IBM Americas, ATS, Washington Systems Center

Crypto Performance Update

Share 13430
Boston, MA August, 2013

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ON DEMAND BUSINESS™

Agenda

- **Crypto Refresher**
  - Crypto Functions
  - Clear Key vs Secure Key vs Protected Key
  - Crypto Hardware
- **Crypto Performance – Raw numbers**
- **Operational 'Things'**
- **Available metrics**

Crypto Functions

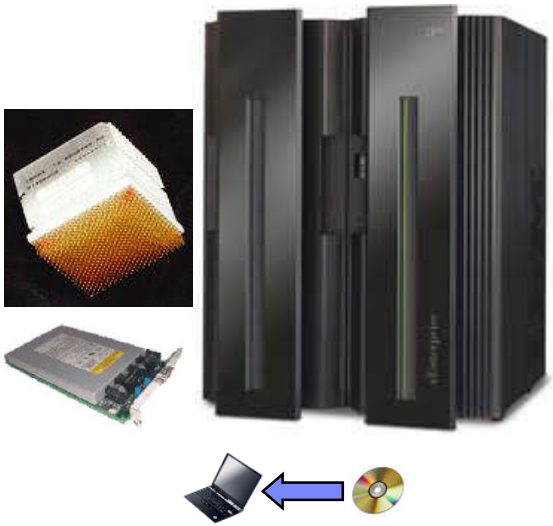
- **Data Confidentiality**
  - Symmetric – DES/TDES, AES
  - Asymmetric – RSA, Diffie-Hellman, ECC
- **Data Integrity**
  - Modification Detection
  - Message Authentication
  - Non-repudiation
- **Financial Functions**
- **Key Security & Integrity**

Clear Key / Secure Key / Protected Key

- **Clear Key – key <u>may</u> be in the clear, at least briefly, somewhere in the environment**
- **Secure Key – key value does not exist in the clear outside of the HSM (secure, tamper-resistant boundary of the card)**
- **Protected Key – key value does not exist outside of physical hardware, although the hardware may not be tamper-resistant**

System z Clear Key Crypto Hardware – zEC12, zBC12, z196/z114

- **CP Assist for Crypto Function (CPACF)**
  - **DES (56-, 112-, 168-bit), new chaining options**
  - **AES-128, AES-192, AES-256, new chaining options**
  - **SHA-1, SHA-256, SHA-512 (SHA-2)**
  - **PRNG**
  - **Protected Key**



TechDoc WP100810 – A Synopsis of System z Crypto Hardware

System z Secure Key Crypto Hardware – CEX4S, CEX3/CEX3-1P

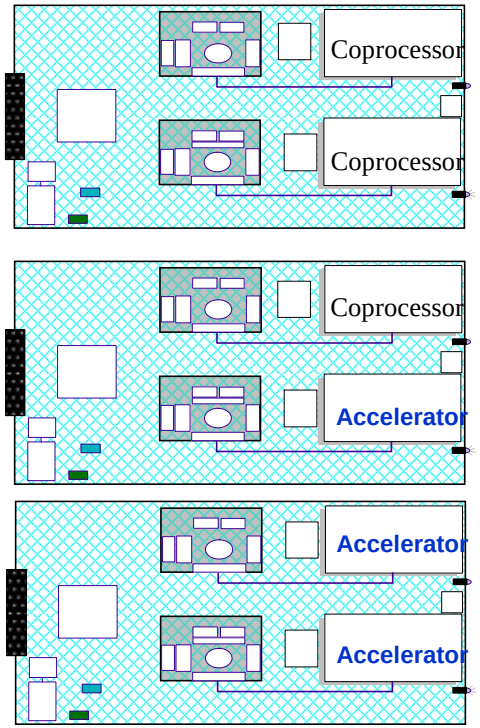
- **Secure Key DES/TDES**
- **Secure Key AES**
- **Financial (PIN) Functions**
- **Random Number Generate and Generate Long**
- **Key Generate/Key Management**
- **SSL Handshakes, ECDSA support**
- **Protected Key Support**
- **PKCS #11 (CEX4S only)**

TechDoc WP100810 – A Synopsis of System z Crypto Hardware

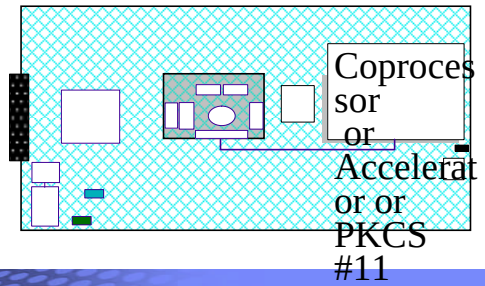
PCI Cards

- **Secure Coprocessor** (default)
  - Requires master key be loaded
  - Data confidentiality
  - Data integrity
  - Financial functions
  - Key generation/manipulation
  - RSA public key operations
- **Accelerator**
  - RSA public key operations
- **Enterprise PKCS #11**
  - PKCS #11 secure key

