z/VM CPU Pooling and ILMT

Damian Osisek – dlosisek@us.ibm.com

z/VM Design and Development

IBM Endicott, NY

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Acknowledgements

- The following people have contributed to this presentation:
  - Bill Bitner
  - Ellen Carbarnes
  - David Chase
  - John Franciscovich
  - Damian Osisek
  - Romney White

- The z/VM CPU Pooling and Environment Information Interface teams:

Doug Breneman	Yanique Moffitt
Ian Broadbent	Michel Raicher
Dean DiTommaso	Garrett Schanck
Larry Hartley	Ann Shepherd
Cathy Hupman	Jim Switzer
Tracy Krein	Don Wilton
Virg Meredith	

Agenda

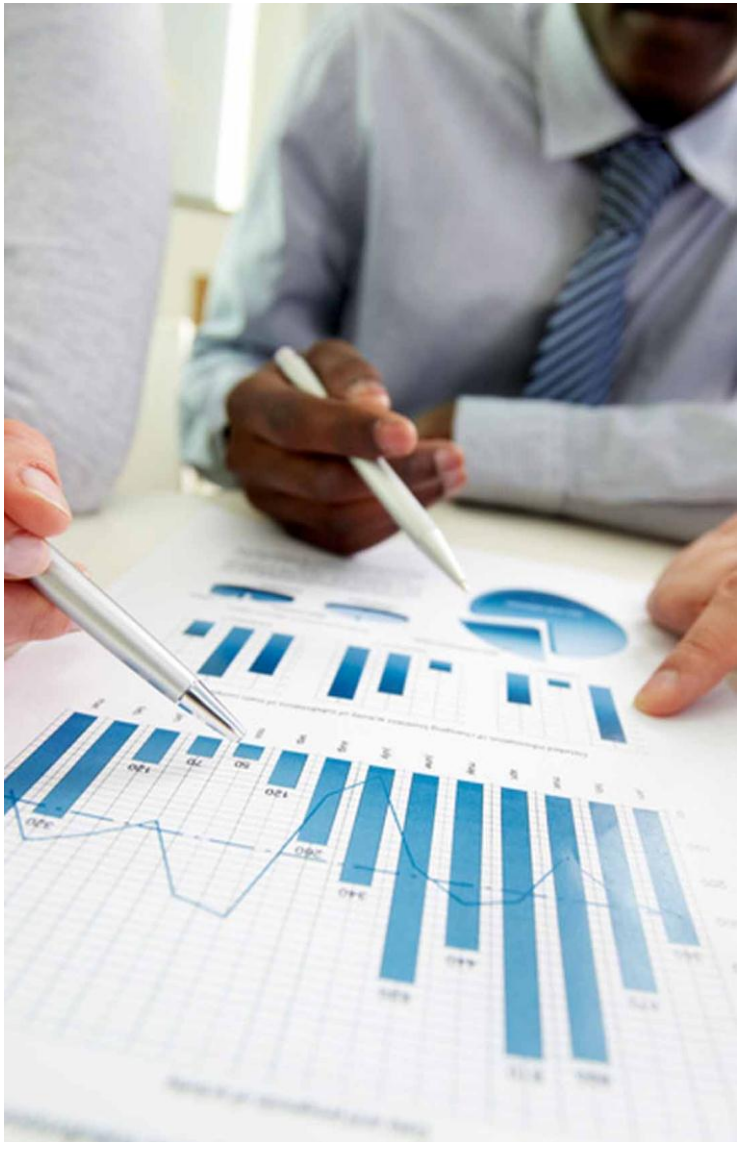
- Software pricing methodologies
- Brief review of z/VM scheduling options
- Overview of CPU Pooling on z/VM V6.3
- Update to IBM License Metric Tool (ILMT) 9.0.1
- Software Pricing with CPU Pooling
- Use case examples
- CPU Pooling with IBM z13 and SMT

z Systems software pricing methodologies offer:

- Price-to-value
- Flexibility to run software where it is most efficient
- Capability to predict software charges
- Help with cost of new applications
- Flexibility to pay for software based on workload requirements

Pricing metrics for z/VM IPLA products:

- z/VM V5 and V6 and certain z/VM related products have pricing based on the number of engines.
  - ***Engine-based Value Unit*** pricing allows for a lower cost of incremental growth with additional engine-based licenses purchased.
- Most IBM middleware for Linux is also priced based on the number of engines.
  - The number of engines is converted into ***Processor Value Units*** (PVUs) under the Passport Advantage® terms and conditions.
- z/VM 6.3 (with APAR) allows ***CPU pooling***.
  - ***ILMT enhancements*** enable using ILMT with pooling.



Limiting Single Guests

- Existing **LIMITHARD** option of **SET SHARE** command bounds guest processor resource consumption

  – **SET SHARE *userid* RELATIVE 2000 ABSOLUTE 40% LIMITHARD**
    - **RELATIVE 2000** defines entitlement: guest is allotted 20 times as much processor resource as the default (RELATIVE 100) user.
    - **ABSOLUTE 40% LIMITHARD** sets the cap: guest cannot consume more than 40% of the processor resource on the z/VM system (e.g. 2 IFLs in a 5-IFL VM partition)

- Applies to processor resource of type where the guest is dispatched
- Scheduler divides this limit evenly among virtual CPUs in a virtual MP
  – Omits stopped vCPUs (e.g., via *cpuplugd*)

Limiting Single Guests

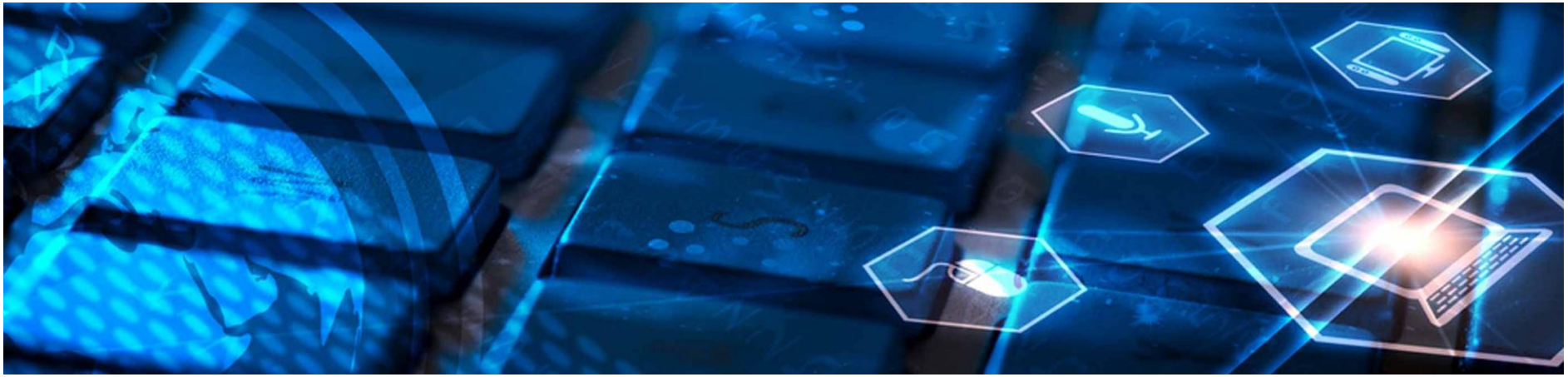
- **SET SHARE LIMITHARD** can be used to
  - Prevent “runaway” virtual machines
  - Limit consumption by less important virtual machines (e.g. test)
  - Help to ensure department budgets are not exceeded
  - Control resources available to contracting clients (service bureau)

- Some drawbacks:
  - Change in number of logical processors (Capacity on Demand, VARY PROCESSOR ON/OFF) affects actual limit imposed
  - Imposed at the individual guest level. Limiting a set of guests may require over-limiting of the individuals.
  - Not recognized as a means of limiting capacity for IBM sub-capacity software license purposes

