IBM zEnterprise EC12 Overview

for NY Metro NaSPA Chapter Meeting
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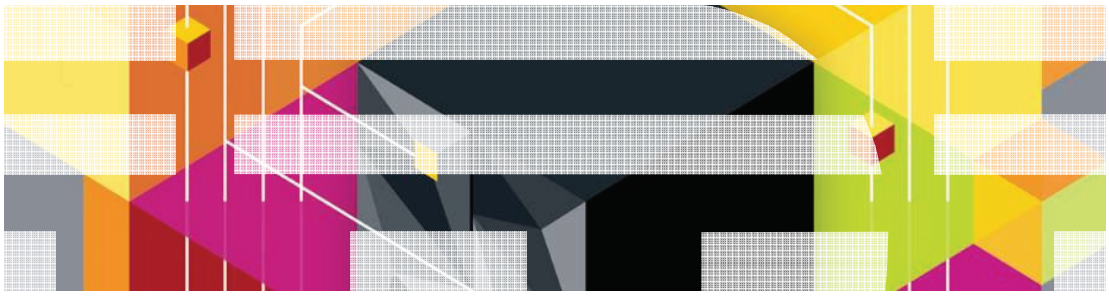

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Agenda

- **zEnterprise EC12 Introduction**
- Processor
- IBM zAware
- IBM Flash Express
- zEC12 System Features
- Summary

Introducing the newest members of the zEnterprise System family

The zEnterprise EC12 and zEnterprise BladeCenter Extension Model 003

IBM zEnterprise EC12 (zEC12)

- zEC12 has the industry's fastest superscalar chip with each core at 5.5 GHz
- New innovation to drive availability with IBM zAware and Flash Express
- Optimized for the corporate data serving environment
- Hardware functions boost software performance for Java™, PL/I, DB2®

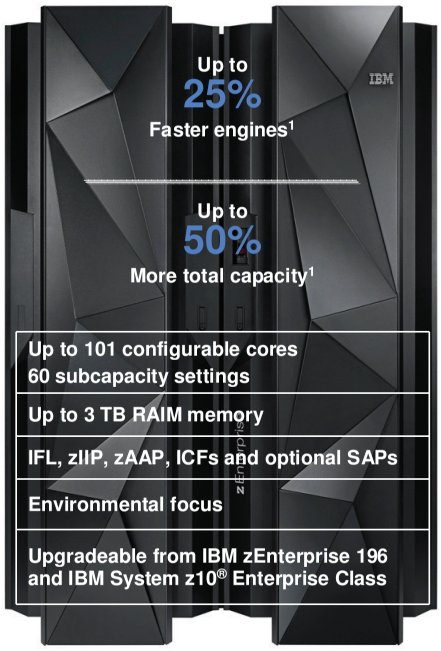
IBM zEnterprise Unified Resource Manager and zEnterprise BladeCenter® Extension (zBX) Mod 003

- Supports the new zEC12 platform
- Hosts PS701 and HX5 blades
- Provides workload-awareness resource optimization
- Enhancements to System Director support zBX
- System z will continue to expand hybrid computing

Plus more flexibility and function by connecting to IDAA

- IBM DB2 Analytics Accelerator (IDAA) allows deployment of business analytics on the same platform as operational applications
- Analytics and OLTP can be run as the same workload