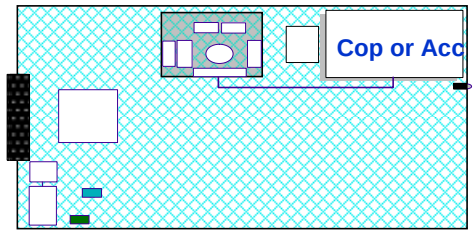
CEX3



CEX4S



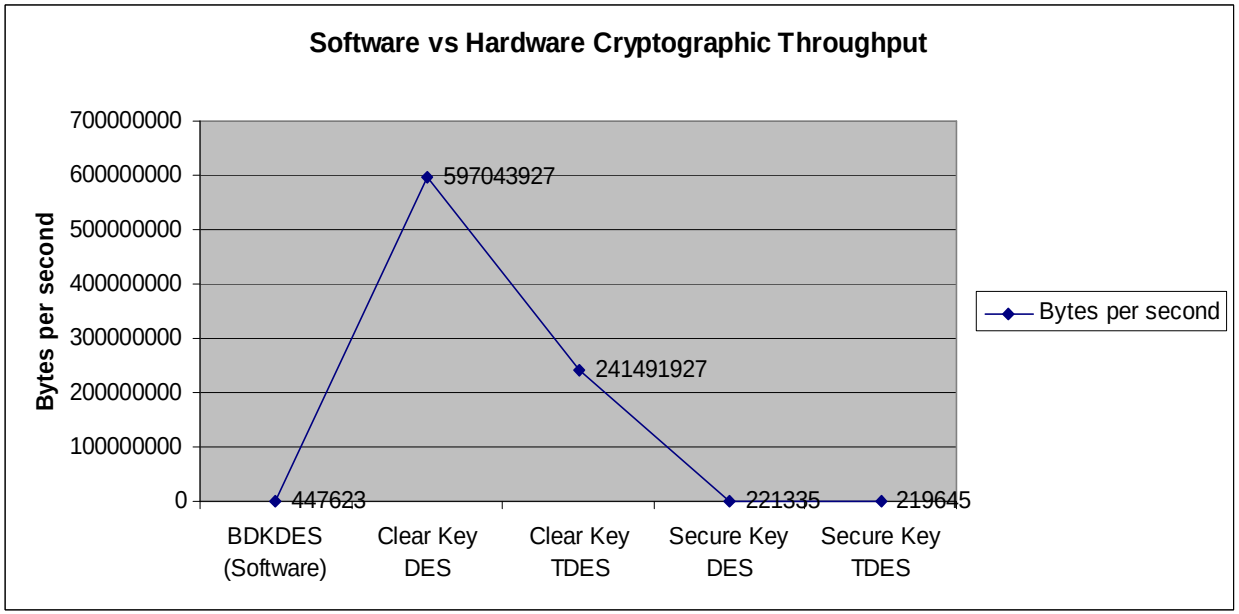
CEX3-1P

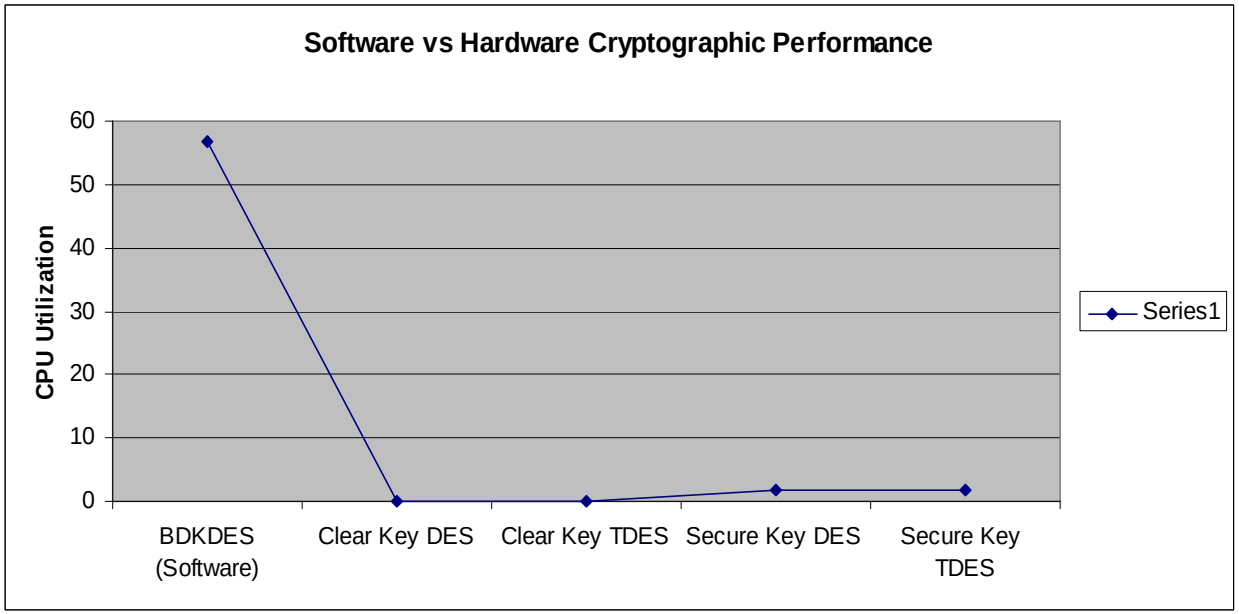


Software vs Hardware Encryption

	Bytes/Sec	CPU Time
BDKDES (Software)	447623	56.82
Clear Key DES	597043927	0.04
Clear Key TDES	241491927	0.09
Secure Key DES	221335	1.66
Secure Key TDES	219645	1.67

- **From Ernie Nachtigall's TechDoc, WP101240 'IBM z10 DES Cryptographic Performance' available at http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP101240**

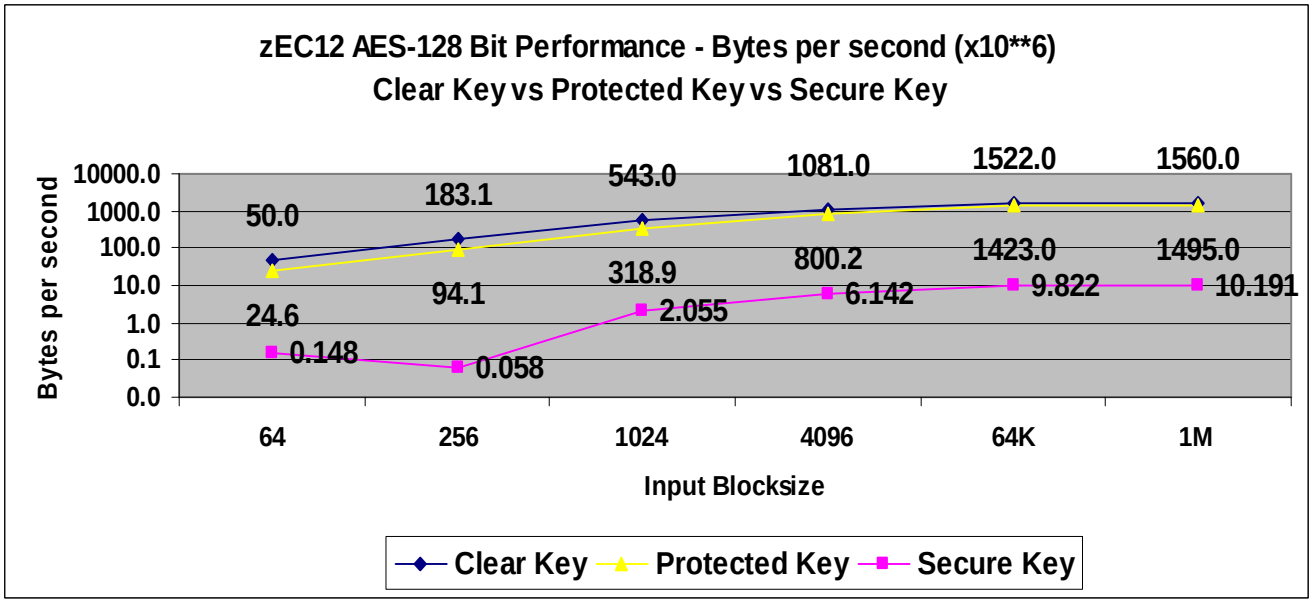


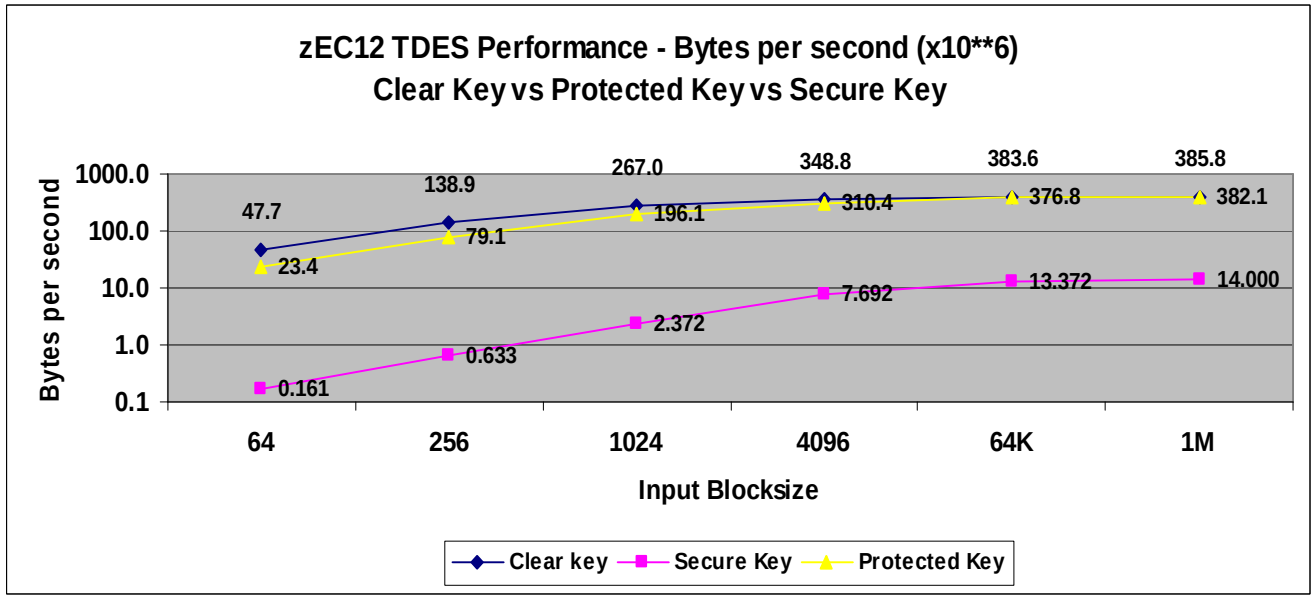


zEC12 Symmetric Key Performance

- **From the Crypto Performance whitepaper at**

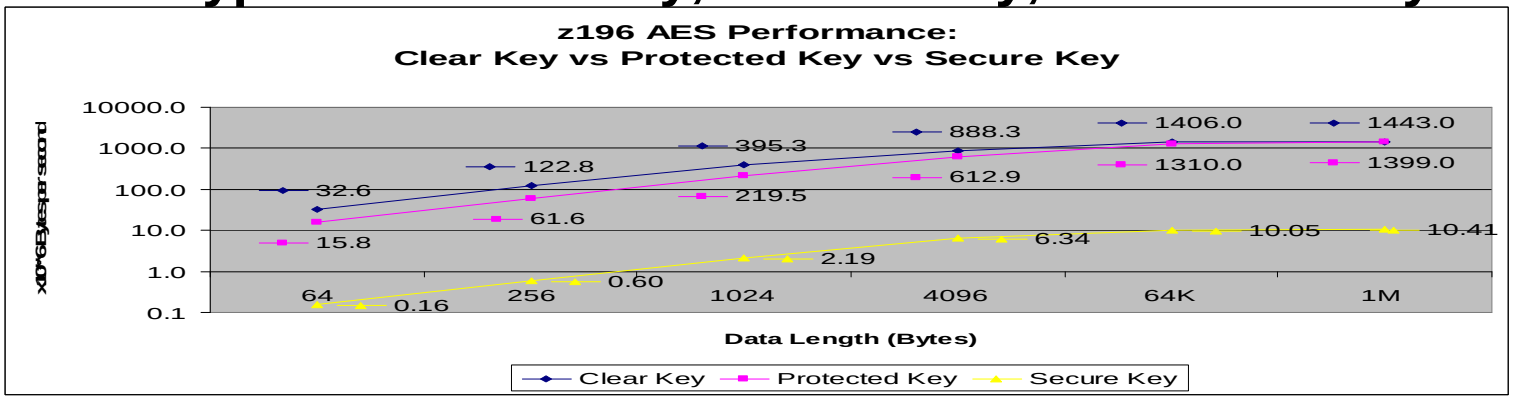
http://www.ibm.com/systems/z/advantages/security/zec12cryptography.html



