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10 / 2013

High Availability solutions with Linux on System z

Enterprise2013

Trademarks

- This presentation contains trade-marked IBM products and technologies. Refer to the following Web site:

  http://www.ibm.com/legal/copytrade.shtml

Definitions

- High Availability (HA) – Provide service during defined periods, at acceptable or agreed upon levels, and masks *unplanned* outages from end-users. It employs Fault Tolerance; Automated Failure Detection, Recovery, Bypass Reconfiguration, Testing, Problem and Change Management

- Continuous Operations (CO) -- Continuously operate and mask *planned* outages from end-users. It employs Non-disruptive hardware and software changes, non-disruptive configuration, software coexistence.

- Continuous Availability (CA) -- Deliver non-disruptive service to the end user 7 days a week, 24 hours a day (there are no planned or unplanned outages).

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Achieving Continuous and High Availability of IT services
- requires a comprehensive long term commitment
- requires continuous improvement.

- **The effort of an IT organization for high availability varies depending on maturity**.
  - Failures across people, process, and technology can inhibit high availability
  - Therefore all potential gaps and inhibitors must be addressed
  - High availability results from doing many things controlled

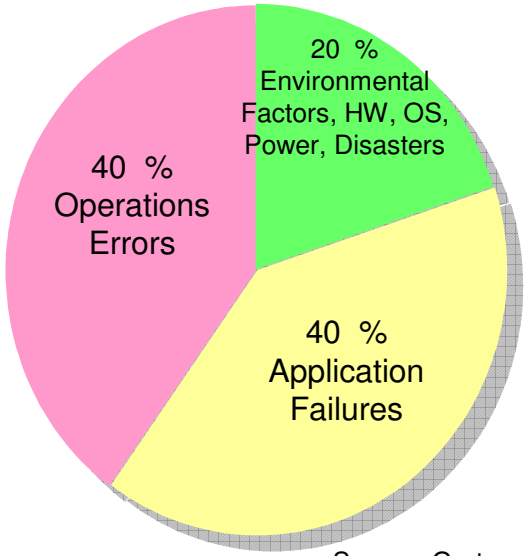
- **High Availability typically requires an one time investment, with ongoing improvements**
  - Initial Assessment, business and process requirements
    - identify gaps, and build a strategic road map.
    - Priority and Dependencies
  - Identify and prioritize key initiatives to improve availability
    - System, application, and data architecture
    - Required support structure and skill development
    - Processes, procedures, and methods supporting High Availability
  - Design, develop, implement, and enhance processes, procedures, methods, technology, tools, IT applications, and skills.

Assess	Plan	Define	Design	Build	Test	Deploy	Run

Business Continuity Issues

What are the reasons for system outages?

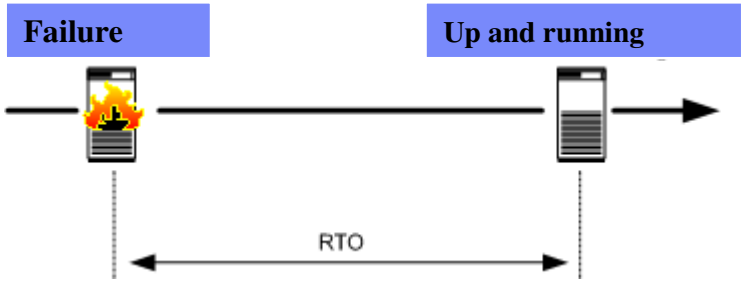
- **Planned** outages
  - Maintenance
  - Tests
- **Unplanned** outages
  - Operator errors
    - Lack of application skills
    - Lack of OS skills in heterogeneous environment
  - Application failures
    - SW exceptions
    - Environment / Configuration problems
  - Environmental failures
    - OS failures
    - HW failures
    - …
    - Disasters



Source: Gartner Group

Identify RTO, RPO und NRO

Business Resiliency Plan



Recovery Time Objective (RTO)

What time difference can be between Failure and a total productional run level ?

Recovery Point Objective (RPO)

What is the toleration for data loss?

RPO = "0" means, NULL data loss acceptable
RPO = "5" means, data loss in last 5 min acceptable

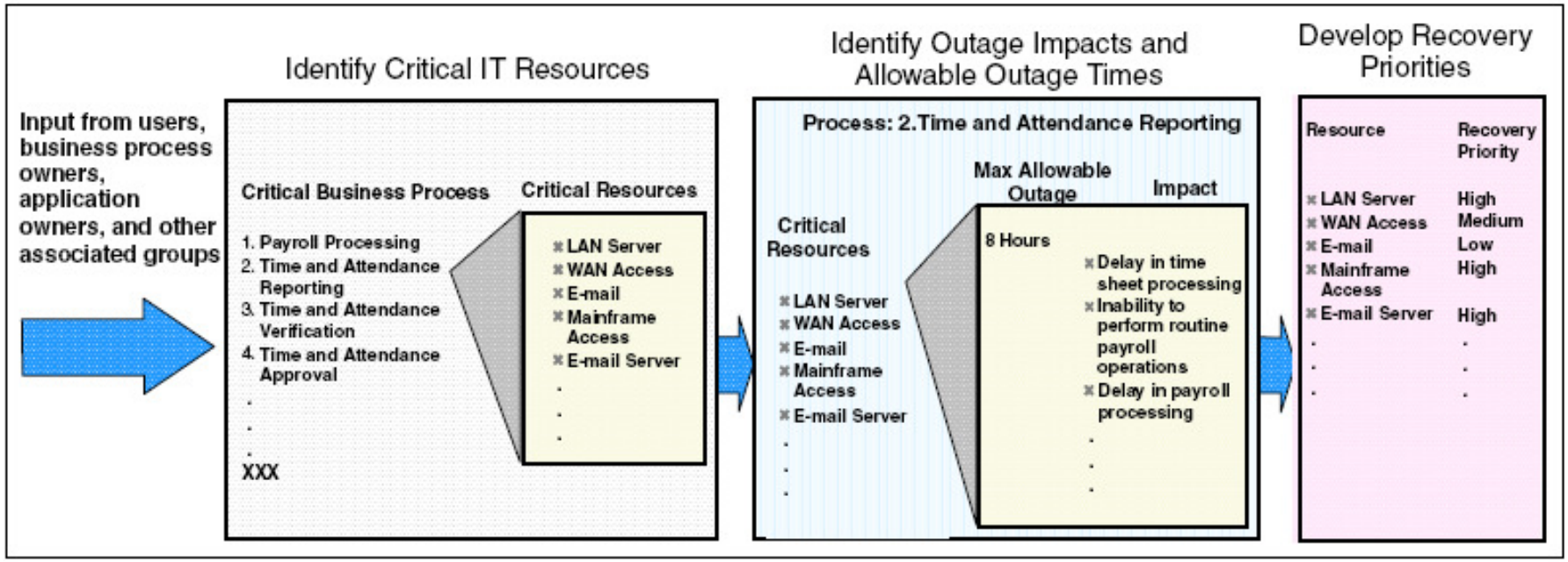
TREND: RPO = 0

Network Recovery Objective (NRO)

Time requirements for network availability.

The Business Impact Analysis (BIA)

- IT Resource relation and priorities for DR
- Consider all environments
- Prioritize based on business importance



Example of the Business Impact Analysis process

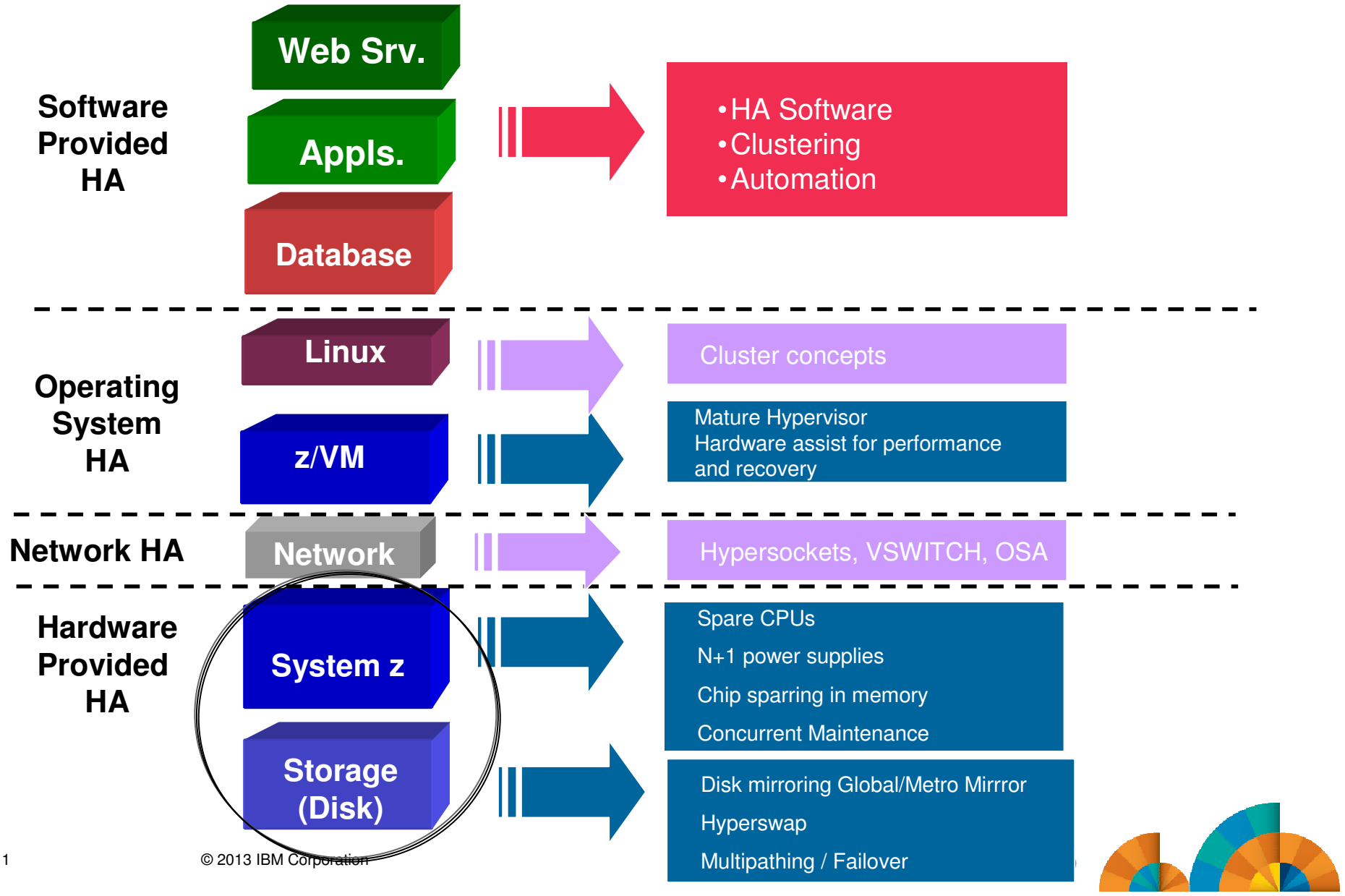
Differences between HA and DR

- **High Availability - HA:**
  - Failover is typically realized via duplication and clustering
  - Failover times measured in seconds and minutes
  - Reliable synchronous inter-node communication
- **Disaster Recovery - DR:**
  - Failover is typically realized with 2 or more sites in case of disasters
  - Failover times often measured in minutes and hours
  - Unreliable inter-node communication assumed

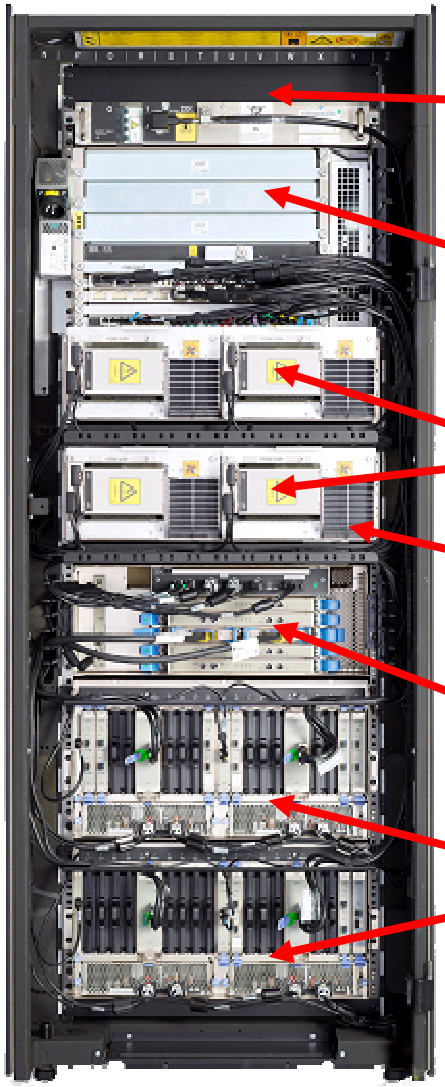
Fundamentals of High Availability

- **Redundancy**, Redundancy, Redundancy
  - Duplicate to eliminate single points of failure.
- **Early detection**
  - To keep offline time as short as possible
  - Reduce risk of wrong interpretation and unnecessary failover
  - Keep offline time as short as possible (mean-time-to-repair MTTR)
- **Protect Data Consistency** – Provide ability for data and file systems to return to a point of consistency after a crash.
  - Journaling databases
  - Journaling file systems
  - Mirroring
  - Routine database backups
- **Automate Detection and Failover -** Let the system do the work in order to minimize outage windows.
  - Multipath
  - VIPA –Virtual IP Addresses
  - Monitoring and heart-beating
  - Clustered middleware
  - Clustered operating systems

Components of HA with Linux on System z



System z and zEnterprise – HA under the covers



Internal Batteries (redundant)

Power Supplies (redundant)

2 x Processor Drawers, Memory & HCAs

RAIM Memory (Redundant Array of Independent Memory)

I/O Drawer (redundant)

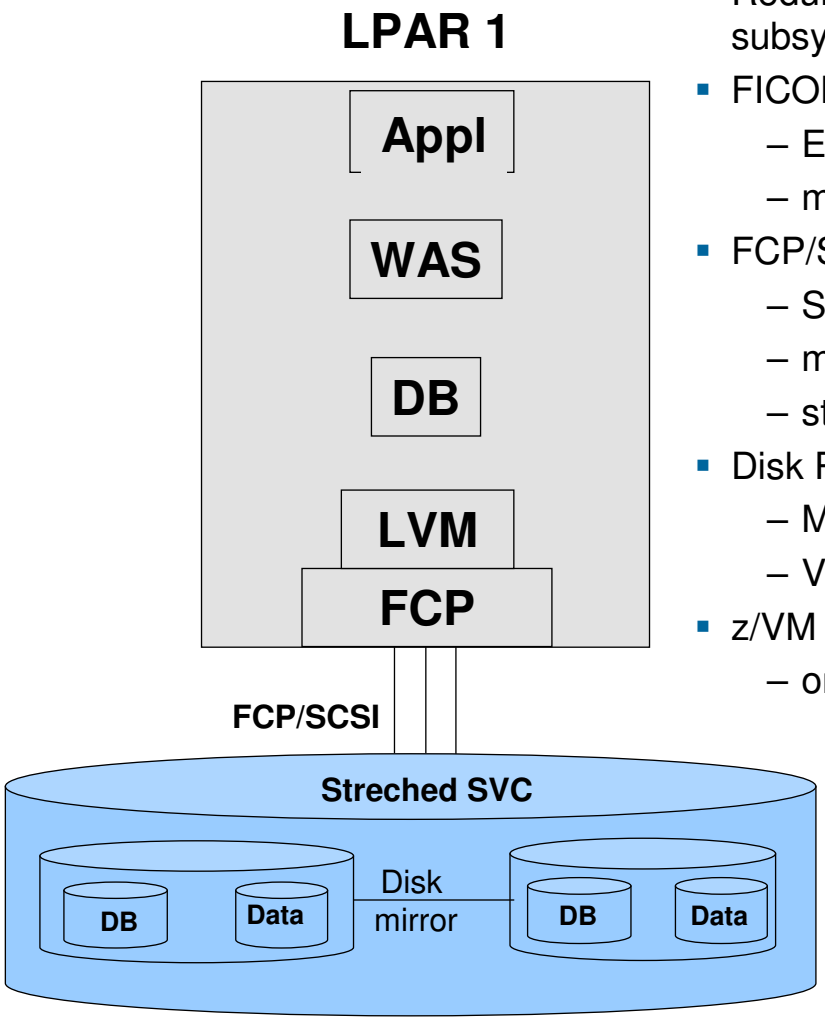
PCIe I/O drawers (redundant)

2 x Support Elements

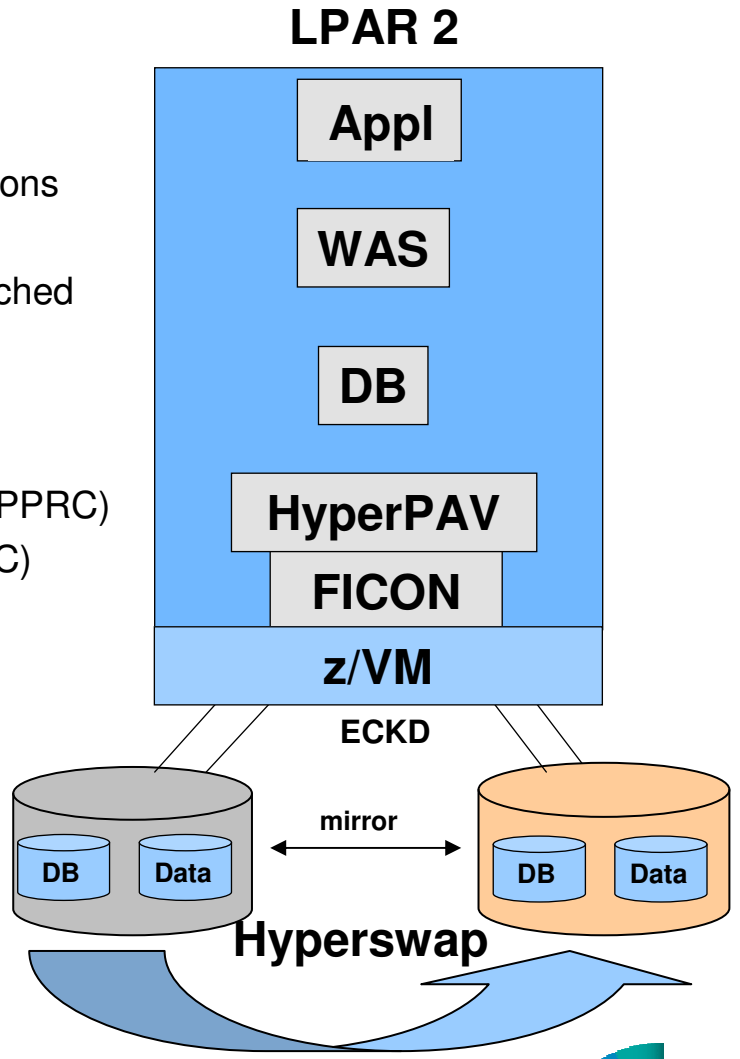
Rear View

Front View

Storage HA Options



- Redundant access to the Storage subsystems
- FICON attached Disks
  - ECKD disks
  - multi channel connections
- FCP/SCSI attached disks
  - SCSI disks - LUN attached
  - multi pathing /LVM
  - streched SVC for HA
- Disk Replication -
  - Metro / Global Mirror (PPRC)
  - Virtual disk mirror (SVC)
- z/VM Hyperswap
  - online disk swap



