

## LPAR Defined Capacity, Initial Processing Weight, the Soft Cap and LPAR Group Capacity Limits

I/S Management Strategies, Ltd.  
+1 414 332-3062  
al@sherkow.com  
<http://www.sherkow.com>

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# Objective

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- Capping Overview
- Explain Defined Capacity
- Explain Why You Need Defined Capacity
- Discuss the Capacity of Your LPARs
- Setting Up LPAR Parameters
- When an LPAR is Soft Capped What is Being Impacted?
- Group Capacity Limits
- Summary and Recommendations
- Questions??

# Reasons for Capping in z/OS<sup>1</sup>

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- **Technical Reasons:**
  - Protect LPARs against other LPARs
  - Influence capacity-based WLM routing
  - Guarantee unused/available CPC processor capacity
    - (Hold back some capacity)
  - Protect workloads (service classes) against other workloads
- **Non-technical Reasons:**
  - Limit Software Charges
    - Capacity limit for one or more LPARs
- You'll need to monitor capping's impact and decide if the impact is acceptable for your site
- Limits should be adjusted as appropriate
  - Based on your site's Service Delivery Requirements (SLAs)

<sup>1</sup> Based on Horst Sinram, IBM, Share 2014

# Defined Capacity

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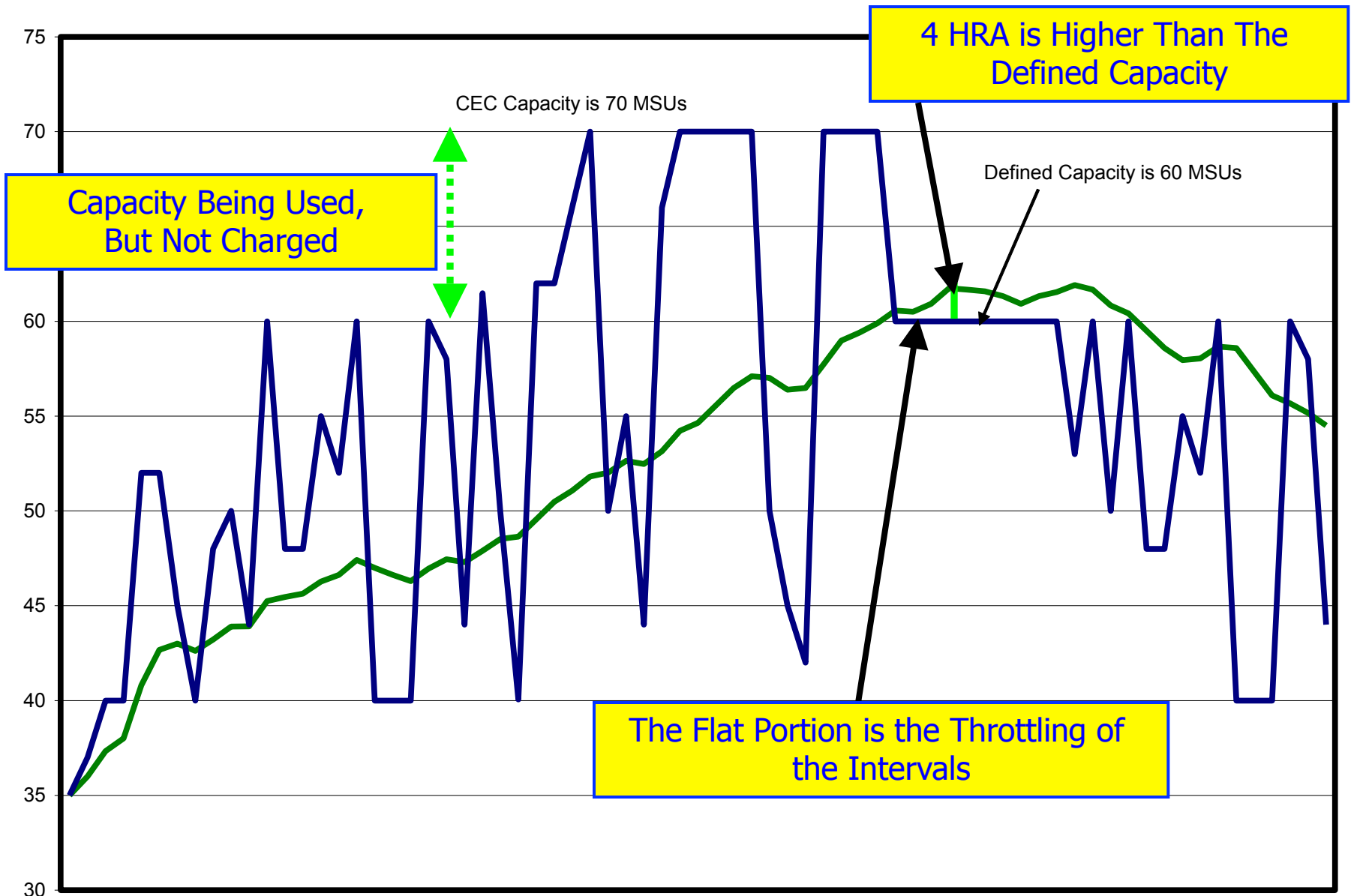
- Defined Capacity Specifies a Limit on the MSUs an LPAR Can Contribute to the Maximum Simultaneous Four-Hour Rolling Average
- Defined Capacity, LPAR Group Capacity Limits and Absolute Capacity are the Only Controls in z/OS That Can Change an LPAR's 4 Hour Rolling Average *In the Future*
  - They Do **Not** Directly Control the 4-Hour Rolling Average
  - Once Capping is Activated It Controls Each Interval's Utilization, Limiting What Each Interval Can Contribute to the 4-Hour Rolling Average Calculation Going Forward (*In the Future*)

# Defined Capacity Sets the Limit on Charges

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- **The Defined Capacity is the Maximum MSU Value That an LPAR Will Be Charged by SCRT**
  - It is not the maximum 4 hour rolling average you will see in the SMF data, that may keep increasing to values higher than the Defined Capacity
  - SCRT will not “report” a 4 hour rolling average greater than the Defined Capacity in an hour
- **Defined Capacity Limits the Software Charges of an LPAR**
- **Defined Capacity Does Not Limit the Software Charges of a Machine**
  - For That You Need to Specify Defined Capacity for All LPARs!
  - Or at Least for the Large LPARs
  - Capacity Group Limits Can Limit the Charges of an Entire Machine
    - If you define a single Capacity Group for all the LPARs

# 4-Hour Rolling Average & Defined Capacity





# Specifying MSUs for LPARs (5 different LPAR sizes)

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1. True Limit on Capacity is the number of Logical General Purpose Engines allocated to the LPAR. This determines the maximum MSUs
  - **For each LPAR**  
LP MSUs = “Number of LPs” times “Engines Size in MSUs”
2. Relative weight (initial processing weight) is only a factor when contention exists for General Purpose Engine resource
  - Indicate a Percentage of the Capacity of the Whole zBox
  - **For each LPAR**  
Weight MSUs = “Normalized Weight” times “Shared LP MSUs”
3. Defined Capacity sets the limit that the rolling 4-hour average is held to by WLM
  - always a factor regardless of machine utilization
  - independent of other LPAR parameters
  - Directly Specifies the Maximum MSUs That Can Be Used for Billing
  - **For each LPAR**  
Defined Capacity MSUs are Set on HMC

# Specifying MSUs for LPARs (5 different LPAR sizes)

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## 4. Group Capacity Limit

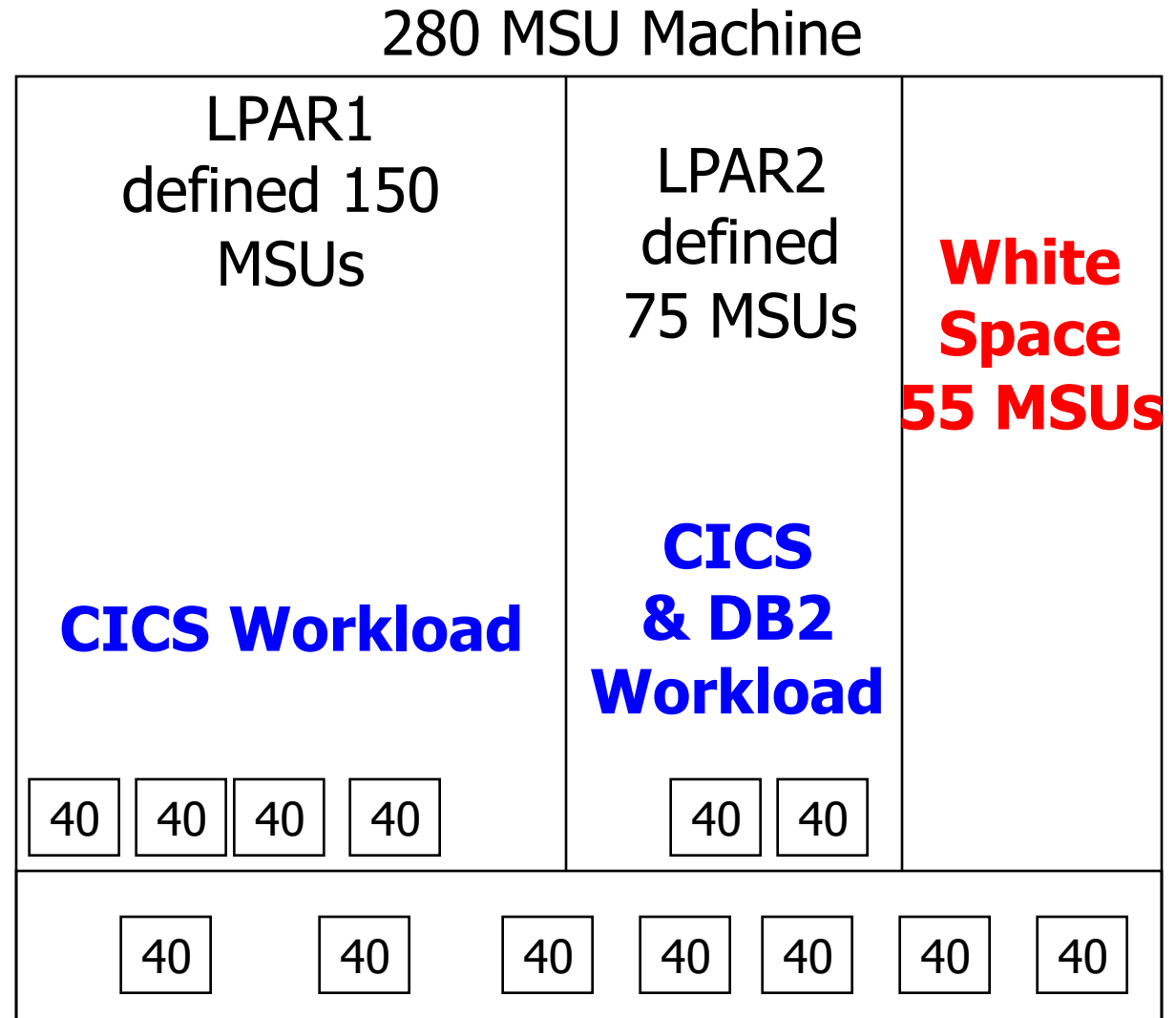
- LPARs on a single machine, Independent of SYSPLEX
- Can be used with Defined Capacity also
- The group's limit is distributed based on relative weight within the group
- Each LPAR manages itself within the group
- Unused capacity is available to other group members

## 5. Absolute Capacity (zEC12 GA2 or later HW)

- Intended for non-z/OS LPARs; but works for z/OS also
- Works with Defined Capacity and/or Group Capacity
- Specified in hundredths of an engine via the logical partition controls of the Hardware Management Console (HMC)
- Can be used to limit an LPAR's access to unused capacity
  - Set this above the Weight MSUs

