System z Expo

*October 13 – 17, 2008 – Las Vegas, Nevada*

# Session Title: z/VSE V4.2 Technical Insights Part 2

## Session ID: zEG05

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Authorized IBM Training

10/01/2008

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# Agenda

- Turbo Dispatcher
- 64 bit implementation
- Capacity Measurement Tool
- SCSI support in z/VSE
- Tape encryption
- More tasks

# Turbo Dispatcher

- Turbo Dispatcher history
  - Introduced in 1994, many enhancements since then.
  - Standard and Turbo Dispatcher until VSE/ESA 2.4.
  - TD the only dispatcher since VSE/ESA 2.4 (1999)

- Turbo Dispatcher Design
  - TD dynamically assigns partitions to CPUs
    - Assignment to one CPU lasts from dispatcher selection to next interrupt = work unit
    - If one task of a partition is active, no other task of the same partition can be selected
  - A partition (VSE/POWER job) processes many work units

# Turbo Dispatcher Design ...

- Work units types:
  - <u>parallel work unit</u>
    - Application code (CICS/VSE, batch)
    - A parallel work unit may run on any CPU concurrently with other parallel or non-parallel work units.
  - <u>non-parallel work unit</u>
    - System code (services, ACF/VTAM)
      - As long as one non-parallel work unit is active on one CPU,
        no other non-parallel work unit can execute on any other CPU.
- VSE/POWER maintask has parallel or non-parallel work units