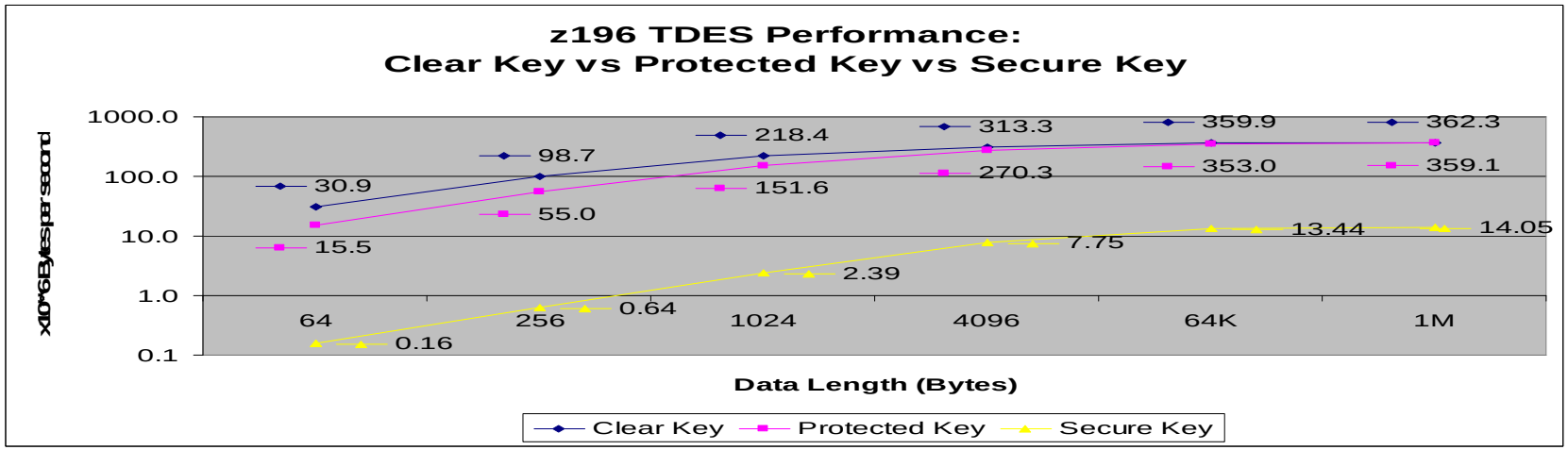


z196 Crypto Performance

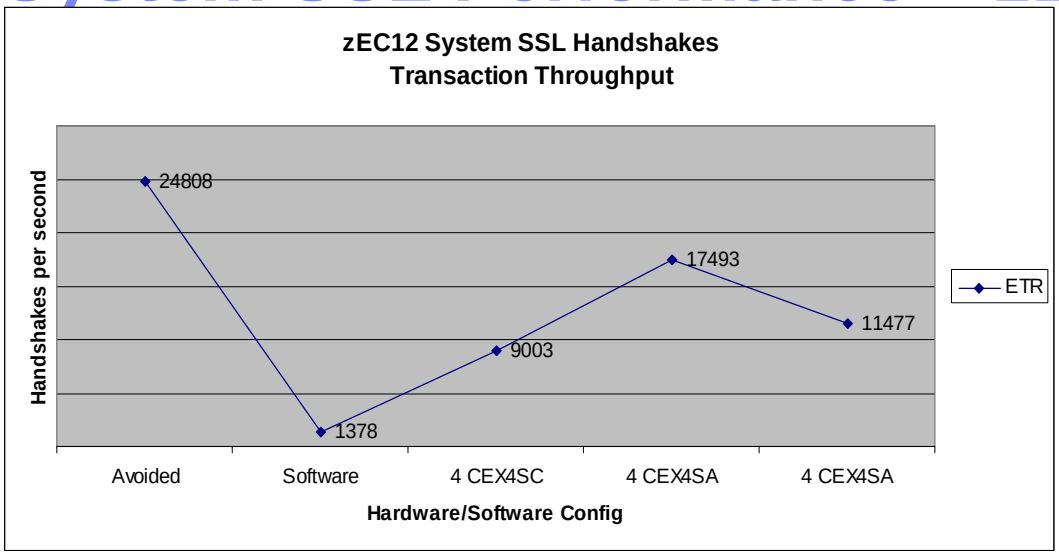
- **AES Encryption – Clear Key, Secure Key, Protected Key**



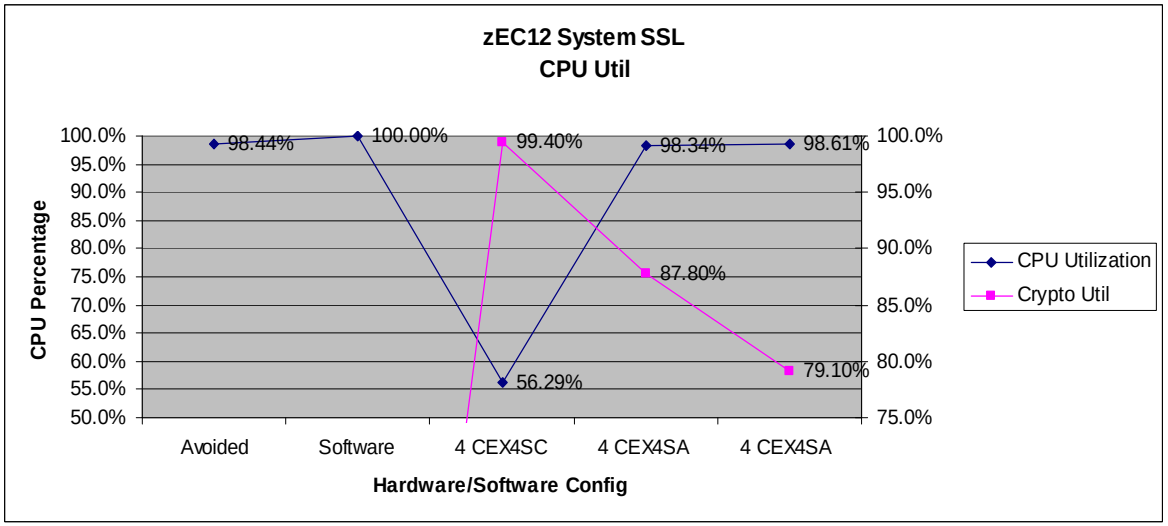
- **TDES Encryption – Clear Key, Secure Key, Protected Key**



