Keys to the Virtual Kingdom

Making the Most of z Systems Crypto for Your Virtual Machines

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The z13 – “Ultimate Security”

Did you know?

- *z Systems is the only commercial operating system that has achieved EAL 5+ certification. This certification means that although different workloads are running on the same hardware, they are protected when running in separate partitions; one logical partition (LPAR) cannot reach across boundaries into the next LPAR and compromise its security. The LPARs are allocated their own resources and are secure and separate environments.*

- *Integrated cryptographic features provide leading cryptographic performance and functions. Reliability, availability, and serviceability (RAS) support for the Crypto Express5S is unmatched in the industry, and the cryptographic solution for the Crypto Express4S received the highest standardized security certification (FIPS 140-2 Level 4). IBM is in the process of gaining FIPS 140-2 Level 4 certification for the Crypto Express5S feature. With FIPS 140-2 Level 4 certified cryptographic hardware, IBM provides the most secure tamper-sensing and tamper-resistant security module that is available in the market.*

From "Ultimate Security with the IBM z13"
IBM Redbooks Solution Guide

… and here’s your cryptography “Bingo” card.

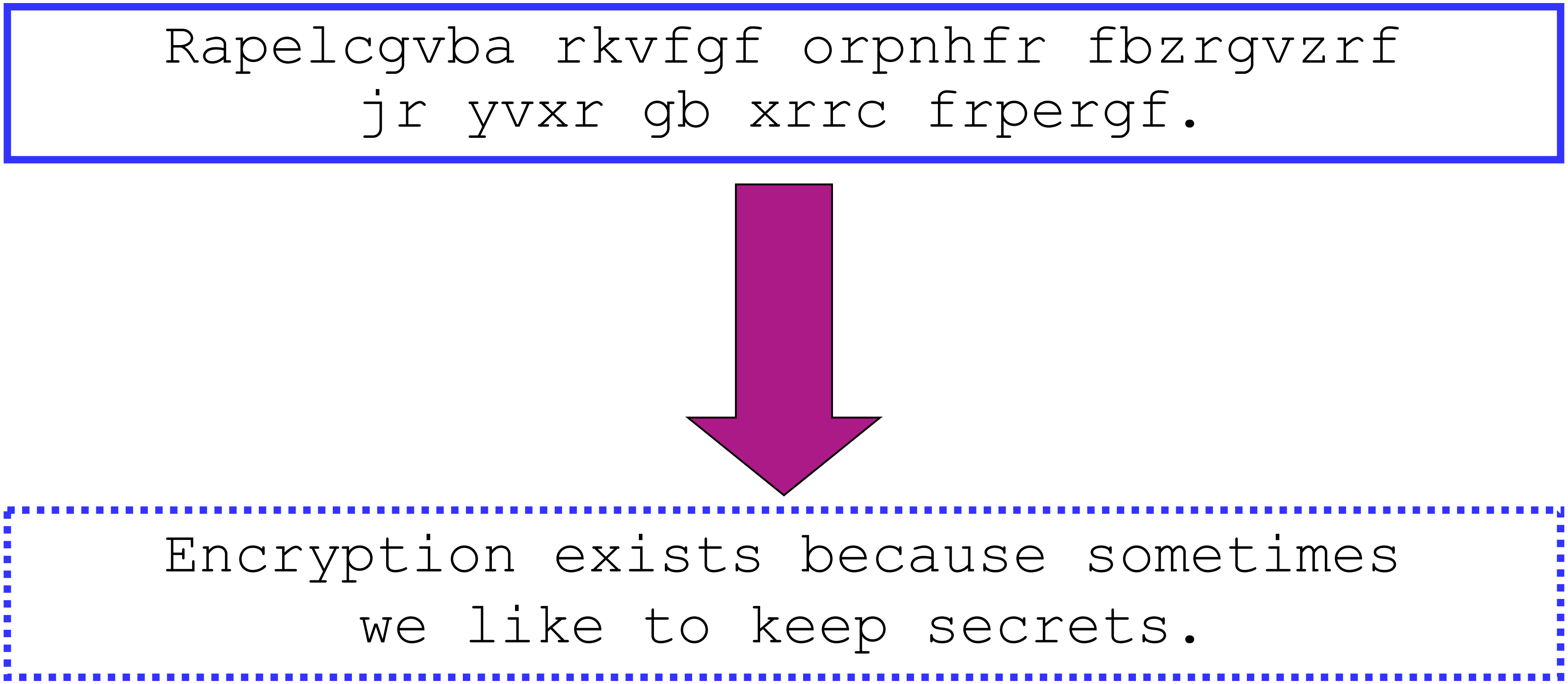
AES	Advanced Encryption Standard
ARL	Authority Revocation List
CA	Certification Authority
CBC	Cipher Block Chaining
CCA	IBM Common Cryptographic Architecture
CCF	Cryptographic Coprocessor Facility
CDSA	Common Data Security Architecture
CEX2/3A	Crypto Express 2/3 Accelerator Mode
CEX2/3C	Crypto Express 2/3 Coprocessor Mode
CFB	Cipher Feedback
CKDS	Cryptographic Key Data Set
CRL	Certificate Revocation List
CRT	Chinese Remainder Theorem
CVC	Card Verification Code
CVV	Card Verification Value
DES	Data Encryption Standard
DSA	Digital Signature Algorithm
DSS	Digital Signature Somethting
ECB	Electronic Code Book
FIPS	Federal Information Processing Standard
GSS	Generalized Security Services
ICSF	Integrated Cryptographic Service Facility
IETF	Internet Engineering Task Force
IPKI	Is Anyone Reading This Line
KGUP	If You Can Read This Raise Your Hand
LDAP	Lightweight Directory Access Protocol
MAC	Message Authentication Code
MDC	Message Detection Code
MD5	Message Digest 5
OAEP	Optimal Asymmetric Encryption Padding
OCSF	OS/390 Open Cryptographic Services Facility
OCSP	Online Certificate Status Protocol
PCICA	PCI Cryptographic Accelerator
PCICC	PCI Cryptographic Coprocessor
PCIXCC	PCIX Cryptographic Coprocessor
PKA	Public Key Architecture
PKCS	Cryptographic Standards
PKDS	Public Key Data Set
PKI	Public Key Infrastructure
RA	Registration Authority
RACF	Resource Access Control Facility
RSA	Rivest-Shamir-Adleman
SET	Secure Electronic Transaction
SHA	Secure Hash Algorithm
SLE	Secure Cookie Monster Encryption
SSL	Secure Sockets Layer
TKE	Trusted Key Entry
TLS	Transport Layer Security
VPN	Virtual Private Network

Agenda

- A Very Quick Intro to Cryptography
  (and why it matters)

- IBM z Systems Hardware Cryptography
  (and why it matters)
- z/VM Virtualization of z Systems Cryptography
  (and how to use it)
- Guest Support: Operating Systems Running on z/VM
- **Extra**: Frequently Asked Questions (if you don't ask them first)

Intro to Crypto
(The Really Short Version)



Rapelcgvba rkvfgf orpnhfr fbzrgvzrf
jr yvxr gb xrrc frpergf.

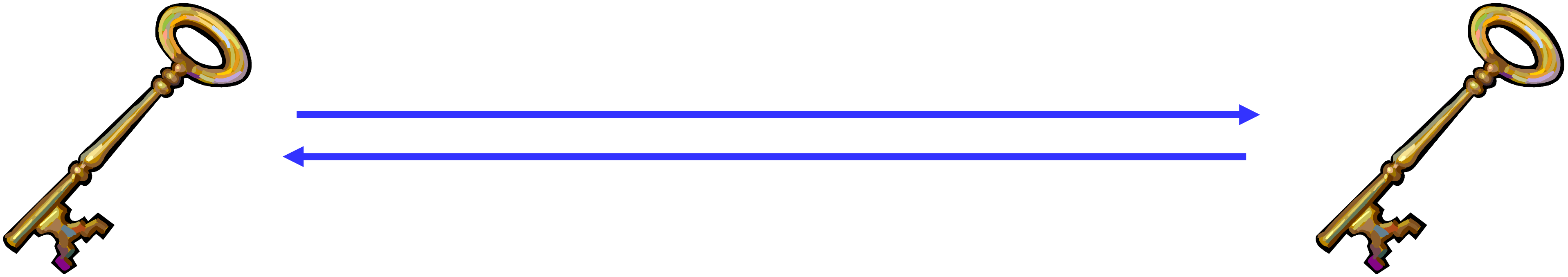
Encryption exists because sometimes
we like to keep secrets.

Cryptography is a mathematical function whereupon plaintext (“information in the clear”) is transmuted into a secret (“encrypted”) and can only be decrypted by someone who shares a common secret.

Symmetric keys

(Examples: DES, Triple-DES, AES)

- A secret held in common by two parties
- Used to encrypt or decrypt a message in flight.
- Without the shared secret, a third party could not reasonably decrypt the message

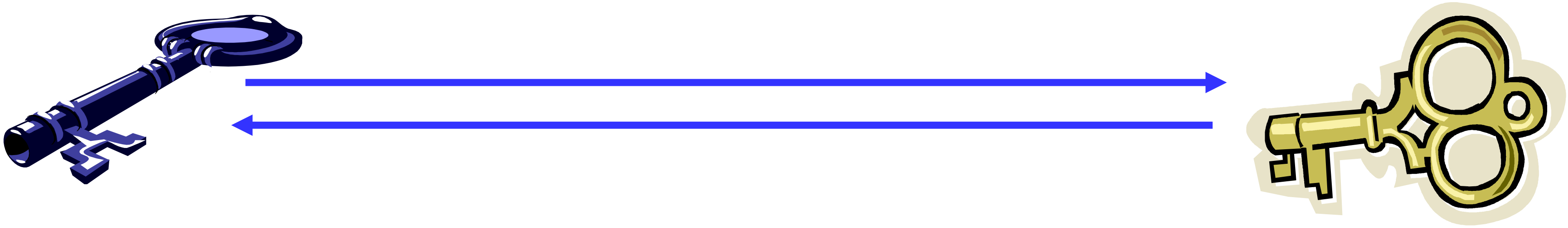


- **The problem**: how does the secret key go from person A to person B?

Asymmetric keys

(Examples: Diffie-Hellman, RSA, DSA, Elliptic Curve)

- Corresponding secrets used to encrypt information
- Data encrypted by the private key can be encrypted by anyone with the public key
  - Only **Alice** has **Alice’s** private key; if we can decrypt this message, it's from Alice.
  - If we encrypt the response with **Alice’s** public key, only **Alice** will be able to read it.



