JES2 Bootcamp – Part 1 of 2
What is JES2 and what does it do

Tom Wasik
IBM Rochester, MN
wasik@us.ibm.com
Wednesday 9:30AM
Session Number 15325

Mainframe 50 April 7th 1964 - April 7th 2014
http://www.ibm.com/mainframe50/
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Brief History of JES

- Original 2 versions
  - Attached Support Processor (ASP)
  - Houston Automatic Spooling Priority (HASP)
- Both affiliated with the US space program
- Both were field developed programs
- Both addressed the problem of slow peripheral I/O
- Spool was staging area for input (jobs) and output (SYSOUT)
- Made more efficient use of expensive CPU resource
- Provided functions the operating system (MVT) chose not to
- Eventually became JES2 (HASP) and JES3 (ASP)
  - JES - Job Entry Subsystem
Why do I need a JES? (What does it do?)

• JES implements SPOOL
  • Storage for job JCL, SYSOUT, SYSIN
• JES manages batch
  • Gets jobs from multiple sources and places them on SPOOL
    • Includes TSO logon, started tasks and Batch
  • Schedules jobs to execute (manages work queues)
    • WLM initiator started by WLM, but JES selects the work
  • Provides interfaces to influence job scheduling
    • SSI, commands, exits
• JES manages SYSOUT
  • Interfaces to JES printers
  • Provides output to “FSS” printers (PSF)
  • Has interface for generic “print” drivers (InfoPrint, etc)
    • SAPI – SYSOUT API
• JES connects multiple MVS images
  • MAS/Complex predates SYSPLEX
  • Allows multiple systems to process single job/output queue (1975)
Why do I need a JES? (What does it do?)

- JES implemented early “client server”
  - RJE/RJP allows jobs from client computers to be run on MVT and get output back (1967)
  - Protocol still used today (though greatly reduced)
- JES implemented multi-node connections
  - NJE – Network Job Entry
  - Allows peer systems to interchange jobs and output for processing (1976)
  - Early e-mail is TSO transmit over NJE
  - Supports TCP/IP as well as traditional BSC and SNA
  - Still actively used by many installations
- Interfaces with other components via the Subsystem Interface (SSI)
  - Gets control from the BCP to process events (command, wto, etc)
  - Invoked to perform functions for other components (Allocate, Open, TSO cancel/status, etc)
  - Provides basic JES2 functions (Extended status, SAPI, SWB read, etc)
What makes JES special (unique)?

- Originally field developed program
  - Not part of the operating system
  - Today, JES would have been considered a mods to the operating system
  - Before the SSI, JES front ended SVCs etc to intercept normal processing
  - Provided functions the operating system (MVT) chose not to
- Rich history of modification by customers
  - Originally as source mods
  - Later as exits
- Source distributed and maintained
  - Mostly assembler code (HLASM), some PL/X and common (IAZ) code in C
  - Customers/vendors look to JES for examples of how to do things
  - Lots of customer written exits to enhance functions
  - One customer has 35K lines of JES2 exit code
  - Customer “interface” to the operating system
How does JES work

- Mini operating system within an operating system
  - Sub dispatches single main task TCB
    - JES2 has hundreds of sub dispatchable units
    - Could not have a TCB for each
      - Serialization and storage constraints
  - Manages data sets on SPOOL
  - Supports rich set of operator commands
  - Implements network protocols
    - BSC is at a CCW level
  - Drives real devices
    - At CCW level
  - Manages work queues, does scheduling
  - Manages initiators that run work
    - Selects work to run in initiators (even WLM initiators)
    - Also manages JES mode initiators

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OK, but why 2 JESes?