zEnterprise EC12 is the core of next generation of System z



zEC12

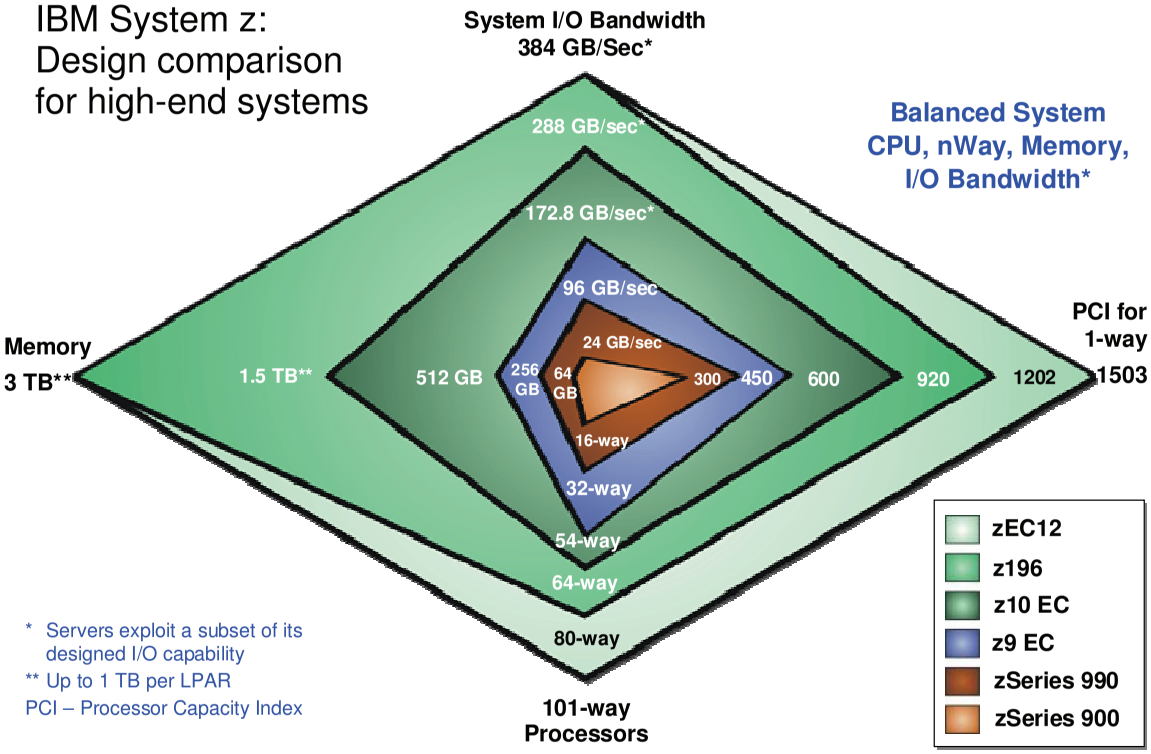
Machine Type: 2827

Models: H20, H43, H66, H89, HA1

- **Advanced technology 5.5 GHz 6-core processor chip delivers a performance boost for all workloads**
- **Innovation to drive availability to superior levels**
  - ***IBM zAware*** offers snap-shot of the current state of your business
  - ***FLASH Express and pageable large pages*** to drive availability and performance for critical workloads
- **Trusted security and resiliency are zEnterprise standards**

[1]Based on IBM internal Study.

IBM System z:
Design comparison
for high-end systems



* Servers exploit a subset of its designed I/O capability

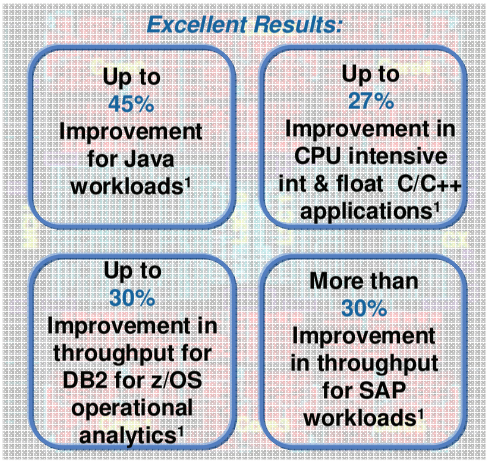
** Up to 1 TB per LPAR

PCI – Processor Capacity Index

Processor chip optimized for software performance

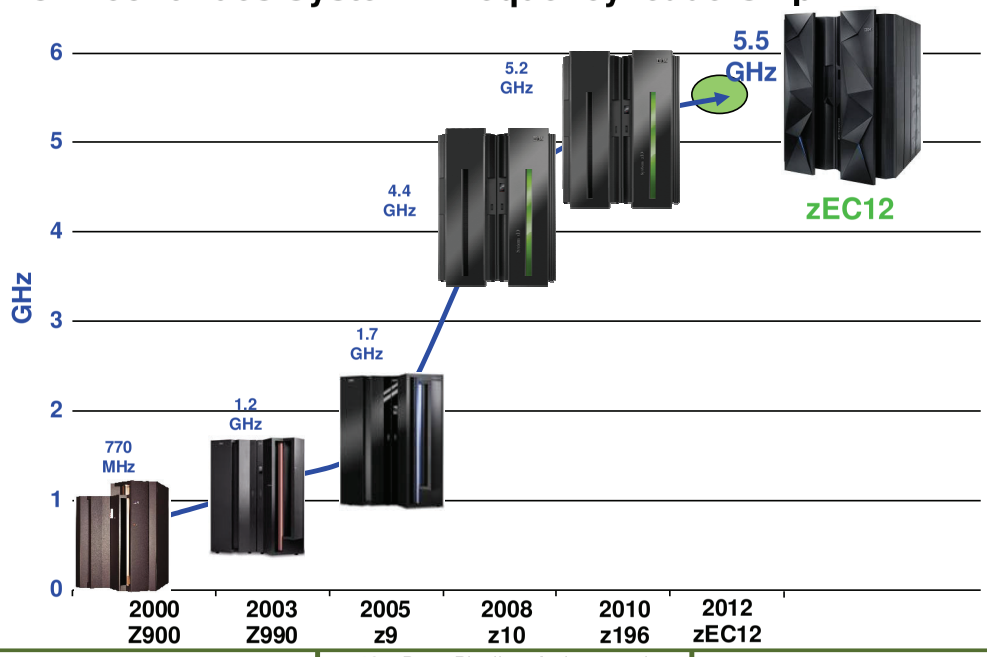
Exploited by Java, PL/I, compilers, DB2, more

- **Our leadership in microprocessor design supports a boost in performance for all workloads**
  - Second generation out of order design
  - Multi-level branch prediction supports complex workloads
- **Larger caches to optimize data serving environments**
  - Almost 2x on chip and 2x additional on book
- **New hardware functions optimized for software performance**
  - ***Transactional Execution Facility*** for parallelism and scalability
  - ***Runtime Instrumentation Facility*** is intended to help reduce Java overhead
  - ***2 GB page frames*** are intended to offer performance Improvements for DB2 buffer pools and Java heaps
  - Up to ***30% improvement in IMS™ throughput*** due to faster CPU and cache, compliers, and more[1]
  - New IBM Enterprise PL/I compiler is planned to exploit and get a performance boost from ***decimal format conversions facility***