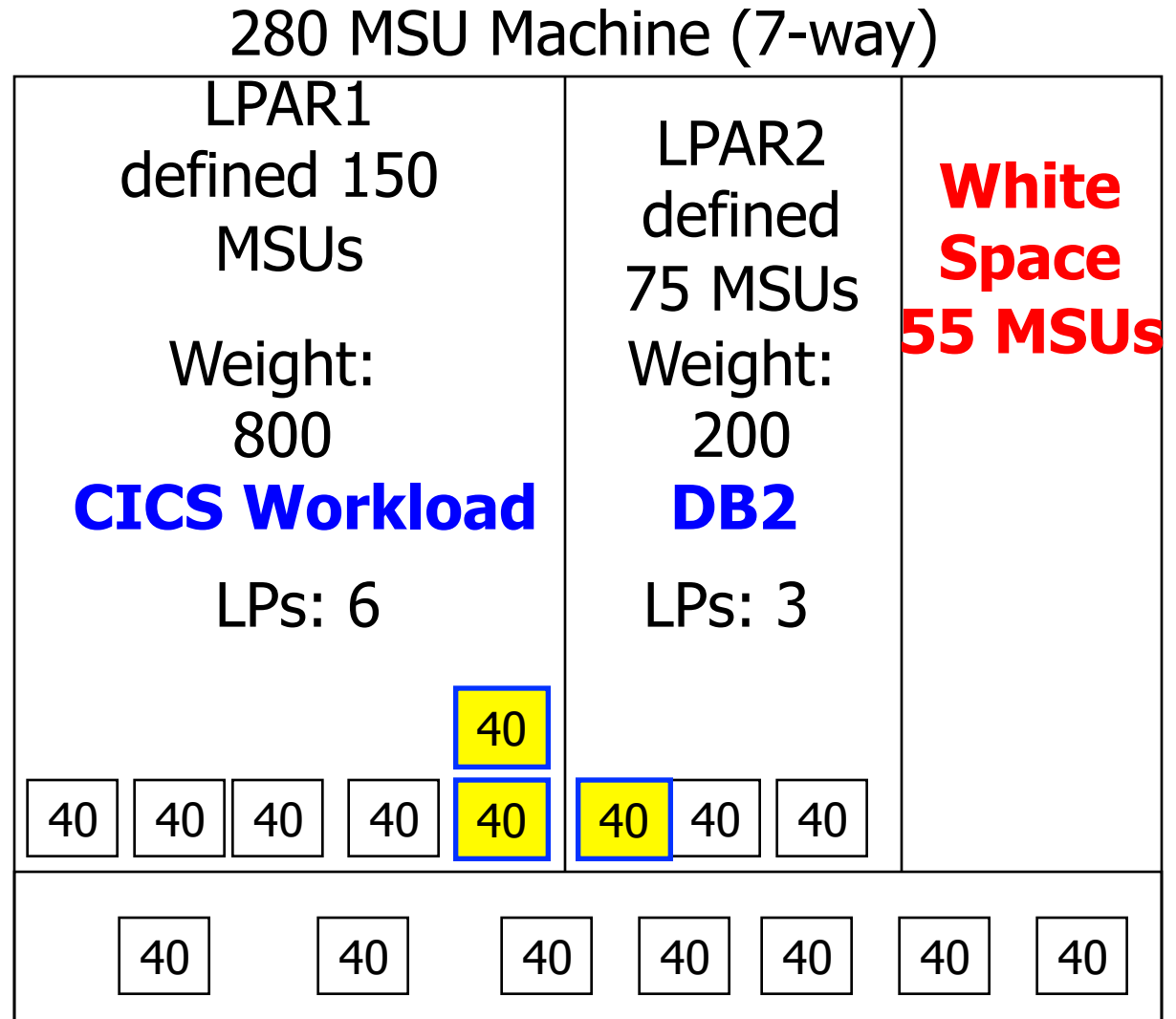
# Now We' ll Setup Some LPARs

- Overly simple starting point for some basic concepts!
- Sum of the LPARs MSUs May Be Less Than Physical Box
- White Space is Not Defined, It is “Left Over” by Your Configuration
- Planned SW Charges:  
CICS and z/OS 225 MSUs,  
DB2 75 MSUs



# Define the LPARs — Weight

- When There Is Contention PR/SM Enforces the Weights
- Recommendation: Should Total 1,000
  - To make the math easy



# Define the LPARs

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## Our Initial Number of LPs

LPAR	Wgt	Wgt%	Target CPs	#LPs	Target LPs
LPAR 1	800	80%	5.6	4	1.40
LPAR 2	200	20%	1.4	2	0.70

## Revised Number of LPs

LPAR	Wgt	Wgt%	Target CPs	#LPs	Target LPs
LPAR 1	800	80%	5.6	6	.93
LPAR 2	200	20%	1.4	3	0.46

- Target CPs is the number of Shared CPs in the whole box times Weight %
- Target LPs is Target CPs divided by #LPs. This shows the loading of the LPs.
  - In this example for LPAR 1, the 4 LPs are not enough to provide the weight.

# Limits of Your Capacity

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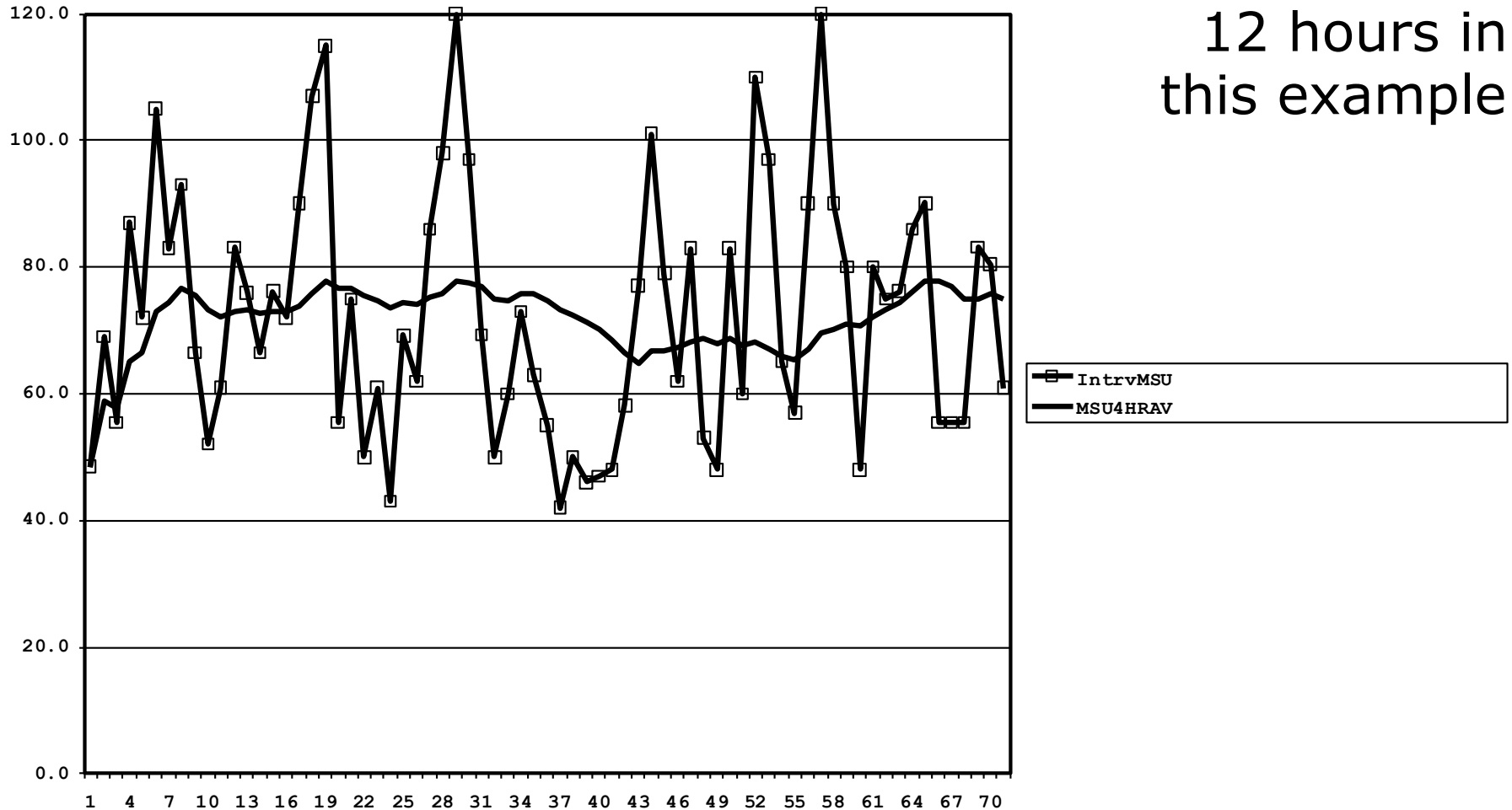
	LPAR 1	LPAR 2
#1 True Limit of Capacity	$6 * 40 =$ 240	120
#2 Weighted LPAR %of the CEC	$80\% * 280 =$ 224	56
#3 Defined Capacity	150	75
MSUs You Cannot Access (Above True Limit)	40	160
Whitespace Above % of the CEC (True Limit – Weighted LPAR % of CEC)	16	64
Whitespace Above Defined Capacity	$240 - 150 =$ 90	45
Defined Capacity Percent of Box	54%	27%

Realize That an LPAR's Whitespace Can Be Larger Than the Whitespace of the Box. The zBox Had 55 MSUs Whitespace but LPAR 1 has 90 MSUs!

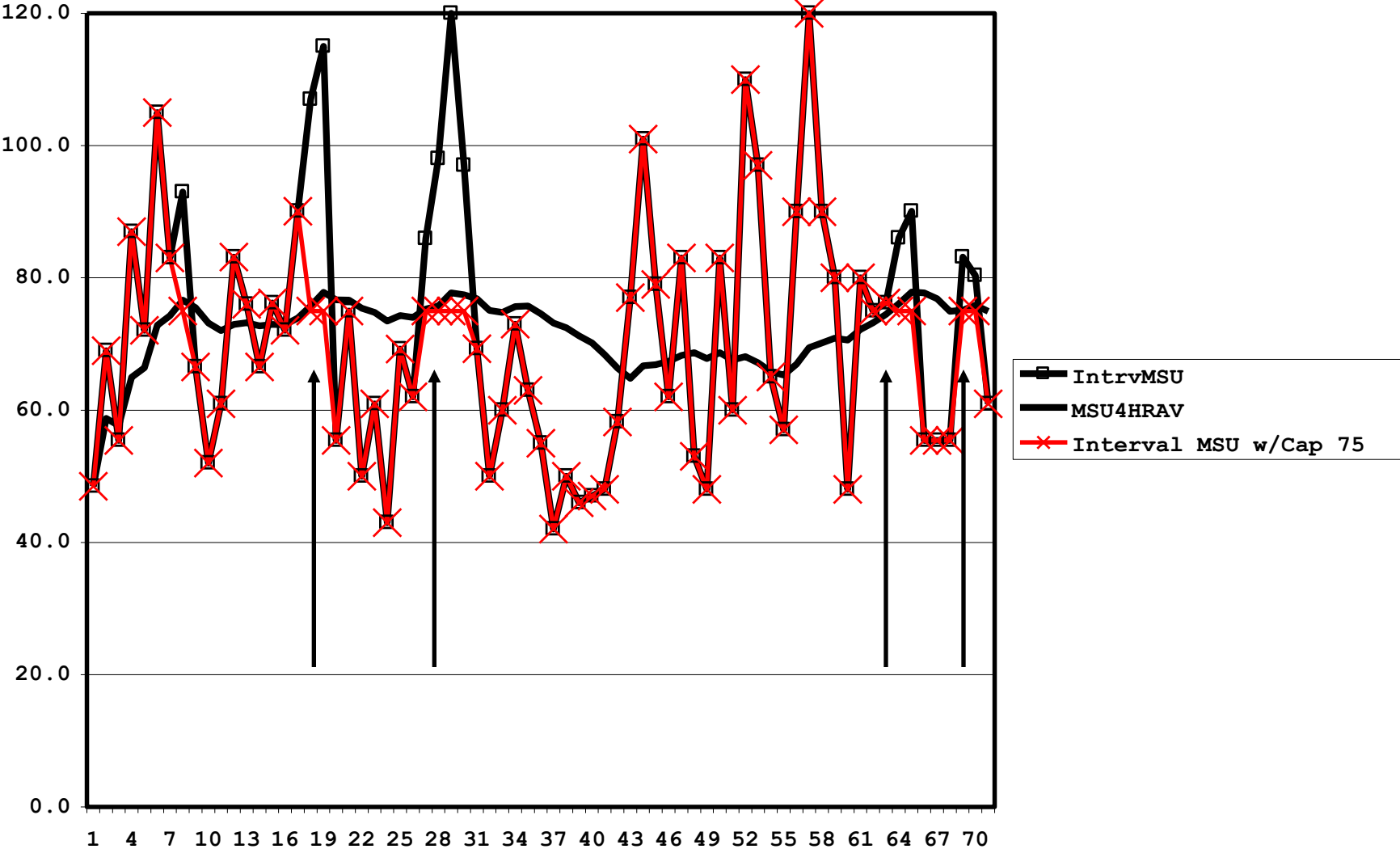
# Soft Cap: Intervals and Rolling 4-hour Average

72 ten-minute intervals and the rolling 4-hour average

12 hours in this example



# Soft Cap: Add Intervals With Soft Capping





# Soft Cap: Intervals That are Capped

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- What About the Intervals That Were Above the Cap?
- Does That Work Still Get Processed?
- Does a Backlog of Deferred Work Build Up?
  