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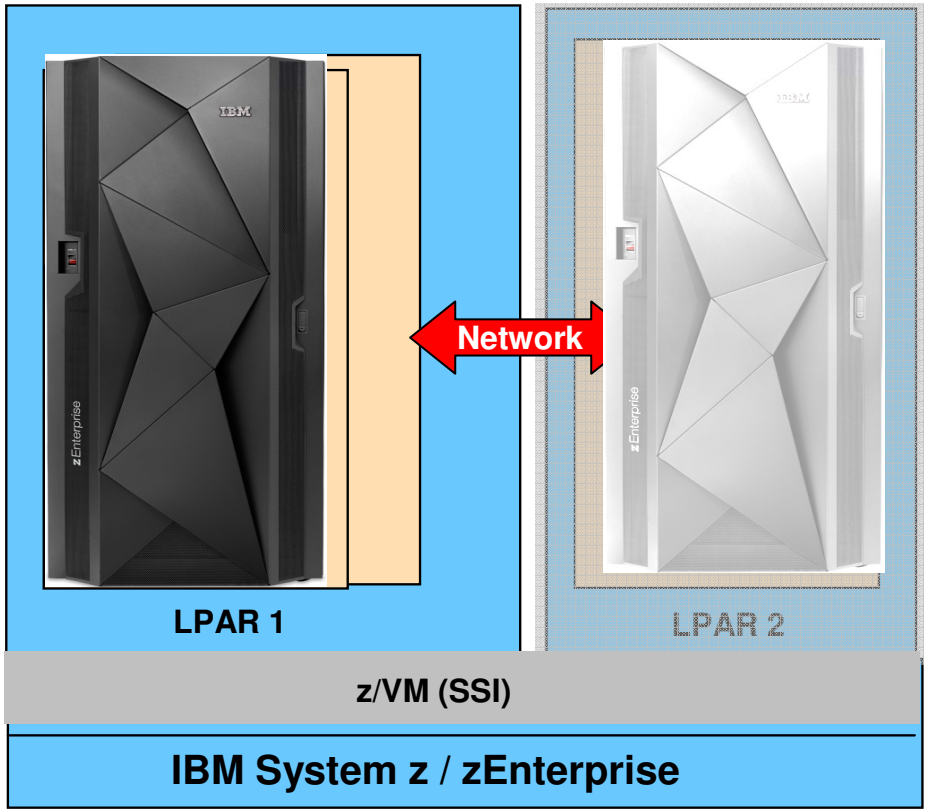
High Availability scenario as Active/Passive with System z

- **Active / Passive Deployment**.
  - Workload normally contained at Site 1, standby server capability at Site 2
  - Primary and secondary disk configurations active at both sites.
  - During fail over, Capacity Upgrade on Demand (CUoD) adds resources to operational site, and standby servers are started. Helps save hardware and software costs, but requires higher recovery time.

- **Hot / Cold scenario**
  - Workload is not split.
  - Each site is configured to handle all operations
  - Cold environment needs longer to get active – often used in DR

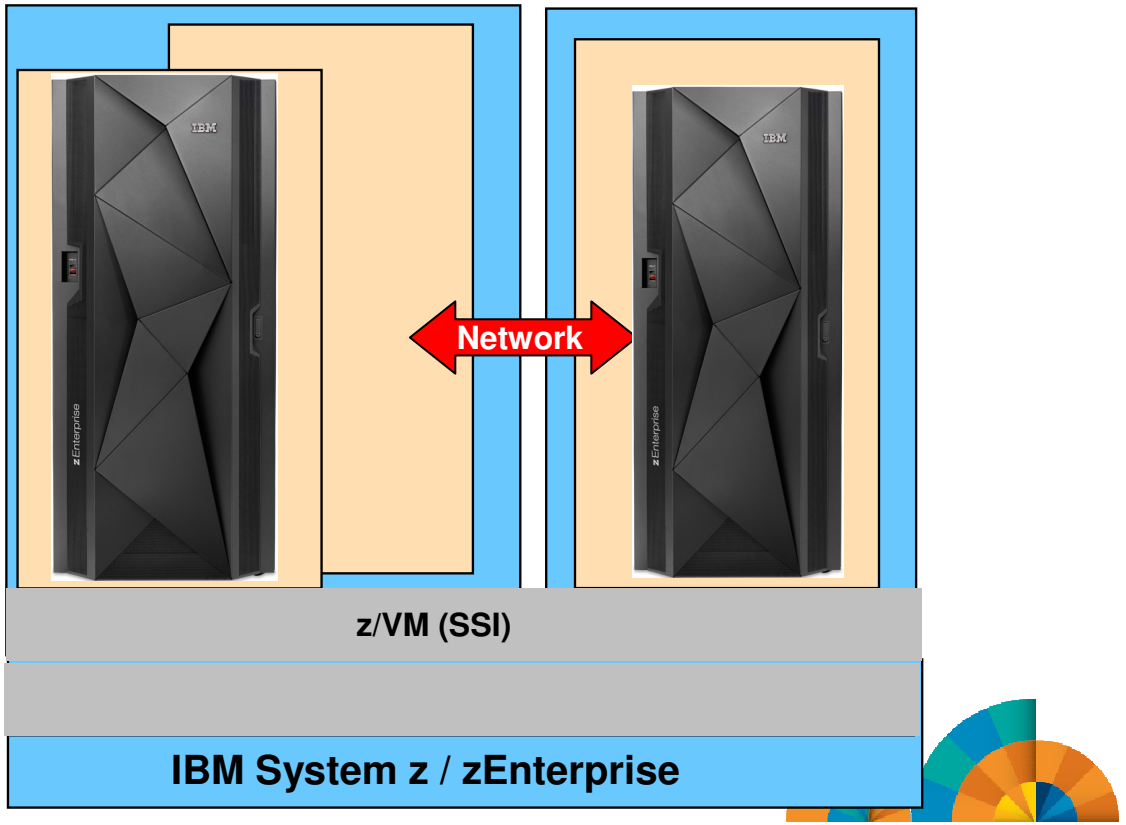
- **Hot / Warm scenario**
  - Workload is not split
  - Each site is configured to handle all operations
  - Warm environment is idling.



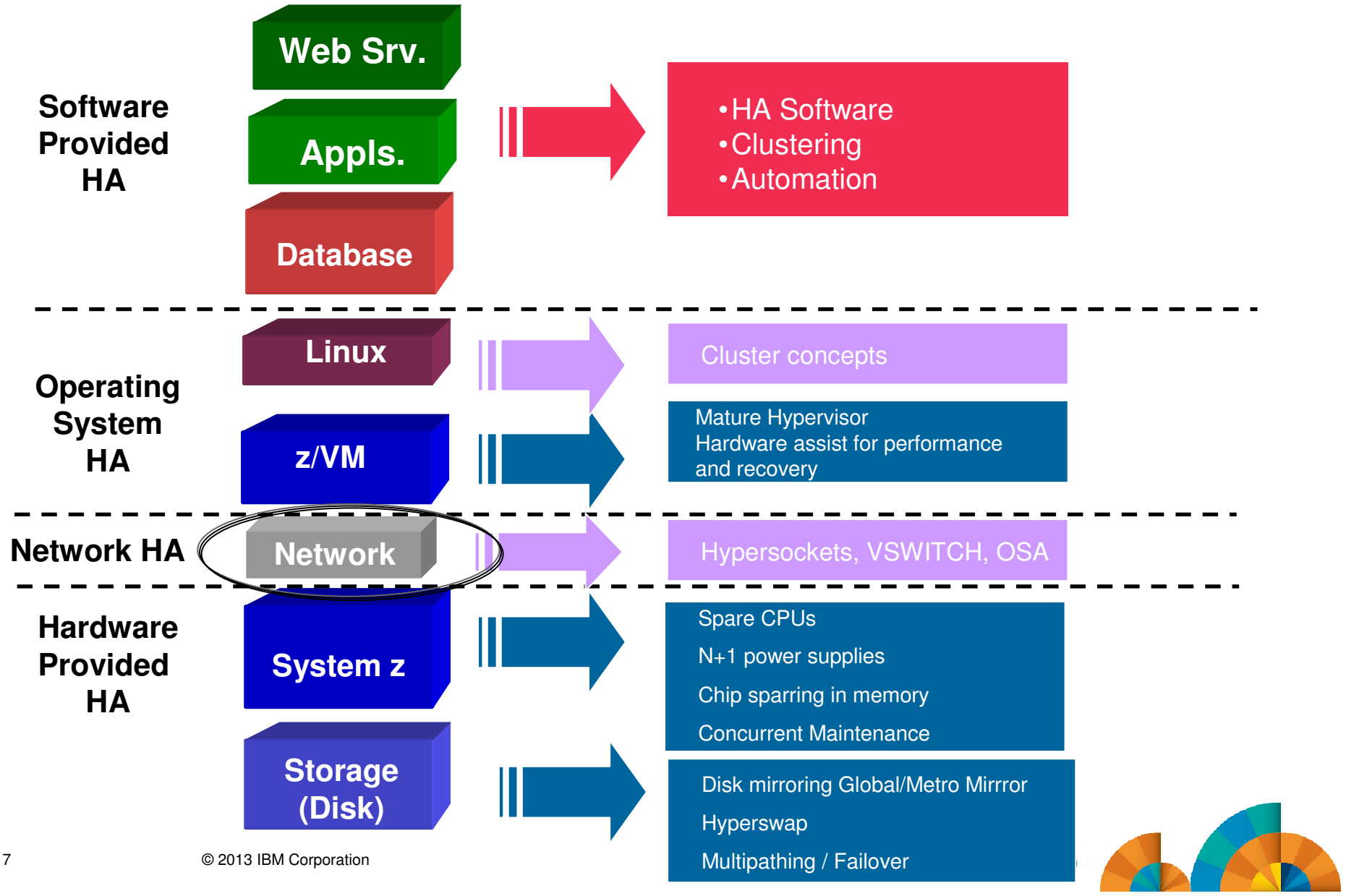
High Availability with an active/active environment on System z

- **Active / Active Deployment -Expendable work.**
  - Workload is normally split between 2 or more sites
  - Each site is (over) configured to be able to instantly cover the workload if needed.
  - During normal operation, excess capacity at each site is consumed by lower priority, work like development or test activities
  - In a failover situation, low priority work is stopped to free up resources for the production site's incoming work.

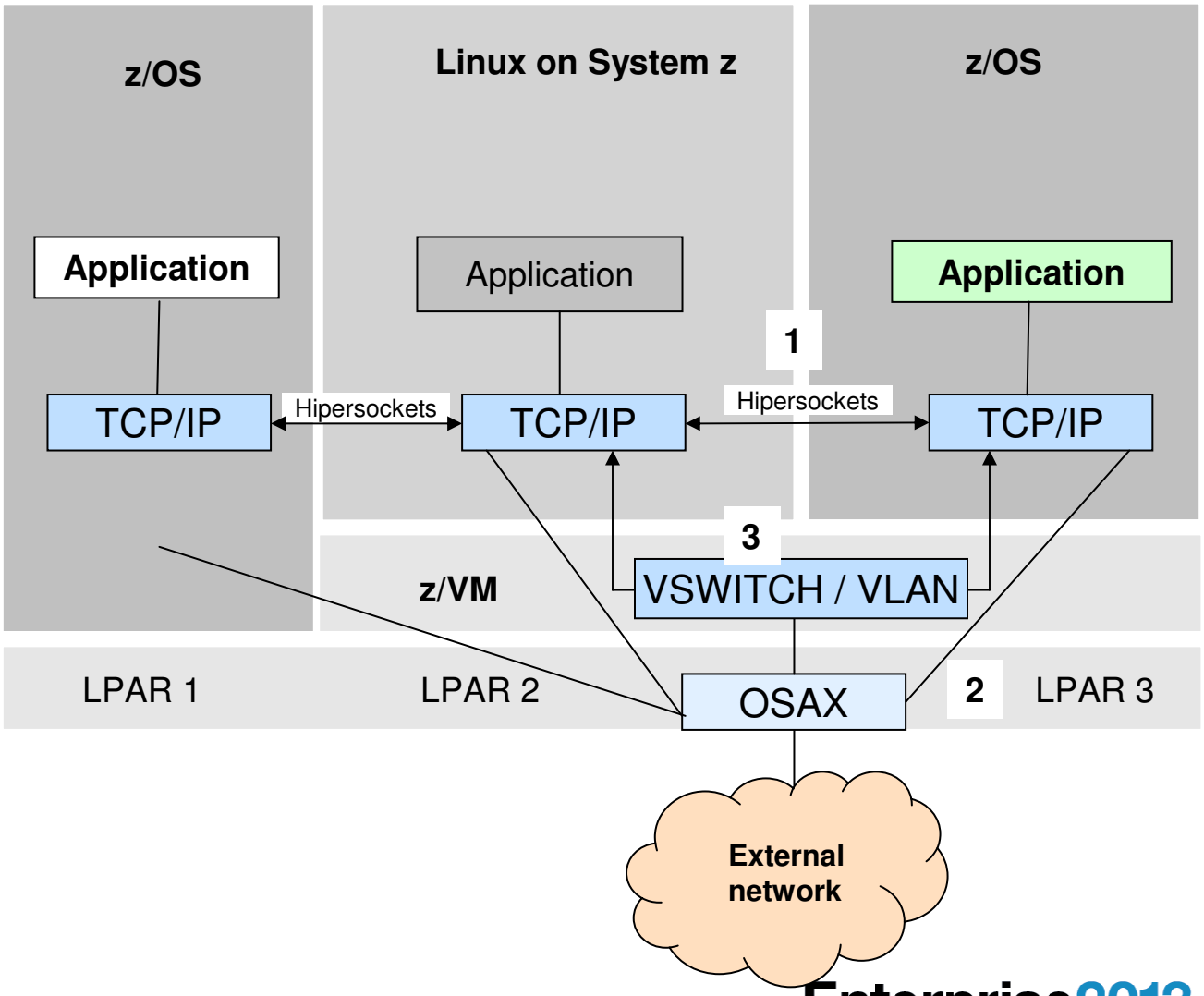
- **Capacity Upgrade on Demand (Active / Active)**
  - Workload is normally split between sites.
  - Each site is configured with capacity to handle normal operations
  - Special setup with Capacity Upgrade on Demand (CUoD).
  - In a failover situation, additional CPUs are enabled at the operational site.



