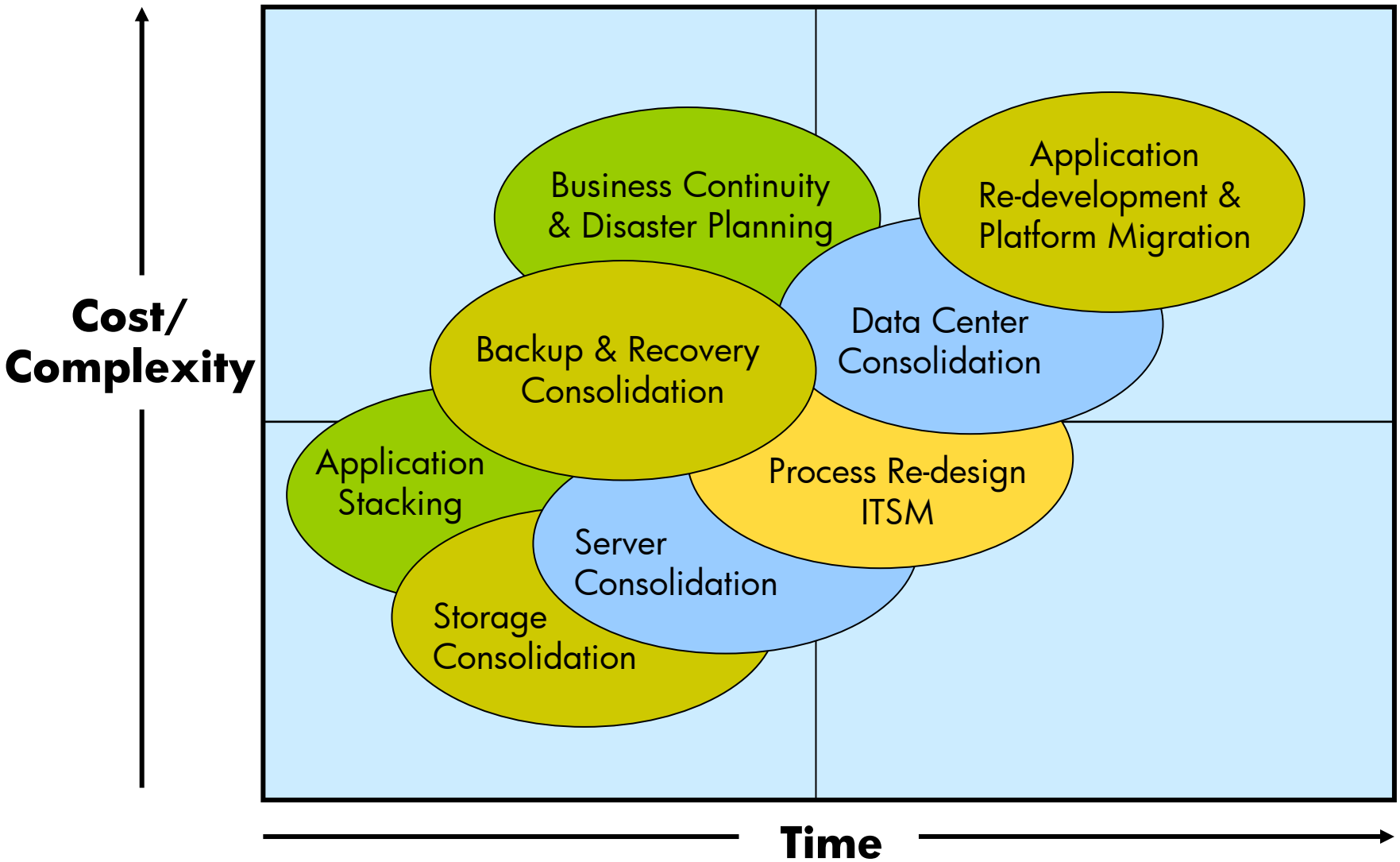


What can be consolidated ?
Consolidation Domains

Services / Applications	Business services and applications with similar or related context
Systems	Reduce number of systems using application stacking, partitioning
Operating Systems	Reduce number of operating system types, images and versions
Management	Streamline systems management processes and tools
Physical / floor space	Floor space - rack n' stack
Storage	Common storage services, SAN's Std media and archive strategies.
Backup	Use larger, but fewer, backup devices. Server license costs reduced.
Configuration	Standardize on client/desktop or server configurations, patches, setup's
Network	Reduce complexity, # of links, improve bandwidth
Development & Test	Common development, cert, test practices, porting environments, tools
Consoles	Use ISV pkgs for remote, secure access. Keep log files of console activity
Help Desk	Centralized db provides single data source for logging, monitoring, reporting
Data center	Merge multiple data centers into fewer
Support	Centralized contract, support management
Disaster recovery	Common recovery sites and platforms
Processes	Reduce number of different but redundant processes
Printers	Install larger, more centralized printers. Staff can handle admin tasks easier.

Consolidation Strategies

One example of Overall Initiative Positioning



Consolidation Strategies
Application and Database Positioning

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With Minimal Application Changes

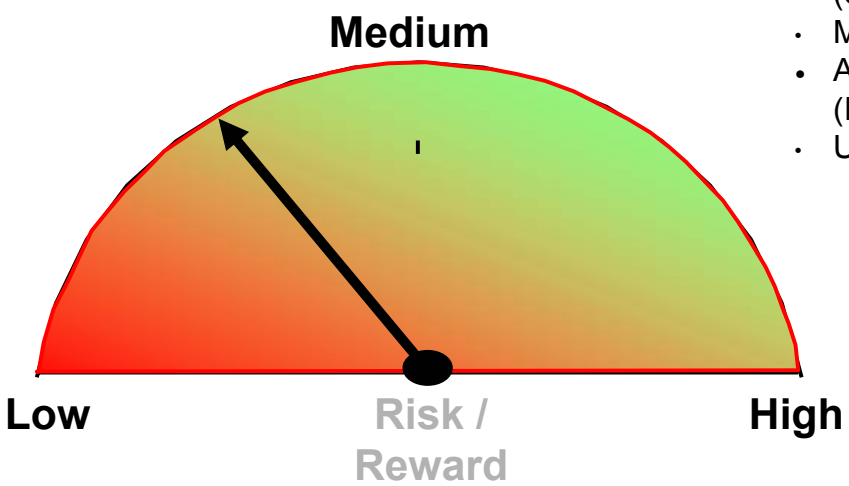
- Data center consolidation (server co-location)
- OS Environment Simplification (Fewer OS releases, better patch mgmt)
- Partitioning of servers
- "Single Application" Consolidation
- Reallocation of Applications (Free underutilized servers)
- Review HA policy (Reduce system count, support costs)

Without Touching Applications

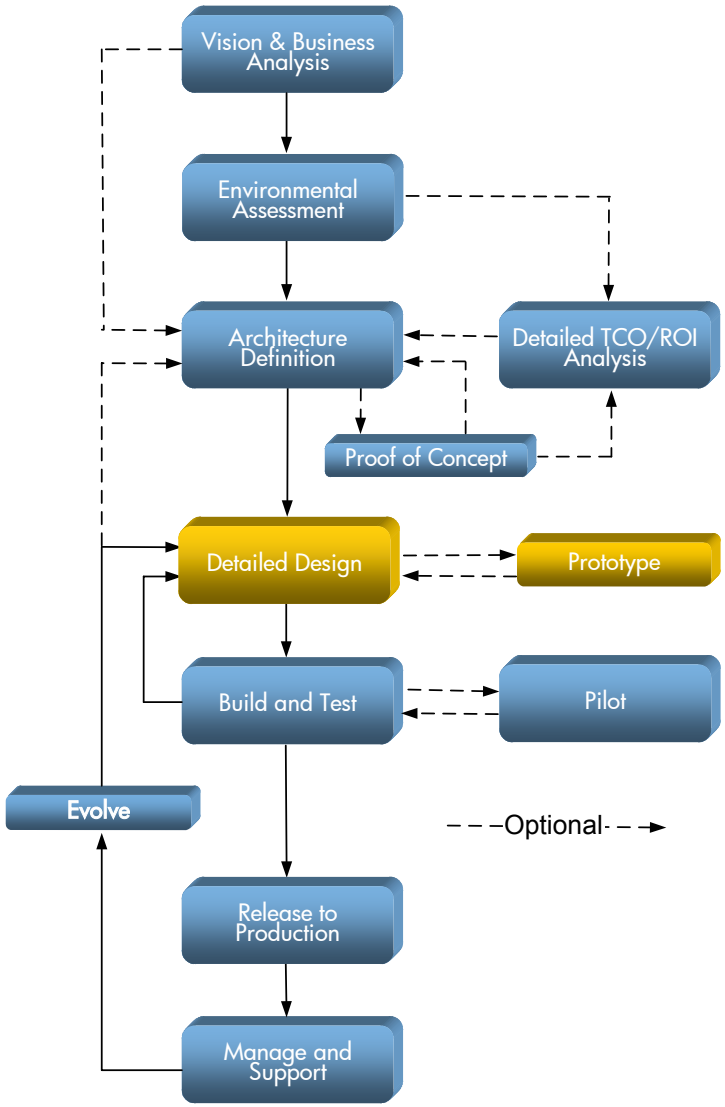
- Dense Racking (40-60% Floor space reduction)
- Console Consolidation (16:1 Console Device Reduction)
- Backup Consolidation (>16:1 Device Reduction)
- Mass Storage Consolidation (Performance, Reliability, Floor space)
- Management Software/ Process Change

Application / Database Rationalization

- Multi-App/Server (Stacking - OS Image reduction)
- Middleware Integration
- Application Retirement (Identify redundant apps)
- Use of newer OS / Features



Sample IT Consolidation and Migration Methodology



Detailed Design Phase (Yellow)

- Inputs - Business drivers, architecture, guiding principles, environmental assessment & current operations feedback.
- Outputs – Detailed design planning specifications document. Draft Build-and-Test plans, Draft Release-to-Production plans.
- Needs to consider people, process and technology issues.
- Hardware and Software compatibility matrix is a critical component.
- Requires regular project and management reviews.
- Configuration & change management processes are critical.

Detailed Design Overview

Inputs

- ***Business drivers***
- ***Environmental Analysis (current state)***
- ***TCO / ROI Analysis***
- ***Architecture Blueprint***
- ***Build and Testing Feedback***
- ***Current Operations Feedback***

Detailed Design

Detailed Design & Specifications

- Detailed Specifications for Future State: network, server, storage, OSs, clusters, Apps, partitioning, tuning, DBs, data centers, third party products
- High Availability
- Storage Mgmt (backup, recovery, archiving)
- Enterprise Management (applications, servers, storage, network, consoles)
- Disaster Recovery and Business Continuity
- Acceptance Test Plans
- Technical Migration Guide

Implementation / Migration Plan

- Site preparation & installation of equipment
- OS, Application, middleware, user files deployment
- Data migration processes
- Functional, User, System, Certification testing
- Operational Schedule
- Estimated effort, skills, and WBS

Outputs

- ***Detailed Design Specifications Document***
- ***Build Plans***
- ***Test Plans***
- ***Move to Production Plans***

Detailed Design Document
What is it?

- Critical planning and design document *
- Purpose:
  - Standalone document that communicates the technical solution details to a wide range of technical, management and business resources
  - Provides direction and input to the subsequent Build-and-Test and Release-to-Production project phases.
  - Provides business groups with an understanding of the impact to them
  - Assists in getting approval from the Business, Technical, Application and Support groups that will be potentially impacted by this project.

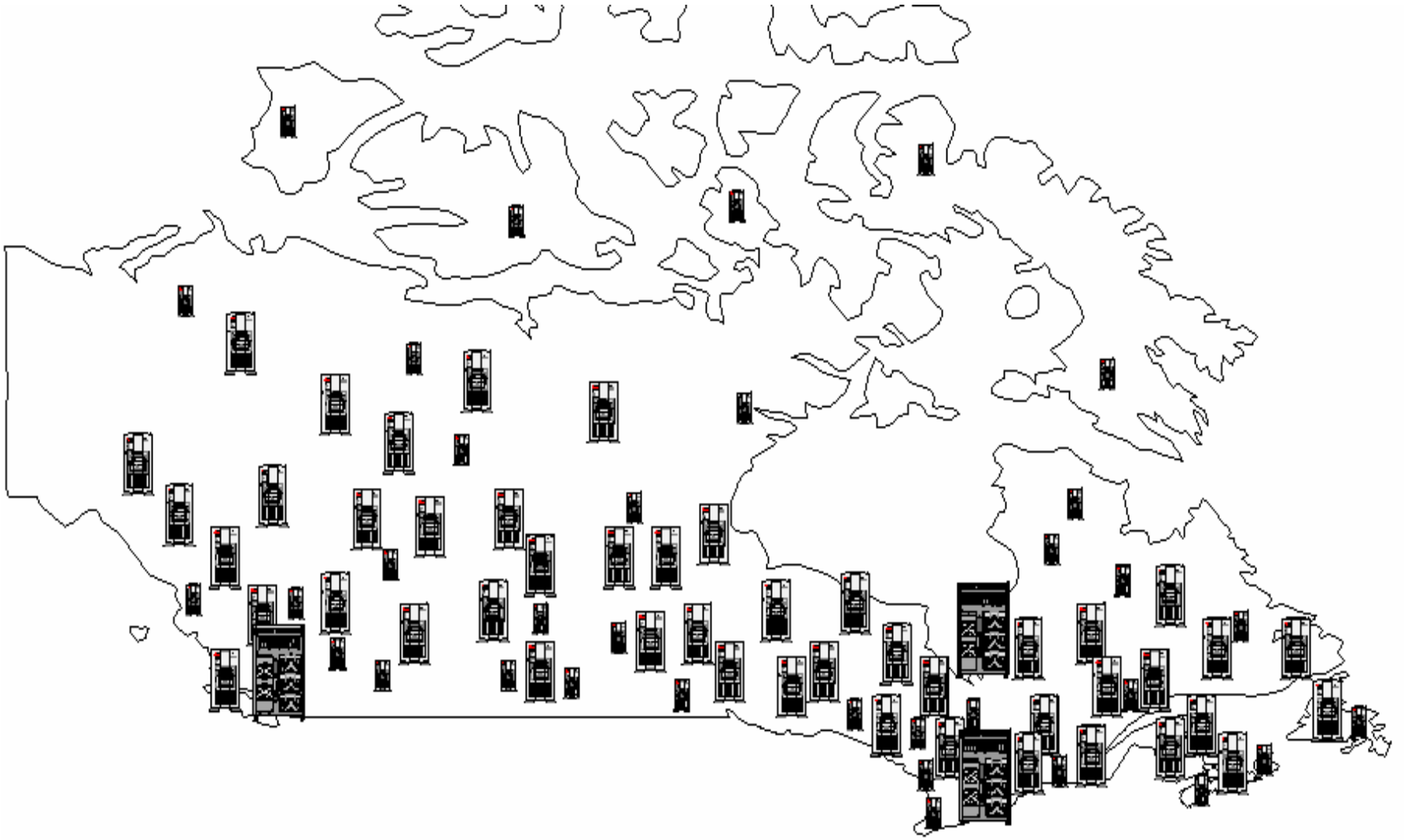
** sometimes referred to as "System Blueprint" document*

Detailed Design Document
Contents

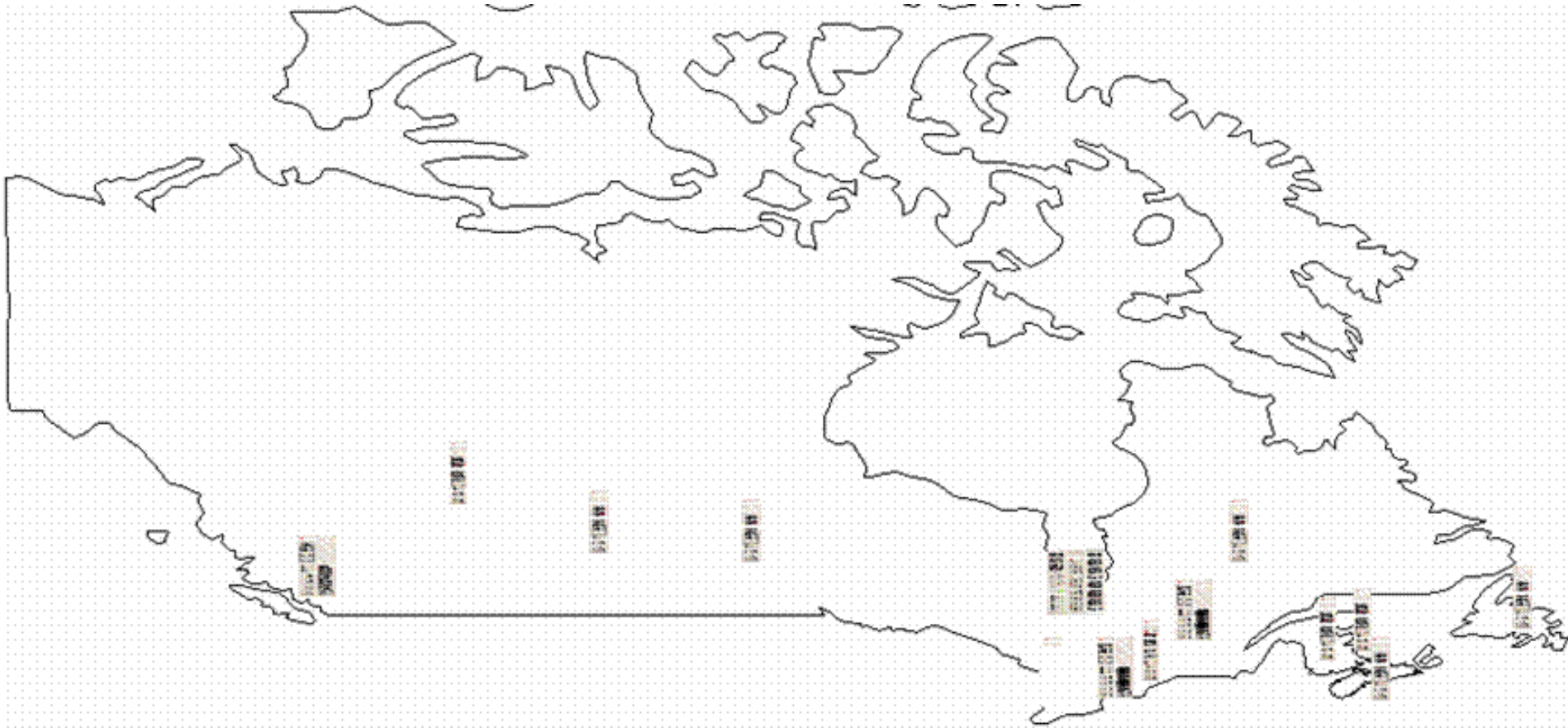
- Current and Future Technical Specifications
- Acceptance Test Plans
- Technical Migration Guide
  - Provides detailed pre-migration, migration and post-migration roles, responsibilities and timelines
  - Provides detailed application, user & data migration flows & processes.
- Design Implementation Timelines
- Living document part of change management processes - updated when any change request affects the current design or architecture.