- It Depends ... ..
  - On Your Environment and Workload
  - If Not Done Now, Will Work Be Abandoned?
  - If Not Done Now, Will the Work Wait?

# Soft Cap: Intervals That are Capped

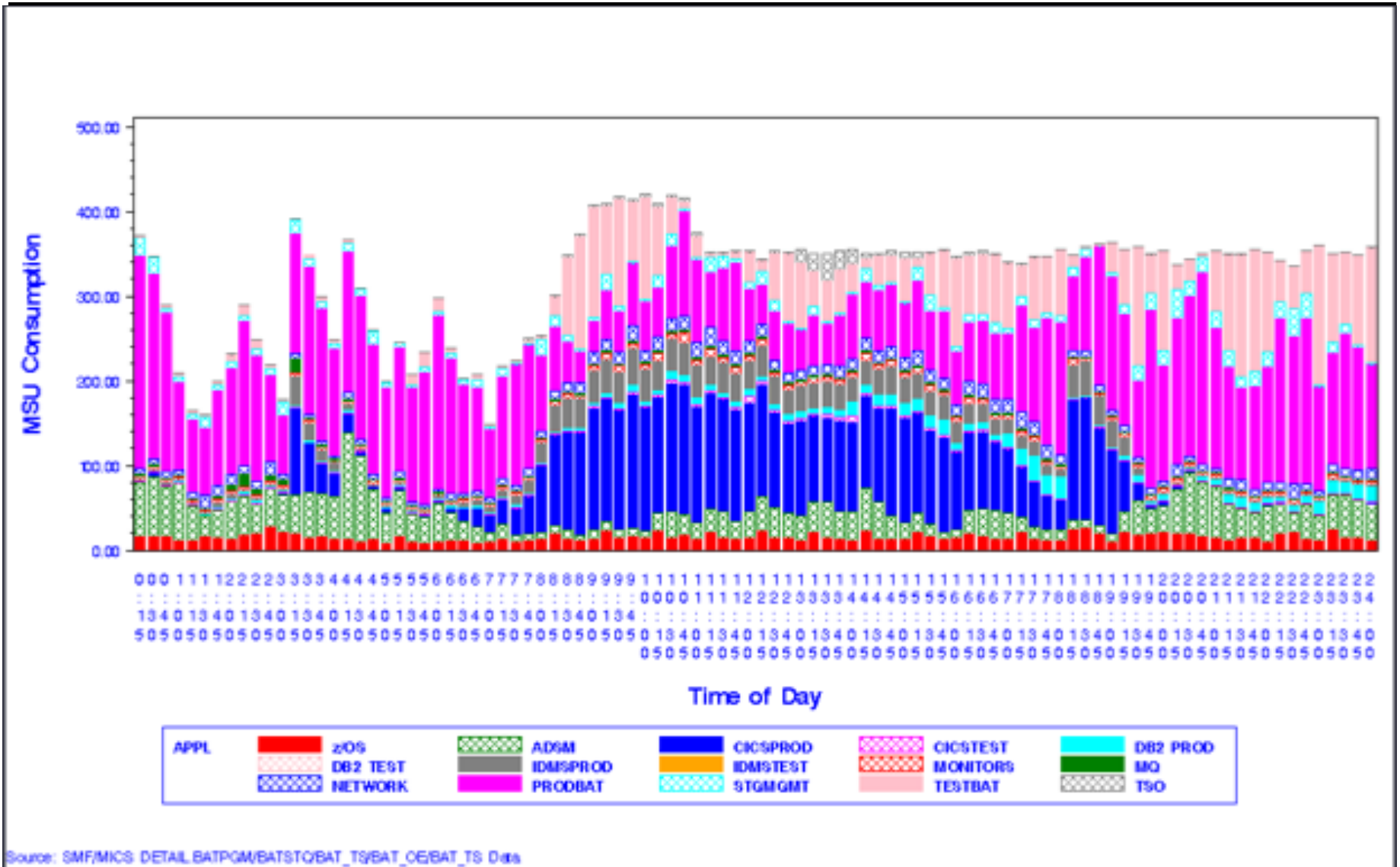
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- This is Why There is WLM Discretionary Work
- During Periods of Capping the Discretionary Work Can be Stopped Without Impacting Your Important Workloads
- During Periods of Excess Capacity, the Discretionary Work Can Fill In the “Valleys”

- The Big **IF**:

–Are Your Workloads/Service Classes Defined Properly in WLM?

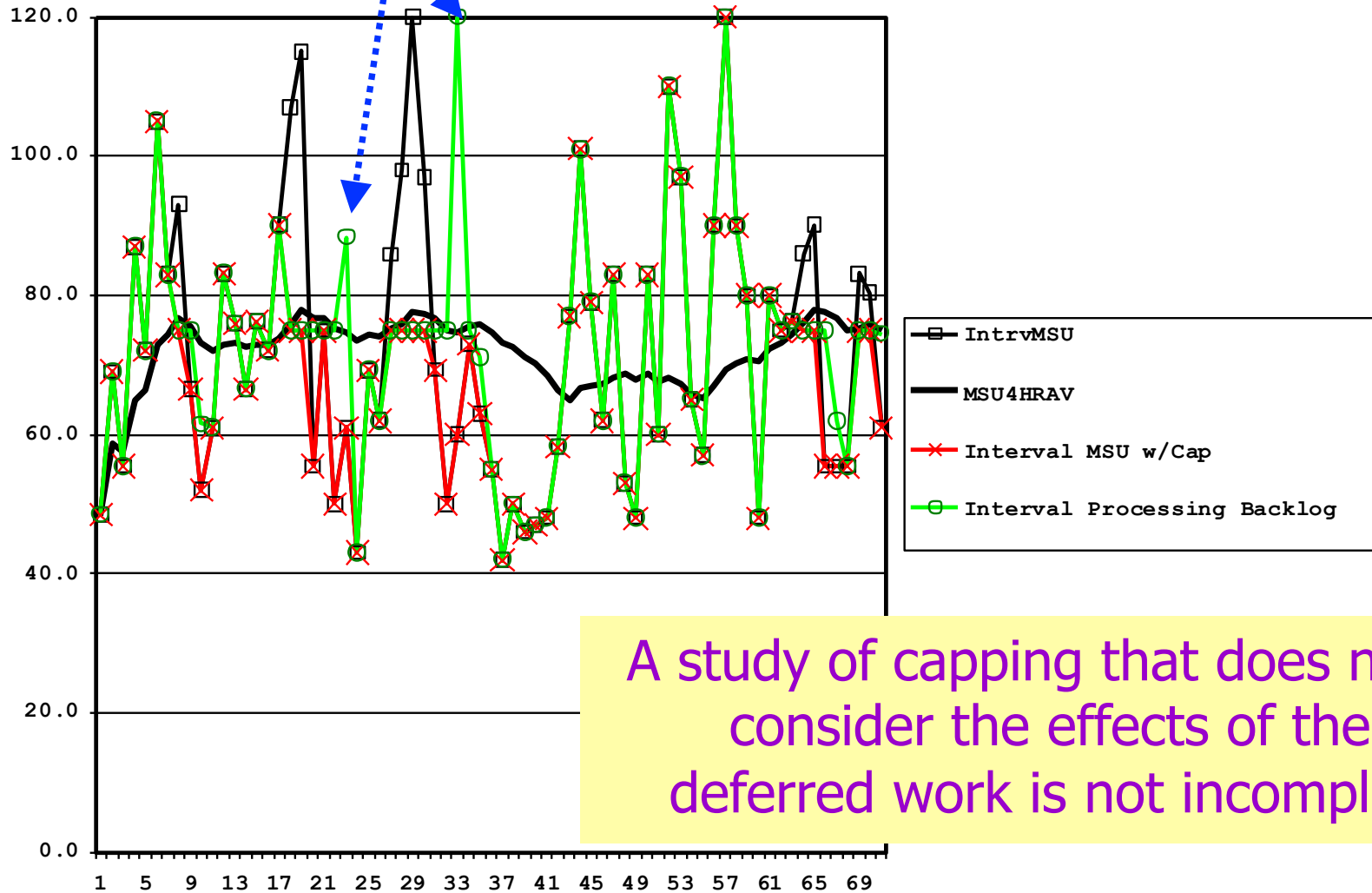
# Soft Cap: Intervals That are Capped



- The pink is test batch, a discretionary workload in this site

# Soft Cap: Processing the Backlog

## Catching Up While not Capped



- New peaks are created by processing the backlog

## Now Let's Look at Weights & Defined Capacity

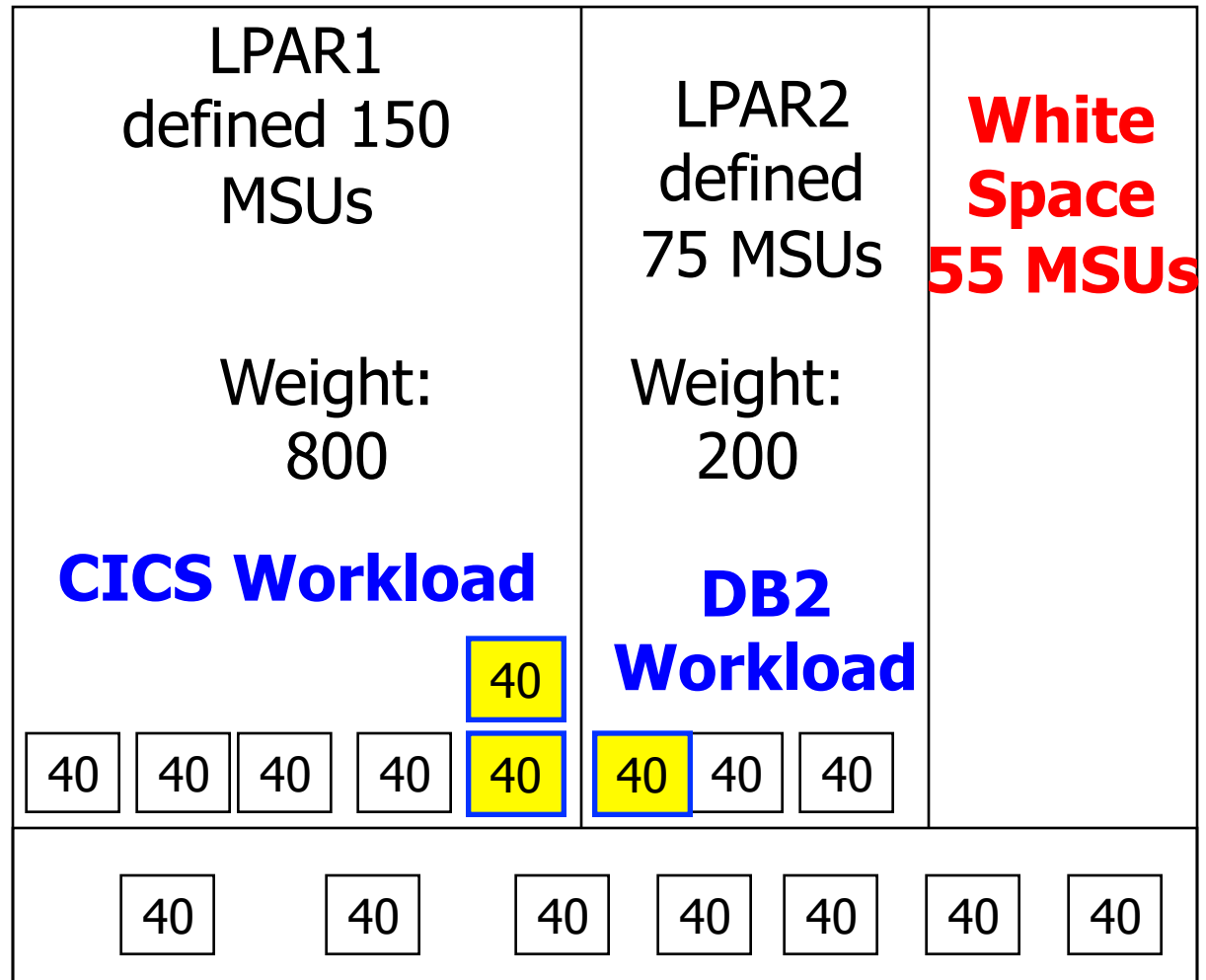
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- PR/SM Implements Caps by Enforcing the Weights You Defined for Your LPARs
- There Is a Relationship Between The LPAR Weights and Defined Capacity

# Soft Cap: Weights > Defined Cap

- Capping enforces the LPAR's "Current" Weight
- 80% of 280 is 224 MSUs
- Is That What Is Needed?