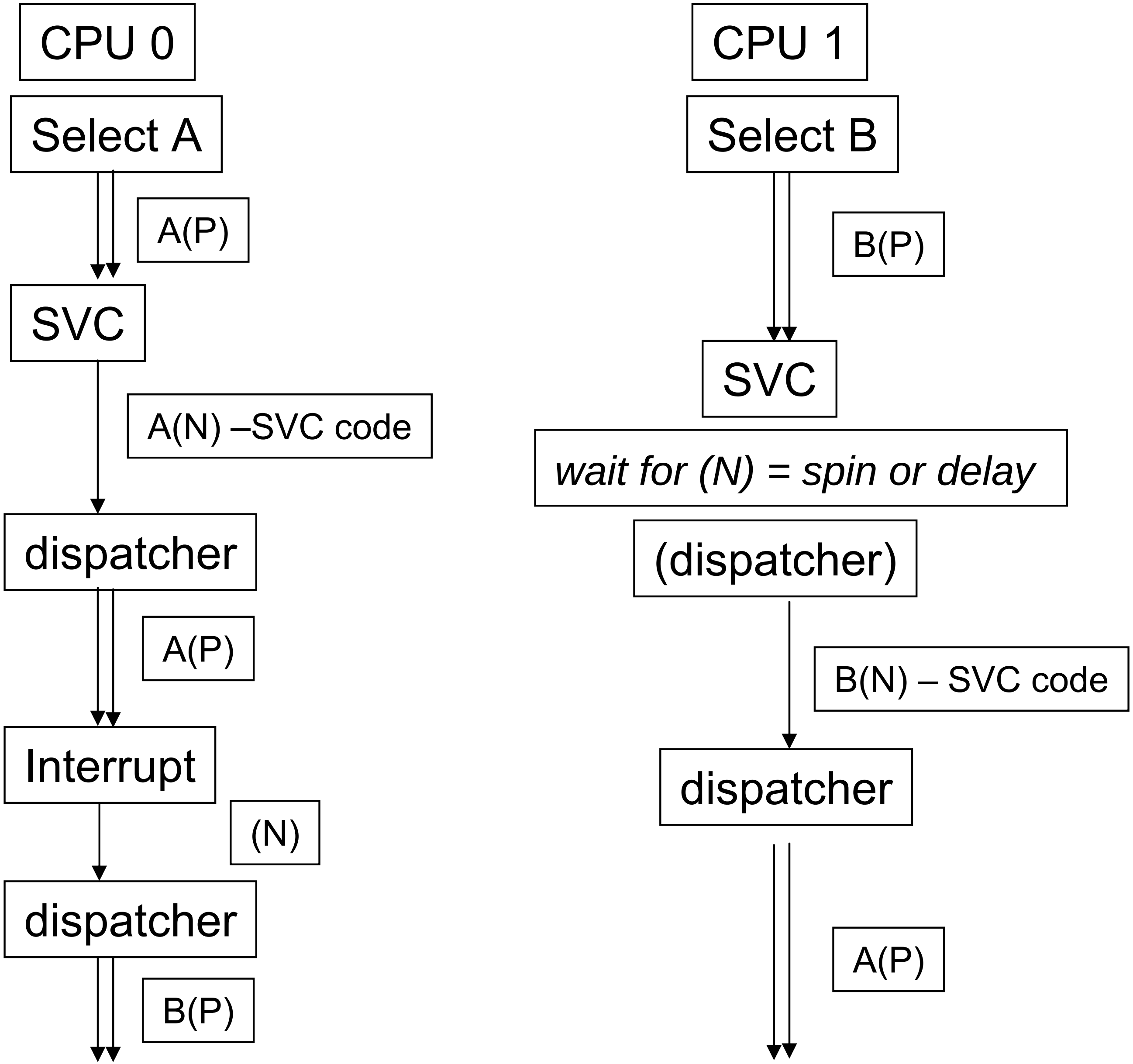
# Turbo Dispatcher Design …

| | | | |
|---|---|---|---|
| JOB A | A1 (N) | A2 (N) | A3 (P) |
| JOB B | B1 (P) | B2 (N) | B3 (P) |
| JOB C | C1 (P) | C2 (P) | C3 (P) |

| | CPU 0 | CPU 1 |
|---|---|---|
| Step 1 | A1 (N) | B1 (P) |
| Step 2 | C1 (P) | A2 (N) |
| Step 3 | B2 (N) | A3 (P) |
| Step 4 | C2 (P) | B3 (P) |
| Step 5 | | C3 (P) |

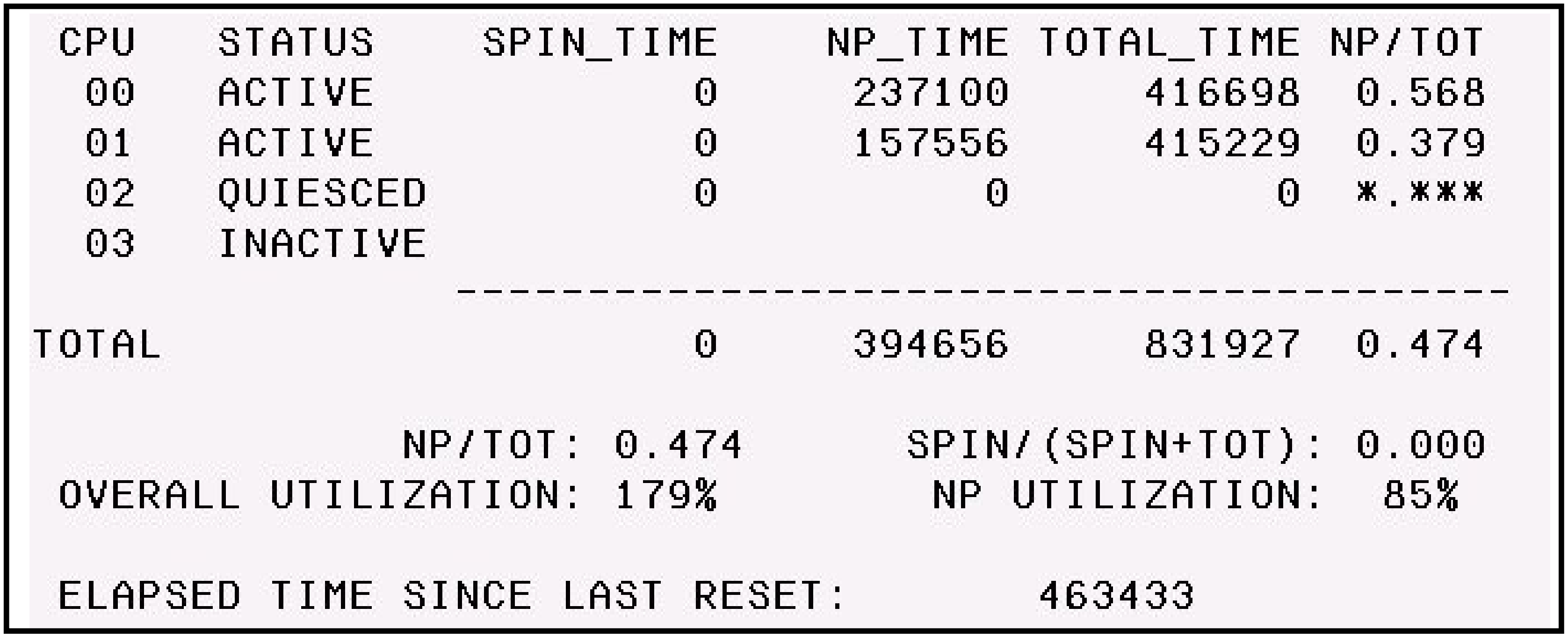
Ax, Bx, Cx = work unit x of JOB A, B, C
(N) = non-parallel work units
(P) = parallel work units