Detailed Design Document
Table of Contents (sample)

Actual Project
Current Environment (start of project)



Actual Project
Future Environment (project 90% done)



Application & OS Matrix
Overview (sample)

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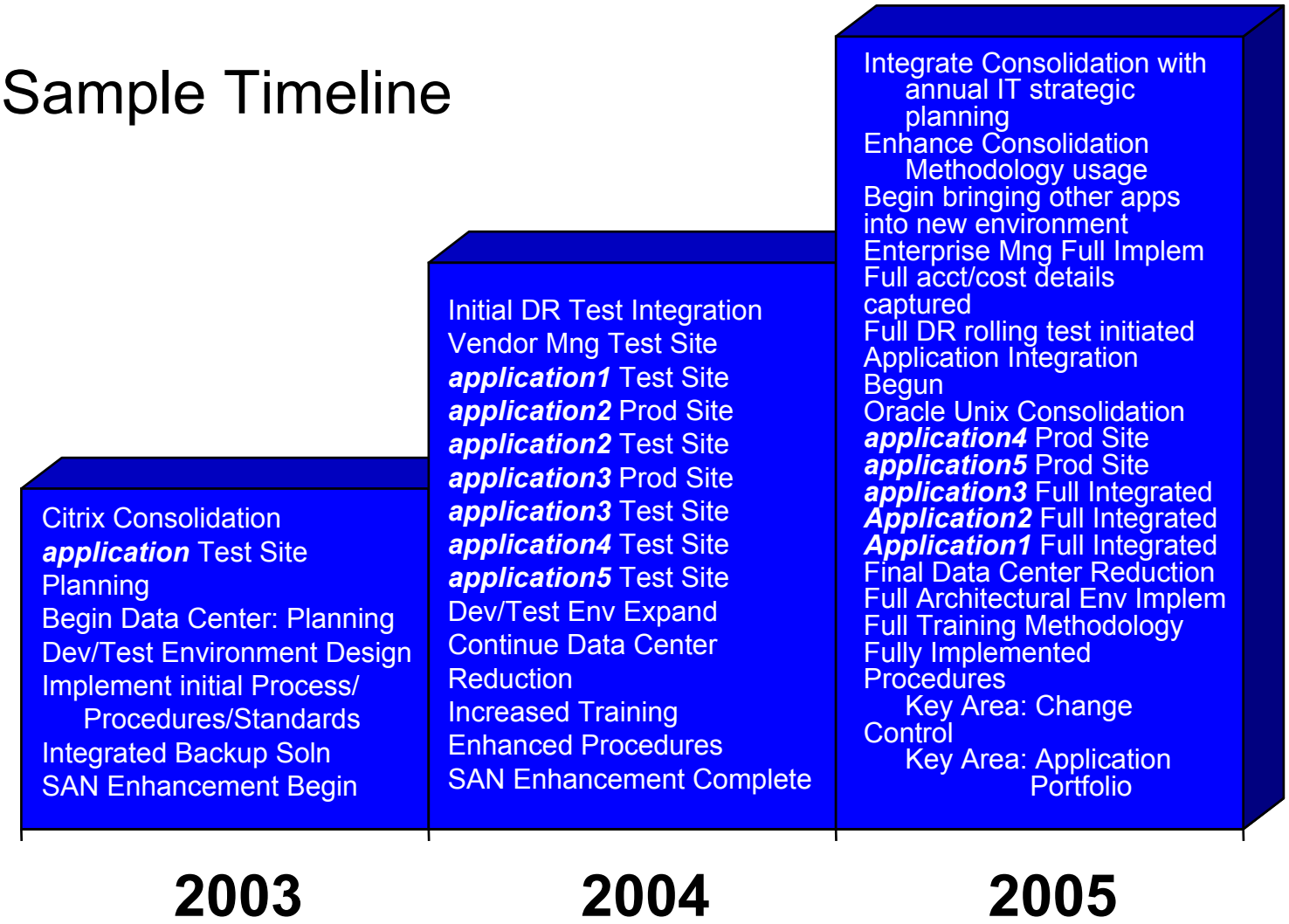
Compatibility & change management of OS, applications and licenses is critical during any IT Consolidation project

#	Original Software Name	Current Version	Req'd Y/N	Alpha OVMS Version	License Required	Where Installed				Order Responsibility			Comments / Replacement Product
						SRV1 ES45 (Prod)	SRV2 ES45 (Prod)	SRV3 ES45 (Prod)	SRV8 DS20E (Dev)	HP		Cust	
										C&I	CS		
1	OpenVMS Cluster	6.2	Y	7.3-1	QL-MUZAE-ZG	X	X	X	--	X	--	--	VAX to Alpha Workgroup system upgrade
2	Unlimited Users	6.2	Y	7.3-1	QL-MT2AE-ZG	X	X	X	X	X	--	--	VAX to Alpha Workgroup system upgrade
3	Volume Shadowing	6.2	Y	7.3-1	QL-2A1AE-ZG	X	X	X	X	X	--	--	VAX to Alpha Workgroup system upgrade. Dev DS20E already has volume shadowing license.
4	DECnet Extended Function	6.2	Y	7.3-1	QL-MTGAE-ZG	X	--	X	X	X	--	--	VAX to Alpha Workgroup system upgrade. DECnet PH IV Routing
5	DECforms Development	2.4	Y	3.2	QL-0J8AE-ZG	--	--	--	X	X	--	--	Forms based development upgrade license
6	DECforms Runtime	2.4	Y	3.2	QL-VNSAA-3B	X	X	X	--	X	--	--	Runtime required on all prod systems. This concurrent license can be moved to Alpha's. No charge - see reconcilled sheet.
7	Code Management System (CMS)	?	Y	4.1	QL-0W2AG-ZG	--	--	--	X	X	--	--	Code Management System (CMS)
8	Language Sensitive Editor (LSE)	?	Y	4.7	QL-0W2AG-ZG	--	--	--	X	X	--	--	Development editor with templates
9	COBOL	5.4	Y	2.8	QL-0JUAE-ZG	--	--	--	X	X	--	--	VAX to Alpha Workgroup upgrade. Need to install both the V2.8 RTL & COBOL kits
10	COBOL Run Time	5.4	Y	2.8	QL-0JUAE-ZG	X	X	X	X	X	--	--	VAX to Alpha Workgroup upgrade.
11	Datatrieve	?	Y	7.2A	QL-0JKAE-ZG	X	X	X	X	X	--	--	VAX to Alpha Workgroup system upgrade
12	SQL/Services	6.1-2	Y	7.1.5.6	Oracle	--	--	X	X	--	--	X	Oracle product - need Alpha upgrade
13	CLEO 2780/3780 Bisync	N/A	Y	?	CLEO	X	X	--	--	--	--	X	CLEO 2780/3780 Bisync product. Discuss
14	TCPware	5.5-3	Y	5.6-2	Process	X	X	X	X	--	--	X	Process Software TCPIP product

Appendix C: Timeline for Detailed Design and Implementation Phases

Sample Timeline

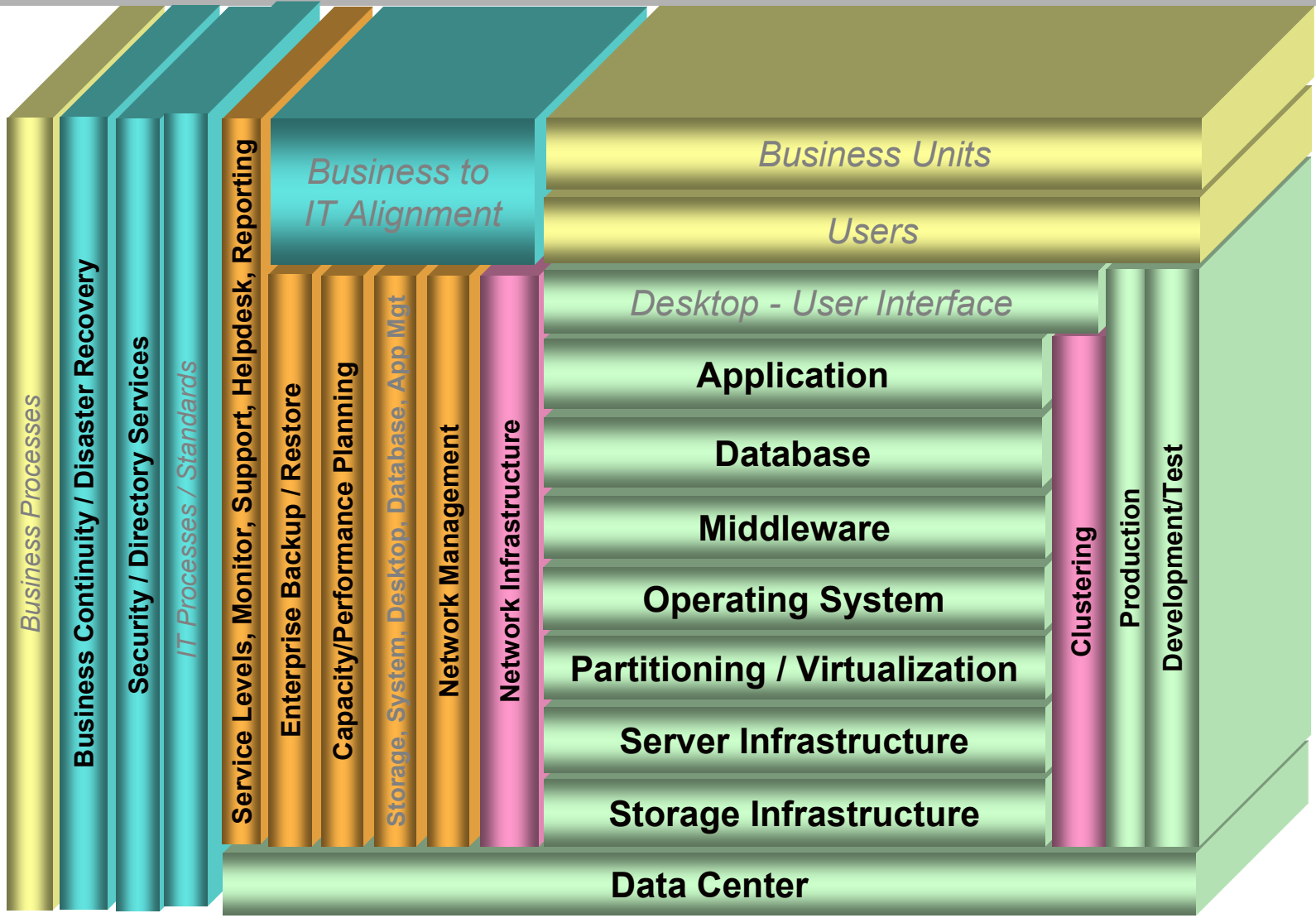


Detailed Design Team

- Project / Program Manager
- Technical Architects: Need at least one team member for each component in the scope of work:
  - Applications
  - Databases
  - Security
  - Operating system, servers
  - Storage
  - Network
  - Desktop
  - Process and IT Organizational Design
  - Management tools
- BU representatives for each major application

Each team member needs to keep their specific group up to speed with what is happening!

Detailed Design Components



Data Center Consolidation
Overview

- Power
- Air Conditioning
- Space
- Site Physical Security
- Weather
- Disaster Planning

Data Center Consolidation
Design Considerations

- Is data center reduction a business requirement?
  - Need to consider location, staffing, network, power outages, time zones, generator issues
  - Location may impact on-site support times from vendor(s)
- Disaster recovery or business continuity requirements?
  - Recommend do NOT consolidate to one site only
- Are target data centers capable of future expansion?
- Non-technical data center considerations
  - Recent SARS health issues. One individual can close entire facility for up to two weeks.
  - Union strikes may result in picket lines that prevent access
  - Leases
  - Local building codes and regulations

Data Center Consolidation
Design Considerations (cont'd)

- Migration to a Consolidated Data Center can be complex. Multiple projects need to be co-ordinated as one program.
- Space considerations - add room for hardware technicians to access **all** sides of the gear.
- Air conditioning and UPS - ensure adequate room for future growth.
- Be aware and careful of fire suppressants. Ensure all regulatory and test requirements are addressed.
- Weight of the equipment often surprises people. Make sure the floor can support both the target environment and projected future growth as well.

Network Consolidation
Overview

- Physical design
- Logical design
- Protocols (TCP/IP, IPX, SNA, DECnet, NetBEUI, LAT)
- TCP/IP Management (WINS, DNS, DDNS, DHCP, Host/LMhost files)
- Load Balancing
- Security
- Future: IPV6?

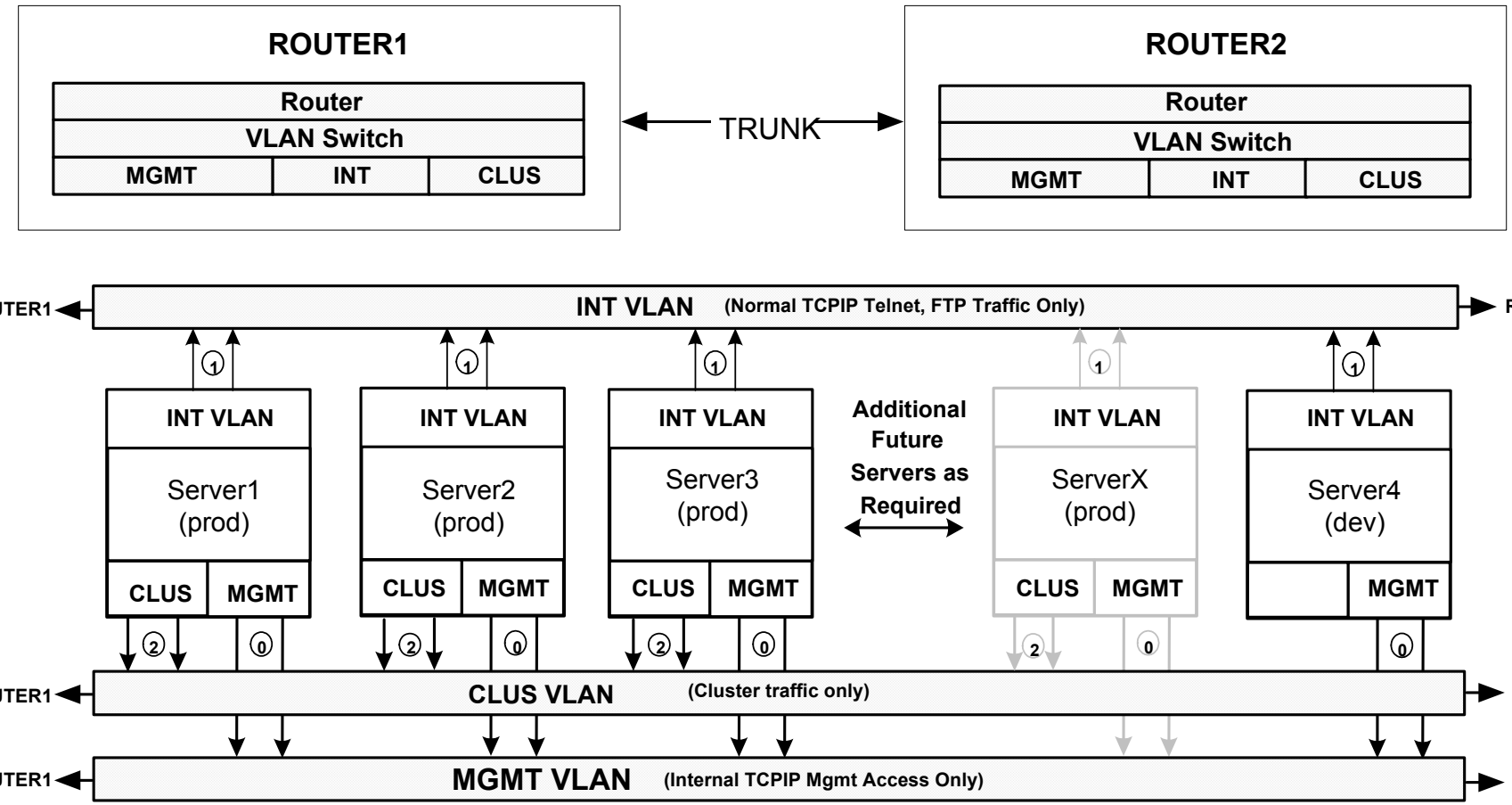
Network Consolidation
Design Considerations

- Requires network configurations & detailed drawings to be current and up to date.
- Current link performance? May improve in the off hours.
- Any future changes planned? IPV6?
- Network load balancing and high availability issues.
- DNS, WINS, DHCP, LMhost / Host and client application configuration file considerations.
- Ensure no single point of failure in overall network design

Network Consolidation
Design Considerations (cont'd)

- Monitor network traffic patterns and trends before, during and after the project.
- Focus on link utilization and latency issues - especially if using a multi-site configuration.
- Ensure latest recommended network router and switch security patches are installed.
- Consider using multiple VLANs to separate traffic and protocols for increased performance and security.