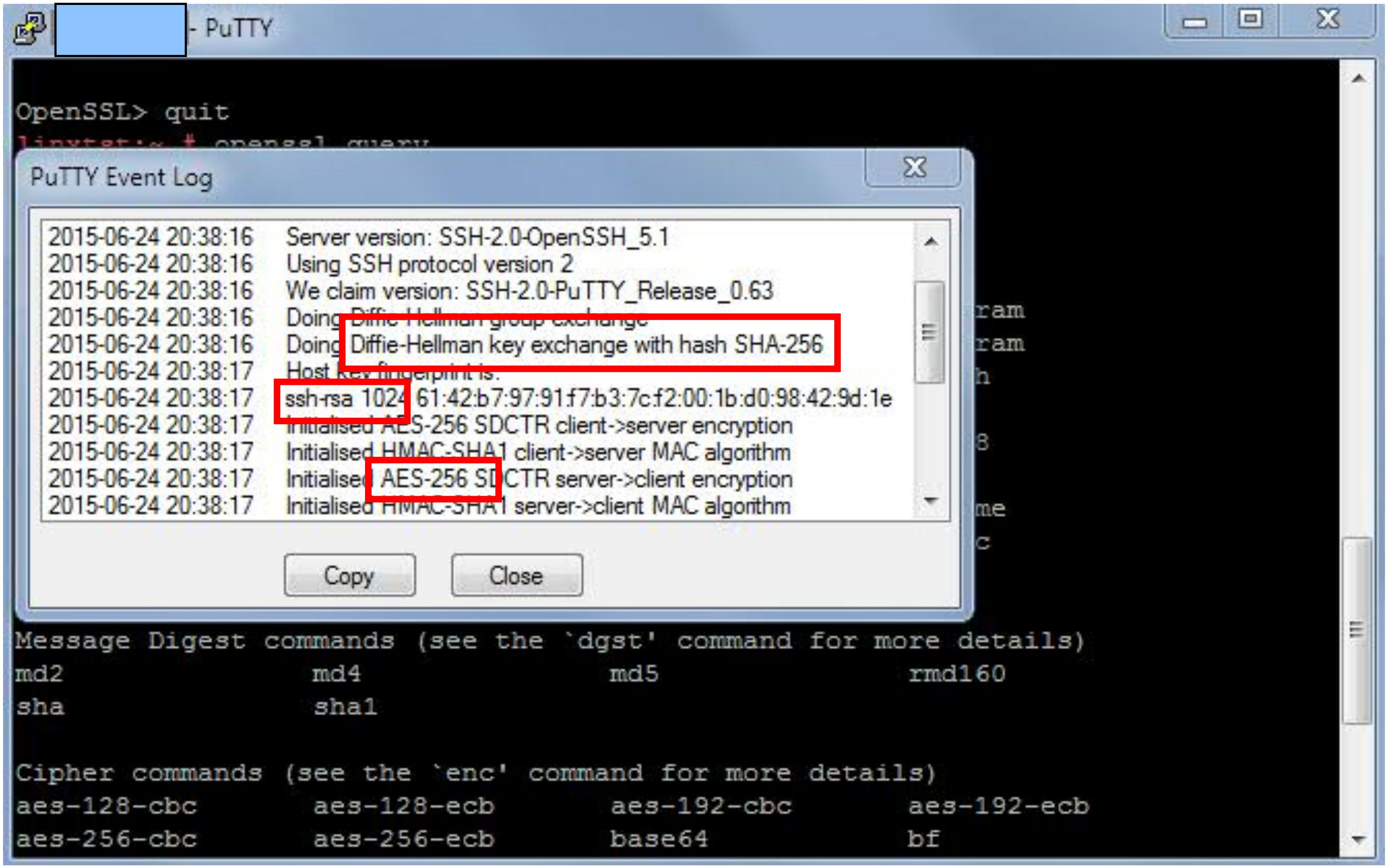
- Mathematically more intensive than symmetric (and therefore much slower)
- **Question**: what if someone drops a bit? What happens to the message?

Hashing

(Examples: MD5, SHA-1, SHA-256, SHA-512, SHA-3)

- Computes a "message digest" based on a set of data
- Used to ensure data integrity
  - Checksum computation
  - Message Authentication Codes (MACs)
  - Makes sure your data is the same at the destination as it was at the source

It looks complicated, but it happens quickly.



```
OpenSSL> quit
linuxtst:~ # openssl query
```

```
2015-06-24 20:38:16    Server version: SSH-2.0-OpenSSH_5.1
2015-06-24 20:38:16    Using SSH protocol version 2
2015-06-24 20:38:16    We claim version: SSH-2.0-PuTTY_Release_0.63
2015-06-24 20:38:16    Doing Diffie-Hellman group exchange
2015-06-24 20:38:16    Doing Diffie-Hellman key exchange with hash SHA-256
2015-06-24 20:38:17    Host key fingerprint is:
2015-06-24 20:38:17    ssh-rsa 1024 61:42:b7:97:91:f7:b3:7c:f2:00:1b:d0:98:42:9d:1e
2015-06-24 20:38:17    Initialised AES-256 SDCTR client->server encryption
2015-06-24 20:38:17    Initialised HMAC-SHA1 client->server MAC algorithm
2015-06-24 20:38:17    Initialised AES-256 SDCTR server->client encryption
2015-06-24 20:38:17    Initialised HMAC-SHA1 server->client MAC algorithm
```

```
ram
ram
h

8

me
c

Message Digest commands (see the `dgst' command for more details)
md2               md4               md5               rmd160
sha               sha1

Cipher commands (see the `enc' command for more details)
aes-128-cbc       aes-128-ecb       aes-192-cbc       aes-192-ecb
aes-256-cbc       aes-256-ecb       base64            bf
```

… so let's apply our newfound knowledge!

- SSH connections and TLS connections use all three
  - Asymmetric key exchange to establish a connection
  - Symmetric keys to encrypt bulk traffic
  - Hashing to validate content between source and target

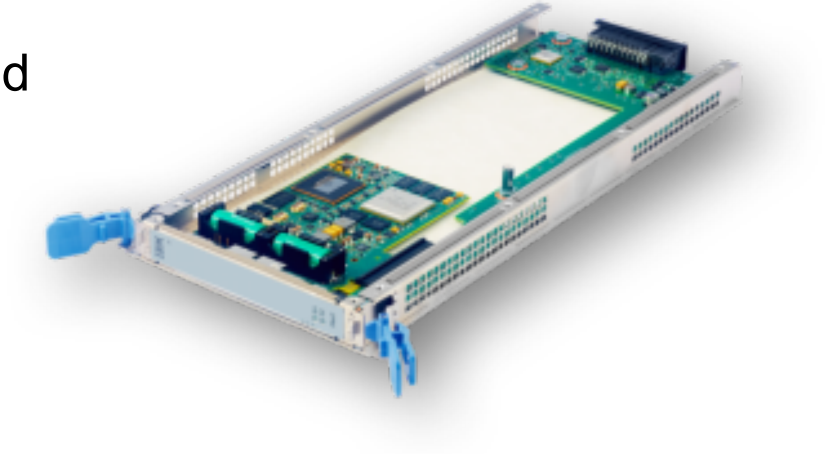
- That's a lot of math … and it's processing power that adds up
  - Happens for every secure operation (connection, application math, etc.)
  - The bigger (more secure) the keys, the longer it takes
  - Costs time, money

IBM z Systems Cryptographic Features

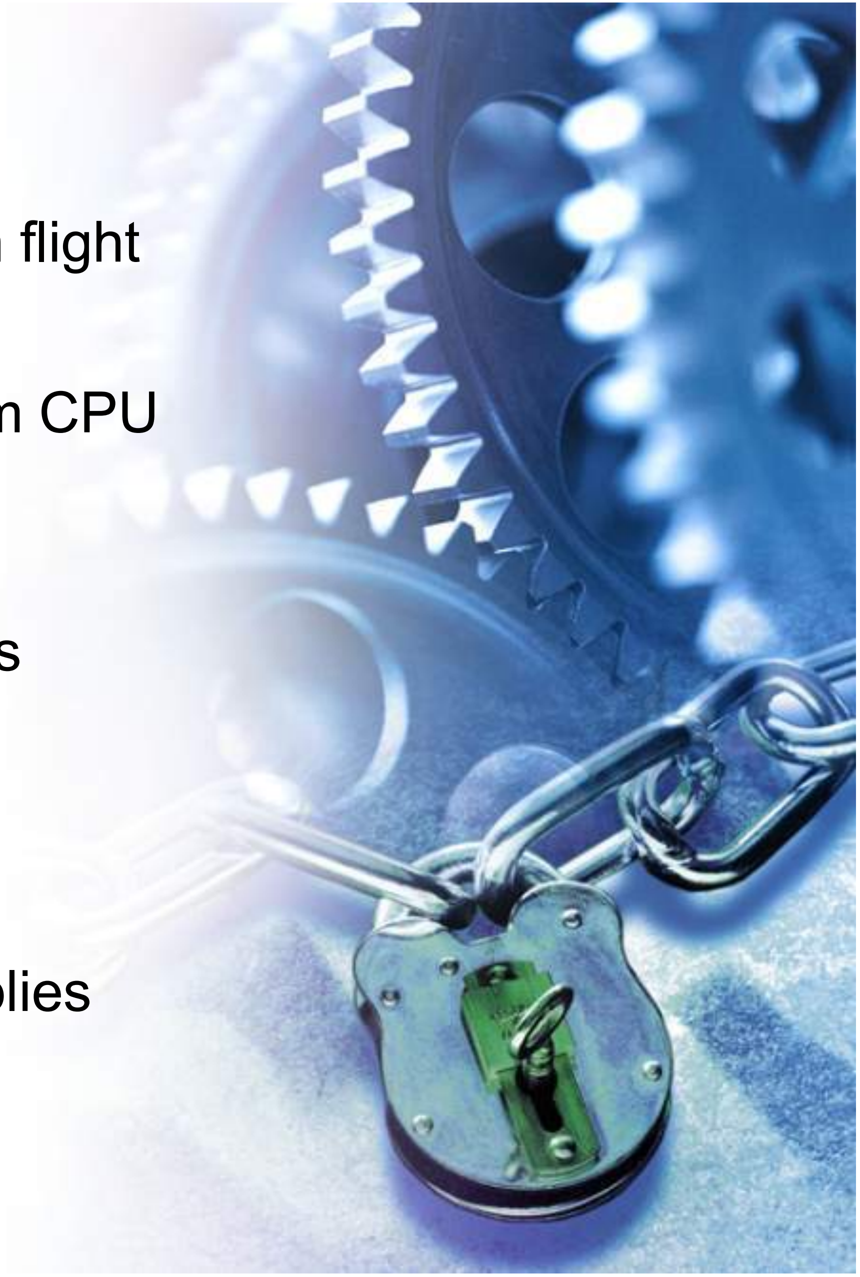
- **IBM z Systems provide two flavors for offloading and accelerating cryptographic operations which help you to**
  - Move cryptographic workload away from central processors
  - Heighten your security level by protecting and securing keys
  - Accelerate encryption and decryption

- *CP Assist for Cryptographic Function* (**CPACF**)
  - Support for **symmetric** and hashing algorithms included in every CP and IFL
  - Pseudo-random number generator

- ***Crypto Express** features*
  - **Asymmetric** and hashing algorithm offload
  - Host master-key storage
  - Hardware RNG
  - PKCS #11 cryptographic support



How do these features help?

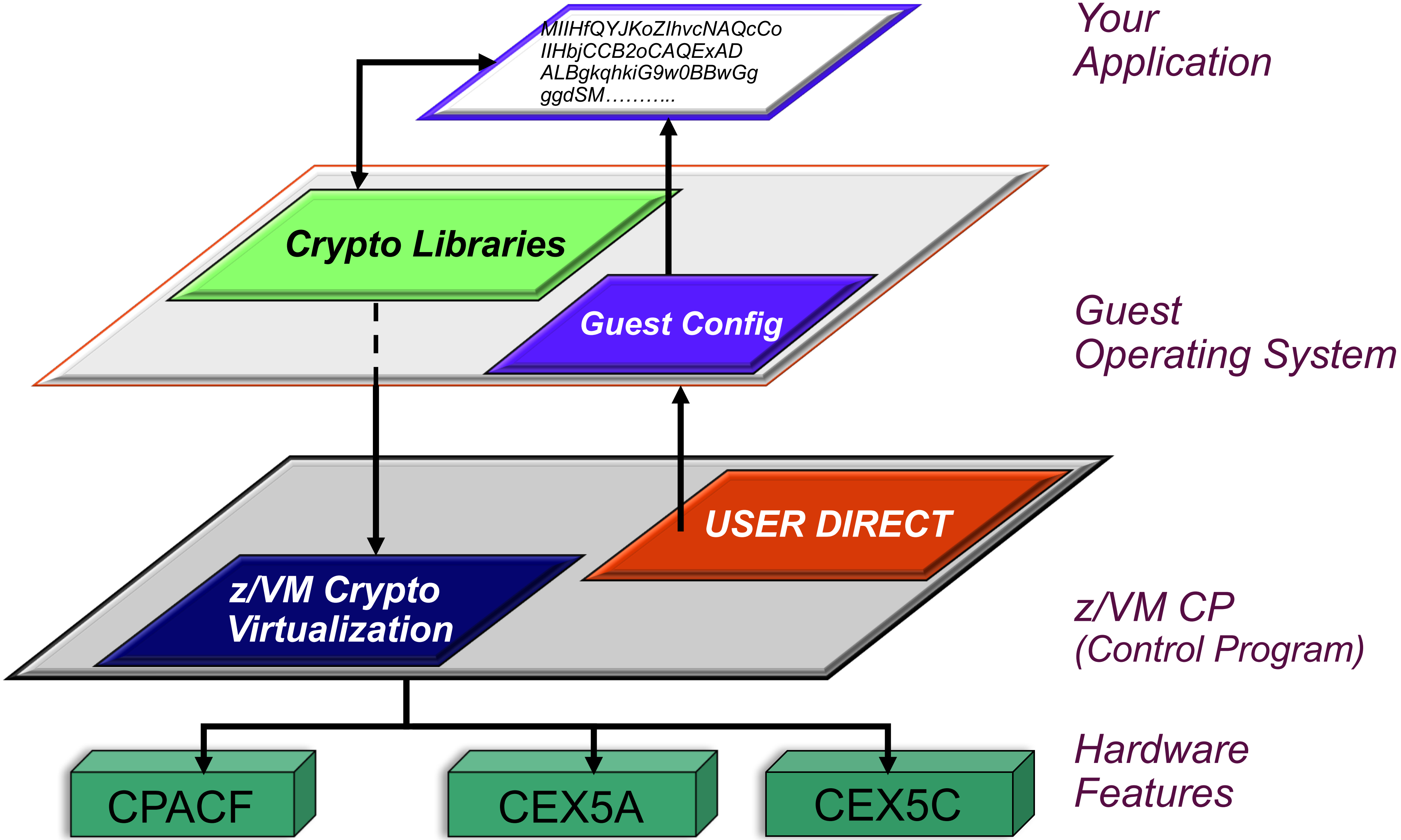


- **Security** – encrypts your data at rest and in flight
- **Cost** – Saves on MIPS since it offloads from CPU
- **Capability** – modern algorithms aren't always implemented in the software libraries
- **Speed** – hardware is faster than software
- **Compliance** – meets regulations and complies with business or government standards