Environment Information Interface

- New interface allows guest to capture execution environment
  - Processor configuration and capacity information
  - Various Levels: Machine, logical partition, hypervisor, virtual machine
- New unprivileged instruction Store Hypervisor Information (STHYI)
- Includes support for CPU Pooling
- Exploited by ILMT 9.0.1 for sub-capacity pricing of Linux on System z middleware
- Support details:
  - z/VM 6.3 with APAR VM65419 (included in RSU 1501)

CPU Pooling with z/VM V6.3



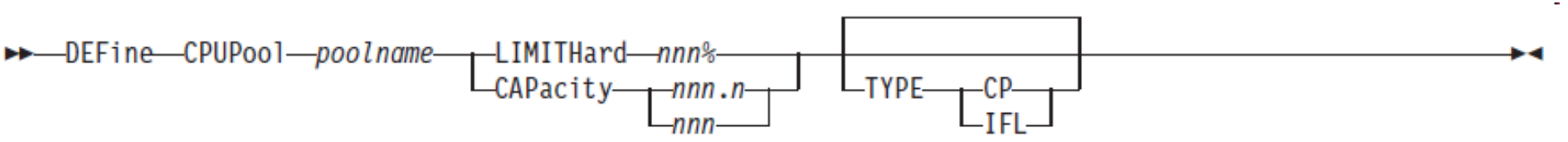
- Create a pool of processor resources available for a group of virtual machines in a z/VM system
- Allows capping of processor utilization for a set of guests to better balance resource utilization
- Allows Live Guest Relocation (LGR) as long as both definitions are compatible
  - Pools are defined and managed independently on each SSI member system
- Available with z/VM V6.3 and APAR VM65418 (in RSU 1501)

Flexible configuration of pools

- Define named CPU pools with associated capacity
  - Number of CPUs of particular type (CP, IFL)
  - Percentage of CPUs of particular type
- Associate guests with CPU pools
- Limit aggregate guest consumption to pool capacity
  - Coexists with individual guest LIMITHARD setting; both limits enforced
  - Otherwise, resource allotted to group members on demand (“first come, first served”)
- Allows overcommit – no restriction on number of pools or aggregate capacity
- New Environment Information Interface obtains pool capacity information
  - Eliminates manual configuration of data collection

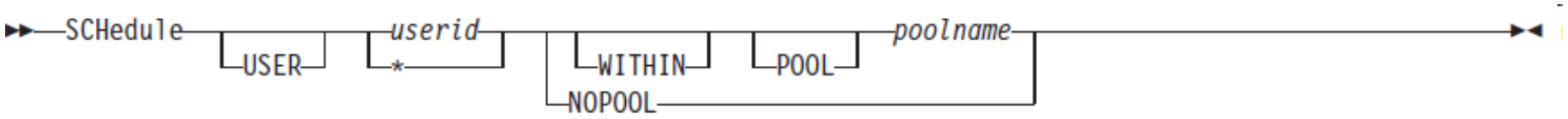
Defining CPU Pools

- Use the **DEFINE CPUPOOL** command to define named pools
  - Define for a particular **TYPE** of core (**CP** or **IFL**)
    - Default is the primary core type (IFL in an IFL-only partition, otherwise CP)
  - **CAPACITY** - number of CPUs' worth of processing power
    - Limit recognized for sub-capacity licensing purposes
    - Can overcommit (i.e. Sum of CPUPOOL CPUs > Logical processors)
  - **LIMITHARD** - % of system CPU resources of that type
    - Same enforcement mechanism as SET SHARE LIMITHARD
    - Does not qualify for sub-capacity licensing



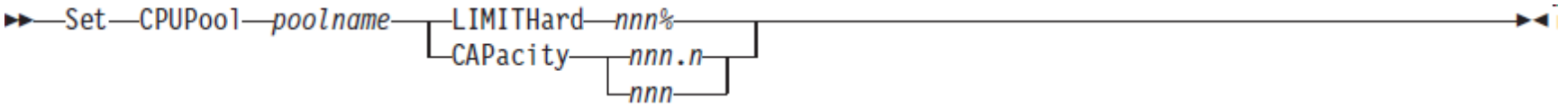
Enrolling virtual machines in a pool

- Assign a guest to or remove it from a CPU pool with the **SCHEDULE** command
  - Specified CPU pool must be already defined
  - Type of CPU in specified CPU pool must match the guest's primary CPU type
    - CPU affinity must be on for the guest
    - If guest is already assigned to a CPU pool it is removed from that pool and added to the specified pool



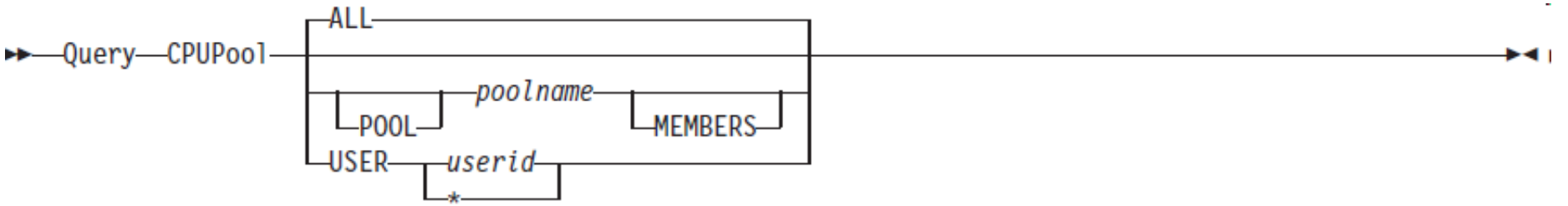
Changing CPU allocation to a pool

- Limits can be changed with the **SET CPUPOOL** command



Displaying CPU Pool information

- Use **QUERY CPUPOOL** to see information about the pools defined on your system



Displaying CPU Pool information

- Display all pool definitions:

```
query cpupool all
CPU pool    Limit      Type    Members
LINUXP2    8.0 CPUs    IFL           0
CPPOOL10    12 %        CP           8
LINUXP3     30 %        IFL         20
LINUXP1    2.5 CPUs     IFL           6
```

- Display one pool definition and member names:

```
query cpupool linuxp1 members
CPU pool Limit         Type    Members
LINUXP1  2.5 CPUs       IFL           6
The following users are members of CPU pool LINUXP1:
D70LIN12 D79LIN03 D79ADM D79LIN10 D79LIN07
D79LIN04
```

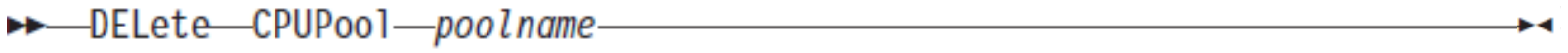
- Display user's pool name:

```
query cpupool user d79adm
User D79ADM is in CPU pool LINUXP1
```

DELETE CPUPOOL

- Use **DELETE CPUPOOL** to delete a pool definition

- Pool must be empty.
  - Use SCHEDULE … NOPOOL first to remove each member.



Automating CPU Pool Management

- Complication:
  - At VM IPL, no pools are defined. (Not remembered from prior IPL.)
  - Can't add users to the pool until the pool is defined.

- One solution:

1. COMMAND statements in directory definition of OPERATOR or AUTOLOG1 to define CPU pools

```
USER OPERATOR . . .
   . . .
   COMMAND DEFINE CPUPOOL WEBSPH CAPACITY   5  TYPE IFL
   COMMAND DEFINE CPUPOOL DB2    CAPACITY   3  TYPE IFL
   COMMAND DEFINE CPUPOOL QADEPT LIMITHARD 10% TYPE CP
```

   …Or include 'CP DEFINE …' commands in AUTOLOG1's PROFILE EXEC.

