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z/OS V2R2 enhancements to Capacity Provisioning

Agenda

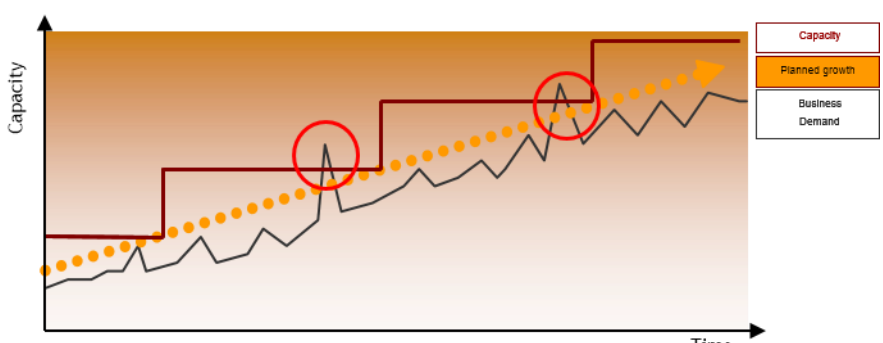
- *Capacity Provisioning Overview*
- *Capacity Provisioning to simplify management of temporary capacity*
  - *Processing Modes*
  - *CPM Configuration*
  - *Reports, Logs, Audit Trails*
  - ***Simplified configuration with Utilization Conditions***
  - *Documentation*

Today's challenges to manage capacity

- Unexpected events and workload spikes can afford higher processing capacity
- Manual capacity management can be time-consuming and error prone
- Capacity provisioning decisions must be made without sound data

IBM z/OS Capacity Provisioning Basics

- **Contained in z/OS base component free of charge**
  - Requires a monitoring component, such as z/OS RMF, or equivalent
  - Base element since z/OS V1.9
- **Exploits on System z On/Off Capacity on Demand Feature**
  - IBM zEnterprise System z10 or later
  - If On/Off CoD is not used CPM “analysis” mode may be used for monitoring and alerts
- **Exploits Defined Capacity and Group Capacity**
  - Defined Capacity with IBM System z10 or later
  - Group Capacity with IBM zEnterprise z196 or later



Capacity Provisioning Capabilities Overview

– The Capacity Provisioning Manager (CPM) can control additional capacity on IBM z13, zEC12, z196, z10
  - Number of temporary zAAPs or zIIPs
  - Temporary general purpose capacity
- Considers different capacity levels (i.e. effective processor speeds) for subcapacity processors (general purpose capacity)
  - Can advise on logical processors
  - Defined capacity and group capacity limits
  - Can control one or more IBM z Systems
    - Including multiple Sysplexes
  - Provides commands to control z196 and later static power save mode
  - Provides commands to control temporary IFLs

CPM allows for different types of provisioning requests:

- Manually at the z/OS console through CPM commands
- Via user defined policy at specified schedules
- Via user defined policy by observing workload performance on z/OS
- Via user defined policy by observing CPC processor consumption

Manual capacity upgrades – How it could look like

1.	Workload increases	0 min
2.	Operator realizes bottleneck	5-10 min
3.	Operator informs system programmers and manager	2 min
4.	Discussion	10 min
5.	Logon to HMC, change capacity	5 min

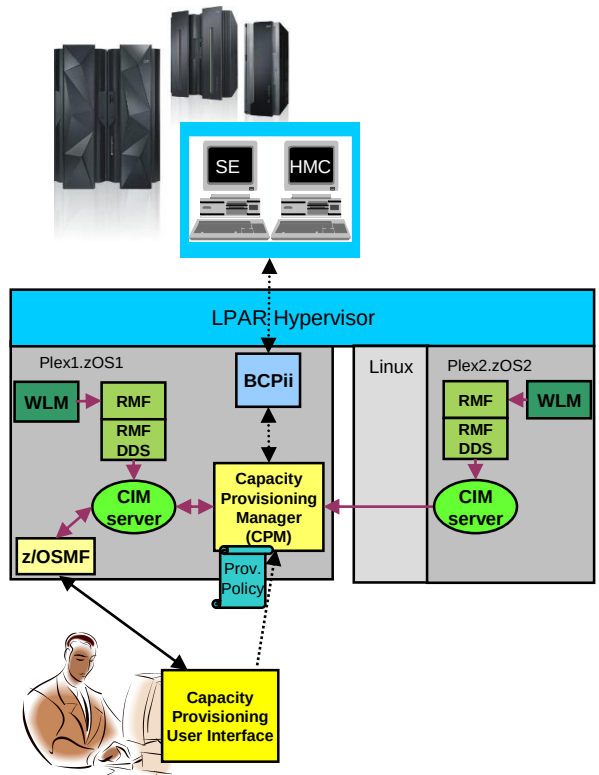
… meanwhile, so much workload may have queued up that a small amount of additional capacity would be insufficient to decrease the queued workload