# Turbo Dispatcher Design …



# Turbo Dispatcher Operation ...

- Retrieve CPU time values: QUERY TD



```
 CPU    STATUS      SPIN_TIME      NP_TIME TOTAL_TIME NP/TOT
  00    ACTIVE              0       237100     416698  0.568
  01    ACTIVE              0       157556     415229  0.379
  02    QUIESCED            0            0          0  *.***
  03    INACTIVE
                       ---------------------------------------
TOTAL                       0       394656     831927  0.474

              NP/TOT: 0.474        SPIN/(SPIN+TOT): 0.000
 OVERALL UTILIZATION: 179%          NP UTILIZATION:  85%

 ELAPSED TIME SINCE LAST RESET:           463433
```

TOTAL_TIME = CPU time used by workload
NP_TIME = non-parallel CPU time, contained in TOTAL_TIME
SPIN_TIME = CPU time needed to wait for a non-parallel work unit
All above values given in milliseconds.

NP/TOT = ratio NP_TIME / TOTAL_TIME = non-parallel share
SPIN/(SPIN+TOT) = spin time ratio

# z/VSE 4.2: CPU Balancing

- When CPU balancing is activated,
  the z/VSE Turbo Dispatcher will only use CPUs required for the current workload

- Can be activated and deactivated via AR/JCL command
  - SYSDEF TD,INT=0 to deactivate, default
  - SYSDEF TD,INT=nn (=1..99) to activate and "nn" interval in seconds, after which the CPU utilization is inspected

- Threshold can be defined after which an additional CPU is activated
  - SYSDEF TD,THR=nn (10..99) in percent

- CPU balancing via stop or quiesce process
  - SYSDEF TD,INT=nn,STOP - the stop process to be used
    - May provide performance improvements for z/VM 5.4 guests
  - SYSDEF TD,INT=nn,STOPQ - the quiesce process to be use, default

- QUERY TD shows current settings

- CPU balancing may reduce multiprocessing overhead

# Performance Hints

- One partition can only exploit the power of a single CPU
- Use as many partitions as required for selected n-way
- Use/define only as many CPUs as really needed
- Full exploitation expected up to 3 CPUs
- Exploitation increases by reduction of non-parallel work units (e.g. by data in memory)
- Partition setup
  - Set up more batch and/or (independent) CICS partitions
  - Split CICS production partitions into multiple partitions (MRO)
  - Use a database (DB2)

# Non-Parallel Components

- A single CPU must be able to handle the non-parallel part of the total workload.
- Non-parallel code limits the maximum MP exploitation.
- QUERY TD command shows non-parallel share (NPS).
- System code (Key 0) code increases NPS.
  - Vendor code can have significant impact.
- TD searches for parallel work, when non-parallel resource is occupied.
- Overhead increases when NP code limits throughput.

# Limited Multiprocessor Benefits

- 'Largest' VSE partition requires more CPU power as available on a single CPU of the n-way
- VSE system limited by system resources other than CPU utilization, e.g. I/O, LTA, System GETVIS (24 bit), ...
- New bottleneck because of more capacity, would also appear on faster uni-processor
- Overall workload's non-parallel share too high
- Not enough partitions concurrently active

# CICS Implications

- Single CICS
  - Can consume processing power of one CPU only
  - If a CICS partition requires more CPU time than a single CPU can provide, the response time increases.
- Multiple CICS partitions (MP exploitation)
  - E.g. non-parallel share of 30 %
    - max. exploitable CPUs = 3
  - Multiple CICS workload alternatives
    - Independent CICS partitions
    - MRO transaction routing
    - MRO function shipping to file owning region
    - Mixtures of transaction routing and function shipping

# Performance Measurements

2 or 3 CPUs can be fully exploited

- ➢Where non-parallel share ranges from 0.5 to 0.25

- Number of CPUs that can be exploited for a given workload:
  - ➢number of CPUs = 0.9/non-parallel share
  - ➢The value 0.9 is used here to take into account the delays caused by waiting for the non-parallel state.