Network Consolidation
Design Consideration - VLAN's



Server Consolidation
Overview

- Hardware Platforms
  - Mid-range
  - Enterprise
- Server Sizing
- RASS
  (Reliability, Availability, Scalability, Security)
- Cluster and Interconnects
- Partitioning
- Workload Management
- Console Management

Server Consolidation
Design Considerations

- Server sizing is critical. Must understand current environment & review the following to decide on target server configurations:
  - nature of applications (stackable, partition-able, unique hardware interfaces and/or cluster ready?).
  - Review server data collected in CMDB (Environmental Analysis phase) i.e. CPU type/speed, memory & peak % CPU utilization.
  - Need to understand current server bottlenecks (memory, CPU, I/O, locking, network etc.)
  - Review job specific workloads on each server and map to new environment.
  - New OS may be required for new server HW. Are applications capable of running with new OS version?

Server Consolidation
Design Considerations (cont'd)

- Server sizing is critical (cont'd)
  - OS, database, ISV, layered products (e.g. Java), home grown application versions and compatibility are major concerns and must be well tested.
  - ISV support for clustered and/or stackable configurations?
  - Can existing servers be re-used in other capacities?
  - What new workloads are coming in next 12-18 months?

Server Consolidation
Design Considerations (cont'd)

- When SLAs require no single point of failure in overall server design, ensure to:
  - Balance disk, network, cluster and SAN adapters across multiple PCI buses to maximize overall system throughput.
  - Use multiple NIC's for TCPIP & cluster traffic high availability.
- Review available clustering and partitioning features to determine if applicable.
- Review batch job and print requirements.
- If clustering or partitioning is used, testing all aspects of different failure scenarios is critical. Need formal test plan.
- Partitioning offers higher availability options than a single OS instance, but not as high as clustering across different servers.
- Ensure system firmware is current

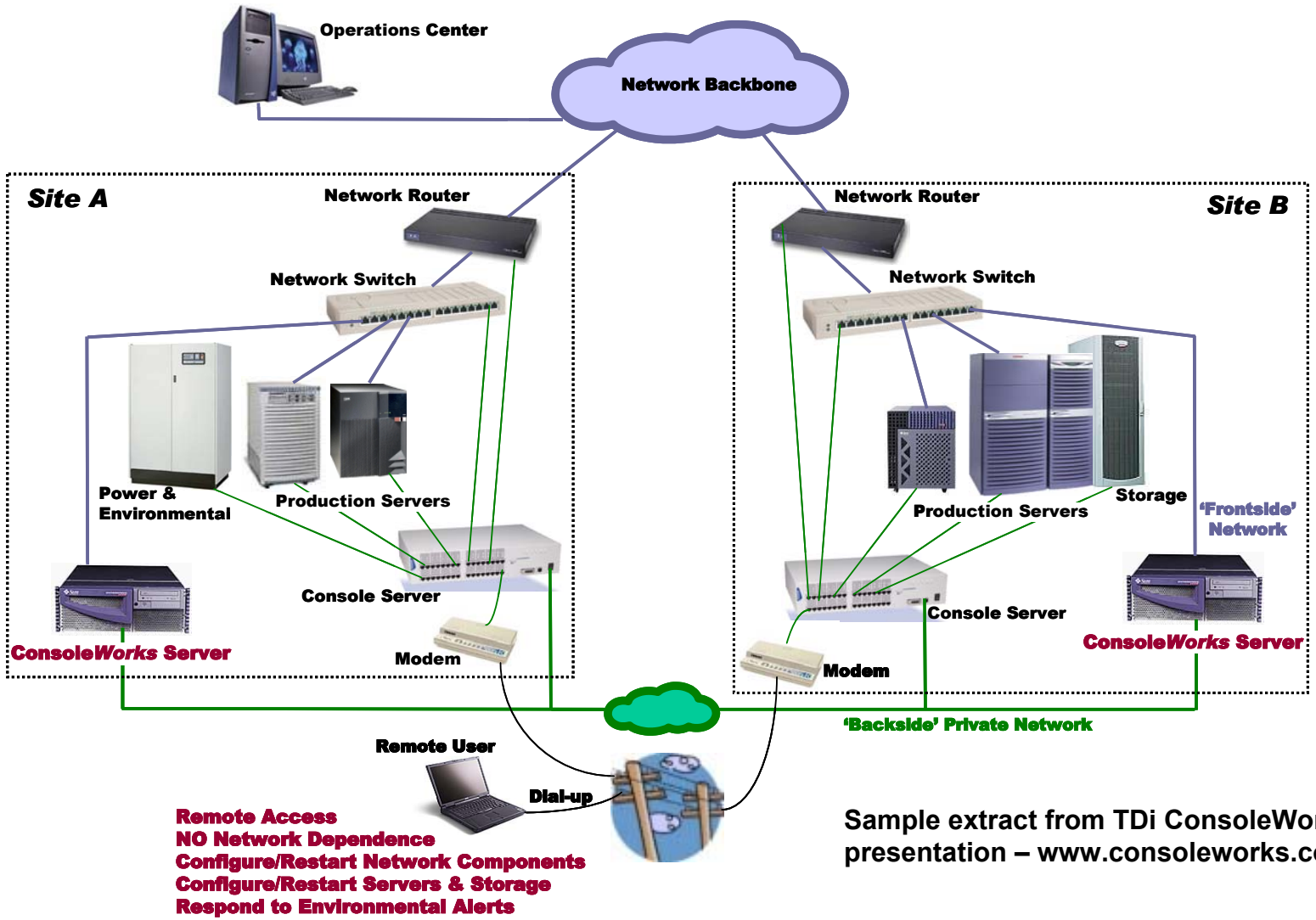
Console Consolidation
Overview

- ISV software and hardware solution that consolidates many consoles down to one or two for availability. Most solutions typically handle any ASCII based console output.
- Provides remote monitoring and management of computing systems, network and telecommunications equipment:
  - Multi-platform (UNIX/Linux, OpenVMS, Windows) Servers e.g. web, file, application, etc,
  - Network routers, switches
  - High-end storage devices (e.g. SAN Controllers)
  - Network appliances
  - Uninterruptible power supplies (UPSs)
  - Network security devices
  - PBX / Phone switches

Console Consolidation
Design Considerations - Benefits

- Remote access to servers, controllers, routers via network or dial-up anywhere on the globe – reduce travel time, response times and support costs.
- Increased security - maintain soft copy log files of all console activity – even when system down. Files can be backed up to tape for future audits.
- Capture messages and console activity not always logged to host system(s) e.g. SAN and disk controllers.
- Monitor console messages with scan files for system specific messages and send SNMP alerts to OpenView, Tivoli, BMC etc.
- Eliminate redundant console terminals, mice and keyboards.
- Consistent Web and GUI access to traditional ASCII based console outputs.

Console Consolidation
Sample Multi-site Configuration



Sample extract from TDi ConsoleWorks presentation – www.consoleworks.com

Storage Consolidation
Overview

- Storage sizing and good documentation is critical.
- Ensure no single point of failure in overall design
- Testing all fail-over AND fail-back features is critical
- Ensure SAN controller and switch firmware is current
- Installing SAN hardware install is relatively easy, but -

Key issue for SAN –

"How do you want it configured?"

(this is where the more difficult planning work takes place)

Storage Consolidation
Design Considerations - Checklist

1. Determine storage requirements – capacity, performance, growth and security needs to be considered. Use spreadsheet to map old to new storage. See example.
2. Review storage / SAN configuration rules.
3. Review current storage configurations, device naming and addressing.
4. Determine if SAN zoning is required for different OS environments. Security is often a reason for zoning.
5. Choose the type of RAID strategies to be used. Typically RAID5 for capacity, RAID0+1 for performance.
6. Determine hot spare strategy and numbers required.

Storage Consolidation
Design Considerations - Checklist (cont'd)

7. Review OS specific considerations e.g. multipath support for disk and tape devices, host based shadowing etc.
8. Review storage disaster tolerant and business continuity multi-site requirements e.g. SAN controller replication (e.g. DRM, CA, SRDF), and/or host based volume shadowing (HBVS) etc.
9. Create configuration profile that documents:
   - Storage controller switches and options to be used for optimal performance.
   - Detailed Storage Map. See example (hidden).

Storage Consolidation
Design Considerations - Checklist (cont'd)

10. Review backup/restore/archiving strategies as they apply to the storage design:
    - System & Application impact (online vs. offline, system disk etc)
    - ISV product decisions
    - Requirement for accessing older media for extended periods
    - Impact on servers? On network?
    - Standardize on media for greater discounts.
    - Off site archiving decisions

Storage Consolidation
Design Considerations – Mapping Old to New Storage

Current Disk Environment								Target Disk Environment							
Label	Physical Device	Disk Contr Pair	Total Vol. Size (Blocks)	Free Space (Blocks)	VMS Clust Size	Vol. Size (Gb)	% Free Space	Label	HBVS Device Name	Physical Device	HW RAID Vol's	Total Vol. Size (Blocks)	VMS Clust Size	Vol. Size (Gb)	Notes
RDAPP1	1DUA101	HSJ001 HSJ002	17,769,177	2,088,792	18	9.1	12	RDAPP1	DSA10	1DGA10 1DGA11	M10 M11	35,556,389	3	18.2	LOCUS data disk
RDAPP2	1DUA102	HSJ002 HSJ001	17,769,177	2,695,032	18	9.1	15	RDAPP2	DSA20	1DGA20 1DGA21	M20 M21	35,556,389	3	18.2	LOCUS data disk
RDAPP3	1DUA103	HSJ001 HSJ002	17,769,177	5,146,722	18	9.1	29	RDAPP3	DSA30	1DGA30 1DGA31	M30 M31	35,556,389	3	18.2	LOCUS data disk
RDAPP4	1DUA104	HSJ002 HSJ001	17,769,177	5,011,002	18	9.1	28	RDAPP4	DSA40	1DGA40 1DGA41	M40 M41	35,556,389	3	18.2	LOCUS data disk
RDAPP5	1DUA105	HSJ001 HSJ002	17,769,177	3,566,394	18	9.1	20	RDAPP5	DSA50	1DGA50 1DGA51	M50 M51	35,556,389	3	18.2	LOCUS data disk
RDAPP6	1DUA106	HSJ002 HSJ001	17,769,177	3,691,908	18	9.1	21	RDAPP6	DSA60	1DGA60 1DGA61	M60 M61	35,556,389	3	18.2	LOCUS data disk
RDAPP7	1DUA107	HSJ001 HSJ002	17,769,177	2,497,428	18	9.1	14	RDAPP7	DSA70	1DGA70 1DGA71	M70 M71	35,556,389	3	18.2	LOCUS data disk
RDSYS1	1DUA191	HSJ002 HSJ001	17,769,177	2,126,610	18	9.1	12	RDSYS1	---	1DGA100	M100	35,556,389	3	18.2	common system disk
RDSYS2	1DUA192	HSJ001 HSJ002	17,769,177	3,581,262	18	9.1	20	RDSYS2	DSA110	1DGA110 1DGA111	M110	35,556,389	3	18.2	2nd system pack, page /swap files, admin tools

Storage Consolidation
Design Considerations – Detailed Diagrams

	PRODUCTION (Access = Server1, Server2, Server3)												DEVELOPMENT (Access = MENKAR)	
	Slot ID 0	**Slot ID 1**	**Slot ID 2**	**Slot ID 3**	**Slot ID 4**	**Slot ID 5**	**Slot ID 8**	**Slot ID 9**	**Slot ID 10**	**Slot ID 11**	**Slot ID 12**	**Slot ID 13**	**Slot ID 14**	**Slot ID 15**
Disk #	**DISK10000**	**DISK10100**	**DISK10200**	**DISK10300**	**DISK10400**	**DISK10500**	**DISK10800**	**DISK10900**	**DISK11000**	**DISK11100**	**DISK11200**	**DISK11300**	**DISK11400**	**DISK11500**
Size-Speed	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	36GB-15K	18GB-15K	18GB-15K	36GB-15K	36GB-15K	72GB-10K	36GB-10K	18GB-15K
RAID	1	1	1	1	1	1	5	5	1	1	JBOD	JBOD	JBOD	1
Container	M10	M21	M40	M51	M70	M200	R500	R410	M100	M310	N/A	N/A	N/A	M700
LUN #	D10	D21	D40	D51	D70	D140	D166	D120	D100	D161	D133	D131	D186	D190
VMS ID #	10	21	40	51	70	200	500	410	100	310	133	510	730	700
VMS Label	RDAPP1	RDAPP2	RDAPP4	RDAPP5	RDAPP7	STAPP11	RDAPP500	RDAPP410	RDSYS1	FORDRB	?	RDAPP510	DEV730	ALPHASYS
Disk #	**DISK20000**	**DISK20100**	**DISK20200**	**DISK20300**	**DISK20400**	**DISK20500**	**DISK20800**	**DISK20900**	**DISK21000**	**DISK21100**	**DISK21200**	**DISK21300**	**DISK21400**	**DISK21500**
Size-Speed	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	36GB-15K	18GB-15K	18GB-15K	36GB-15K	36GB-15K		18GB-15K	18GB-15K
RAID	1	1	1	1	1	1	5	5	1	1	JBOD		5	1
Container	M10	M21	M40	M51	M70	M200	R500	R410	M100	M310	N/A		R720	M700
LUN #	D10	D21	D40	D51	D70	D140	D166	D120	D100	D161	D134		D168	D190
VMS ID #	10	21	40	51	70	200	500	410	100	310	134		720	700
VMS Label	RDAPP1	RDAPP2	RDAPP4	RDAPP5	RDAPP7	STAPP11	RDAPP500	RDAPP410	RDSYS1	FORDRB	?		DEV720	ALPHASYS
Disk #	**DISK30000**	**DISK30100**	**DISK30200**	**DISK30300**	**DISK30400**	**DISK30500**	**DISK30800**	**DISK30900**	**DISK31000**	**DISK31100**	**DISK31200**	**DISK31300**	**DISK31400**	**DISK31500**
Size-Speed	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	18GB-15K	36GB-15K	36GB-15K	18GB-15K	18GB-15K	18GB-15K
RAID	1	1	1	1	1	1	5	5	JBOD	1	1	JBOD	5	5
Container	M11	M30	M41	M60	M71	M210	R400	R410	N/A	M311	M320	N/A	R720	R710
LUN #	D11	D30	D41	D60	D71	D150	D130	D120	D101	D162	D163	D135	D168	D165
VMS ID #	11	30	41	60	71	210	400	410	120	311	320	135	720	710
VMS Label	RDAPP1	RDAPP3	RDAPP4	RDAPP6	RDAPP7	STAPP12	RDAPP400	RDAPP410	RDSYS3	FORDRB	FORDRB2	?	DEV720	DEV710

OS Consolidation
Overview

- User Account and Data Migrations
- Software Licenses
- Dynamic Resource Sharing
- Clustering
- Load Balancing
- Networking
- Workload and Resource Management
- Security
- Partitions

OS Consolidation
Design Considerations

- Upgrading to new OS versions may be opportunity for consolidation and move to new standards.
- User Account Strategies
  - Naming, passwords
  - Duplicate accounts
  - Files and data migration strategy
  - Security policy review & establish new standards
- Files and directories must be copied with right permissions (partner tools).
- Verify & test operational procedures & utilities. Backup and restore need to be well tested.