→ Much more capacity has to be added

CPM can react faster and reduce cost

Capacity Provisioning – Infrastructure in a Nutshell

- z/OS WLM manages workloads to goals and business importance
- WLM indicators available through monitoring component
  - E.g. z/OS Resource Measurement Facility (RMF)
  - One RMF gatherer per z/OS system
  - RMF Distributed Data Server (DDS) per Sysplex
- Capacity Provisioning Manager (CPM) retrieves critical metrics through CIM
- CPM communicates to support elements or HMC, via BCPii.
- Capacity Provisioning User Interface is front end to administer Capacity Provisioning policies
  - z/OSMF Capacity Provisioning task

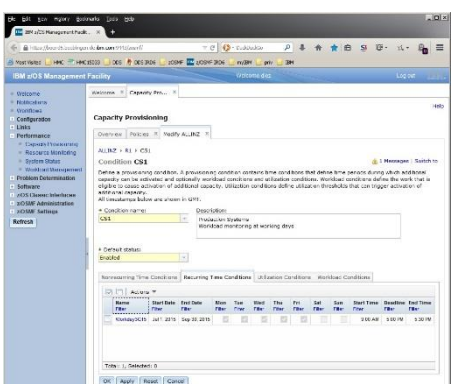


Main Components of Capacity Provisioning

- **The Capacity Provisioning Manager** (CPM)
  - The server program that monitors defined systems and CPCs, is customized by the policies and domain configurations, and takes actions as appropriate.

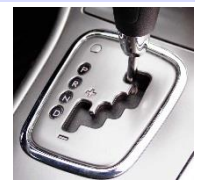
```
MODIFY CPOSERV,APPL=REPORT ACTIVITY

Number of activities between 11/26/2014 and 01/28/2015 was 6
Activation for CPC ECL2 at 01/28/2015 15:02:01
 Activation of model  729, 2 zAAPs and 2 zIIPs
 Active resources before activation: model  728, 2 zAAPs, 2 zIIPs
 Inducing policy element is policy ECL2U, rule R1,
  provisioning condition CS1, time condition Year2015
  Inducing utilization condition UC1
…
Activation for CPC ECL2 at 01/28/2015 10:10:38
 Activation of model 728, 2 zAAPs and 2 zIIPs
 Active resources before activation: model 727, 2 zAAPs, 2 zIIPs
 Inducing policy element is policy CKPOLICY, rule R1,
  provisioning condition C1, time condition nRTC1
  Inducing system is IRD5 in sysplex IRD4PLEX
  Inducing workload is WLM service definition WLMCPOS1,
   policy CPOPOL#1, service class period CPULOW.1
```

- **The z/OSMF Capacity Provisioning task**
  - The browser-based user interface for administering provisioning policies and domain configurations, and to interact with CPM.
  - Requires z/OS V1.13 or higher.
  - Is not required for regular operation of CPM.



Processing Modes

CPM can operate in one of four modes that allow for different degrees of automation



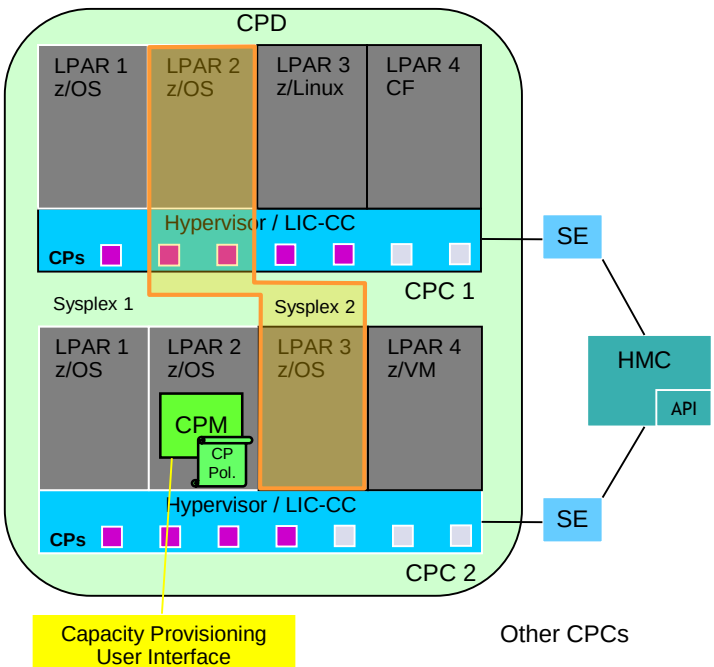
- **Manual mode**
  - Server capacities can be controlled via CPM commands
  - Command driven mode where no CPM policy is active
- **Analysis mode**
  - CPM processes capacity provisioning policy and informs the operator when a provisioning / deprovisioning action would be due according to criteria specified in the policy.
  - It is up to the operator either to ignore that information or to perform the up-/downgrade manually (using the HMC/SE or the available CPM commands)
- **Confirmation mode**
  - CPM processes the policy and interrogates the On/Off CoD record to be used for capacity provisioning.
    Every provisioning action needs to be authorized (confirmed) by the operator.
- **Autonomic mode**
  - Similar to the confirmation mode, except that no human (operator) intervention is required.