2. COMMAND statements in virtual machine definitions to place them into pools as they log on

```
USER WASPROD1 . . .
   . . .
   COMMAND SCHEDULE * WITHIN POOL WEBSPH
```

Single System Image considerations

- CPU pools are defined and managed independently on each member of an SSI cluster

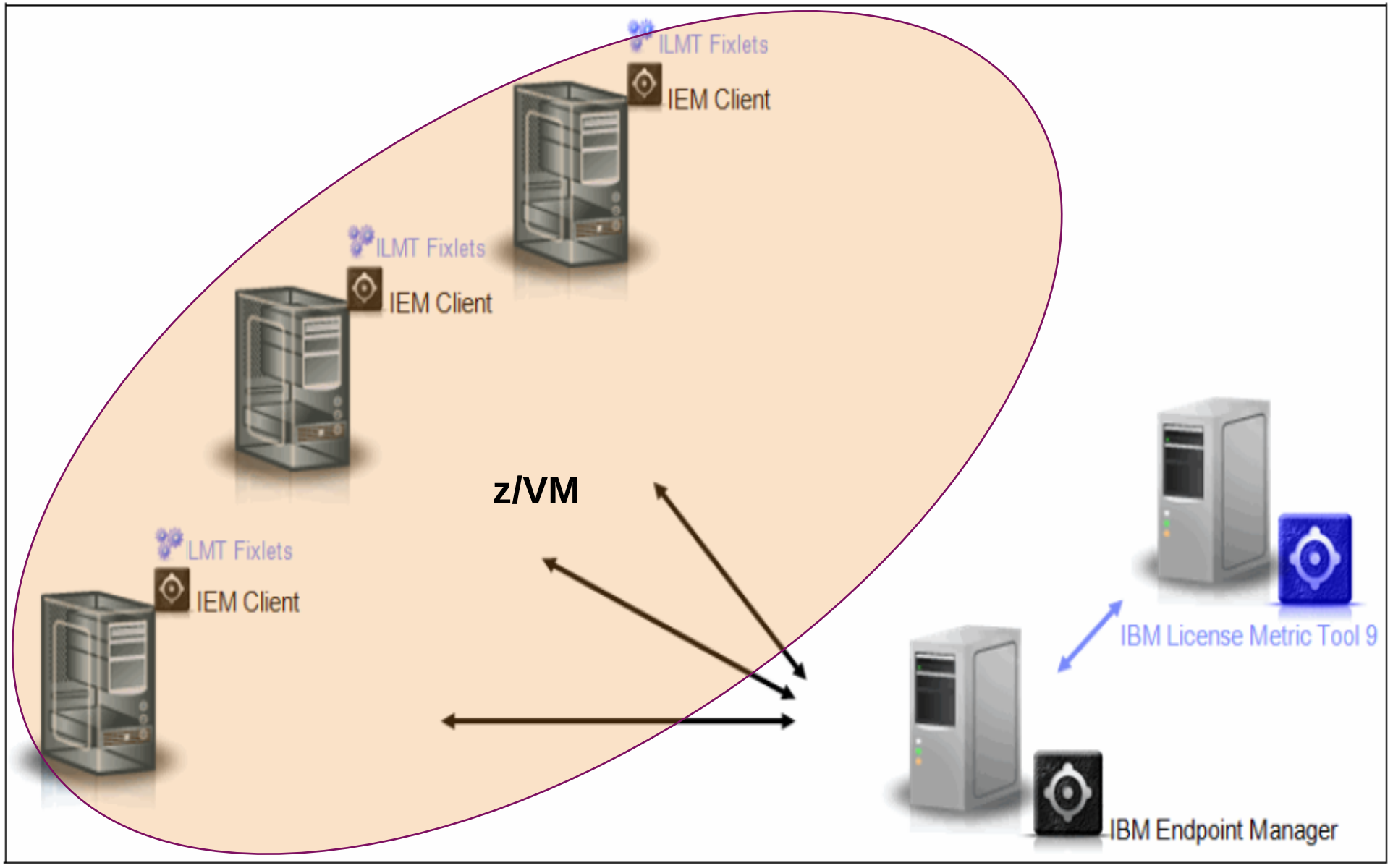
- A guest in a CPU pool can relocate to another system if a CPU pool with the same name and type is defined on the target system
  - Need not have the same limits

- Administrator is responsible for adjusting pool limits if needed
  - May affect software license requirements

Track License Requirements with IBM License Metric Tool

- IBM License Metric Tool (ILMT) is a no-charge tool used to determine PVU licensing requirements
- New Linux interface will be exploited by ILMT to assess software license conformance
  - Invokes z/VM Environment Information Interface
- Ability to track CPU pools available in ILMT 9.0.1 available August 12, 2014
  - Improvements also made to reduce CPU overhead incurred with ILMT
- Using ILMT you are only charged for the CPU pool capacity assigned to Passport Advantage PVU-based software