- 2 philosophies of system management:
  - **JES2**
    - A collection of peer systems sharing a single job/output queue
    - Each system selects the work it can processes
  - **JES3**
    - A single job/output queue managed on one system with work being passed from main (global) system to worker (local) system for processing
    - Centralized control of where work is sent to be processed

- Functional differences
  - **JES2**
    - Simpler to use and set up
    - Changes can be made dynamically
    - No single control point to fail
  - **JES3**
    - More functions
      - *Dependent job control*
      - *Resource scheduling*
      - *Deadline scheduling*
    - Additional complexity to set up, less dynamic
JES2

- Common set of work queues stored in its checkpoint
  - Member adds to or selects work from this common queue
  - Checkpoint is time-sliced among members
- Simple mechanisms for managing work
  - Resource management done by MVS
  - Depend on MVS (scheduling environment, etc) to determine eligibility to select jobs for execution
  - Jobs sit in initiators waiting for resources (e.g., DSN ENQs)
- Peer to Peer relationship between members
  - Members select work that it can process
    - Little regard to other members
  - No single point of control
  - No critical member
- Primary communication via JES2 checkpoint data set
  - XCF usage is increasing with time
  - Mostly special purpose requests
    - Device settings
    - Status updates
    - Managing processes (like checkpoint reconfiguration, and spool migration)
- ENF used for reporting job and SYSOUT status
  - Used to track device activity and job status
  - Allows application to listen to signaling sent between members
JES2 MAS

All members perform:
- Input processing
- Spool Management
- Job Scheduling
- SYSOUT scheduling
- SSI processing
- NJE/RJE
# JES2 related address spaces

## JES2 Member

<table>
<thead>
<tr>
<th>JES2</th>
<th>JES2AUX</th>
<th>JES2MON</th>
<th>JESXCF</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local JES2 requests</td>
<td>Remote buffer retrieval</td>
<td>Monitor</td>
<td>XCF interface</td>
<td>Interpreter Input Extended Status</td>
</tr>
<tr>
<td>Input Converter BSC NJE SNA NJE</td>
<td>Owns Resources</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Printer FSS**
- **NETSERV**
- **JES2CI**
  - FSS printers
  - NJE over TCP/IP
  - Converter Interpreter
  - New in z/OS 2.1 (Optional)

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JES2 Structure

- JES2 address space
  - Main task
    - Sub-dispatched (shared) with multiple processes
  - Subtasks to perform tasks that must MVS wait
- Auxiliary address space to own processes/objects
  - Allows JES2 address space to fail yet JES functions continue
- JESXCF services
  - Provide XCF communications between address spaces
    - Mainly used for enquiry/posting function for JES2
    - More messaging is done in recent releases
  - Manages status of JES2 address spaces
    - Notifies other members of a JES2 failure
- JES2 address space can terminate yet “JES2” is active
  - Address space is only part of JES2 function
  - Other address spaces and SSI survive when JES2 address space terminates
  - Can restart JES2 address space and resume full JES2 function
  - Can cleanly terminate JES2 when all address spaces using JES2 are terminated
JES2 PCEs

- JES2 Main task processing is performed by PCEs
  - Sub-dispatchable units of work running under main task
  - Cooperative dispatching (non-interruptible from a JES2 point of view)
    - Control given up by a $WAIT macro
    - SHOULD NEVER EVER MVS WAIT
    - Need to understand is a called service can MVS wait
- Most job phases are processed by a PCE type
  - Conversion, Execution, Output, Purge
- JES2 functions are also implemented by PCEs
  - Checkpoint, spool management, etc
- Table pairs can be used to define and created PCEs
  - Tables are defined in modules loaded via JES2 LOADMOD initialization statement
  - Can be dynamically created using $ADD LOADMOD command
- Table pairs can be used to extend other things in JES2
  - This is in addition to exit points
  - Installations can add entries to various processing tables dynamically
  - For example commands and initialization statements
Job Phases
JES2 Input Processing