- Measurements with our workloads
  - ➢Batch workload (16 partitions):
    - •TD overhead: 15 %, NPS: 0.48, MP factor (2-way): 1.4
  - ➢Online workload, TD overhead 4%, NPS: 0.27
    - ➢2-way, 3xCICS: MP factor: 1.75, utilization: 93%
    - ➢3-way, 4xCICS: MP factor: 2.35, utilization: 84%
  - ➢Online Workload, more I/O intensive, TD overhead 7%, NPS: 0.31
    - ➢2-way, 3xCICS: MP factor: 1.65, utilization: 77%
    - ➢3-way, 4xCICS: MP factor: 2.17, utilization: 82 %

# Turbo Dispatcher - Summary

- VSE workload can exploit up to 3 CPUs
- One partition can only exploit the power of one CPU
- A lower non-parallel share value will allow a better multiprocessor exploitation.
- Try to minimize the number of CPUs to run your workload
  - To reduce the multiprocessor overhead

# 64 bit real

- Processor storage > 2 GB, up to 8 GB
  - **z/VSE 4.2: up to 32 GB**
- Virtual address/data space size remains at max. 2 GB
- 64 bit virtual addressing not supported
- 64 bit addressing  mode not supported for applications or ISVs
- Implementation transparent to user applications
- Performance: 64 bit real can reduce / avoid paging
- In most cases the NOPDS option can be used

# 64 bit real – z/Architecture vs ESA/390 Architecture

| **z/Architecture** | **ESA/390 Architecture** |
|---|---|
| 24-bit and 31-bit addressing (up to 2GB)<br>64-bit addressing mode (more than 2GB) | 24-bit and 31-bit addressing (up to 2GB) |
| 16-byte PSW (64-bit instruction address) | 8-byte PSW (31-bit instruction address) |
| 8-byte general purpose registers | 4-byte general purpose registers |
| 8-byte control registers | 4-byte control registers |
| 4-byte access registers | 4-byte access registers |
| Prefix area is 8K (8K low core) | Prefix area is 4K (4K low core) |
| In Prefix area: changed locations of<br>New / old PSWs<br>Interrupt information like<br>page fault address<br>Store status save area .... | |
| Location of ESA/390 PSWs not used by HW | |

# z/Architecture - z/VM Display Examples

```
VM CP: D PSWG:  PSW = 04042000 80000000 00000000 0000CEDA (31-bit)
       D PSWG:  PSW = 04042000 00000000 00000000 0000CEDA (24-bit)
       D PSWG:  PSW = 04042001 80000000 00000000 0000CEDA (64-bit)
       D GG8 :  GRG  8 =  FFFFFFFF  8001760C
       D G8 :    GPR  8 =  8001760C
                 LA    41808000          0001760C   (4-byte reg. Instruction)
       D GG8  : GRG  8 =  FFFFFFFF 0001760C
                 ST    5080xxxx     --- only low-order 4-byte are stored
                 D VTxxxx :   0001760C
        D XG1:  CRG  1 =  0000000003F3F00
        D X1:    ECR  1 =  03F3F00
```

# 64 bit real - Implementation

- IPL starts in ESA/390 mode and switches to z/Architecture mode during the IPL process
- Simulation of ESA/390 low core fields
- Only the z/VSE page manager has access to the area above 2GB
- Virtual pages can be backed by 64 bit real page frames
- PFIX or TFIX requests will use real page frames below 2 GB
- Page manager control blocks below 2GB
- **z/VSE 4.2: Page manager control blocks above 2 GB**
- 64-bit page frames used directly for page-in and page-out I/O

# 64 bit real – Implementation …

- Hardware uses z/Architecture new and old PSWs and interrupt locations for interrupts
  - Interrupts: external, SVC, I/O, machine check, program check
  - Interrupt processing; hardware stores old PSW and interrupt information and passes control to interrupt new PSW

- In z/VSE z/Architechture new PSWs point to emulation code
  - Prepares ESA/390 interrupt information
  - Pass control to z/VSE interrupt handlers
  - ESA/390 interrupt information is not used by hardware

- Task save areas are not extended, therefore only selected system routines can run in 64 bit mode or use 8 byte registers

# 64 bit real – ESA/390 Emulation

- In most cases system programs use ESA/390 locations
  - Such as ESA/390 old PSWs
  - Emulation guarantees that system code runs unchaged

- When an interrupt occurs, emulation code provides
  - Transalation of z/Architecture old PSW into ESA/390 old PSW
  - Setup of ESA/390 interrupt information
  - Continuation at ESA/390 new PSW address (z/VSE interrupt handler)

- Interrupt handlers/dispatcher work with ESA/390 information/locations

# ESA/390 Emulation – Program Check Example

Generated within Supervisor:
ESA/390 PC New PSW at 00000068: 000C0000 8000F142 (points to interrupt handler)
z/Arch PC New PSW at 000001D0: 00040000 80000000 00000000 0000F0B2
(points to emulation code)

Program check (page fault) occurs:

```
00000000000133B8    MVC   D21F10009398    00506000
00000000000133B8    PROG    0011 -> 0000F0B2
```

Hardware sets:
z/Arch PC Old PSW at 00000150: 04040000 00000000 00000000 000133B8
z/Arch Transl. Excep. at 000000A8: 00000000 00506000 (page fault address)