But that’s just the hardware,
and you’re probably not running
a single guest on an entire z13.

So let’s take a look at how this ties
into the rest of the z Systems
virtual ecosystem.

z/VM Virtualization of Hardware Cryptography



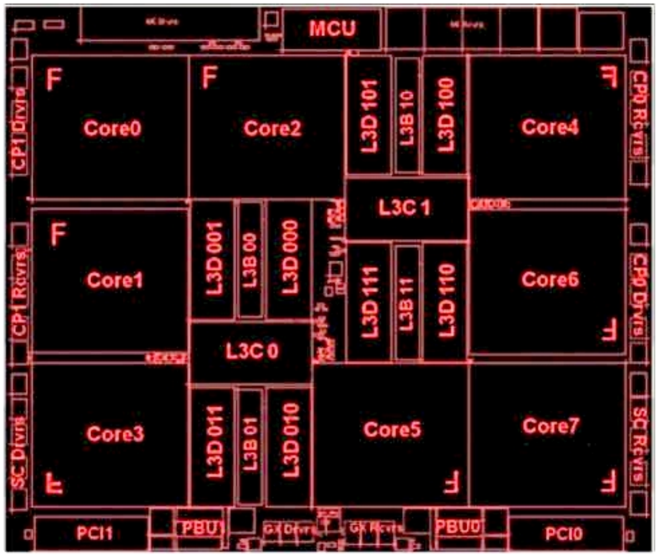
CP-Assisted Cryptographic Facility (CPACF)

CPACF Support (Feature 3863)

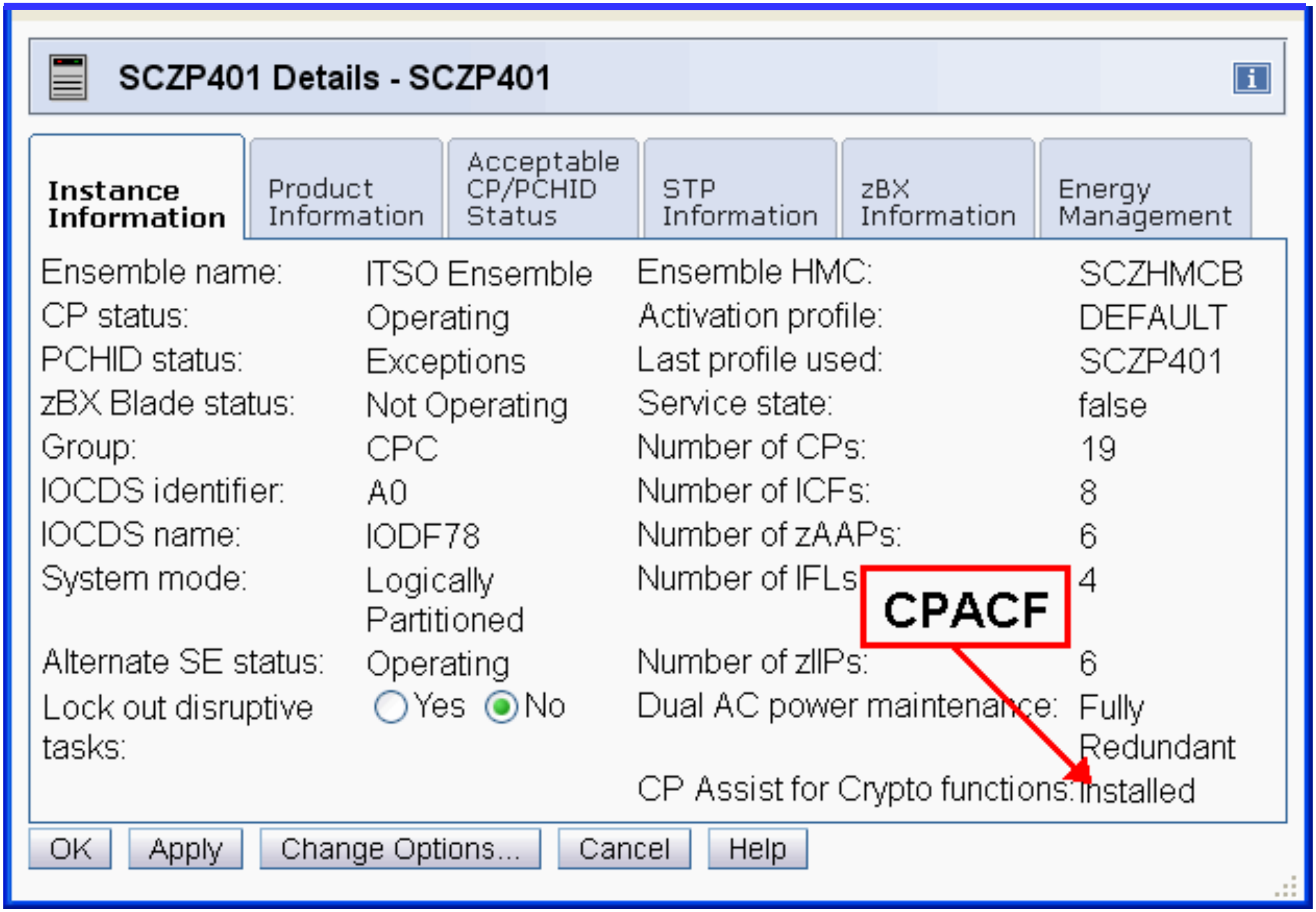
- Available on all modern z Systems hardware but it must be explicitly enabled
- Provides on-CPU cryptographic processing ***at a higher throughput***
- Supports the following algorithms:
  - DES
  - TDES
  - AES-128
  - AES-256 (z10 onward)

  - SHA-1
  - SHA-224 and SHA-256
  - SHA-384 and SHA-512 (z10 onward)

  - Single-length key MAC
  - Double-length key MAC



CP-Assisted Cryptographic Facility (CPACF)



Ensemble name:	ITSO Ensemble	Ensemble HMC:	SCZHMCB
CP status:	Operating	Activation profile:	DEFAULT
PCHID status:	Exceptions	Last profile used:	SCZP401
zBX Blade status:	Not Operating	Service state:	false
Group:	CPC	Number of CPs:	19
IOCDS identifier:	A0	Number of ICFs:	8
IOCDS name:	IODF78	Number of zAAPs:	6
System mode:	Logically Partitioned	Number of IFLs:	4
Alternate SE status:	Operating	Number of zIIPs:	6
Lock out disruptive tasks:	○ Yes ● No	Dual AC power maintenance:	Fully Redundant
		CP Assist for Crypto functions:	Installed

IBM z Systems Crypto Express Features

Crypto Express Support comes in three flavors

- IBM Common Cryptographic Architecture (CCA):
  - **CCA Accelerator mode**: meant for offload and acceleration of CPU intensive public/private key operations. Pertinent to workloads such as TLS and SSH, where secure handshaking factors heavily.
  - **CCA Coprocessor mode**: Accelerates public/private key operations and also supports secure key operations for encryption and decryption.
    - Coprocessor mode is the more cryptographically interesting of the two
    - Host master keys would be stored in Coprocessor domains
- **EP11 Mode (Coprocessor Only)**
  - Available on the Crypto Express4S
  - Enables PKCS#11 operations
  - *Must be set for the entire feature*

Crypto Express5S

- One PCIe adapter per feature
  - **Initial order – two features**
- Designed to be FIPS 140-2 Level 4 compliant
- Installed in the PCIe I/O drawer
- Up to 16 features per server
- Prerequisite: CPACF (#3863)

Three configuration options for the PCIe adapter

- Only one configuration option can be chosen at any given time
- Switching between configuration modes will erase all card secrets

Accelerator

TKE	N/A
CPACF	NO
UDX	N/A
CDU	N/A

Clear Key RSA operations

CCA Coprocessor

TKE	OPTIONAL
CPACF	REQUIRED
UDX	YES
CDU	YES(SEG3)

Secure Key crypto operations

EP11 Coprocessor

TKE	REQUIRED
CPACF	REQUIRED
UDX	NO
CDU	NO

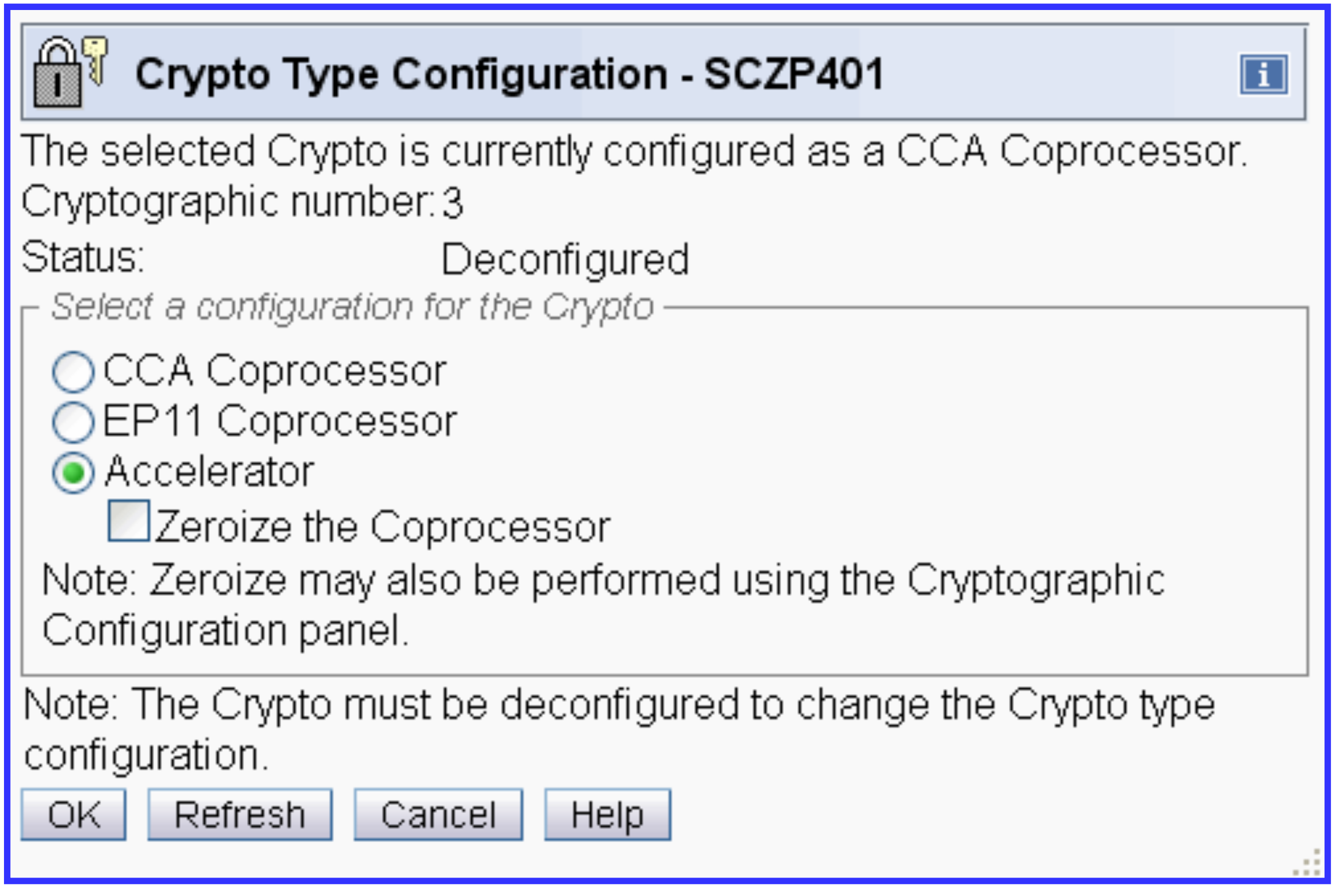
Secure Key crypto operations

Business Value

- High speed advanced cryptography
- Intelligent encryption of sensitive data that executes off processor saving costs
- PIN transactions, EMV transactions for integrated circuit based payment cards (chip & pin), and general-purpose cryptographic applications using symmetric key, hashing, and public key algorithms, VISA format preserving encryption (FPE), and simplification of cryptographic key management.

