Why Linux on

IBM System z

version 1.0

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Notes:

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.

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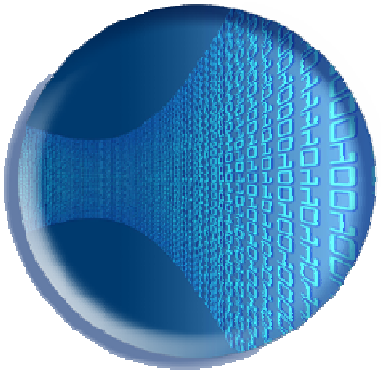
Why Linux on System z - Topics

- **Data Centers**
- **System z Virtualization**
- **System z Engines**
- **System z Security**
- **System z**
  - High Availability (HA)
  - Disaster Recovery (DR)



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System z

Data Centers

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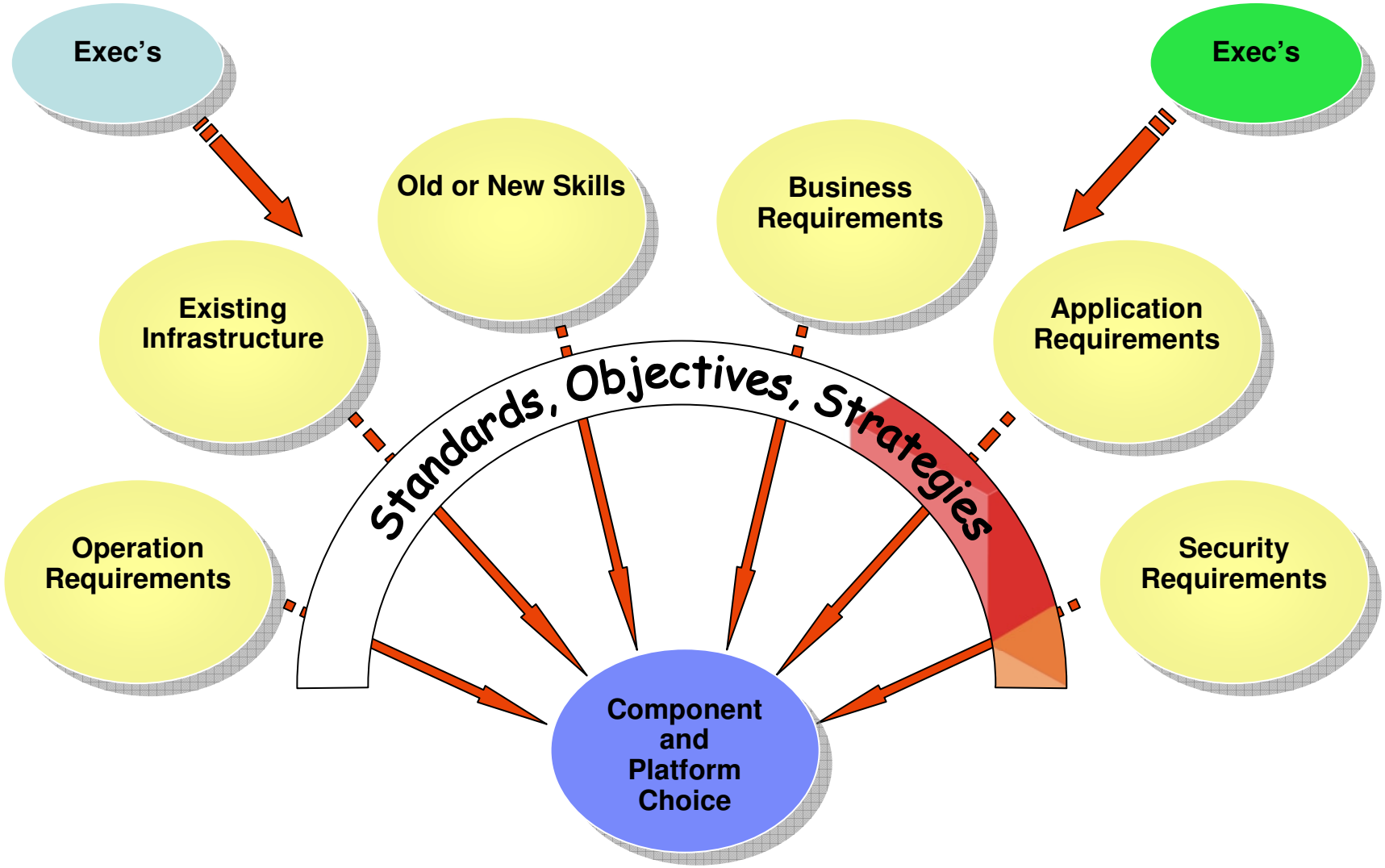
Factors in choosing a platform



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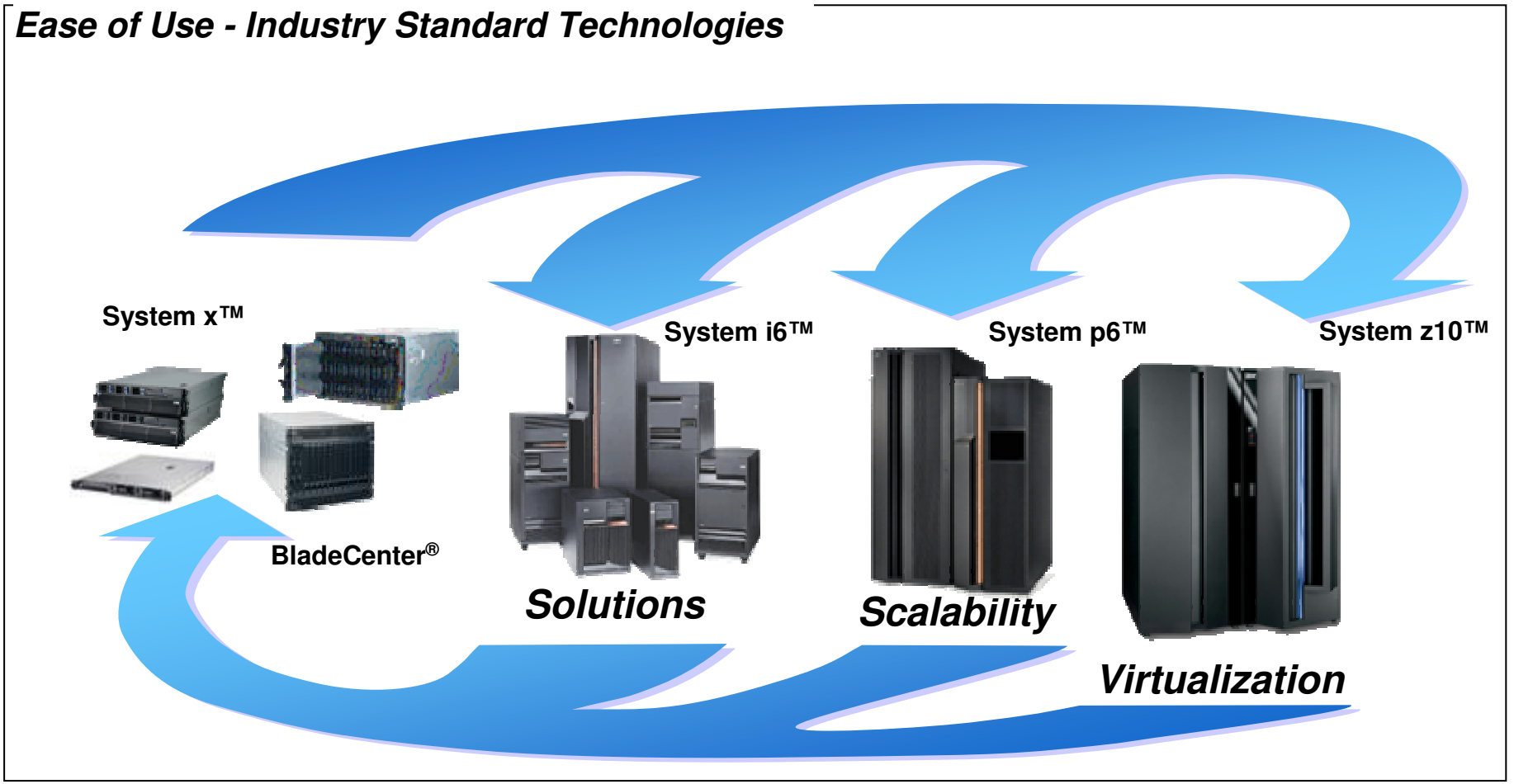
IBM STG Architecture

A design blueprint for building proven IBM enterprise capability



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New Enterprise Data Center

- Evolutionary
- Resilient
- Efficient

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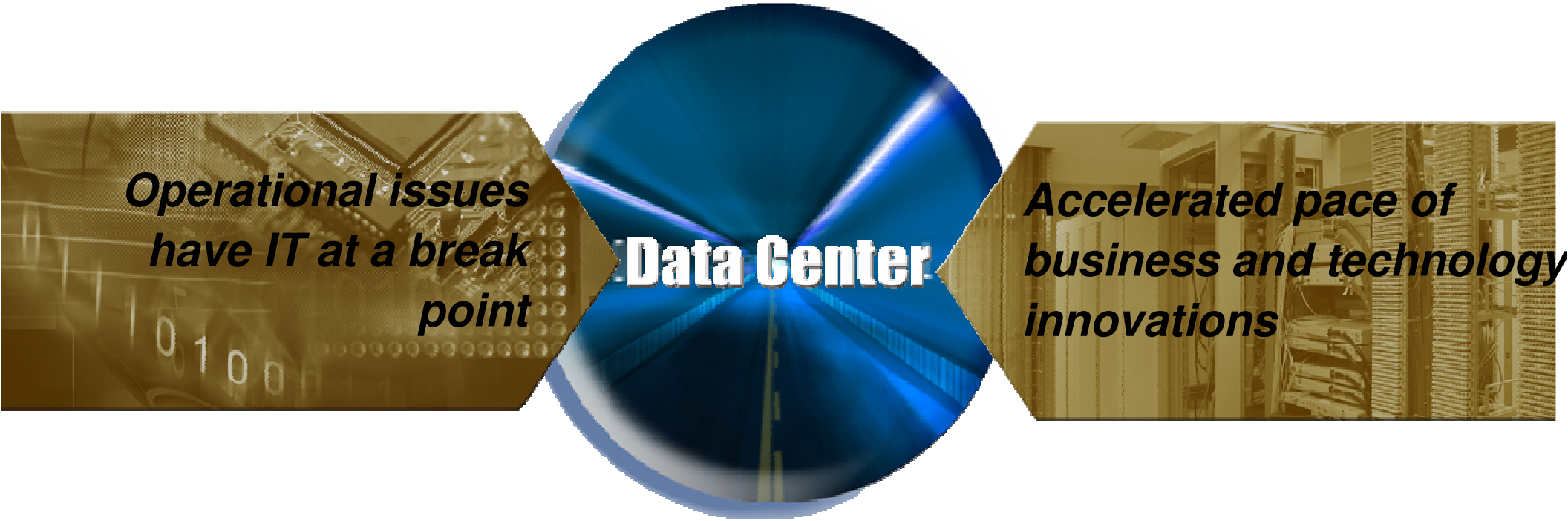
Multiple forces are driving a transformation of the data center