OS Consolidation
Design Considerations (cont'd)

- Recommended OS / ISV patches.
- New licenses may be required for larger servers:
  - Might be cheaper overall - especially for database and middleware product offerings that charge on a per cpu basis.
  - Partitioning and clustering may require additional system specific licenses.
- Verify & test batch and print queues.
- Review batch jobs for system specific dependencies to ensure they will run in target environment.
- Performance products critical for planning & monitoring.
  - OS based performance utilities provide base functionality, but ISV package add trending, application internals and modeling capabilities.

OS Consolidation
Design Considerations (cont'd)

- Ensure focus on security during migration!
  - Consider removing inactive users and their data if they have not logged in for over x months. No sense copying potentially large amounts of stale data.
  - When copying user files and sensitive data, ensure that target location has appropriate owner, group and world access rights in place.
  - As with any new project with many changes occurring, it is easy to miss and/or ignore normal monitoring duties.

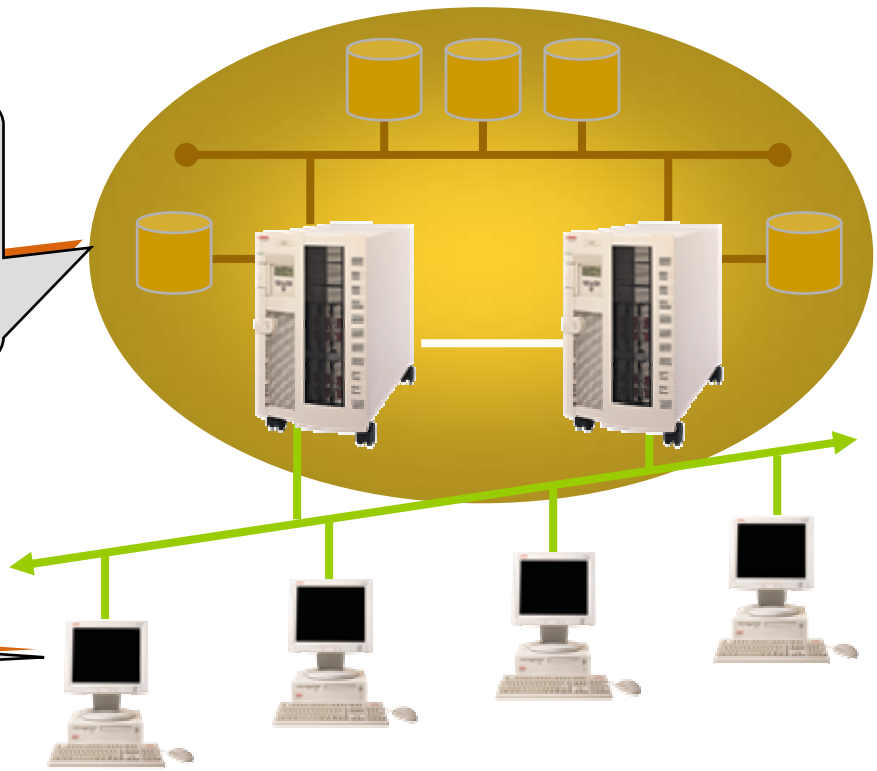
Clustering
Overview

- Clusters can provide many features - all with the goal of enhancing server:
  - ***Availability*** –
    - If a system is down, after a brief fail-over period, app's are still useable by the end users via alternate servers
  - ***Scalability*** –
    - Applications can often perform more work than is possible with a single hardware system
    - Large SMP servers can also be clustered as well
  - ***Manageability*** –
    - Clustered systems can be easier to manage than many single systems

Clustering
Design Considerations

- Clustering is combining multiple servers to provide available, scalable and manageable services to clients
- Depending on the OS, typical server numbers supported in a cluster range from 2-96. Technical computing clusters support higher numbers

A cluster generally comprises:
•Multiple Servers in 1 or more cabinets
•One or more interconnects
•Shared storage (often with RAID)
The total configuration delivers availability & scalability for…..



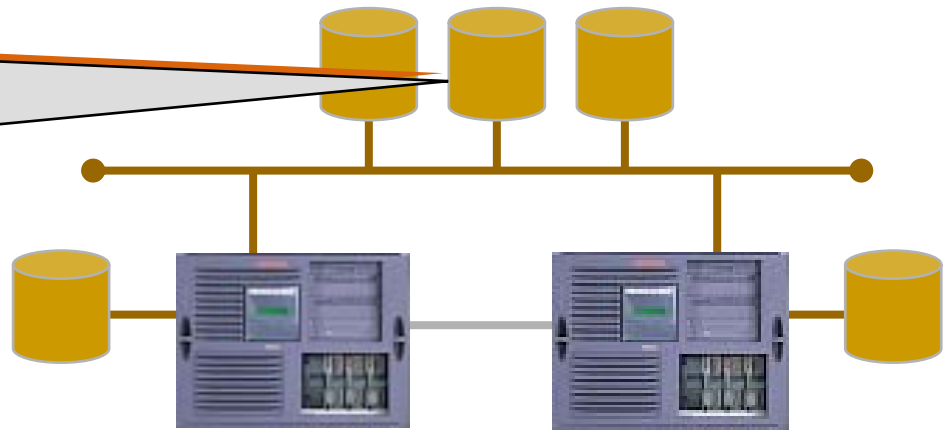
….clients and applications

Clustering
Design Considerations (cont'd)

- Two main types of clustering – shared everything and shared nothing (some OSs support both)
- Both have advantages and disadvantages
- Differences relate to how access to common data is coordinated
- Applications must follow cluster rules specific to each OS

Permitting 2 or more servers to modify the same file system at the same time requires careful synchronization between the servers to avoid disk corruption….

….this synchronization is typically done by the cluster file system



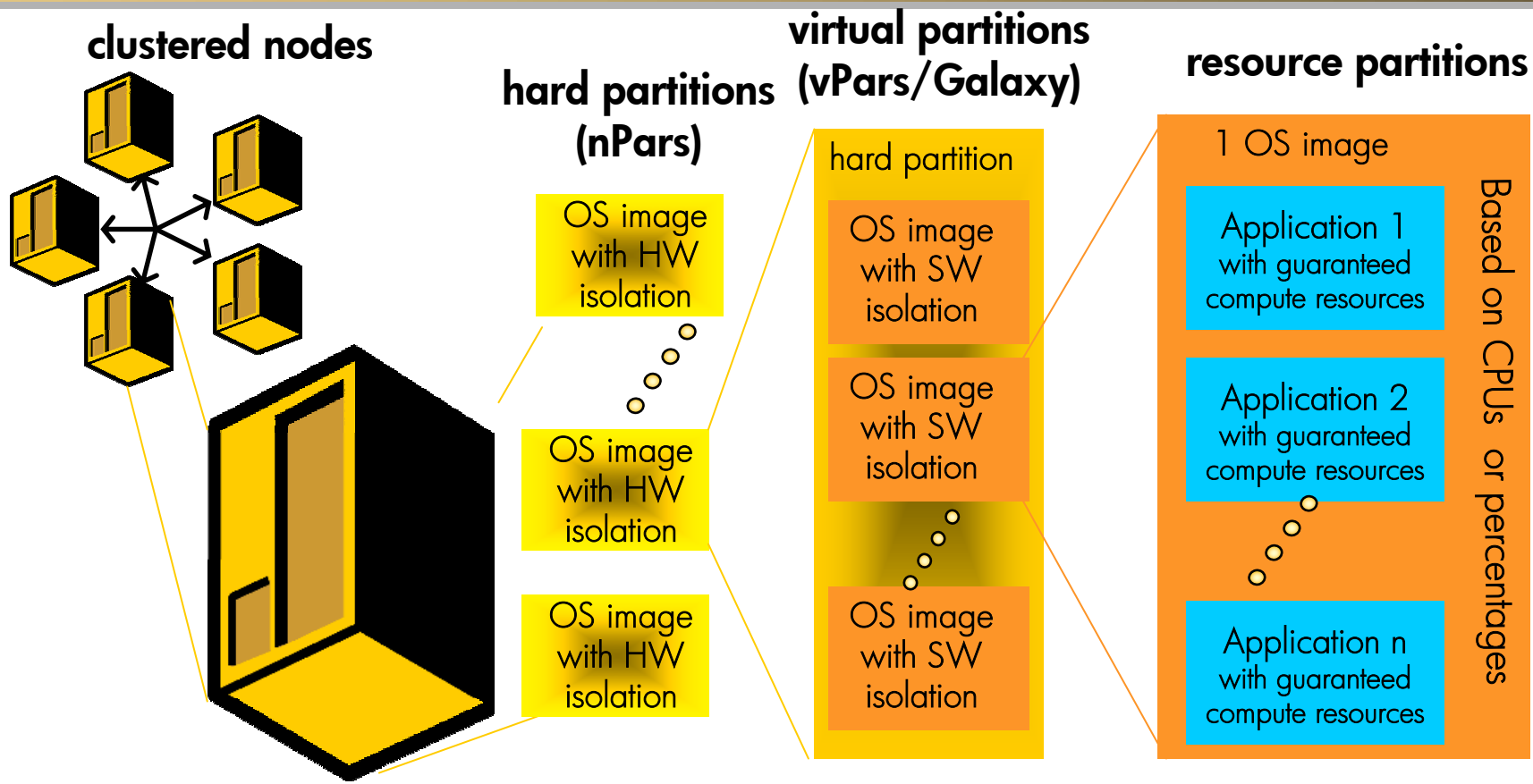
Server and OS Consolidation
What is "Partitioning"?

- Partitions are physical or logical mechanisms for isolating operational environments within single or multiple servers to offer the flexibility of dynamic resizing while ensuring that applications can enjoy protection from unrelated events that could otherwise cause disruption, interruption, or performance degradation.

Partitioning and Virtualization
Overview

- **Resource Partitioning** – a segment of a servers total processor and memory resources that is reserved for specific processes.
- **Hard Partitioning** (nPars) – Multiple instances of an operating system running on physically separate hardware resources that are part of a single server.
- **Logical or Soft Partitioning** (vPars) – Multiple instances of an operating system running independently on the same physical hardware resources.
- **Dynamic Allocation** – Physical resources are automatically shifted into and out of Resource and OS Partitions.

Partitioning and Virtualization
Design Considerations



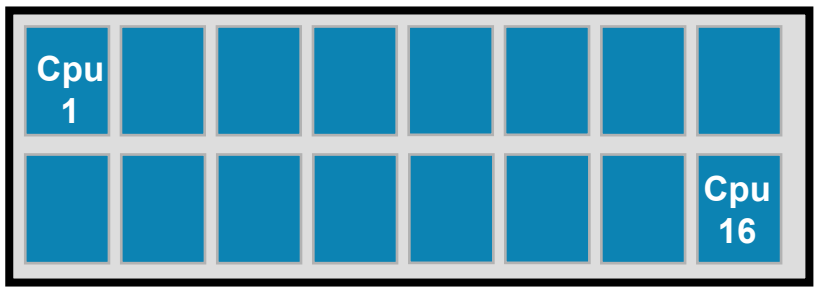
Partitioning and Virtualization
Design Consideration - Benefits

- Can offer service level guarantees at more reasonable costs.
- Improve utilization of server resources.
- If applications do not co-exist well, then partitioning is an option to consider.
- Address high fluctuation of web and application traffic by sharing cpu resources (dynamically and manually) between OS partitions.
- Provides flexibility.
  - Provide Test environment similar to Production
  - Privacy and High Availability

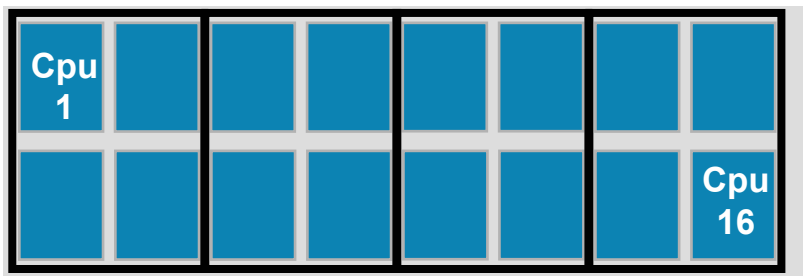
Partitioning and Virtualization
Design Considerations – Hard Partitions / nPars

Multiple applications on the same server with hardware isolation

1 nPar - 16 CPUs - 1 OS instance



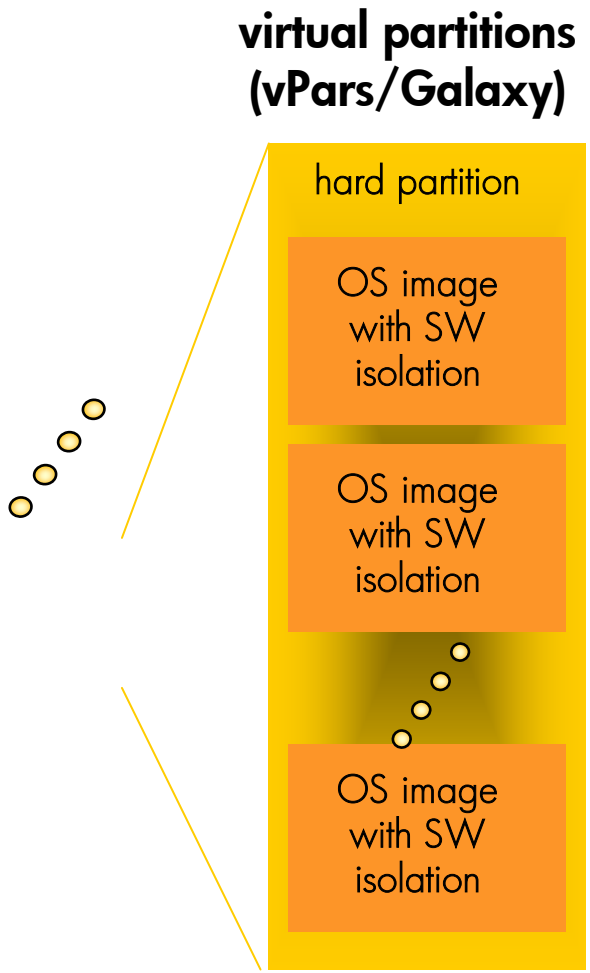
4 nPars - 16 CPUs - 4 OS instances



- Increased system utilization
  - partition server into physical entities
- Increased Flexibility:
  - multi OS support: HP-UX, OpenVMS, Linux (*), Windows (*)
  - multi OS version support
  - multiple patch level support
- Increased Uptime
  - hardware (electrical) and software isolation across nPartitions
  - In box support for ServiceGuard and OpenVMS / Tru64 UNIX Clusters
  - Available on Superdome, Alpha GS Series, rp8400, rp7410

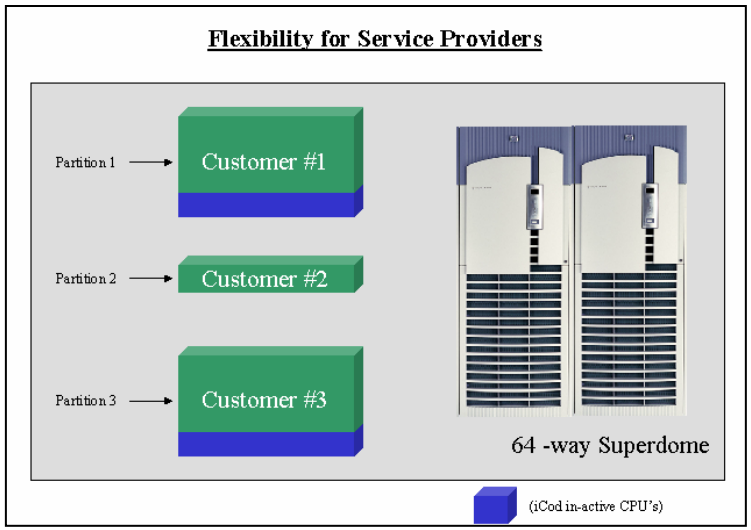
Partitioning and Virtualization
Design Considerations - Soft Partitions / vPars