[1] Based IBM Internal Study

zEC12 continues System z frequency leadership



▪ **z900** – Full 64-bit z/Architecture ▪ **z990** – Superscalar CISC pipeline ▪ **z9** – System level scaling	▪ **z10** – Deep Pipeline, Arch. extensions ▪ **z196** – Out-Of-Order (OOO), Additional Architectural Extensions	▪ **zEC12** – OOO+, Architectural Extensions, Enablement for new Software Paradigms

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- **Processor**
- IBM zAware
- IBM Flash Express
- zEC12 System Features
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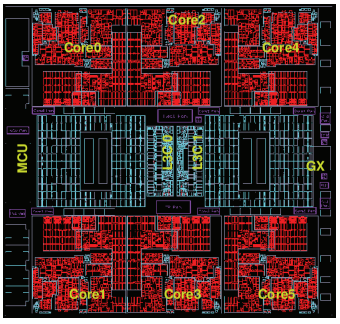
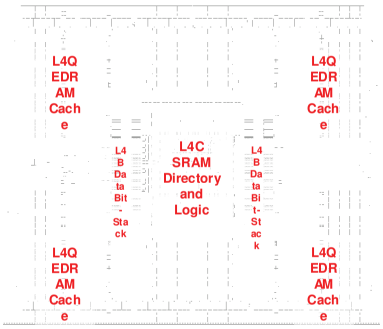
zEnterprise EC12 processor design

- Built on solid foundation of z196
  - Leverage IBM 32nm SOI technology with eDRAM
- Enhanced high-frequency out-of-order core
  - Instruction pipeline streamlined for smoother flow
  - 2nd-level BTB expands branch prediction coverage
  - Millicode performance improvements
- Cache hierarchy leadership extended
  - New structure for 2nd-level private cache
    - Separate optimizations for instructions and data
    - Reduced access latency for most L1 misses
  - 3rd-level on-chip shared cache doubled to 48MB
  - 4th-level book-shared cache doubled to 384MB
- More processors in the same package as z196
  - 6 processor cores per CP chip
  - Crypto/compression co-processor per core
  - Same power consumption as z196

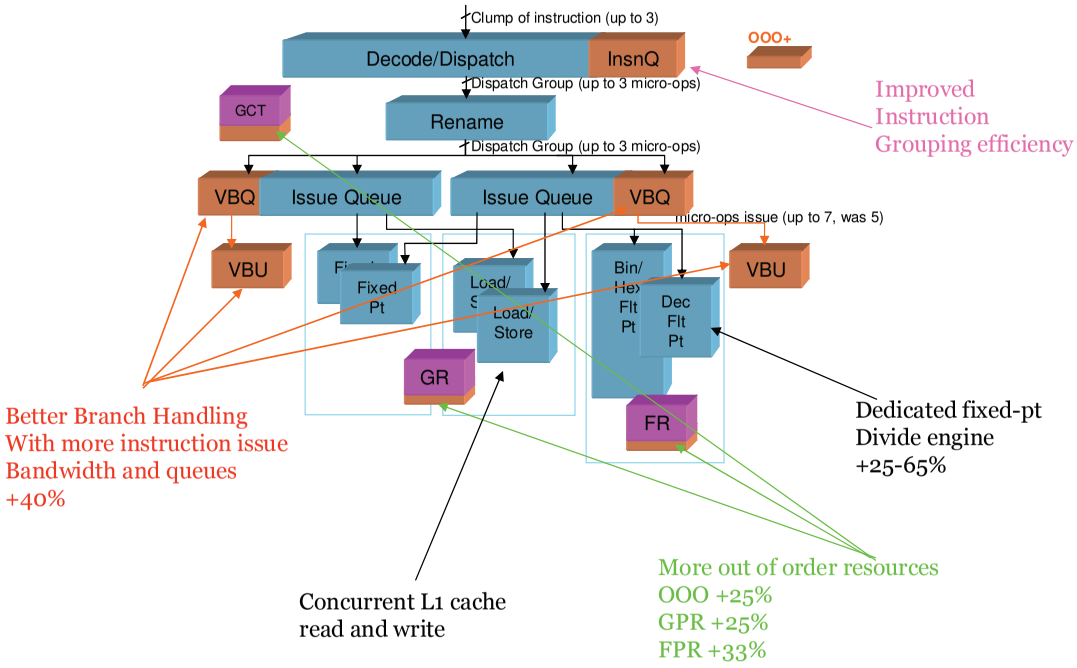


zEC12 PU Chip: 6 cores, 598 mm² chip



zEC12 SC Chip: 192MB cache, 526 mm² chip

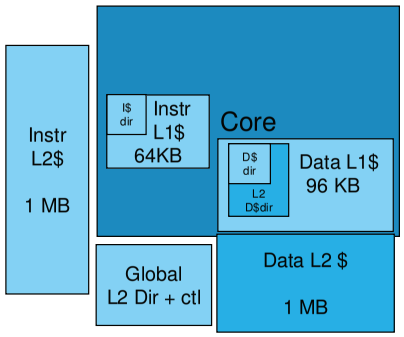
Improving out of order processing



zEC12 cache innovations

- Split Level 2 Cache (instead of unified)
  - 1M-byte instruction, 1M-byte data
  - Inclusive of instruction-L1 (64 Kbyte) and data-L1 (96 Kbyte)
  - Bigger aggregate L2 with shorter latency
- Integrated data-L2 directory
  - Data-L2 directory is merged into data-L1 directory
  - Logically indexed like in data-L1 directory
  - L2 Hit / miss knowledge at L1 miss time