• Internal reader processing occurs in submitter address space
  • Request sent to JES2 address space to get a job number, job structure (in checkpoint), and initial SPOOL space
  • JCL is parsed, SYSIN data sets created, and SPOOLed in submitter address space
  • Passed symbols are saved on SPOOL (JES2 2.1)
• Job completes input processing when
  • ENDREQ macro is issued
  • /*EOF card submitted
  • New job card is encountered
  • INTRDR “data set” is closed
• NJE/TCP processing is similar (occurs in NETSERV address space)
• Other input processing occurs in the JES2 address space (main task)
  • BSC and SNA NJE, RJE, SPOOL Reload, and card readers
• Single submission streams are limited by ability to access the JES2 checkpoint
  • Parallel streams can submit much faster (10 parallel streams are 10x one single stream)
JES2 Conversion Processing

- Converts JCL into internal format needed to run job
  - Two part process – Conversion and interpretation
- JCL interpretation can occur either
  - Before job starts execution in target address space
  - After conversion processing in the JES2CI address space
- Controlled by JOBDEF INTERPRET=JES|INIT
- In either case
  - PCE selects job and sets up environment
  - Subtask used to call z/OS converter and optionally interpreter
- Certain JCL error only detected by interpreter
- Converter parms (defaults) based on JOBCLASS settings
  - Journal, BLP, SMF exits, PROCLIB, region, SWA ABOVE, etc
Execution phase - JES2 Job Scheduling

- Device/Data set scheduling managed by MVS
  - Job starts in initiator and waits for needed resources
  - GRS ENQ at allocation performs serialization and reports contention
- Allocations managed at a STEP level
  - No issues if one step creates data sets used by later steps
  - Steps that are skipped (due to conditional JCL) do not reserve resources
- System affinity and Scheduling environment used
  - Controls what jobs can be selected for execution
- Some balancing done for WLM initiators
  - Keep same percent busy on all members
WLM and JES – Managed Initiators

- **WLM initiators**
  - Initiators started and managed by WLM
  - Initiators associated with WLM service class
    - Only select work for a specific service class
    - Job class can influence service class assignment
  - WLM starts initiators based on
    - System capacity (WLM tries to balance work across SYSPLEX)
    - Whether service class is meeting goals
    - Relative importance of the service class

- **JES tells WLM on each system how many jobs are waiting**
- **Based on service class, resource availability, where jobs can run**
- **JES decides what job to start in each initiator**
- **Specified by MODE=WLM on JOBCLASS statement**

- **JES initiators**
  - Type of initiator used based on a JOBCLASS MODE=
    - Applies to all members of the MAS
  - **MODE=WLM JOBCLASS uses WLM initiators**
    - MODE=WLM cannot be selected by JES2 initiators
    - Work selected by service class
  - **MODE=JES JOBCLASS uses JES2 initiators**
    - Initiators started and managed by operator commands ($SI)
    - Number of initiators defined at initialization
    - Work selected by an ordered list of job classes and/or job class groups
  - **Start job command, $S J(nnn), causes WLM to start an initiator to run a specific job**
    - Job can be in a WLM or JES mode job class
Why WLM-managed over JES-managed?

- Fewer and simpler externals are needed to control WLM-managed initiators and to perform workload balancing.
- Managed according to the service classes and performance goals specified in the WLM policy.
- Externals reflect customer expectations typically in terms that are found in service level agreements.
- Workload balancing is automatic as the number of initiators running is based on performance goals and the importance of batch work with respect to other work.
- Dynamic, goal oriented initiator management allows the system to adapt to changing conditions and how well the work is meeting its performance goals.
JES2 Job Limits and Affinities

- JOBCLASS limits exist on a JESPLEX and member level
  - Number of concurrent jobs that can be active in JOBCLASS
  - Applies to JES and WLM mode JOBCLASSes (JOBs)
  - Limits affect number of available jobs reported to WLM
    - Impacts number of initiators WLM starts
- JOBCLASS affinity controls member where class is active
  - Lists systems that can select from the job class
  - Holding class same as null affinity list
  - Applies to JES and WLM mode JOBCLASSes
  - Affect number of available jobs reported to WLM
- Service class affinity limits where service class is active
  - Service class only registered if member in affinity list
  - WLM only starts initiators if service class is active
Execution services