Energy costs 8x

Management costs 4x

70% of IT budget is operational overhead

Globalization

Acquisitions

Green

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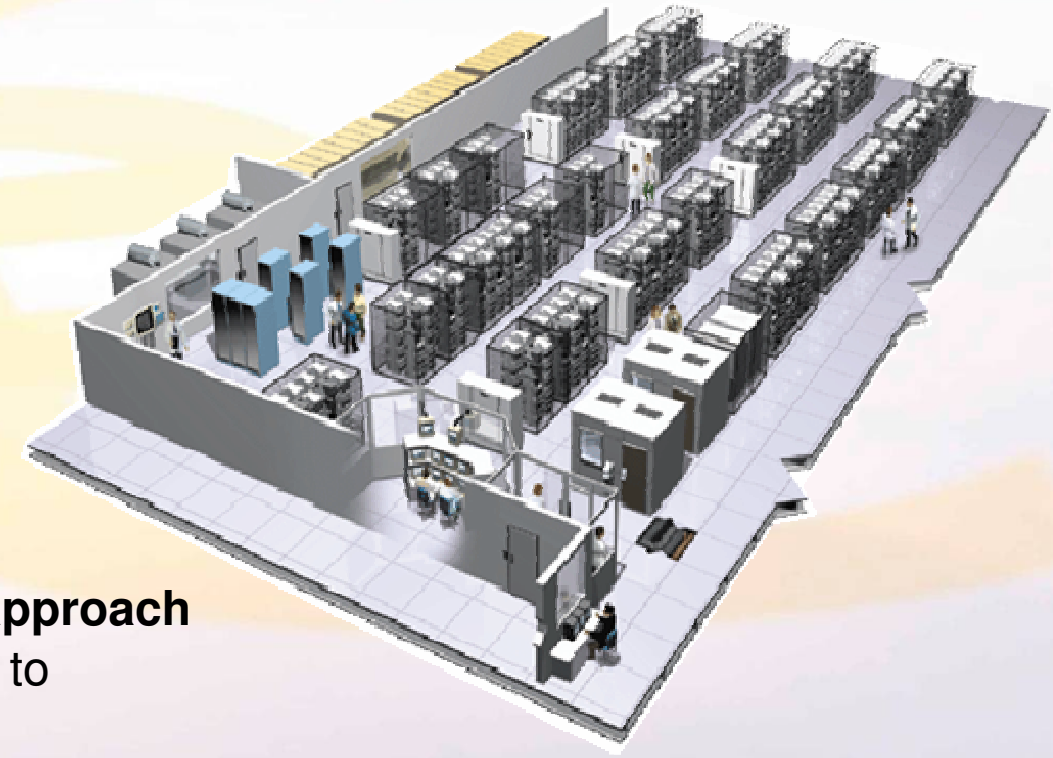
We really examined the growth of distributed servers in Data Centers

A source of complexity and cost, and a Savings Opportunity

Distributed-systems can proliferate IT costs:

- Cost and complexity (e.g., more physical servers, real network gear)
- Excessive energy usage and heating problems
- Inadequate power and cooling infrastructure
- Data silos and data synchronization
- Linear staffing costs
- Linear per processor software costs
- Frequent outages



IBM System z10 EC suggests an alternate approach

- Use fewer, more powerful z10 EC servers to unlock the savings in your Data Centers

LESS IS MORE – Focus on highly efficient use of FEWER servers

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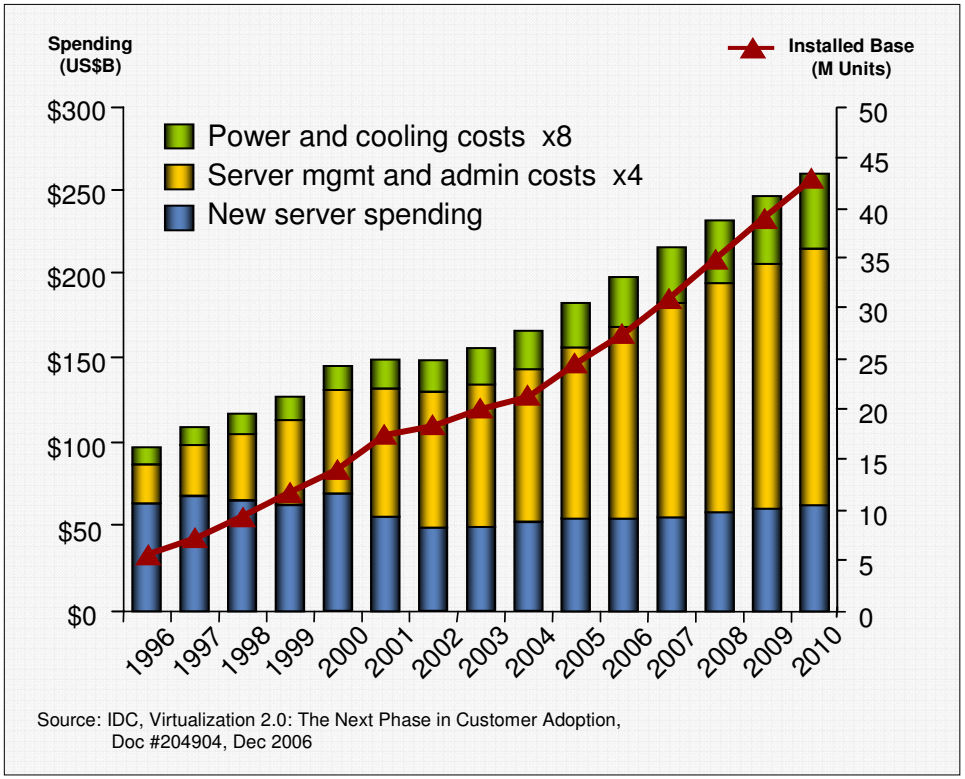
Cost of Ownership

- **TCO model should include all relevant costs**
  - People costs have doubled as a % of total IT cost since 1996
  - Software costs have grown linearly. Much of it is CPU based.
  - Energy costs could approach total hardware spend in the next several years
  - Hardware spend has been flat



Source: IDC, Virtualization 2.0: The Next Phase in Customer Adoption, Doc #204904, Dec 2006

A TCO model that focuses primarily on hardware spend will ignore many of the most significant costs in the datacenter.

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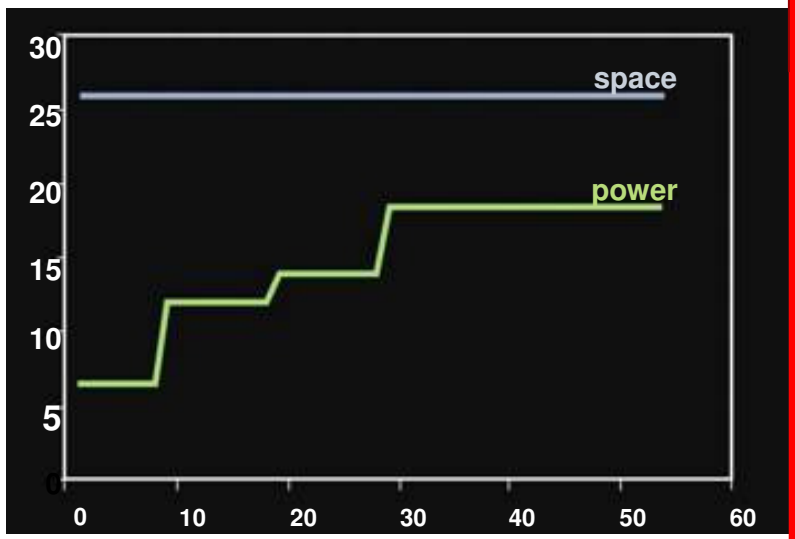
When consolidating Linux on low utilization Intel servers, the System z10 Mainframe's ability to provide high utilization may help to reduce both power and facility costs

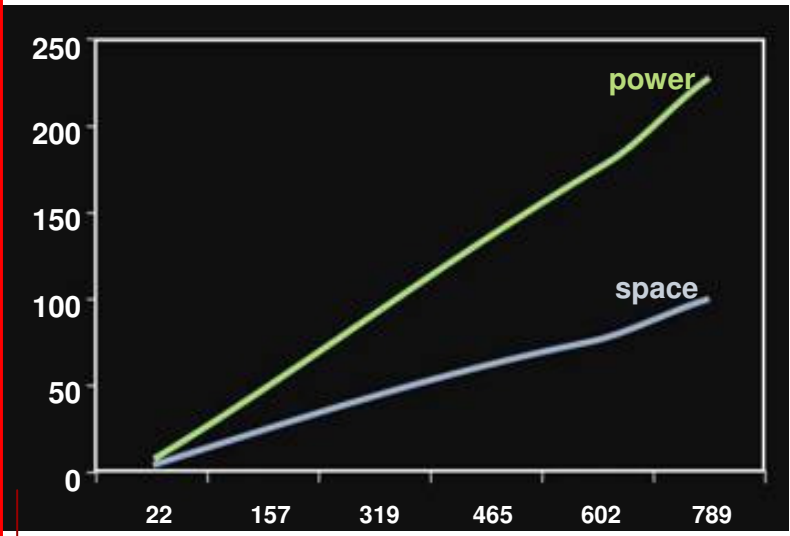
Power and Space Consumption

In a consolidation, the System z10 may provide up to 4 times the same work in the same space and may provide up to 12 times the work for the same power consumption

System z10 EC



Linux on Intel



The Linux on Intel servers selected in this example are functionally eligible servers considered for consolidation to a System z running at low utilization such that the composite utilization is approximately 5%. The utilization rate assumed for System z10 EC is 90%. This is for illustration only, actual power and space reductions, if any, will vary according to the actual servers selected for consolidation.

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Linux on System z - Potential Candidates

Medium Peak to Average or Small Workloads (HW / SW Savings)

- Development and test
- Apps with multiple environments that cumulatively have medium peak to average ratios
- Oracle/DB2 databases
- WebSphere
- Tivoli Monitoring
- Sandbox / Training servers

Quality of Service (People / Business Impact)

- System z Hardware RAS
- z/VM - very mature Hypervisor
- Fewer critical Linux patches
- Service bureau virtual hosting
- Lotus Domino
- Infrastructure – LDAP, DNS, TSM, TIM/TAM, FTP
- Critical DR applications

Co-located Applications (with z/OS or other Linux) (Performance / Security / HW)

- CICS / IMS Gateways
- DB2 connect
- Applications with significant z/OS data affinity such as WAS
- SAP Application Servers with z/OS database
- Communication Controller
- MQSeries Queue Manager
- IBI WebFOCUS
- Chatty Linux applications
- Applications that could eliminate security layers between components

Reduce other TCO Factors (People/Other Savings)

- Application environments that can be cloned or replicated (e.g. WebSphere)
- Applications/middleware that can take advantage of shared OS or application binaries
- Speed to market

Linux Strategy (People / Flexibility)

- Significant industry growth in the Linux applications
- IFLs have strong IT industry adoption
- Common OS across platforms reduces administrative costs

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Smart, new approaches to data center IT management