LPAR 1 Exceeding Defined Capacity  
280 MSU Machine (7-way)

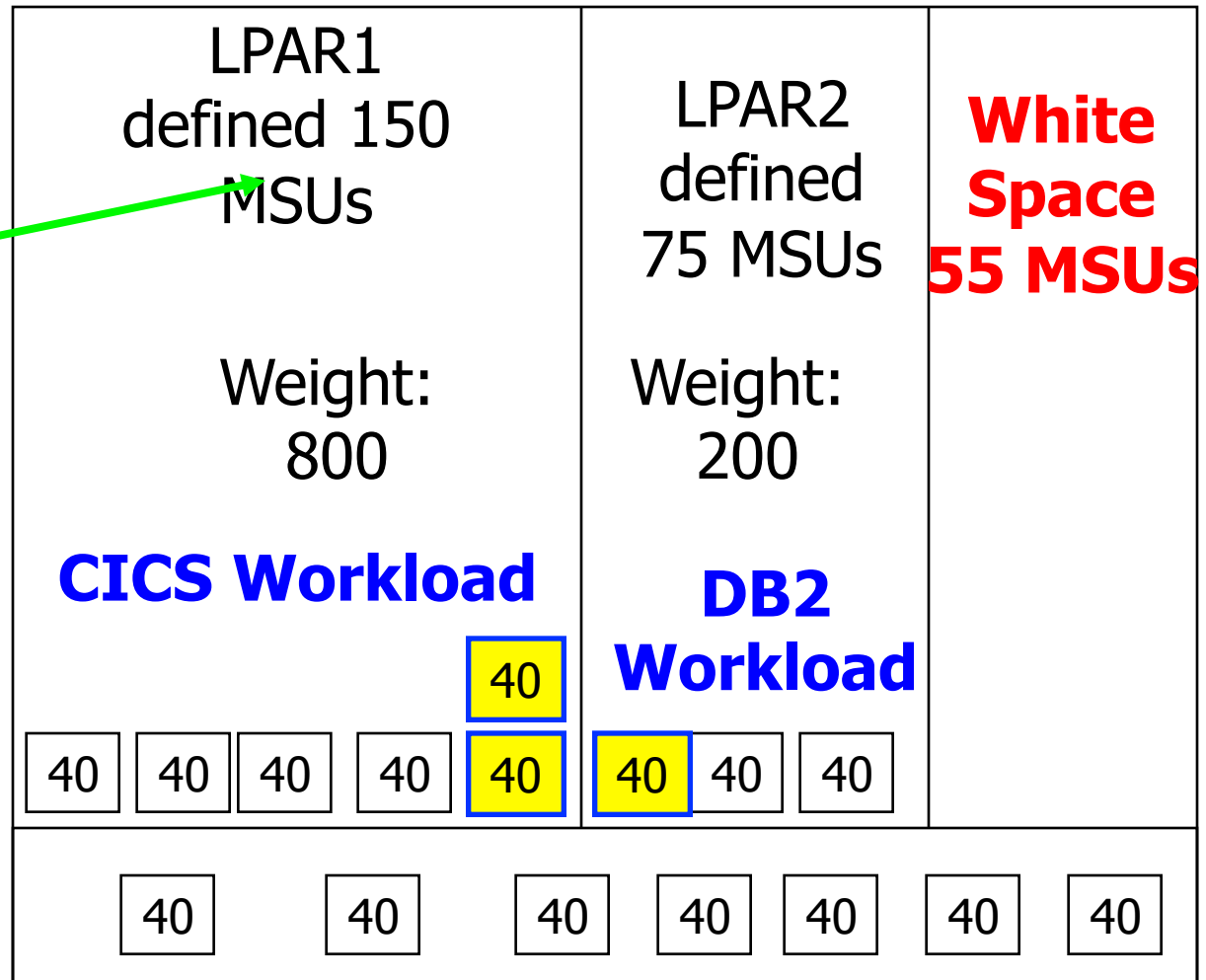


# Soft Cap: Weights > Defined Cap

- PR/SM Needs to Change the Weight Temporarily
- LPAR1 Needs to be Limited to 150 MSUs
- How Do They Do That?

## LPAR 1 Exceeding Defined Capacity

280 MSU Machine (7-way)



# Soft Cap: Weights > Defined Cap

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- PR/SM Caps at Weighted LPAR % of CEC
- WLC Wants the Cap to Be at the Defined Capacity
- So ... ..
- PR/SM Calculates a Temporary Weight, named “Phantom Weight”, Assigns it to the LPAR
- When the LPAR is Capped It Will Cap at the Correct Level
- LPAR 1’s Defined Capacity is 54% of the CEC
- What “Phantom Weight” Leads to a Normalized LPAR Weight of 54%??? (Holding the weight of the other LPAR constant)

$$800 / (\text{Phntm Wgt} + 800 + 200) = 0.54$$

$$\text{Phntm Wgt} = 481.48$$

- Does it Work?

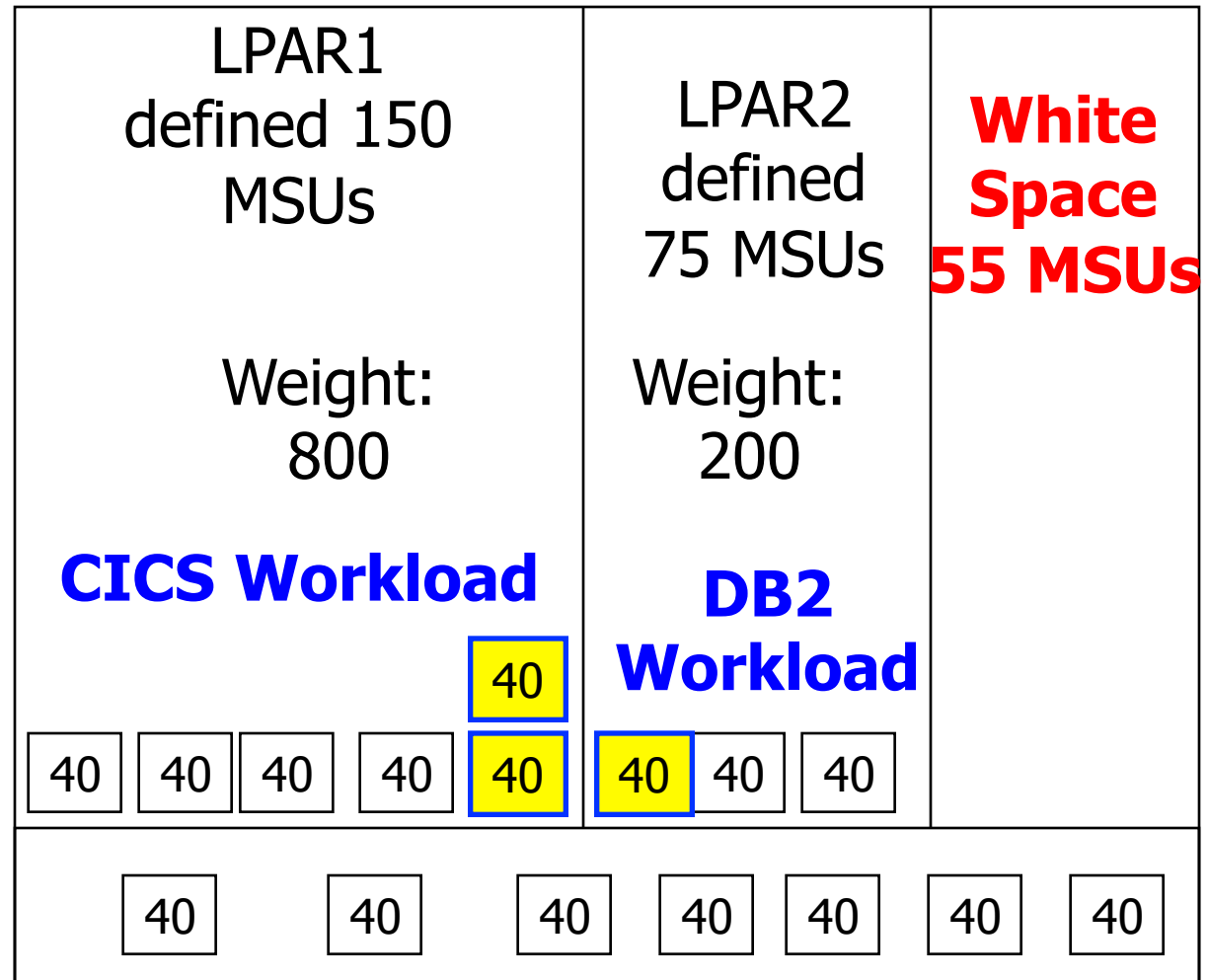
$$800 / (481.5 + 800 + 200) = 0.539$$



# Soft Cap: Weights < Defined Cap (pre-zEC12 GA2)

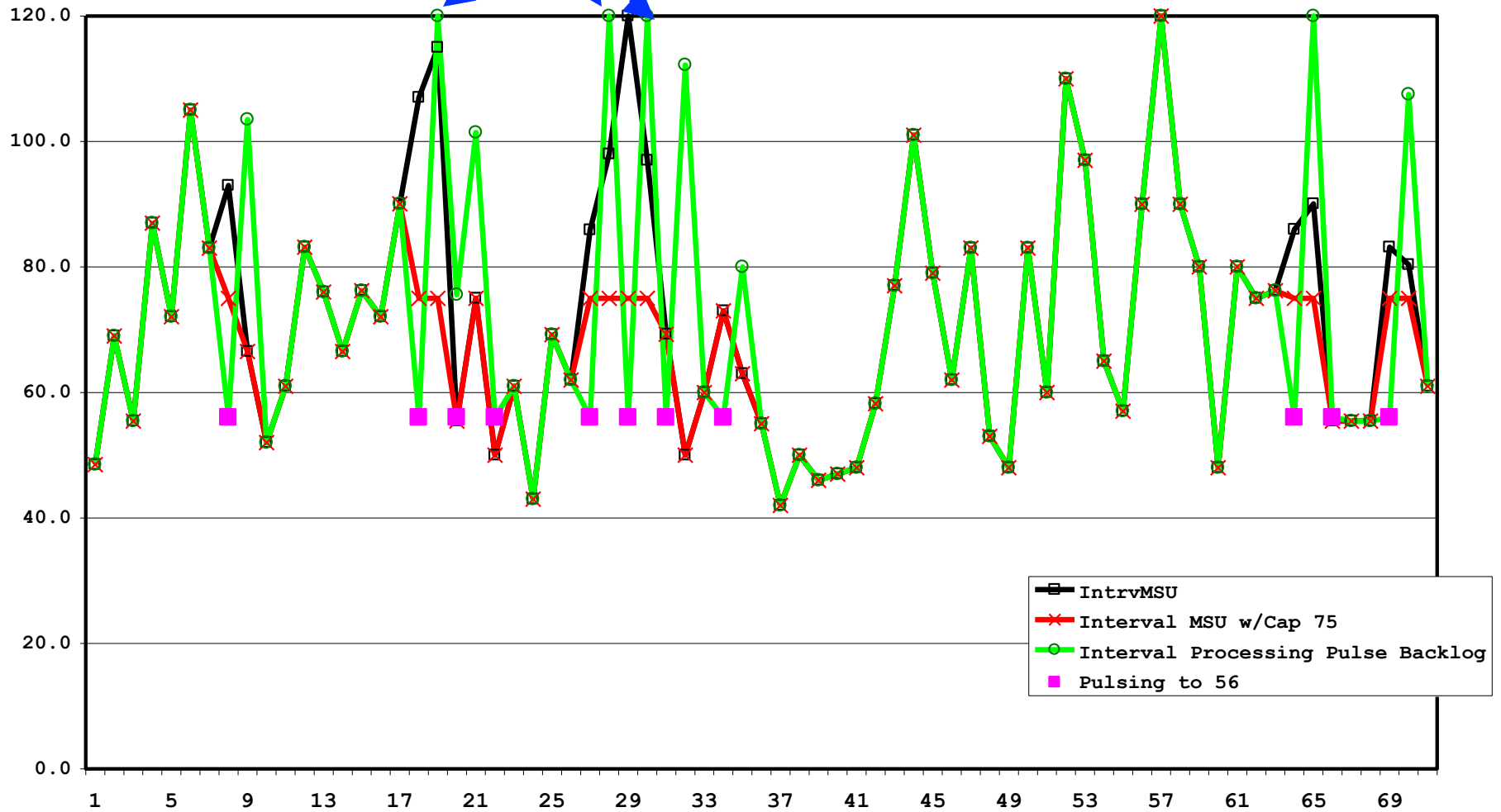
- z/OS V1 with any hardware
- Capping Enforces Initial Weights
- 20% of 280 is 56 MSUs
- So ...
  - Enforce at 56
  - Release
  - Enforce at 56
  - Release
- Continue & Monitor Until 4HR Rolling Average is Below Defn' d Cap