ILMT Architecture Overview

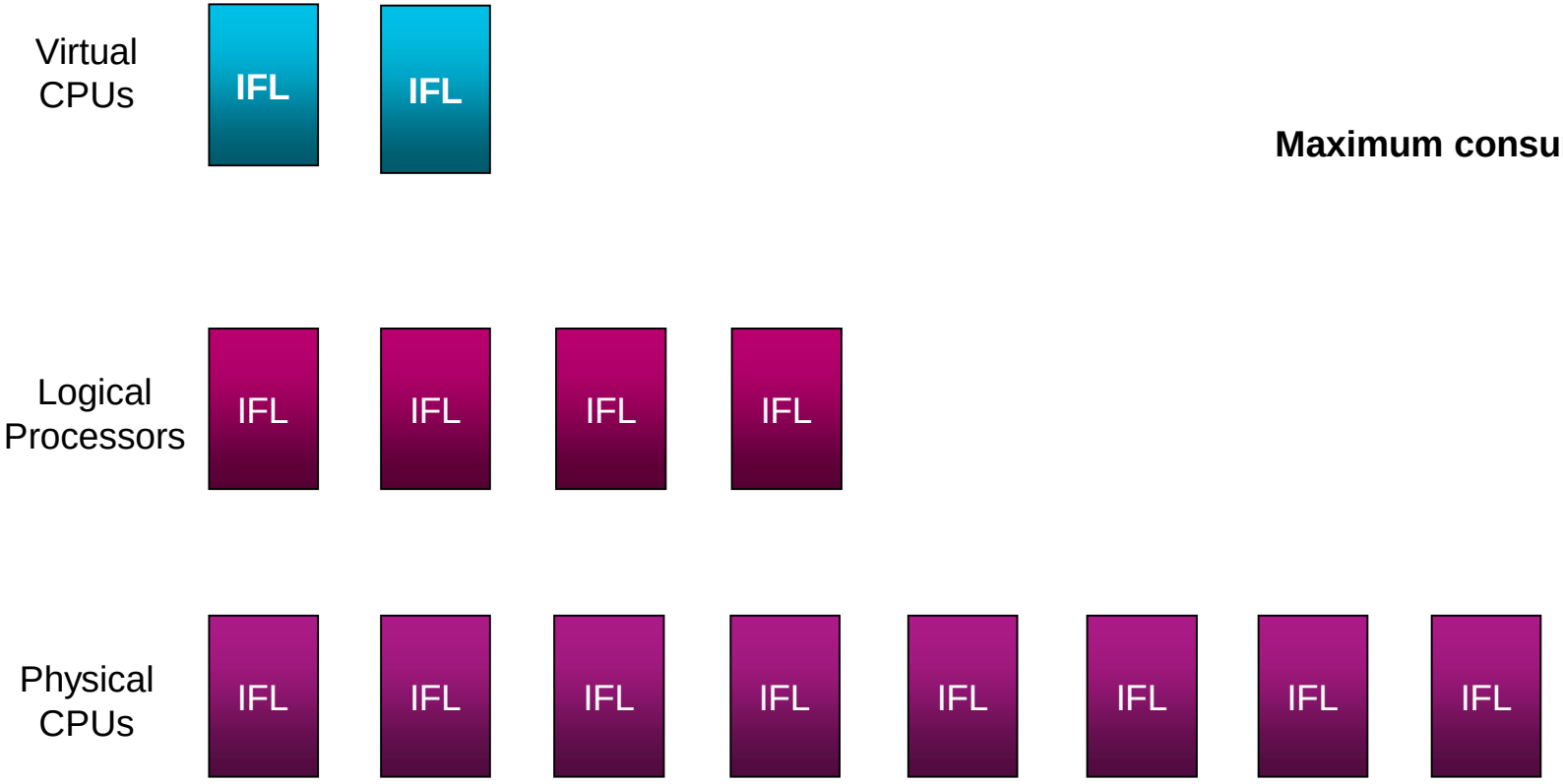


Software Licensing Key Learning Points

- IBM's two Software Categories are z Systems software and Distributed software and the entitlements are not interchangeable
- Value Units (VUs) are used to license z Systems IPLA software and Processor Value Units (PVUs) are used to license Distributed Passport Advantage software
- Distributed Sub-Capacity Terms require customers to keep track of the maximum processor capacity available to a program:
  - IBM License Metric Tool calculates this
  - Customers run the tool and retain the reports
- When running z/VM virtual machines and/or LPARs a customer is required to license for only the real hardware resources actually available to each program, not all the virtual resources
- PVUs are based on the processor family, for example
  - IFL on z114 might be 100 PVUs while IFL on zEC12 could be 120 PVUs
  - See IBM pricing expert for details
- On the z13, licensing granularity is one core's worth of processing power
  - No thread-based licensing

Current Linux Guest Software Pricing

Pricing rule for products in Linux guests: The lower of the sum of the virtual engines available to guests running a product or the engine capacity of the z/VM LPAR from which the guests obtain their resources.



Maximum consumption: 2 IFLs

Linux Guest Software Pricing With CPU Pooling

Pricing rule for products in Linux guests: The lowest of the sum of the virtual engines available to guests running a product, the engine capacity of the CPU pool to which the guests are assigned, or the engine capacity of the z/VM LPAR from which the guests obtain their resources.

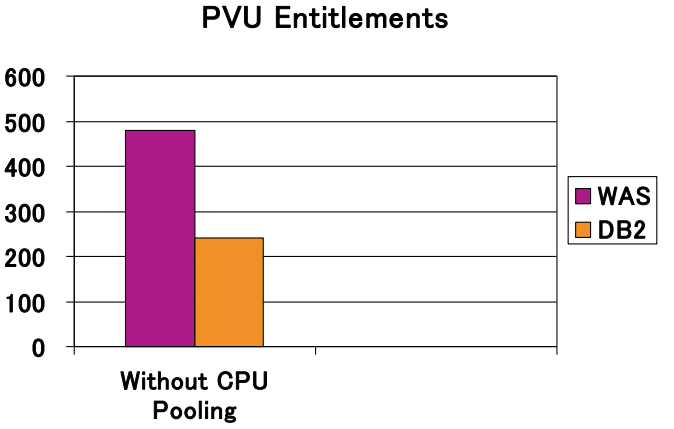
Maximum consumption: 2 IFLs

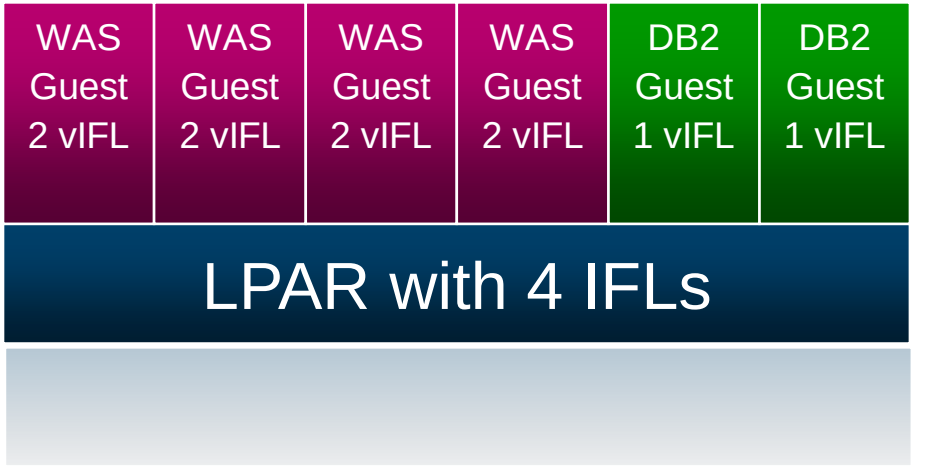
Use cases for CPU Pooling

- Department budgeting
  - Assign each department's guests to CPU pool with contracted capacity
- Grow workloads without affecting the budget
  - Add New Workload
  - Add Capacity
  - Combine LPARs
  - Handle fractional workload requirements
- Prevent resource over-consumption
  - Limit aggressive workloads

Add New Workload Without CPU Pooling

- 4 WAS production guests
  - Requires 4-engine WAS entitlement
- Add 2 DB2 production guests
  - Requires 2-engine DB2 entitlement

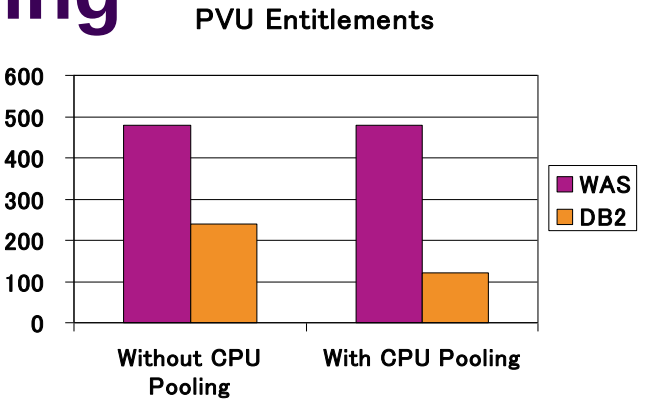




Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Add New Workload With CPU Pooling

- 4 WAS production guests
  - Requires 4-engine WAS entitlement
- Create a 1-IFL pool
- Put the 2 DB2 production guests in pool
  - Requires 1-engine DB2 entitlement (avoiding the need for 2-engine DB2 entitlement)

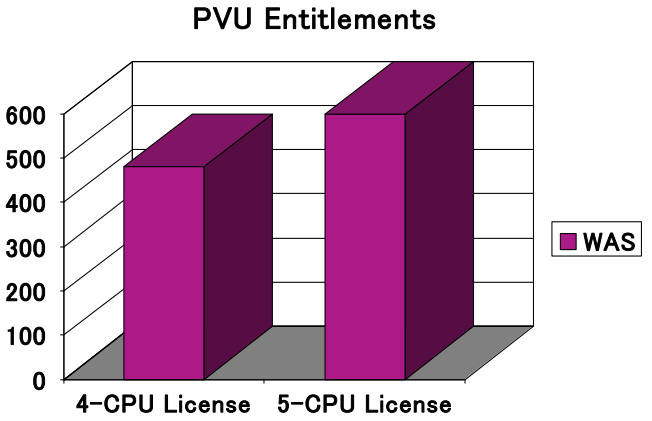


- Allows new workloads to be added cost effectively
- Encourages additional workload consolidation after initial success

Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Add Capacity Without CPU Pooling

- 4 WAS production guests
  - Requires 4-engine WAS entitlement
- Add another IFL to the LPAR
  - Requires increase to 5-engine WAS entitlement