Components of HA with Linux on System z



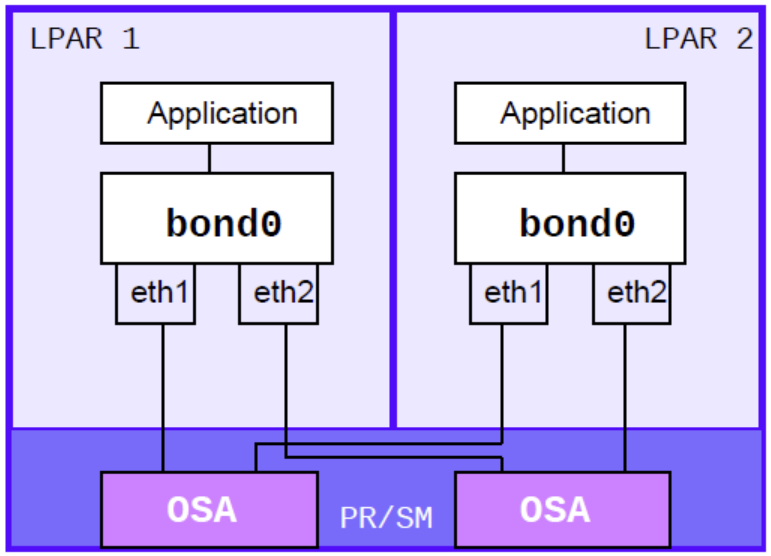
Linux and network alternatives in System z



Network Interface HA and Automated Failover

OSA-card HA

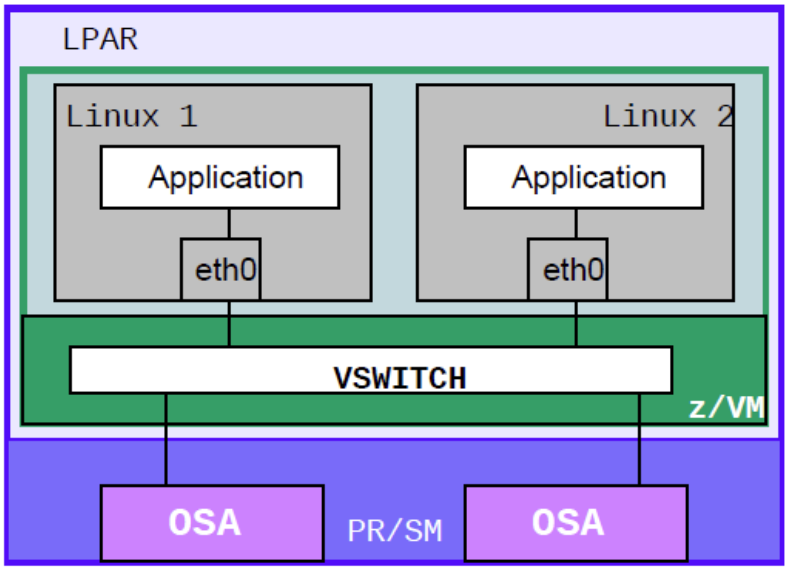
Channel Bonding for enhanced bandwidth



- Linux *bonding* driver enslaves multiple OSA connections to create a single logical network interface card (NIC)
- Detects loss of NIC connectivity and automatically fails over to surviving NIC
- Active/backup & aggregation modes
- **Separately configured for each Linux**

Network HA with z/VM VSWITCH

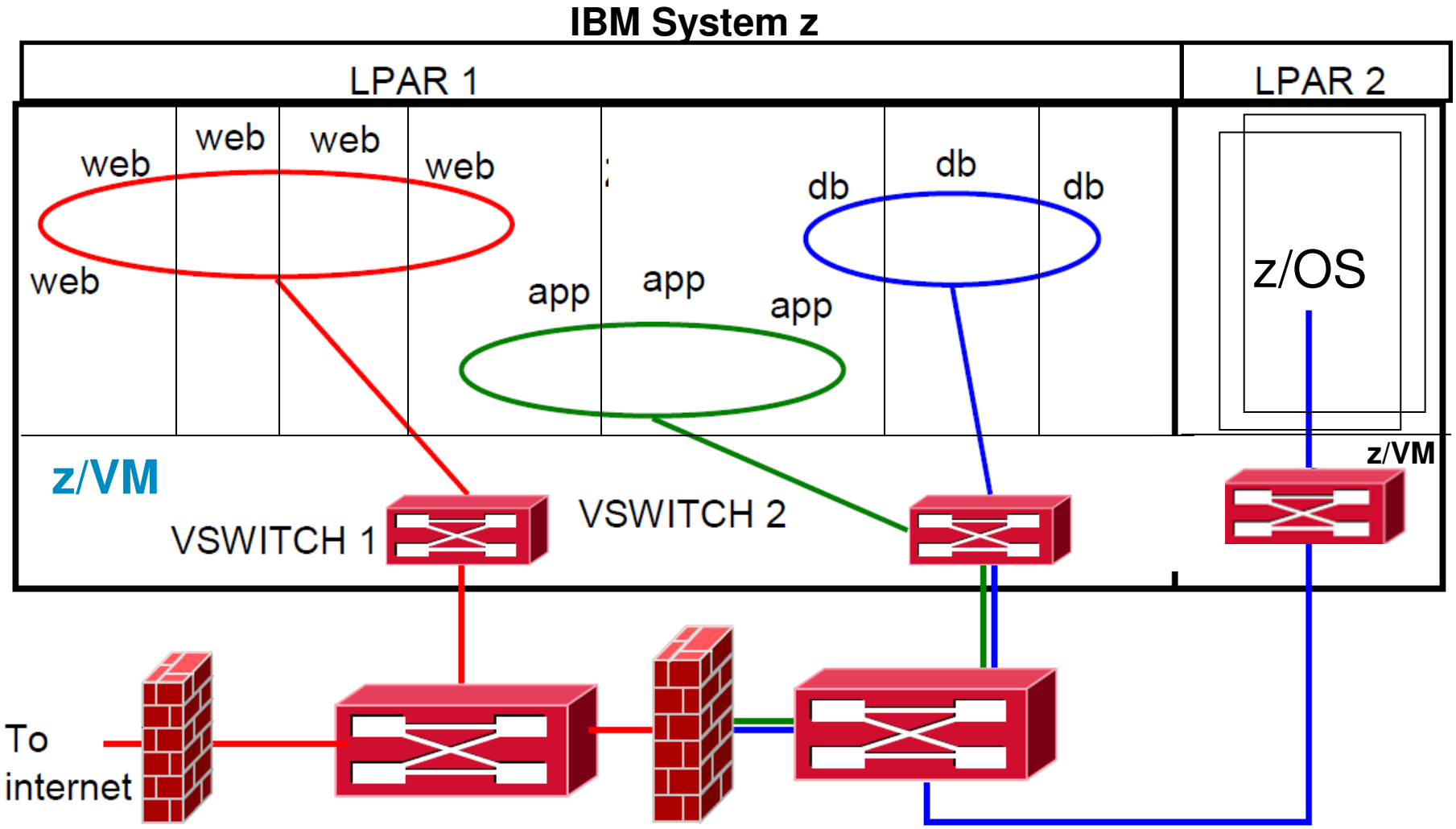
Port aggregation for enhanced bandwidth



- z/VM *VSWITCH* enslaves multiple OSA connections. Creates virtual NICs for each Linux guest
- Detects loss of physical NIC connectivity and automatically fails over to surviving NIC
- Active/backup & aggregation modes
- **Centralized configuration benefits all guests**

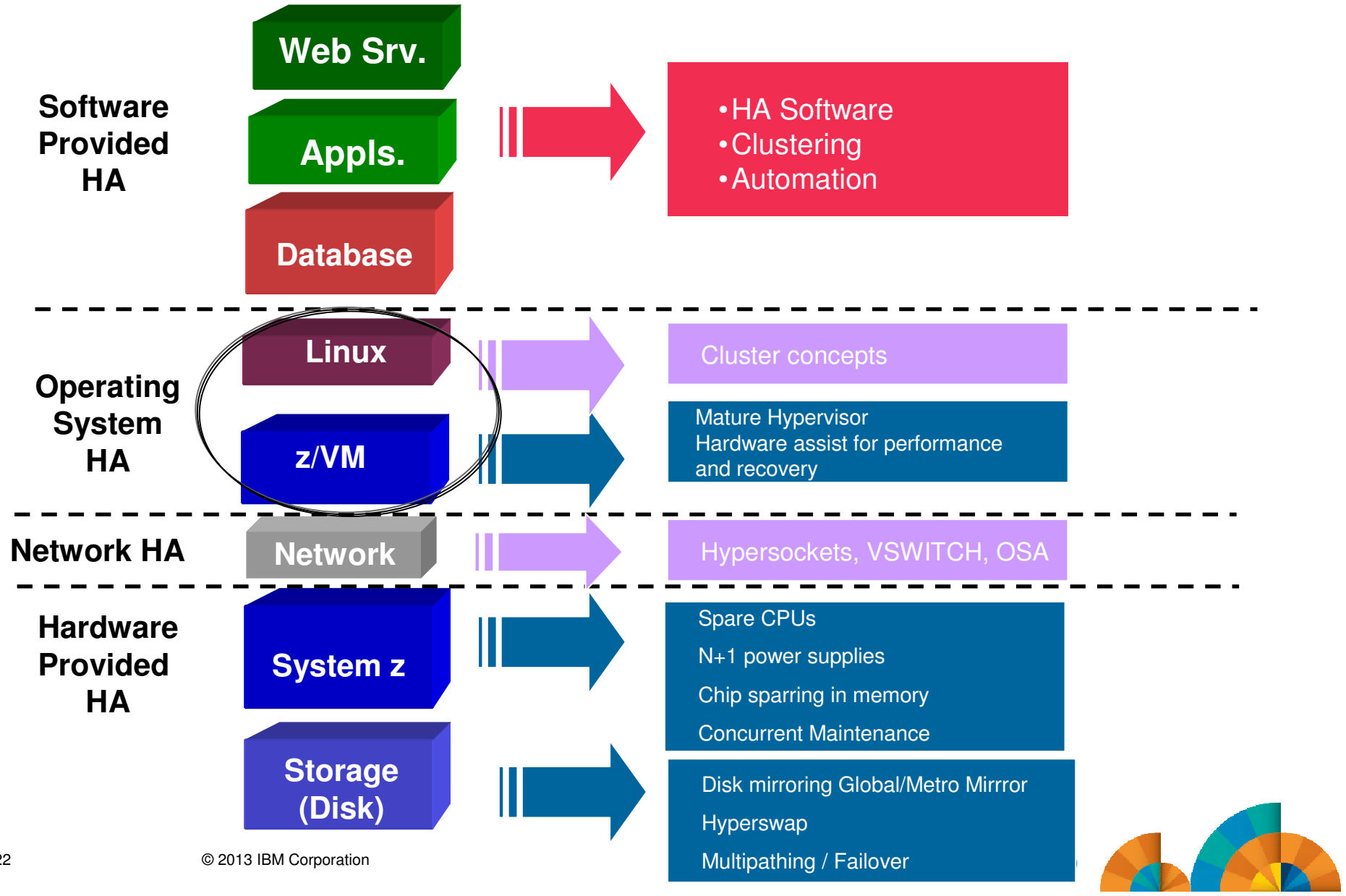
System z network HA options

Multi-zone Network VSWITCH (red zone physical isolation)



With 2 VSWITCHes, 3 VLANs, and a multi-domain firewall

Components of HA with Linux on System z

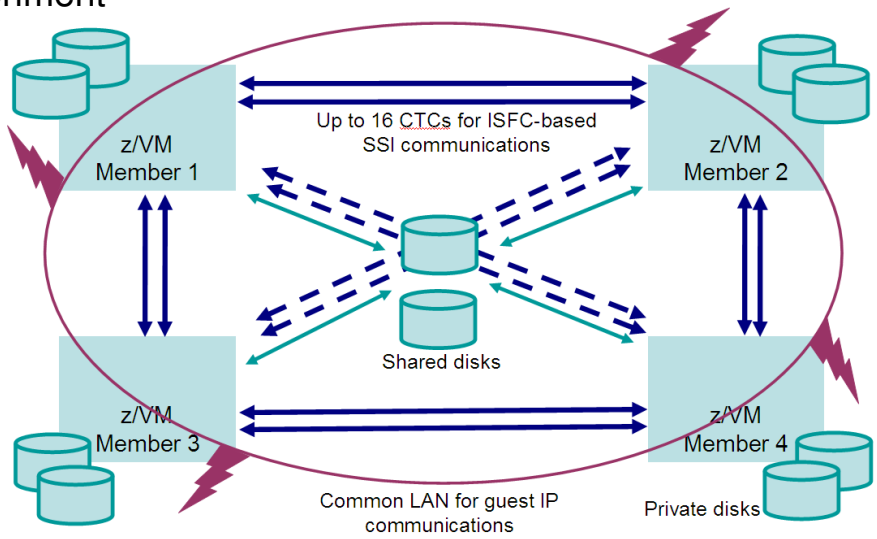


z/VM V6.2 - Increase Availability for Linux guests

Single System Image, Clustered Hypervisor, Live Guest Relocation

Single System Image (SSI)

- connect up to four z/VM systems as members of a cluster
- Provides a set of shared resources for member systems and their hosted virtual machines
  - Directory, minidisks, spool files, virtual switch MAC addresses
- Cluster members can be run on the same or different z10, z196, or z114 servers
- **Simplifies systems management** of a multi-z/VM environment
  - Single user directory
  - Cluster management from any member
    - Apply maintenance to all members in the cluster from one location
    - Issue commands from one member to operate on another
  - Built-in cross-member capabilities
  - Resource coordination and protection of network and disks



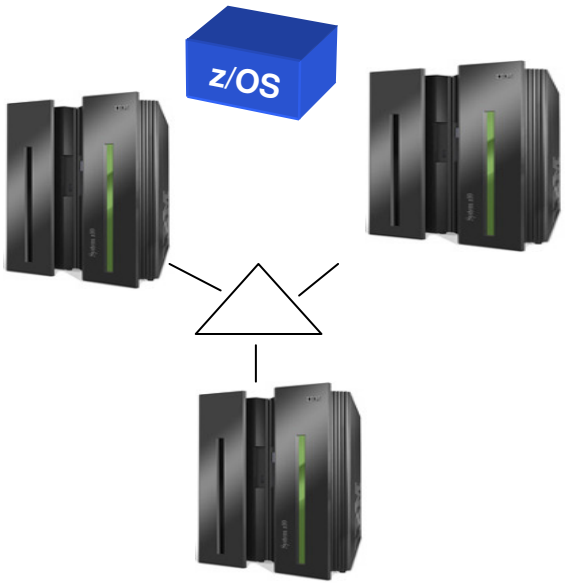
Live Guest Relocation (LGR)

- – Dynamically move Linux guests from one z/VM member to another

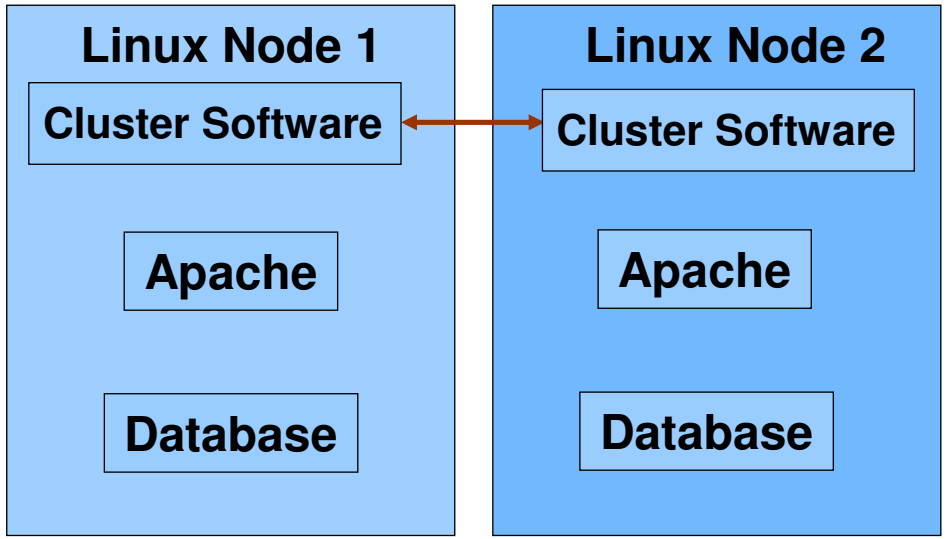
  Reduce planned outages; enhance workload management
  - Non-disruptively move work to available system resources **and** non-disruptively move system resources to work
  - When combined with Capacity Upgrade on Demand, Capacity Backup on Demand, and Dynamic Memory Upgrade, you will get the best of both worlds

High Availability for Operating Systems: z/OS and Linux

- z/OS Parallel Sysplex HA incl. memory sharing



- Linux on z HA using cluster software



Clustering Concepts

Computer Cluster

- A computer cluster consists of a set of loosely connected computers that work together so that in many respects they can be viewed as a single system. (Wikipedia definition: Computer Cluster)

High Availability Cluster

- A computer cluster where each cluster operates as workload node. When one node fails another node takes over the entire workload: IP address, data access, services, etc.
- The key of High Availability is avoiding single points of failure
- High Availability adds costs because of added complexity due to redundant resources in the environment

High Availability Cluster concepts

- Split-Brain
- Quorum
- Fencing
- Data Sharing

Split Brain

- If the heartbeat between nodes fails, all nodes can still be active and:
  - detect the other as failing
  - the status of an unreachable node is unknown
- Communication/heartbeat failures between cluster nodes can lead to isolated actions in separated partitions of the cluster
- If those partitions each try and take control of the cluster, then it's called a split-brain condition
- This can lead to data corruption or inconsistency, therefore split brain has to be inhibited

http://www.linux-ha.org/SplitBrain

Quorum

- Quorum is an attempt to avoid split brain for most kinds of failures
- Typically the Cluster Management Software tries to make sure only one partition can be active
- Quorum is the term for methods for enforcing which part of the cluster is active:
  - A quorum server – as additional node-can decide more reliably
  - Quorum server is in a quorum daemon
- Most common kind of quorum is voting – and only one partition can run the cluster

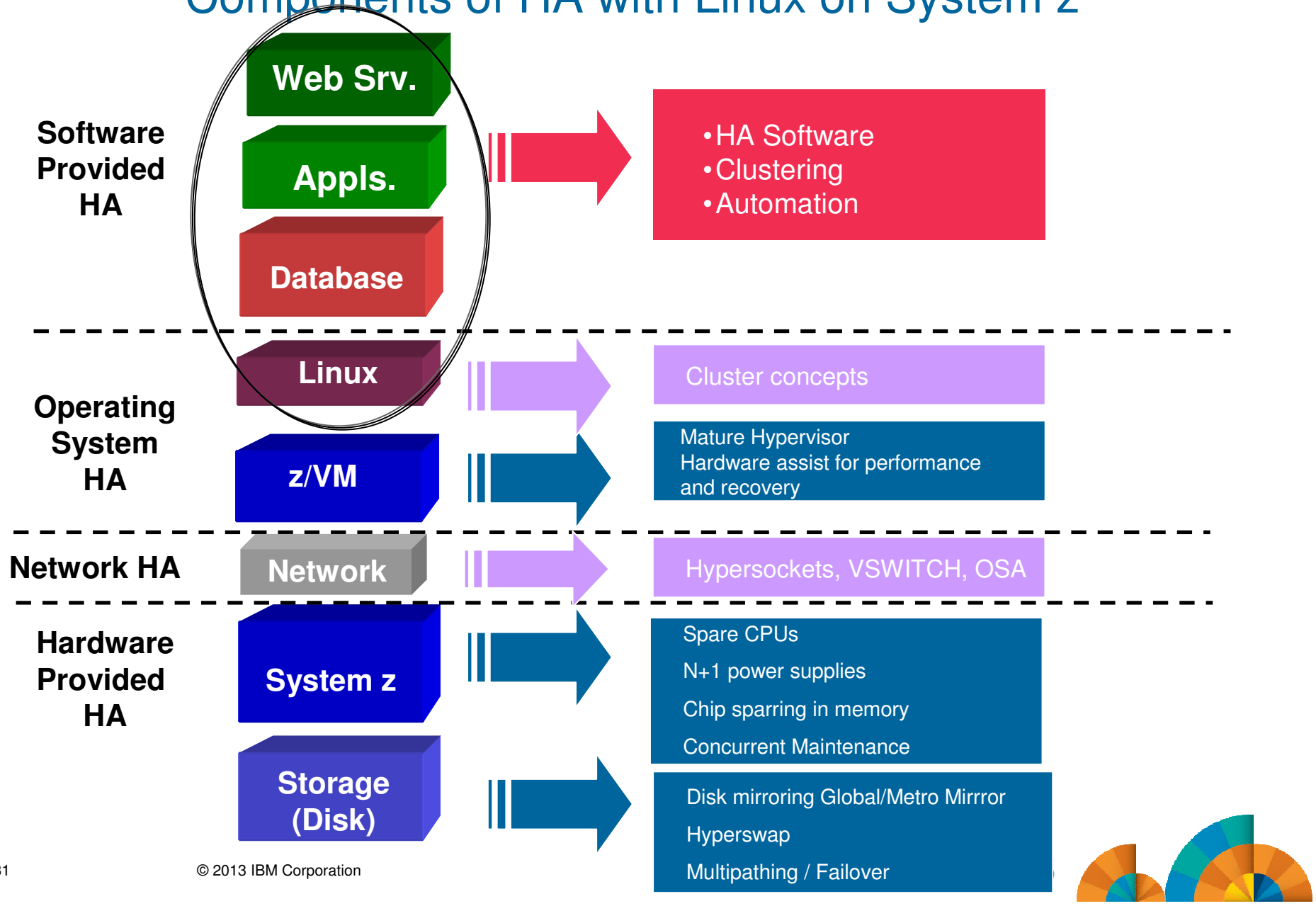
http://linux-ha.org/wiki/Cluster_Concepts