Setting Personality for a Crypto Express Feature

- Hardware configuration for the feature is done on the Support Element
  - Step 1: Make sure CPACF is enabled.
  - Step 2: Select feature, then choose personality type



Crypto Type Configuration - SCZP401

The selected Crypto is currently configured as a CCA Coprocessor.

Cryptographic number: 3

Status: Deconfigured

Select a configuration for the Crypto

○ CCA Coprocessor

○ EP11 Coprocessor

● Accelerator

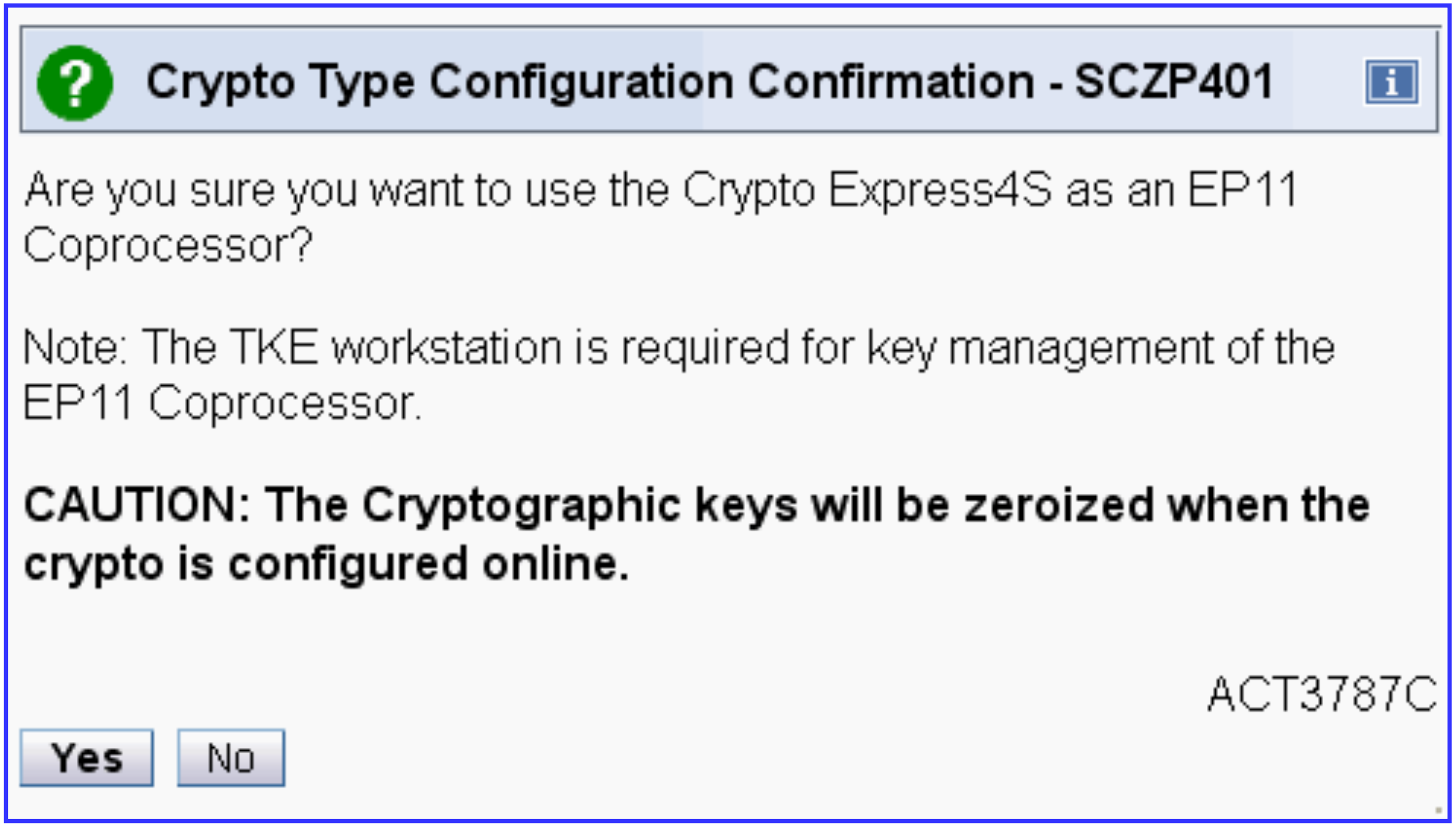
□ Zeroize the Coprocessor

Note: Zeroize may also be performed using the Cryptographic Configuration panel.

Note: The Crypto must be deconfigured to change the Crypto type configuration.

Setting Personality for a Crypto Express Feature

- Validate option selection
- May zeroize existing keys in the process (destroy any residual secrets)



Crypto Type Configuration Confirmation - SCZP401

Are you sure you want to use the Crypto Express4S as an EP11 Coprocessor?

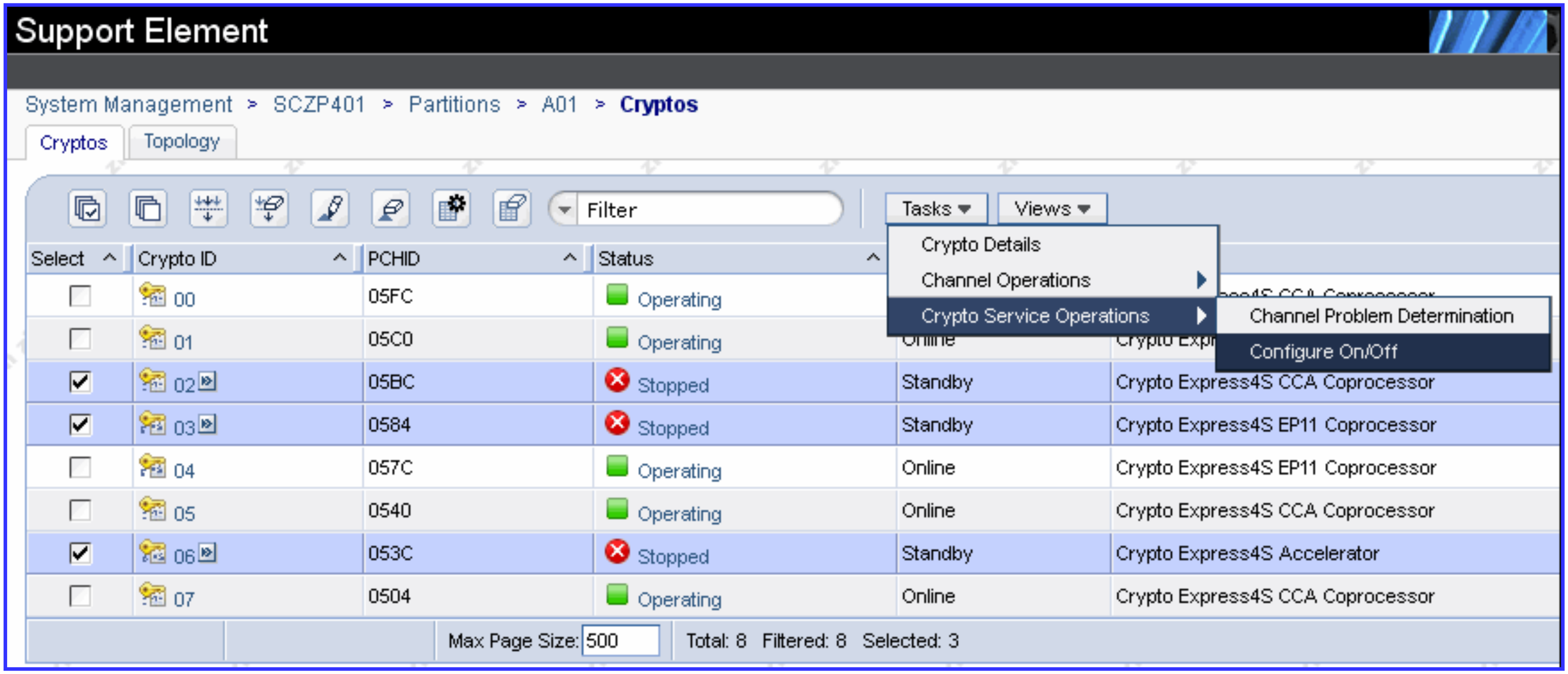
Note: The TKE workstation is required for key management of the EP11 Coprocessor.

CAUTION: The Cryptographic keys will be zeroized when the crypto is configured online.

ACT3787C

Activating a Crypto Express Feature

- Hardware activation is done from the Support Element
- Select pertinent feature, "Configure On/Off"


Support Element
System Management > SCZP401 > Partitions > A01 > Cryptos
Cryptos
Topology
Filter
Tasks
Views
Crypto Details
Channel Operations
Crypto Service Operations
Channel Problem Determination
Configure On/Off