System SSL Performance – zEC12

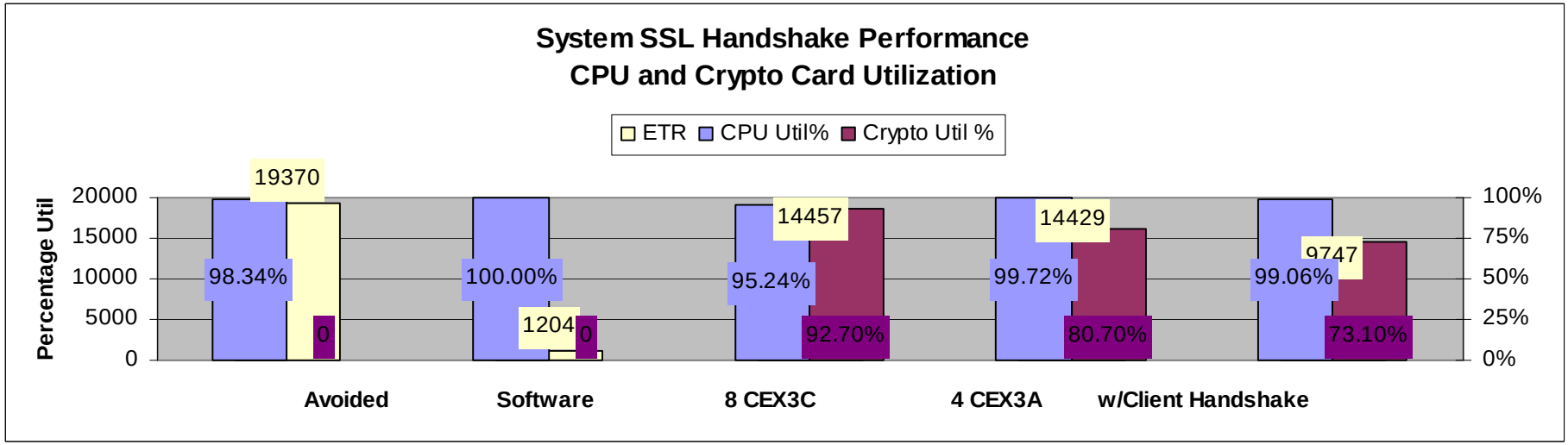


Caching SID/Client Authentication	Handshake	ETR	CPU Util%	Crypto Util %
100%/No	Avoided	24808	98.44%	NA
No/No	Software	1378	100.00%	NA
No/No	4 CEX4SC	9003	56.29%	99.40%
No/No	4 CEX4SA	17493	98.34%	87.80%
No/Yes	4 CEX4SA	11477	98.61%	79.10%



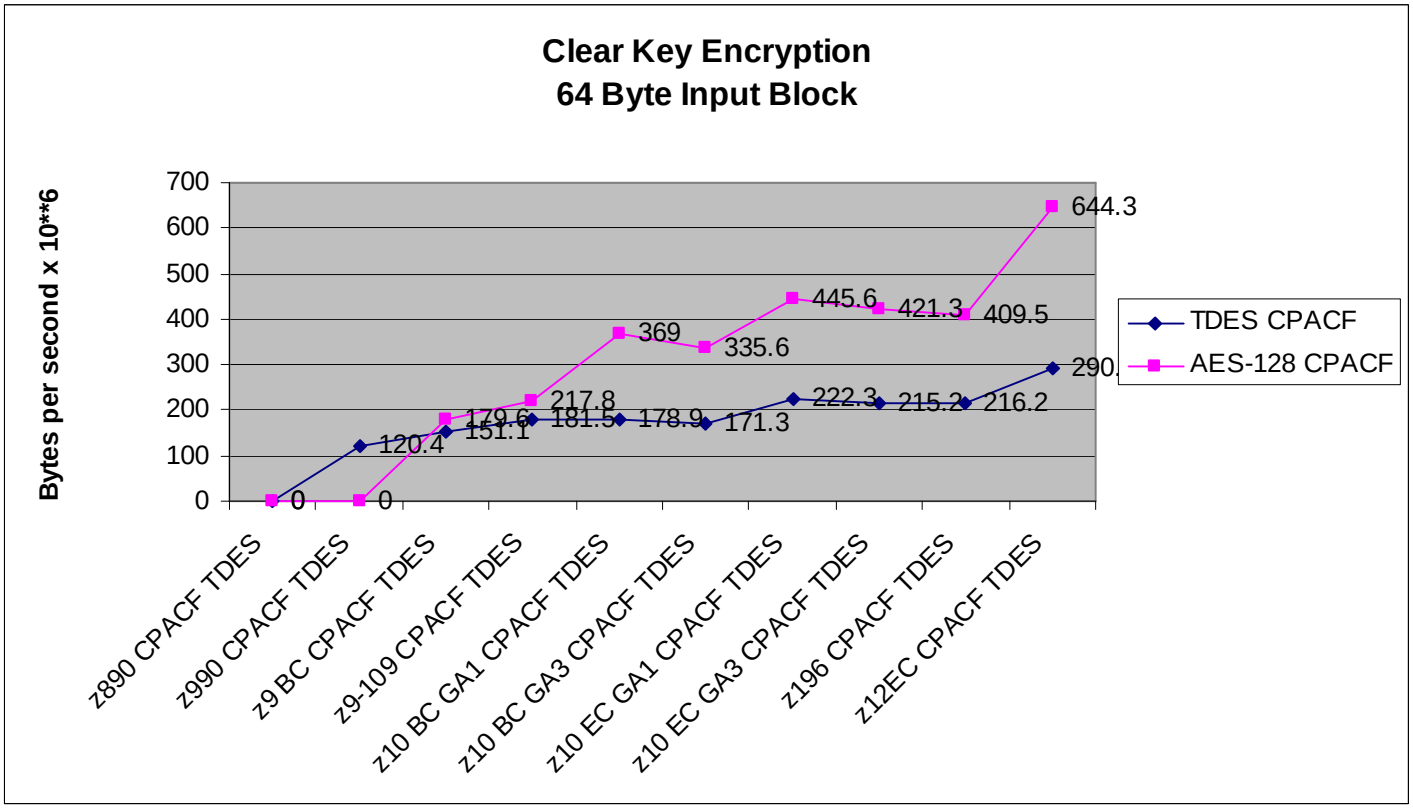
zEC12 HA1 – 4 CPs

System SSL Performance – z196

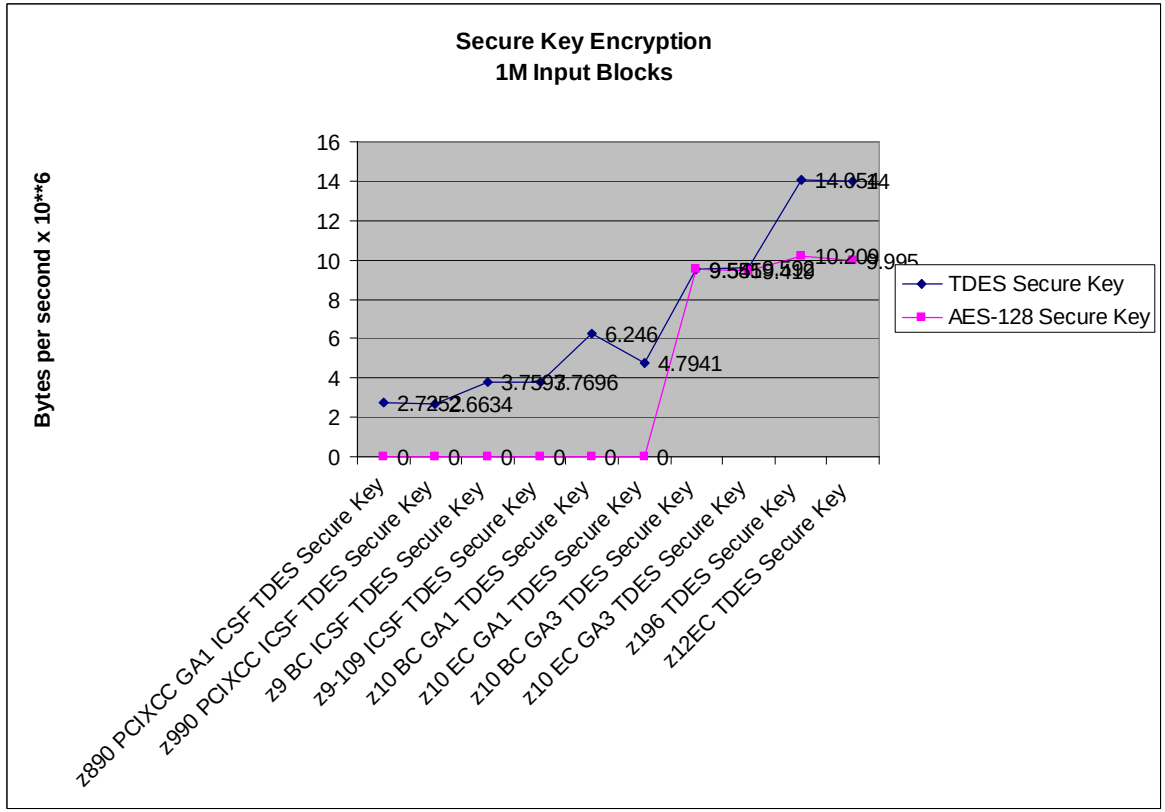


Caching SID	Handshake	ETR	CPU Util%	Crypto Util %
100%	Avoided	19370	98.34%	NA
No	Software	1204	100.00%	NA
No	8 CEX3C	14457	95.24%	92.70%
No	4CEX3A	14429	99.72%	80.70%
No	4 CEX3A	9747	99.06%	73.10%