Fencing

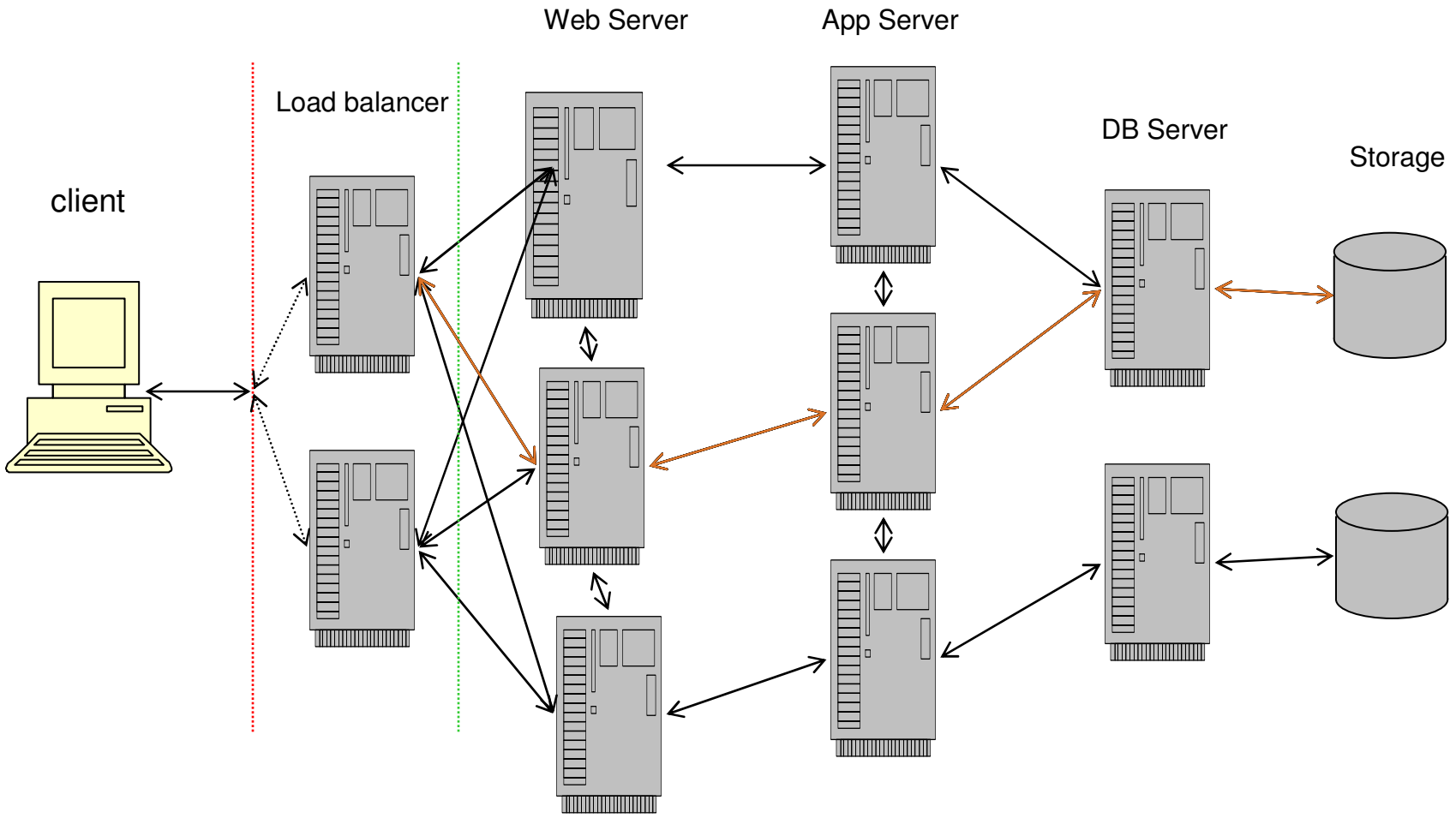
- Fencing puts a fence around an errant node or inhibit a failed node from accessing cluster resources
- This way one doesn't have to rely on correct behavior or timing of the errant node
- This is often implemented via STONITH
  - STONITH: Shoot The Other Node In The Head
- Other techniques also work
  - use of hardware or software watchdog timers
  - self shutdown / restart
  - Shared device for notification instead of heartbeat

http://www.linux-ha.org/fencing

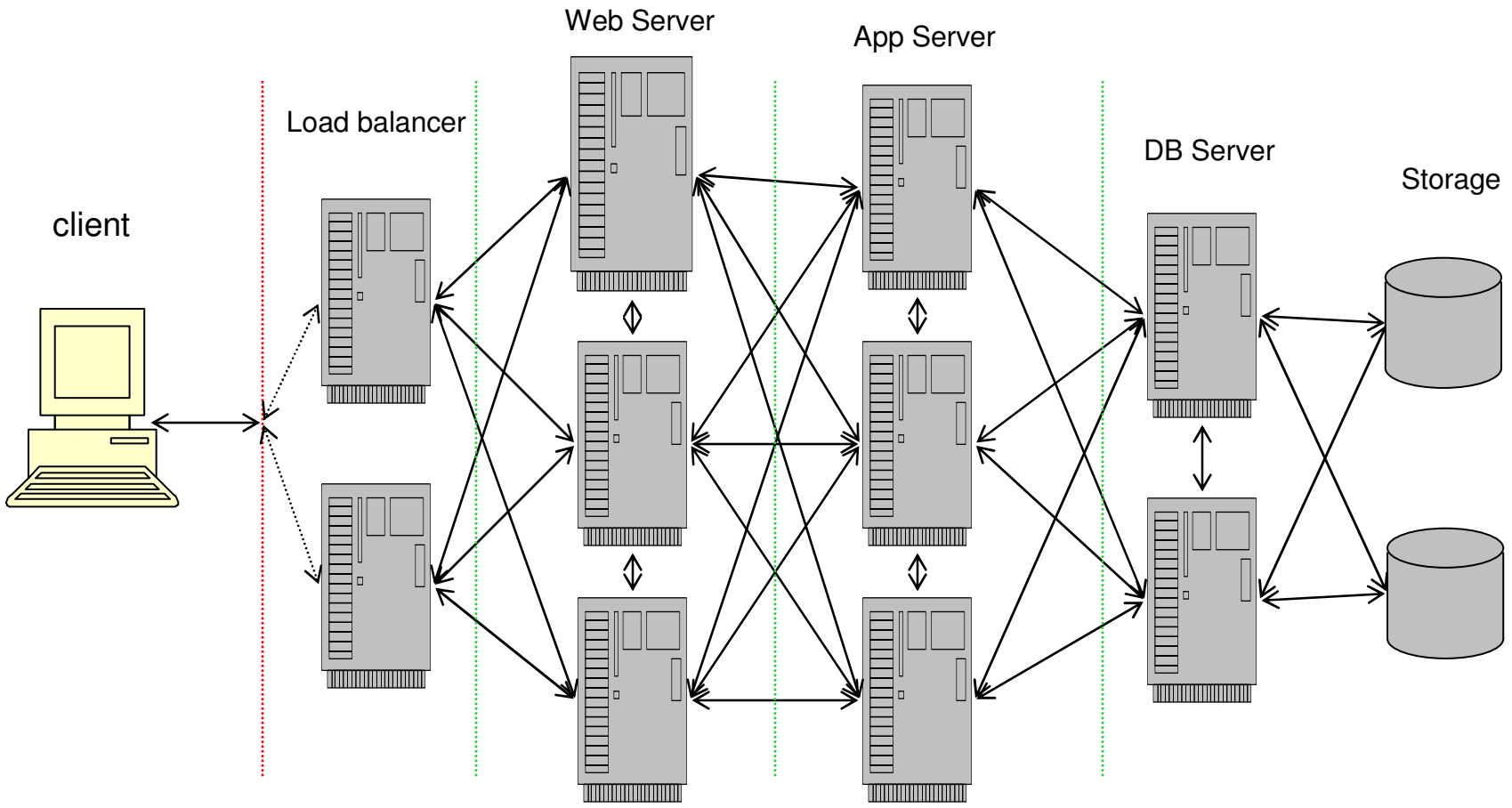
Components of HA with Linux on System z



HA with Independent Complete Path Execution Streams



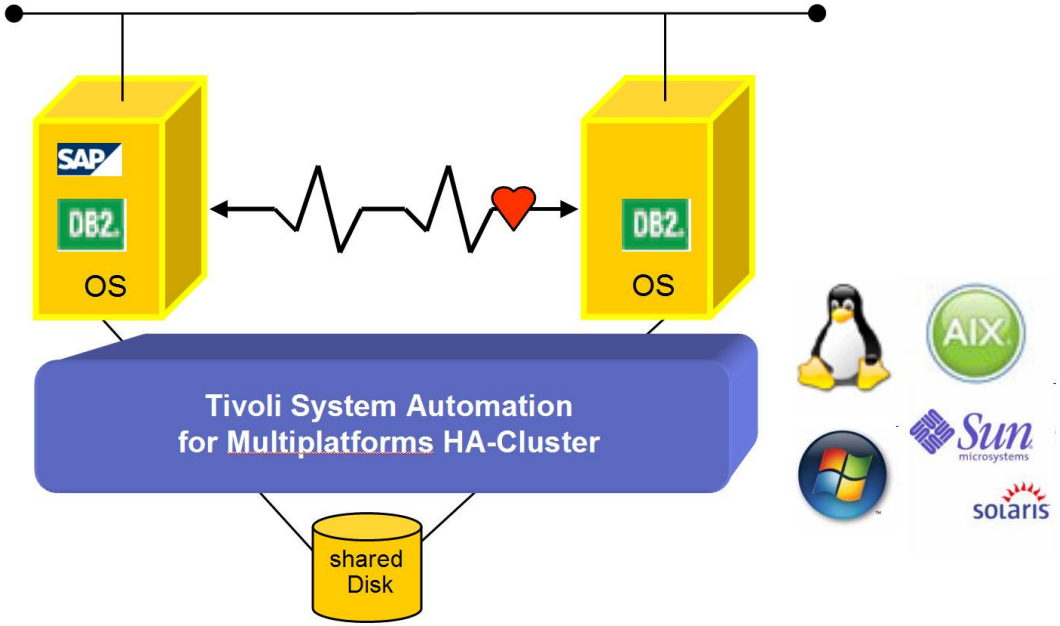
HA with Independent Tiered Execution Streams



High Availability Clustering

- **Linux-HA package implementations**
  - **for Linux environments**

- **Tivoli System Automation for Multiplatforms**
  - **for z/OS**
  - **for multiplatforms**
  - **for distributed heterogeneous environments**



Linux-HA package - High Availability components

- Heartbeat
  - Messaging between nodes to make sure they are alive and available
  - Action required if heartbeat stops after certain tries
- Cluster-glue
  - Everything that is not messaging layer and not resource manager
- Resource-agents
  - Agents running in clustered systems or remote
  - Agents are able to start, restart or stop services
- Pacemaker
  - A Cluster Resource Manager (CRM)
- OpenSAF checkpoint APIs
  - SAF -> Service Availability Forum – created the Service Availability Specifications
  - OpenHPI - The Hardware Platform Interface (HPI) abstracts the differences between hardware implementations, providing a uniform interface to hardware features.
  - OpenAIS - The Application Interface Specification (AIS) specifies an interface that applications interchange information with the service availability middleware (i.e. CRM).

HA support in RedHat Distribution for Linux on System z

- Linux clustering
  - **is not implemented/supported in the RHEL Distro for Linux on System z**
  - It can be introduced from 3rd party provider – Sine Nomine
    - Sine Nomine provides support for Linux-HA on RHEL on System z

      http://www.sinenomine.net/products/linux/systemz/hao4relz

- HA Concepts with RHEL rely on the layered duplication only:
  - Using application HA, like Oracle RAC for example
  - Mirroring the disks DASD/FCP volumes with IBM GDPS/PPRC
  - Strengthening parts of the operating system, like using multipath for disk failover and VSWITCH for network failover

- An alternative is NFS version 4, which has cluster/locking built in
  - The idea is to use virtual networking (hipersockets ideally, or VSWITCH) to connect to a virtualized NFS share.
  - Performance will be similar to I/O to disk and NFS handles multiple read/write access to the same data

HA support in SUSE Distribution for Linux on System z

- HA for Linux on z using clustering
  - is implemented in the SLES Distro for Linux on System z
  - License is part of SLES for Linux on System z
  - HA implementation bases on Linux-HA
  - Graphical tools included for cluster management and monitoring resources
- SUSE Linux Enterprise High Availability Extension delivers all the essential monitoring, messaging and cluster resource management functionality
- HA Add-on: Geo Clustering for SUSE Linux Enterprise High Availability Extension lets you deploy Linux clusters between data centers spread anywhere in the world.

- In the SLES HA Extension, Pacemaker is included, a scalable cluster resource manager with a flexible policy engine that supports n-node clusters

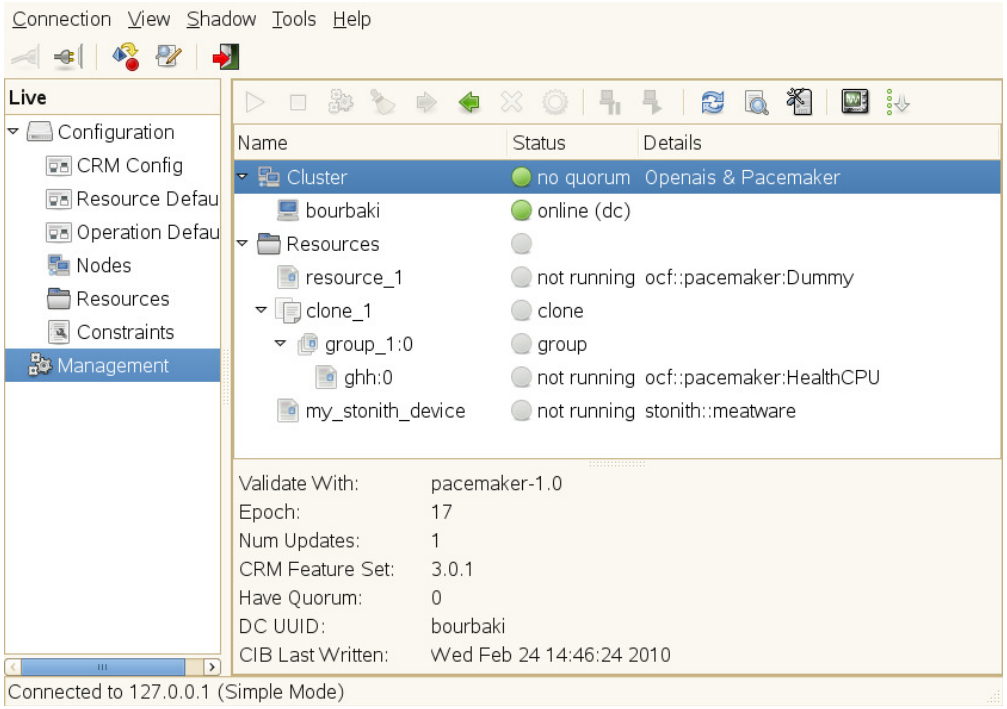
- OpenAIS, as one of the leading standards-based communication protocol for server and storage clustering is used for communication

- Using OpenAIS and Pacemaker, you can continuously monitor the health of your resources, manage dependencies, and automatically stop and start services based on highly configurable rules and policies

User-friendly management tools

SUSE Linux Enterprise High Availability Extension includes a powerful new unified command-line interface for experienced IT managers to quickly and easily install, configure and manage their clustered Linux servers.