Leveraging the best traditional structures with new high level approaches

Industrial Strength, Universal Connectivity

Content Browsers Standards

Transactions Systems Mgmt

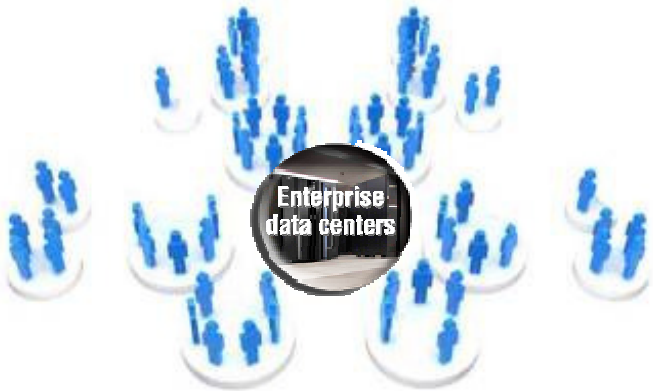
Web Servers Availability

Security Java

Traditional IT

Cloud Computing

Efficient, dynamic and responsive



Fragmented, less efficient islands of computing

Massive Scalability, Rich Diversity

Business Services Autonomic Management

Sensors Devices Real-time Info

Consumer Services Massive Compute Capacity

Scale-out data center designs

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System z

Virtualization

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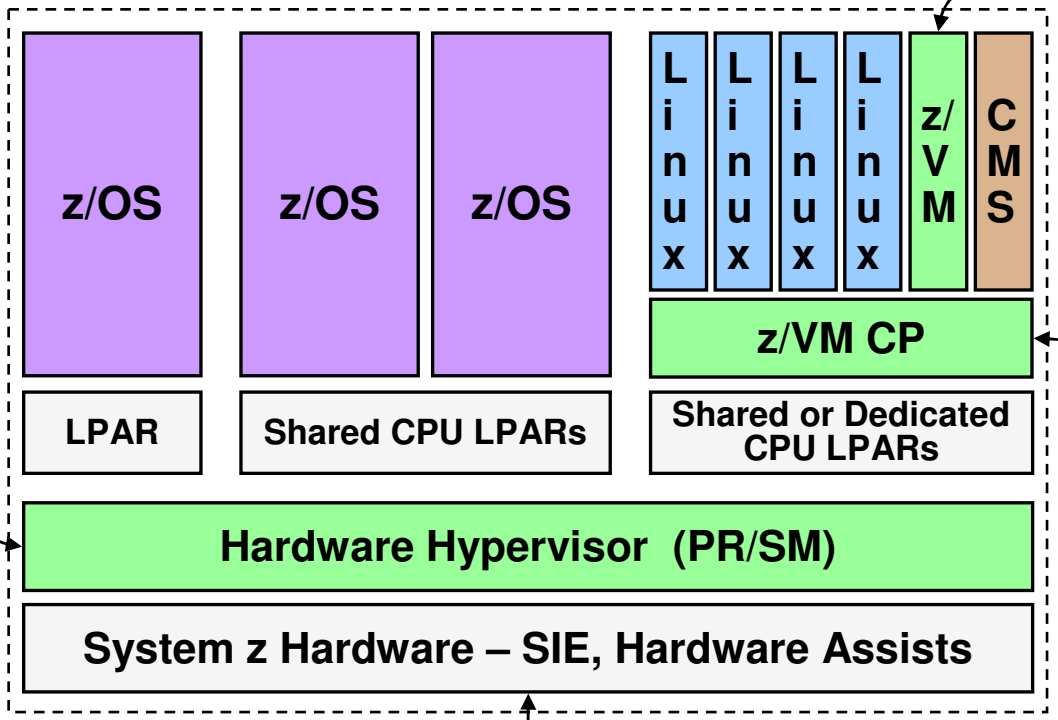
System z Virtualization

Can run z/VM as a guest under z/VM

Isolates and dispatches LPARs

Facilitates virtualized networking between LPARs

Uses virtualization hardware



Isolates and dispatches guests

Provides virtualized CPU, memory and I/O for guests

Other guest services

Uses virtualization hardware

- The majority of virtualization functions are done directly in hardware
- Hardware - saves and loads guests, does address translation, optimizes wait states and spin locks, provides timer facilities, reflects I/O and timer interrupts directly to guests, provides buffer state management for QDIO, allows for second level Hypervisor (z/VM), and other functions
- Results in low latency, low overhead virtualization capabilities

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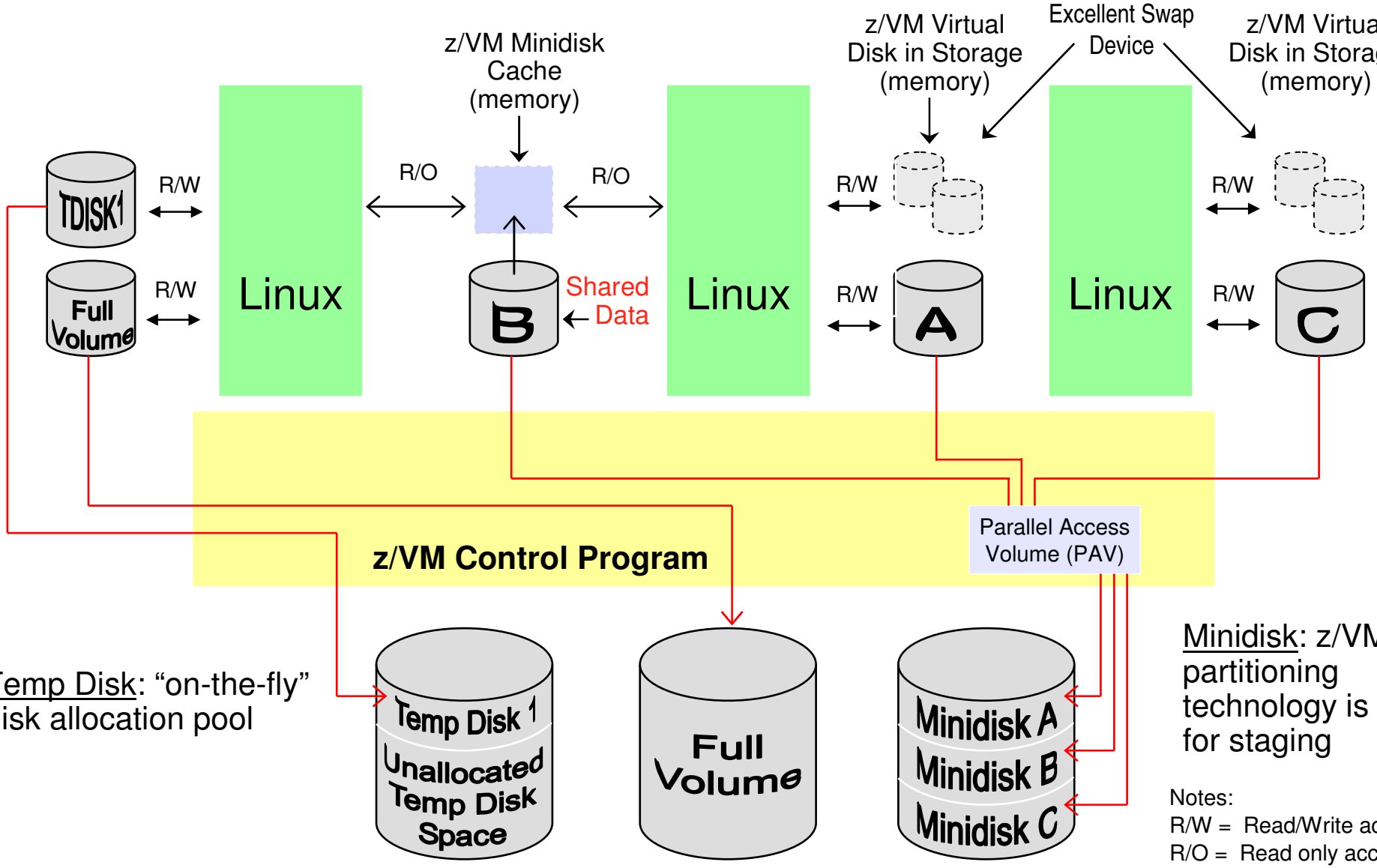
z/VM Technology: Advanced Disk Support



Temp Disk: "on-the-fly" disk allocation pool

Minidisk: z/VM disk partitioning technology is great for staging

Notes:
R/W = Read/Write access
R/O = Read only access

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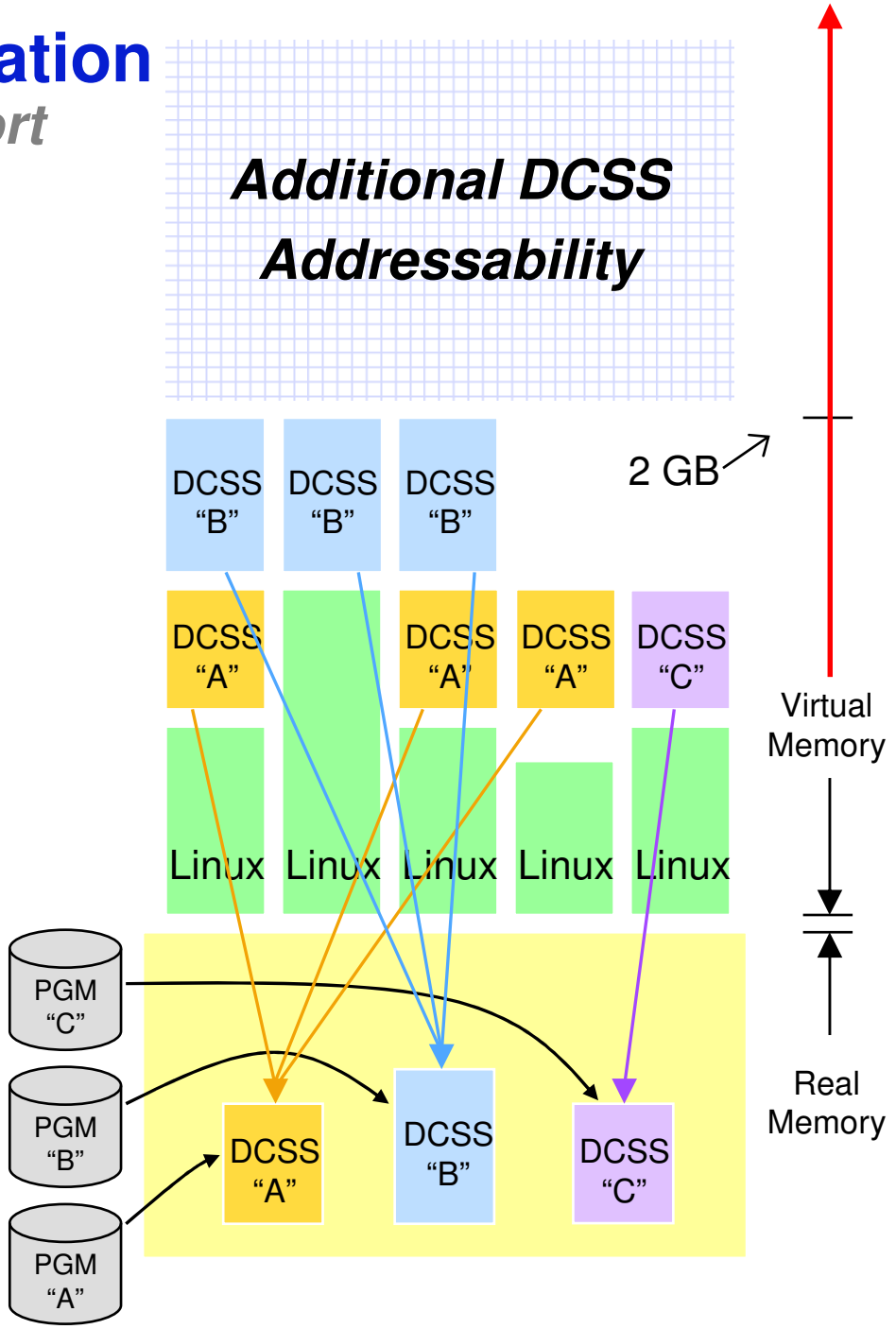
Extreme Linux-on-z/VM Virtualization