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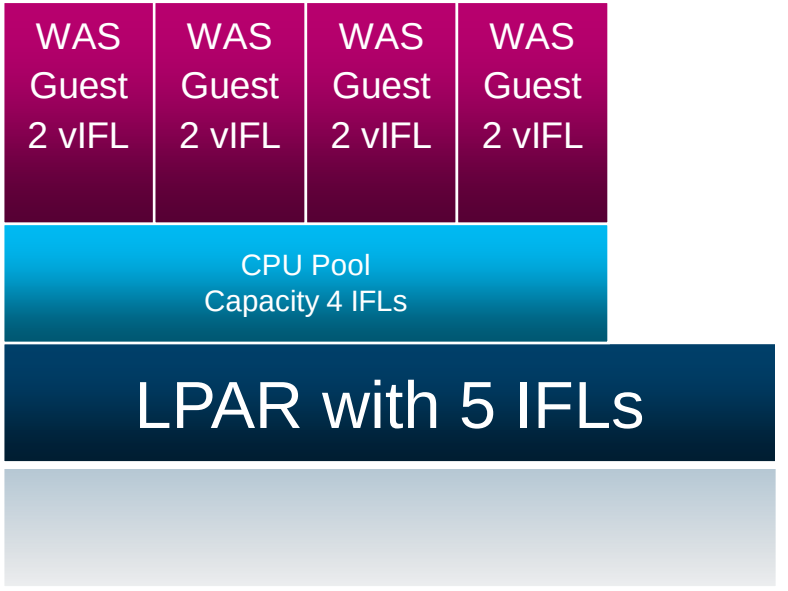
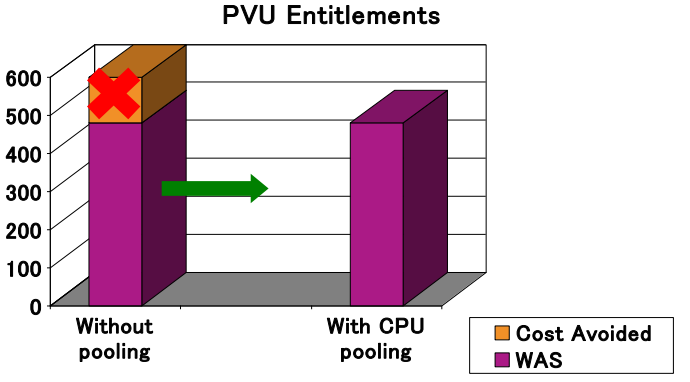
Add Capacity With CPU Pooling

- LPAR with 4 IFLs
- Set up CPU Pooling for 4 IFLs
  - 4 WAS production guests require 4-engine WAS entitlement
- Add another IFL to the LPAR
- Avoids an incremental WAS entitlement license – allows capacity to be added without increasing software license charges
- Encourages adding capacity for other workloads (e.g., open source applications)





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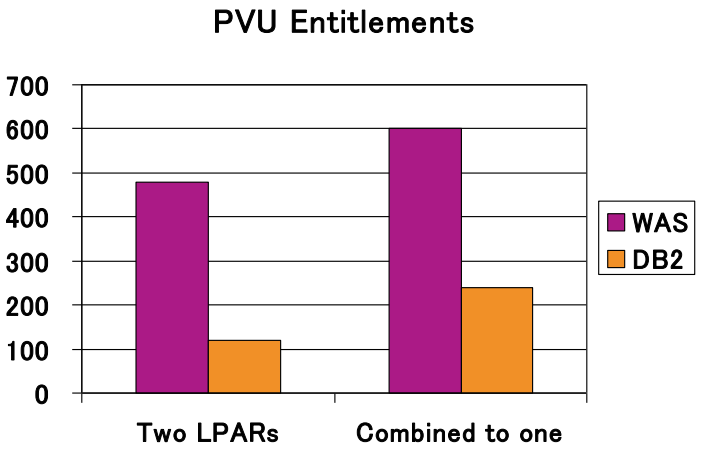
Combine LPARs Without CPU Pooling

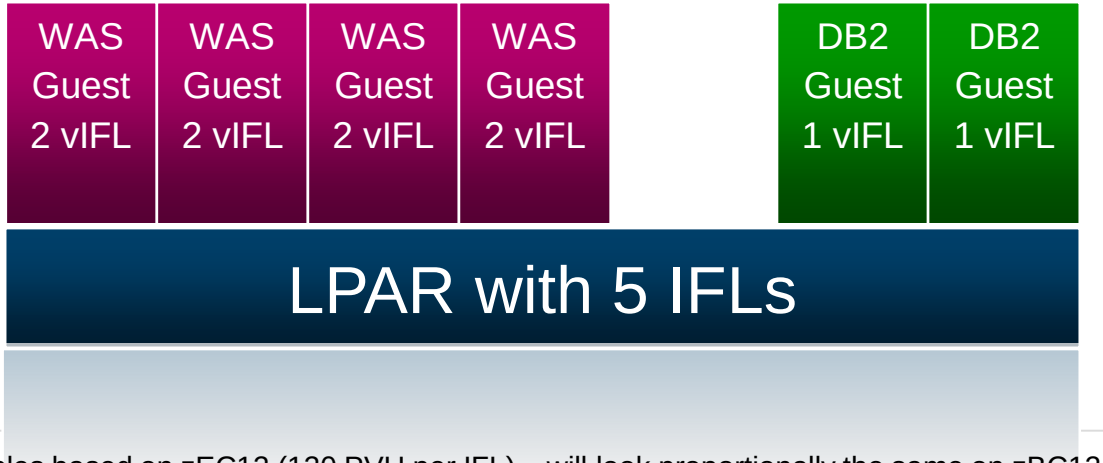
- **LPAR with 4 IFLs and 4 WAS production guests**
  - **Requires 4-engine WAS entitlement**
- **LPAR with 1 IFL and 2 DB2 production guests**
  - **Requires 1-engine DB2 entitlement**

Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Combine LPARs Without CPU Pooling

- LPAR with 4 IFLs and 4 WAS production guests
  - Requires 4-engine WAS entitlement
- LPAR with 1 IFL and 2 DB2 production guests
  - Requires 1-engine DB2 entitlement
- LPARs merge to one LPAR with 5 IFLs
  - Requires increase to 5-engine WAS entitlement
  - Requires increase to 2-engine DB2 entitlement





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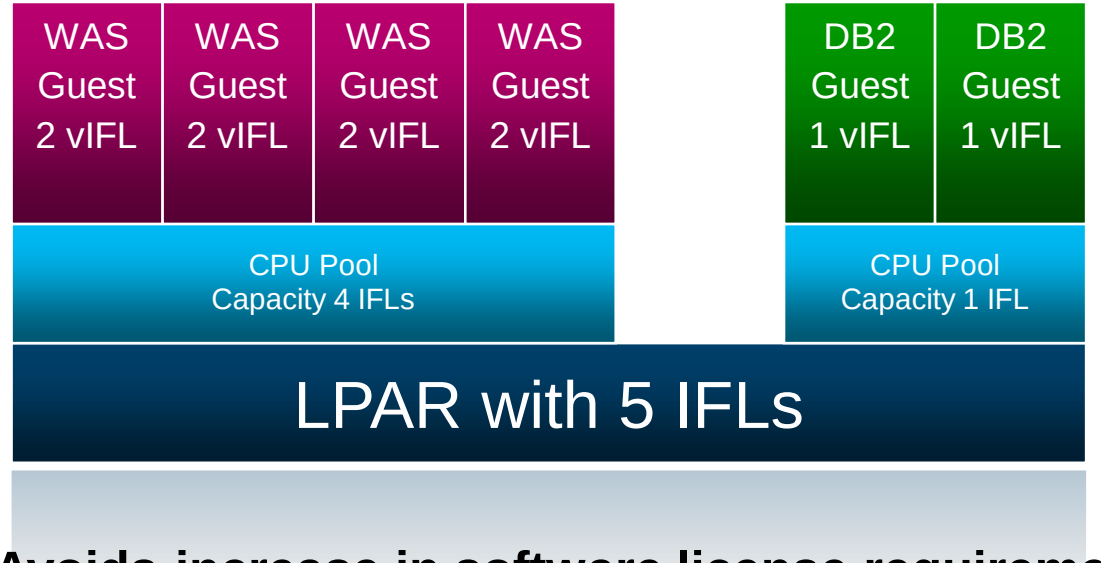
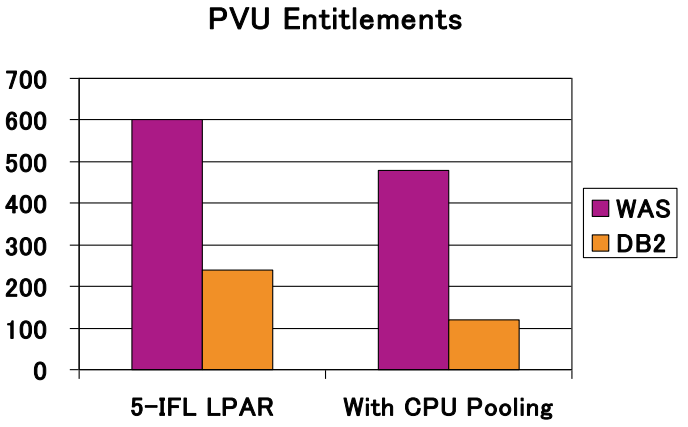
Combine LPARs With CPU Pooling