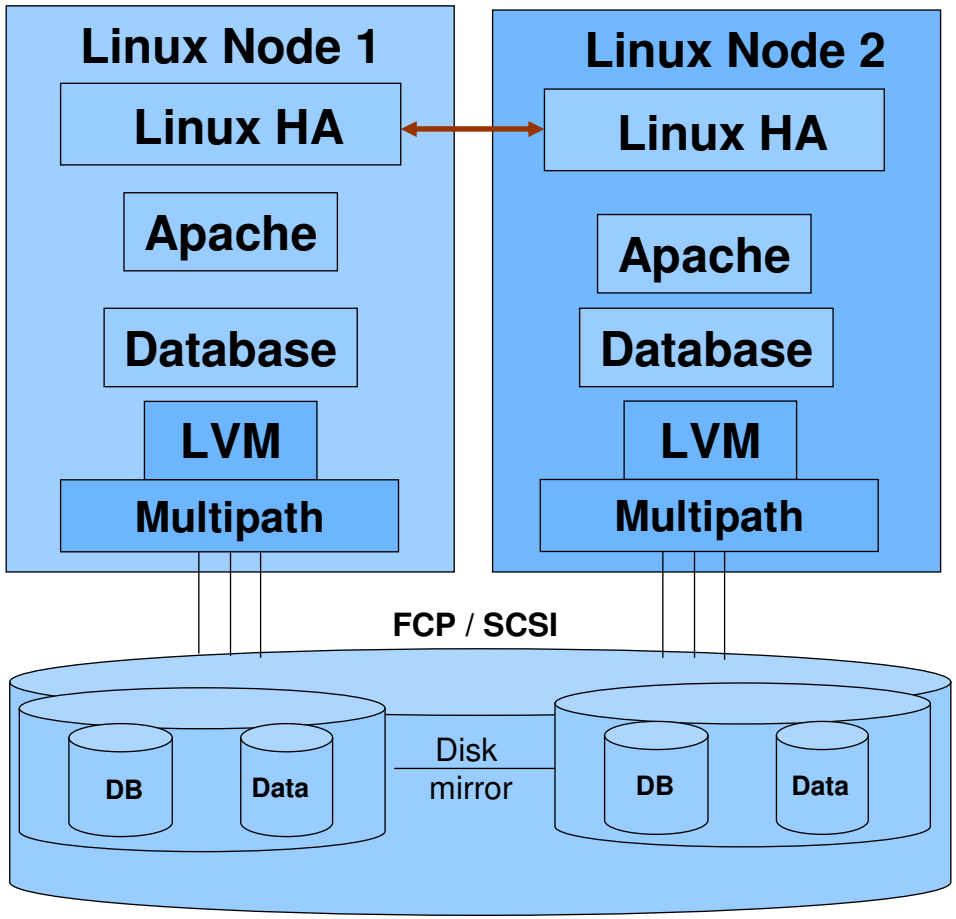
- Graphical user interface that provides operators with a simple, user-friendly tool for monitoring and administering their clustered environment.
- New YaST2 modules for the configuration:
  - of DRBD,
  - openAIS
  - multipath



Supported Platforms

- SUSE Linux Enterprise Server 11
- for x86, x86_64,
- Itanium*,
- Power*
- System z* architectures

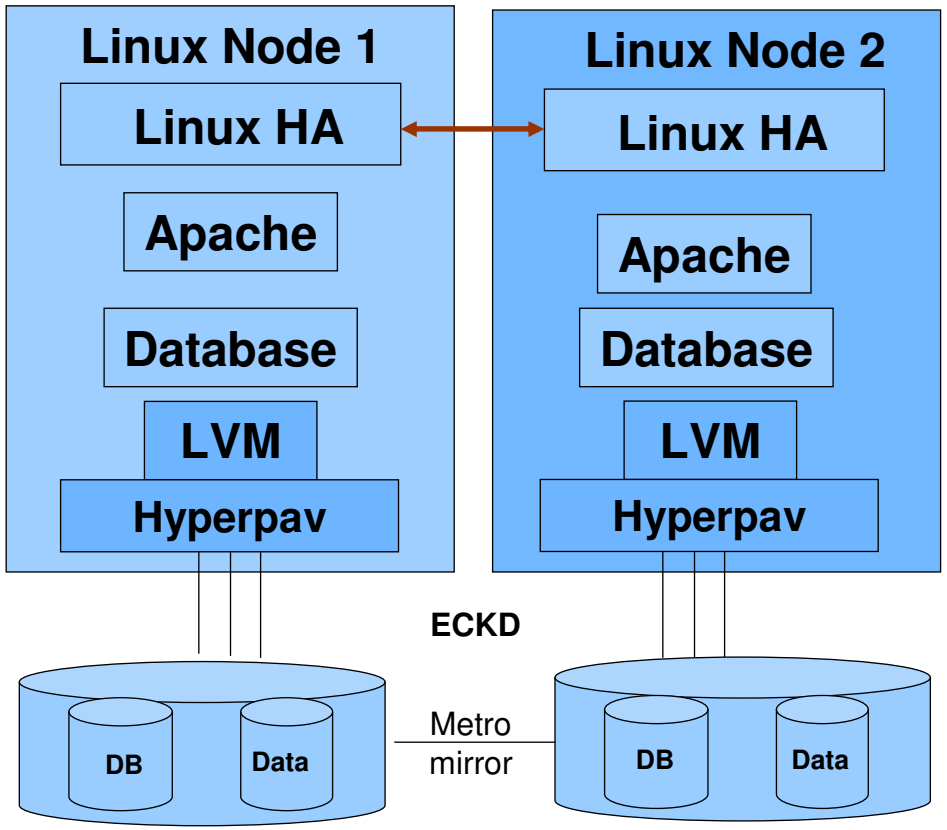
HA with Open Source SW and Linux-HA with Data-mirroring



Linux-HA
- **Heartbeat**
- **LVM**

Disk HA and Virtualization:
- **HA with stretched SVC**
- **HA with IBM Storage Mirroring**

HA with Open Source SW and Linux-HA with Data-mirroring



Linux-HA
- **Heartbeat**
- **LVM**
- **Hyperpav**

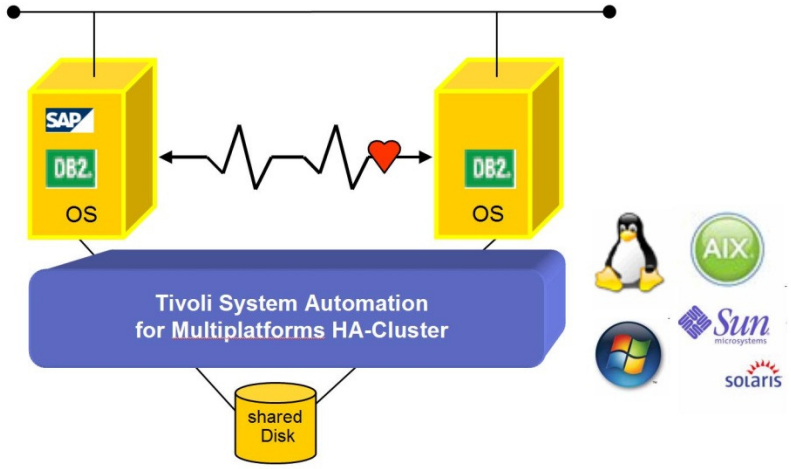
Disk HA and Virtualization:
- **HA with IBM Storage Mirroring**

HA with IBM Tivoli System Automation multiplatform support

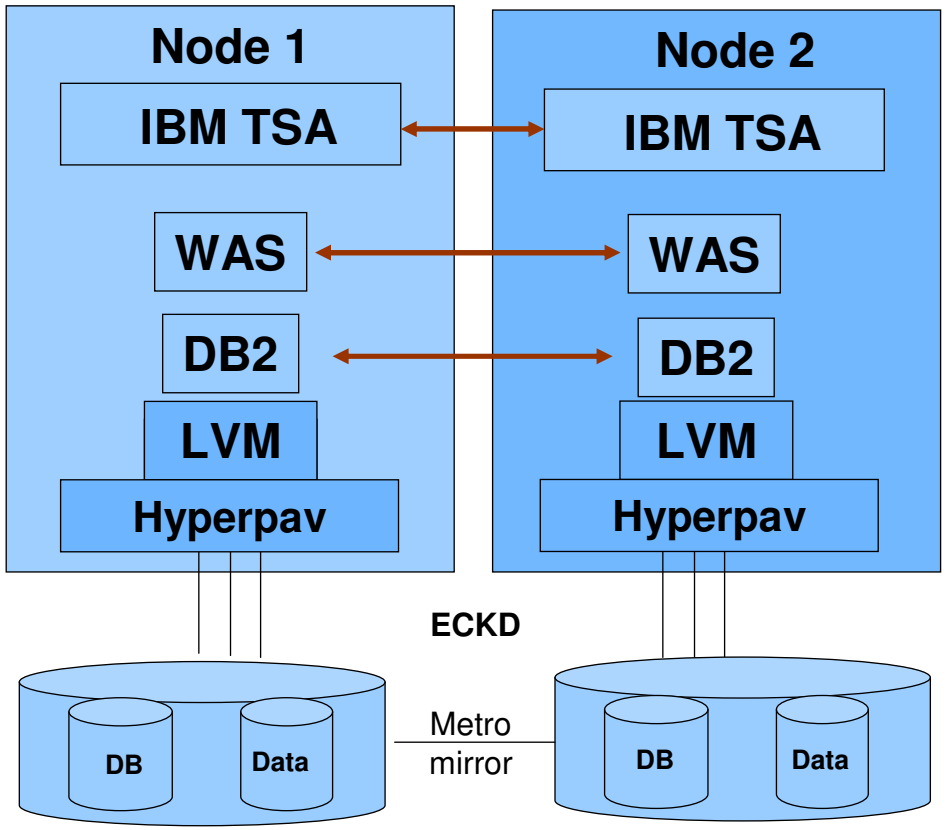
- IBM Tivoli System Automation for Multiplatform (SA MP) can take advantage of:
  - Linux-HA heartbeat environment
  - enable cross platform HA
  - z/OS High availability together with Linux
  - implements advanced resource group automation
  - dependencies and policy management and hierarchies
  - can be used in HA for non-clustered systems and applications
  - supports various platforms including System z
  - contains a variety of predefined HA adapters for middleware (i.e. DB2, SAP, WebSphere, Apache …)

High Availability Clustering

- **Tivoli System Automation for Multiplatforms**
  - Provides a **High Availability Cluster**
  - **Automates startup and shutdown** in correct sequence of complex, statefull applications
  - **Actively monitors** all resources and **reacts on outages of SW and HW** components by automatic restart in correct context
- **Automation Policies** define the **Automation Scope**
  - Describe **resources**, **groups** and **relationships**
  - **Define the desired target availability situation**
  - No need to develop automation workflow scripts.



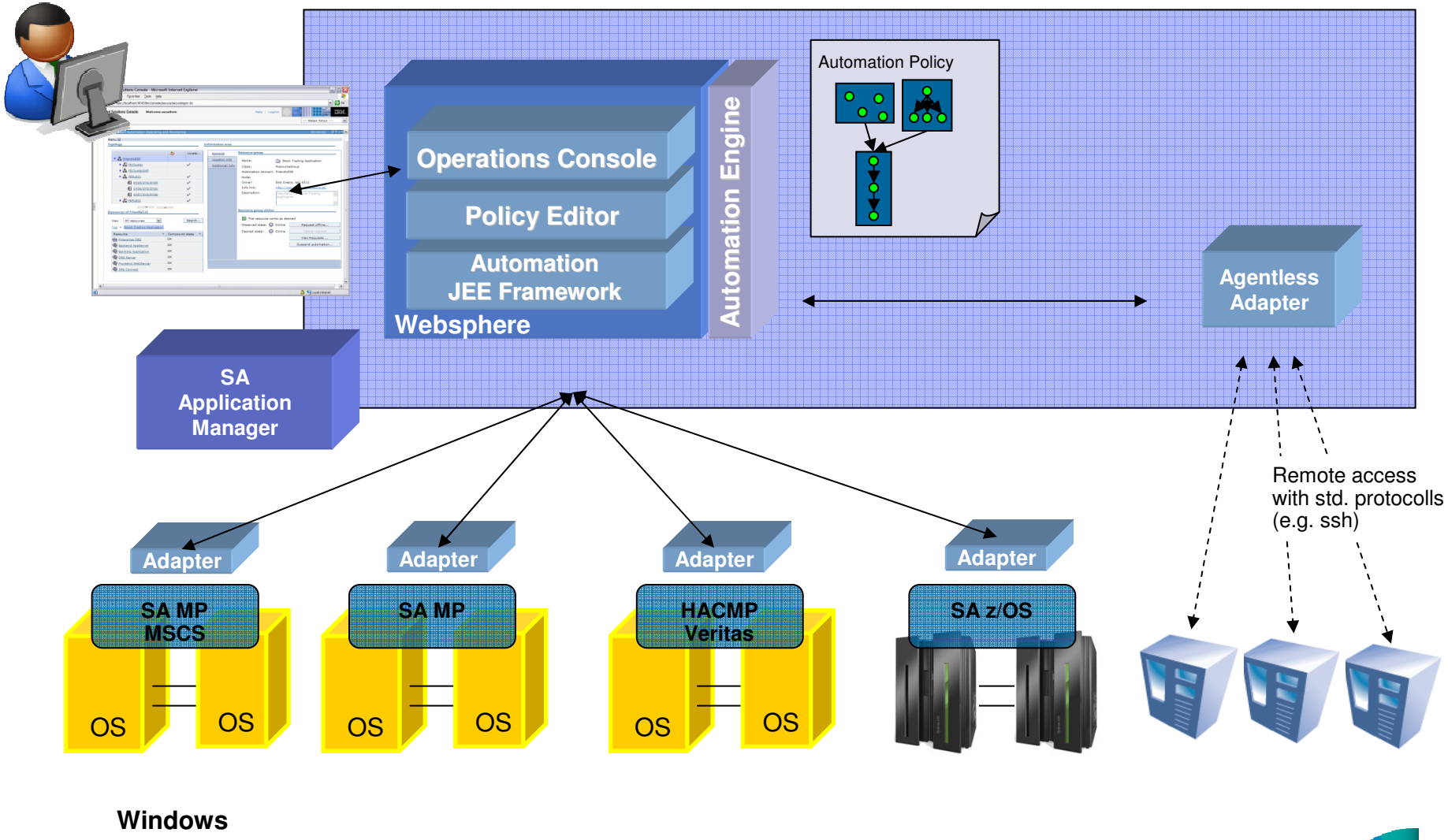
HA with IBM SW products clustered on each level including Data HA and mirroring



IBM Tivoli System Automation
- **Heartbeat**
- **WebSphere App. Server**
- **DB2**
- **LVM**

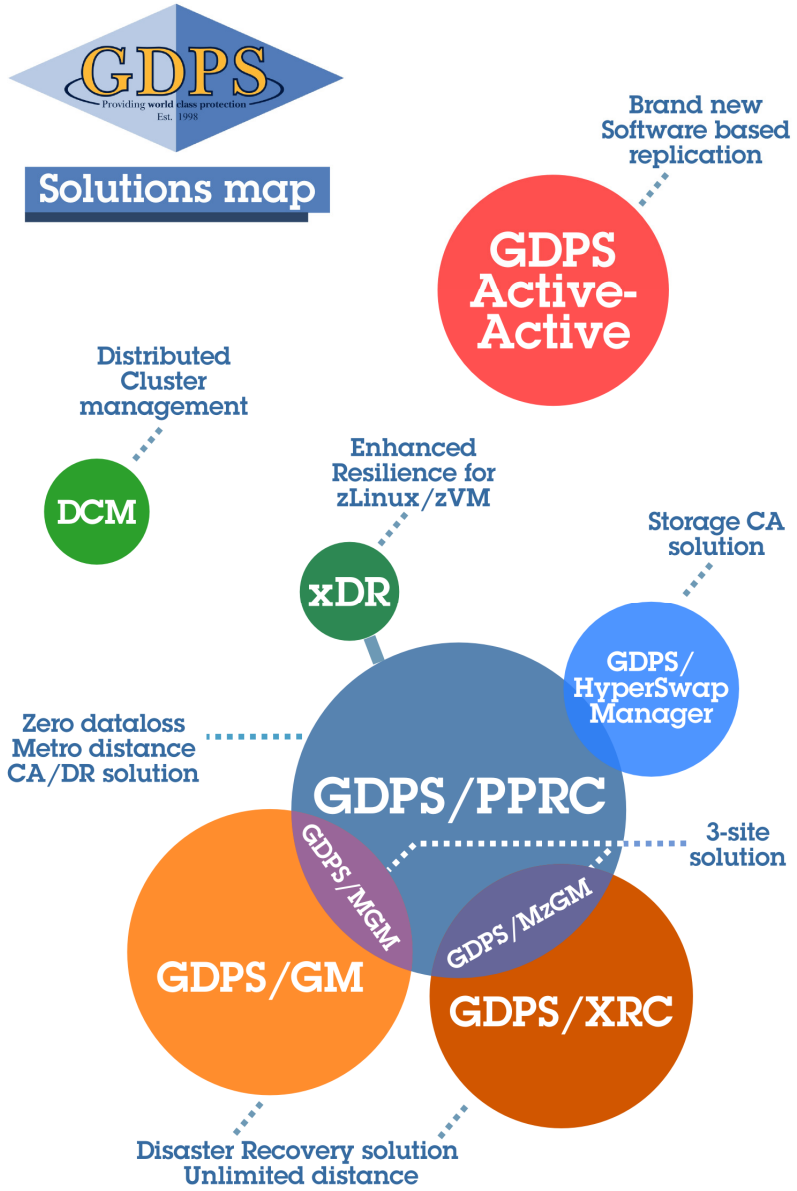
Disk HA and Virtualization:
- **HA with stretched SVC**
- **HA with IBM Storage Mirroring**

SA Application Manager Adapter Infrastructure

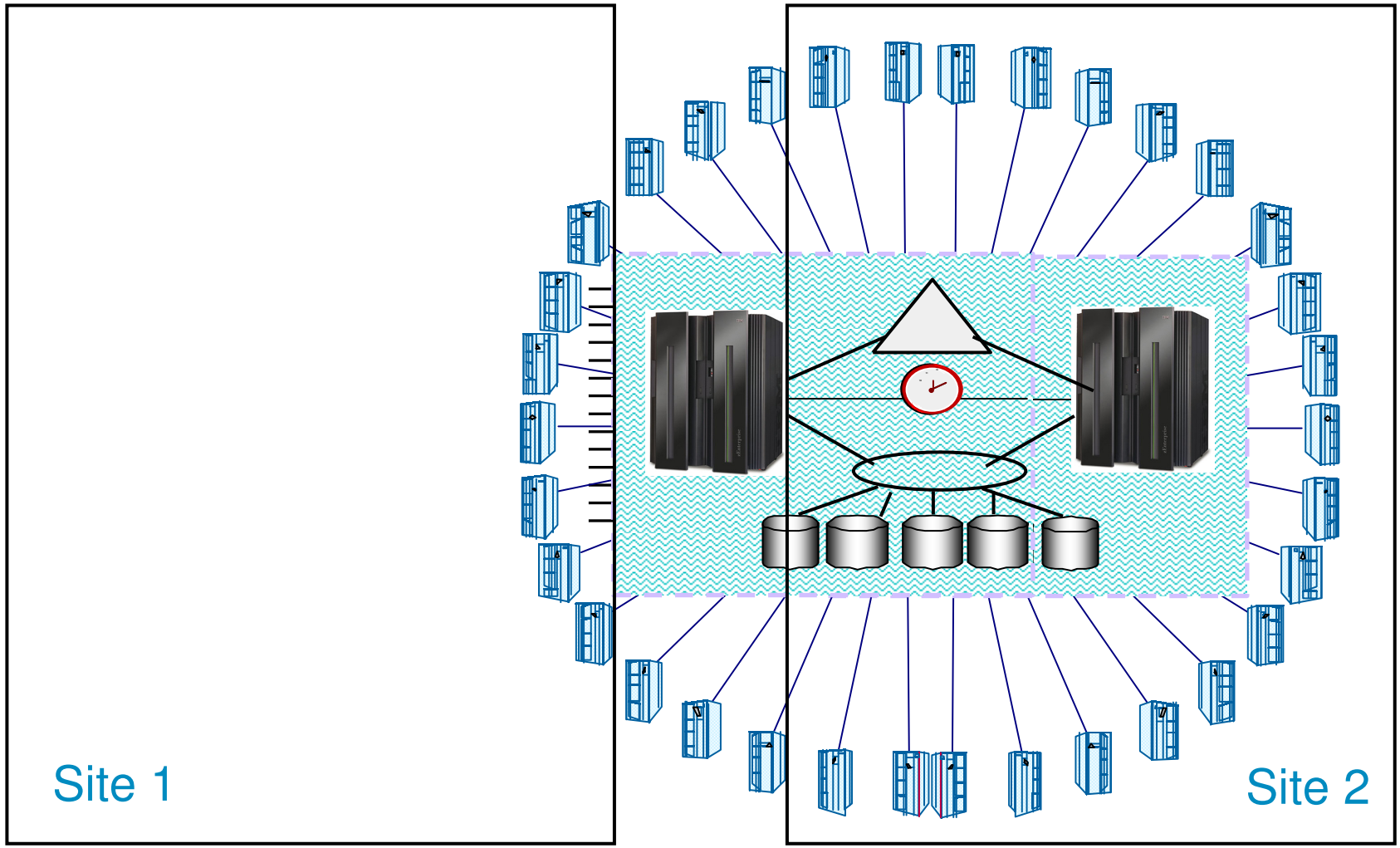


What is GDPS?