Linux Exploitation of z/VM DCSS Support

- Discontinguous Saved Segments (DCSS)
  - Share a single, real memory location among multiple virtual machines
  - Can reduce real memory utilization
- Linux exploitation: shared program executables
  - Program executables are stored in an execute-in-place file system, then loaded into a DCSS
  - DCSS memory locations can reside outside the defined virtual machine configuration
  - Access to file system is at memory speeds; executables are invoked directly out of the file system (no data movement required)
  - Avoids duplication of virtual memory
  - Helps enhance overall system performance and scalability
- **z/VM V5.4 support enhancements:**
  - Segments can reside above 2 GB address line
  - Enables even greater system scalability
  - New addressing limit is 512 GB



Note: Maximum size of a single DCSS is 2047 MB

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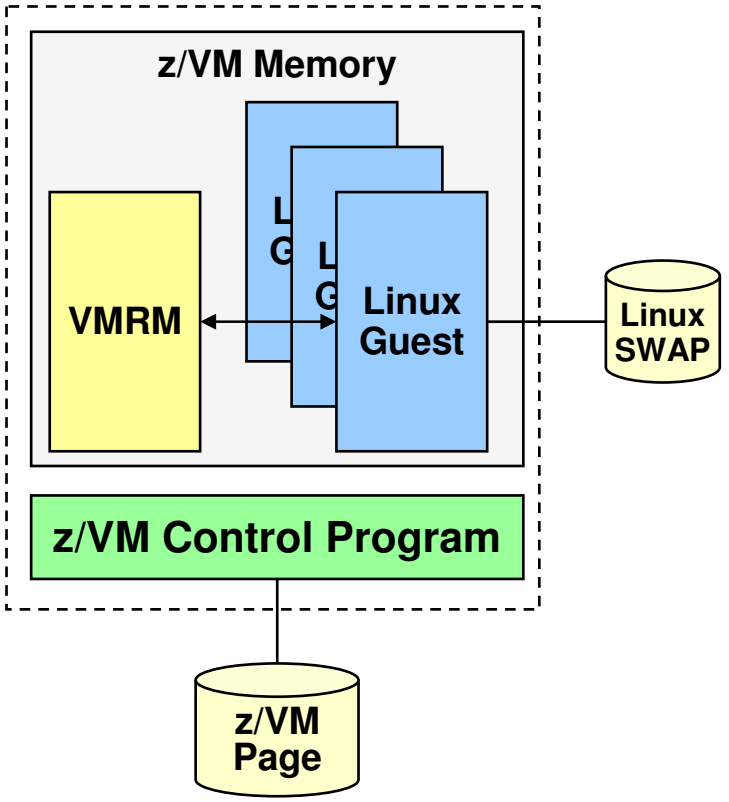
Linux and z/VM Technology Exploitation

Cooperative Memory Management (CMM)

- **Problem scenario:**
  - Virtual memory utilization exceeds real memory availability
  - z/VM paging operations become excessive
  - Overall performance suffers
- **Solution:**
  - Real memory constraint detected by z/VM Virtual Machine Resource Manager (VMRM)
  - Linux images signaled to reduce virtual memory consumption
  - Linux memory pages are released
  - Demand on real memory is reduced
  - Improves performance and throughput



http://www.vm.ibm.com/sysman/vmrm/vmrmcmm.html

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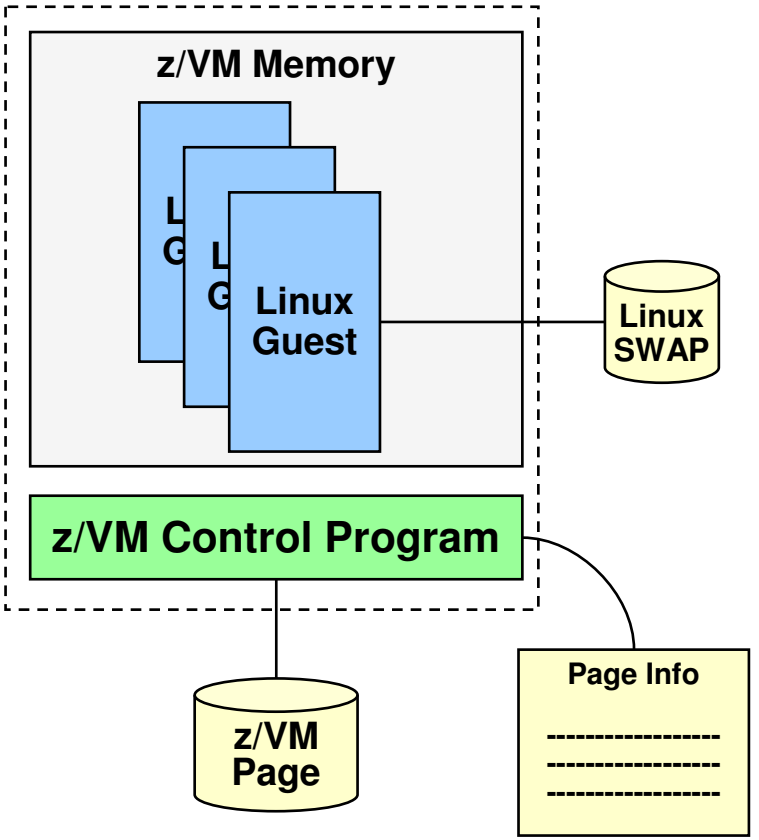
Linux and z/VM Technology Exploitation

- **Collaborative Memory Management Assist**
  - Coordination of memory and paging between Linux and z/VM to the level of individual pages
  - z/VM knows when..
    - Linux has released a page of memory
    - Linux is able to just re-read a page from disk
    - Pages are meaningless to Linux
- **Linux knows which pages are resident**
  - Supported by System z9 and z/VM V5.3, SLES10, upstream in Linux kernel
- **Host Page-Management Assist**
  - Allows the hardware to assign, lock, and unlock page frames without z/VM assistance



Can help z/VM host more virtual servers in the same amount of memory

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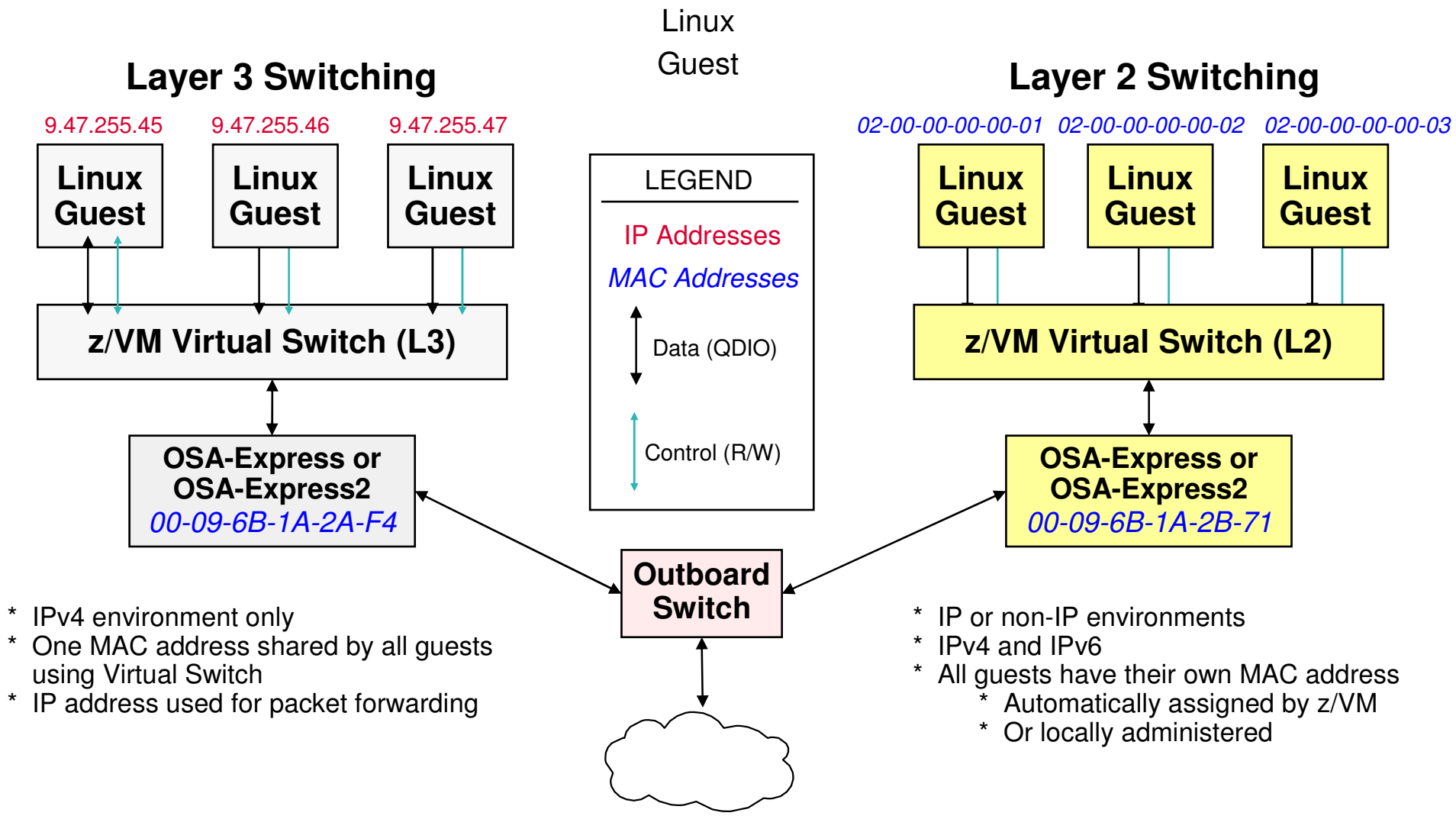
z/VM Virtual Switch Support

Layer 3 Compared to Layer 2 Switching



* IPv4 environment only
* One MAC address shared by all guests using Virtual Switch
* IP address used for packet forwarding

* IP or non-IP environments
* IPv4 and IPv6
* All guests have their own MAC address
  * Automatically assigned by z/VM
  * Or locally administered