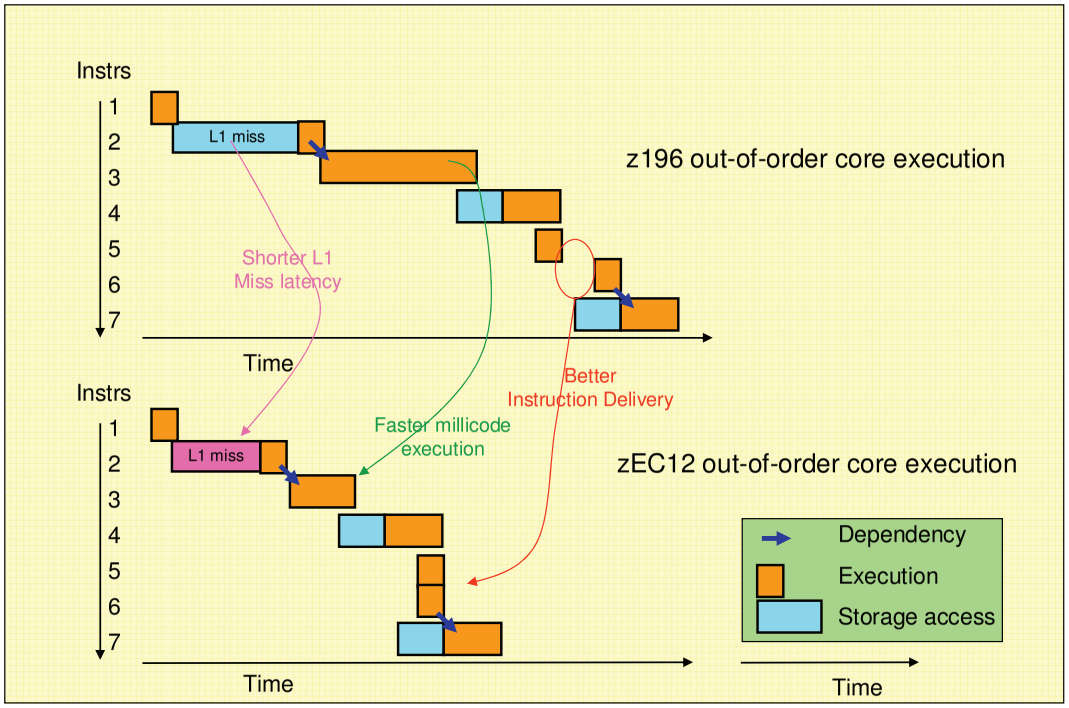
  ➔ L1 miss, L2 hit latency reduced by up to 45%



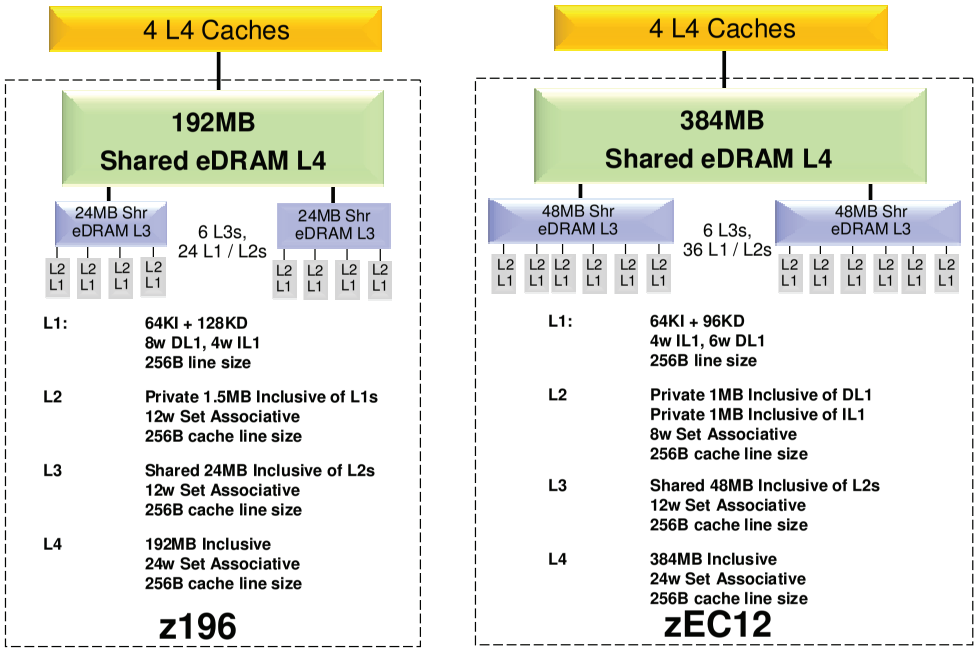
- Store "gathering" cache
  - Circular queue of 64 entries of half-lines (128 bytes)
  - Merges stores to same half-line post L1 updates
  - Reduces pipeline usage for stores in L2 and L3
  - Hardware transactions storage updates