Various reports are available with information about workload, processor consumption, provisioning status, and the rationale for provisioning recommendations

CPM Policies and Processing Parameters

- CPM server uses three types of input:
  - Domain configuration defines the topology and connections, such as the CPCs and z/OS systems that are to be managed by the server
  - Policy contains the information as to
    - which work or which consumption level is provisioning eligible, under which conditions and during which timeframes
    - how much capacity may be activated when the work suffers due to insufficient processing capacity
  - PARM data set contains setup instructions such as UNIX environment variables, and various processing options that may be set by an installation.

Domain Configuration



- The *domain configuration* defines the CPCs and z/OS systems that are controlled by an instance of the CPM
- One or more CPCs, sysplexes and z/OS systems can be defined into a domain
- Sysplexes and CPCs do not have to be completely contained in a domain but must not belong to more than one Capacity Provisioning domain
- One active Capacity Provisioning policy per domain
- Multiple Sysplexes and hence multiple WLM service definitions may be involved

Policy Approach

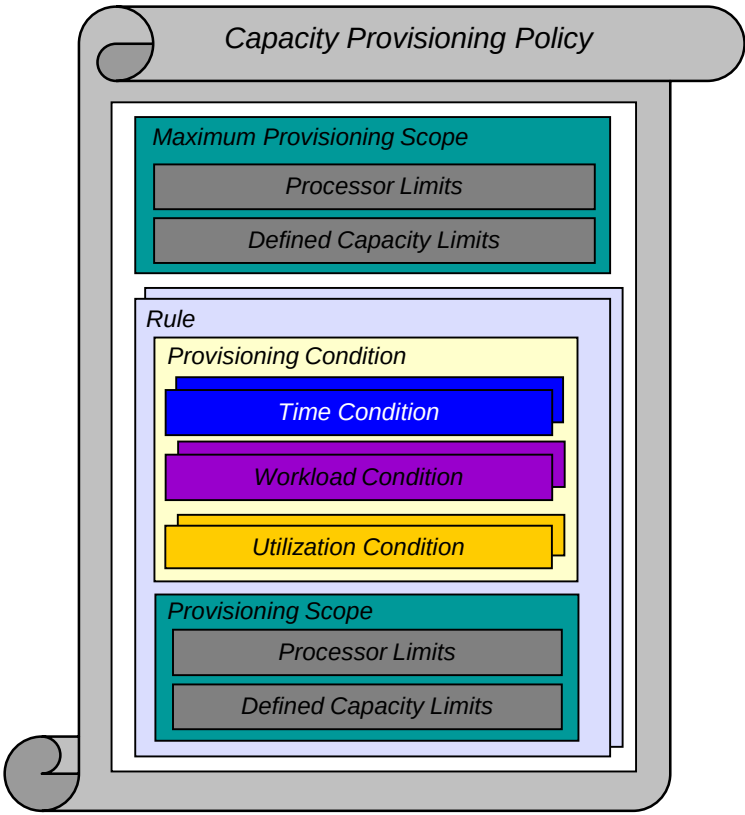
The Capacity Provisioning policy defines the circumstances under which additional capacity may be provisioned:

- Three “dimensions” of criteria considered:
  - **When** is provisioning allowed
  - **Which** work or processor load qualifies for provisioning
  - **How much** additional capacity may be activated
- These criteria are specified as “rules” in the policy:

```
If
{  in the specified time interval
   the specified work or processor “suffers”
}
Then up to
{     - the defined additional capacity
      may be activated
}
```

- The specified rules and conditions are named and may be activated or deactivated selectively by operator commands