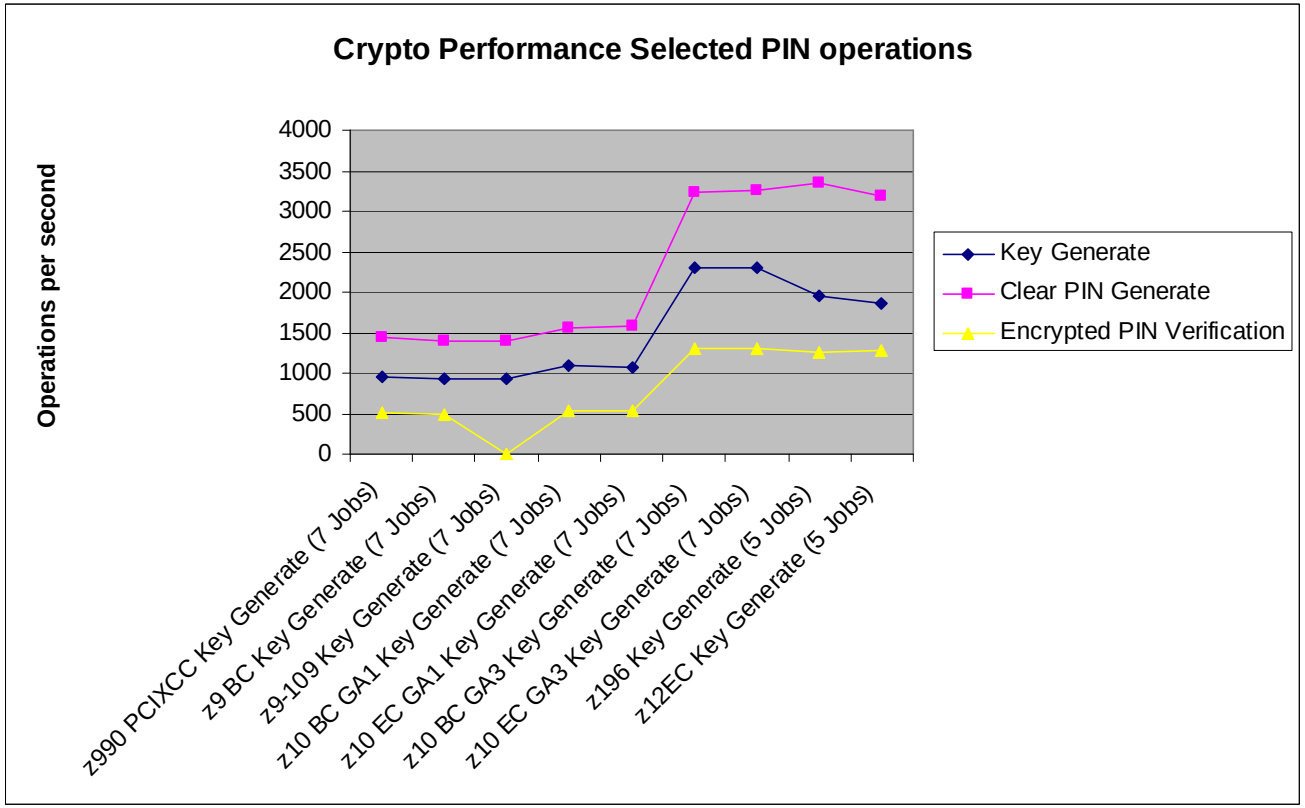
Crypto performance across CECs – Native Clear Key



Crypto performance across CECs – Secure Key



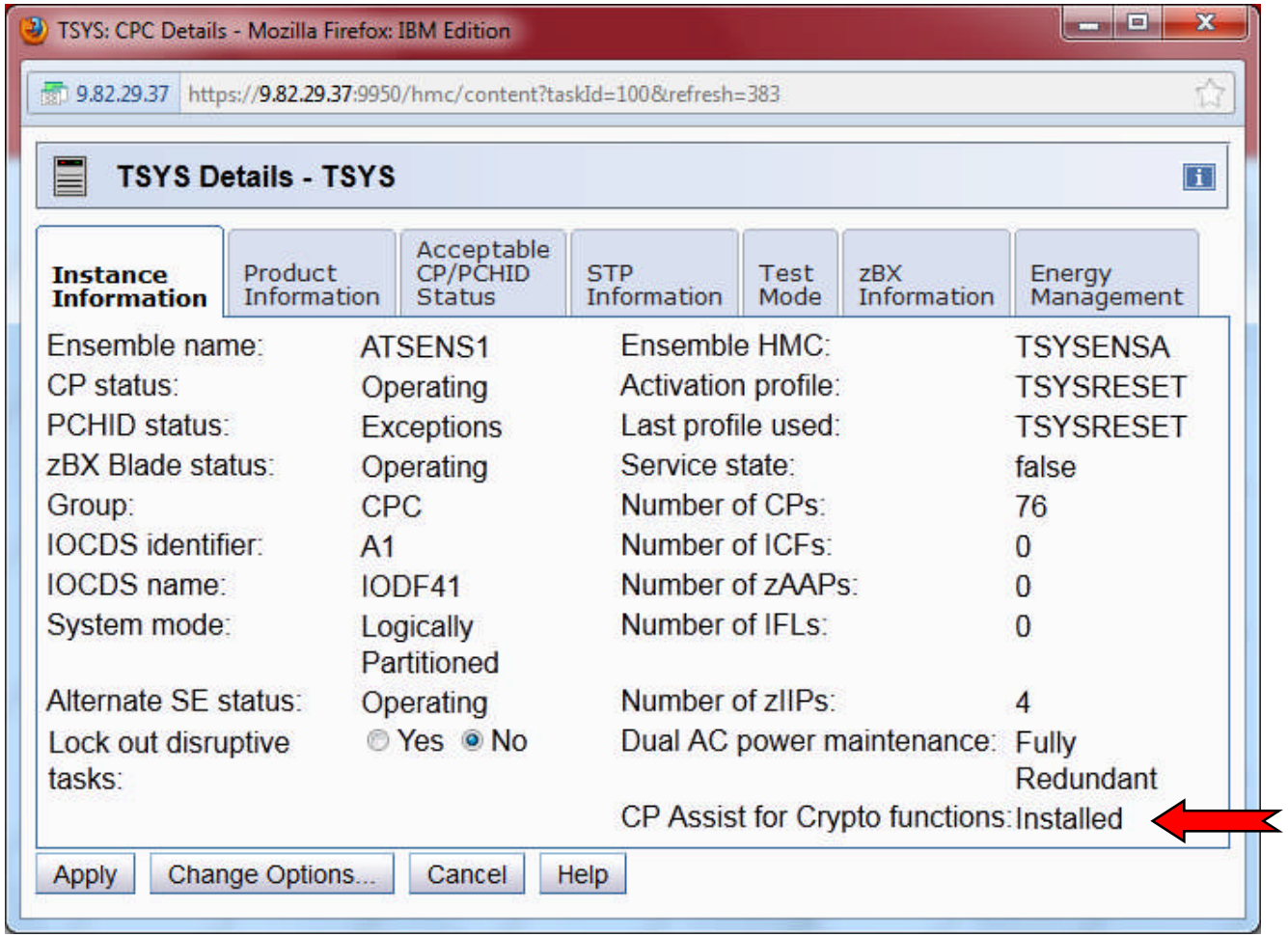
Crypto Performance across KEKs - PIN



ICSF Options - Performance Considerations

- **KEYAUTH(YES/NO) – check key integrity in memory**
- **CKTAUTH(YES/NO) – check key integrity on DASD**
- **CHECKAUTH(YES/NO) – skip SAF checks for Supervisor State or System Key callers**
- **SYSPLEXCKDS / SYSPLEXPKDS / SYSPLEXTKDS – enqueues and contention between systems**

Crypto Microcode Installed?