  ➔ Store traffic to L3 typically reduced by ~50%

zEC12 out of order execution enhancements



System z Cache Topology – z196 vs. zEC12 Comparison



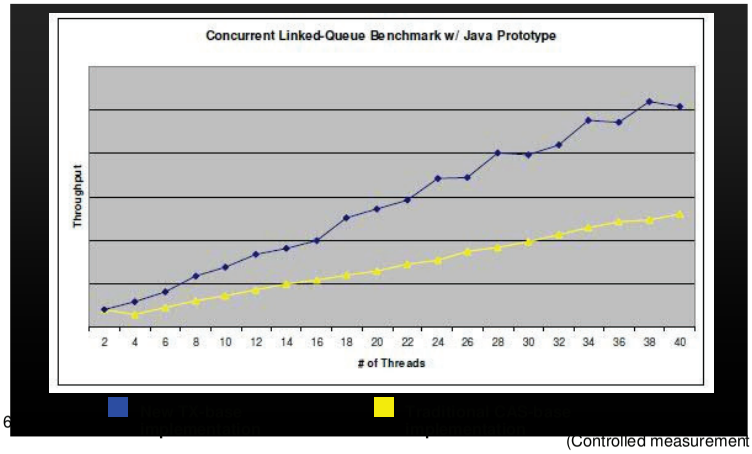
zEC12 architecture extensions

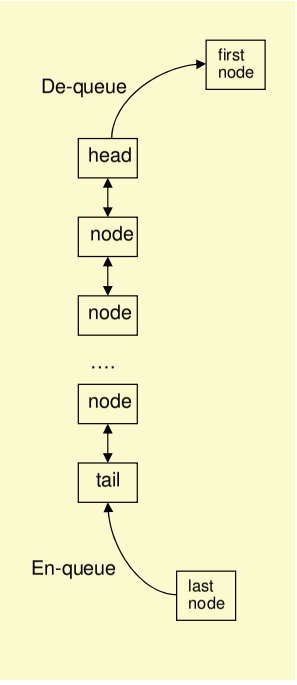
- Transactional execution (a/k/a transactional memory)
  - Software-defined sequence treated by hardware as atomic "transaction"
    - "All or nothing" execution
  - Implemented in core hardware
    - Monitor storage locations accessed
    - Buffer updates until transaction completes
    - Auto-retry for "constrained" transactions
  - Enables significantly more efficient software
    - Highly-parallelized applications
    - Speculative code generation
    - Lock elision
  - Staged software exploitation plan
    - Initial support in Java
    - C/C++, other languages to follow
    - Leverage for high-n-way scaling enhancements

```
BEGIN
Change memory location A
Change memory location B
…
Change memory location n
END
```


Transactional Execution: Concurrent Linked Queue

- ***~2x improved scalability of juc.ConcurrentLinkedQueue***
- ***Unbound Thread-Safe LinkedQueue***
  - First-in-first-out (FIFO)
    - Insert elements into tail (en-queue)
    - Poll elements from head (de-queue)
  - No explicit locking required
- ***Example usage: a multi-threaded work queue***
  - Tasks are inserted into a concurrent linked queue as multiple worker threads poll work from it concurrently





(Controlled measurement environment, results may vary)

zEC12 architecture extensions - continued

- Runtime instrumentation
  - Real-time information to software on dynamic program characteristics
  - Enables increased optimization in JVM/JIT recompilations
  - Additional exploitation opportunities in the works
- 2 GB page frames
  - Increased efficiency for DB2 buffer pools, Java heap, other large structures
- Software directives to improve hardware performance
  - Data usage intent improves cache management
  - Branch pre-load improves branch prediction effectiveness
- Decimal format conversions
  - Enable broader exploitation of Decimal Floating Point facility by applications

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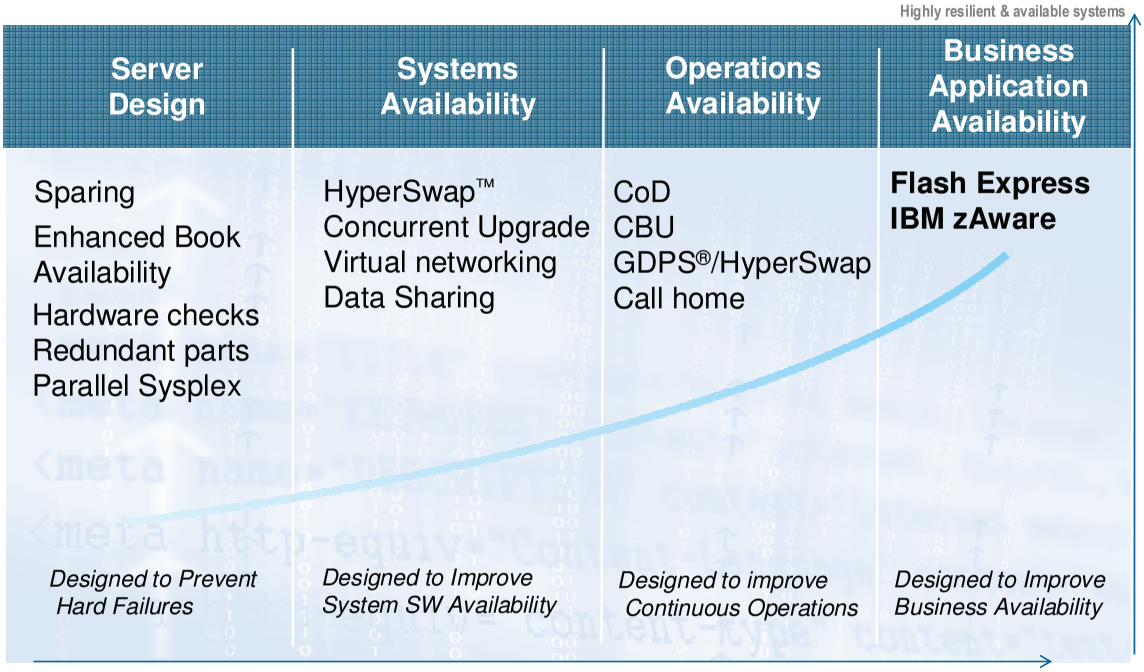
Extending System z Availability with Flash Express and IBM zAware