Policy Overview

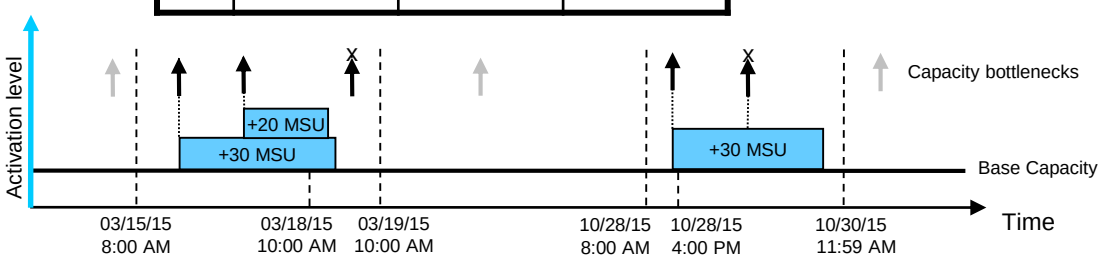


- The „Maximum Provisioning Scope“ defines the maximum additional capacity that may be activated, by all the contained rules
- „Provisioning Condition“ is a combination of Time and Workload Conditions that can be referred to via its name
- “Provisioning Scope” defines the maximum capacity that may be activated based on the rule
  - Specified as number of zAAP / zIIP processors
  - MSU for general purpose capacity
  - MSU for Defined Capacity
  - MSU for Group Capacity

Rules: Provisioning Conditions - Time

- Time condition defines when temporary capacity may be activated.
  Non-recurring time conditions specify
  - Start Time: provisioning of additional capacity allowed
  - Deadline: provisioning of additional capacity no longer allowed
  - End Time: deactivation of additional capacity should begin

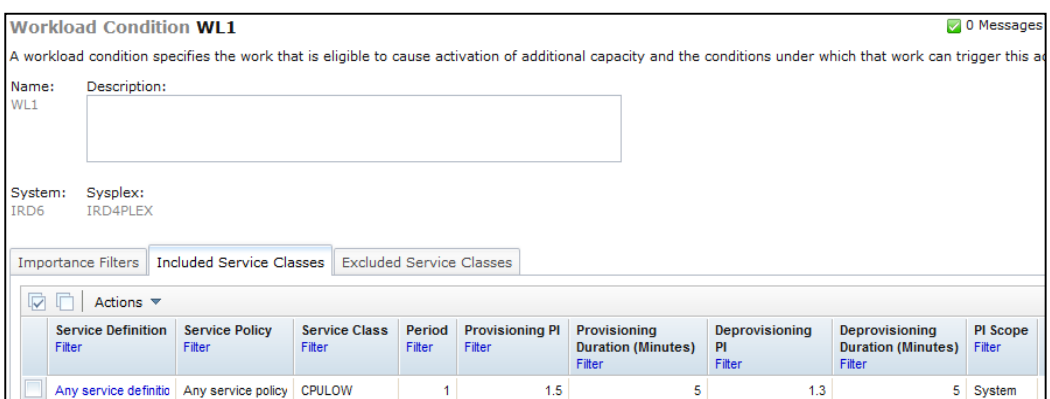
Name	Start Time	Deadline	End Time
TC1	03/15/15 08:00 AM	03/18/15 10:00 AM	03/19/15 10:00 AM
TC2	10/28/15 08:00 AM	10/28/15 04:00 PM	10/30/15 11:59 AM



- Without additional workload or utilization condition, **scheduled** activation will be performed:
  - Full capacity as specified in the rule scope
  - Unconditionally at the start and end times of the time condition

Rules: Provisioning Conditions - Workload

- Identifies the work that may trigger the activation of additional capacity,
  - When that work does not achieve its goal due to insufficient capacity and additional capacity would help
  - Expressed as one or more WLM service class periods, and a WLM Performance Index limit



Workload Condition Parameters

- Parameters:
  - Sysplex/Systems: The z/OS systems that may run eligible work
  - Workload specification:
    - Importance Filter:
      Eligible service class periods, identified by WLM importance
    - Included Service Classes: Eligible service class periods

      Extends the set of Service Class periods with qualified work (extends the default set of default eligible service classes) and may specify different PI criteria
    - Excluded Service Classes: Identifies service class periods, that should not be considered

Workload Condition Parameters cont.

- PI (Performance Index) criteria:
  - Activation threshold:

    PI of service class periods must exceed the activation threshold for a specified duration before the work is considered to require help.