LPAR 2 Exceeding Defined Capacity  
280 MSU Machine (7-way)



# Pulse to 56, Every Other Sample

Catching Up Reaches the LPAR's MSU Limit

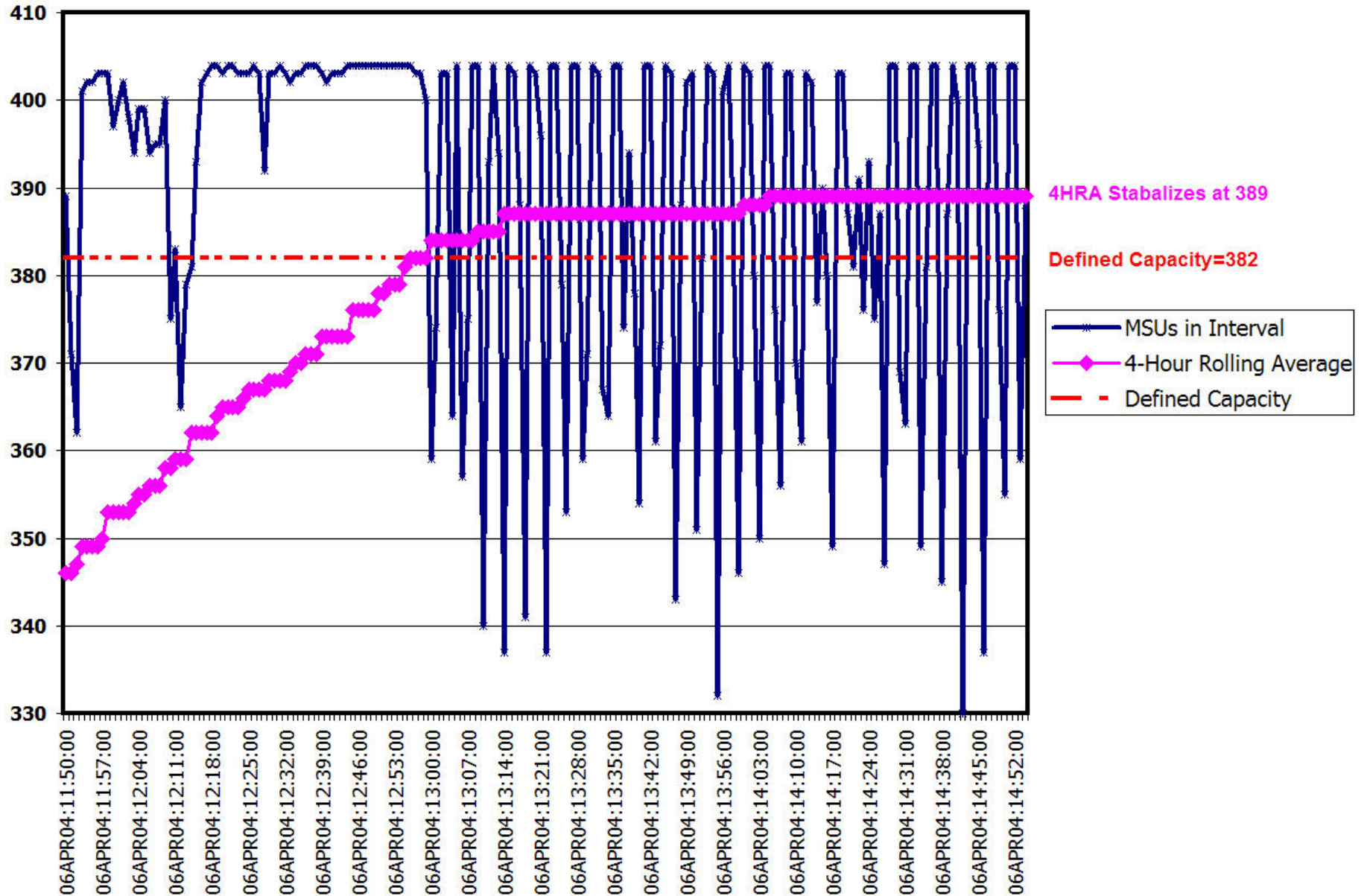


# Soft Cap: Weights < Defined Cap

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- On zEC12 (GA2) and later with z/OS V2 Negative Phantom Weights are Calculated
- This provides for a smoother capping behavior

# Real Data Minute by Minute



# Why Does That Happen?

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- From the PR/SM Planning Guide for any Hardware:
  - For LPs without processor resource capping, PR/SM LPAR enforces the processing weights to within 3.6% of the LP's physical CP share for logical CPs ... .. Typically, PR/SM LPAR will manage the processing weights to within 1% of the LP's physical CP share.
- This was true in 1988 with the first PR/SM implementation on the 3090 machines
- WLM, knowing that PR/SM may be -3.6% compensates by doing the calculations for soft capping so that the 4HRA stabilizes at the Defined Capacity MSUs +3.6%
- With this Understanding
  - If you set the Defined Capacity at last month's SCRT level you're telling z/OS not to grow, but you may grow by + 3.6% while not paying for the 3.6%

# Review

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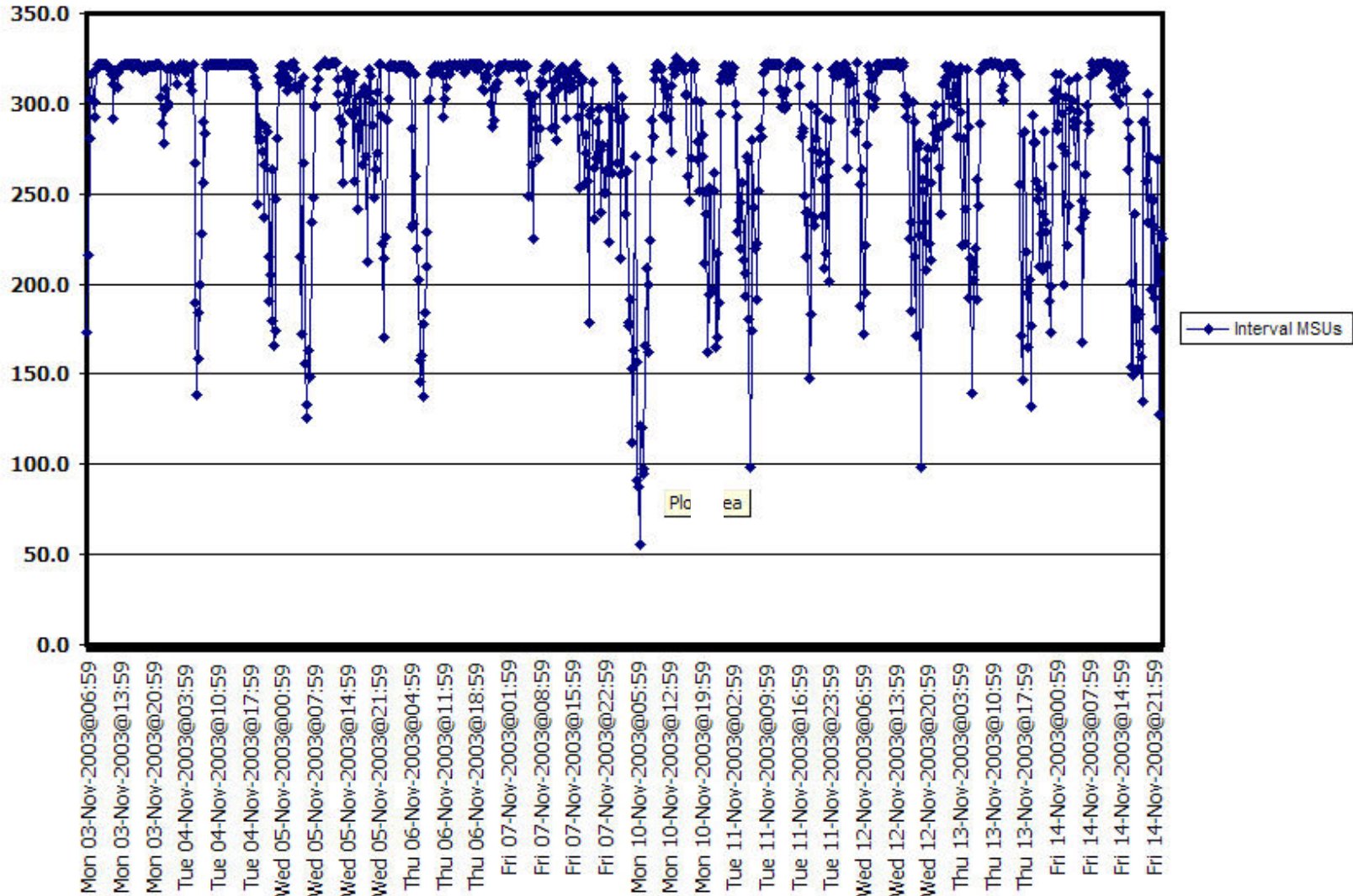
- Weight in MSUs > Defined Cap MSU
  - Phantom Weight Must be Used
- Weight in MSUs < Defined Cap MSU
  - Pulsing Is Used with z/OS V1 and pre-zEC12 GA2 Machines
  - Negative Phantom Weight with z/OS V2 and zEC12 GA2+
- Weight in MSUs = Defined Cap MSU
  - Enforcement