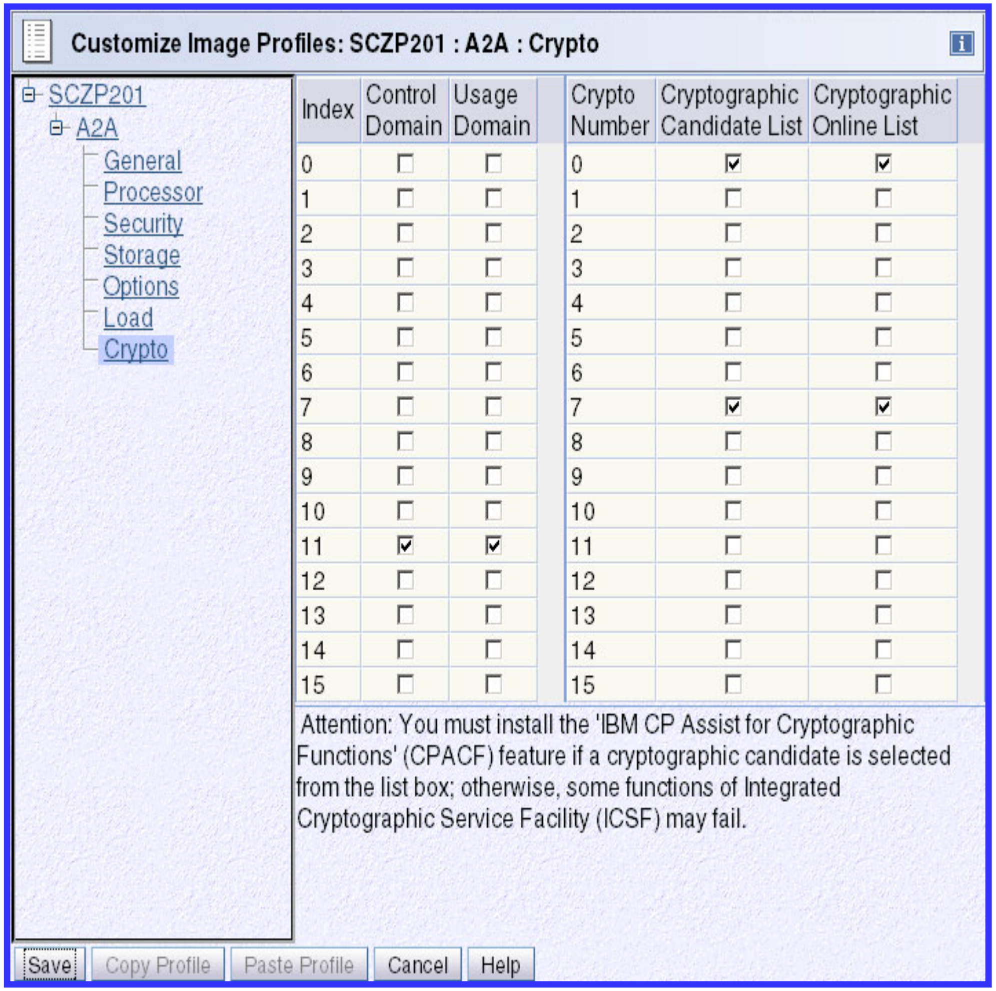
Select	Crypto ID	PCHID	Status		
☐	00	05FC	🟩 Operating		ess4S CCA Coprocessor
☐	01	05C0	🟩 Operating	Online	Crypto Expr
☑	02	05BC	☒ Stopped	Standby	Crypto Express4S CCA Coprocessor
☑	03	0584	☒ Stopped	Standby	Crypto Express4S EP11 Coprocessor
☐	04	057C	🟩 Operating	Online	Crypto Express4S EP11 Coprocessor
☐	05	0540	🟩 Operating	Online	Crypto Express4S CCA Coprocessor
☑	06	053C	☒ Stopped	Standby	Crypto Express4S Accelerator
☐	07	0504	🟩 Operating	Online	Crypto Express4S CCA Coprocessor

Max Page Size: 500 Total: 8 Filtered: 8 Selected: 3

#vmworkshop #IBMz #zVM

Attaching a Crypto Express Domain to an LPAR

- LPAR assignation is done from the HMC (building an activation profile)
  - **Candidate list**: domains on this AP which are eligible to be accessed by this partition
  - **Online List**: processors automatically brought online at LPAR startup.
  - **Usage Domain**: bundles domains together inside a common cryptographic boundary
  - **Control Domain**: identifies domain index pertinent to TKE control of the LPAR. Must also contain Usage Domain.
- z/VM will only detect those cards and domains assigned to the LPAR



Customize Image Profiles: SCZP201 : A2A : 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: You must install the 'IBM CP Assist for Cryptographic Functions' (CPACF) feature if a cryptographic candidate is selected from the list box; otherwise, some functions of Integrated Cryptographic Service Facility (ICSF) may fail.

Getting Keys into z Systems

- **Trusted Key Entry (TKE) Workstation** – an optional priced feature which communicates directly with the Crypto Express features over a secure TCP/IP connection.
  - Functions as a separate physical device to the side of your z System
  - Card reader for crypto secret storage
  - Generates new secrets, stores data in Crypto Express domains
  - Required for EP11 Crypto Express features!

- **z/OS Integrated Cryptographic Services Facility (ICSF)** – a base component which allows interaction with Crypto Express features. (Requires MVS.)

- **Panel and Catcher Utilities for Linux** – **Panel** is a Linux package installed as part of the IBM .rpms which allows for key management function. **Catcher** is the Linux daemon for communicating with TKE.
  - `/opt/IBM/CEX5C/bin/panel.exe`

- **IBM Enterprise Key Management Foundation (EKMF)** – an IBM Lab Services offering for flexible and secure key management services.
  - See also *Advanced Crypto Service Provider*
  - http://www-05.ibm.com/dk/security/cccc/products/acsp.html

Securing the Keys Once They're Installed

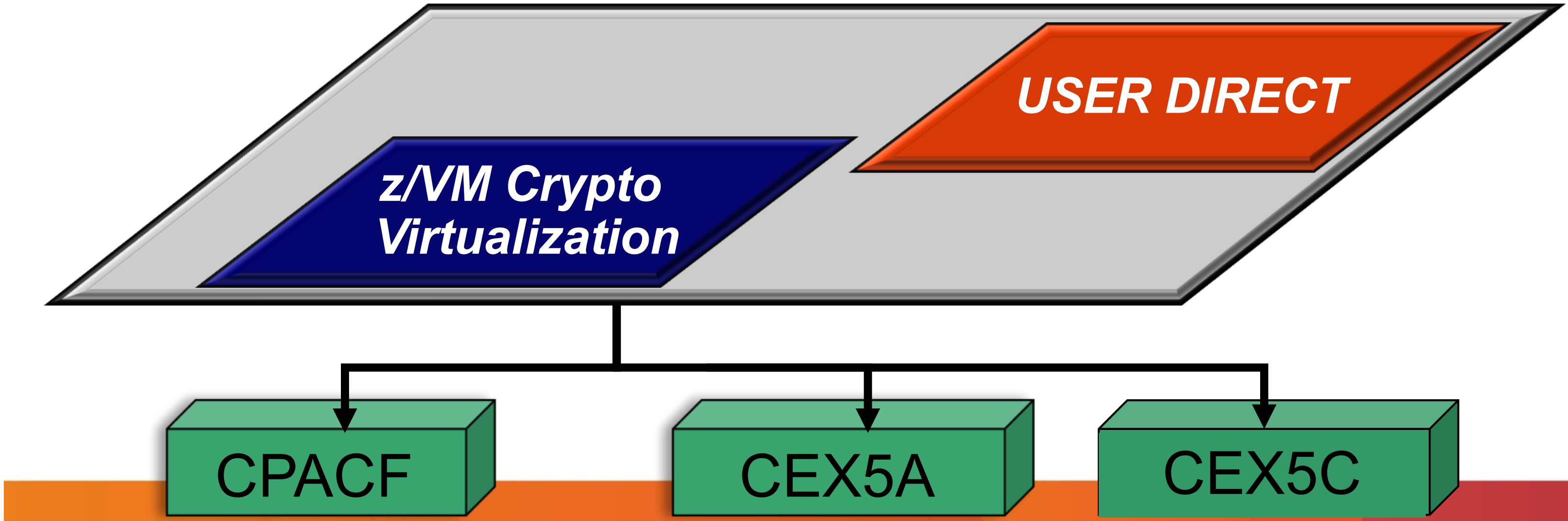
Three different types of key protection in the **IBM Crypto hardware:**

- **Clear keys:**
  - The security of keys is provided by operating procedures.
  - This means keys may appear in the clear in the environment somewhere

- **Secure keys: (FIPS 140-2 Level 4 certified)**
  - Secure keys are protected by another key (the master key) stored in hardware
  - When a secure key must leave the hardware, the key is encrypted under the master key … so the value of the secure key is never exposed to the operating system

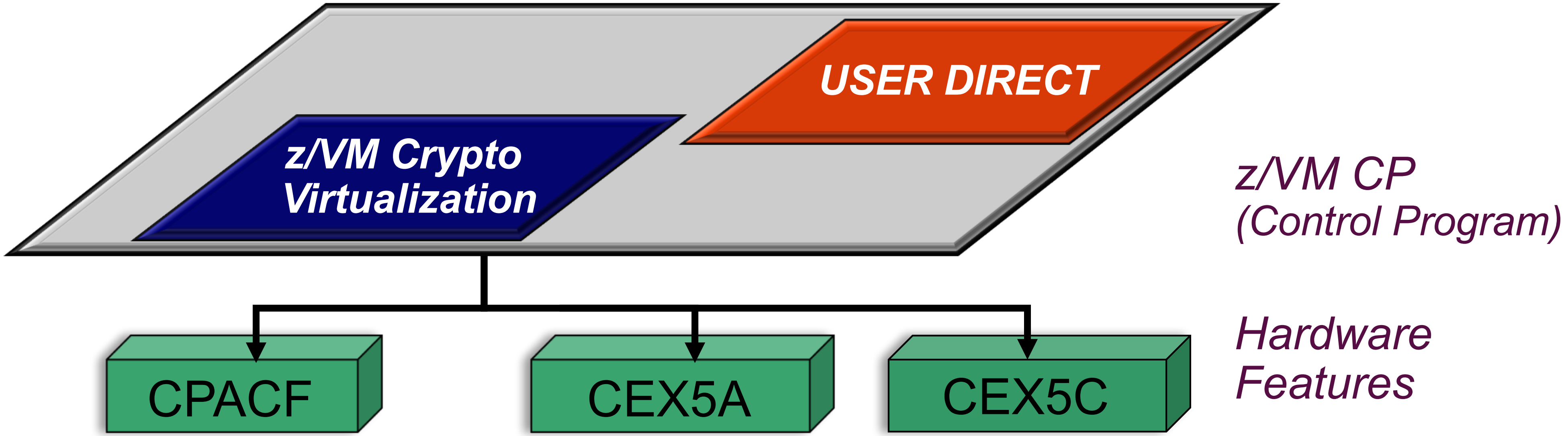
- **Protected keys (CCA only):**
  - Protected keys are encrypted under a Wrapping Key uniquely created for each LPAR
  - Cryptographic operations using protected keys can benefit from **CPACF** performance

z/VM Configuration for z Systems Cryptography

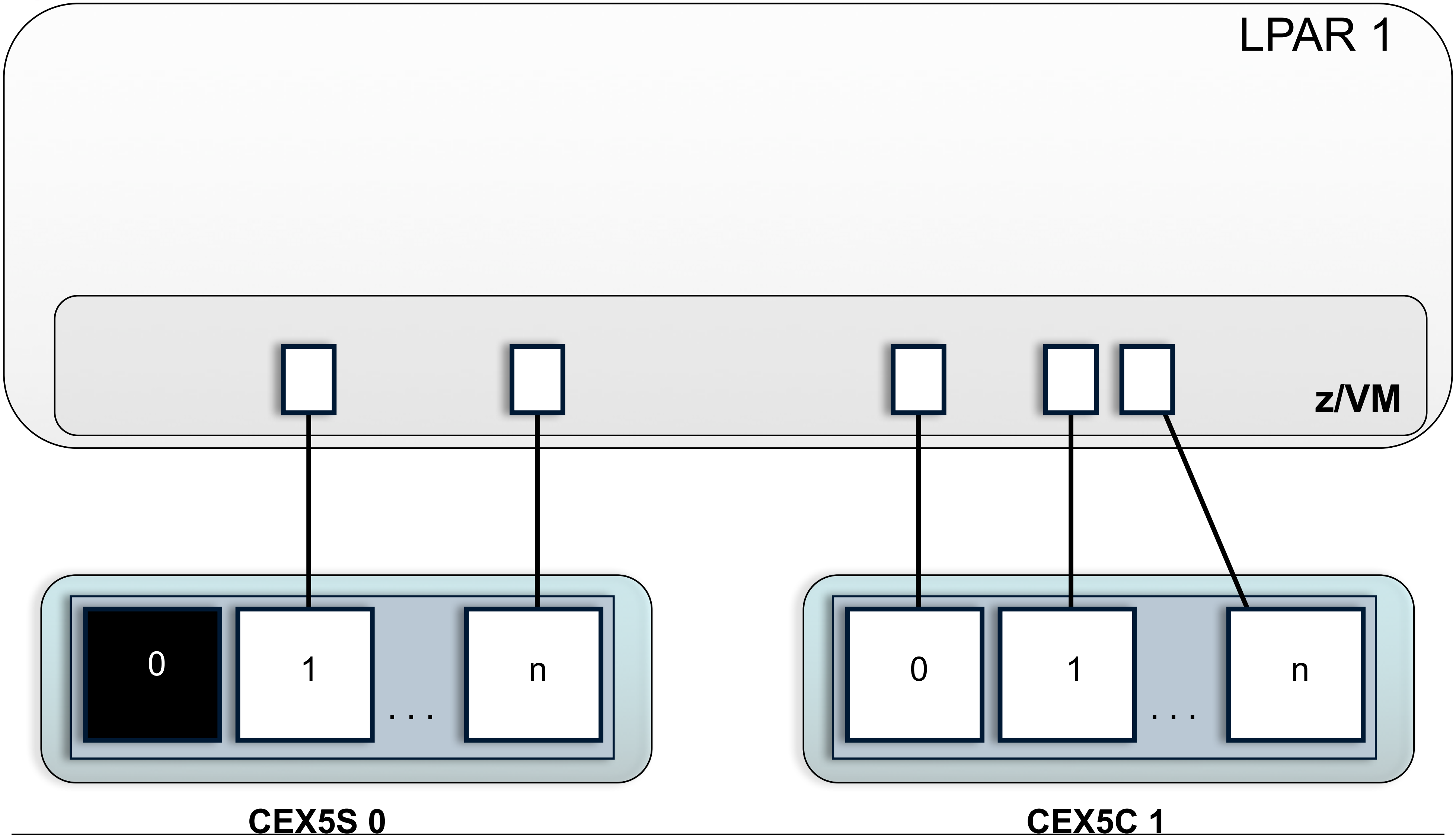


z/VM Virtualization of Hardware Cryptography
(stack view)