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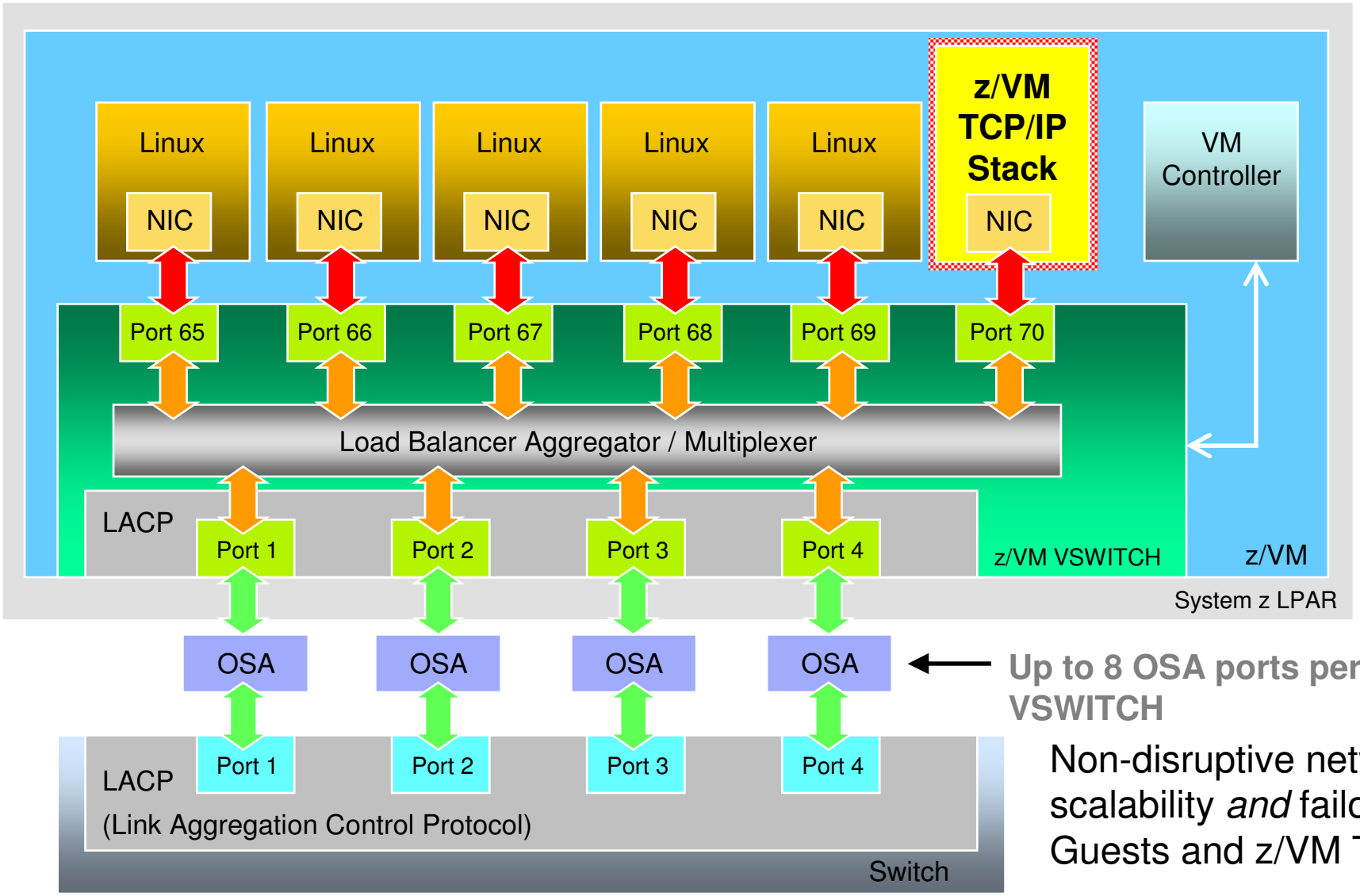
z/VM Virtual Switch Link Aggregation

With z/VM TCP/IP Stack Connectivity Support in z/VM V5.4



Non-disruptive networking scalability *and* failover for Guests and z/VM TCP/IP.

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Brief History of z/VM

Product	Years	Additional Capacities
CP40	1965-1967	Research projecting on developing a virtual machine CMS, minidisks
CP/67	1967-1972	Time sharing operating system Provide as open source – IBM Type III Library Trap and emulate – problem state/ supervisor state
VM/370	1972-1980	First IBM VM Product RSCS, Virtual Memory, VM under VM, Virtual Storage VM Assist Microcode
VM/SP	1980-1990	REXX, Networking Utilities, Xedit, GCS Shared File Systems, Name Save Systems Discontiguous Saved Segments
VM/HPO	1981-1990	Enhanced performance and memory addressability Preferred Machine Assist
VM/XA	1983-1990	31-bit Addressability Mini-disk cache Start Interpretive Execution Instruction (SIE)
VM/ESA	1990-2000	Queued Direct I/O FICON Channels, CMS Pipelines
z/VM	2001-Present	64-bit Addressability Virtual LANs, HiperSockets, VSWITCH Fibre Channel support

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Announcing new releases of:
z/OS, z/VM, and z/VSE

- **"Three operating systems, Many improvements, One conclusion... IBM System z is serious about enterprise data and applications."**
  - **z/OS Version 1 Release 10**
  - **z/VM Version 5 Release 4**
  - **z/VSE Version 4 Release 2**

- **Operating Systems announcement web site:**
  www.ibm.com/systems/z/os/announcement_080508.html

- **System z Web site:**
  www.ibm.com/systems/z/

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System z

Engines

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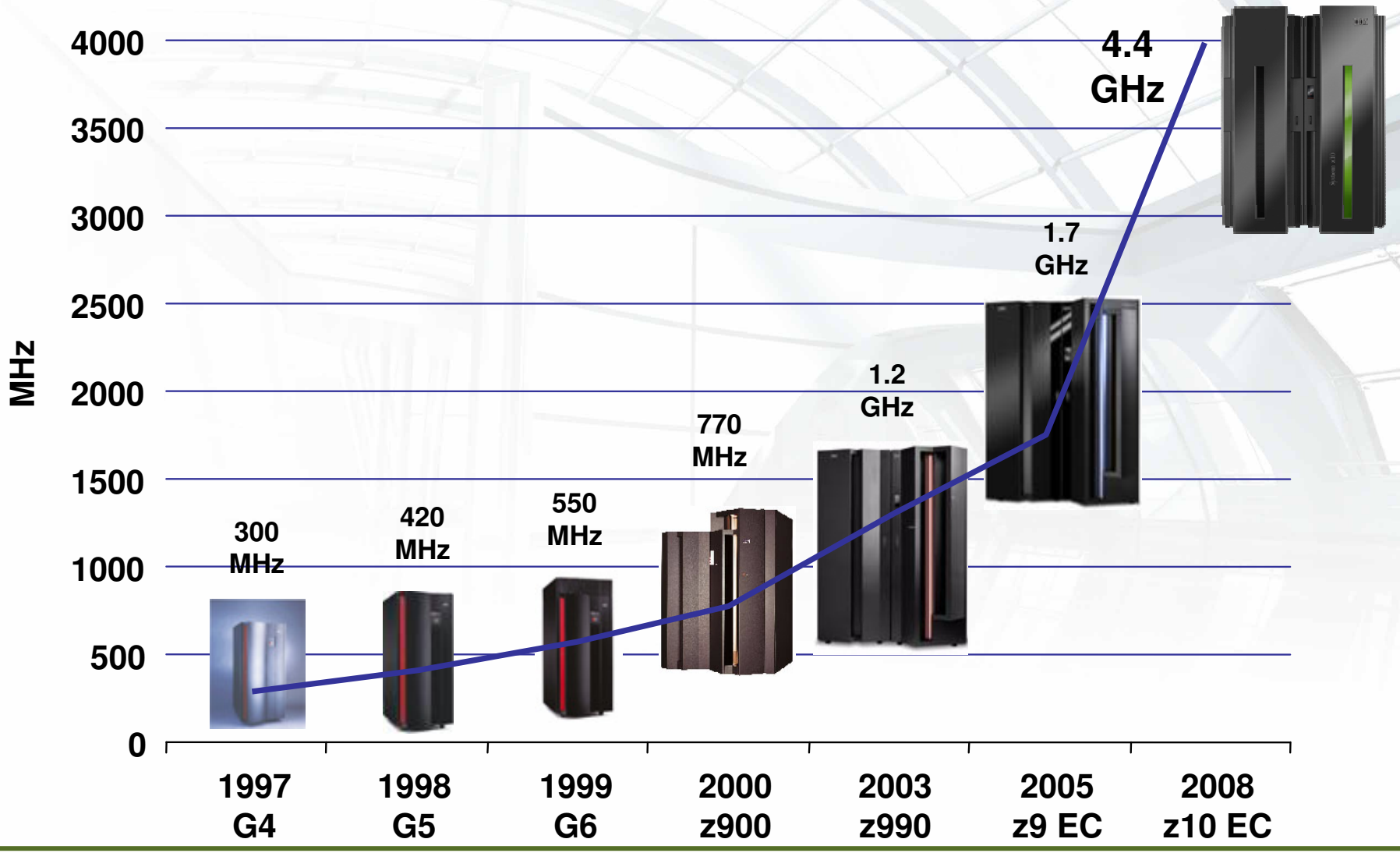
IBM z10 EC Continues the CMOS Mainframe Heritage



- G4 - 1st full-custom CMOS S/390
- G5 - IEEE-standard BFP; branch target prediction
- G6 - Cu BEOL
- z900 - Full 64-bit z/Architecture
- z990 - Superscalar CISC pipeline
- z9 EC - System level scaling
- z10 EC – Architectural extensions

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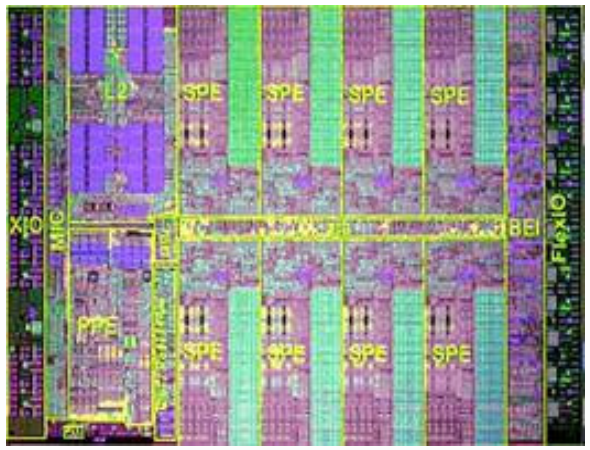
Evolution of System z Specialty Engines



Cell Broadband Engine™

Building on a strong track record of technology innovation with specialty engines – DB Compression, SORT, Encryption, Vector Facility

Integrated Facility for Linux (IFL) 2000

System z Application Assist Processor (zAAP) 2004

Eligible for zAAP:

- Java™ execution environment
- z/OS XML

IBM System z9 Integrated Information Processor (IBM zIIP) 2006

Eligible for zIIP:

- DB2 remote access and BI/DW
- ISVs
- New! IPSec encryption
- z/OS XML
- z/OS Global Mirror*

Internal Coupling Facility (ICF) 1997

z/VM 5.4 with the new System z10 EC now allows for any combination of CP, zIIP, zAAP, IFL, and ICF processor-types to reside in the same z/VM LPAR