- **From the HMC, you must be in Single Object Mode, then look at the CPC Details**

PCI Configuration

SSYS: Cryptographic Configuration - Mozilla Firefox: IBM Edition

9.82.29.37 https://9.82.29.37:9950/hmc/content?taskId=35&refresh=112

Cryptographic Configuration - SSYS

Cryptographic Information

Select	Number	Status	Crypto Serial Number	Type	Operating mode	TKE Commands
◉	0	Configured	16C3L316	X4 CCA Coprocessor	IBM Default	Denied
○	1	Configured	16C2D340	X4 Accelerator	IBM Default	Not supported
○	2	Configured	16C3L329	X4 Accelerator	IBM Default	Not supported
○	3	Deconfigured	Not available	X4 CCA Coprocessor	Not available	Not available
○	4	Deconfigured	Not available	X4 CCA Coprocessor	Not available	Not available
○	5	Deconfigured	Not available	X4 CCA Coprocessor	Not available	Not available
○	6	Configured	16C2H307	X4 CCA Coprocessor	IBM Default	Permitted
○	7	Configured	16C2D337	X4 EP11 Coprocessor	IBM Default	Permitted
○	8	Deconfigured	Not available	X4 CCA Coprocessor	Not available	Not available
○	9	Deconfigured	Not available	X4 CCA Coprocessor	Not available	Not available

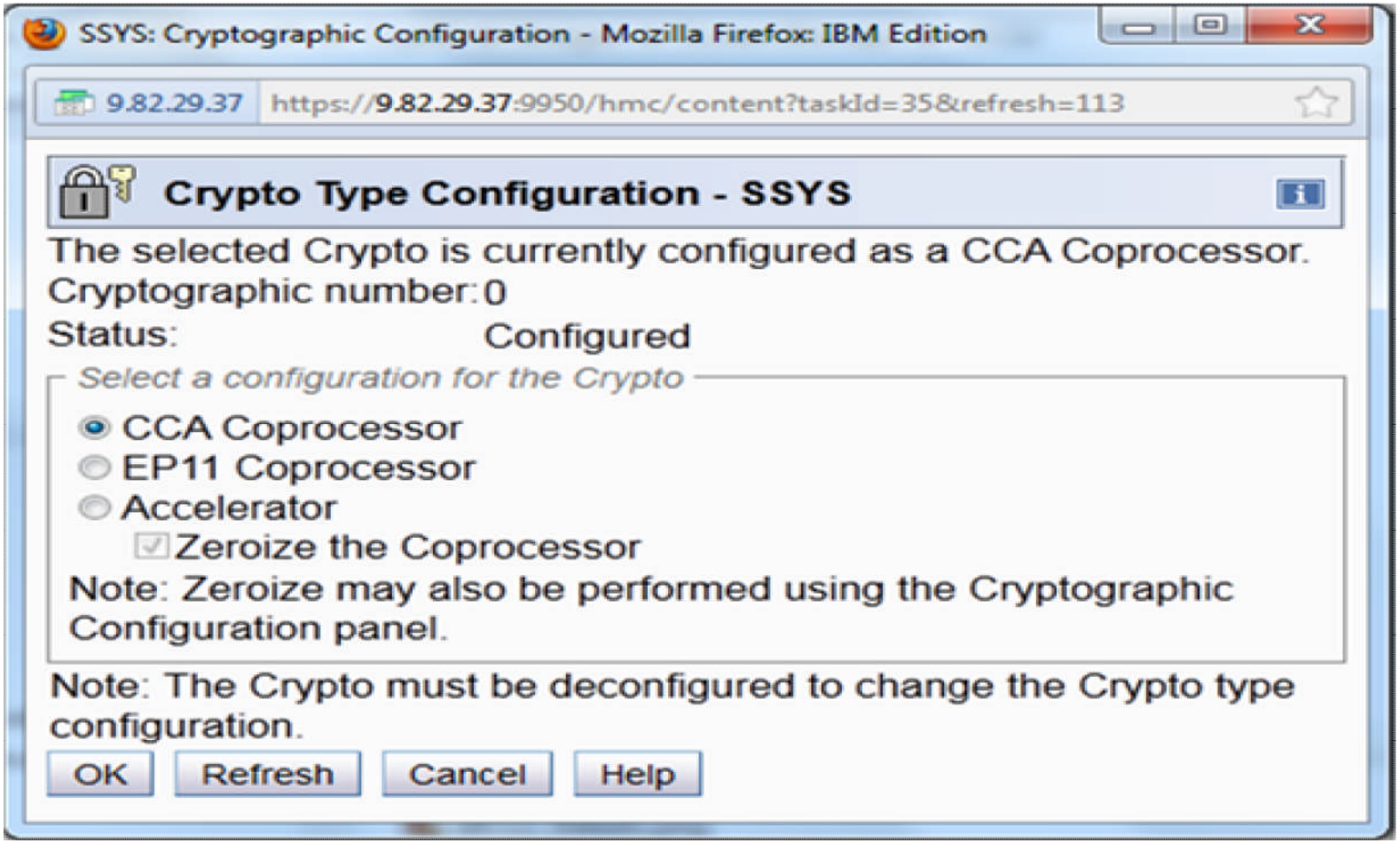
Select a Cryptographic number and then click the task push button.

View Details... | Test RNG/CIS | Zeroize | Usage Domain Zeroize | TKE Commands... | Crypto Type Configuration...

Zeroize All | Test RNG/CIS on All | UDX Configuration... | Refresh | Cancel | Help

From CPC Operational Customization, click on View LPAR Cryptographic Controls

Reconfig



PCI Assignments

SSYS: Customize/Delete Activation Profiles - Mozilla Firefox: IBM Edition

9.82.29.37 https://9.82.29.37:9950/hmc/content?taskId=33&refresh=104

Customize Image Profiles: SSYS : SOSP01 : Crypto

- SSYS
  - SOSP01
    - General
    - Processor
    - Security
    - Storage
    - Options
    - Load
    - Crypto

Index	Control Domain	Usage Domain		Crypto Number	Cryptographic Candidate List	Cryptographic Online List
0	☐	☐		0	☐	☐
1	☑	☑		1	☐	☐
2	☐	☐		2	☐	☐
3	☐	☐		3	☐	☐
4	☐	☐		4	☐	☐
5	☐	☐		5	☐	☐
6	☐	☐		6	☑	☑
7	☐	☐		7	☑	☑
8	☐	☐		8	☐	☐
9	☐	☐		9	☐	☐
10	☐	☐		10	☐	☐
11	☐	☐		11	☐	☐
12	☐	☐		12	☐	☐
13	☐	☐		13	☐	☐
14	☑	☑		14	☐	☐
15	☐	☐		15	☐	☐

Attention: Some functions of Integrated Cryptographic Service Facility (ICSF) may fail if the 'IBM CP Assist for Cryptographic Functions' (CPACF) feature is not installed.

Cancel | Save | Copy Profile | Paste Profile | Help

Are your Master Keys loaded and correct?

CoProcessor	Serial Number	Status	AES	DES	ECC	RSA
__ G01	00000001	ONLINE	U	U	C	U
__ G02	00000002	ACTIVE	A	U	A	E
__ G03	00000003	ACTIVE	A	U	A	C
__ E05	00000004	ACTIVE	A	U	-	C
__ H07		ACTIVE				

How do I tell, which ciphersuites – F GSKSRVR,CRYPTO

GSK01009I Cryptographic status

Algorithm	Hardware	Software
DES	56	56
3DES	168	168
AES	256	256
RC2	--	128
RC4	--	128
RSA Encrypt	4096	4096
RSA Sign	4096	4096
DSS	--	1024
SHA-1	160	160
SHA-2	512	512
ECC	--	521

CPU MF COUNTERS – What and Why

- **What is CPU MF?**
  - A new z10 and later facility that provides cache and memory hierarchy COUNTERS
  - Also capable of time-in-Csect type SAMPLES
  - Data gathering controlled through z/OS HIS (HW Instrumentation Services)
    - Collected on an LPAR basis
    - Written to SMF 113 records
    - Minimal overhead
- **How can the COUNTERS be used today?**
  - To supplement current performance data from SMF, RMF, DB2, CICS, etc.
  - To help understand why performance may have changed
- **How can the COUNTERS be used for future processor planning?**
  - They provide the basis for the new LSPR workload categories
  - zPCR automatically processes CPU MF data to provide a workload "hint" based on RNI
    - zPCR still defaults to old IO-based methodology for workload selection
    - RNI "hint" is a "work in progress"

Measurement Facility Counters

Counter Number	Counter
64	PRNG function count
65	PRNG cycle count
66	PRNG blocked function count
67	PRNG blocked cycle count
68	SHA function count
69	SHA cycle count
70	SHA blocked function count
71	SHA blocked cycle count
72	DEA function count
73	DEA cycle count
74	DEA blocked function count
75	DEA blocked cycle count
76	AES function count
77	AES cycle count
78	AES blocked function count
79	AES blocked cycle count