- Once domains are added to an LPAR running z/VM, they become available for guest use



z/VM Virtualization of Hardware Cryptography
(z/VM's view)



#vmworkshop #IBMz #zVM

z/VM Virtualization of Hardware Cryptography

The **CRYPTO User Directory statement** grants a z/VM userid access to cryptographic features associated with the hardware:

```
                     v----------+                          v--------+
CRYPto -+- DOMAIN ---+-domains -+- APDEDicated -+- aps --+---><
        |                                                |
        +- APVIRTual-------------------------------------^
```

APDED

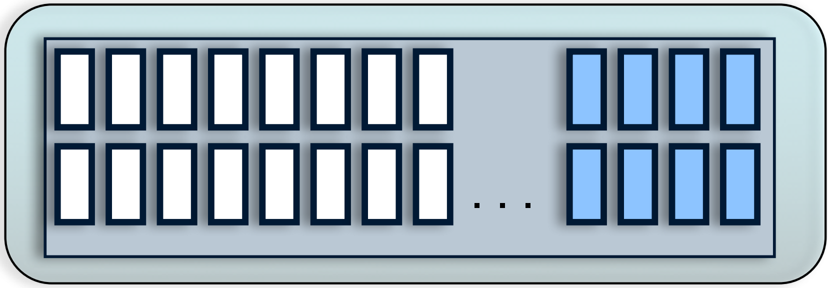
Dedicates a particular AP domain (or set of domains) to this virtual machine. Domains granted in the directory are “reserved for dedication”; they are not actually in-use until the virtual machine logs on.

APVIRT

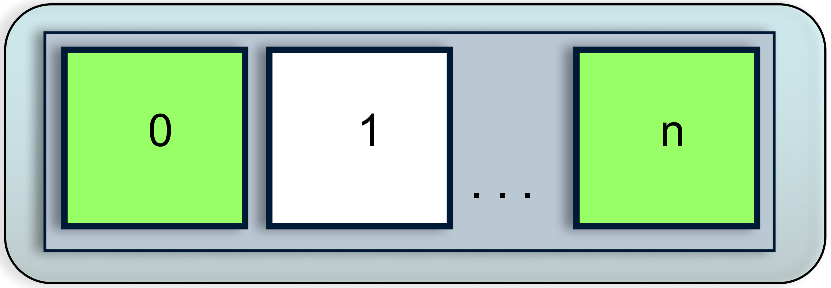
Virtual machine can access a collection of domains controlled by the system.

Support for Crypto Express5S

- z/VM 6.2 and z/VM 6.3 only
  - z13 GA 1 – APAR VM65577
  - z13 GA 2 and z13s GA 1 – apply GA 1 service, then APAR VM65716
- Expanded domain selection for dedicated domains
  - z/VM supports architected limits for CryptoExpress domains
  - CEX5S on z13 supports 85 domains per feature, maximum of 16 features
  - Z13s supports 40 domains per feature
- APDED really does mean dedicated; no collision is permitted
  - In a race, the first guest to LOGON has all requests fulfilled
  - Collisions void the latter guest's domain claims for an entire AP