- Integrated / Automated solution
- Manages application and data availability in and across sites
  - Monitors systems, disk & tape subsystems
  - Manages planned and unplanned activities
    - System/disk maintenance/failure
    - Site maintenance/failure
- Builds on proven high availability technologies
  - Clustering
  - Remote copy (disk and tape)
  - Automation
- Easy to use interface
  - Intuitive panel interface
  - Simple scripting



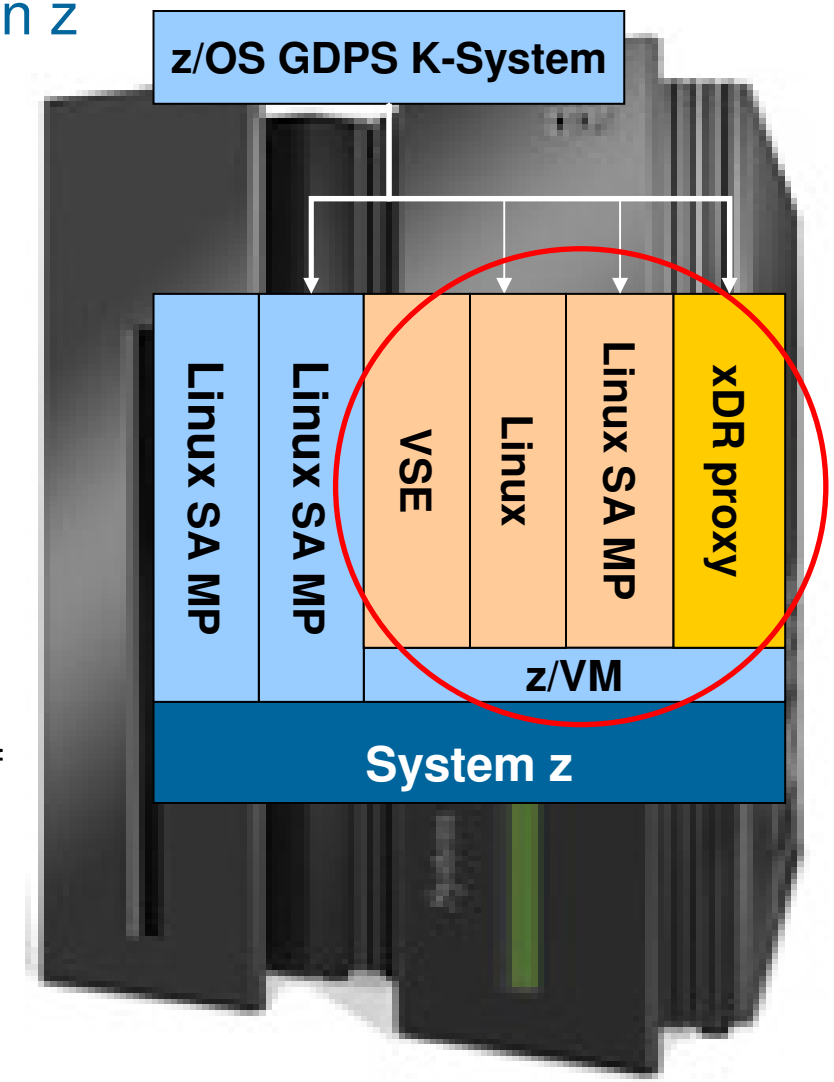
GDPS Topology for z/OS



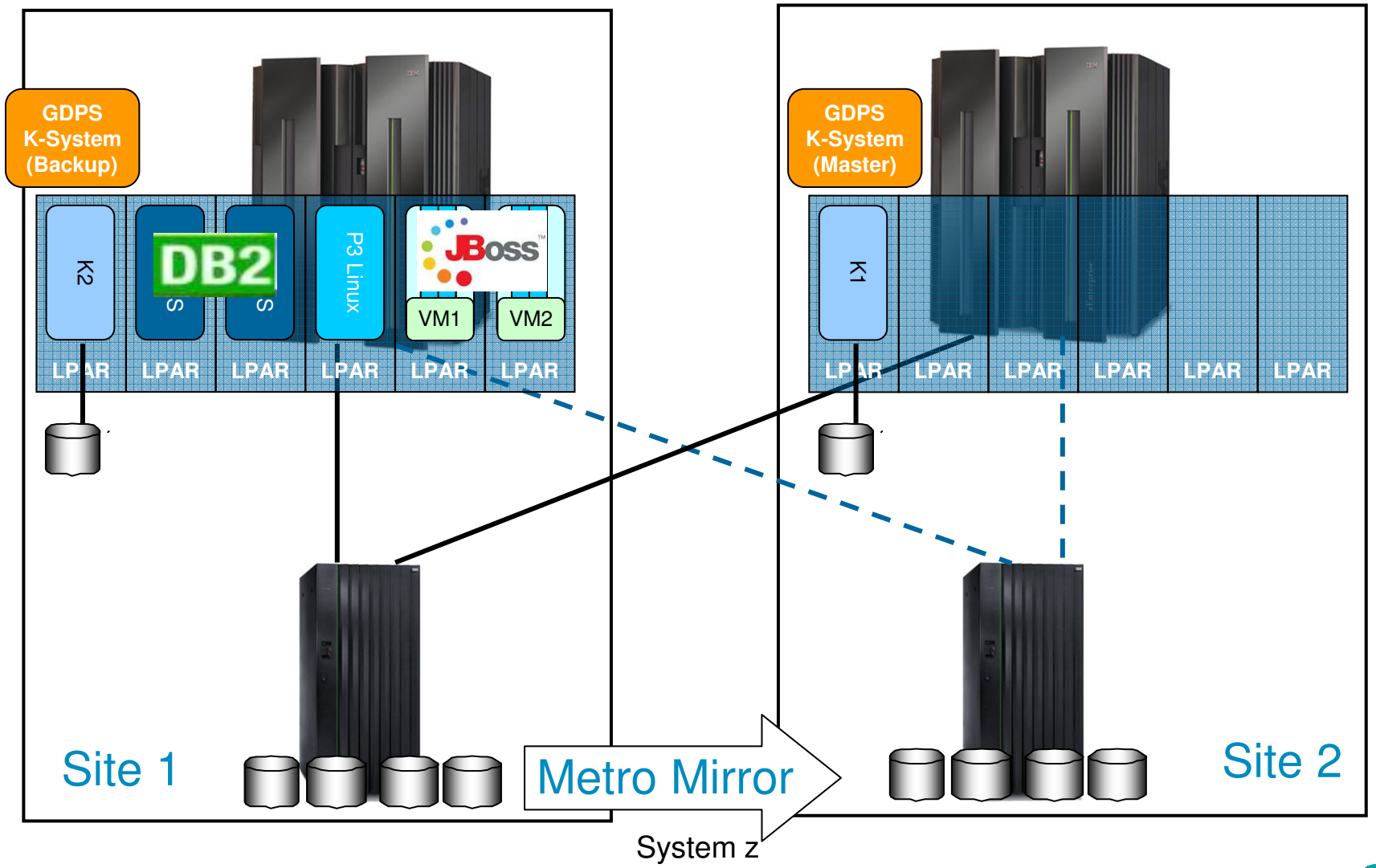
System z

xDR – the GDPS extension for Linux on z

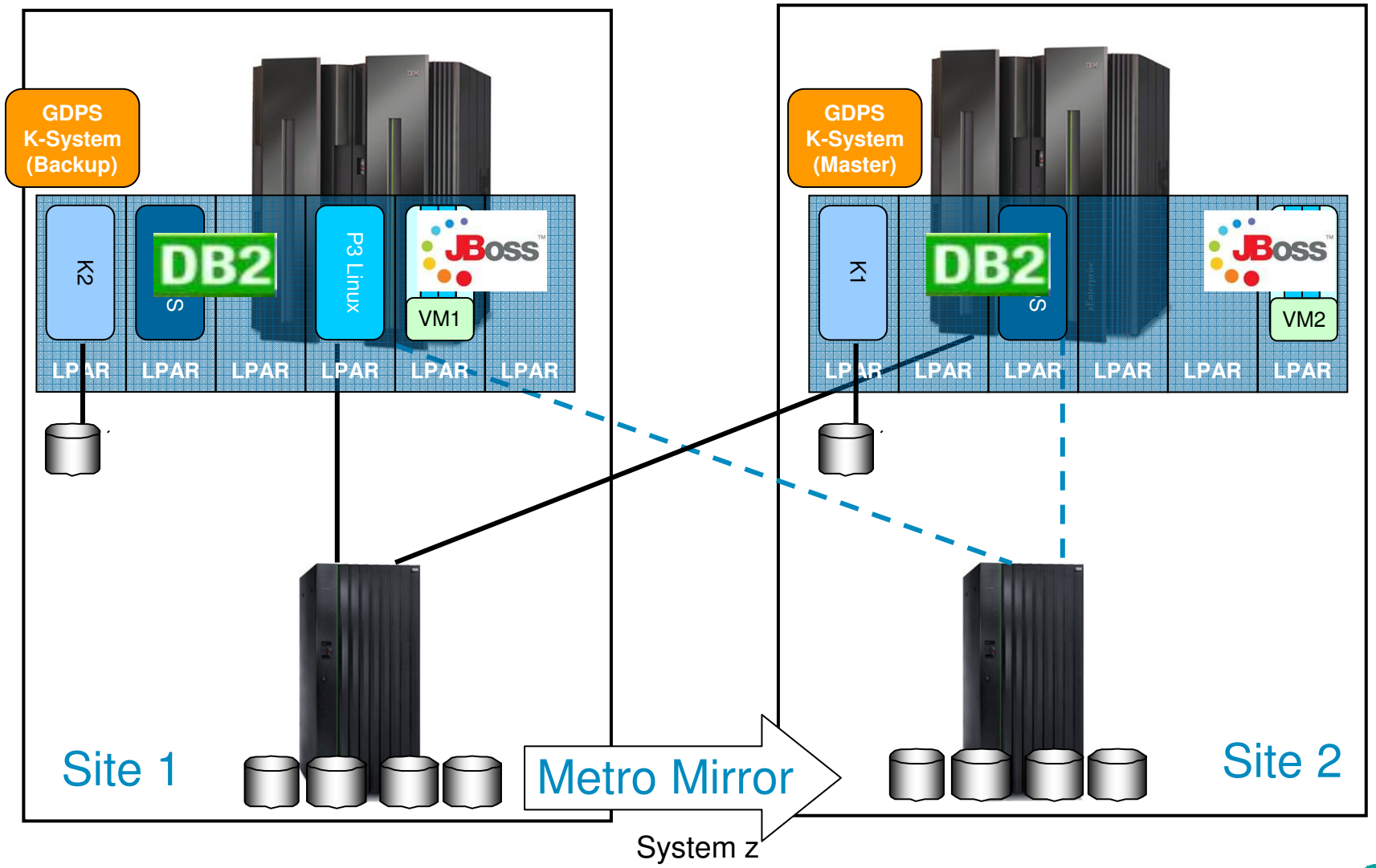
- xDR provides similar DR capabilities for Linux running on System z as GDPS for z/OS
- Highly automated tasks reduce risk for operating errors
- Disaster Detection on Linux e.g. disk failure, system failure
- Clustering and High availability – provides high availability in case of system, application or network failure
- Single point of control from GDPS
- A complete cross-platform disaster recovery task can be done by operator – no need for availability of all experts for e.g. storage team, hardware team, OS team, application team etc.
- Supported Platforms
  - Linux running as guest on z/VM (xDR on z/VM)
  - Linux running native in LPAR (xDR native)
    - Only reduced set of Linux Distributions are supported