  - Deactivation threshold:

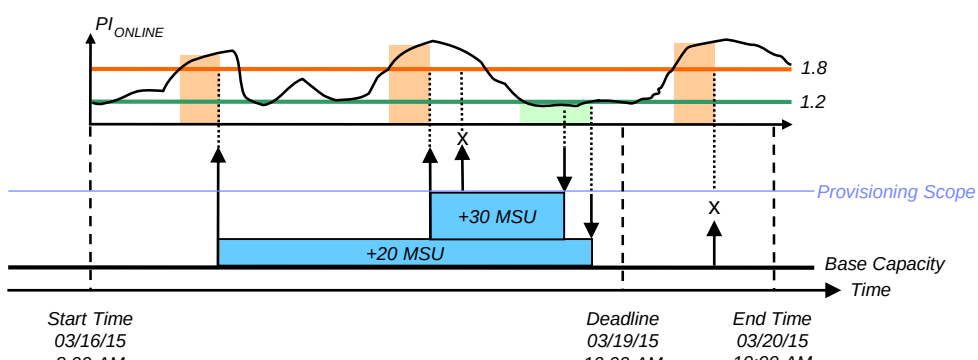
    PI of service class periods must fall below the deactivation threshold for a specified duration the work is considered to no longer require help.

Sample Workload Condition

Sample definition:

Name: *PT1*
Sysplex: *PLEX1*
System: *SYSA*
Included Service Class Periods:
ONLINE in WLMSD with ***PI >= 1.8*** *for 10 min until* ***PI <= 1.2*** *for 10 min*
Excluded Service Class Periods:
BACKUP in WLMSD

Monitor all "ONLINE" Service Class PIs except of SC "BACKUP":



Rule: Provisioning Scope – Processor Limits

- CPC within provisioning domain for which activation of resources is allowed
- Max number of additional MSU / zAAPs / zIIPs that may be activated
  - Only the required delta capacity will be activated by the CPM
- Provisioning scope exists in two flavours:
  - Maximum provisioning scope defines an upper limit of resources that may be activated in total for all the contained rules at any point in time. Additionally, capacity increments can be defined. Increments are defined in MSU for general purpose capacity and number of processors for zIIP and zAAP processors.
  - Provisioning scope on the „rule“ level defines an upper limit of resources that may be activated for the single rule at any point in time
  - Allows for definitions like „I authorize 300 MSU for workload 1 and 200 MSU for workload 2, but at no point in time more than 400 MSU.“

CPC	*Max MSU*	*Max zAAPs*	*Max zIIPs*
CPC1	400	3	5
CPC2	800	0	0

Rule: Provisioning Scope – Defined Capacity Limits

- System within provisioning domain for which to increase defined capacity limit
- Max number of increased MSU capacity
  - Only the required delta capacity will be activated by the CPM
- Provisioning scope exists in two flavours:
  - Maximum provisioning scope defines an upper limit of MSU that may be increased in total for all the contained rules at any point in time. Additionally, capacity increments can be defined. Increments are defined in MSU.
  - Provisioning scope on the „rule“ level defines an upper limit of MSU that may be increased for the single rule at any point in time
  - Allows for definitions like „I authorize 30 MSU for workload 1 and 20 MSU for workload 2, but at no point in time more than 40 MSU.“

System	*Sysplex*	*Max. Increase (MSU)*
SYS1	PLEX1	15
SYS2	PLEX1	40

Rule: Provisioning Scope – Group Capacity Limits

- Capacity group of a CPC within provisioning domain for which activation of resources is allowed
- Max number of increased MSU
  - Only the required delta capacity will be activated by the CPM
- Provisioning scope exists in two flavours:
  - Maximum provisioning scope defines an upper limit of MSU that may be increased in total for all the contained rules at any point in time. Additionally, capacity increments can be defined. Increments are defined in MSU.
  - Provisioning scope on the „rule“ level defines an upper limit of resources that may be activated for the single rule at any point in time
  - Allows for definitions like „I authorize 30 MSU for workload 1 and 20 MSU for workload 2, but at no point in time more than 40 MSU.“

Group	***CPC***	***Max. Increase (MSU)***
GROUP1	CPC1	15
GROUP2	CPC2	40

Additional CPM Processing and Directives

- For workload-based provisioning it is a necessary condition that the performance index exceeds the specified provisioning PI
  - However, it is **not at a sufficient condition**
  - The underlying CPM processing examines many metrics and parameters to ensure that
    - the observed performance bottleneck is caused by a capacity shortage of the respective type, and
    - that additional capacity could actually be consumed by the workload that incurred the capacity demand
- Deprovisioning is under control of additional parameters
  - The “minimum activation time” specifies for how long any added capacity must remain active a*t a minimum.*
  - Specified in the PARM member
- For many aspects of the CPM processing, additional directives may be specified in the PARM member
  - Refer to documentation for full list

Overview on Observed Metrics

CPC Metrics

- *Per processor type*
  - *Shared physical utilization*
  - *Total logical processors*
  - *Total weights*
  - *Physical processors*
- *Group capacity*