- LPAR with 5 IFLs
- Create 2 Pools – one with 4-IFLs and one with 1-IFL
- Place the four WAS guests in the 4-IFL pool and the two DB2 guests in the 1-IFL pool
  - Requires 4-engine WAS entitlement
  - Requires 1-engine DB2 entitlement



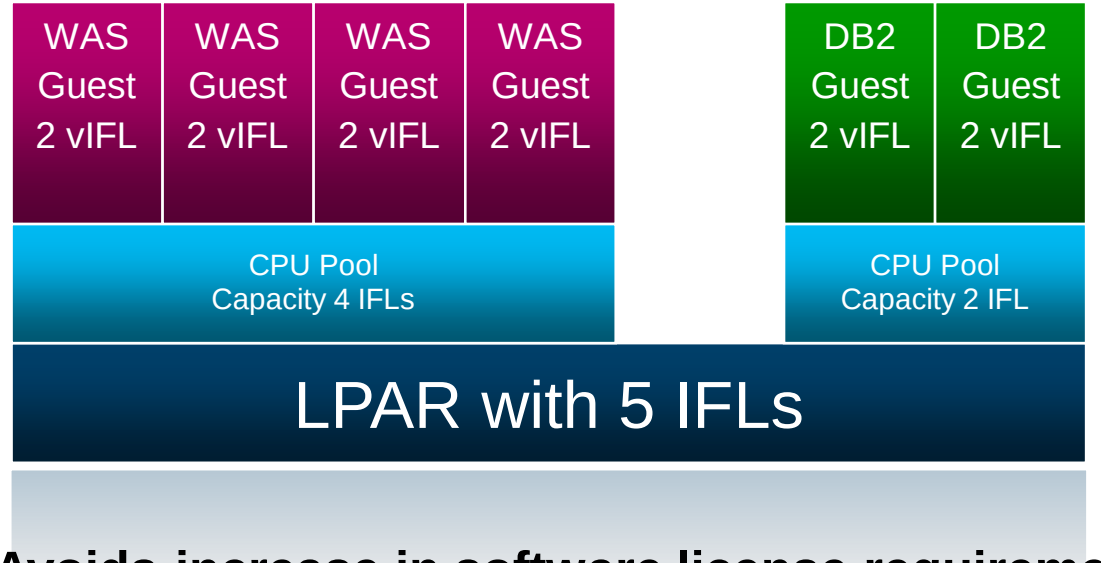


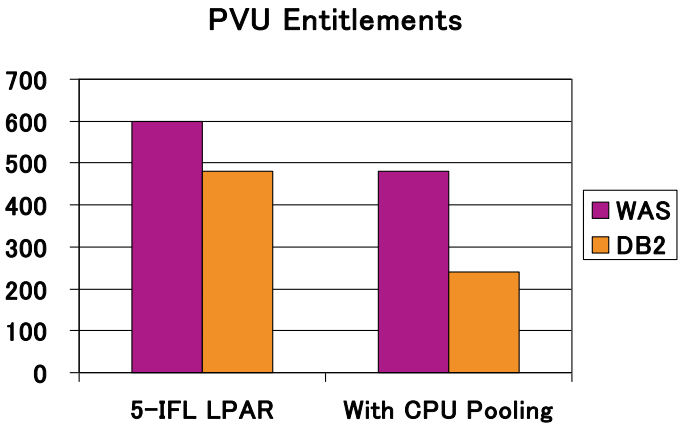
- Avoids increase in software license requirements (and costs)
- Reduces z/VM system management and maintenance workload
- Consolidates resources (memory, paging, network) for greater efficiency

Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

CPU Pools that Overcommit

- LPAR with 5 IFLs
- Create 2 Pools – one with 4-IFLs and one with 2-IFLs
- Place the four WAS guests in the 4-IFL pool and the two DB2 guests in the 2-IFL pool
  - Requires 4-engine WAS entitlement
  - Requires 2-engine DB2 entitlement



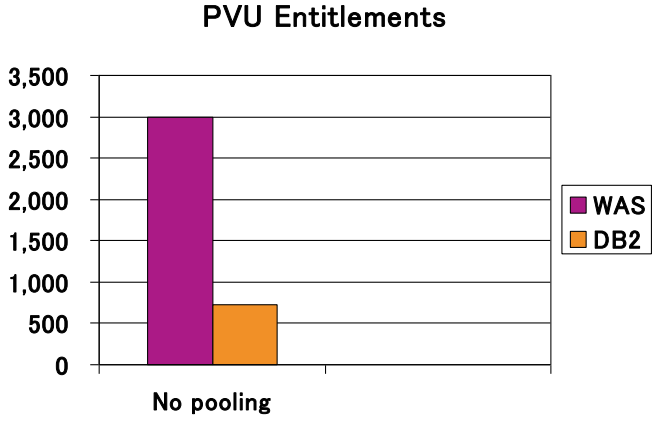


- Avoids increase in software license requirements (and costs)
- Reduces z/VM system management and maintenance workload

Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Large system with virtual machines that require fractional IFL capacity

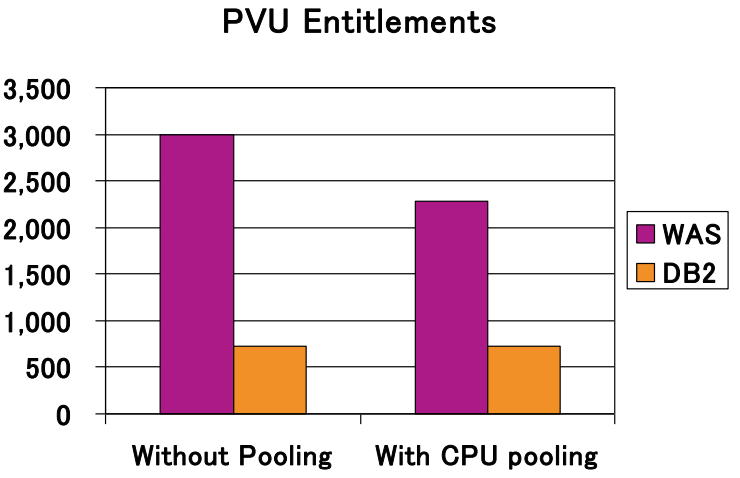
- LPAR with 25 IFLs
- 2 DB2 production guests
  - Requires 6-engine DB2 entitlement
- 3 WAS production guests and 12 small WAS test guests
  - Requires 25-engine WAS entitlement



Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Align fractional capacity virtual machines to small CPU pools