Emulation code at F0B2 provides:
ESA/390 PC Old PSW at 00000028: 040C0000 000133B8
ESA/390 Transl. Excep. at 00000090: 00506000
Supervisor can continue at F142 (program check handler) as in ESA/390 mode

# Capacity Measurement Tool (CMT)

- Tool can be activated on z9 and z10 models
- z/Architecture mode required -> z/VSE 4.1 / 4.2 only
- z/VSE supported in LPAR and as z/VM guest
- Implementation
  - ➢ New system task
    - Will measure CPU usage and calculates MSUs
    - Measurement interval every 30 minutes
    - Calculation of the 4 hour rolling average
    - SMF like (SCRT89) records written to datasets
  - ➢ Datasets is input for the Sub-Capacity Reporting Tool (SCRT)
- Required for Midrange Workload License Charges (MWLC)
  - ➢ Sub-capacity option
- 13 z/VSE products participate in MWLC

# Capacity Monitoring Tool …

- CMT requires 3 (sequential BAM) disk files
  - One control file and 2 data files, size depends on configuration

- Once a month the input to the input to SCRT need to be prepared

- Sub-capacity Reporting Tool (SCRT)
  - SCRT with support for z/VSE 4.1 / 4.2
  - Analyzes SCRT89 records produced by CMT
  - SCRT Output is a report, similar to a spreadsheet report
  - Report to be send to IBM via web interface

# Capacity Monitoring Tool …

- Required steps for all z/VSE systems
  - ➢ Allocate/intitialize datasets for SCRT89 records
  - ➢ Update STDLabel procedure with DLBL and EXTENT info
  - ➢ Start capacity measurement
    - o To be started after IPL complete with unique id
    - o Update member USERBG.PROC with EXEC statement
    - o Can be started through // EXEC IJBCMT,PARM=‘START ID=xxxx‘
      - o xxxx must be unique within the CPC
  - ➢ You may check via STATUS or SIR command if measurement is active
  - ➢ CMT can be stopped via // EXEC IJBCMT,PARM=‘STOP‘
  - ➢ Use SCRT to analyze the measured data.
  - ➢ Send the final report to IBM once a month

# SCSI Support in z/VSE

- SCSI disks as emulated FBA disks on z/VM V5.2 or higher
  - ➢ z/VSE supports a max. size of 2 GB
- Direct attached SCSI disks
  - ➢ z/VSE supports up to 24 GB (VSAM: 16 GB)

# SCSI Support in z/VSE

- z/VSE supports SCSI disk devices only
- Impact on applications
  - Transparent to all VSE applications and subsystems,
    - Minimal impact on ISV system management tools
  - Reasons for transparency:
    - z/VSE’s SCSI implementation is based on FBA support
    - Applications can not exploit SCSI commands directly
    - FBA to SCSI emulation on low level I/O interface

# SCSI Support in z/VSE

- Access SCSI devices through Fibre Channel Protocol (FCP)
  - ➢ Support available on System z processors
  - ➢ OS interfaces
    - Operating system communicates with FCP adapter
    - FCP adapter communicates with the SCSI device
  - ➢ SCSI disk devices utilize fixed block sectors
    - Therefore VSE treats them as FBA devices

# SCSI Support – Content / Limitations

- z/VSE’s SCSI support includes:
  - SCSI for system and data device (SCSI only system)
  - Multipathing for fail-over

- SCSI support transparent to existing (I/O) APIs

- Block size restricted to 512 bytes,
  even if the SCSI device can be configured with larger block sizes

- Max. SCSI disk size about 24 GB, VSAM 16 GB

- FSU from SCSI to SCSI device only

# SCSI Support - Configuration

- New IPL / JCL commands and dialog to define and query a SCSI device
- Required steps to get a SCSI device known to z/VSE
  - Device configuration
  - Switch configuration
    - In case of point to point connections (System z9) no longer necessary
  - FCP Adapter to be configured in IOCDS (CHIPID type FCP)
  - FCP adapter and SCSI disk to be defined in VSE via
    - IPL ADD commands to define FCP and FBA device
    - IPL DEF or JCL SYSDEF command to define connection to LUN

# SCSI Configuration in z/VSE (Example)

- Define FCP Devices, SCSI Disks and Connection Paths to z/VSE

  - FCP Devices
    - ADD C00,FCP (ADD C00:C0F,FCP)
    - ADD D00,FCP (ADD D00:D0F,FCP)

  - FBA Devices:
    - ADD 700:701,FBA
    - Note: these devices must not exist in the IOCP or under VM

  - Define a Connection Path (IPL)
    - DEF SCSI,FBA=700,FCP=C00,WWPN=5005076300CA9A76,LUN=5600
    - DEF SCSI,FBA=701,FCP=C00,WWPN=5005076300CA9A76,LUN=5601