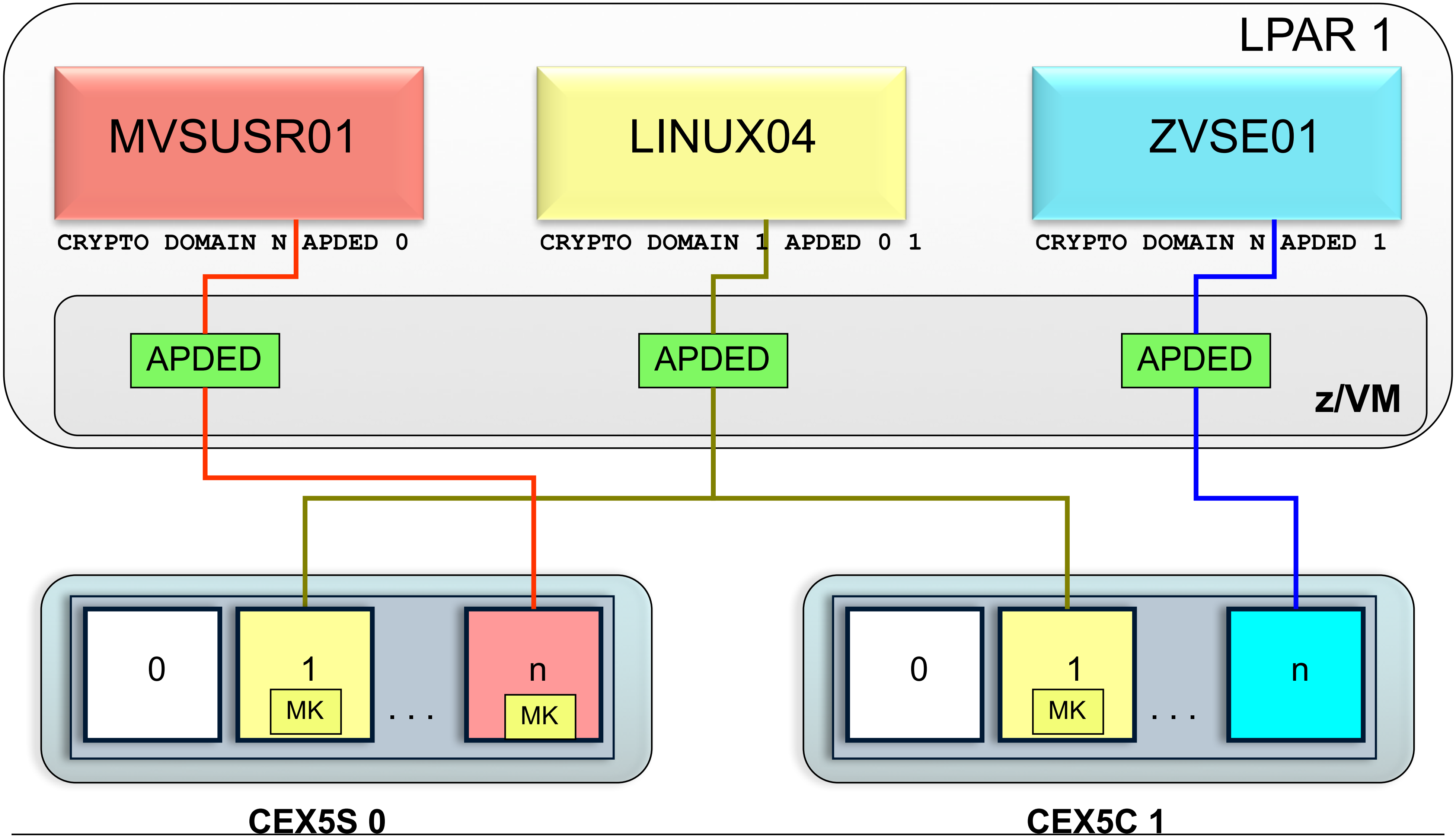


CEX5C 0

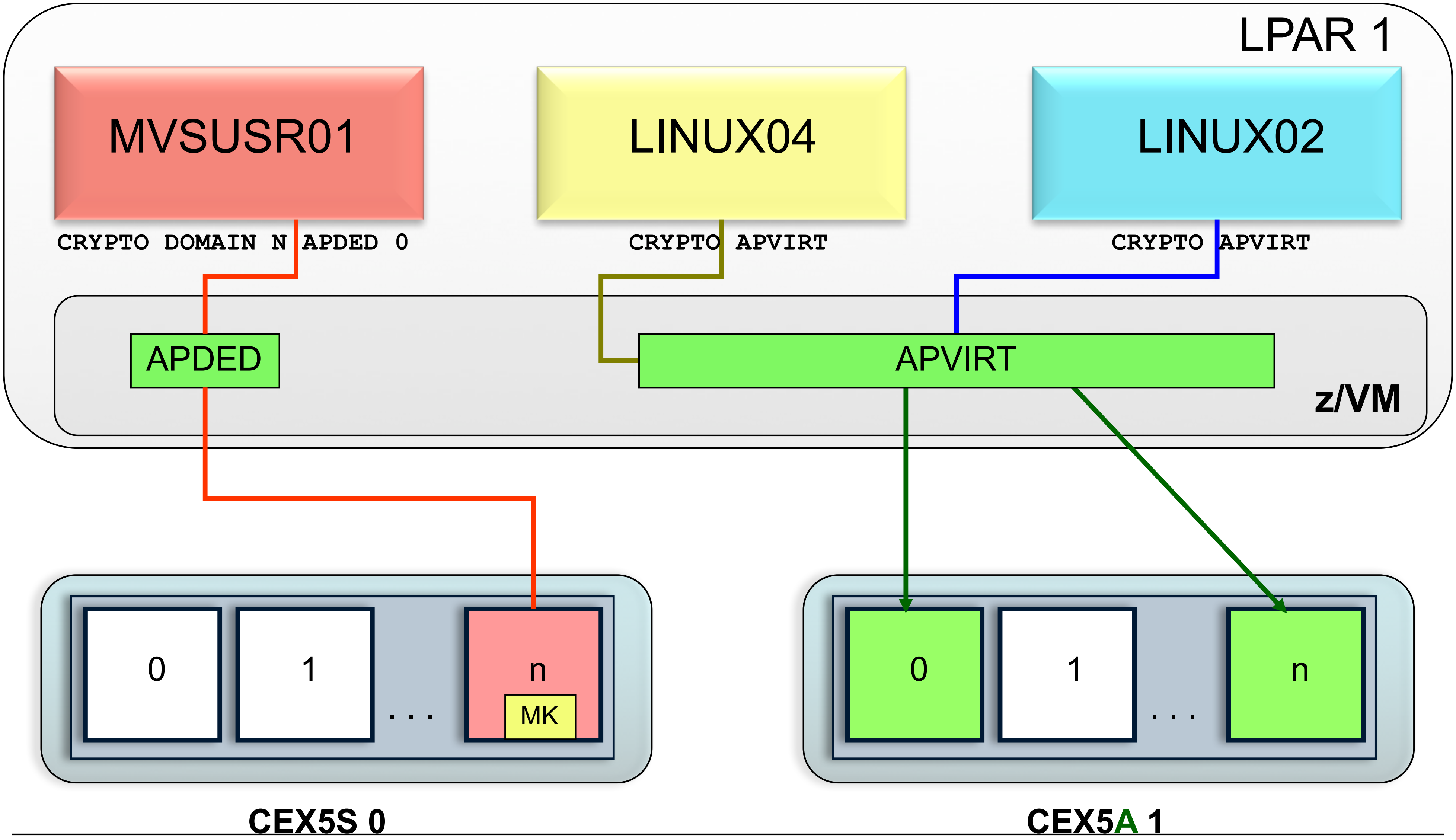


CEX5A 1

Assigning AP Domains to z/VM Guests



Assigning AP Domains to z/VM Guests

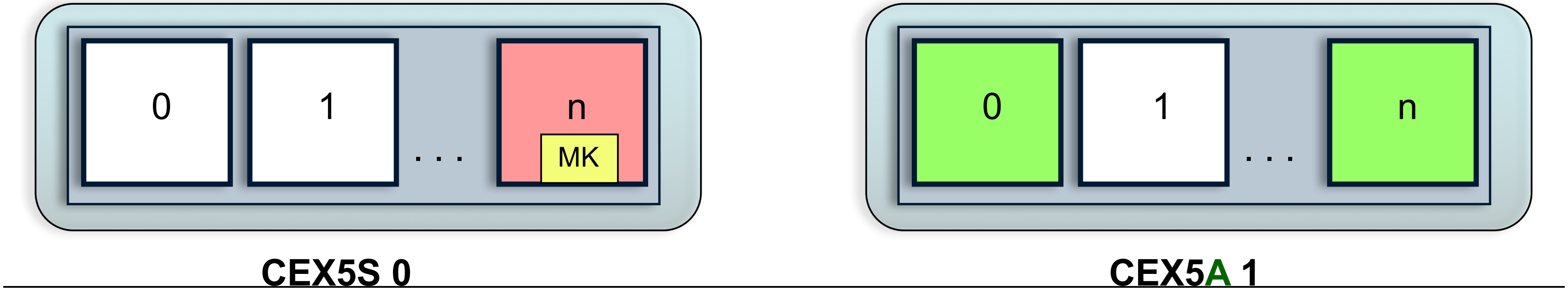


Notes on APVIRT Domain Selection

- Any domain in APVIRT will behave as an accelerator (**clear-key RSA**)
  - – Whether it is or not it is configured as one or not
  - – CP will discard coprocessor operations sent to an APVIRT domain
  - – This is done for security context reasons (and why APVIRT is meant for clear-key)

- APVIRT domains are selected by mode and release level
  - – Default behavior if nothing specified in System Configuration file (see next slide)
  - – Accelerator is chosen before coprocessor
  - – CEX5S is chosen before CEX4S before CEX3 …

- EP11 domains cannot be used for APVIRT



Assigning Domains to APVIRT

(z/VM V6 APAR VM65577, or in V6.4 Base)

- z/VM supports a new System Configuration statement for z/VM V6 which allows a system administrator to assign APVIRT domains for use by CP:

```
CRYPTO APVIRT AP 1 DOMAIN 0 1
CRYPTO APVIRT AP 0 DOMAIN 22
```

- Usage Notes:
  - z/VM will designate the first available domain in its list as the type
  - Any other available domains in SYSTEM CONFIG that are also of that type are designated for APVIRT usage
  - Domains that do not meet criteria are ignored.

- If this statement is not present in the System Configuration file, z/VM will use default APVIRT domain selection behavior

Assigning Domains to APVIRT

(z/VM V6 APAR VM65577, or in V6.4 Base)

- Given the following System Configuration:

```
    CRYPTO APVIRT 1 2 DOMAIN 7 8
    CRYPTO APVIRT 4 DOMAIN 9
```

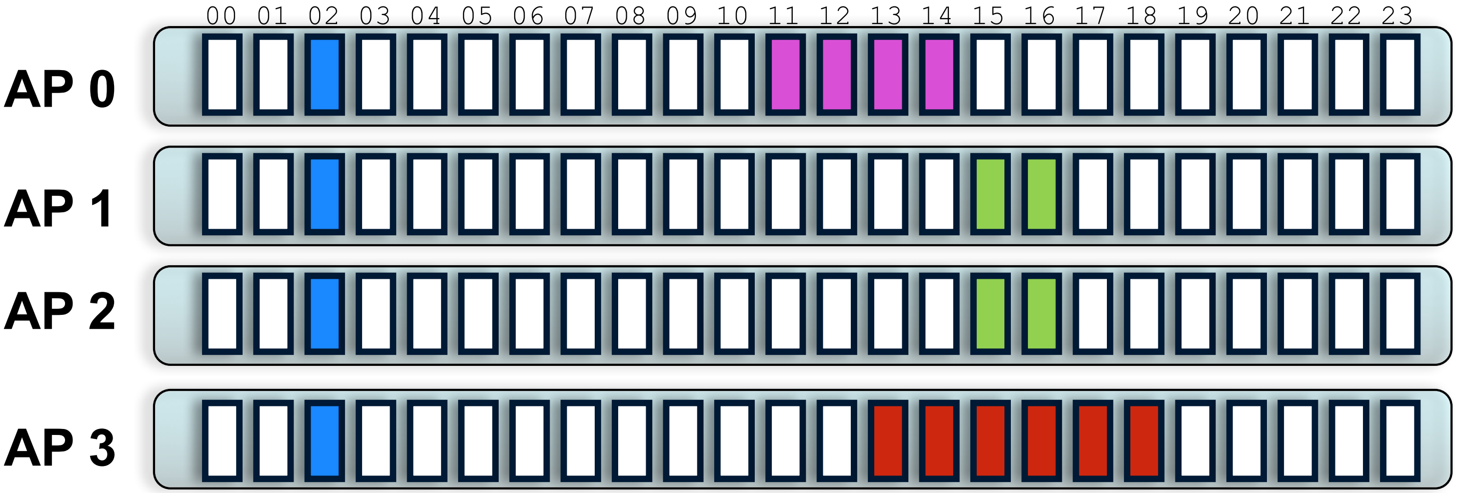
… z/VM V6 will check domains in the following order:

```
    AP 1 DOMAIN 7          /* CEX5A */
    AP 1 DOMAIN 8          /* CEX5A */
    AP 2 DOMAIN 7          /* CEX4A */
    AP 2 DOMAIN 8          /* CEX4A */
    AP 4 DOMAIN 9          /* CEX5C */
```

- If **AP 1 DOMAIN 7** is available at system initialization, it will be APVIRT.
  - APVIRT must use type CEX5A
  - Only AP 1 DOMAIN 8, with a matching type, is set as APVIRT
  - If a guest lists AP 1 DOMAIN 7 as **APDED**, the guest will be denied access

Example: Assigning Domains for z/VM

- **System Configuration:** CRYPTO APVIRT AP 1-2 DOMAIN 15-16
- **Guest A:** CRYPTO DOMAIN 13-18 APDED 0-3
  /* Conflicts on AP 1-2; no domains granted on AP 1 or 2. */
- **Guest B:** CRYPTO DOMAIN 11-14 APDED 0
  /* Conflict at Domain 14. No Domains granted on this AP. */
- **Guest C:** CRYPTO DOMAIN 2 APDED 0-3
  /* No conflicts. */
- **Reverse the logon order** of Guest A and Guest B ...



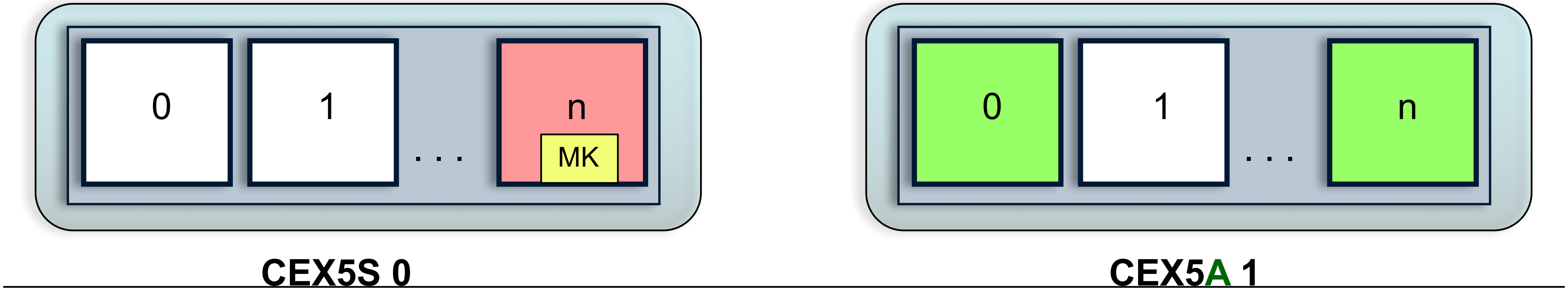
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AP 0	□	□	🟦	□	□	□	□	□	□	□	□	🟪	🟪	🟪	🟪	□	□	□	□	□	□	□	□	□
AP 1	□	□	🟦	□	□	□	□	□	□	□	□	□	□	□	□	🟩	🟩	□	□	□	□	□	□	□
AP 2	□	□	🟦	□	□	□	□	□	□	□	□	□	□	□	□	🟩	🟩	□	□	□	□	□	□	□
AP 3	□	□	🟦	□	□	□	□	□	□	□	□	□	□	🟥	🟥	🟥	🟥	🟥	🟥	□	□	□	□	□

z/VM Virtualization of Hardware Cryptography

QUERY CRYPTO

(Class A, B, C, or E) will display which domains/APs are available. Note that this list will be limited to devices available to a z/VM instance.

```
>>-Query--CRYPto--+--------------------+-------------------><
                  '-DOMains--+-------+-'
                             '-Users-'
```



z/VM Virtualization of Hardware Cryptography

```
QUERY CRYPTO DOMAINS USERS
```

AP device Domain nn device status system usage planned usage

```
01: AP 02 CEX3C  Domain 08 available    free                  unspecified
01: AP 03 CEX3A  Domain 06 available    dedicated to BWHUGEN  dedication
01: AP 03 CEX3A  Domain 07 available    free                  unspecified
01: AP 03 CEX3A  Domain 08 available    shared                shared
01: AP 04 CEX4C  Domain 06 available    free                  dedication
01: AP 04 CEX4C  Domain 07 available    free                  dedication
01: AP 04 CEX4C  Domain 08 available    free                  unspecified
Ready;
```

z/VM Virtualization of Hardware Cryptography

QUERY VIRTUAL CRYPTO

(Class G) will display virtual crypto facilities for your guest.

Keyword “virtual” required for Guests with A, B, C, or E privileges.

```
           ,--Virtual---,
>>-Query--+------------+--CRYPto---->< 
```

```
QUERY VIRTUAL CRYPTO
```

```
AP 03 CEX3A Domain 06 dedicated
Ready;
```

Assigning AP Domains to z/VM Guests

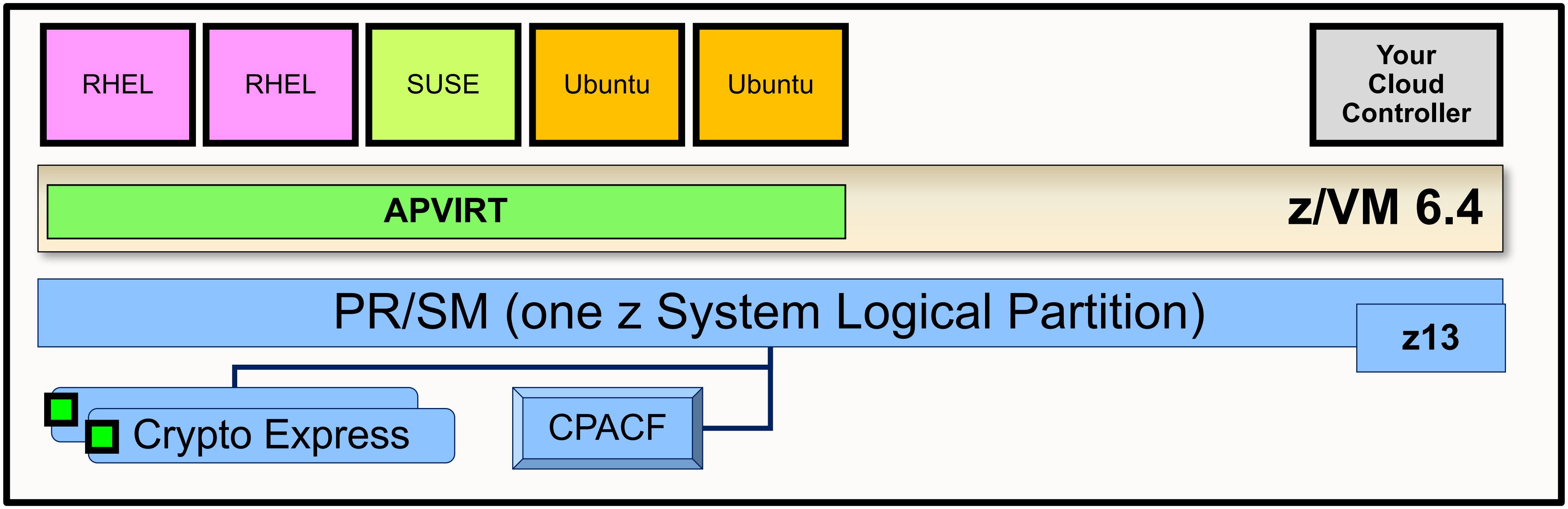
- **The Big Question: Which type of domain do I want to assign to my guest?**

- **It depends:**
  - Do you need secure key operations? (APDED)
  - Does your security policy require physical isolation? (APDED)
  - Do your guests need to exploit EP11 mode? (APDED **only**)
  - Do you need to relocate your guest? (APVIRT*)
  - Can you share your domains without impact to security or performance? (APVIRT)
  - Are you running out of domains attached to the LPAR?
  - Are your guests similar, cloned, or tied to HA solutions?
  - Does your guest operating system have particular restrictions?