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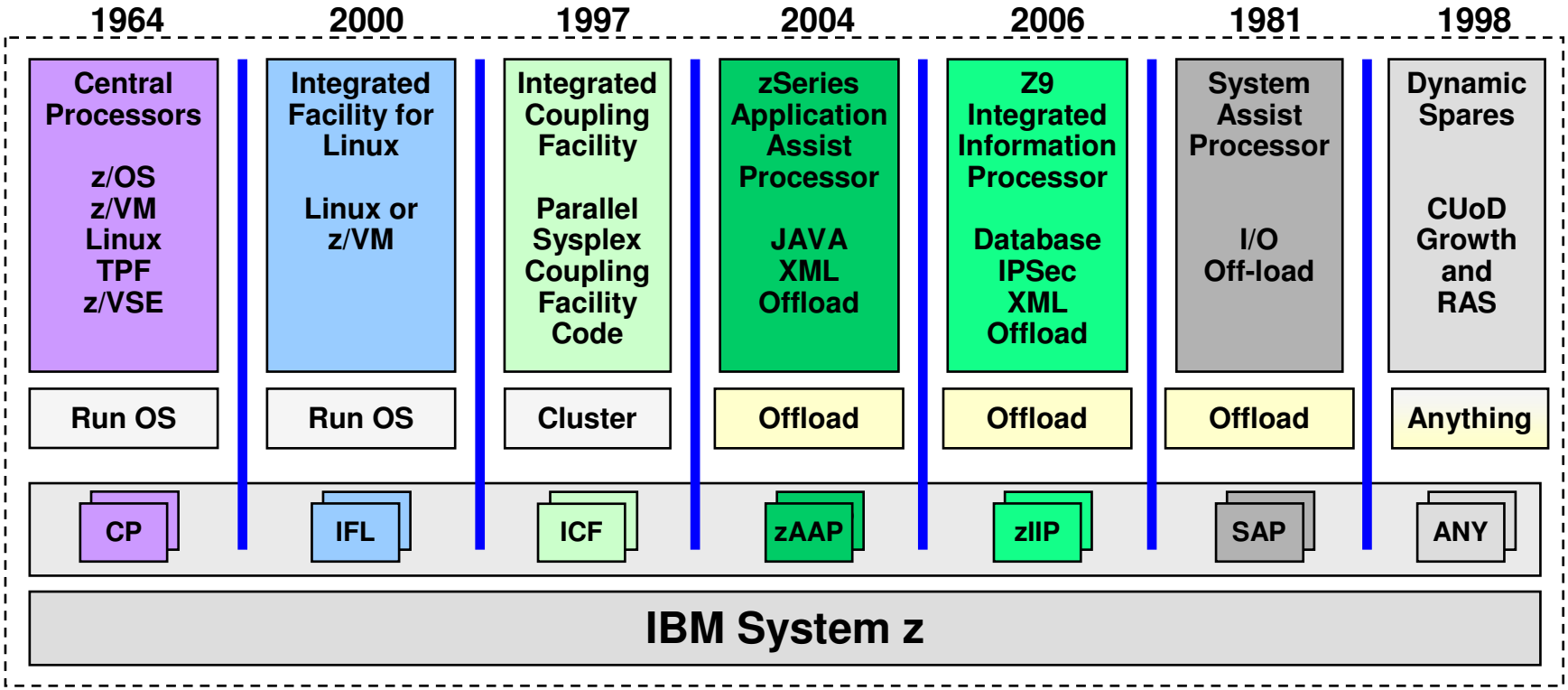
System z Terminology – Processors



- **Runs operating systems**
  - Central Processor (CP)
  - Integrated Facility for Linux (IFL)
- **Used for clustering**
  - Integrated Coupling Facility (ICF)
- **Central processor offload**
  - I/O (SAP), Java (zAAP), DB2 (zIIP)
  - Lower hardware and software costs
- **Spares**
  - Can dynamically replace any other processor or be turned into any processor for growth

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Benefits of zAAP on the Mainframe: Farmers Insurance

Farmers Zurich

Farmers online application experiences CICS transaction volumes of up to 45 million per day, supporting approximately 50,000 users

90% of the revenue business is supported by applications running within WAS for z/OS, which also communicates with applications running off-platform

zAAPs reduced the MIPS on a key application from 1200 MIPS to 700 MIPS (42%)

"Experiences tell us that zSeries is a must, because that is the only platform that can help us deliver all of these qualities. Quality is really, really important, because our customers are dependent upon the availability of these applications and the platform."

- Claudia Ku,
Dir of Tech Services

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Svenska Handelsbanken looks to zIIP up security

"zIIP Assisted IPSec provides us with the security our clients demand at an attractive cost to the business"

"Protecting our critical business data and applications is paramount to our business and our clients, so securing our communications from our core mainframe applications to our international offices is a critical element of our overall security policies.

We have successfully tested the integrated IPSec support in z/OS which enables end-to-end encryption from the mainframe all the way to the end device and plan to put into production soon. With the announcement of the zIIP Assisted IPSec, this solution delivers greater value to our business because of the improved price / performance provided by the zIIP specialty engine."

Ingemar Gustafson,
Manager of zSeries Networking
Svenska Handelsbanken

Svenska Handelsbanken has worked with IBM for many years. The IBM mainframe is a key element of our infrastructure, hosting our critical applications and data. Our mainframe connections were historically secured end-to-end with proprietary SNA connections. As we moved to an all Internet environment, we have implemented end-to-end encryption with IPSec on z/OS for our most secure connections.

The announcement of zIIP Assisted IPSec will improve the economics of this solution as much of the IPSec work can be directed lo the lower cost zIIP engines. This will enable our company to expand our use of IPSec-communications directly from our mainframe to our internal servers and to other financial institutions. The ability to use the zIIP engines for much of the IPSec encryption and decryption is a most welcomed enhancement to the overall security solution provided on IBM System z.

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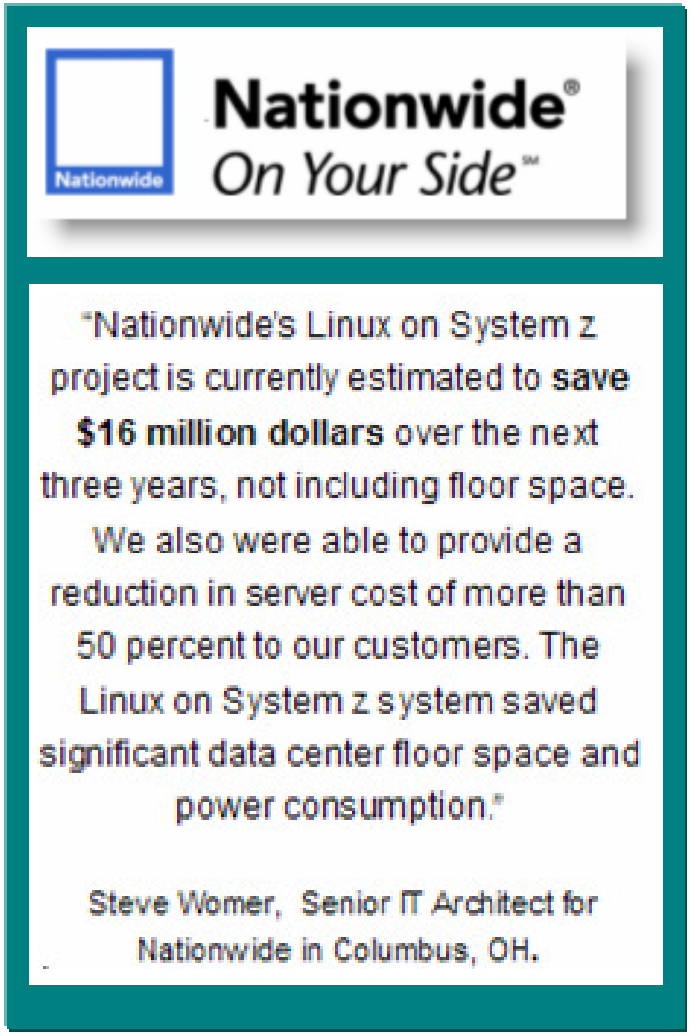
Nationwide partners with IBM to improve financial squeeze

- **Business Challenge**
  - Pressure on IT growth was forcing them to prioritize IT investments. What started as consolidation project, created unexpected energy savings bonus
- **Solution**
  - Use z/VM virtualization to significantly consolidate servers
- **Benefits**
  - Expect to save $16M over the next 3 years
  - Initial phase: 250 Prod / Test / Dev ➔ 6 IFLs
  - Lower power and floor space by 80% over alternatives
  - Lower middleware costs (DB2, WebSphere, Oracle)
  - 50% reduction in monthly charges for Web infrastructure
  - Dramatically improved server provisioning speed
  - Able to add workloads with out additional FTEs



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IBM Consolidation Announcement Highlights

- **IBM Consolidation Effort**
  - 3900 servers to 15 - z10 mainframes
  - 80% savings in annual energy usage
  - 85% savings in total floor space
  - Labor: 54% reduction
  - Software: 36% reduction
  - Improved availability and DR

IBM'S PROJECT BIG GREEN SPURS GLOBAL SHIFT TO LINUX ON MAINFRAME

Plan to shrink 3,900 computer servers to about 30 mainframes targets 80 percent energy reduction over five years

Optimized environment to increase business flexibility

ARMONK, NY, August 1, 2007 – In one of the most significant transformations of its worldwide data centers in a generation, IBM (NYSE: IBM) today announced that it will consolidate about 3,900 computer servers onto about 30 System z mainframes running the Linux operating system. The company anticipates that the new server environment will consume approximately 80 percent less energy than the current set up and expects significant savings over five years in energy, software and system support costs.

At the same time, the transformation will make IBM's IT infrastructure more flexible to evolving business needs. The initiative is part of Project Big Green, a broad commitment that IBM announced in May to sharply reduce data center energy consumption for IBM and its clients.

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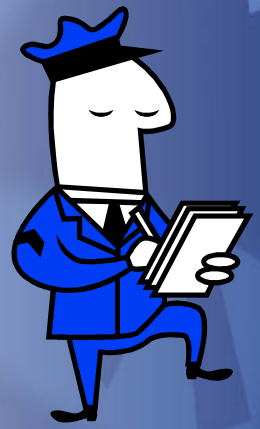
System z

Security



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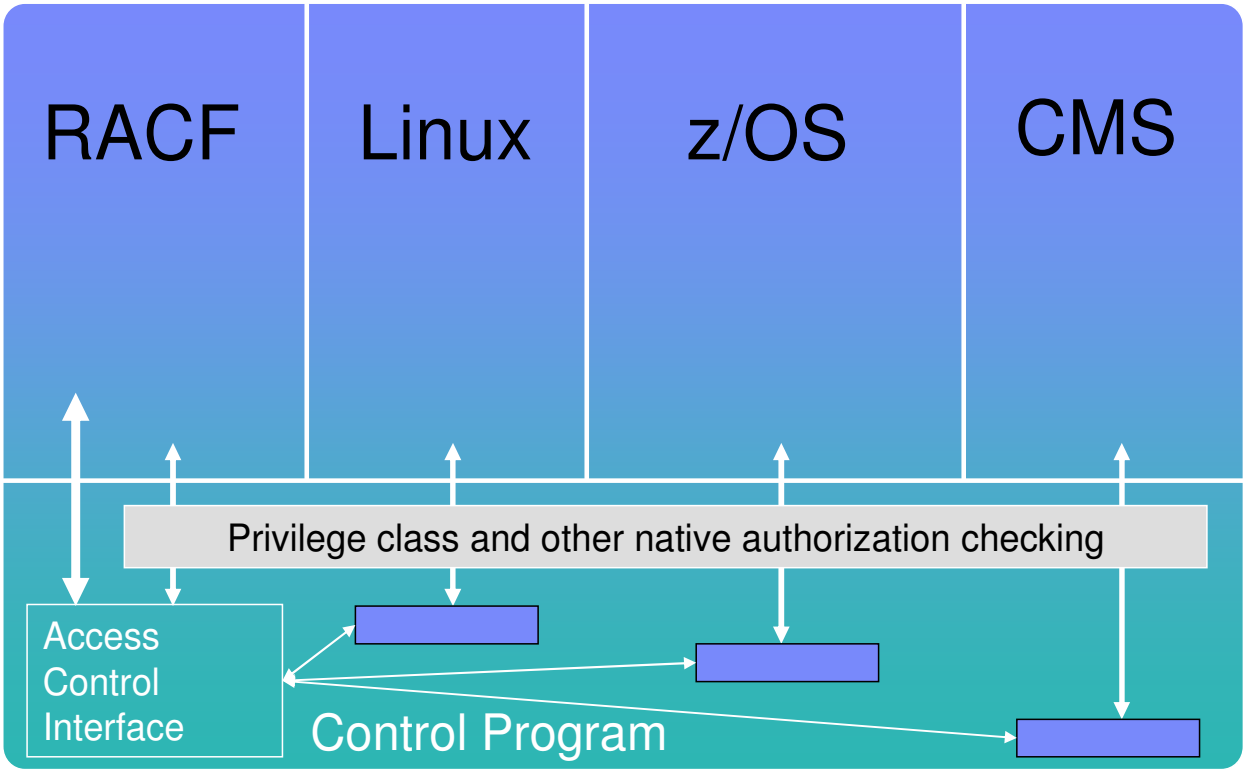
What is z/VM System Security?