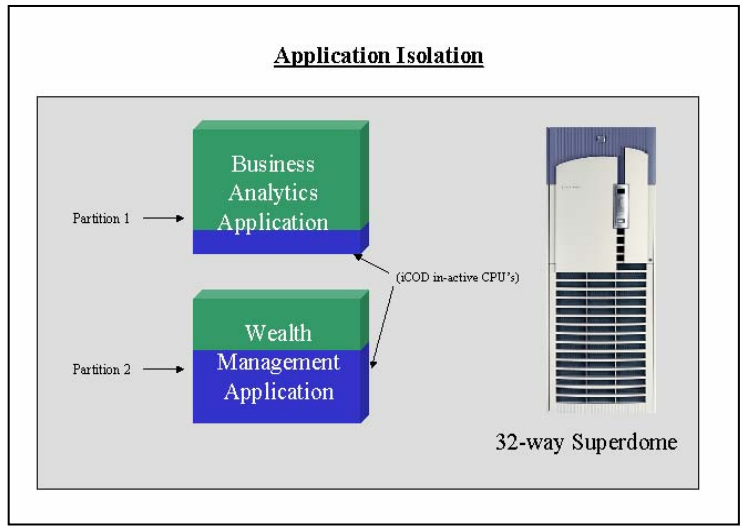
- Multiple O/S instances per nPartition with S/W & resource isolation, and flexibility
  - Increased system utilization
  - Increased isolation
    - of OS, applications, resources
    - individual reconfiguration & reboot
  - Greater flexibility
    - multiple independent OS's
    - 1 CPU granularity per vPar
    - dynamic movement of CPU power between vPars e.g. mid tier App Server can share CPUs with back-end Database server.
    - resources not tied to physical configurations (like hard partitions)

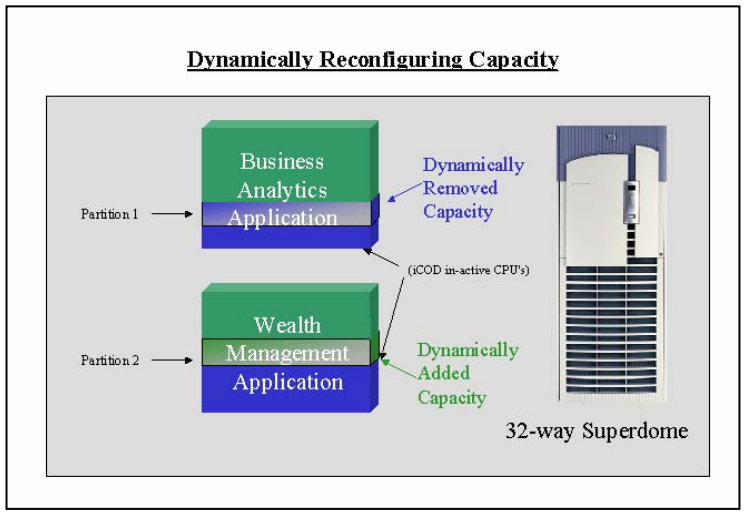


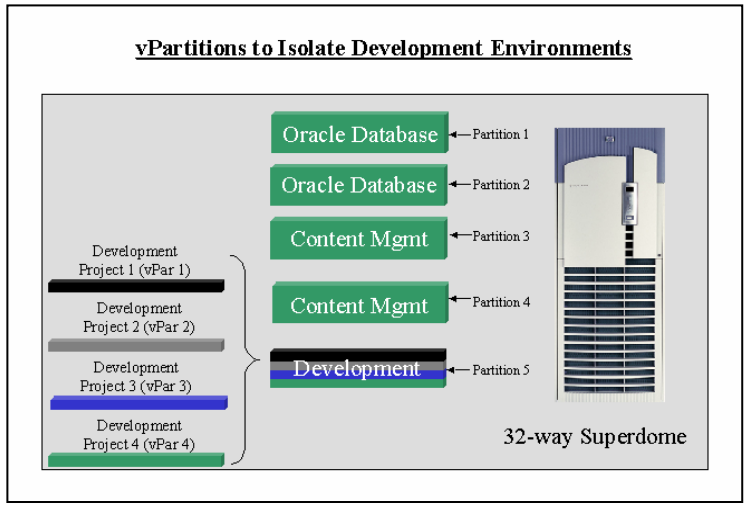
Partitioning and Virtualization

Sample Config: HP-UX and Superdome Partitioning

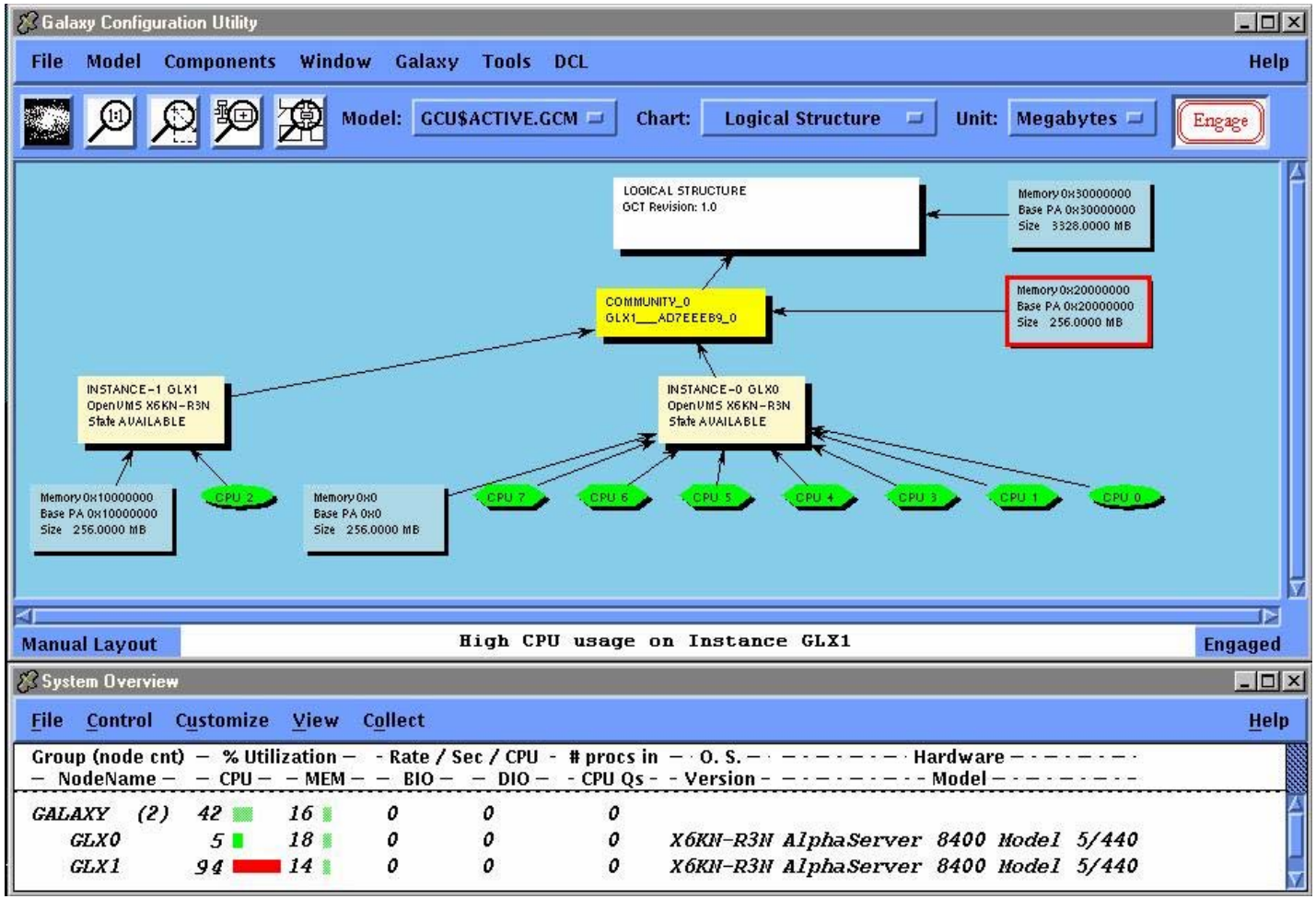








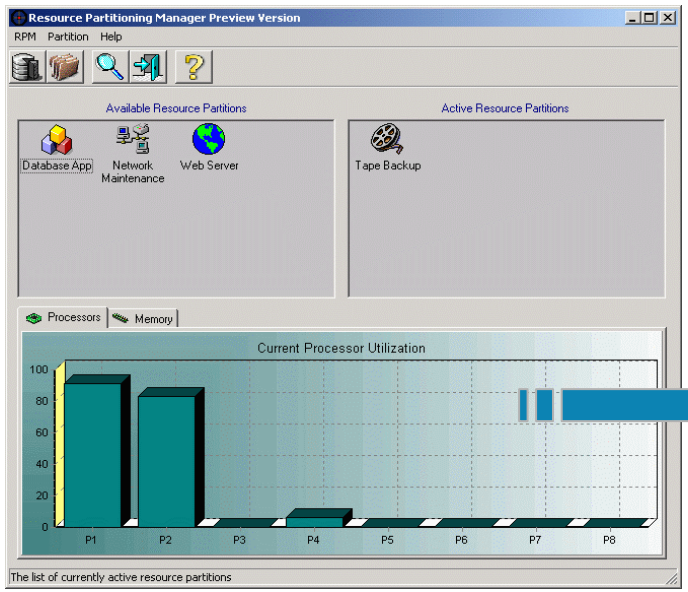
Partitioning and Virtualization
Sample Management: OpenVMS & Alpha (Galaxy)

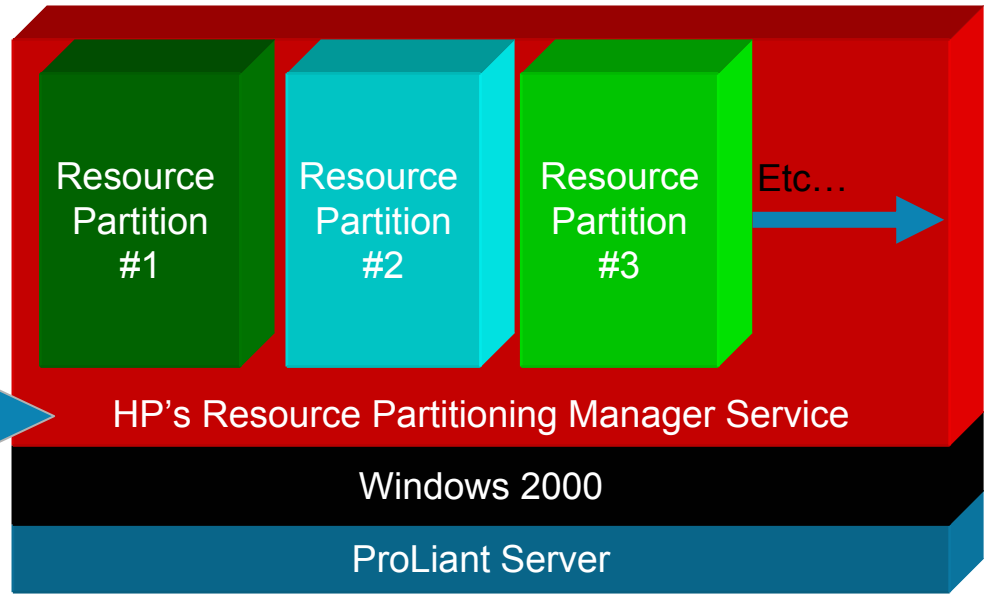


CPU resources can be migrated dynamically (rules) or manually (drag-n-drop)

Partitioning and Virtualization

Resource Partition Manager (RPM) – Windows 2000/2003





Users employ an easy-to-use interface to

- Define resource partitions
- Establish dynamic reallocation rules
- Activate resource partitions
- View configuration and utilization

The Resource Partitioning Manager Service

- Translates user commands
- Communicates configuration to the OS
- Monitors utilization
- Reallocates resources based on configured rules

Note - RPM is now part of the HP ProLiant Essentials Workload Management Pack (WMP).

HP Workload Management Pack

Server consolidation tool primarily for 4 & 8-way servers.

Enables monitoring of performance characteristics
Partitioning of applications to discrete resources on the server.

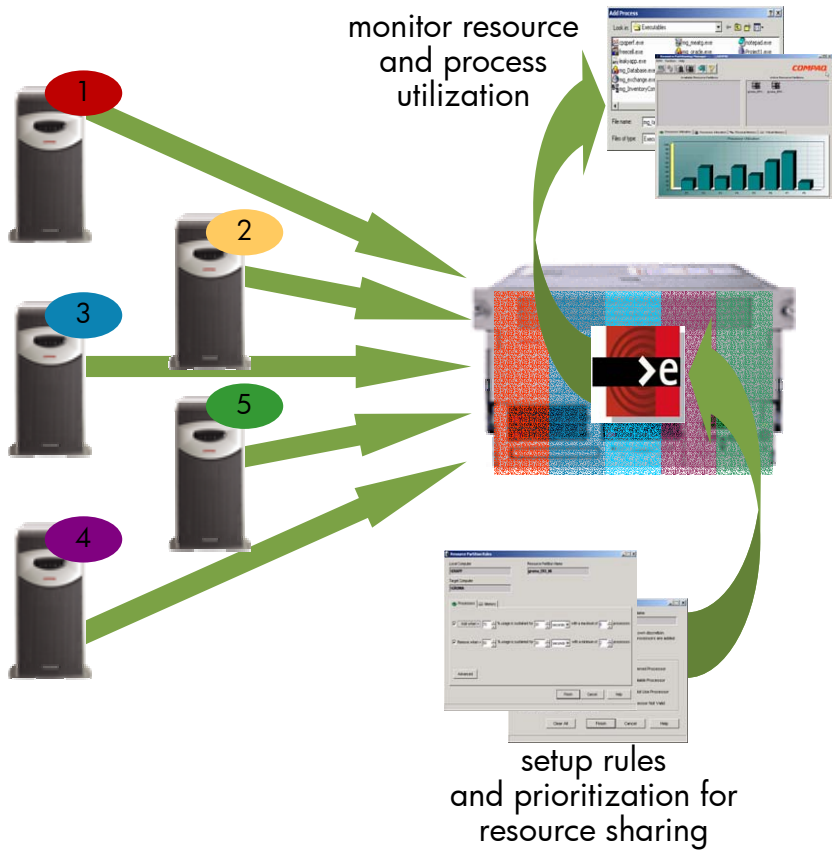
heterogeneous consolidation

- web services
- application (PeopleSoft®)
- backend database (Microsoft® SQL Server™)

or

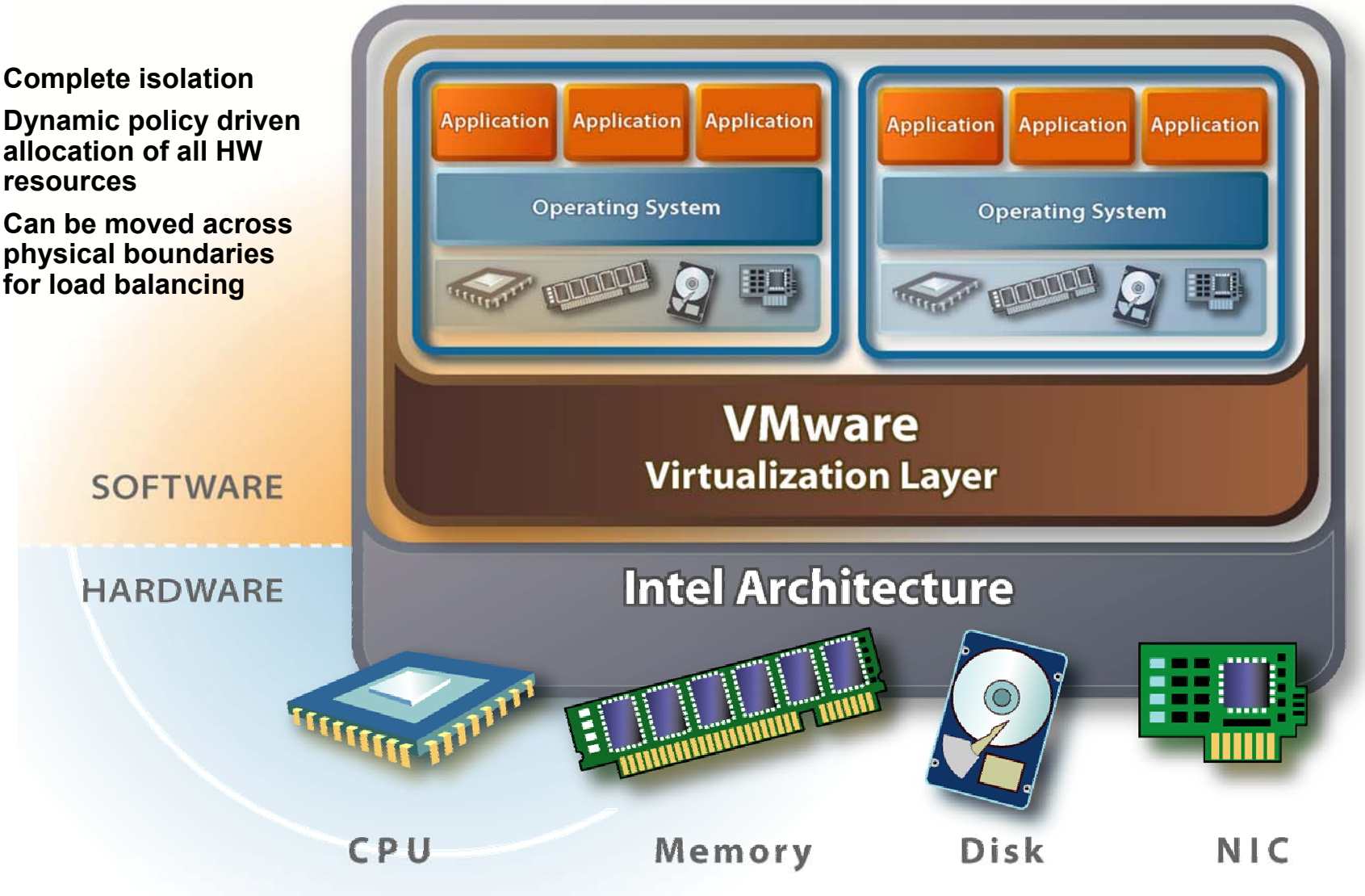
multiple instance consolidation

- development system (SAP®)
- QA system (SAP®)
- production system (SAP®)