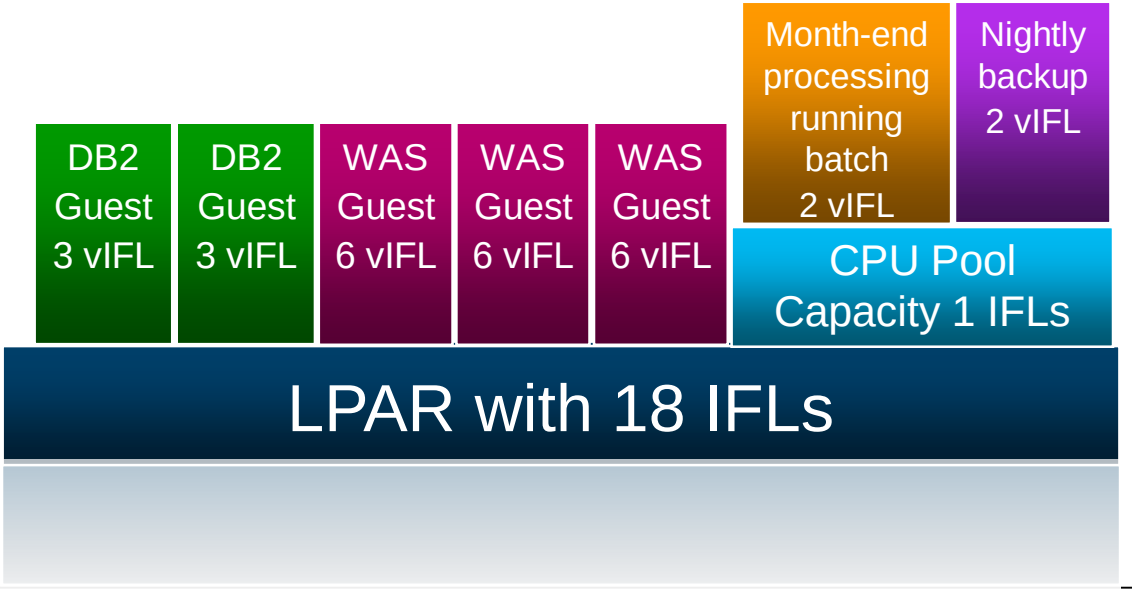
- LPAR with 25-IFLs
- Set up a 1-IFL pool
- 2 DB2 production guests
  - Requires 6-engine DB2 entitlement
- 3 WAS production guests and 1-IFL pool with 12 small WAS test guests
  - Requires 19-engine WAS entitlement



Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Contain workloads that take too many resources

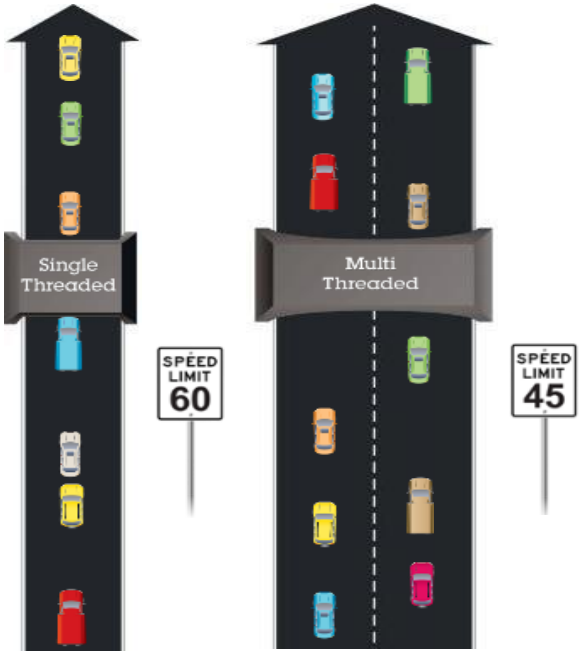
- LPAR with 18-IFLs
- 2 DB2 production guests and 3 WAS production guests are sharing the 18-IFLs
- Month-end processing or nightly backup uses any available capacity – could take from production guests
  - Set up a 1 IFL CPU pool for running these tasks



Note: All PVU Entitlement examples based on zEC12 (120 PVU per IFL) – will look proportionally the same on zBC12 (100 PVU per IFL)

Simultaneous Multithreading (SMT)

- Objective is to improve capacity, not performance.
- Allows z/VM to dispatch work on up to two threads of a z13 IFL
- VM65586 for z/VM 6.3 **only**
  - PTFs available March 13, 2015
- At least z13 millicode bundle 11
- Transparent to virtual machine
  - Guest does not need to be SMT aware
  - SMT is not virtualized to the guest
- z13 SMT support limited to IFLs and zIIPs
  - z/VM support is only for IFLs
- SMT is disabled by default
  - Requires a System Configuration setting and re-IPL
  - When enabled, applies to the entire z/VM partition
- Potential to increase the overall capacity of the system
  - Workload dependent



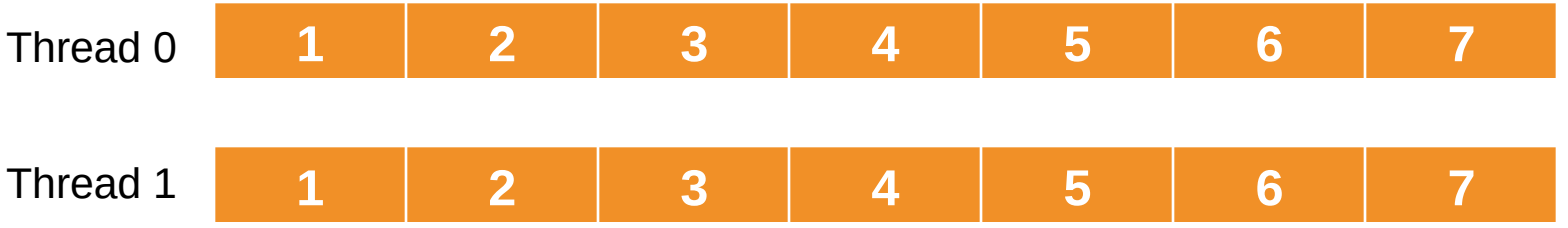
Which approach is designed for the higher volume of traffic? Which road is faster?

****Illustrative numbers only***

Additional Work Capacity

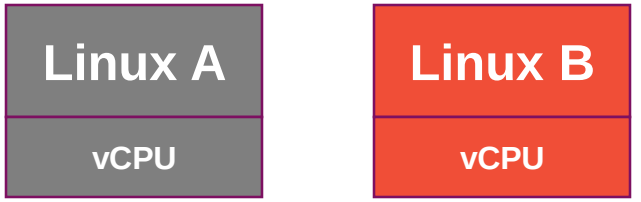
IFL (SMT disabled) – Instruction Execution Rate: 10

IFL (SMT enabled) – Instruction Execution Rate: 7



- **Numbers are just for illustrative purposes**
- **Without SMT, 10 / second**
- **With SMT, 7 / second but two threads yields capacity of 14 / second**

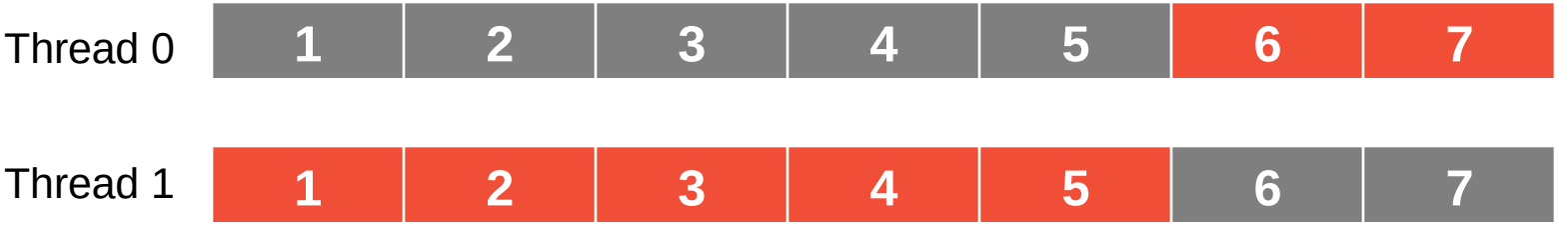
Interleaving Virtual CPUs of Guests



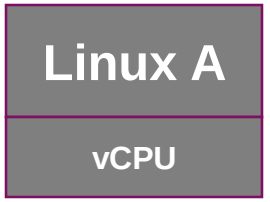
- In single core, we time slice access with each guest getting 5 ops completed.
- With SMT, each guest gets 7 ops completed for total of 14