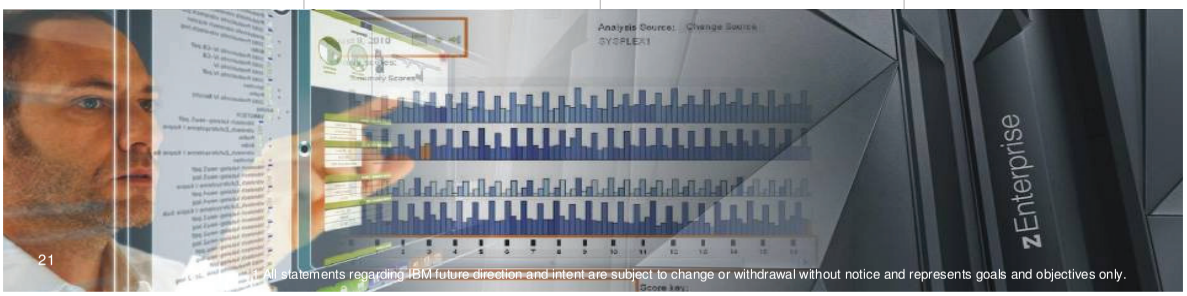
IBM System **z** **A**dvanced **W**orkload **A**nalysis **Re**porter (IBM zAware) Smarter Computing for Faster Service Restoration

- The complexity and rate of change of today's IT infrastructures stress the limits of IT to resolve problems quickly and accurately--while preserving SLAs
- IT is challenged to diagnose system anomalies and restore service quickly
  - Systems often experience problems which are difficult or unusual to detect
  - Existing tools do little to identify messages preceding system problems
  - Some incidents begin with symptoms that remain undetected
  - Manual log analysis is skills-intensive, and prone to errors
- IBM zAware with Expert System Diagnostics Gets it Right, Fast
  - IBM zAware helps improve problem determination in *near real time* – helps rapidly and accurately **identify problems** and **speed time to recovery**
    - Analyzes **massive amounts of data** to identify problematic messages, providing information to enable faster corrective action
    - Analytics on log data provides a near real time view of current system state
    - Cutting edge pattern recognition examines system behavior to help pinpoint deviations
    - Machine learning, modeling and historical data work to analyze the client's **unique environment**
- Benefits
  - Can reduce problem determination and troubleshooting
  - Particularly helpful when problems involve multiple teams
  - Helps diagnose problems quickly and more accurately to improve service recovery time
  - Easy-to-use graphical interface

IBM zAware – Identifies unusual system behavior

IBM zAware contains sophisticated analytics, applies IBM insight, and machine learning to understand your unique system.

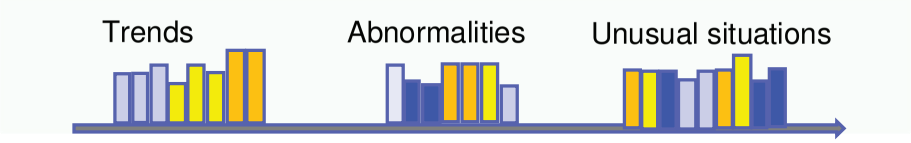
Monitoring	Detection	Frequency	Reporting
▪ Supports IBM and non-IBM middleware and applications ▪ Monitors OPERLOG in a sysplex or monoplex ▪ Assigns a message anomaly score to help identify potential issues	▪ Detects anomalies other solutions might miss ▪ Can find the rare or infrequent message ▪ Can detect an unusual number of normal messages ▪ Can detect messages issued out of context	▪ Samples every 2 minutes ▪ 10-minute interval ▪ Uses 90-day rolling baseline; a utility provided to populate baseline; flexibility provided	▪ Near real-time analysis ▪ Intuitive reporting – both high level and drill down ▪ Color-coded browser display ▪ XML output can feed ISVs or processes ▪ Tivoli intends to provide alert and event notifications[1]



Specific applications of IBM zAware – answer critical question in near real time

- Identify a possible z/OS incident
  - ***Which image is having unusual behavior?***
    - Examines unique message behaviors
    - High score generated by unusual messages or message patterns
  - ***When did the behavior start?***
    - For a selected 10 minute interval either the current 10 minute interval or past intervals
      - Which messages are unusual?
      - How often did the message occur?
      - When did the message start to occur?
  - ***Were similar messages issued previously?***
    - Understands message characteristics and message patterns
- Identify behavior after a change has been made
  - ***Are unusual messages being issued after a change?***
    - New software levels (operating system, middleware, applications)
    - Updated system settings or system configurations
- Diagnose intermittent problems
- *Are new unusual messages being issued when an intermittent problem occurs?*
  - Are more messages issued then expected?
  - Are messages issued out of a normal pattern?