Partitioning and Virtualization
VMware - Multi-Platform

- Complete isolation
- Dynamic policy driven allocation of all HW resources
- Can be moved across physical boundaries for load balancing



Partitioning and Virtualization
VMware Positioning

Potential Candidates

- Development servers
- Test servers
- File/Print
- IIS Web Servers
- Small/Mid Databases
- Web App Servers
- Imaging / Fax Servers
- Domain Controllers
- Active Directory Servers

Likely NOT Candidates

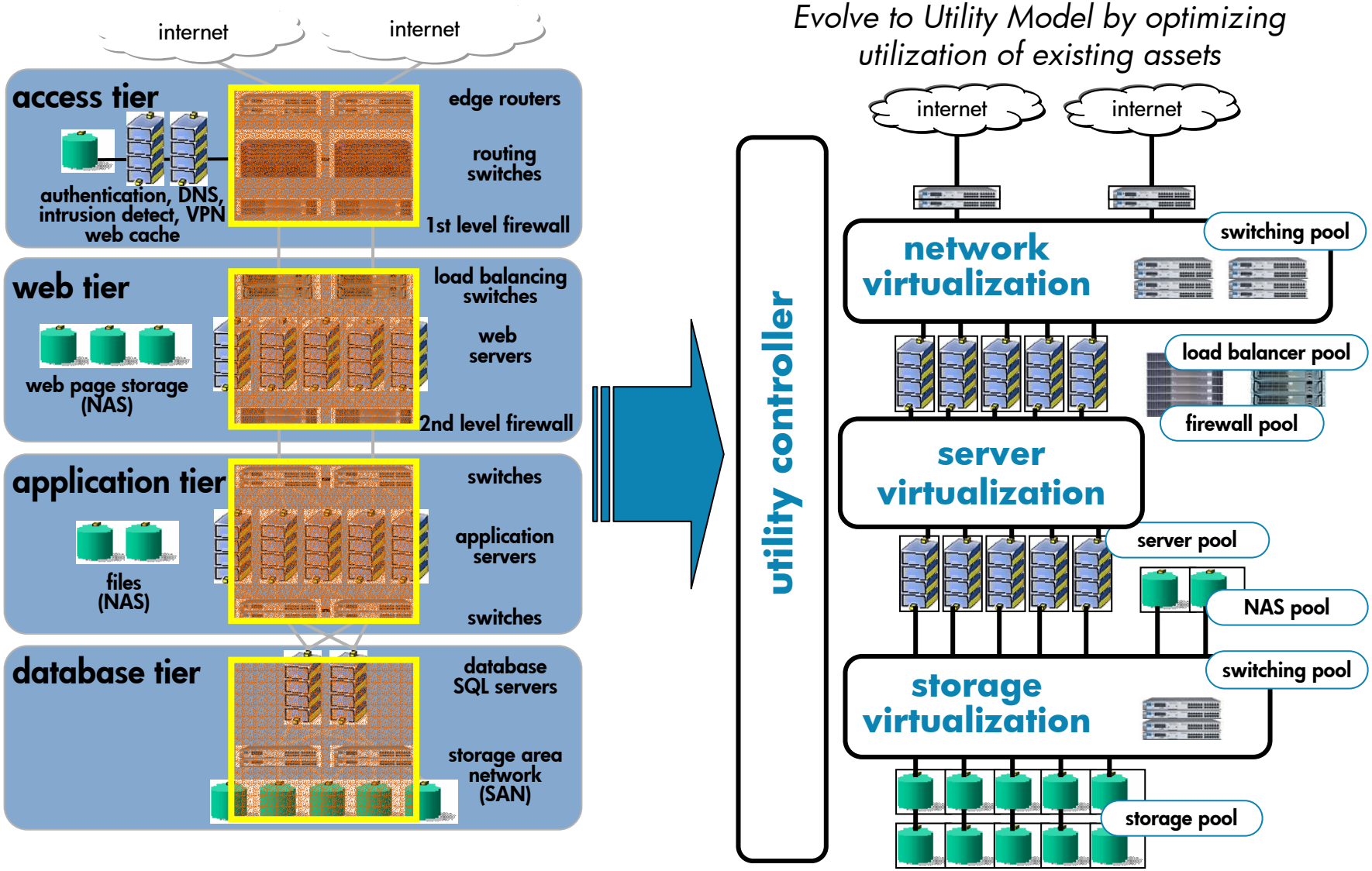
- Exchange servers
- Applications that can effectively utilize more than 2 CPUs
- Large database-focused apps
- Applications finely tuned to specific hardware
- Mission critical environments
- Homogeneous environments

Partitioning and Virtualization

Microsoft Virtual Server

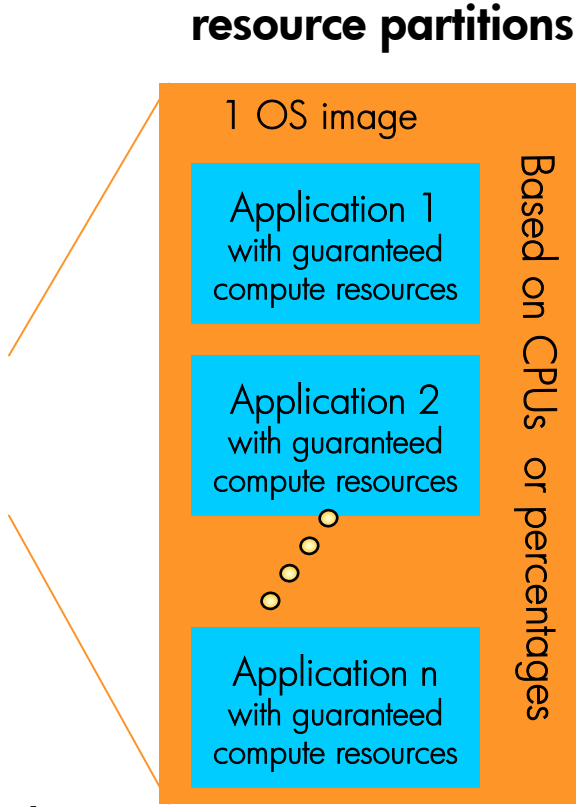
- Microsoft has acquired technology (and resources) from Connectix
- Beta sites and JDP being sought for V1
- Expected release date of end of year 03
- Differences to VMware
  - Will only be hosted on MS OSs
  - V1 is for single processor support per partition

Virtualizing Your Data Center
UDC Overview



Workload Management (WLM)
Design Considerations

- Designed to make better use of existing system resources.
- If the applications have *varying loads and varying priorities*, WLM can be used to ensure the Resources get used to the best business advantage possible.
- Can be used to ensure one process does not take over the system at the expense of other processes.
- Optimize application mixing & dynamic workloads by using soft and hard partitioning
- Class Schedulers is industry term used to describe WLM feature i.e. improved resource management



Workload Management
Design Considerations (cont'd)

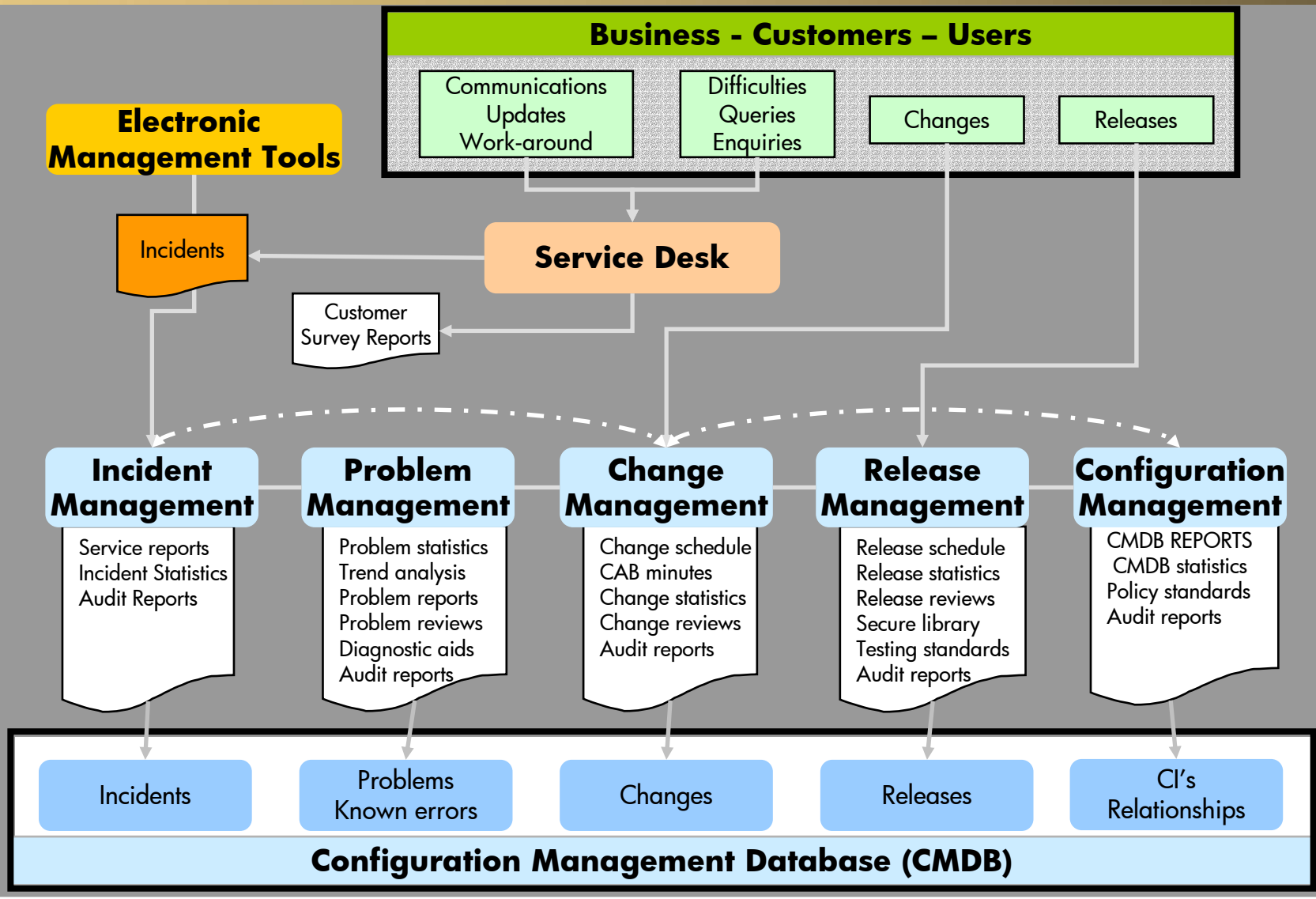
- WLM provides better management and increased capability for enforcement of SLAs
- Sample HP/Partner technologies:
  - Process Resource Manager (HP-UX). PRM provides static resource management for pre-configured resource groups.
  - Workload Manager (HP-UX). Integrated with PRM; provides capability to adjust resource groups dynamically.
  - Galaxy Config Utility and Class Scheduler (OpenVMS).
  - ProLiant Essentials Workload Management Pack (Windows 2000/2003)
  - Microsoft Windows System Resource Manager (Windows 2003)
  - ISV Aurema tools (Tru64 UNIX)

Application Consolidation
Overview

Definition –

Reducing the number of application instances onto fewer, but potentially larger, server platforms that have much improved management as a means to reduce overall support costs and reduce the overall IT infrastructure complexity.

Application Consolidation
Map to Configuration Management Database



Application Consolidation
Design Considerations – CMDB Content

- CMDB = configuration management database. Needs to be populated / updated in “Environmental Analysis” phase. This is “heart” of future configuration and change management IT processes. See previous slide.
- Application specific CMDB content:
  - Contact Information
    - Business group owner(s)
    - Application support
    - Application development manager
  - SLA support criticality e.g. 1=low, 5=high.
  - Peak number of associated batch jobs.

Application Consolidation
Design Considerations – CMDB Content (cont'd)

- Application specific CMDB content (cont'd):
  - Required version information:
    - Operating System
    - Applications
    - Database
    - Required ISV Products
    - Interfaces, other application dependencies
    - Supporting layered products
  - Disaster Recovery
    - Recovery Point (RP) requirements
    - Recovery Time (RT) requirements
    - Estimate of $'s per hour of downtime impact

Application Consolidation
Design Considerations - Step-by-Step

1. Determine scope and focus with Management: e.g. by Corp vs. Regional, by platforms type (UNIX, Windows, OpenVMS, Netware, NSK, Banyan ect.) or by functional service area - see a).

   a) Group target servers into functional application service areas:

Email (messaging)	File-n-Print
Web Servers	Security (RAS, VPN, LDAP etc)
Applications (custom or commercial)	Directory
Operations (backups, restores, archiving, IT management, help desk, console)	Middleware Integration (J2EE, .Net, other)
Database	Network (DNS, DHCP, WINS etc)
Development	QA and Test
Other	

   b) What functional areas makes the most business sense to analyze further? Can some of these services be combined on the same server?

Application Consolidation
Design Considerations - Step-by-Step

2. Complete Environmental Analysis of current state.
   a) all HW / OS / Application / Database / Storage versions and dependencies are collected using tools, native OS utilities, interviews, existing sources, manual scripts etc.
   b) Update CMDB (config management database)
   c) Run detailed reports and various “what-if” scenario’s against CMDB as required.
   d) Interview Application groups to verify accuracy of report data collected, get more details on applications and to better understand their future directions. Update CMDB as required.
   e) If required, complete detailed TCO / ROI analysis.
3. Group candidate areas into short-medium-long term timelines e.g. 0-6, 7-12, 13-24+ months. Look for quick wins to build momentum for future projects.
4. Develop target architecture. Partitions, clusters, middleware, re-hosting? If needed - proof-of-concept.

Application Consolidation
Design Considerations - Step-by-Step (cont'd)

5. Develop detailed design specifications document. Products, versions, configurations etc. If needed, do prototype.
   a) Group candidate areas into focus / ignore categories:
      1) Non-Strategic (ignore)
      2) Partition Ready (focus)
      3) Stackable (focus)
      4) Cluster Aware (focus)
      5) Non-Moveable (ignore)
   b) Review ISV support guidelines. Some require dedicated server(s).
   c) Some applications will need to be updated to fit into one of the focus categories in a).