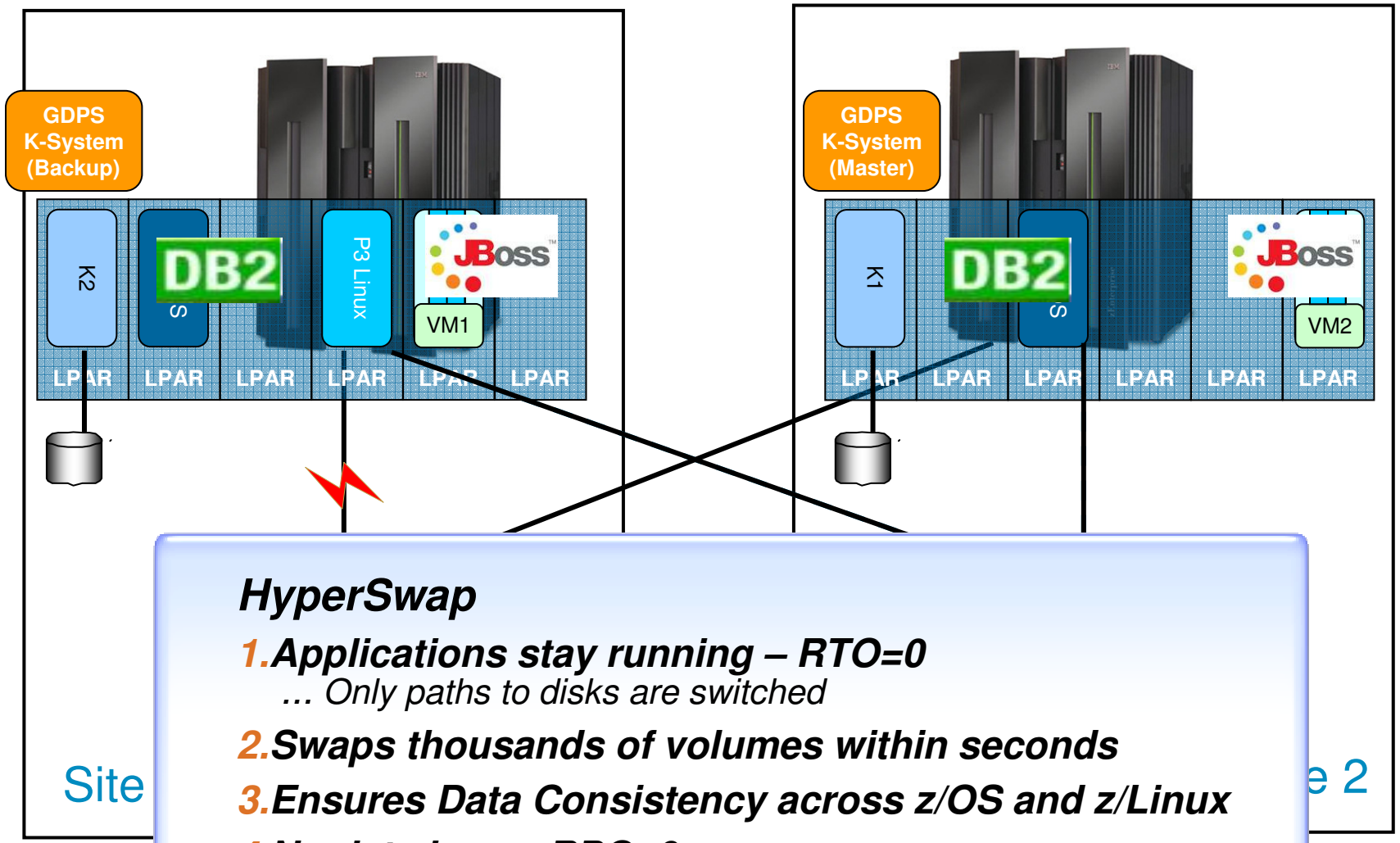
GDPS Topology – Simplified



GDPS with xDR Topology



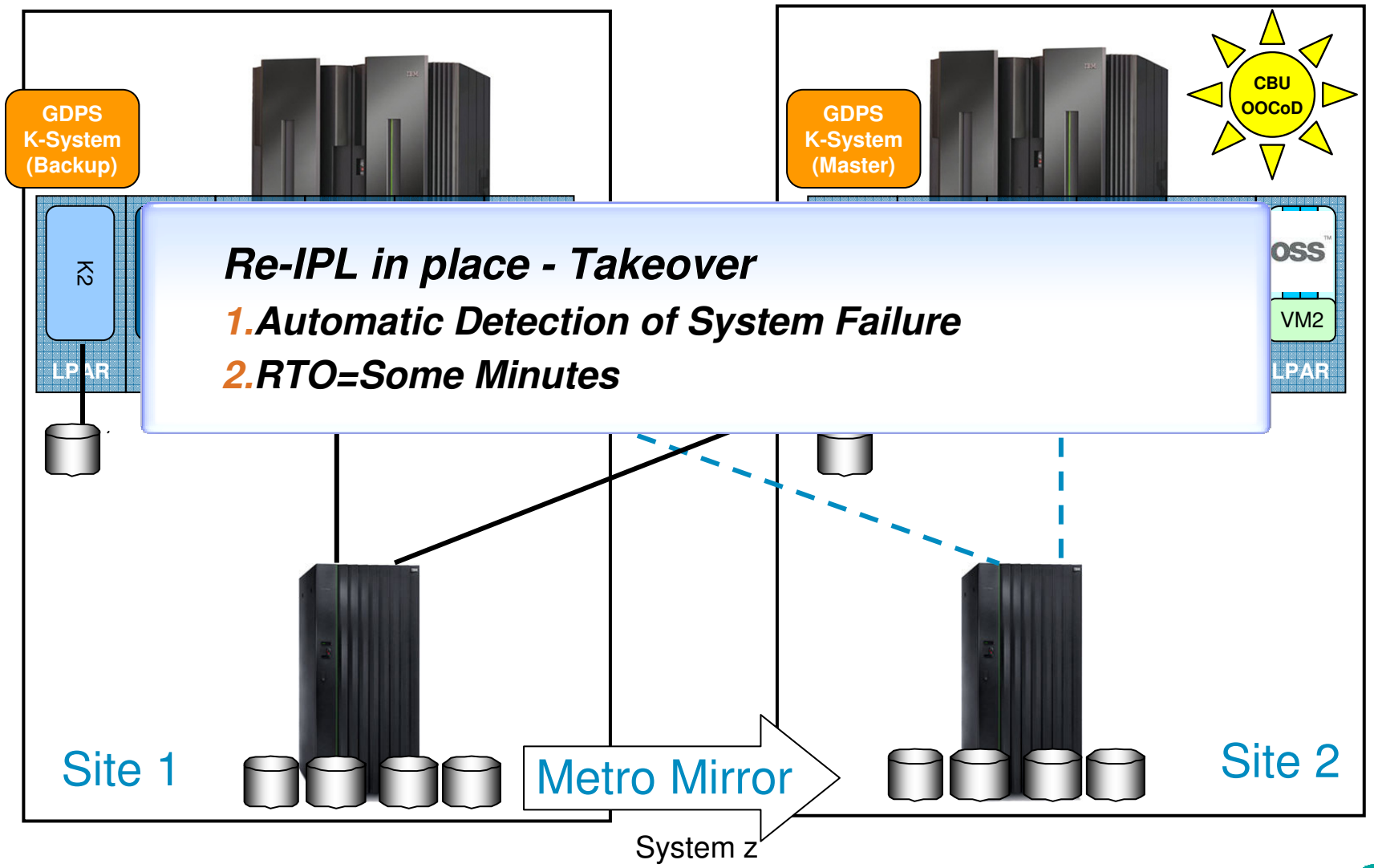
Scenario 1: Continuous Availability of Data



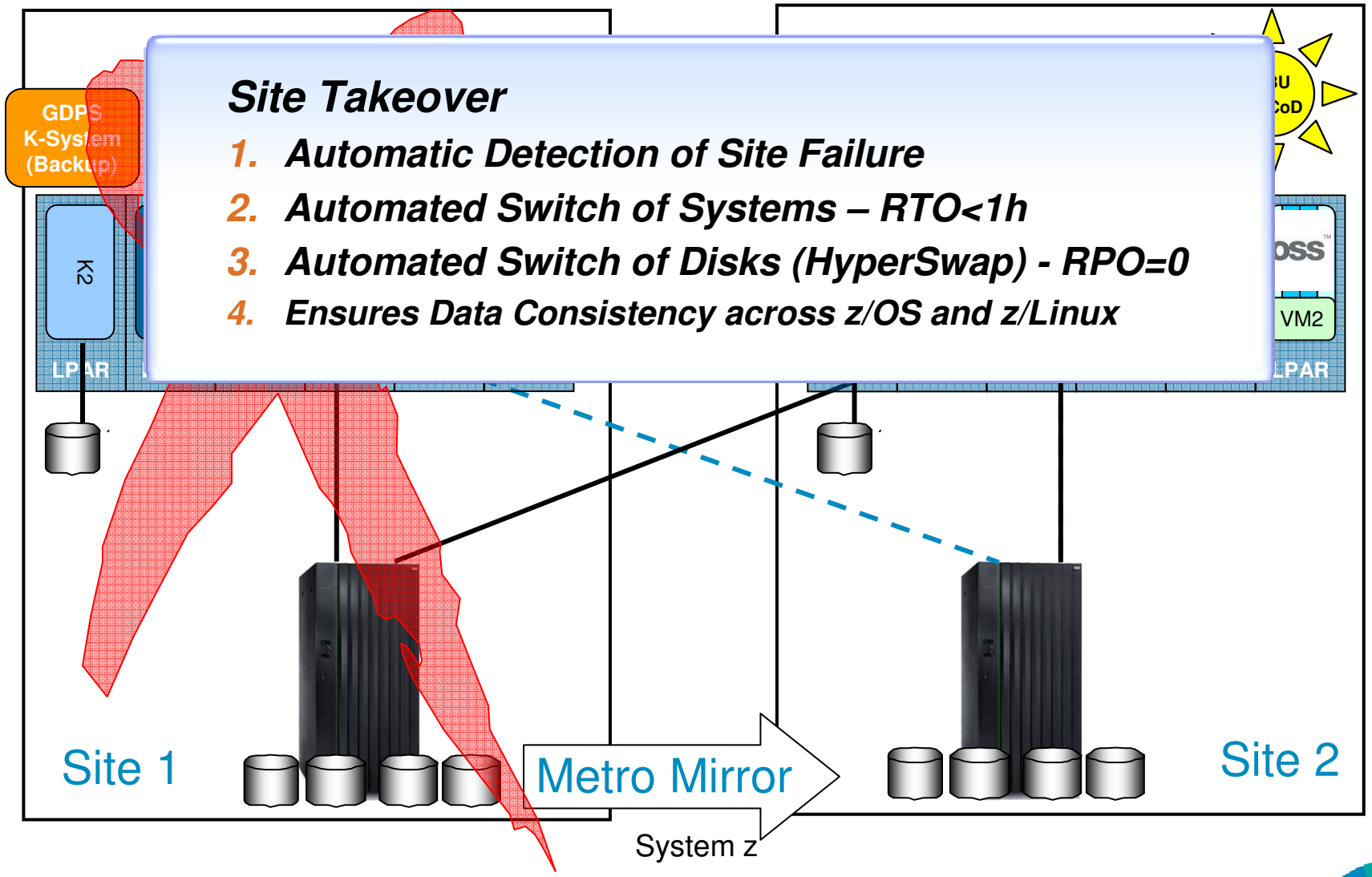
HyperSwap

1. ***Applications stay running – RTO=0***
   … Only paths to disks are switched
2. ***Swaps thousands of volumes within seconds***
3. ***Ensures Data Consistency across z/OS and z/Linux***
4. ***No data loss – RPO=0***

Scenario 3: High Availability of z/VM and guest systems

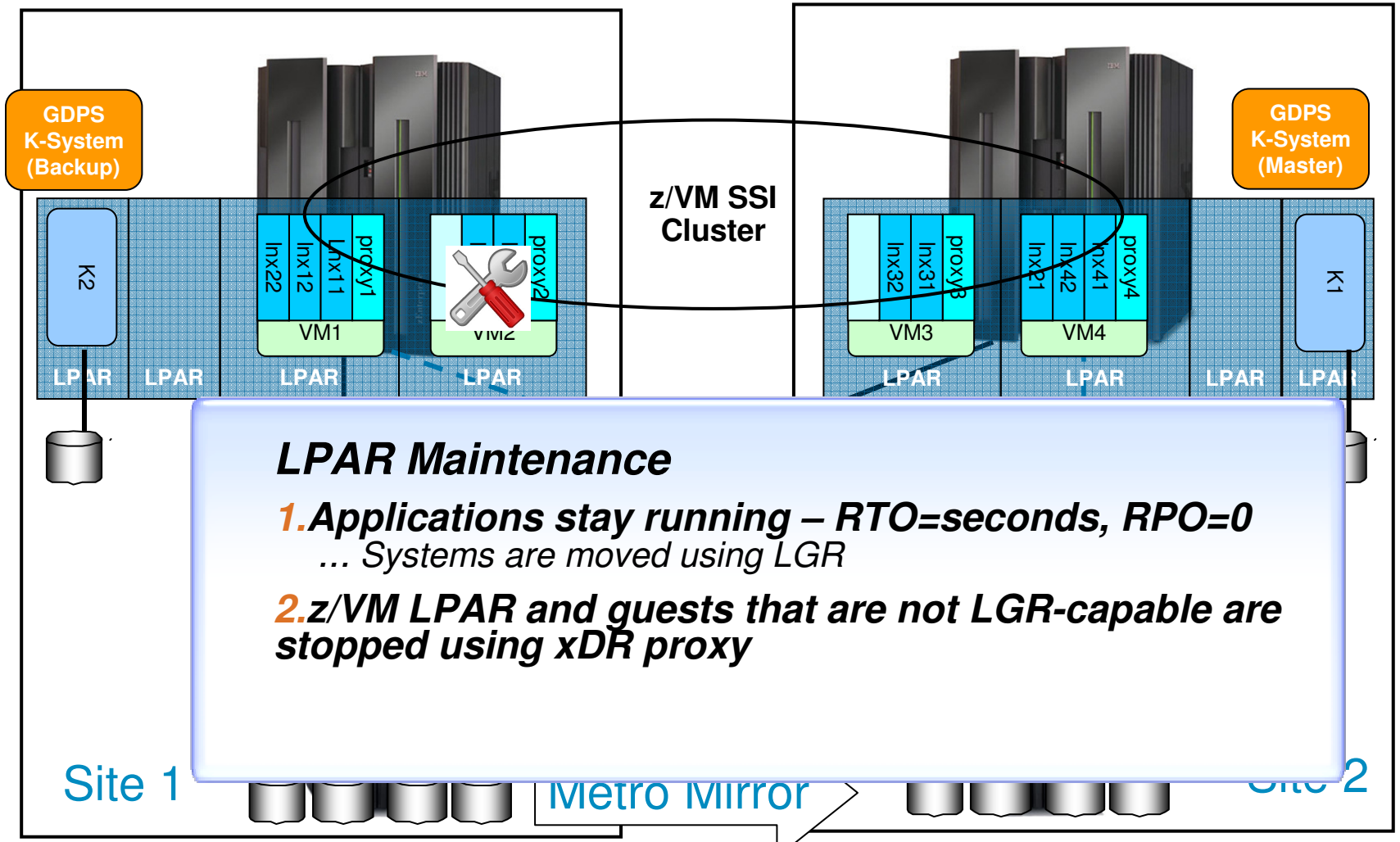


Scenario 4: Site Failure



z/VM SSI and GDPS support

z/VM or LPAR Maintenance - Continuous Availability of z/VM Guests

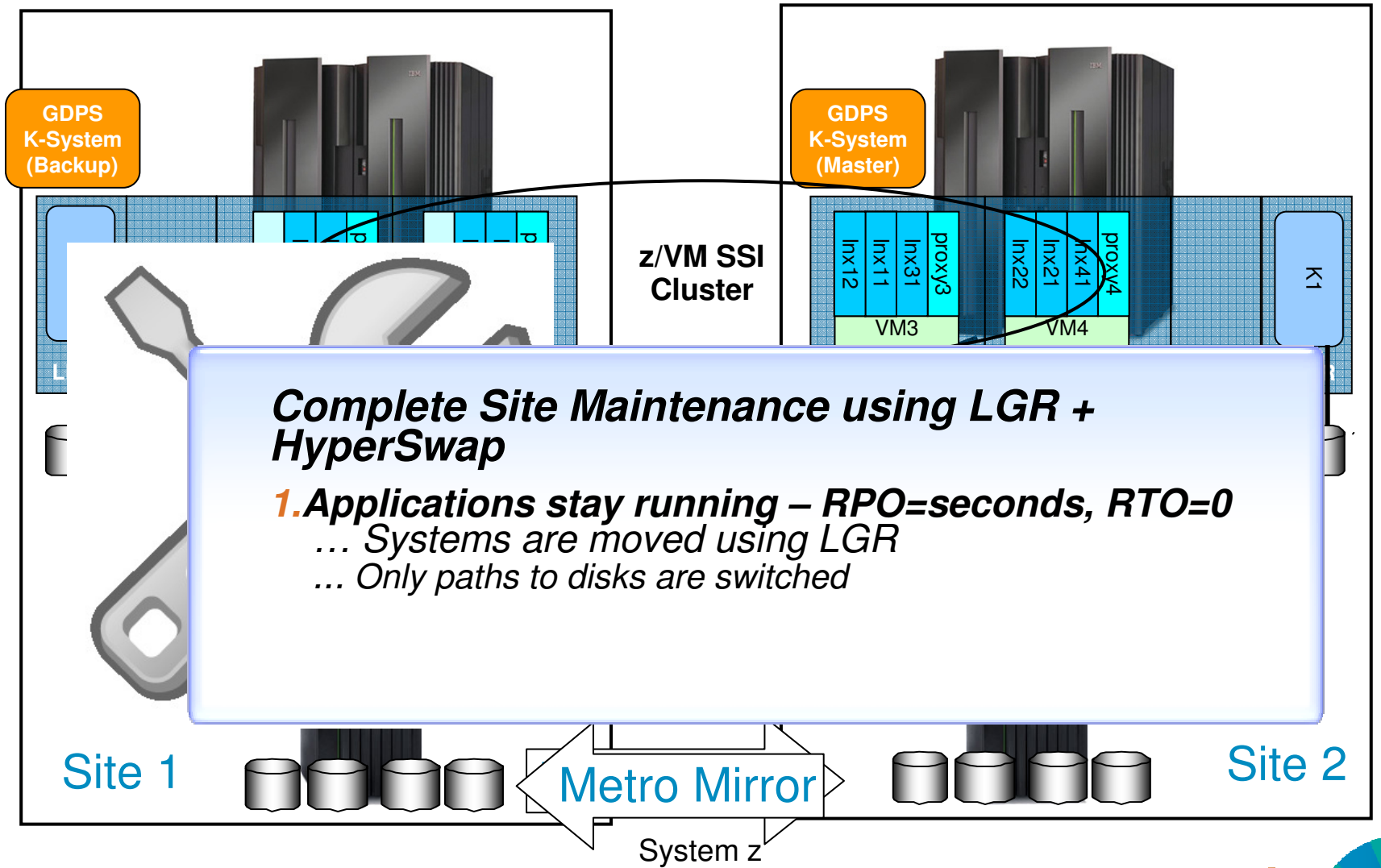


LPAR Maintenance

1. ***Applications stay running – RTO=seconds, RPO=0***
   … Systems are moved using LGR
2. ***z/VM LPAR and guests that are not LGR-capable are stopped using xDR proxy***

z/VM SSI and GDPS support

Site Maintenance - Continuous Availability of z/VM Guests

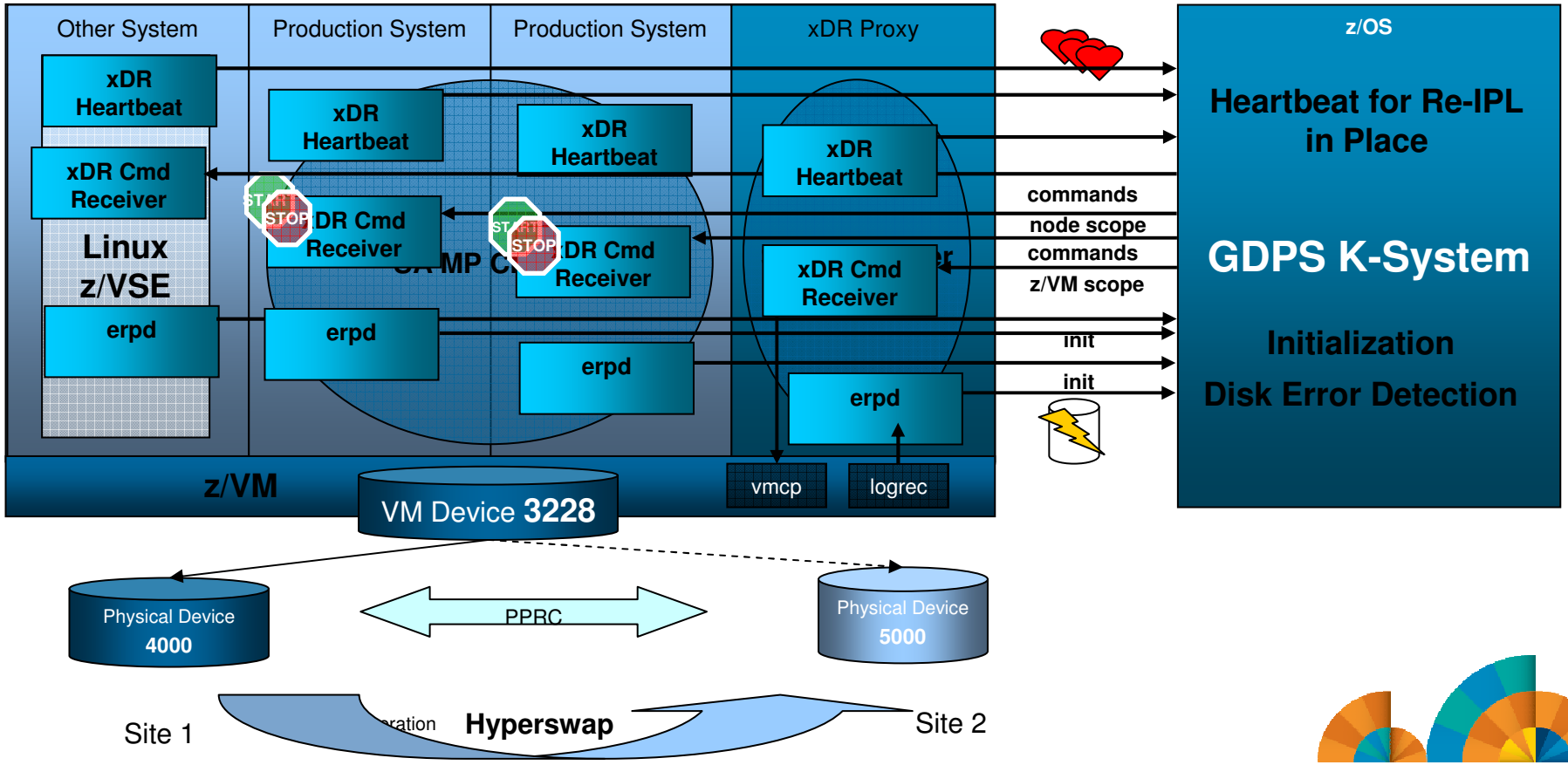


Complete Site Maintenance using LGR + HyperSwap

1. ***Applications stay running – RPO=seconds, RTO=0***
   … Systems are moved using LGR
   … Only paths to disks are switched