LPAR/System Metrics

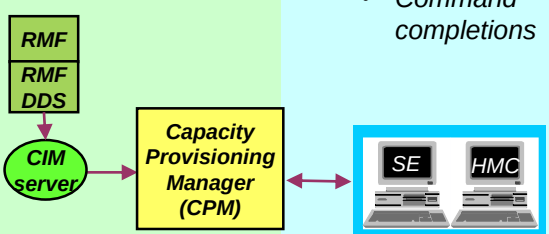
- *WLM Service definition, policy, service classes Shared/dedicated*
- *Initial capping*
- *Defined capacity*
- *Capping & time-to-cap*
- *4h Rolling Average*
- *Dispatchable units (InR Queue)*
- *IRD weight & vary CPU mgmt.*
- *Per processor type*
  - *Online CPs, zAAPs, zIIPs*
  - *Reserved processors*
  - *LPAR weight*
  - *MVS utilization*
  - *LPAR utilization*

Service Class Period Metrics

- *Local PI*
- *Sysplex PI*
- *%Capped*
- *Delays*
- *Per processor type*
  - *Processor delays*
  - *TCB, SRB*

Support Element

- *H/W model*
- *Spare processors*
- *Installed OOCoD records including Activation limits, validity, current activation level*
- *Current S/W model*
- *Current number of processors*
- *Power save (z196 and later)*
- *Event subscriptions*
  - *Capacity and accounting change*
  - *Command completions*



Reports, Logs, Audit Trails

- History of actual workload and system activity available with CPM reports
  - Especially REPORT WORKLOAD, REPORT UTILIZATION, REPORT ACTIVITY
  - Available at the z/OS console, and in the z/OSMF Capacity Provisioning task (starting with z/OS V1.13)
  - Reports can be directed to files and archived
- History of capacity changes available via CPM logging
  - Metrics, decisions and other data can be logged to file system
  - Binary format
- Other information available:
  - RMF Mon III data sets
  - Model and capacity changes recorded outside CPM
    - SMF22
    - RMF 70.1, 72
    - Current capacity information also available via STSI instruction, and related MVS programming interfaces

New with z/OS 2.2:
Simplified configuration with Utilization Conditions

- CPM requires the definition of *Workload Conditions* in order to provision capacity that meets processor bottlenecks **on demand**

- Potential obstacles to defining Workload Conditions

  – A *Workload Condition* needs to specify appropriate WLM *service classes* and Performance Index (PI) limits which indicate provisioning-worth situations
    - *Service class* PIs may not indicate performance bottlenecks quickly enough
    - Some installations (WLM service definitions) may lack of adequate *service classes*

  – CPM checks for 'secondary' conditions before provisioning on behalf of Workload Conditions
    - High logical processor utilization
    - High LPAR busy rate
    - …

    In some situations, these conditions may not be met, although provisioning of capacity would be advisable

New with z/OS 2.2: Simplified configuration with Utilization Conditions cont.

- For some installations, the overall physical processor consumption may be sufficient to indicate a demand for temporary (OOCoD) processor capacity
- Utilization Conditions allow to specify CPC-wide processor utilization limits which qualify for provisioning of additional capacity
  - Utilization Conditions can **only** trigger provisioning of physical temporary (OOCoD) capacity
  - Activation is independent of workload- or system-specific bottlenecks
  - Will not discriminate between business-critical or insignificant workload which might be causing the high processor consumption
- Utilization Conditions can be used as a simplistic alternative to Workload Conditions

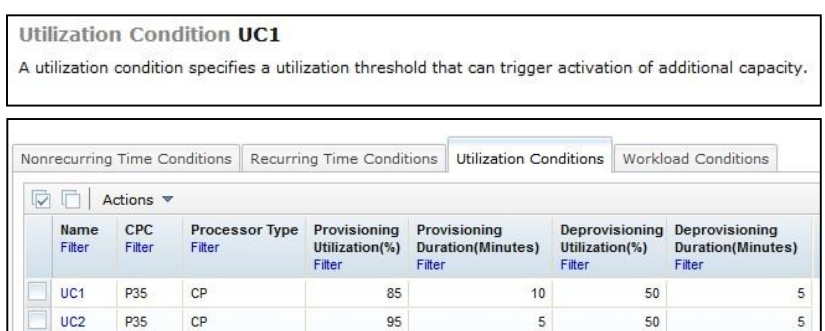
New with z/OS 2.2: What you need to define

- The **Domain Configuration** defines a Capacity Provisioning management domain, specifying;
  - *CPCs* where processor capacity should be managed
  - ***At least one system*** **on that CPCs, used to provide metrics about the CPC-wide CPU consumption**

- The **Policy** defines scopes and rules for changes of Processor Capacity
  - *Processor Scopes* define the increments and total amount of allowed changes
  - *Time Conditions* define when increases and decreases of capacity should, in combination with
  - ***Utilization Conditions*** **specify when a CPC is physically constraint and CPM should initiate a step-by-step increase and decrease of processor capacity**