IFL (SMT disabled) – Instruction Execution Rate: 10

IFL (SMT enabled) – Instruction Execution Rate: 7



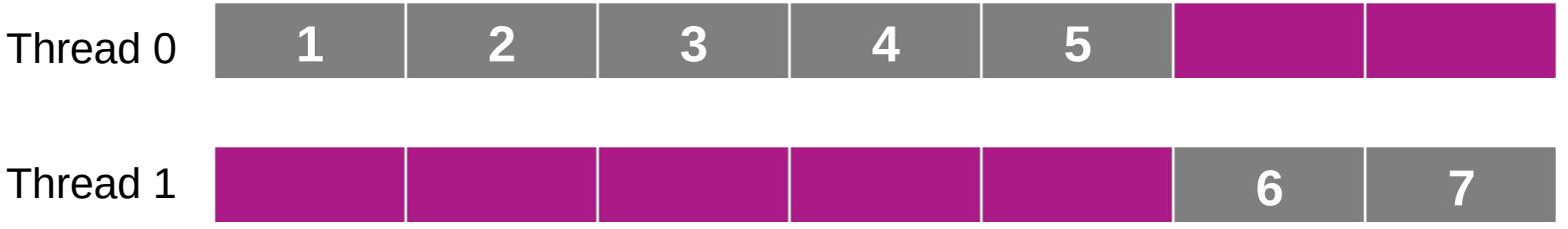
Potential Need to Increase Virtual CPUs



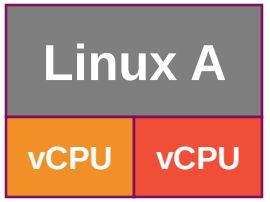
- **Lets look at a single guest that hits maximum of its virtual resources**
- **In single core, it can execute 10 ops, but only 7 with SMT as there is only one virtual CPU to dispatch.**

IFL (SMT disabled) – Instruction Execution Rate: 10

IFL (SMT enabled) – Instruction Execution Rate: 7



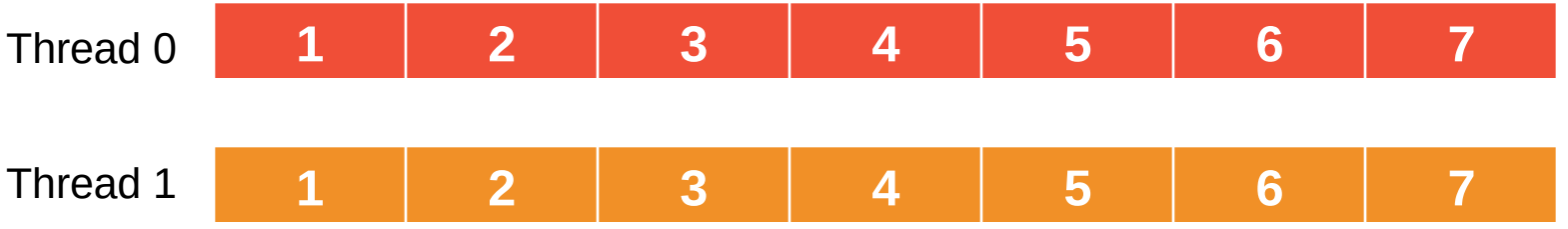
Potential Need to Increase Virtual CPUs



- **Taking that guest and giving it a second virtual CPU allows additional work to be completed**
  (if guest can exploit multiple virtual CPUs)

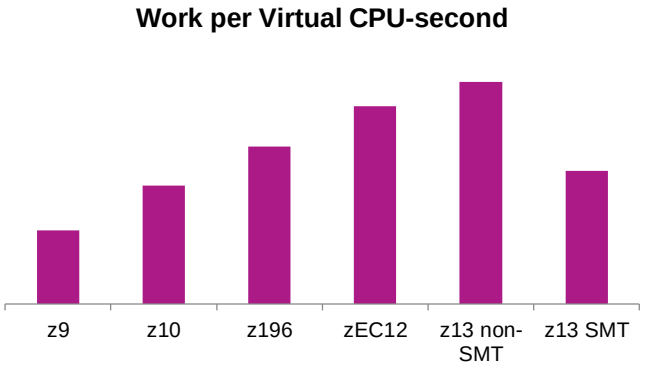
IFL (SMT disabled) – Instruction Execution Rate: 10

IFL (SMT enabled) – Instruction Execution Rate: 7



SMT - CPU Pooling Implications

- With SMT enabled
  - **CAPACITY** limit for CPU pools is defined as processing power of a number of IFL cores …. but limit enforcement is based on thread utilization (raw time)
  - In some cases, guests in a CPU pool will not be able to complete the same amount of work as before SMT with the same capacity limit
    - Capacity limits for CPU pools might need to be increased
    - More problematic when trying to match experience from zEC12 processor than older, slower processors



Prorated Core Time (availability TBD)

- Prorated core time will divide the time a core is dispatched proportionally among the threads dispatched in that interval
  - Full time charged while a vCPU runs alongside an idle thread
  - Half time charged while a vCPU is dispatched beside another active thread
- Therefore:
  - CPU pool capacity consumed as if by cores
  - Suitable for core-based software licensing
- When SMT is enabled, prorated core time will be calculated for users who are
  - In a CPU pool limited by the **CAPACITY** or **LIMITHARD** option
  - Limited by the **SET SHARE LIMITHARD** command
    (currently raw time is used; raw time will continue to be used when SMT is disabled)
- Only CAPACITY-based CPU pools meet requirements for sub-capacity pricing
- **QUERY CPUPOOL** will report capacity in terms of cores' worth of processing power instead of CPUs'
- Prorated core time will be reported in monitor records and the new Type F accounting record.
- Watch for APAR VM65680

Summary

- CPU Pooling offers greater control over resource allocation
  - By workload
  - By department
  - By software product

- With ILMT 9.0.1, can limit software license costs, particularly where multiple software products are run in the same z/VM system
  - Enables organic growth of individual workloads
  - Avoids paying for capacity not used for a software product
  - Broadens options for workload consolidation, lowering overhead and administrative costs

- New implications for capacity and licensing with IBM z13 and Simultaneous Multithreading
  - Watch for Prorated Core Time enhancement

More information

- IBM z Systems Software Pricing
  - http://www-03.ibm.com/systems/z/resources/swprice/subcap/linux.html
- Processor Value Unit (PVU) Licensing for Distributed Software
  - http://www-01.ibm.com/software/passportadvantage/pvu_licensing_for_customers.html
- Passport Advantage Sub-Capacity FAQ:
  - http://www.ibm.com/software/passportadvantage/subcapfaqov.html
- Virtualization Capacity License Counting Rules
  - http://www.ibm.com/software/passportadvantage/Counting_Software_licenses_using_specific_virtualization_technologies.html
- ILMT 9.0.1 Blog on August Update with new CPU pooling support
  - http://ibm.biz/cpupoolilmt
- IBM Redpaper – Simplify Software Audits and Cut Costs by Using the IBM License Metric Tool (September 2014)
  - http://www.redbooks.ibm.com/abstracts/redp5107.html?Open
- ILMT Youtube page
  - https://www.youtube.com/user/IBMLicenseMetricTool

Thanks!

Damian Osisek
IBM
z/VM Design and Development
Endicott, NY
dlosisek@us.ibm.com