Sample Report – Crypto COUNTERS provide measurement of CPACF Crypto Co-Processor Usage

```
*** z10 Summary - CRYPTO  Counters Information ***
***              TOTAL for all CPUs              ***

PRNG Function Count                          0/Sec
PRNG Cycle Count                             0/Sec
PRNG Blocked Function Count                  0/Sec
PRNG Blocked Cycle Count                     0/Sec
SHA Function Count                        0.73/Sec
SHA Cycle Count                         592.47/Sec
SHA Blocked Function Count                   0/Sec
SHA Blocked Cycle Count                      0/Sec
DEA Function Count                     6277.39/Sec
DEA Cycle Count                  332273396.24/Sec
DEA Blocked Function Count                   0/Sec
DEA Blocked Cycle Count                      0/Sec
AES Function Count                           0/Sec
AES Cycle Count                              0/Sec
AES Blocked Function Count                   0/Sec
AES Blocked Cycle Count                      0/Sec

***              CRYPTO BUSY SUMMARY             ***

PRNG  Crypto Busy:   0.00%  - for the 3 CPUs
SHA   Crypto Busy:   0.00%  - for the 3 CPUs
DEA   Crypto Busy:   2.55%  - for the 3 CPUs
AES   Crypto Busy:   0.00%  - for the 3 CPUs
---------------------------
Total Crypto Busy:   2.55%  - for the 3 CPUs
```

This information may be useful in determining:

- A count of How Many CPACF encryption functions were executed
- How much CPU Time (cycles) were used

The encryption facility executed both SHA functions and TDES functions for this specific test.

Ran DASD dumps sequentially over 20 minute duration

With option: ENCRYPT(CLRTDES) -

These numbers come from a synthetic Benchmark and do not represent a production workload

- **It is important to remember that other Crypto functions may be executing in software and/or on Crypto Express Cards (if installed & implemented). This is not measured by the CPU MF Crypto COUNTERS**
- **CPU MF Crypto COUNTERS can help assess how many of the Crypto Functions are occurring on the CPACF Co-Processors**

See "A Synopsis of System z Crypto Hardware" by Greg Boyd **WP100810**
http://www.ibm.com/support/techdocs

SMF Type 82 – ICSF Record

- **Subtype 1 – ICSF Initialization**
- **Subtype 3 – change in number of available processors**
- **Subtype 4 – when ICSF handles error conditions for crypto feature failure or tampering**
- **Subtype 5 – change in SSM**
- **Subtype 6 & 7 – when a key part is entered via Key Entry Unit (KEU)**
- **Subtype 8 – when in-storage CKDS is refreshed**
- **Subtype 9 – when CKDS is updated by dynamic CKDS update servcie**

SMF Type 82 – ICSF Record (cont.)

- **Subtype 10 – when clear key part entered for PKA-MK**
- **Subtype 11 – when clear key part entered for DES-MK**
- **Subtype 12 – for each request and reply from calls to CSFSPKSC service by TKE**
- **Subtype 13 – when the KDS is updated by dynamic PKDS update**
- **Subtype 14 – when clear key part is entered for any PCICC master key**
- **Subtype 15 – when a PCICC retained key is created/deleted**
- **Subtype 16 - for each request and reply from calls to CSFPCI service by TKE**

SMF Type 82 – ICSF Record (cont.)

- **Subtype 17 – periodically to provide some indication of PCI Cryptographic Coprocessor usage**
- **Subtype 18 – when a PCICC, PCICA, PCIXCC, CEX2 or CEX3 comes online or offline**
- **Subtype 19 – when a PCIXCC operation begins or ends**
- **Subtype 20 – record processing times for PCIXCCs and CEX2Cs**
- **Subtype 21 – when IXCJOIN or IXCLEAVE the sysplex group**
- **Subtype 22 – when Trusted Block Create API invoked**
- **Subtype 23 – when the TKDS is updated**

SMF Type 82 – ICSF Record (cont.)

- **Subtype 24 – when duplicate tokens are found**
- **Subtype 25 – when key store policy is activated**
- **Subtype 26 – when PKDS is refreshed**
- **Subtype 27 – information about PKA Key Management Extensions**
- **Subtype 28 – information about High Performance Encrypted Key (Protected Key)**
- **Subtype 29 – for each TKE Workstation audit record received from a TKE workstation**

REXX EXEC CSFSMFR

- **Formats the SMF Type 82 records into a readable report**
  - Sample Job, CSFSMFJ to
    - Capture the Type 82 records (with IFASMFDP)
    - Sort the records
    - Execute CSFMFR, via Batch TSO
  - Output may be large – multiple lines per Type 82 record
  - It's more readable than the raw SMF record, but …

Subtype=0014 Cryptographic Coprocessor Timing
Written periodically to provide some indication of coprocessor and accelerator
Nov 2011 0:00:19.26
TME... 00000786 DTE... 0111305F SID... SYSC SSI... 00000000 STY... 0014
TFL... 10000000
TFL 10 Coprocessor is a CEX3C
TNQ... C89B5841F5841AB1 TDQ... C89B5841F59D39B1 TWT... C89B5841F59D5AB1
TQU... 00000000 TSF... áä TIX... 00
TSN... 91008705 TDM... 02 TRN... 40

- **Forensics, more than performance**

SMF Type 70, Subtype 2 - RMF Processor Activity . . .

- **Cryptographic Coprocessor Data Section**
  - Processor Index, Processor Type
  - Scaling Factor
  - Execution Time of all operations
  - Number of all operations on the coprocessor
  - Number of all RSA-key-generation operations
- **Cryptographic Accelerator Data Section**
  - Processor Index, Processor Type
  - Validity bit mask, Number of engines on the accelerator
  - Scaling factor
  - Execution time & number of operations by
    - 1024-bit-ME 2048-bit-ME
    - 1024-bit-CRT 2048-bit-CRT
    - 4096-bit-ME 4096-bit CRT

SMF Type 70, Subtype 2 - RMF Processor Activity (cont.)

- **ICSF Services Data Section**
  - Single DES (Encipher & Decipher): Number of calls, bytes, and instructions
  - Triple DES (Encipher & Decipher): Number of calls, bytes, and instructions
  - MAC Generate/Verify: Number of calls to generate/verify, number of bytes for which MAC was generated/verified, number of PCMF instructions used to generate/verify the MAC
  - SHA-1: Number of calls to hash, number of bytes that were hashed, number of PCMF instructions used to hash the data
  - PIN: number of translate calls, number of verify calls
  - SHA-224, SHA-256, SHA-384, SHA-512 : Number of calls to hash, number of bytes that was hashed, number of PCMF instructions used to hash the data
  - ICSF Data Level
  - AES Encipher & Decipher: number of calls sent to cop, number of bytes processed, number of operations

RMF Crypto Hardware Activity Report

C R Y P T O H A R D W A R E A C T I V I T Y PAGE 1

z/OS V1R13 SYSTEM ID TRX2 START 09/28/2011-08.15.00 INTERVAL 007.14.59

RPT VERSION V1R13 RMF END 09/28/2011-15.30.00 CYCLE 1.000 SECONDS

-------- CRYPTOGRAPHIC COPROCESSOR --------

		-------- TOTAL -------			KEY-GEN
TYPE	ID	RATE	EXEC TIME	UTIL%	RATE
CEX2C	0	0.00	0.000	0.0	0.00
	1	2.16	295.9	63.9	2.14
	2	0.00	0.000	0.0	0.00
CEX3C	4	2.15	227.8	48.9	2.15