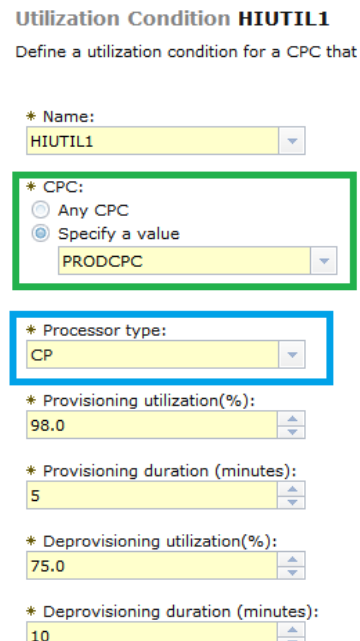
New with z/OS 2.2:
Rules - Provisioning Conditions – Utilization Condition

- Identifies processor consumption limits that trigger the activation of additional temporary (OOCoD) capacity,
  - When the processor consumption limit is exceeded
  - Expressed as physical processor utilization %, for a specific processor type



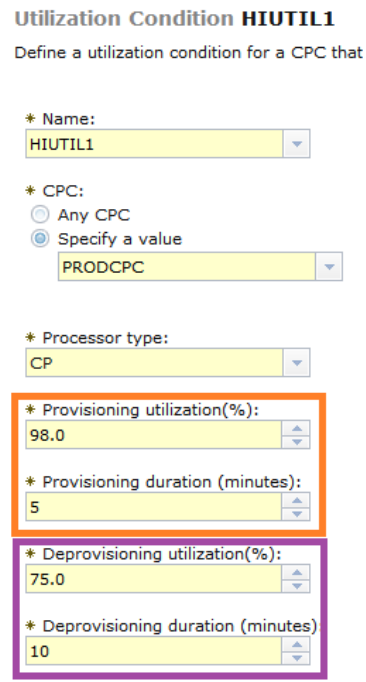
New with z/OS 2.2:
Rules - Provisioning Conditions – Utilization Condition 2

- Define **where** capacity should be managed, either:
  - A CPC listed in the active *Domain Configuration* and with a defined *Processor Limit*
  - *Any CPC* to apply this condition to all CPCs of the active *Domain Configuration* and with a defined *Processor Limit*
  - The Provisioning Manager will automatically observe suitable systems running on that CPC, to monitor CPC-wide CPU consumption data
- Define **what kind** of processor type is managed:
  - General Purpose (CP)
  - zIIP
  - zAAP



New with z/OS 2.2:
Rules - Provisioning Conditions – Utilization Condition 2

- Define **which situations** qualify for provisioning and deprovisioning additional processor capacity:
  - *Provisioning utilization (%)* the CPC-wide CPU consumption level of the given *Processor type* that must be exceeded to trigger provisioning
  - *Provisioning duration (minutes)* the minimum time during which the CPC-wide CPU consumption must exceed the *Provisioning utilization* to trigger provisioning
  - *Deprovisioning utilization (%)* the CPC-wide CPU consumption level of the given *Processor type* must fall below this limit to trigger deprovisioning of additional processor capacity
  - *Deprovisioning duration (minutes)* the minimum time during which the CPC-wide CPU consumption must fall below the *Deprovisioning utilization* to trigger deprovisioning



New with z/OS 2.2:
Utilization Condition Parameters

- CPC:
  Name of the CPC for which processor utilization should be monitored and where temporary capacity should be activated when needed

- Processor type:
  Either CP/general purpose, zIIP, or zAAP

- Utilization limit criteria:

  - Activation threshold:

  CPC-wide processor utilization must exceed the activation threshold for a specified duration before the work is considered to require help

  - Deactivation threshold:

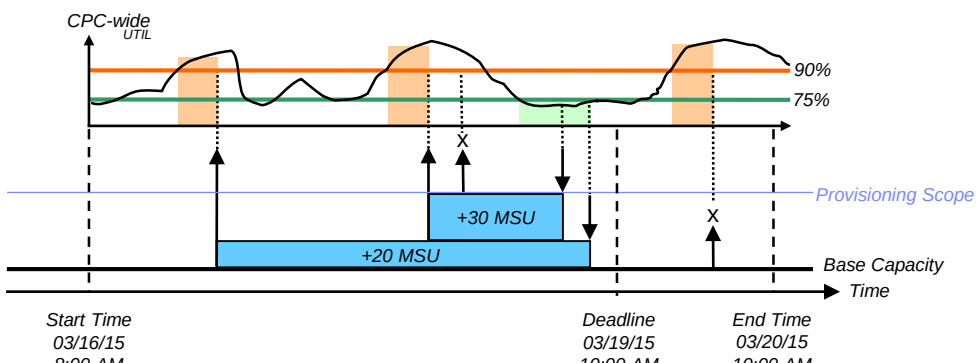
  CPC-wide processor utilization must fall below the deactivation threshold for a specified duration the work is considered to no longer require help