X I Expect No One Wants to Be Pulsing!! X

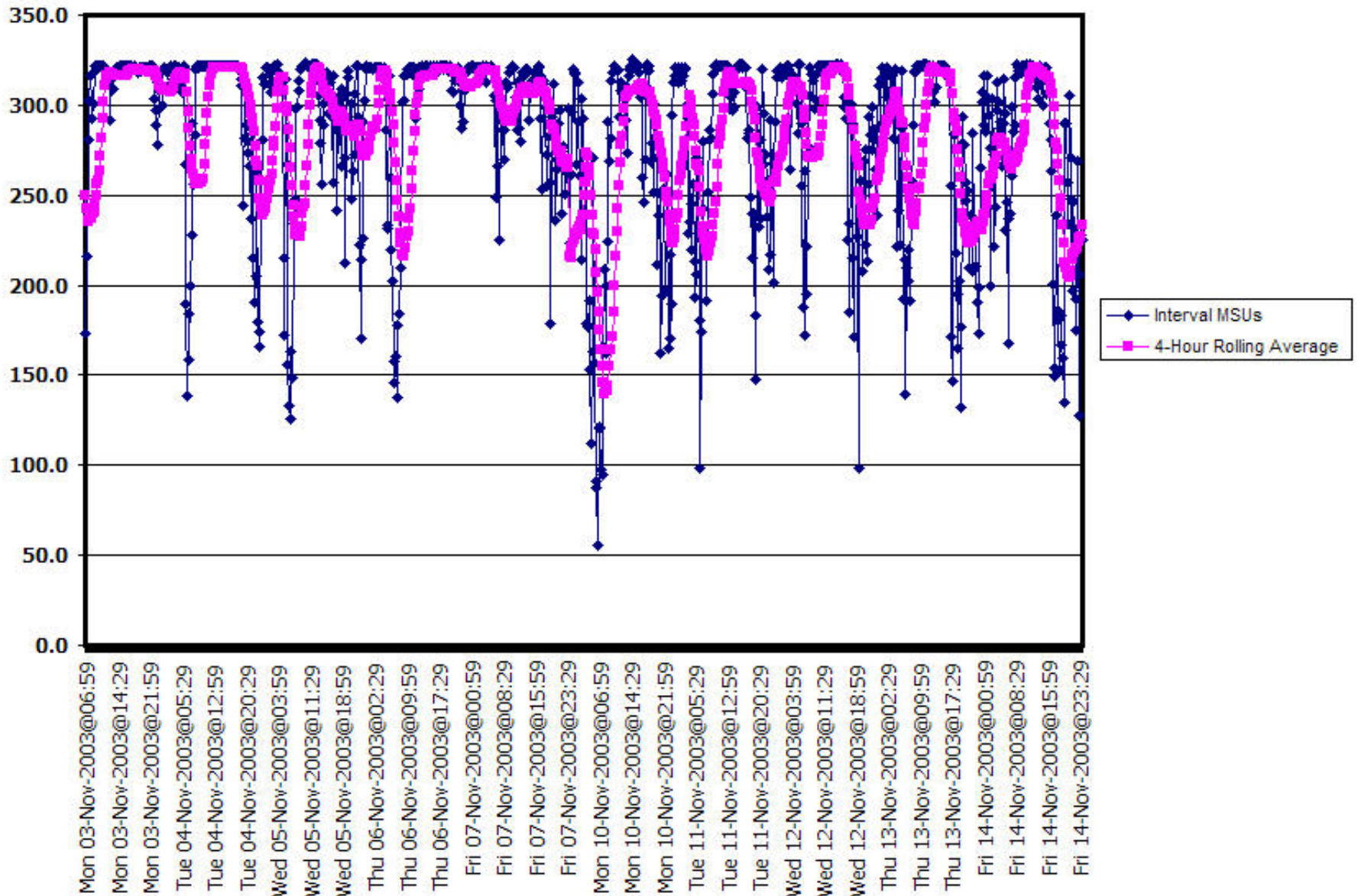
Pulsing is Fine, As Long As You NOW Understand!!

# Beginning Your Analysis

- What is Your 4 Hour Rolling Average Today?



# Add 4-Hour Rolling Average





# Potential for Savings

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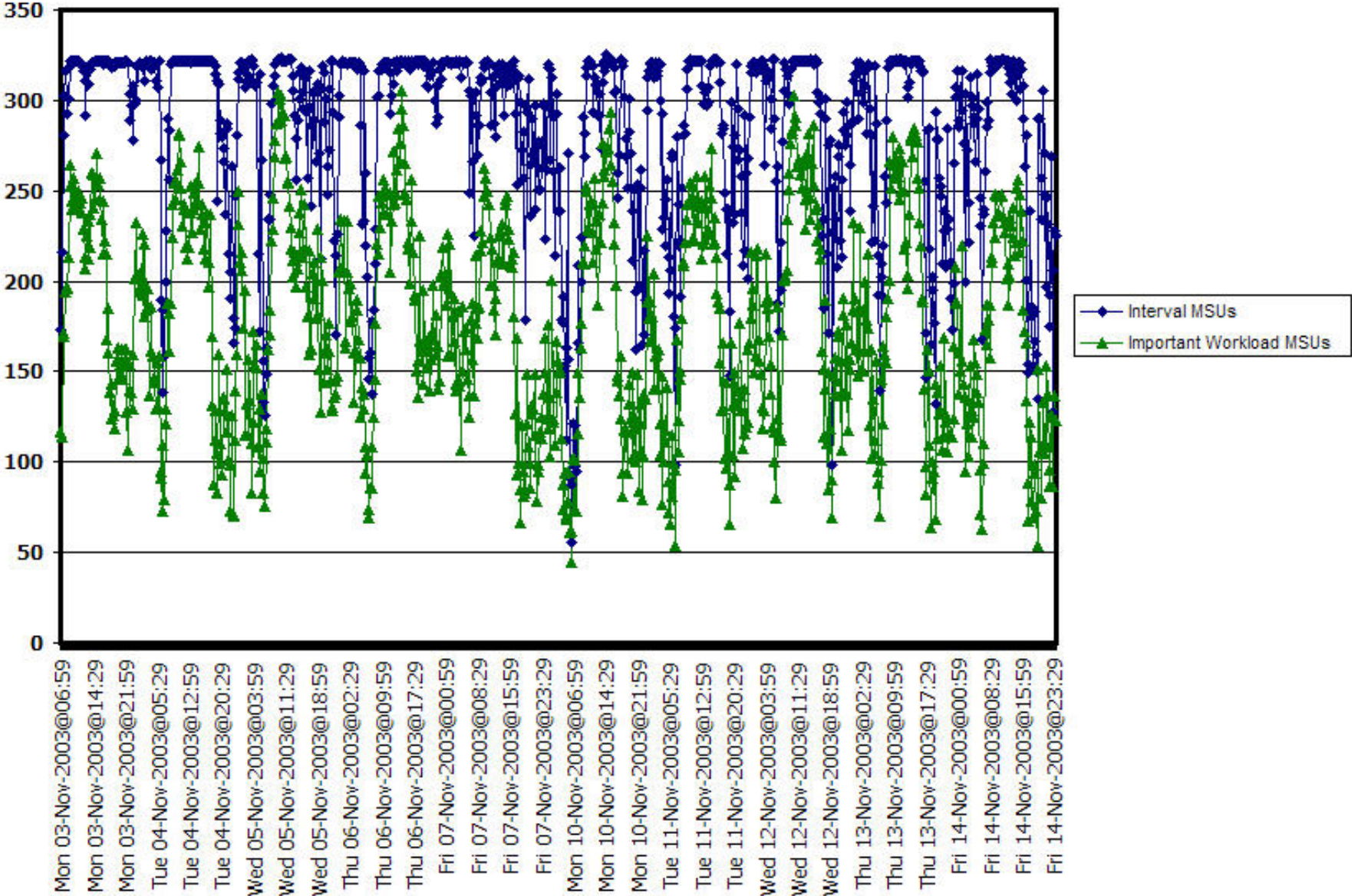
- Consider 1 or 2 MSUs
- Remember, The Soft Cap Limits the CPU During Intervals While the CAP is ON
- What Will Be Impacted?
- What Workloads Are Using Your Capacity?

# Soft Capping Causes CPU Shortage

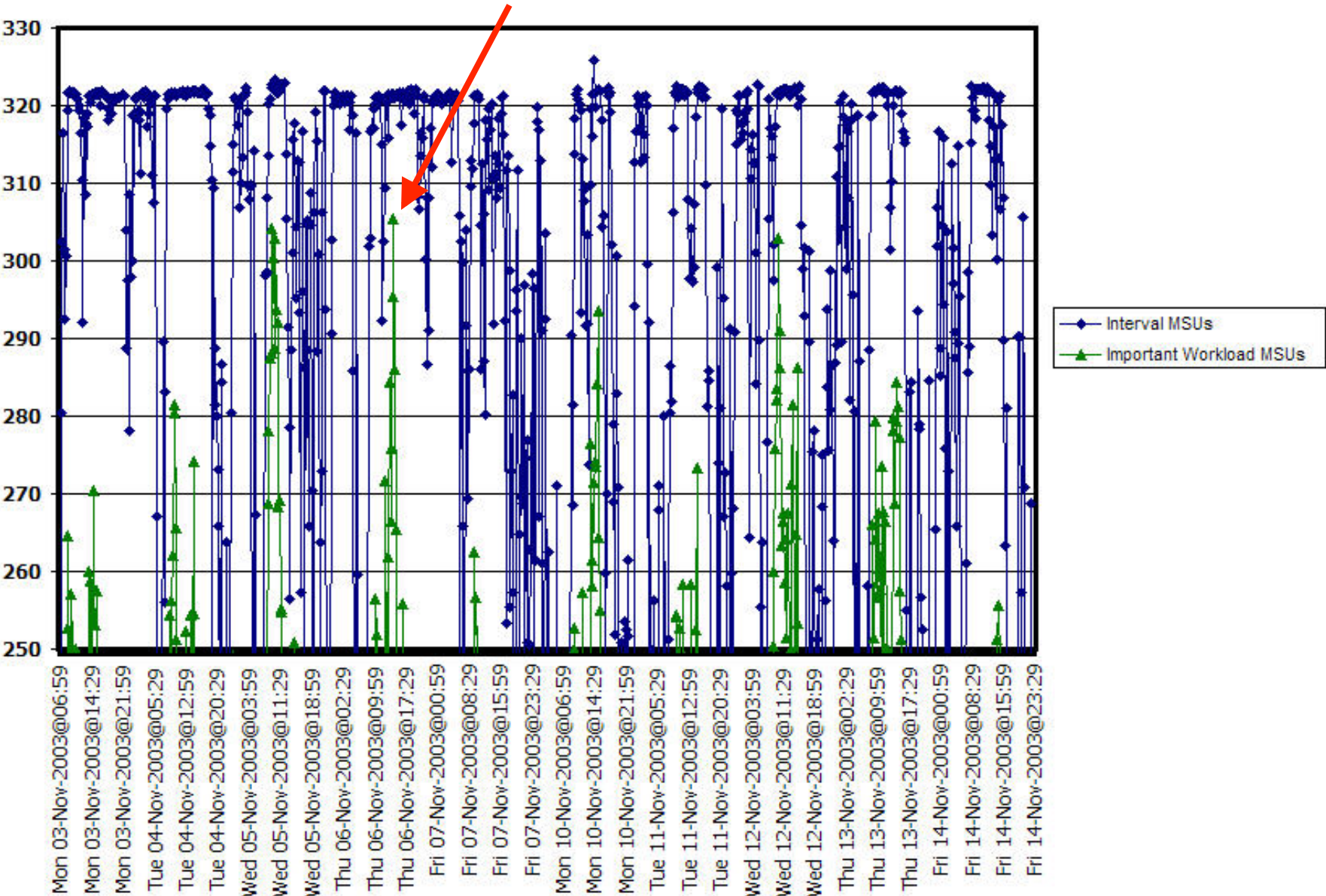
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- WLM Will Manage Workloads to Handle CPU Shortage
- Low Priority Work Will Suffer the Impact
- What is Your Low Priority Work?
  - Each Site Tells WLM of Priority With “Workload Importance”
  - WLM Uses Importance for Guidance in Determining Which Goals are More Important Than Other Goals
    - 1 Highest Importance To Your Business
    - 2
    - 3 Medium Importance
    - 4
    - 5 Lowest Importance
    - Discretionary Goals Assigned in WLM are Considered Less Important than Importance Level 5