    Only one FCP cuu required to access the LUNs

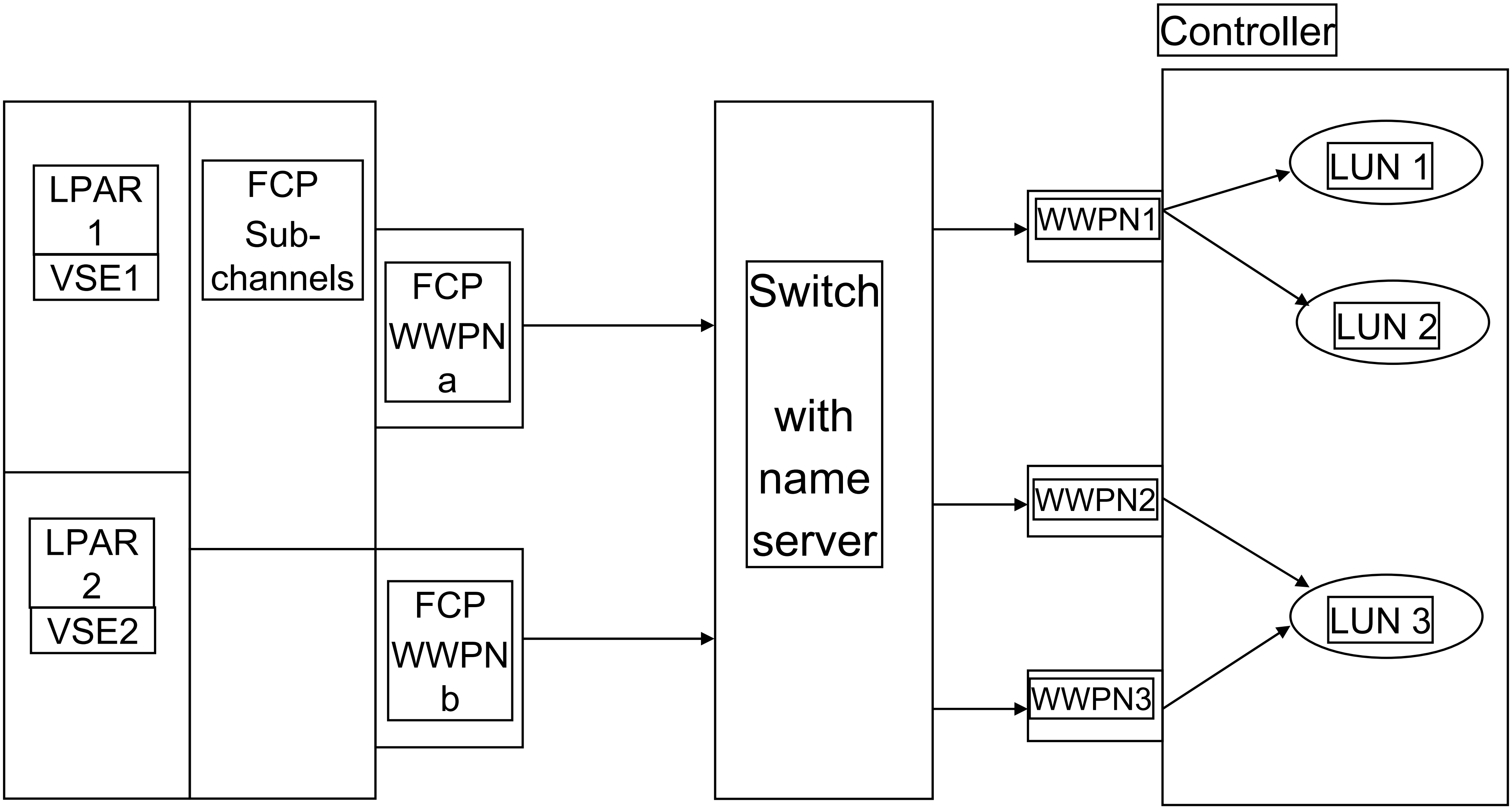
  - Define a Connection Path (after IPL)
    - SYSDEF SCSI,FBA=702,FCP=C00,WWPN=5005076300CA9A76,LUN=5602
    - Note: The FBA and FCP devices added during IPL.