- JES is involved to provide services while a job executes
  - Creation of SYSOUT data sets
  - Job submission services
  - Job message logging
  - Other JES services (SSI functions)
- One special type of SYSOUT data set is a SPIN data set
  - Allocated separate from normal job output on spool
  - Queued to JES for output processing when closed/unallocated
  - Available to print while job is still running (separate JOE)
  - Purging data set (JOE) frees spool space
OUTPUT phase – SYSOUT Grouping

- The OUTPUT phase builds output groups from SYSOUT data sets
  - A SYSOUT group is defined as the set of data sets that prints between a set of job separator pages
  - Always for the same job and security information
  - For SAPI, between group begin and group end indicators
  - For SDSF, data sets in a row on the O or H panel
- Grouping based on various characteristics
  - SYSOUT class, forms, writer name, hold type, destination, security info, etc
- Print scheduling based on output group (JOE)
  - PSO conversational support is only exception
- SPIN data sets are never grouped with other data sets
- Can influence (prevent) grouping using JCL (GROUPID=)
- Re-grouping only done with SAPI
  - PSO for certain held data sets
- SYSOUT cloning can create multiple copies
  - /* JOBPARM COPIES=
  - Allows multiple copies of entire job output
    - ABC – ABC vs AABBCC
  - Cannot be re-grouped
  - Problem for SAPI/PSO
Hardcopy phase

- Parking place for job that have run and are waiting to print
  - No real actions taken on the job level
  - Processing is based on the output groups (JOEs)
- Once output for the job has been processed, job complete
  - Job queued to purge processing
Functional Subsystems (FSS)

- Interface to offload function to separate address spaces
  - Reduces workload on JES main task
  - Used in JES2 for printer support
  - Removes printer “driver” knowledge from JES2
    - Associates them with FSS software
- JES managed interface
  - Controlled by JES commands
SYSOUT API (SAPI)

- A general purpose API to process output groups (JOEs)
  - Another way to implement a “printer”
  - Application manages the device
    - No JES2 definition or control for the device
  - Local/RJE destined output (no NJE data passed)
- Can also be used as a logical interface to manage output
  - Can change certain characteristics at a data set level
  - Results in JOEs being re-grouped
    - Only SAPI can regroup any JOE’s data sets
    - PSO (an older API) can regroup certain held JOEs
- Very common SYSOUT interface (use growing)
Purge phase

- Frees spool space and deletes jobs and output groups
  - Both job and JOEs can be queued to purge
- Job purge processing
  - Jobs enter purge when all JOEs are processed (gone)
  - All track groups returned and control blocks frees
- Output group (JOE) purge processing
  - Used for SPIN data sets (JOEs)
  - Used to perform cleanup for data set purge
  - If appropriate, frees spool space
  - Control blocks are then freed
Is it JES or MVS?

- JCL processing:
  - JES processes
    - /* JES2 JECL cards
    - //XMIT cards
    - Instream (SYSIN) DD data
      - Except in PROCs and INCLUDES
    - Some keywords on JOB, DD, and JCLLIB cards
  - MVS converter process
    - All other JCL cards
  - PROCLIBs defined and OPENed by JES2
    - Read and processed by MVS converter

- SYSLOG
  - MVS writes to SYSLOG data set
  - JES stores data on spool
- JOBLOG data set (1st data set in output)
  - JES captures messages to place in JOBLOG
- System messages data set (3rd data set)
  - MVS writes messages to the data set
Is it JES or MVS?

- **TSO TRANSMIT/RECEIVE**
  - TSO formats data and writes it to spool
  - JES sends data to correct system
- **RACF checking for new work**
  - Started tasks and TSO logon is verified by MVS/TSO
  - Batch jobs are verified (VERIFYX) by JES
- **TSO SUBMIT**
  - Submit pre-processes JCL and writes it to JES
- **DD SYSOUT=(A,INTRDR)**
  - Each record written is processed by JES directly
Questions?

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Mainframe 50 April 7th 1964 - April 7th 2014
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