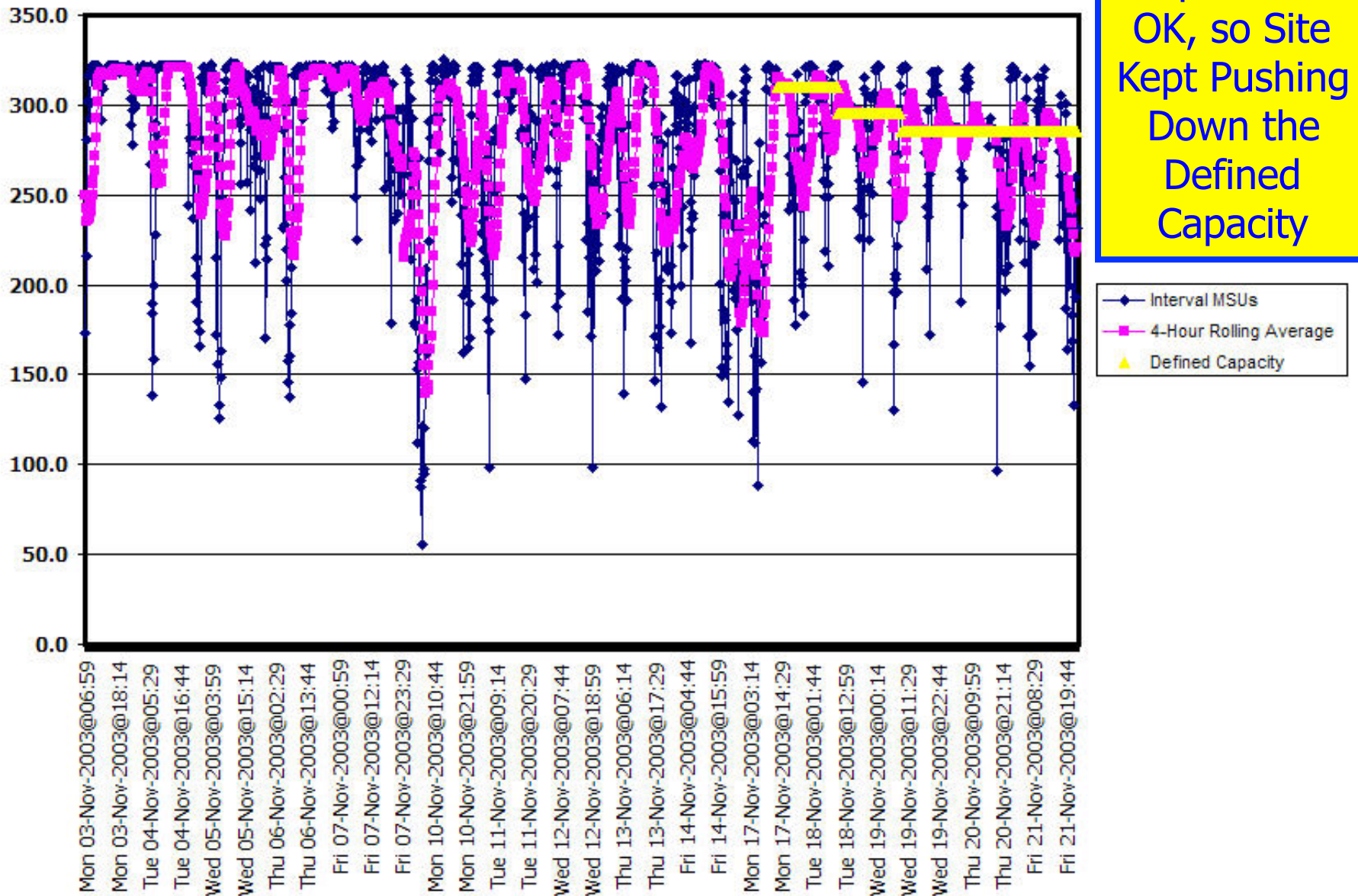
# Add Important Workloads to the Chart



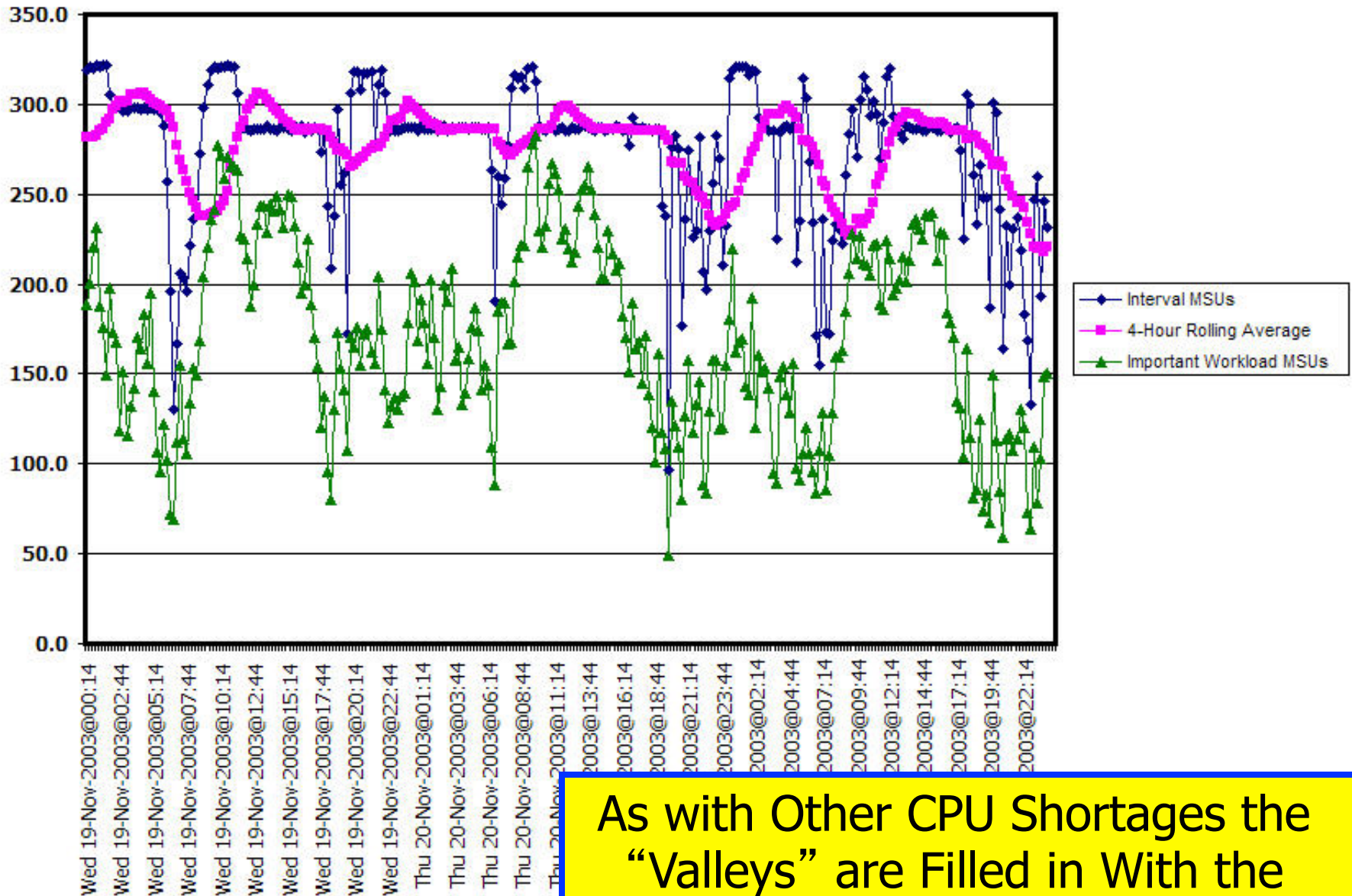
# Zoom In Only Over 250 MSUs



# Initial Caps at 310, 295, 285 MSUs



# 3 Day Zoom In



As with Other CPU Shortages the “Valleys” are Filled in With the “Low Importance” Workloads

## Bonus (FREE) SW MSUs

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- Often, Very Often, the Intervals MSUs Are Above the Defined Capacity While an LPAR is Capped
- The 4-Hour Rolling Average Often “Stabilizes” Above the Defined Capacity While an LPAR is Capped
- If This Happens in Your Environment
  - You Can Use Defined Capacity to Lower Your Software Charges Without Any Impact on Your Workloads!

# Getting Started

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- Study The Data In Your Shop
- Initially, Learn How to Set, Change and Remove Defined Capacity on a Non-Important LPAR
  - This is Done at the Hardware Management Console
  - WLM Responds Within 60 seconds to a Change in Defined Capacity
- Agree on How to “Observe System Behavior” In Your Site!
  - Important Work Not Being Delayed
  - RMF III to Monitor Workload Delays or Your Tool of Choice
  - Remember an LPAR with a Soft Cap is “CPU Constrained”
  - SERVICE LEVELS



## Getting Started In Your Shop (cont.)

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- Set Defined Capacity to 1 MSU Below True Limit of Capacity and Observe System Behavior
  - You Probably Will Not See Any Difference
- Continue by Setting the Defined Capacity to 1 MSU Below Your Peak and Observe System Behavior
- Next Move Defined Capacity to 2-3% Below Your Peak and Observe System Behavior
- Push It Down
  - Push It Down
    - Push It Down
      - Push It Down
        - » Push It Down

## Continue Saving \$\$, or Your Currency of Choice!

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- Push It Down! Every MSU Saves Software Charges
- Too Low? Simple Hardware Management Console Command to Increase Defined Capacity
  - Remember You Were Supposed to Practice Back on Page 27!
  - Note: Increasing the Defined Capacity is Most Likely Increasing Your Software Charges! You Are Adjusting the Throttle Upwards
    - IBM Billing Months Run from the 2<sup>nd</sup> to the 1<sup>st</sup>
      - That is, November 2 to December 1
    - Lower Defined Capacity Before the 2<sup>nd</sup> to Start the Next Month with the new Limit
  - Who In Your Organization Can Authorize This Change?
- What is Impacted?
  - WLM's Low Priority Work

# Summary for Defined Capacity

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- **I Propose:**
  - You Can Use Defined Capacity To Limit Some or All of Your LPARs and Lower Software Cost
  - Defined Capacity Exposes You to Soft Capping
  - The More Dynamic Your Environment, the More Exposure to Soft Cap
- **When Soft Capped What is Being Impacted?**

**WLM Controls Who Suffers  
the CPU Resource Impact**

**Who Controls WLM?**

# Defined Capacity Opportunities

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- Lowering the Defined Capacity is Lowering the Limit on the MSUs that an LPAR can Contribute to the Simultaneous 4-hour Rolling Average
- Three Key Questions
  - What Should the new Defined Capacity be?
  - What will the Impact be?
  - How Much Will be Saved?