- **Knowing who is accessing the system or its resources**
- **Ensuring a user only has access to system resources specifically permitted**
- **Knowing who is accessing (or failing to access) what resources**
- **Security is only meaningful in the presence of system integrity**
  - Integrity prevents bypass of security controls
  - Audit trail confirms conformance



Learn more: "z/VM Security and Integrity" – ibm.com/servers/eserver/zseries/library/techpapers/pdf/gm130145.pdf

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The Mainframe Delivers Great Security at Every Level

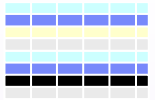
Crypto Cards

Tape encryption

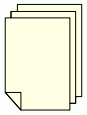
TS1120

Key management

Multilevel security

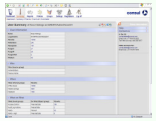


System z SMF



Consul Insight

Consul System z Tools



DB2 Audit Management Expert

Data Privacy

Compliance and Audit

Extended Enterprise

Tivoli Identity Manager

Tivoli Federated Identity Mgr

Platform Infrastructure

Common Criteria Ratings

Support for standards

PKI services

Supports VPns etc

RACF

Provides audit, authorization, authentication and access

Communications Server

Network intrusion detection

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Built in Secured System z Processing Reduces Risk

- **Workload Isolation**
  - Each user runs in a separate address space
  - Supervisor state & system programs separated
  - LPAR separation ensures processing integrity
  - Storage Protection controls access to protected areas of storage
  - HiperSockets communication secures network communications at memory speed
- **Encryption**
  - Support for encryption in middleware
  - Tape Encryption
  - Key serving
  - System z cryptographic capabilities
- **System Integrity Statement**
  - For both z/OS and z/VM
  - Common Criteria
- **Scalability**
  - Encryption offload enabled by zIIP
  - High performance solution

Allows customers to place multiple workloads on single z/OS & Linux Images.

Helps prevent malware, viruses and worms from disrupting systems operations.

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z/VM Security Examples

- **Privilege Class**
  - A - System operator
  - B - Real device management
  - C - System programmer
  - D - Spooling operator
  - E - Systems analyst
  - F - Service representative (CE)
  - G - General user
  - H - Reserved for IBM
  - Customer can use I-Z and 1-6
- **I/O Protection**
  - Access to real devices is controlled by the system administrator
  - I/O commands which affect device or subsystem require additional authorization
  - Virtual Switch – restricted use
  - Minidisks can be shared or non-shared
- **External Security Manager (RACF)**
  - Can audit all privileged commands and limit use to specific individuals
  - Use Access Control List for minidisks instead of minidisk password
  - Secures “the on/off switch”
- **Intrusion Detection**
  - Incorrect passwords
  - Network – Certain denial of service attacks are detected and reported on TCP/IP console
  - Journaling - Guest logons and linking to other guest minidisks are detected and recorded
- **Cryptography**
  - Supports the use of all installed cryptographic options simultaneously by different guests on a z/VM system
- **z/VM Currently certified at EAL 4+**

Note: This security is in addition to security provided by guest operating systems such as Linux.

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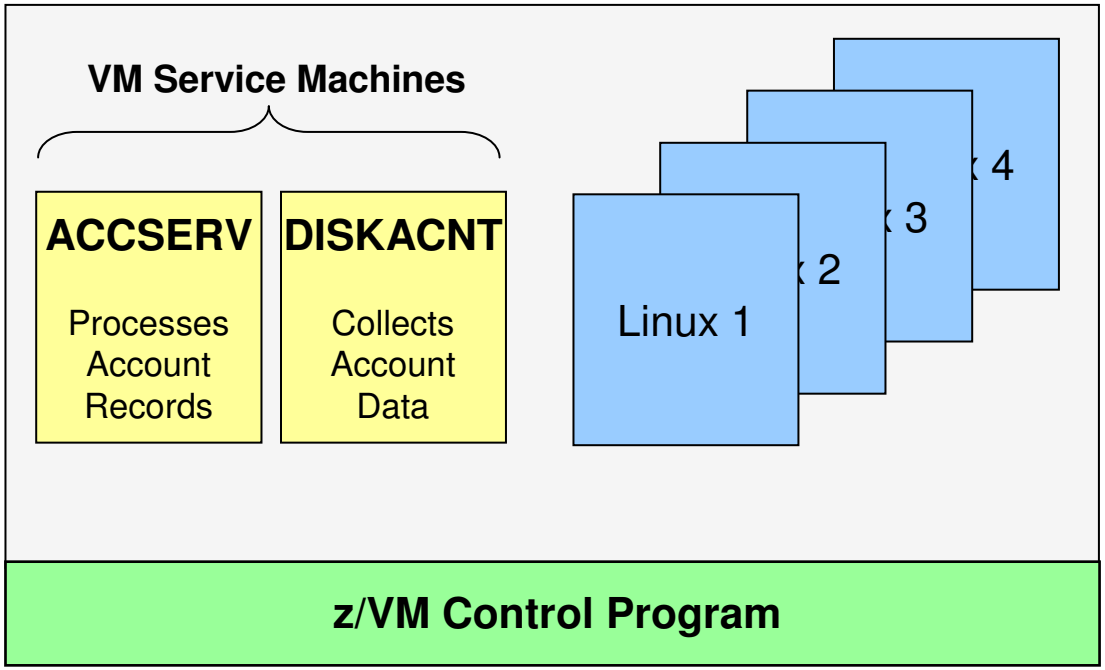
z/VM Accounting

- **Collect accounting data**
  - CPU
  - Memory
  - Network devices
  - I/O adapters
  - Disk space
- **Useful for charge back purposes**
- **Use in-house reporting scripts or commercial packages**



Additional Information: "**Accounting and monitoring for z/VM Linux guest machines**"
Source: http://www.redbooks.ibm.com/redpapers/pdfs/redp3818.pdf

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Virtualization and Security

Should IT Managers Be Concerned?

Virtualization security risks being overlooked, Gartner warns

Gartner raises warning on virtualization and security.

Companies in a rush to deploy virtualization technologies for server consolidation efforts could wind up overlooking many security issues and exposing themselves to risks, warns research firm Gartner.

"Virtualization, as with any emerging technology, will be the target of new security threats," said Neil MacDonald, a vice president at Gartner, in a published statement.

– NetworkWorld.com, April 6, 2007

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System z

HA and DR

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Generic Linux – High Availability

- **Clustering Software (Examples)**
  - Tivoli System Automation for Multiplatforms (IBM)
  - Linux HA (open source)
  - Linux Virtual Server (open source)

- **Application Clustering (Examples)**
  - Websphere ND
    - Clusters share session data and logs
    - HAManager (new in V6) allows recovery of in-flight 2PC
  - DB2 HADR
    - Provides failover between primary and backup DB2 servers
    - Data is mirrored between servers
    - Fast takeover
  - Oracle RAC
    - Can be run active/active or active/passive
    - Less CPU overhead and faster failover with active/passive configuration

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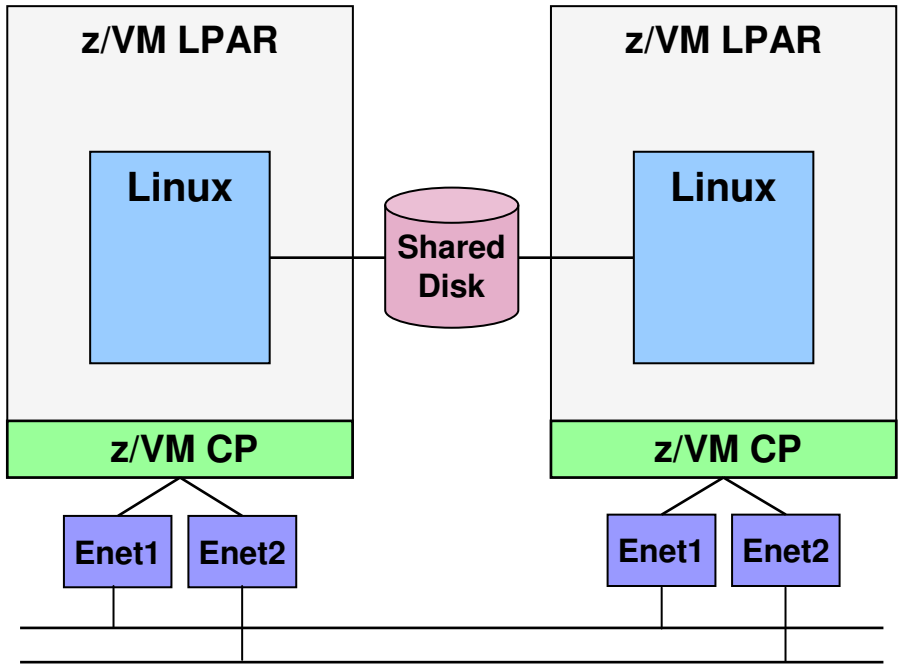
Linux & z/VM High Availability

- **Probably of different scenarios varies greatly**
  - Application is most likely to fail, entire System z box is least likely
  - System z MTBF measured in decades
  - Most hardware and firmware upgrades can be done concurrently
- **Designing HA solution**
  - How much availability is enough?
  - Configure for what you need
  - Can provide multiple Linux and z/VM instances within the same frame



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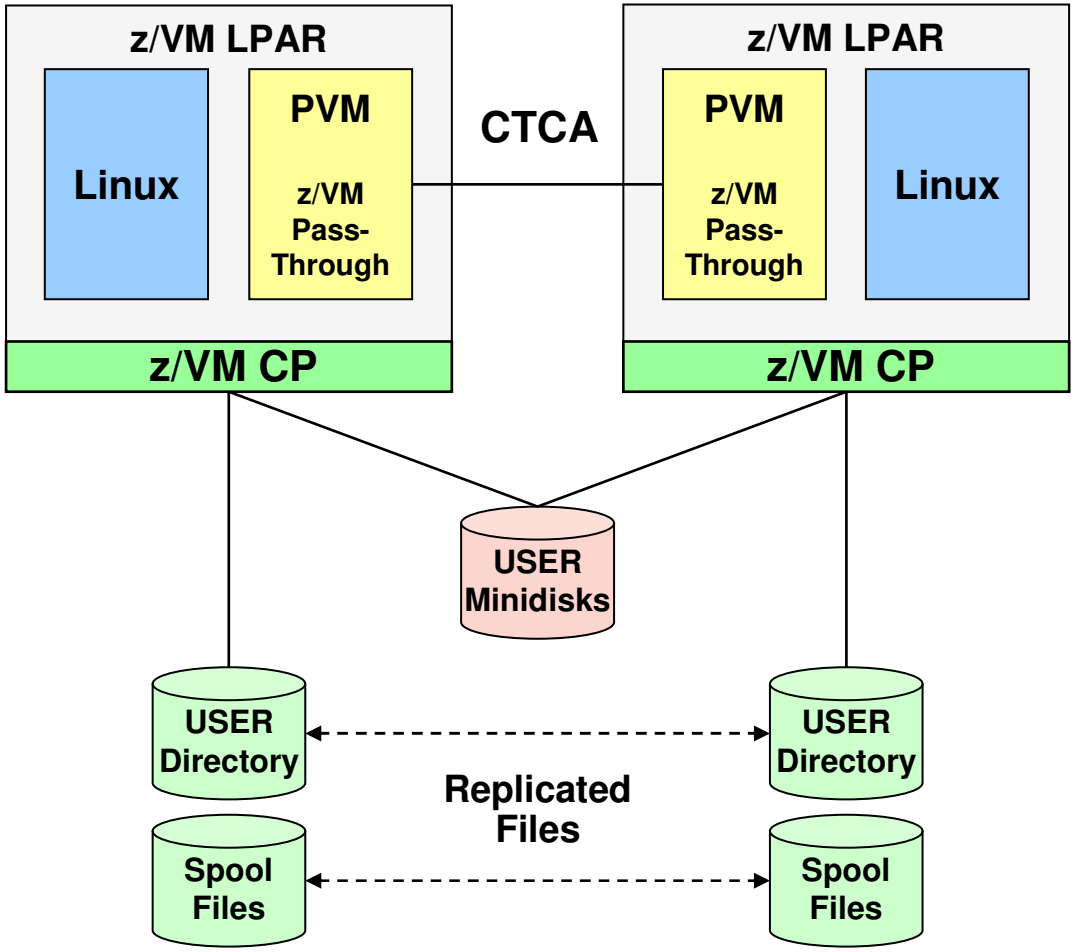
Cross System Extensions (CSE)