New with z/OS 2.2:
Sample Utilization Condition

Sample definition:

Name: *UC1*
CPC: *CPCPROD1*
Processor type: *CP*
Provisioning Criterion: ***CPC-wide utilization >= 90%*** *for 3 min.*
Deprovisioning Criterion: ***CPC-wide utilization <= 75%*** *for 7 min.*

Monitor all CPC-wide utilization of CP processors on CPCPROD1:



New with z/OS 2.2: Utilization Report

Current CPU consumption and detected demands for increasing Processor Capacity on account of Utilization Conditions can be queried at runtime

- **Example on console:**

```
MODIFY CPOSERV,APPL=REPORT UTILIZATION CPC=ECL2

Utilization is observed for 1 CPC(s)
CPC ECL2: utilization from 01/28/2015 14:56
 CP 92.6%, zAAP -%, zIIP -%
 Utilization condition UC1
  PU/PD/DU/DD/PT 91.7% 2 33.3% 15 CP
  Last CPC utilization threshold crossing was at 01/28/2015 14:53
  Demand for additional physical CPs recognized
  Demand for capacity level increase recognized
End of report
```

New with z/OS 2.2:
Defined Capacity manual interference alert

- While CPM is actively managing Defined Capacity, the operator might **concurrently** turn down the Defined Capacity limit
- As soon as the bottleneck situation has disappeared, CPM will de-provision the total **amount of additional** Defined Capacity MSU it originally activated
- The resulting Defined Capacity limit may be way below the initial Defined Capacity limit, and may restrain the system excessively

New with z/OS 2.2: Defined Capacity management Interference Alert cont.

- CPM constantly monitors managed Defined Capacity for manual changes
- CPM detects ‘significant’ manual Defined Capacity reductions and alerts the operator, asking how CPM should proceed with its management

CPM Defined Capacity management

```
CPO3986I Defined capacity observed. Current capacity is 50 MSU
  for LPAR IRD4 of CPC ECL2 with system IRD4 in sysplex IRD4PLEX

CPO3960I Defined capacity base is 50 MSU for LPAR IRD4 of CPC ECL2 with
  system IRD4 in sysplex IRD4PLEX

CPO3962I Defined capacity increase initiated to 80 MSU for LPAR IRD4
  of CPC ECL2 with running system IRD4 in sysplex IRD4PLEX
```

Manual Defined Capacity reduction

```
CPO3984I Defined capacity change detected. New defined capacity is
  60 MSU for LPAR IRD4 of CPC ECL2 with system IRD4 in sysplex IRD4PLEX
```

Interference Alert

```
*76 CPO4218I New DC for IRD4/IRD4PLEX. Previous base 50 MSU.
  Enter 1 to set base to 60 or 2 to set to 30 MSU
```

New with z/OS 2.2:
Defined Capacity management Interference Alert cont.

- Explanation of the WTOR

CPO4218I: New DC for *system name/sysplex name*. Previous base *previous value* MSU. Enter 1 to set base to *current value* or 2 to set to *new value* MSU

Explanation: The Provisioning Manager detected a significant change to the defined capacity that was not originated by the Provisioning Manager. This change leads to a new defined capacity management base.

User Response: Enter '1' to reset the management base to the current capacity value and to set the managed defined capacity to 0 MSU. Enter '2' to adjust the defined capacity base due to the new defined capacity value. The managed capacity will remain unchanged. If you need more detailed information about the defined capacity of the specified system then use the REPORT DEFINEDCAPACITY command to display the current values.

- Sensitivity of the interference alert can be adjusted with control parameter `DefinedCapacity.BaseToleration`
  - Default is 15, meaning that manual Defined Capacity reductions of by at least 15% will trigger the alert

Documentation

- *For more information contact: IBMCPM@de.ibm.com*
- *Website http://www.ibm.com/systems/z/os/zos/features/cpm*
- *z/OS MVS Capacity Provisioning User's Guide, SC34-2661-01, at http://publibz.boulder.ibm.com/epubs/pdf/iea3u110.pdf*
- *IBM DEMOzone Demonstration of Capacity Provisioning*
  http://www14.software.ibm.com/webapp/download/demo.jsp?id=IBM+z%2FOS+Capacity+Provisioning+Jan09
- *ITSO Redbook:*
  System z10 Enterprise Class Capacity on Demand, SG24-7504
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