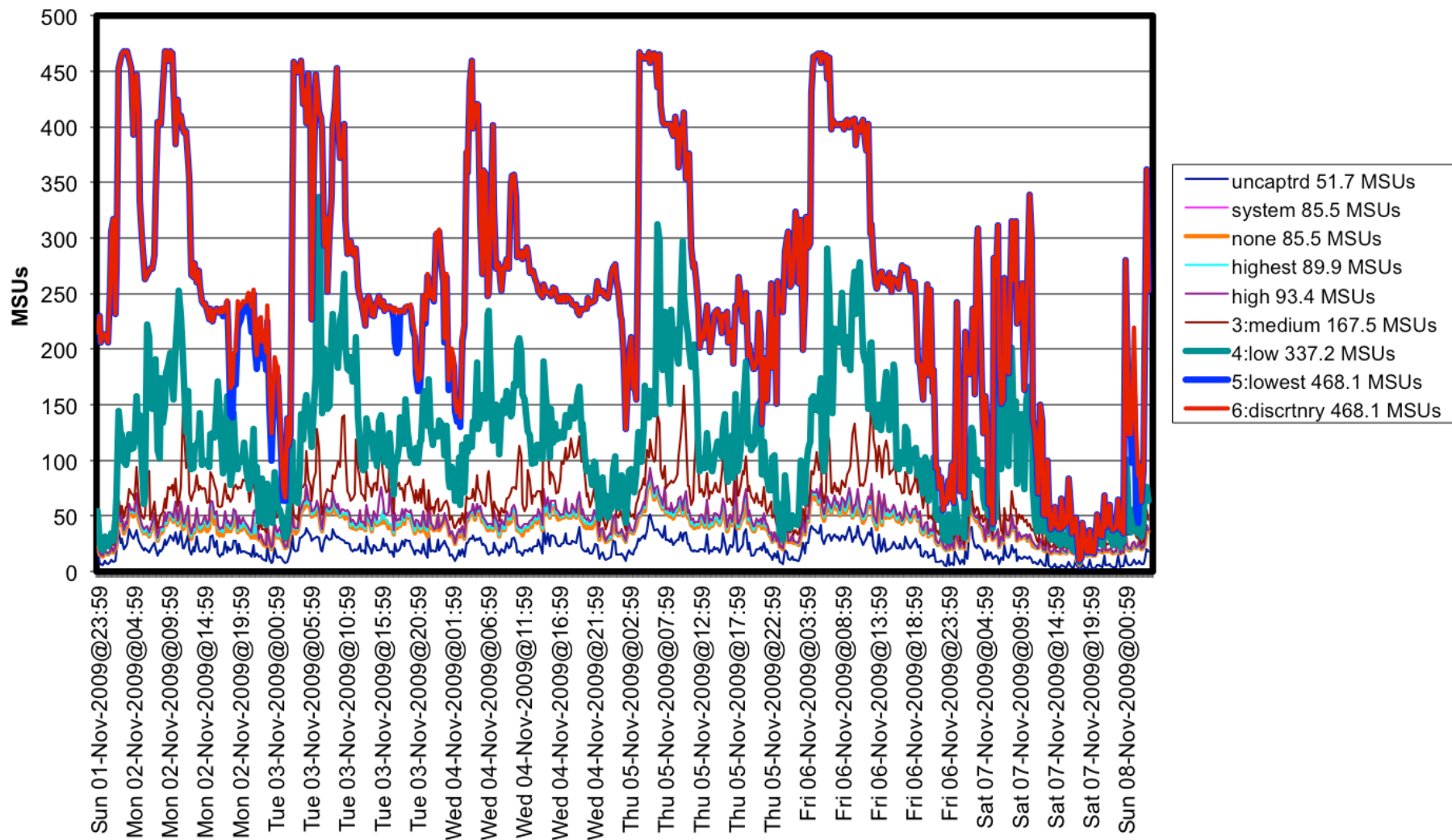
# The Impact — Expendable MSUs

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----- LCS Interval Analysis -----
                                     |-- MSUs in This Interval -
Beginning      Intervl   Limit Amt Ovr Intvls |
of the Interval  4HRA   on LPAR   Limit Capped |
-----|-----|-----|-----|-----|
01MAR2006:12:29    840     840     59 Capped |      862      216.2
01MAR2006:12:14    840     840     58 Capped |      862      183.1
01MAR2006:12:44    840     840     53 Capped |      860      193.1
01MAR2006:11:59    840     840     52 Capped |      862      216.3
01MAR2006:12:59    840     840     48 Capped |      862      354.5
01MAR2006:13:14    840     840     43 Capped |      862      206.5
01MAR2006:11:44    840     840     42 Capped |      862      193.1
01MAR2006:13:29    840     840     37 Capped |      862      261.6
01MAR2006:11:29    840     840     33 Capped |      862      245.5
01MAR2006:13:44    840     840     33 Capped |      862      234.0
01MAR2006:11:14    840     840     31 Capped |      862      241.2
27FEB2006:14:44    840     840     28 Capped |      844      262.0
  
```

- Extreme Example, I've Also Seen Reports With Zero Expendable MSUs
- You Can Find the Interval With Max Non-Expendable MSUs

# Find the Expendable Limit on Your Data



# The Impact — Expendable MSUs

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SCRT1C: Top 25 Four-Hour Rolling Averages by LPAR

Machine Identifier 2094#0XXX, Reporting Period is 02FEB2006

Sysplex and System: PRDPLEX\_LCSD and for MVS SYSNAME: LCSD and LPAR: LCSD

Based on Pricing Analysis of 21MAR2007:23:03 the Charge Per MSU is:  
171.00USD

The Maximum MSUs That This LPAR Can Contribute to the Simultaneous 4HRA:	840 MSUs
Hourly Bonus MSUs That Will Not Appear On Your Bill Due to Soft Capping:	55 MSUs
The True Maximum 4HRA Based on Intervals:	899 MSUs
Interval Bonus MSUs That Will Not Appear On Your Bill Due to Soft Capping:	4 MSUs
Maximum MSUs Used in Any Interval by Non-Expendable Workloads:	749 MSUs
Maximum MSUs Used in Any Interval by All Workloads:	878 MSUs

\*\*NOTE: 91 Expendable MSUs Are Included in Your Billable MSUs.

\*\*NOTE: This is a Defined Capacity Opportunity!

\*\*NOTE: The Defined Capacity Could Be 749 MSUs Without Impacting Important Work.

\*\*NOTE: The Potential Savings is: 15,498.80USD Per Month

# Users Want Group Capacity

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- Earliest Request, Even Before WLC Was Officially Announced

“How Do I Limit A Machine’s Charges to 85% of Capacity?”



# Definition of Group Capacity Limits

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- **Group Limit and Group Name Are Input Values on the HMC**
  - Multiple Groups Can Be On A Machine
  - Group Limit Is Entered in “Software” MSUs
- **Next LPARs Can Be Added to the Groups**
  - An LPAR May Only Be A Member of One Group At A Time
  - Defined Capacity Does Not Change
    - An LPAR May Have Either or Both
- **Capacity Groups Are Independent of MVS SYSPLEXes and LPAR Clusters**

# Benefits of Group Capacity Limits

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- **Better sharing of CPU resources**
  - LPARs with greater CPU demand may have access to it with GCL that would have been prevented with individual LPAR Defined Capacities
  - If you have two LPARs you want to limit to 100 MSUs each
    - You need defined capacity=100 for both
    - OR a GCL with a limit of 200 for the group
      - The GCL is much more flexible!
  
- **A new level of Granularity for managing and monitoring the capping function**
  - You may be able to eliminate some LPARs' defined capacities

# How It Works: MSUs Group Limit

- Each LPAR Manages Itself
- It “knows” of the Other LPARs, and Their Group Parameters

CEC MSU	MSU Value	690								
LPAR	Group Name	Group Limit (MSUs)	Initial LPAR Weight	Managed by IRD	Current LPAR Weight	LPAR Defined Capacity (MSUs)	Normalization of Weights	MSUs Based on LPAR Weight	Percent of Group Capacity Based on Weight	Target Consumption of Group Based on Weight (MSUs)
TEST2T	GROUP1	660	48	N		none	4.7%	32.5	4.7%	31.1
TEST2W	GROUP1		60	N		none	5.9%	40.6	5.9%	38.8
PRODA	GROUP1		355	Y	373	none	36.6%	252.3	36.6%	241.4
PRODT	GROUP1		55	Y	37	40	3.6%	25.0	3.6%	23.9
PRODW	GROUP1		482	Y	482	none	47.3%	326.1	47.3%	311.9
PRODW	none	n/a	20	N		none	2.0%	13.5		n/a

- Available to Each LPAR is the Unused Group Capacity
  - With This Information Each LPAR Knows When to Initiate a Group Cap in Its Own LPAR

# SCRT and Group Capacity Limit

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- The Sum of the 4 Hour Rolling Averages of the LPAR in a Capacity Group May Exceed the Group Limit
- This is the Same as an Individual LPAR's 4HRA Exceeding the Defined Capacity
- When this Happens SCRT Uses the Group Limit Rather than the Individual LPAR's Contributions to the Simultaneous 4 Hour Rolling

# Where to Set the Caps: Top 25 Simultaneous 4HRAs

TOP25CEC: LPAR Components of Top 25 Simultaneous 4HRAs

					LPARName, Sysplex, System and Sysname				LPAR Capacity Groups
					TST1	PRDD	PRDM	PRDS	
					TSTPLEX	PPLEX	PPLEX	PPLEX	
Date Hr	Billable 4HRA MSUs	Expndabl MSUs in Hour	Savings Due To Groups	MSUs Without Groups	TST1	PRDD	PRDM	PRDS	GROUPCP
05OCT:12	1,355	125	159	1,514	5	GROUPCP	GROUPCP	GROUPCP	1,350
						1,054G	418G	37G	<-- MSUs While Group Capped
					0	101	23	1	<-- Expendable MSUs in LPAR
05OCT:15	1,355	60	24	1,379	5	GROUPCP	GROUPCP	GROUPCP	1,350
						1,001*	305*	68*	<-- MSUs While Group Capped
					0	45	15	0	<-- Expendable MSUs in LPAR
19OCT:23	1,355	25	20	1,375	5	GROUPCP	GROUPCP	GROUPCP	1,350
						735*	556*	79*	<-- MSUs While Group Capped
					0	20	5	0	<-- Expendable MSUs in LPAR

- Expendable work is running during the peak periods
- The Group Cap could be lower...

– You’ ll quickly find out if WLM is setup properly!

## Upgrades and New Machines (Same Technology)

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- If You Want 15 MSUs Can You Buy 15 MSUs?
- Upgrades Are Not In the Increments We Need Them to Be!
- Recommendation for Same Technology:
  - Keep the Defined Capacity and Group Capacity Limits the Same on the New Machine as the Old Machine
  - The Spikes in Utilization Can Be Higher Due to Increased Capacity You've Acquired BUT Why Should You Pay for That?

# Upgrades and New Machines

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- **You Did the Upgrade Because the Capacity Was Needed**
  - Raise the Defined Capacity Slowly Based on “Observed System Behavior”
- **Leverage the Price/Performance of New Hardware**
  - Reduce the MSU Limits. While current machines do not have the same 10% MSU change of the earlier “Technology Benefit” the hardware is significantly different and your workloads will likely perform better on the newer technology.
    - *Certainly not a guarantee, but let’s assume this is true*
  - So lower the MSUs by 2% or 3% and monitor how the work performs. You can always raise the limits dynamically.
  - *If You Do Not Reduce the MSU Limits, You May Give Up the Benefit of the new Technology*

**Increase MSU Limits Based on  
Required Service Levels**

## Other Issues

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- If you're adjusting DCs or GCL be certain to lower the controls being adjusted to lower values BEFORE you raise any controls
  - You want to avoid setting a new “high” value because you were changing these controls
  - True even when changing controls on different machines
- If you're adding zXXP engines reduce the caps by the amount you expect to move from the LPARs to the zXXP engines



# Automated Capping Adjustment Tools

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- Defined Capacity and GCL work on single machines
- There are some scenarios for work that could run in different LPARs on different machines
  
- The automated tools could lower limits on one machine and raise them on another while still controlling total MSUs
  
- Complicated as today each machine goes through SCRT separately
  - Country Multiplex Pricing will find the Simultaneous 4HRA Across ALL Machines in a “country”
    - An interesting new twist
    - Come to the next Share for more information on Country Multiplex Pricing (if my presentation is accepted)

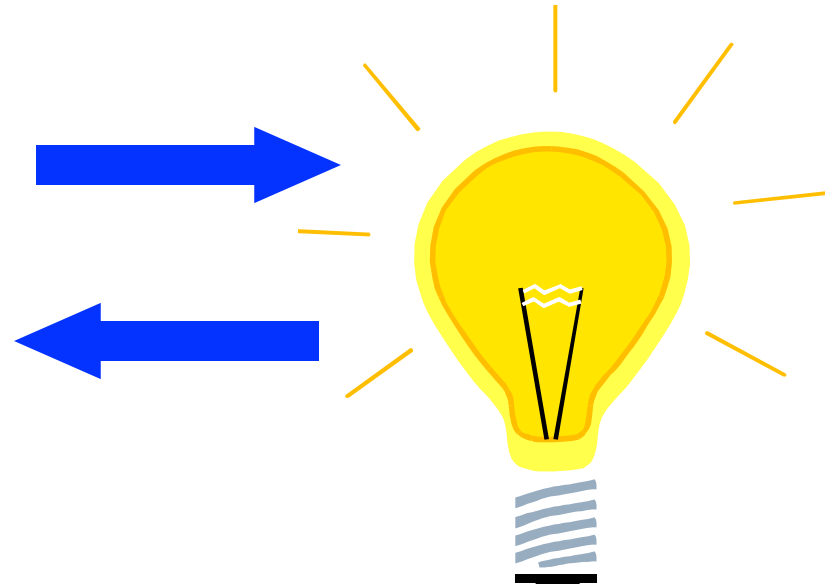
# The Big Change: Are We Managing the Right Metric?

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- Defined Capacity and GCL control the 4HRA of an LPAR or group of LPARs
- Remember the 5 sizes...
  - For CICS and IMS Integrated Workload Pricing provides a new smaller size
  - Some WebSphere Brand products are sized by Getting Started Sub-Capacity Prices
  - Mobile Workload Pricing makes LPARs smaller by 60% of the Mobile CPU
  - Collocated Application Pricing (zCAP) removes new Applications/products in an LPAR from the 4HRA of other products
    - And 50% of the zCAP MSUs are removed from z/OS
  - Country Multiplex Used the Max Simultaneous 4HRA across ALL the machines in the geography
    - So the Max 4HRA on a machine is even less important. One machine can be very high, but others that are low at the same time offset that
- So we have 10 sizes; let that sink in...
- Capping LPARs, and deferring work are different now
- **Are you deferring work when it does not matter and does not lower your \$s?**

# Discussion, Questions?

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Al Sherkow  
I/S Management Strategies, Ltd.

[al@sherkow.com](mailto:al@sherkow.com)

+1 414 332-3062