- **Guests may access files from any z/VM image in the cluster**
  - Single sign-on for guests
  - Maximum 4 nodes
  - ECKD Storage Devices
  - DirMaint - manage directories
- **Capability to share**
  - Minidisks
  - Replicate spool files
- **Commands may be sent among images in the cluster**
  - Cross System Messages
  - Cross System Query



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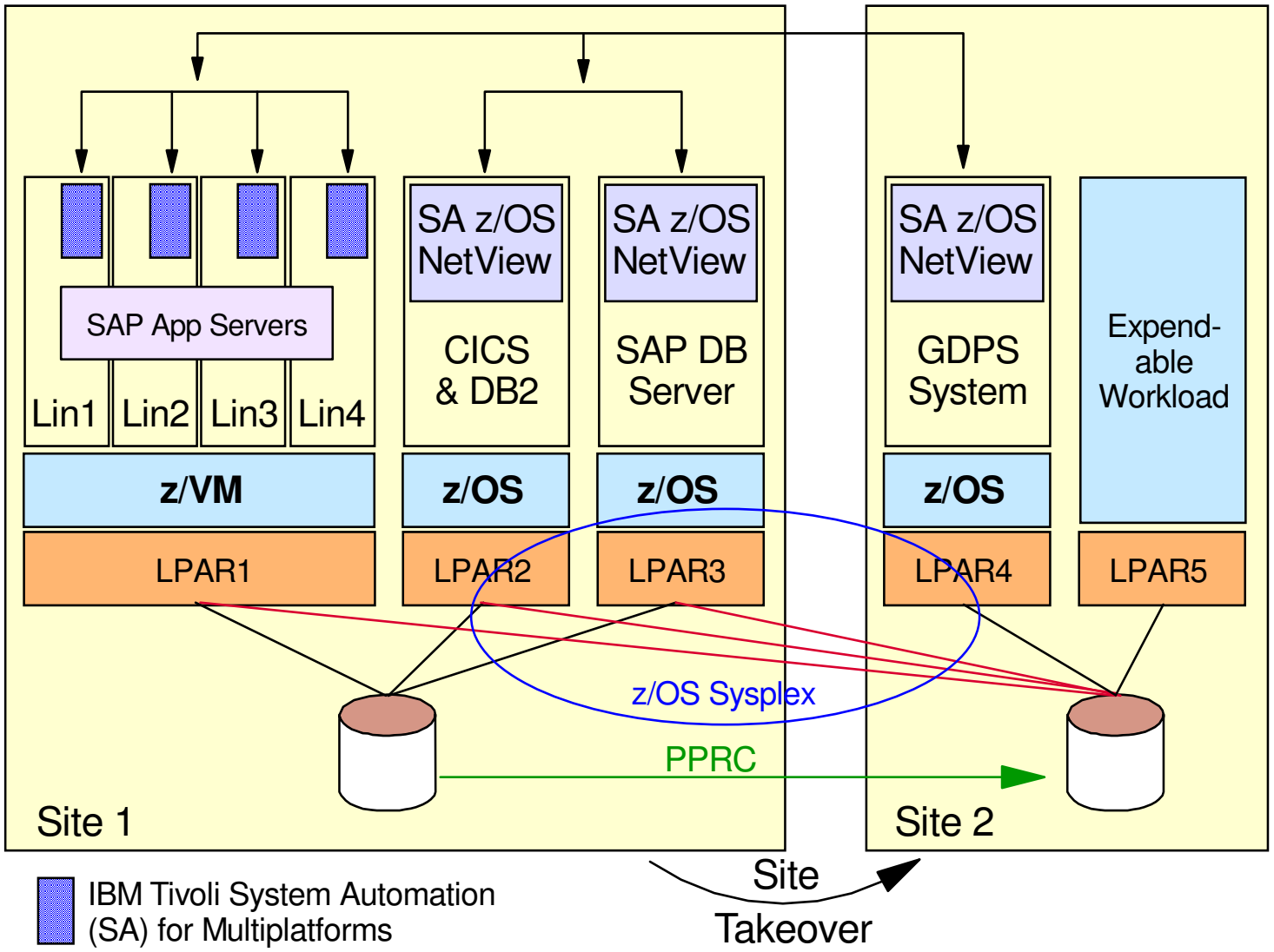
GDPS/PPRC Multiplatform Resiliency for System z



- Designed for customers with distributed applications
- SAP application server running on Linux for System z
- SAP DB server running on z/OS
- Coordinated near-continuous availability and DR solution for z/OS, Linux guests, and z/VM
- Uses z/VM HyperSwap function to switch to secondary disks
- Sysplex support allows for site recovery

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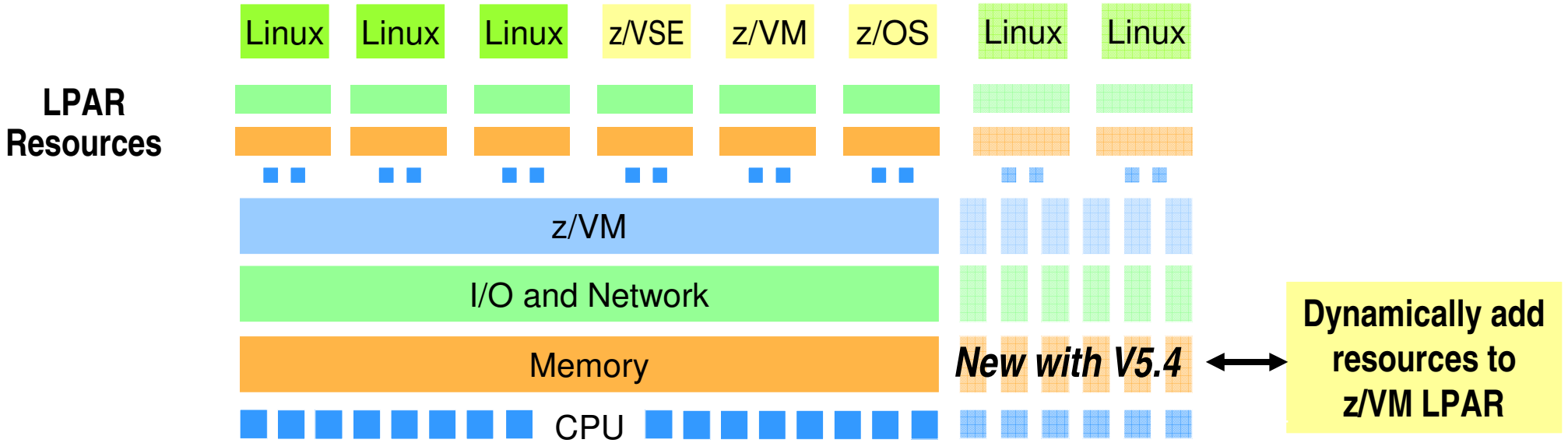
z/VM Dynamic Memory Upgrade

New z/VM V5.4 Function Enhances System Availability

- **Users can non-disruptively add memory to a z/VM *LPAR***
  - Additional memory can come from: *a)* unused available memory, *b)* concurrent memory upgrade, or *c)* an LPAR that can release memory
  - Memory *cannot* be non-disruptively removed from a z/VM LPAR
- **z/VM virtualizes this hardware support for *guest machines***
  - Currently, only z/OS and z/VM support this capability in a virtual machine environment
- **Complements ability to dynamically add CPU, I/O, and networking resources**



Smart economics: non-disruptively scale your z/VM environment by adding hardware assets that can be shared with every virtual server

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Disaster Recovery Options

Recover Point & Recovery Time Objectives	MIPS	Memory	Data	Notes
Low	Cold site Device drivers simplifies	Cold Site	Usually Tape Vaulting	System Z easier than on generic Linux due to device drivers
Moderate	CBU Contract for MIPS	Memory must be available	PPRC to Tape Vaulting	
High	Hot site available	Hot Site Available	PPRC with Hyperswap	Can use VMRM to prioritize workload in active/active configuration

Need MIPS, memory, data (and network) to handle DR. RPO and RTO objectives will dictate possible approaches.

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Disaster Recovery – Tape Options

- **Full volume backup**
  - Can be done with z/OS, or z/VM
  - Very fast tape drives
  - May need to quiesce systems (not always)
    - Flashcopy can reduce downtime
  - Most useful for major problems
    - DR
    - Entire volume loss
    - Etc.
  - Easily incorporated into existing z/OS backup strategies
- **File by file backup**
  - Numerous products, e.g. TSM, Veritas
  - Incremental backup – quick
  - Full restore can be slow and network limited
  - Most useful for “oops” scenario
    - Need to retrieve single file
- **Most companies use both for Linux on Z**
  - Different recoveries for different failure scenarios

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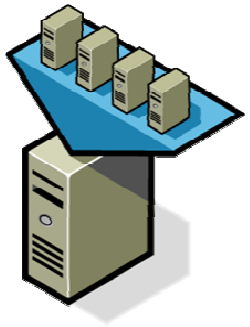
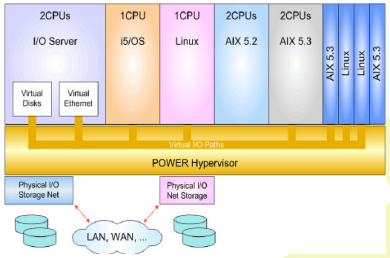
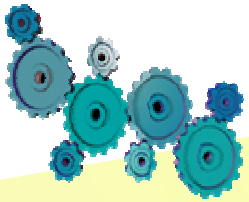
Evolution of data center energy efficiency







Application Integration

Virtualization

- Migrate many applications into fewer images
- Simplify IT environment
- Reduction of operations resources
- Improve application specific monitoring and tuning

Physical Consolidation

- Remove physical resource boundaries
- Increased hardware utilization
- Allocate less than physical boundary
- Reduce software licensing costs

Centralization

- Consolidate many servers into fewer on physical resource boundaries
- Reduce system management complexity
- Reduce physical footprints

- Consolidate many centers into fewer
- Reduce infrastructure complexity
- Improve facilities management
- Reduce staffing requirements
- Improve business resilience (manage fewer things better)
- Improve operational costs

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Time for ?

Always time for follow-up

Thank You

Want help with System z virtualization strategy planning, server consolidation, and complete data center management solutions:

Your local IBM sales rep has new workload sales specialist ready to help create successful project plans with you today.

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