Application Consolidation
Design Consideration - Step-by-Step (cont'd)

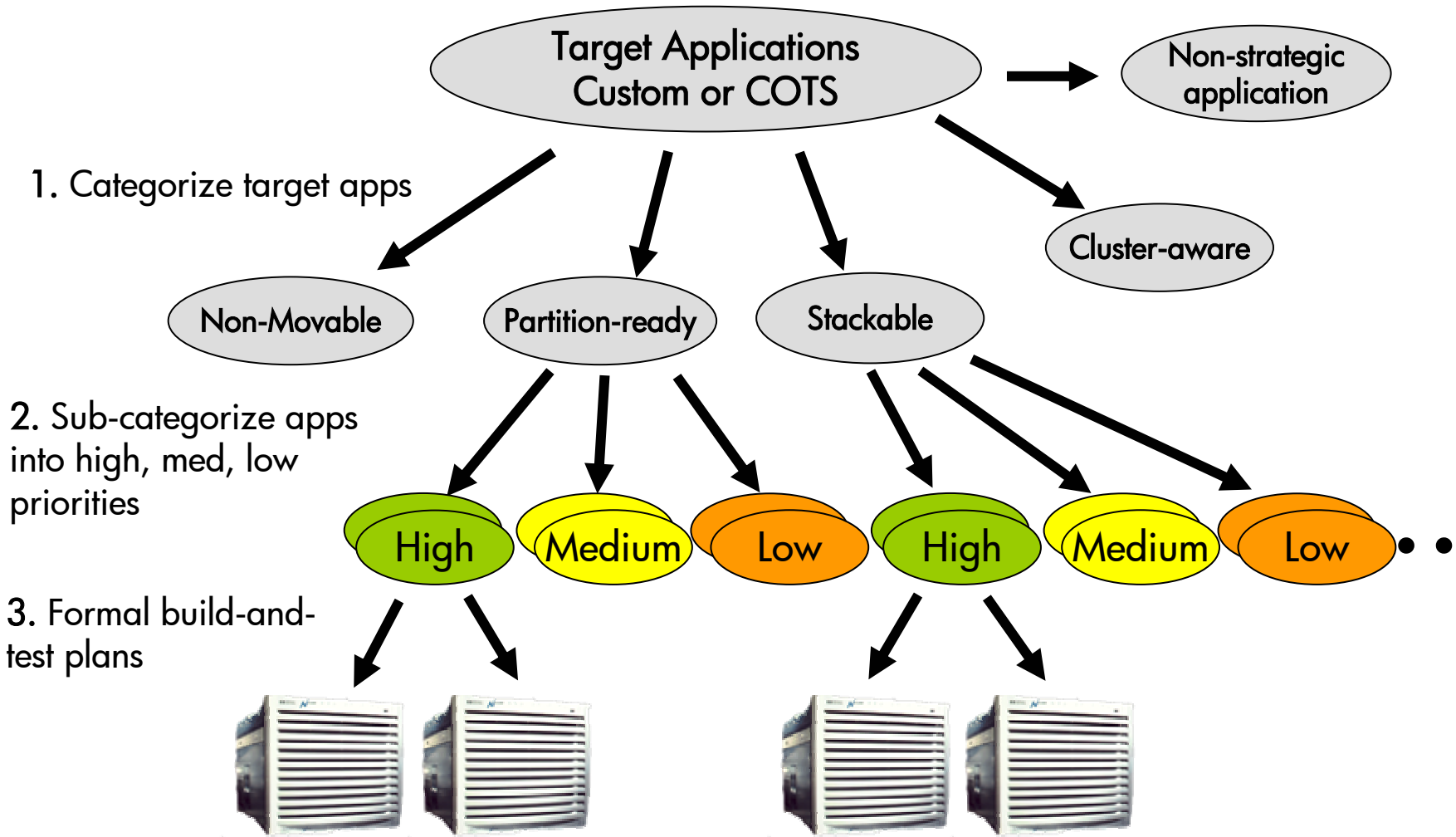
5. Develop Build-and-Test plan to address:
   a) Design details and configurations, version compatibilities, user / data / application migration flows and processes, system management products
   b) Implement pilot with formal testing plan that addresses the following tests of the target solution:
      1. Functional
      2. Regression
      3. End User
      4. Performance Benchmark
   c) Company QA requirements
   d) Formal documentation
      1. Training Plan
      2. Operations, Support, and Recovery Procedures

Application Consolidation
Design Consideration - Step-by-Step (cont'd)

6. Develop Release-to-Production plan to address:
   a) Communications and release notification updates with Management and End Users
   b) Operations, Support, Applications training
   c) Production implementation and scheduling
   d) End user acceptance testing plans
   e) Fail-back plans if problems occur

Application Consolidation

Design Considerations - Priority and Rating



Application Consolidation

Design Considerations - Priority and Rating (cont'd)

Select applications that will easily stack or partition in order to…

- Reduce Risk
- Minimize Effort

Application stacking / partitioning rules and rating factors:

- Technical validation rules
  - Resource Consumption and control
  - Capacity variations
  - System Impact
  - Application architecture & design
  - Stability
- Confidence and support
  - Vendor Support
  - Empirical Data
- Business validation rules
  - Organizational Boundaries
  - Business Criticality
  - Security/Confidentiality
  - Strategic / Obsolete
  - Trust / budgets
  - Corporate standards and directions
  - Possible cost reductions
- Environment commonality rules
  - Operating System
  - Subsystems, databases & middleware
  - Production vs. Development/Test
  - Maintenance windows
  - Frequency of change
  - UIDs, GIDs

Application Consolidation
Design Considerations - General

- Are applications (ISV utilities, custom apps) “cluster aware” and/or “stackable”?
- Time zone considerations
- Application and OS version compatibility issues
- Resource contention
- Security between users & applications
- Understanding relationships and interdependencies between applications
- Any new applications and/or major changes in next 6-12 months?
- Licenses (OS and ISVs)

Application Consolidation
Design Considerations - General (cont'd)

- After hours vendor support
- Impact on test / development areas
- Consideration - use multiple instances of the same application on one OS image (e.g. multiple instances of Oracle)
- Consideration - combine application servers and database servers onto a common server - example: SAP and Oracle; Oracle Financials and Oracle Database.
- Testing, testing, testing – functional, regression, stress loading & power users (there is NO substitute for testing)

Application Consolidation
Design Considerations - General (cont'd)

- Applications that are intensive on different resources (e.g.: CPU intensive vs. I/O intensive) or at different times (example Batch and OLTP) are good consolidation candidates.
- Firewall/Security products generally require dedicated servers.
- Existing homegrown applications are generally not the first choice of application consolidation candidates unless the source code is available.
- Sharing servers across business units requires high level management commitment and sponsorship

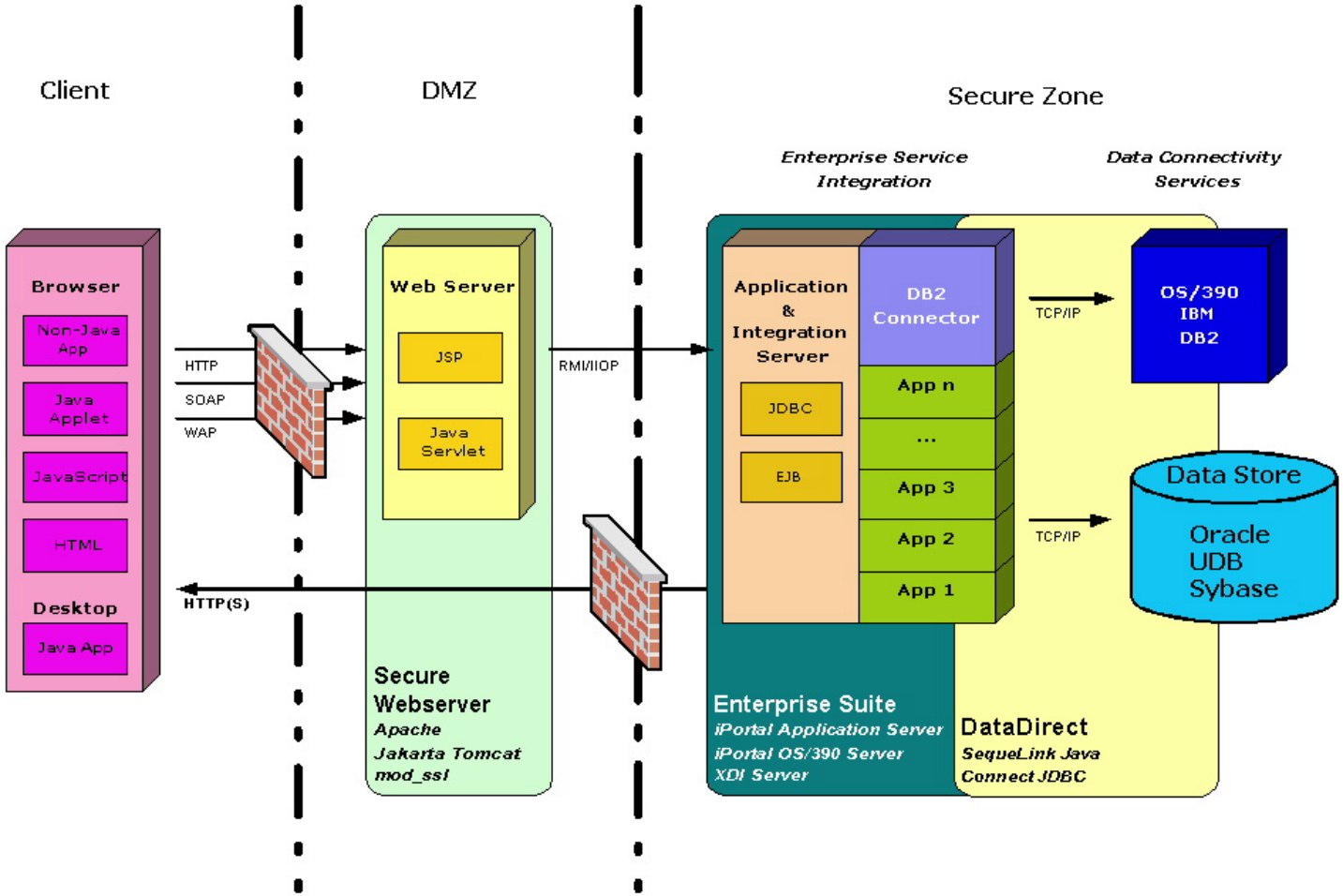
Application Consolidation
Design Considerations - General (cont'd)

Issue Type	Specific Issues	Best Practice Recommendation
Time to Market Driven	• Old OS Environments • Co-existence & testing issues • Old hardware platforms	• Usually not large high growth apps • Usually want to spend minimum time & resource on conversion • Don't stack • Focus on small, cost effective servers
Performance Level/Growth	• Small to Large Applications Low to High Growth	• Focus on Resource management (WLM/PRM) • Consistent architecture
Scaling/Sizing	• Compute, I/O, Memory requirements and Tradeoff Options • Specialized I/O requirements • Adding capacity w/o redesign	• Watch for 'specialized' interconnect • Propose I/O slot efficient technologies • I/O & Mass Storage scaling determination
Criticality of Application	• Need for absolute isolation of app. • HW Redundancy & HA • When & when not to stack / partition	• Which apps. must reside on a separate system • Review # HA backup systems & policy • Partitioning / Stacking and PRM rules • Test methodology and environment
ISV Issues	• Application not ported to latest OS • Application 32-bit not 64 • Vendor requires separate systems • Vendor does not support consolidation	• System Types • Hard Partitioning • Co-existence & Stacking • ISV Support for consolidation configurations
'homegrown' Applications	• How do I handle my 'custom' applications?	• Find out if sources/developers exist • Move to higher performance box
Corporate Standardization	• Standardized on old OS - now what? • Standardized on old HW	• Determine if there are any OS restrictions • Determine if there are any HW restrictions • Consolidate where appropriate

Middleware / Enterprise Integration
Overview

- Middleware Integration and/or EI (enterprise integration) has become a high priority for companies as they begin to share resources across Lines of Business and even across other companies. When planning consolidation projects, it is critical to understand where the company is going with respect to these issues.
- Enterprise integration (EI) is the ***convergence*** of application integration, middleware, and web services. EI solutions focus on connecting systems, applications, business processes, people and data together across all aspects of an extended enterprise.

Enterprise Integration (EI) and IT Consolidation



Actual Customer EI proposal (logical view) – consolidate 150 small UNIX servers into two large clustered UNIX J2EE App servers with high availability. Data sources to remain as is.

Middleware Integration
Design Considerations

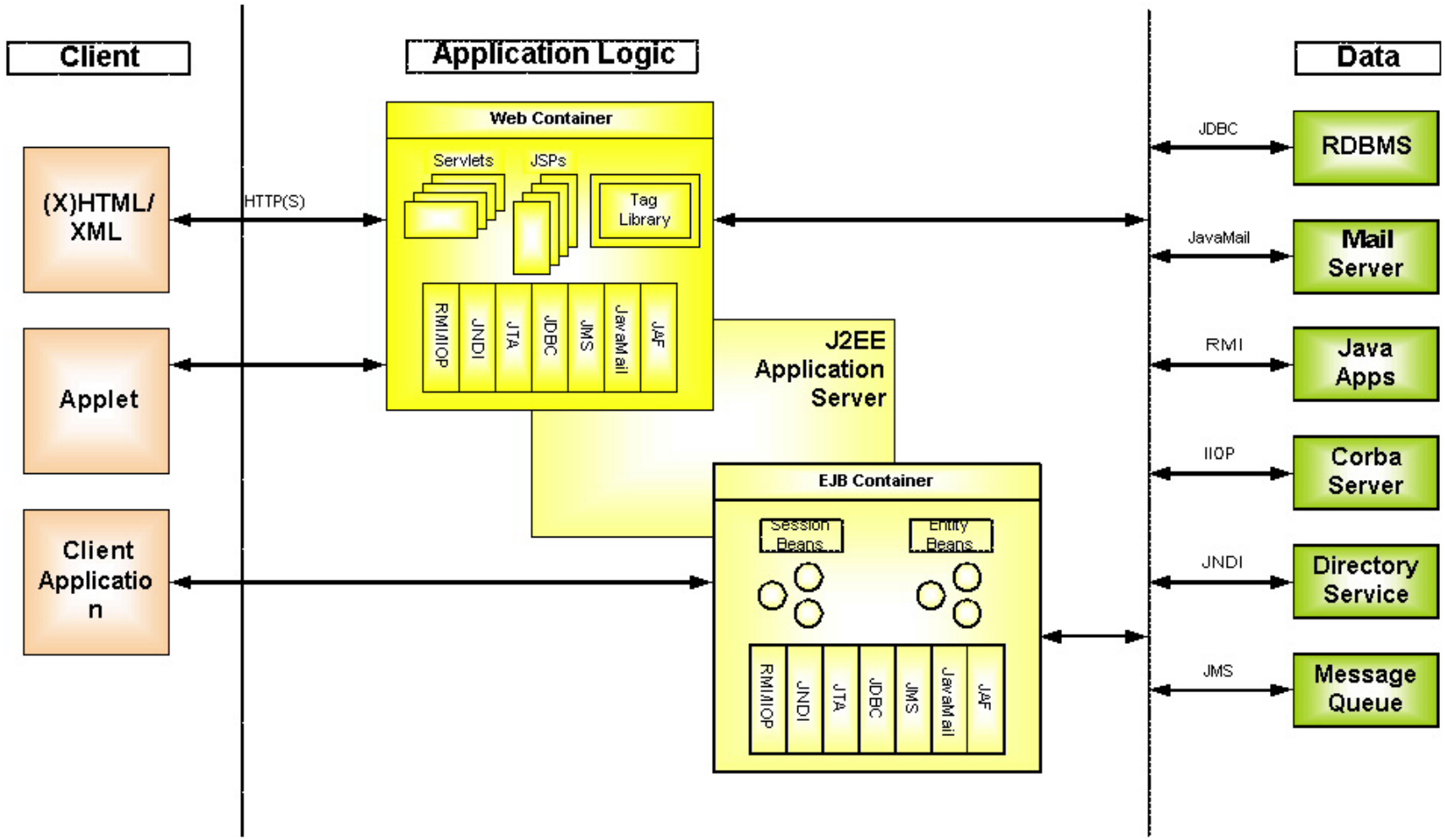
- Application Interoperability Framework – The standards, specifications, philosophies, and methodologies for building interoperable applications. For example, XML, SOAP, WSDL, and UDDI are the most widely discussed Web service framework specifications.
- Software Architecture –
  - The applications and services developers build using these standards, specifications, and philosophies.
  - Two industry strategies:
    - J2EE (Multi-platform build-deployment focus)
    - .Net (Microsoft build-deployment focus)

    (Both J2EE and .Net have strengths and weaknesses)

Middleware Integration
Design Considerations

- Most medium-large companies will have a mix of J2EE and .Net solutions.
- Middleware vendors typically charge on per-cpu basis, hence IT Consolidation at the mid tier can save significant ISV licence and annual support costs.
- J2EE and .Net are BOTH object oriented models – both require training and a different mind set for traditional programming and support staff.
- Security concerns need to be addressed. Web Service industry standards are only now emerging.
- Scaling and interoperability testing is critical
- Do not buy into industry hype – ensure solution chosen is right for you. Remember that the traditional development languages are not going away – and that includes COBOL!

Web Services Middleware
J2EE Architecture



Database Consolidation
Overview

- Why consider database consolidation?
  - To gain maximum benefit when re-architecting High Availability solutions.
  - Reduce hardware maintenance/effort/OS instances and simplify infrastructure management (by combining instances that were on separate servers).
  - Reduce database license fees by combining schemas into a single instance.
  - Leverage enterprise data by merging multiple application schemas.
  - Improved access to information

Database Consolidation
Design Considerations

- Understanding the databases to be consolidated
  - Data relationships, especially keys
  - Performance: all queries should be thoroughly analyzed and tuned for “current state” health before beginning the consolidation process
  - Know how the data is used (business cycles)
- Must understand not only the company’s future database strategies, but also the future application strategies as well.
- “Integrating” too many systems can lead to a “North American Roadmap” design of data flows that make change almost impossible. Keep it reasonable for implementation, performance and maintenance needs.

Database Consolidation
Design Considerations

- Think about growth before you grow; be willing to address issues early; test everything in a heavy load situation; make sure you understand true “outage” and “recovery” issues.
- The more consolidated (and integrated) and environment becomes, the more crucial testing becomes.
- As part of consolidation process - clean up the data i.e. massive scrubbing, integrity checks
- Standardize database definitions

Database Consolidation
Design Considerations (cont'd)

- Have target databases been stressed via load testing?
- Is a documented data export, import and verify strategy in place?
- Configure storage and database tuning in sync with each other e.g. block sizes, transaction logs etc.
- Has the database been tested for cluster awareness and/or multiple instances?
- Are there any Middleware interoperability and/or scaling issues (e.g. JDBC)?
- Database gateway consideration – are they a single point of failure or a potential bottleneck in the new environment?