Finds anomalies that would be difficult to detect



Reduces time and effort to identify and diagnose problematic messages

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- **IBM Flash Express**
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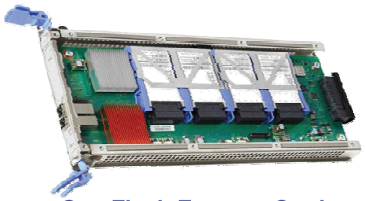
IBM Flash Express – Smarter availability for smarter computing

NEW

- **Flash Express is an innovative solution designed to help organizations compete effectively in today's marketplace**
  - Automatically improve availability for key workloads at critical processing times
  - Drive availability and performance for workloads that cannot tolerate paging spikes or inconsistent performance
  - Slash latency for critical application processing such as diagnostics collection
- **Extends IBM's expertise in memory management introducing a new tier of memory using Flash Express**
- **Provides a secured, resilient and immediately usable solution**
- **Planned Flash Express and pageable large page exploiters:**
  - z/OS V1.13 ***Language Environment***
  - ***Java SDK7*** and by extension
    - ***WAS Liberty Profile*** v8.5
    - ***DB2***
    - ***IMS 12***
    - And a future release of ***CICS Transaction Server***
  - ***IMS 12 Common Queue Server***

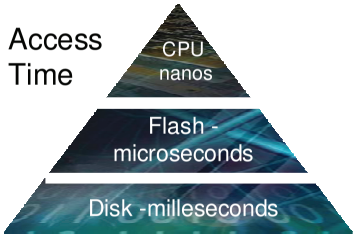
Flash Express – what is it?

- Physically comprised of internal storage on Flash SSDs
- Used to deliver a new tier of memory, storage class memory
- Uses standard PCIe I/O drawer
- Supported on z/OS V1.13 plus web deliverable
- Flash Express cards delivered as a RAID 10 mirrored card pair



One Flash Express Card

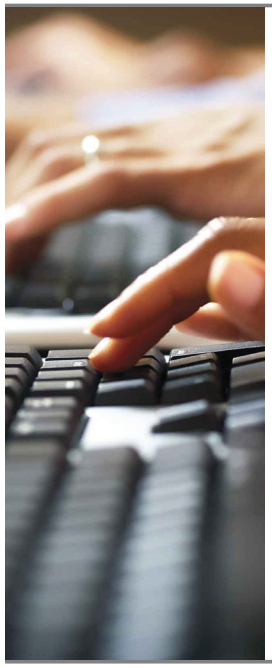
- Sized to accommodate *all LPAR paging*
  - Each card pair provides **1.6 TB** usable storage (3.2 TB total)
  - Maximum 4 card pairs (4 X1.6=6.4 TB)
- Immediately usable
  - No capacity planning needed
  - No intelligent data placement needed
  - Full virtualization of card across partitions
- Robust design
  - Designed for long life
  - Designed for concurrent replacement or upgrade



Flash memory blurs the distinction between memory and storage characteristics

- Security characteristics
  - Data encrypted on the flash express adapter with 128-bit AES encryption
  - Keys stored on smart cards plugged into the System z SE
  - Removal of smart cards renders data unusable

Flash Express – representative use cases



Flash Express can reduce latency delays from paging to bring system availability to new heights and improve overall service levels

Application related errors will require collection of diagnostics. These diagnostics can be collected faster with Flash Express, reducing paging related delays that can impact your overall availability.

Having your working data resident in Flash can help accelerate start of day processing, and improve service for many industries at the busiest time of their work day - a time when they cannot afford disruptions.

DB2® and Java™ in memory buffer pools work to store and process application data. DB2 and Java can benefit from 1MB pageable large pages with Flash Express, improving overall CPU performance.

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IBM System z Security as the Enterprise Standard

- **Intrinsic platform security and privacy for transactions and sensitive data helps enable System z to be the secure enterprise application server and data vault**
  - Hardware cryptography built into each general purpose CP and IFL, and via the new Crypto Express4S coprocessors
  - Secure your critical information assets (or data) throughout their life cycle
- **Security capabilities that span the needs of multiple industries**
  - Strong focus on security and crypto functions required by the Banking/Finance industries
  - Support for the payment card industry with solutions that leverage the zEC12 for compliance and security (i.e. EMV for American Express)
  - New IBM Enterprise PKCS #11 Coprocessor firmware and support from z/OS helps meets the requirements of the European Union and public sector clients
- **Leveraging the strengths of operating system security and cryptographic capabilities**
  - Qualities needed by enterprises adopting cloud application architectures
  - Wide range of cryptographic primitives exploited by operating system and middleware to help secure and accelerate workloads
- **zEC12 supports the System z exclusive protected key processor based cryptography**
  - Blends the speed of processor based crypto with the security of the Crypto Express coprocessor
- **PR/SM™ designed for EAL 5+ certification**

CP Assist for Cryptographic Function (CPACF)

- Available on every Processor Unit defined as a Central Processor (CP) and or Integrated Facility for Linux (IFL)
  - Supported by z/OS, z/VM, z/VSE, z/TPF and Linux on System z
- Provides a set of symmetric cryptographic functions and hashing functions
  - Enhances the encryption/decryption performance of clear-key operations for:
    - SSL
    - VPN
    - Data storing applications
- Must be explicitly enabled, using a no-charge enablement feature (FC 3863)
  - SHA- 1, SHA-224, SHA-256, SHA-384 and SHA-512 shipped enabled with each server
- Protected key support for additional security of cryptographic keys
  - Crypto Express3 or Crypto Express4S required
- Provides functions for:
  - Data privacy and confidentiality
  - Data integrity
  - Random Number Key generation
  - Message Authentication