-------- CRYPTOGRAPHIC ACCELERATOR ----------

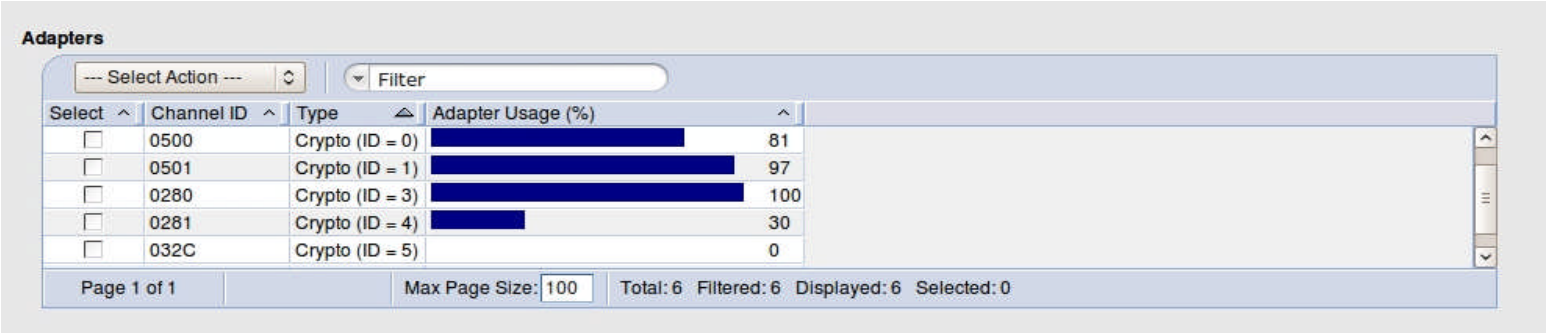
		-------- TOTAL ------- --				ME-FORMAT RSA OPERATIONS --			-- CRT-FORMAT RSA OPERATIONS --		
TYPE	ID	RATE	EXEC TIME	UTIL%	KEY	RATE	EXEC TIME	UTIL%	RATE	EXEC TIME	UTIL%
CEX2A	3	766.9	0.434	33.3	1024	362.4	0.521	18.9	369.5	0.183	6.8
					2048	0.00	0.000	0.0	34.99	2.175	7.6
CEX3A	5	998.9	0.365	36.5	1024	246.4	0.534	13.2	554.3	0.205	11.3
					2048	0.00	0.000	0.0	83.16	0.689	5.7
					4096	0.00	0.000	0.0	115.1	0.547	6.3

-------- ICSF SERVICES ----------

	---- ENCRYPTION -----			---- DECRYPTION -----			--------- MAC --------- -		---------- HASH ----------			---------- PIN ----------	
	SDES	TDES	AES	SDES	TDES	AES	GENERATE	VERIFY	SHA-1	SHA-256	SHA-512	TRANSLATE	VERIFY
RATE	15.41	10.27	0.02	5.14	10.27	0.02	34.23	35.87	15352	<0.01	<0.01	8.97	5.14
SIZE	3200	4400	189.0	800.0	4400	189.5	4573	4400	105.0	48.00	48.00		

Crypto Function Integration (Monitors Dashboard Support)

- The Monitors Dashboard on the HMC and SE was enhanced with a new Adapters table for zHelix.
- The Crypto Utilization percentage is displayed on the Monitors Dashboard according to the pchid number. The associated crypto number (AP Number) for this pchid is also shown in the table.
- The Utilization on the card is calculated using the formula:
  U = (Ta2 - Ta1) * S / (T2 -T1)
  Ta: time used for execution S: scaling factor T: Time of measurement interval



Workload Activity SMF Type 72, Subtype 3

– Crypto Using and Delay Samples

- CAM crypto using samples: a TCB was found executing on a cryptographic asynchronous message processor
- CAM crypto delay samples: a TCB was found waiting on a cryptographic asynchronous message processor
- AP crypto using samples: a TCB was found executing on a cryptographic assist processor
- AP crypto delay samples: a TCB was found waiting on a cryptographic assist processor

SMF Type 30 - Common Address Space Work

- **SMF30CSC – ICSF Service Count**
  - **CSNBENC (Single-DES) - # of service calls, # of bytes, # of CMD instructions**
  - **CSNBENC (Double & Triple-DES) - # of service calls, # of bytes, # of CMD instructions**
  - **CSNBDEC (Single-DES) - # of service calls, # of bytes, # of CMD instructions**
  - **CSNBDEC (Double & Triple-DES) - # of service calls, # of bytes, # of CMD instructions**
  - **CSNBMGN (MAC Generate) - single and various double key MAC; # of service calls, # of bytes, # of CMD instructions**
  - **CSNBMVR (MAC Verify) - single and various double key MAC; # of service calls, # of bytes, # of CMD instructions**
  - **CSNBOWH (SHA-1) - # of Service calls, # of bytes, # of PCMF instructions**
  - **CSNBOWH (SHA-256 which includes SHA-224) - # of Service calls , # of bytes, # of PCMF instructions**
  - **CSNBOWH (SHA-512 which includes SHA-384) - # of Service calls , # of bytes, # of PCMF instructions**
  - **CSNBPTR - # of Service calls**
  - **CSNBPVR - # of Service calls**

Omegamon

Service Call Performance - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://9.82.38.36:1920///cnp/kdh/lib/cnp.html?-12000=SYSADMIN&-5001=MOPHYSICAL&-1021A=REPORT

Welcome SYSADMIN

Tivoli Enterprise Portal

File Edit View Help

View: Physical

GRS Ring Systems Data for Sysplex
Report Classes Data for Sysplex
Resource Groups Data for Sysplex
Service Classes Data for Sysplex
Service Definition Data for Sysplex

Universal Message Console

Average Arrivals per Minute — Calls per minute

Average Service Time per Call — msec per call

Service Call Performance

SvcDesc	ArrivalRate	SvcTime	Pending	Bytes	SMFID	SvcCall
ANSI X9.17 EDC Generate	0	0.000	0	0	SYSD	CSNAEGN
ANSI X9.17 Key Export	0	0.000	0	0	SYSD	CSNAKEX
ANSI X9.17 Key Import	0	0.000	0	0	SYSD	CSNAKIM
ANSI X9.17 Key Translate	0	0.000	0	0	SYSD	CSNAKTR
ANSI X9.17 Transport Key Partial ...	0	0.000	0	0	SYSD	CSNATKN
Cipher Decipher	0	0.000	0	0	SYSD	CSFEDC
Ciphertext Translate	0	0.000	0	0	SYSD	CSNBCTT
Ciphertext Translate with ALET	0	0.000	0	0	SYSD	CSNBCTT
Clear Key Import	0	0.000	0	0	SYSD	CSNBCKI
Clear PIN Encrypt	0	0.000	0	0	SYSD	CSNBCPE
Clear PIN Generate	0	0.000	0	0	SYSD	CSNBPGN
Clear PIN Generate Alternate	0	0.000	0	0	SYSD	CSNBCPA
Control Vector Translate	0	0.000	0	0	SYSD	CSNBCVT
Cryptographic Variable Encipher	0	0.000	0	0	SYSD	CSNBCVE
Data Key Export	0	0.000	0	0	SYSD	CSNBDKX
Data Key Import	0	0.000	0	0	SYSD	CSNBDKM
Decipher	0	0.000	0	0	SYSD	CSNBDEC
Decipher with ALET	0	0.000	0	0	SYSD	CSNBDEC
Decode	0	0.000	0	0	SYSD	CSNBDCC
Digital Signature Generate	0	0.000	0	0	SYSD	CSNDDSG
Digital Signature Verify	0	0.000	0	0	SYSD	CSNDDSV
Diversified Key Generate	0	0.000	0	0	SYSD	CSNBDKG
Encipher	0	0.000	0	0	SYSD	CSNBENC
Encipher under Master Key	0	0.000	0	0	SYSD	CSFEMK
Encipher with ALET	0	0.000	0	0	SYSD	CSNBENC
Encode	0	0.000	0	0	SYSD	CSNBECC

Average Pending per Call — Pending requests per call

Average Bytes... — Bytes per call

Hub Time: Wed, 02/06/2008 07:43 AM | Server Available | Service Call Performance - 9.82.38.36 - SYSADMIN

Applet CMWApplet started | Internet

IBM Redbooks & Manuals

- **SG24-6645 Effective zSeries Performance Monitoring Using Resource Measurement Facility**
- **REDP-4358 Monitoring System z Cryptographic Services**
- **SA22-7630 z/OS System Measurement Facilities (SMF)**

z/OS Web Download Site

- **http://www.ibm.com/systems/z/os/zos/downloads/**

Crypto Performance Whitepapers

- **zEC12**
  - http://www.ibm.com/systems/z/advantages/security/zec12cryptography.html
- **z196 and z10**
  - http://www.ibm.com/systems/z/advantages/security/z10cryptography.html

CPU Measurement Facility Doc

- **IBM Research article**
  - ***"IBM System z10 performance improvements with software & hardware synergy"***
  - http://www.research.ibm.com/journal/rd/531/jackson.pdf
    - Contact IBM team for copy of the article
- **Feb 2011 *Hot Topics - A z/OS Newsletter* - GA22-7501**
  - ***"A whole lot of benefits from HIS data" article page 24***
    - ***COUNTERS and an update on SAMPLING - HIS report tool and STG Lab Services***
- **Redpaper *Setting Up and Using System z CPU Measurement Facility with z/OS***
  - **http://www.redbooks.ibm.com/redpieces/pdfs/redp4727.pdf**

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Time for…

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