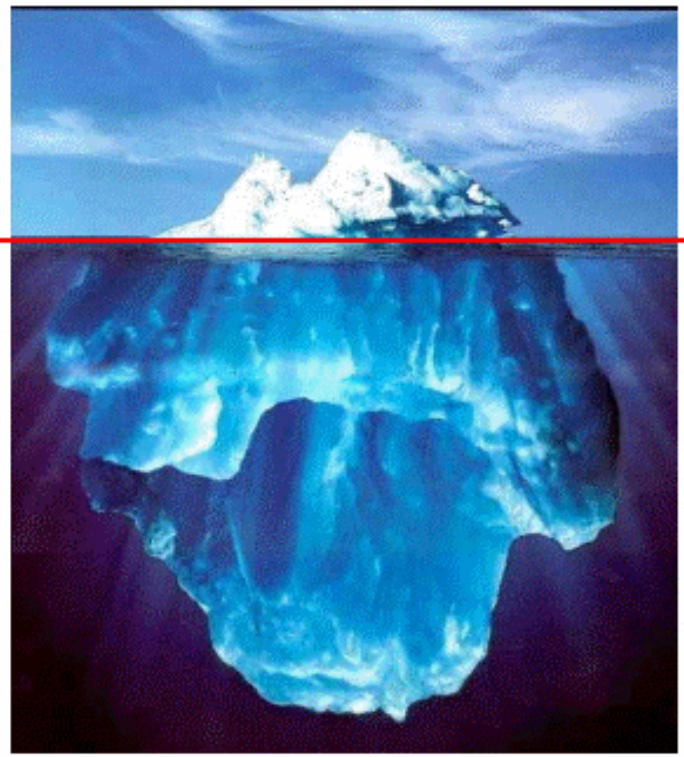
Enterprise Management
Overview

IT Service Management

- Performance / Capacity
- Change / Configuration
- Job Automation
- Resource Accounting
- Event / Fault Management and Escalation
- Software Distribution
- Help Desk Integration
- Backup / Restore
- Network, System, Storage, Desktop, Database, Application Management

Enterprise Management
The Big Picture

During an IT Consolidation Project, many IT Organizations focus too heavily on tools and technology. Moving to a more consolidated IT environment typically requires change across many aspects of the organization.



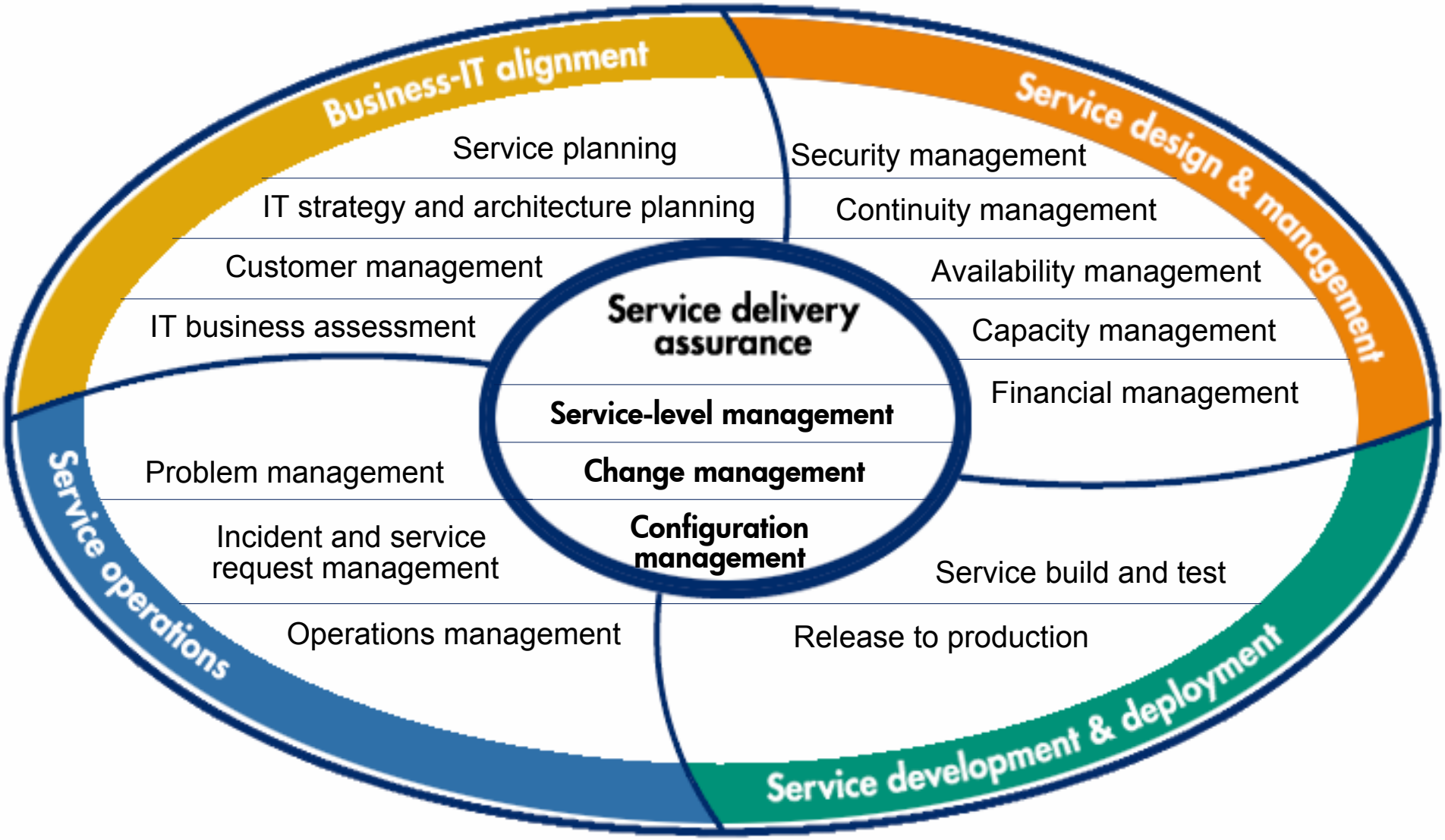
Technology: Tools and Infrastructure

Process: Definition/Design, Compliance and Continuous Improvement

People: Roles & Responsibilities, Management, Skills Development & Discipline

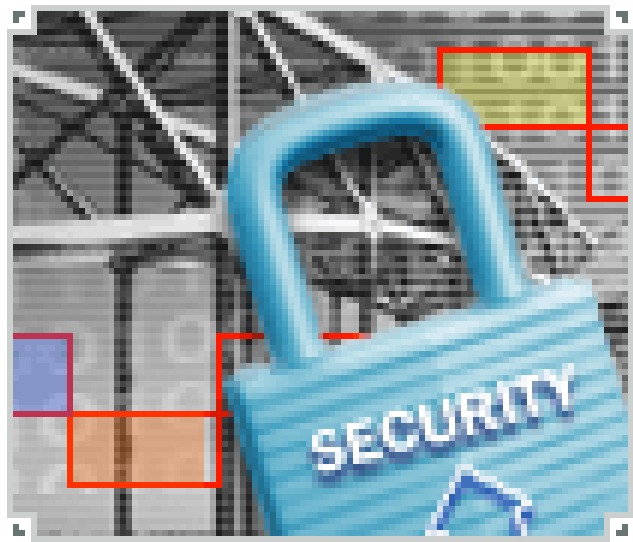
Culture: Values, Unspoken norms, Often experienced and not seen

Enterprise Management
Processes: HP's IT Service Management



Directory Services and Security
Overview

- X.500, Active Directory, NDS
- LDAP
- PKI (Public Key Initiative)
- Kerberos
- Authentication
- Policies
- Firewalls



Directory Services and Security

Design Considerations

- Common considerations
  - Directory & security technologies are no longer the focus
  - Identity access and management (IA&M) is new focus
  - OS based security no longer meets requirements for common profiles
  - IT consolidation is an opportunity to plan future IA&M strategy
- Directory considerations
  - Internal politics
  - Interoperability standards
    - Impact of Web Services & XML
  - Performance and availability
  - Replication impact on network
  - Integration with security model

Security

Design Considerations

- Should a new security policy be adopted? (hope is not a good strategy)
- SSO (single sign-on) vs. RSO (reduced sign-on) plans
- Application security and interoperability
- Account clean-up. Remove elevated privileges from accounts that do not need them
- Beware - during change, security is typically lowered & less priority. Maintain focus on environment monitoring & log files.
- Post migration – ensure old server and data is tightly secured
- **Planning & testing is critical!**

Business Continuity / Disaster Recovery

Definition and Challenges

Per the Disaster Recovery Institute:

- Business Continuity Planning - Process of developing advance arrangements and procedures that enable an organization to respond to an event in such a manner that critical business functions continue without interruption or essential change.

Challenges:

- Determine balance between business needs and risks, to appropriate level of contingency and continuity planning recovery.
- Typically, in a consolidated environment, the goal is to provide minimal to zero downtime or continuous availability.
- Obtaining and keeping senior management commitment.

Business Continuity / Disaster Recovery

Design Considerations

- With tragic 9/11 events, and increased emphasis on IT Technology, the basic rule is to never consolidate to one site.
- Recent SARS health issues. One individual walking into the facility can (and did) close an entire facility for up to two weeks.
- If Business Continuity is a business requirement, this will greatly influence the technical design. It impacts all aspects of the target IT solution. See next slide.
- In most areas, network and storage costs are now only a fraction of the cost of what it used to be. Increasing network link speeds and duplicating storage is now easier to justify.

Business Continuity / Disaster Recovery

Design Considerations

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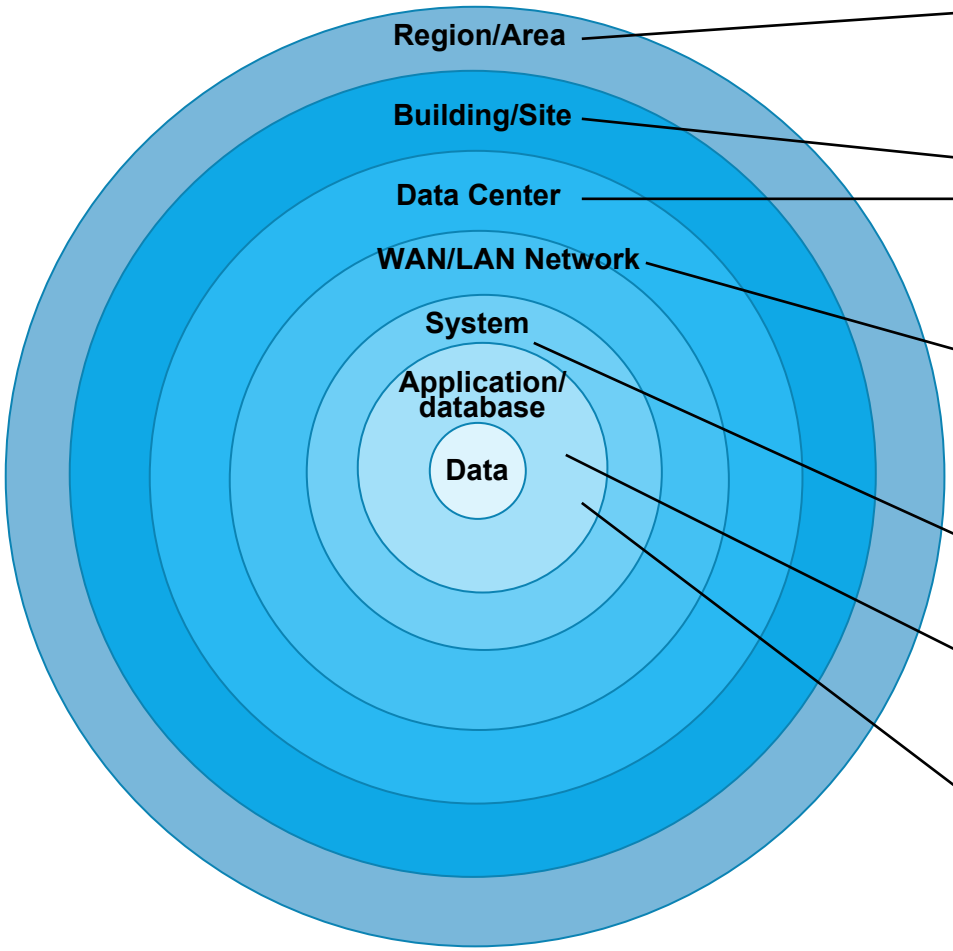
Business Continuity Layers



Emergency Operations Center (EOC)
Command center
Trauma/crisis management

Internal hot-site
Commercial hot-site
Continental Clusters
User/work area recovery

Redundant/re-routable networks
Backup networks
Backup routers
Hot swaps
Alternate LAN cards

Failover/Redundancies:
Data Center Clusters
Campus Clusters
Metropolitan Clusters

Database archive logs
Database backups

Data backups
Off-site media storage
Disk mirroring (software)
Data replication (local/remote)

The Evolution of Business Continuity -
How We Got Here

	80's	90's	00's
Business Focus	Traditional	dot.coms	E-business
Requirements	Tape restore, recover	High-availability	24x7, continuous, scalable
Driven by	Regulation	E-commerce	Competition
Magnified by	Disaster	Absence of "brick and mortar"	Total dependence on computers
Recovery expectation	Hardware (days/hours)	Hardware, data (minutes, seconds)	Hardware, data, application (seconds, transparent)
Decision	Optional		Mandatory

Review

- IT Consolidation Overview
  - Definition
  - What Can Be Consolidated?
  - Consolidation Strategies
  - Consolidation Methodology
- Detailed Design
  - Document
  - Project Team
  - Components
- Summary

IT Consolidation
Resource Links

- HP IT Consolidation

http://www.hp.com/go/consolidation Consolidation Home

http://www.hp.com/hps/consolidation Services

http://www.hp.com/hps/consolidation/cn_wshop.html Consolidation Workshop

- IT Service Management (ITSM)

http://www.hp.com/hps/itsm/

- Utility Data Center (UDC)

http://h71028.www7.hp.com/enterprise/html/4269-0-0-0-121.html

- Operating Systems (OS)

http://www.hp.com/products1/unix/operating/index.html HP-UX
http://h71000.www7.hp.com/openvms/whitepapers/index.html OpenVMS

http://h30097.www3.hp.com/literature.html Tru64 UNIX
http://h18001.www1.hp.com/partners/microsoft/windowsserver2003/ Windows 2003
http://h71033.www7.hp.com/ NonStop Kernel (NSK)

- Servers

http://welcome.hp.com/country/us/eng/prodserv/servers.html HP Home

IT Consolidation
Resource Links (cont'd)

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- Meta Group Server Consolidation Best Practices

http://www.compaq.com/hps/ipf-enterprise/download/META_group_migration_whitepaper.pdf

- IDC and Datacenter Consolidation

http://h18002.www1.hp.com/alphaserver/news/idc_it_center_paper.html

- DH Brown Server Consolidation Case Studies and Best Practices (lessons learned apply to any OS platform)

http://h71000.www7.hp.com/openvms/whitepapers/dhbrown_ovms_casestudy.pdf

http://h18000.www1.hp.com/solutions/consolidation/whitepapers/Services/DHBrown%20Methodology.pdf

- IT Virtualization

http://h71028.www7.hp.com/enterprise/html/4255-0-0-0-121.html

- Enterprise Management

http://www.openview.hp.com/ OpenView

- Customer Consolidation Examples

http://www.hp.ca/portal/enterprise/case_studies/nesbitt_02_03.php Nesbitt Burns
http://www.hp.ca/portal/enterprise/case_studies/starkey_02_03.php Oracle 11i Applications
http://h71000.www7.hp.com/openvms/journal/articles/rdb.html SIAER
http://h30097.www3.hp.com/oracle9irac/greenmountainpower.html Green Mountain

Summary and Keys to Success
Technical Design

- Key to great design solutions is gathering input from all impacted groups – establish cross-functional teams.
- Detailed Design Phase assumes the following have already been completed:
  - Business and Vision (requirements, directions)
  - TCO analysis
  - Environmental Analysis (HW / OS / SW / Apps versions, constraints in CMDB)
  - Architecture Definition
- *Remember the iceberg* – many of the benefits to an improved IT Infrastructure is in the Process and People areas.

Summary and Keys to Success
Technical Design (cont'd)

- Focus on what is both technically & politically possible. A key consideration is that the best technical solution may NOT be the one most suited for an organization. A balance is required.
- Ensure key business and technical objectives and findings from earlier phases are followed.
- Planning and well managed, cross functional projects are key to a successful consolidation initiative.
- A detailed design document is critical.
- Include Test plans in the detailed design document – load, functional, cluster and power users.

Summary and Keys to Success
Technical Design (cont'd)

- Continuous performance monitoring of network, servers, databases & applications is required.
- Consider proactive enterprise management strategies.
- Strong Project Management is required for more complex consolidation projects.
- Communication, communication, communication!

Tough issues on project will not be technical!!!

Questions??

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