  - IUI Dialogs are available to configure SCSI Devices

# SCSI Support - Configuration

- System z FCP adapter supports switched network (z/VSE 3.1),
  Point-to-point connection with z/VSE 4.1/4.2 and z9 BC, z9 EC, z10 EC:
  - ➢ Each FCP adapter has an associated port (WWPN)
  - ➢ FCP adapter configured in IOCDS with subchannel type FCP
  - ➢ FCP adapter connects to a switch
  - ➢ Switch connects to a controller with one or multiple ports
  - ➢ Controller accesses one or more SCSI devices (LUNs)
- **z/VSE 4.2: SAN Volume Controller (SVC) support**

# SCSI Support - Configuration



# SCSI Support – System z9 / z10 Exploitation

- N_Port ID Virtualization (NPIV) for (CHPID type) FCP channels
  - Multiple virtual FCP channels can be defined each with its own unique Fibre Channel port name and FC N_Port ID
      - Each FCP device (ADD device,FCP) has its own portname
  - NPIV allows sharing the Lock file on SCSI between multiple z/VSE systems using the same physical FCP adapter (CHPID)
    - DEF SCSI,FBA=600,FCP=C00,WWPN=5005076300CA9A76,LUN=5750 (VSE1)
    - DEF SCSI,FBA=600,FCP=C01,WWPN=5005076300CA9A76,LUN=5750 (VSE2)
      - 600 is the lock file disk. With NPIV, C00 and C01 can be on same FCP CHPID
  - To use NPIV, the Fibre Channel switch must support NPIV
  - Without NPIV,
    - Each FCP channel(device) has the portname of the FCP CHPID
    - Each z/VSE needs its own physical FCP adapter to access the lock file

- FCP point-to-point attachments
  - FCP feature can directly attach to storage devices. No switch required.

# Data Encryption (z/VSE 4.1 + PTF, z/VSE 4.2)

- IBM TS1130 Tape Drive with encryption feature
  - Supported by z/VSE 3.1, z/VSE 4.1, z/VSE 4.2
  - Supports data encryption within the drive itself
  - Using Systems Managed Encryption with the TS1130
  - z/VSE support will require the Encryption Key Manager (EKM) component running on another operating system other than z/VSE using an out-of-band connection.
    - Generation and communication of encryption keys for tape drive
    - TCP/IP connection between EKM and the tape controller
  - Data encryption is transparent to z/VSE applications
  - Data encryption
    - Data will be encrypted and compressed, when specified
    - Default: encryption disabled
  - **z/VSE 4.2: encryption re-keying support to encrypt data key of encrypted tape cartridge**
  - More details on z/VSE home page

# Data Encryption …

- Encryption Key Manager (EKM)
  - ➢ EKM is a Java application, used to generate and protect AES keys
  - ➢ On request EKM generates AES (256 bit) data keys and protects those keys
  - ➢ Key encryption key label (KEKL) identifies the encryption keys
  - ➢ The KEKL or the hash value of the public key can be stored on the cardridge.

  - ➢ You may download EKM from the internet

# Data Encryption …

- In z/VSE jobs must have an ASSGN statement and KEKL statement to access or write encrypted data

- ASSGN statement
  - ➢ ASSGN SYSnnn,cuu,mode
    - – cuu = device address
    - – mode =
      - 03 encryption wirte mode
      - 0B encryption and IDRC write mode
      - 23 encryption and unbuffered (compression) write mode
      - 2B encryption and IDRC and unbuffered write mode

- KEKL statement
  - ➢ // KEKL UNIT=cuu,KEKL1=key_label_1,KEM={L|H}
    - – KEM = key encoding mechanism
      - L = label, H = public key hash

# Data Encryption …

- Write encryption data example
  - // JOB ENCRYPT
  - // ASSGN SYS005,480,3
  - // KEKL UNIT=480, KEKL1=,HUSKEK1‘,KEM1=L
  - // EXEC LIBR
    BACKUP LIB=PRD2 TAPE=SYS005
  - /*
  - /&