HA with z/OS GDPS and xDR with z/VM guests

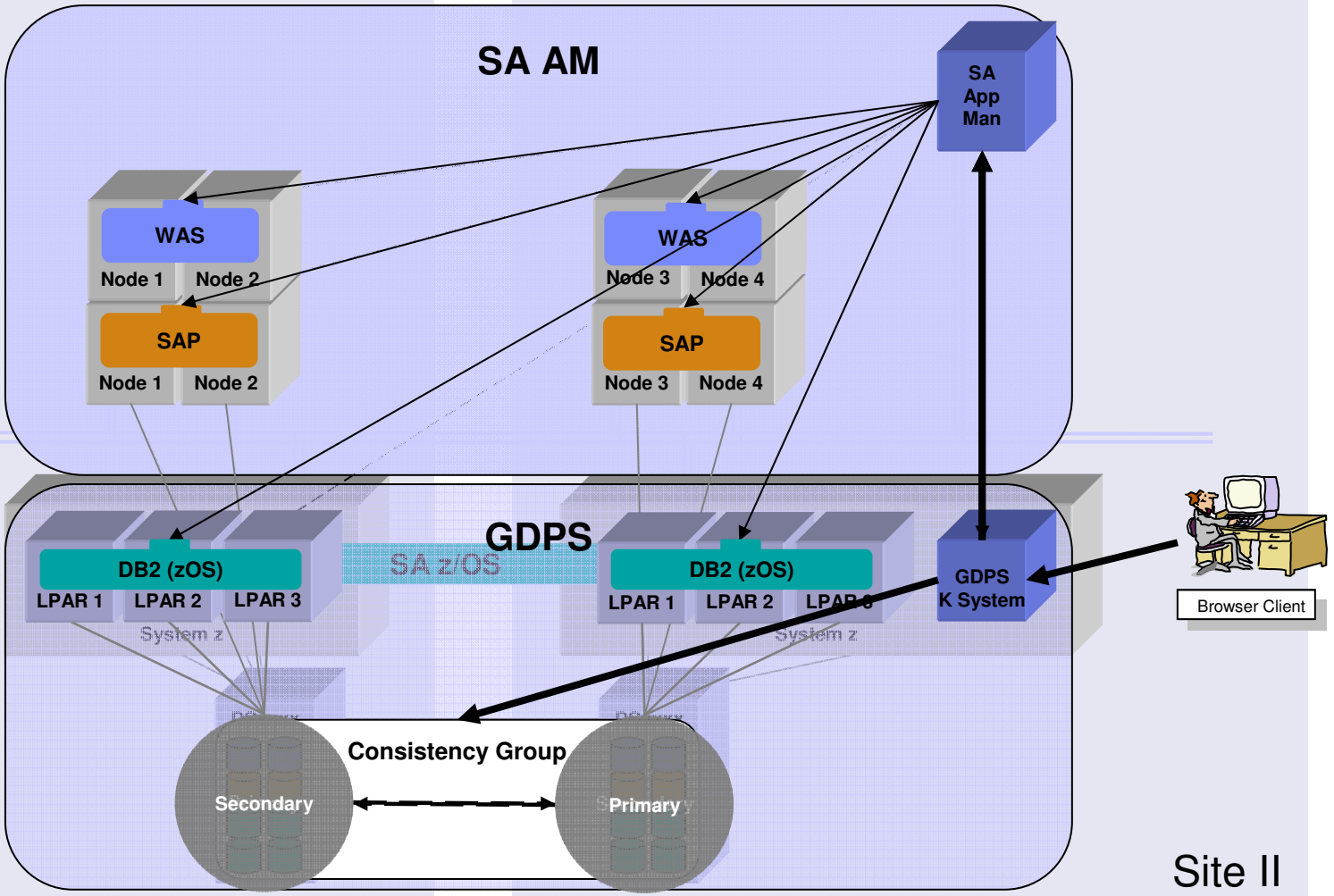
- Proxy
  - One linux system is configured as Proxy for GDPS which has special configuration
    - (Memory locked, Access rights to VM, One-Node-Cluster)
  - Is used for tasks that have z/VM scope
    - HyperSwap, shutdown z/VM, IPL z/VM guest
- Production Nodes
  - Run Linux Workload
  - Are used for local actions (Shut down node, Maintenance Mode)
- Other Systems
  - Enabled for HyperSwap via xDR Proxy (Linux, z/VSE)
  - No re-IPL in place, no start/stop via GDPS (init, reipl, maint)



GDPS/SA AM (DDR) – Planned Site Switch

Steps:

1. Operator initiates planned site switch
2. GDPS triggers SA AM to stop enterprise-wide application components on site 1
3. Switch replication direction
4. GDPS triggers SA AM to start enterprise-wide application components on site II

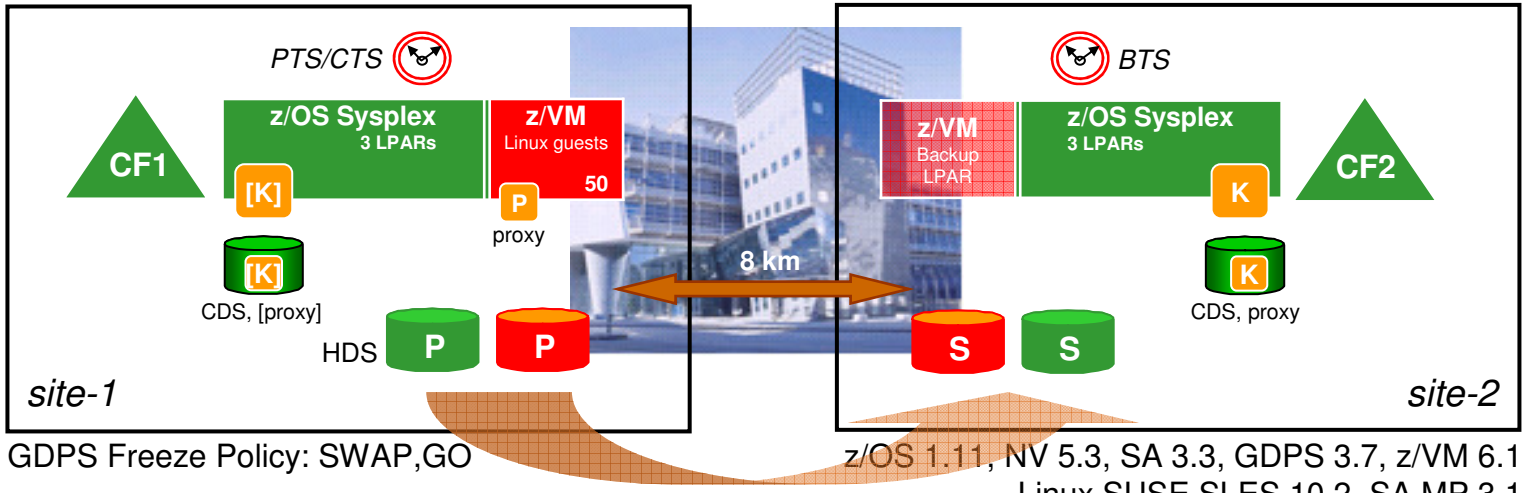


GDPS/PPRC xDR – active / active

- HyperSwap Experience

Bern, Switzerland
[public sector]

7-way zOS Parallel Sysplex (CICS, DB2, Websphere) & zVM Cluster (51 Linux Guests)



GDPS Freeze Policy: SWAP,GO

z/OS 1.11, NV 5.3, SA 3.3, GDPS 3.7, z/VM 6.1
Linux SUSE SLES 10.2, SA MP 3.1

planned & unplanned HyperSwap

Business Requirements:

No data loss (RPO 0 sec)

Continuous data availability for z/OS and Linux hosted by z/VM

Coordinated disaster recovery for heterogeneous System z applications (RTO < 2 hours)

z/OS PPRC Pairs	z/OS LSS	z/VM PPRC Pairs	z/VM LSS	Planned HS RESYNC UIT	Planned HS SUSPEND UIT	Unplanned HyperSwap UIT
414 (3390-9,-54)	4	382 (3390-9,-54)	2	59 sec	16 sec	6 sec

UIT = User Impact Time (seconds)

12/2010

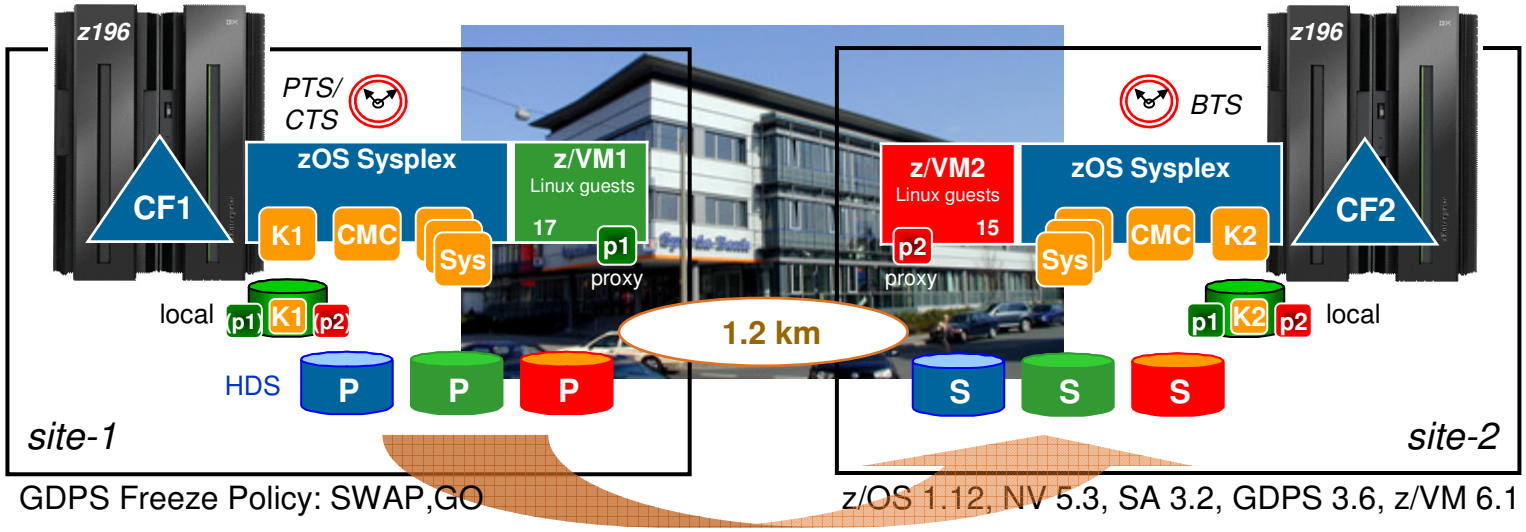
SDV

Nuremberg, Germany
[finance sector]

GDPS/PPRC xDR – active / active

- HyperSwap Experience

10-way zOS Parallel Sysplex (CICS, DB2, Websphere) & two zVM Clusters



GDPS Freeze Policy: SWAP,GO

z/OS 1.12, NV 5.3, SA 3.2, GDPS 3.6, z/VM 6.1

planned & unplanned HyperSwap

Business Requirements:

No data loss (RPO = 0)

Continuous data availability for z/OS and Linux hosted by z/VM

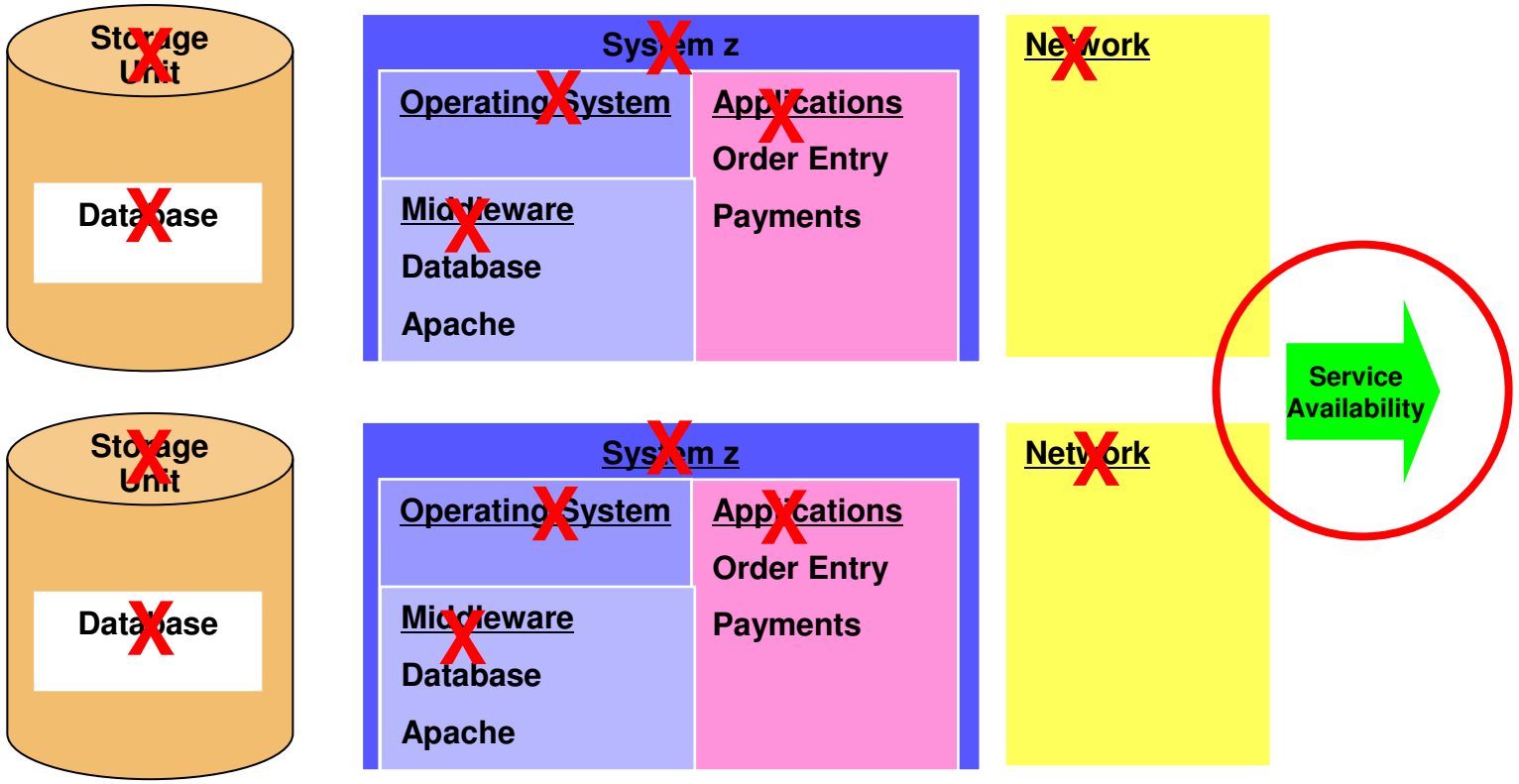
Coordinated disaster recovery for heterogeneous System z applications (RTO < 1 hour)

z/OS PPRC Pairs	z/OS LSS	z/VM PPRC Pairs	z/VM LSS	Planned HS SUSPEND UIT
1,224	**36**	**578** (374 | 204)	**17** (11 | 6)	**4-5 sec**

UIT = User Impact Time (seconds)

10/2010

An ideal High Availability architecture allows service to continue no matter what fails.



- **An HA architecture protects the service from product failures by eliminating Single Points of Failure (SPoFs) at all layers (not just internal within the box).**
  - –Facilities, HW & SW components, Middleware or subsystems, Applications, Dat, etc.a
- **This ideal approach is typically referred to as an active/active solution and may eliminate any service disruption for a single failure scenario.**

Find Information Online

https://www.ibm.com/developerworks/servicemanagement/dca/index.html

Additional documentation

- Linux-HA project Open source
  http://www.linux-ha.org/wiki/Main_Page
- Suse SLES 11 SP2 High Availability Guide
  http://www.suse.com/documentation/sle_ha/pdfdoc/book_sleha/book_sleha.pdf
- Tivoli System Automation for Multiplatforms
  http://www-01.ibm.com/software/tivoli/products/sys-auto-multi/
- Redbook:
  - Achieving High Availability on Linux for System z with Linux-HA Release 2
    SG24-7711 : http://www.redbooks.ibm.com/abstracts/sg247711.html?Open

Questions?

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