Introducing Crypto Express4S

- Latest cryptographic feature designed to complement the cryptographic functions of CPACF
- Provides state-of–the art tamper sensing and responding, programmable hardware to protect the cryptographic keys and sensitive custom applications
  - Unauthorized removal of the adapter zeroizes its content
- Suited to applications requiring high-speed security-sensitive cryptographic operations for data encryption and digital signing, and secure management and use of cryptographic keys
  - Functions targeted to Banking/Finance and Public sector
- FIPS 140-2 Level 4 hardware evaluation
- Performance of Crypto Express4S is similar to a single processor on Crypto Express3

zEC12 – Supports efficiencies in the data center

- **New non-raised floor option offers flexible possibilities for the data center**
- **Continuing to support options for better control of energy usage and improved efficiency in your data center**
  - zEC12 has a new radiator-based air cooled system design for more efficient cooling and improved concurrent maintenance
  - Water cooled options on zEC12 allow for up to 9% additional data center energy savings[1]
  - Savings with optional HV DC power when implemented in a new data center could be on the order of 7-12% of server input power[1]
- **More capacity but little change to the footprint in the data center**
  - Identical floor cutouts for zEC12 as the z196 and z10 EC[3] with no significant increase in weight
  - Depth of system with covers will increase by 64 mm / 2.52 inches
- **Over 12 years experience in designing and building earthquake resistant servers**

[1] Based on IBM Study
[2] With the exception of water cooling and overhead cabling

Operating System Support for zEC12

- **The following are the minimum operating systems planned to run on zEC12:**
  - z/OS
    - z/OS V1.12, V1.13
    - z/OS V1.11, V1.10 Lifecycle Extension
  - Linux on System z distributions:
    - SUSE Enterprise Server (SLES) SLES 10 and SLES 11
    - Red Hat Enterprise Linux (RHEL) 6 and RHEL 5
  - z/VM
    - VM V5.4, 6.1, 6.2 with PTFs
    - z/VM V6.1, 6.2 for zBX support
  - z/VSE
    - z/VSE V4.3, V5.1, with PTFs
    - z/VSE V5.1 with PTFs for Crypto Express4S toleration
  - z/TPF V1.1
- **Using the general purpose application server blades we have:**
  - Linux: Red Hat RHEL 5.5, 5.6, 5.7, 6.0 6.1 & SUSE Linux Enterprise Server (SLES) 10 (SP4) and SLES 11 SP1
  - Microsoft Windows Server 2008 R2 and Microsoft Windows Server 2008 (SP2) (for either Windows we recommend Datacenter Edition)
  - AIX: AIX 5.3 Technology Level 12 or higher, AIX 6.1 Technology Level 5 or higher, AIX 7.1

Agenda

- zEnterprise EC12 Introduction
- Processor
- IBM zAware
- IBM Flash Express
- zEC12 System Features
- **Summary**

IBM zEnterprise EC12: An optimized system

Semiconductor Technology	Microprocessor Design	Systems Design	Virtualization & Operating Systems	Compilers & Java Virtual Machine	Optimized Middleware
• eDRAM cache integrated on processor chip • Efficient packaging • Optimized high-K metal gate transistor design • 2x transistor density for logic and on-chip memory	• World's fastest chip at 5.5 GHz • More cache for superior data serving • On-chip crypto and data compression • Instruction co-optimized with compilers, Java, DB2 • Transactional Execution • Runtime Instrumentation • Decimal Format Conversions • 2 GB page frames	• Optimized I/O pathways & subsystems with massive scale • Best-of-breed reliability, availability & serviceability • RAIM memory for high availability • Integrated cryptographic coprocessor • I/O cryptographic coprocessor • Highest commercial security certification in industry (EAL5+ & FIPS 140-2 level 4) • Multi-platform design of mainframe and distributed technologies • Designed for highest utilization with heterogeneous workloads	• Intelligent policy management of mainframe & distributed technologies • Granular, scalable virtualization of servers, memory and I/O with low overhead • PR/SM and z/VM offer two-tier approach for superior virtualization supporting native Linux • Dispatching on z/OS keeps software close to cache for optimized performance • Highly available and resistant partition architecture suitable for private cloud	• Java, ASM, C/C++, PL/I Compilers optimized to exploit hardware architecture • Java Runtime Environment exploits dynamic optimization (transactional execution)	• WebSphere, MQSeries, DB2 exploit multi-system workload management, scale and availability • Middleware optimized and tuned to scale up • Tivoli optimized for operations management and security • High volume, high performance, low cost transaction processing with CICS and IMS

* Compared to z196

Summary

IBM zEnterprise EC12 Extends the Value of System z

- Increased processor and system capacity
- Efficient scaling with consistent performance
- Support for mission-critical workloads
- Availability enhancements: IBM zAware and Flash Express
- Security enhancements" CPACF and Crypto Express 4S

zEC12 is Designed for Today's Complex Workloads

- Integration of analytics with existing data and transactions
- Optimization across the Hardware / OS / Middleware stack
- Leverage other technologies via hybrid systems
- Platform management for improved operational efficiency

System z is Positioned for the Future

- Evolving system design to meet technology challenges
- Preserving mainframe values and client investment
- Sustaining growth in system performance and function

Thank you!
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