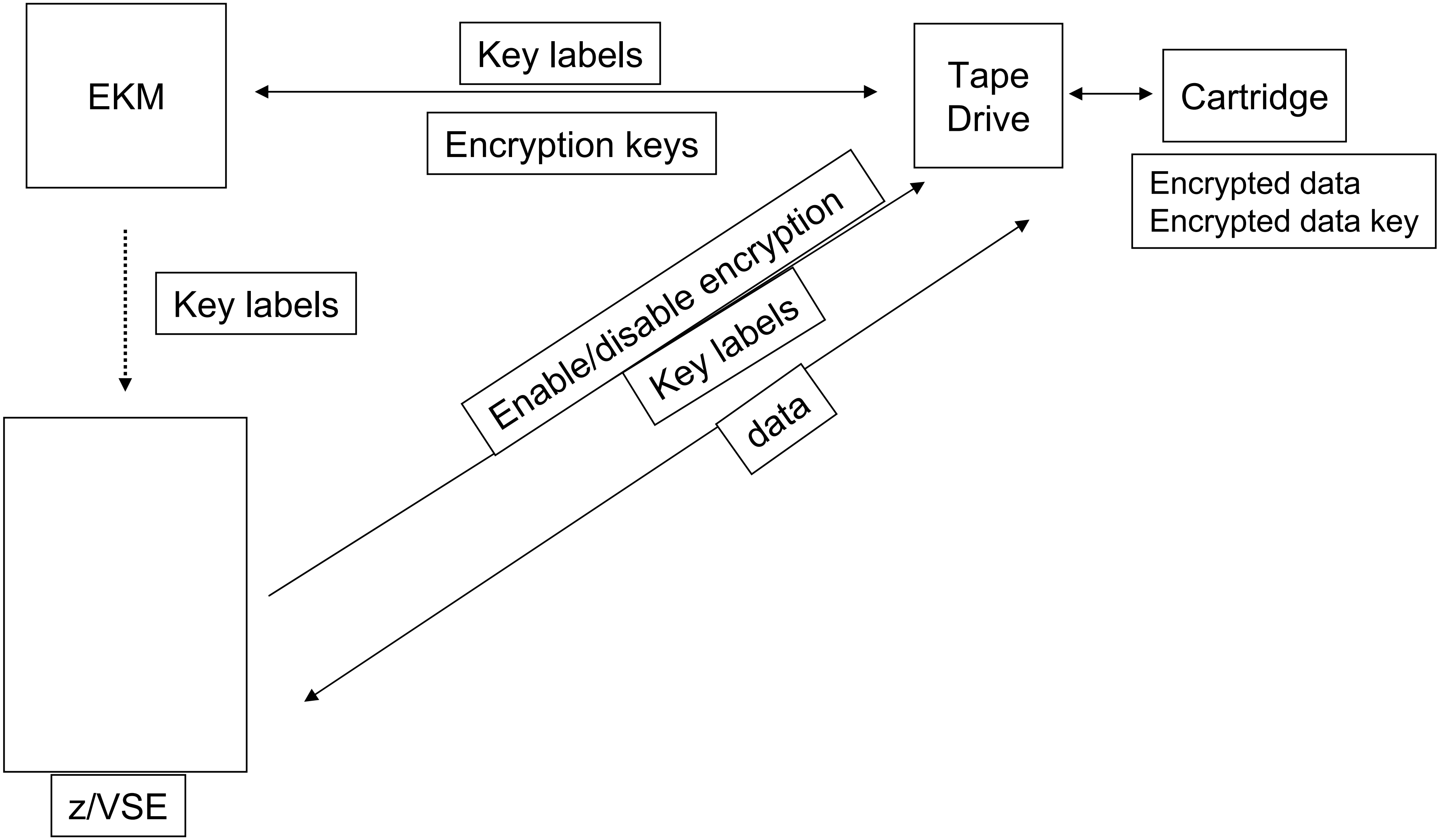
- Read encrypted data
  - No need to specify the ASSGN mode or KEKL
  - The control unit recognizes the encrypted tape and tries a key exchange with the EKM and the KEKL saved in cardridge memory.

# Data Encryption …

- Steps to encryption
  - 1. Load cartridge
  - 2. EKM to tape drive: specify encryption, provide key labels
  - 3. Tape drive requests data key from EKM
  - 4. EKM generates key and encrypts with public and session keys
  - 5. EKM to tape drive: Encrypted keys transmitted
  - 6. Tape drive writes encrypted data and stores encrypted data key on cartridge

- Implementation in z/VSE
  - VSE JCL enhancements
    - For encryption setting (via ASSGN)
    - Key Encryption Key Label (KEKL) may be specified
  - I/O Supervisor
    - retrieves encryption information, activates encryption and transfers KEKL

# Data Encryption …



# z/VSE 4.2: up to 512 tasks

- Up to 512 VSE tasks, still 32 VSE tasks per partition
- Task id (TID = 2 byte field) in SYSCOM and other control blocks
  - ➢ Old tasks (up to 255) = 1st byte zero, 2nd byte holds task id
    - – Highest task id X'00FF'
  - ➢ New tasks: X'0100' .. X'01FF'
  - ➢ System and maintasks will always receive old task ids

# z/VSE 4.2: up to 512 tasks …

- No IPL option required
- System option (SYSDEF) to set max. number of tasks and defaults
  - SYSDEF SYSTEM,NTASKS=(nnn|MAX),TASKS=(ANY|OLD)
- EXEC parameter for compatibility mode
  - // EXEC phase,TASKS=(ANY|OLD)
- MAP/QUERY / SIR to show more task details
  - Display settings via QUERY command / MAP command

# More Information

- … on VSE home page:

http://ibm.com/vse