- Different guests will have different needs, based upon their drivers and configuration requirements …

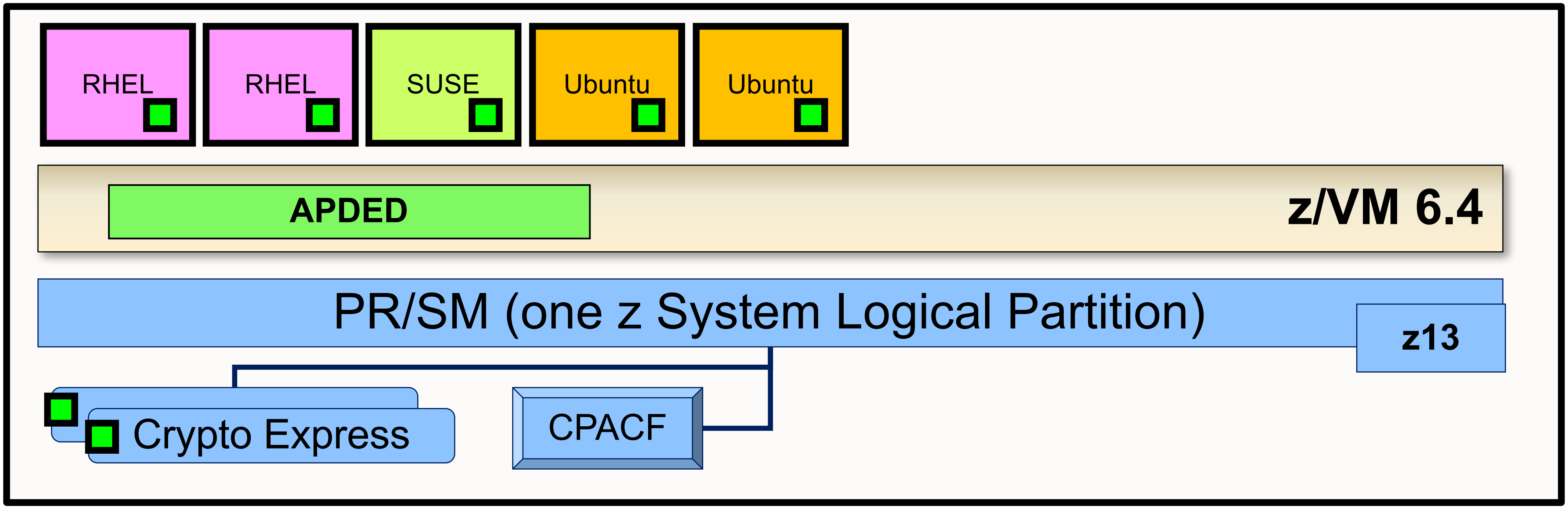
*Note: some restrictions apply. Consult the *CP Planning and Administration Guide* or *Getting Started With Linux* manuals.

Sample: LinuxONE Developer Cloud

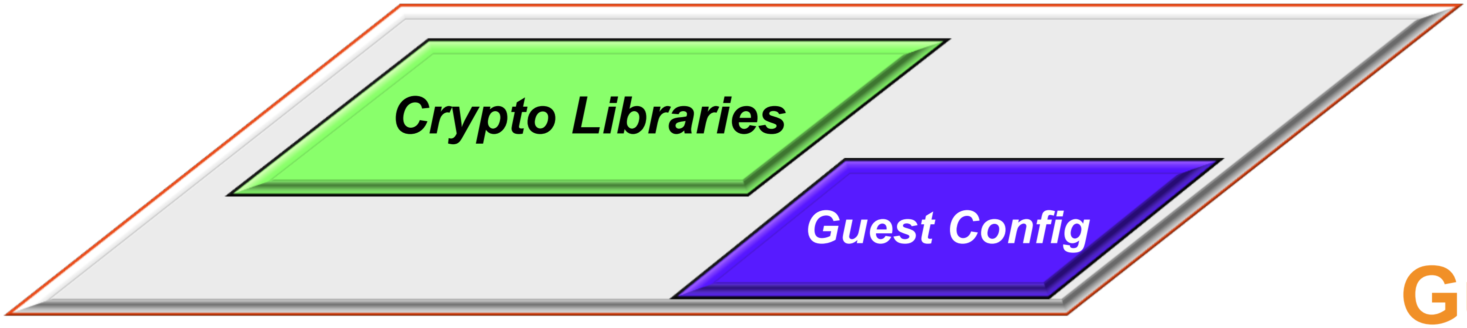


- **Crypto operations**: SSH (RSA, SHA-2, AES), and *whatever stuff you write inside the guests*
- **Environmental Requirements**: Relocatable (it's a cloud)
- **Recommended Hardware**:
  - CPACF
  - Crypto Express CCA Accelerator
    - Assign 1 domain from 2-3 different features (hardware failover, performance)

Sample: Linux on z Blockchain (*not* HSBN)

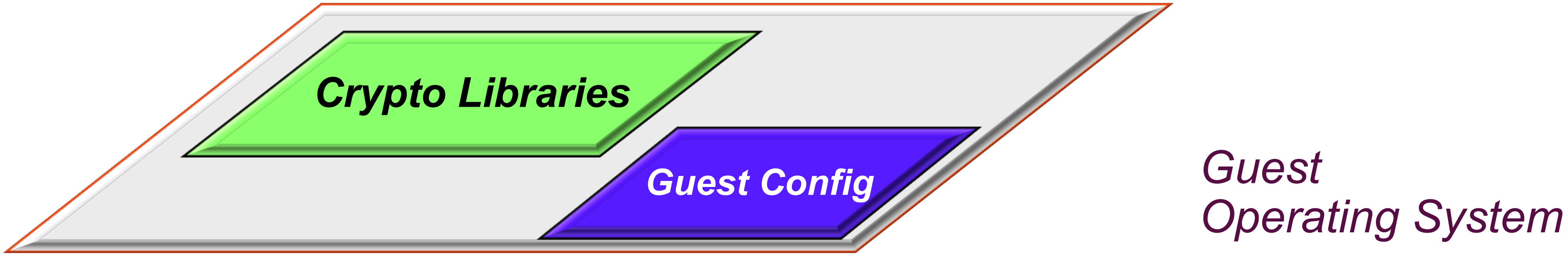


- **Crypto operations**: A lot. It's a Blockchain
- **Environmental Requirements**: Protection of key material. (It's a Blockchain.)
- **Recommended Hardware**:
  - CPACF (required for secure and protected key ops on the crypto adapters)
  - Crypto Express CCA Coprocessors
    - One domain per guest participating in the Hyperledger fabric



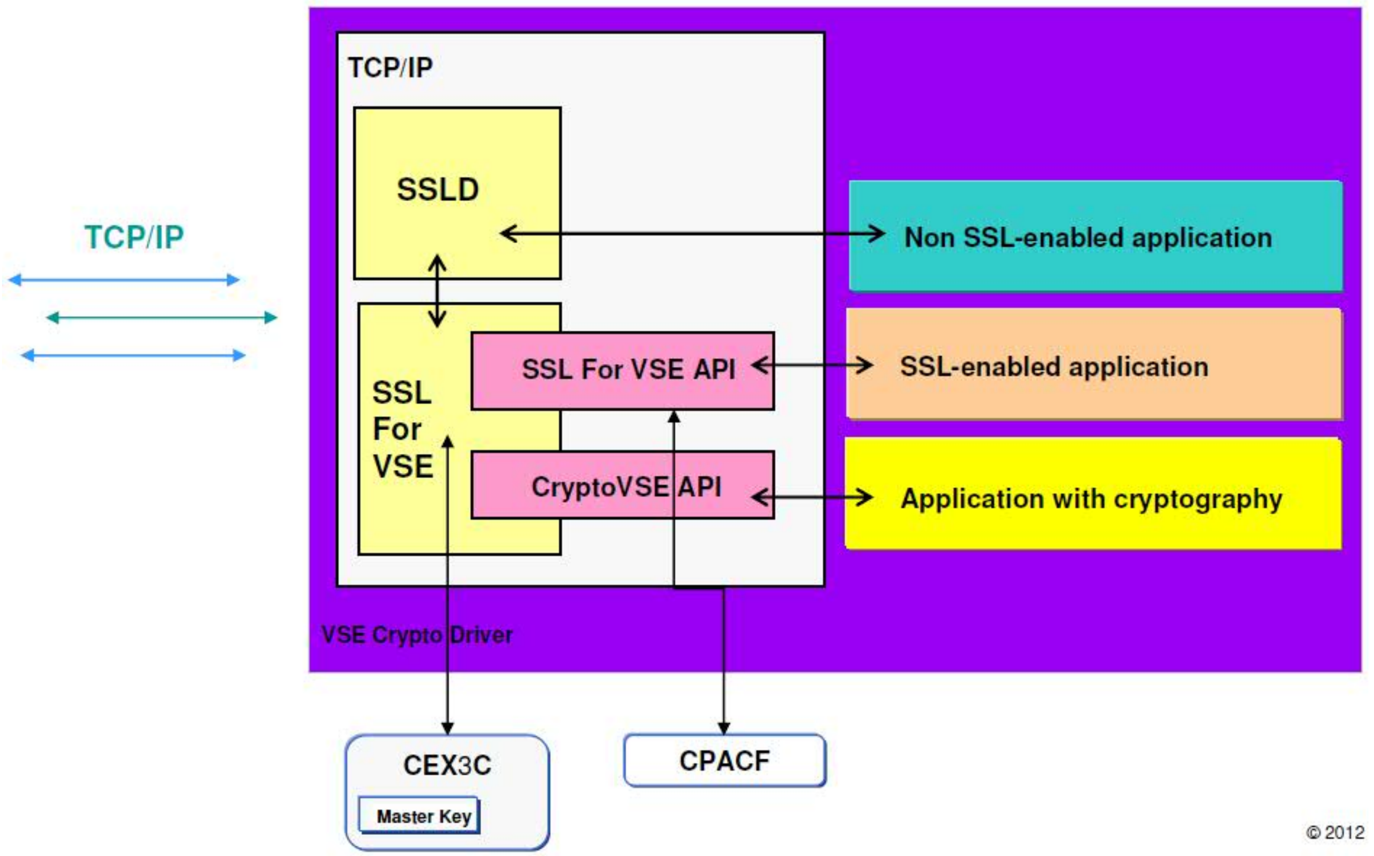
Guest Usage of the z Systems Cryptographic Features

z/VM Virtualization of Hardware Cryptography



- Cryptographic libraries will vary from operating system to operating system
- Some may require specific configuration to make use of certain features
- Consult pertinent local documentation

z/VSE Cryptographic Infrastructure



- z/VSE automatically detects any Crypto Express features dedicated to (or shared with) the virtual machine in which it's running

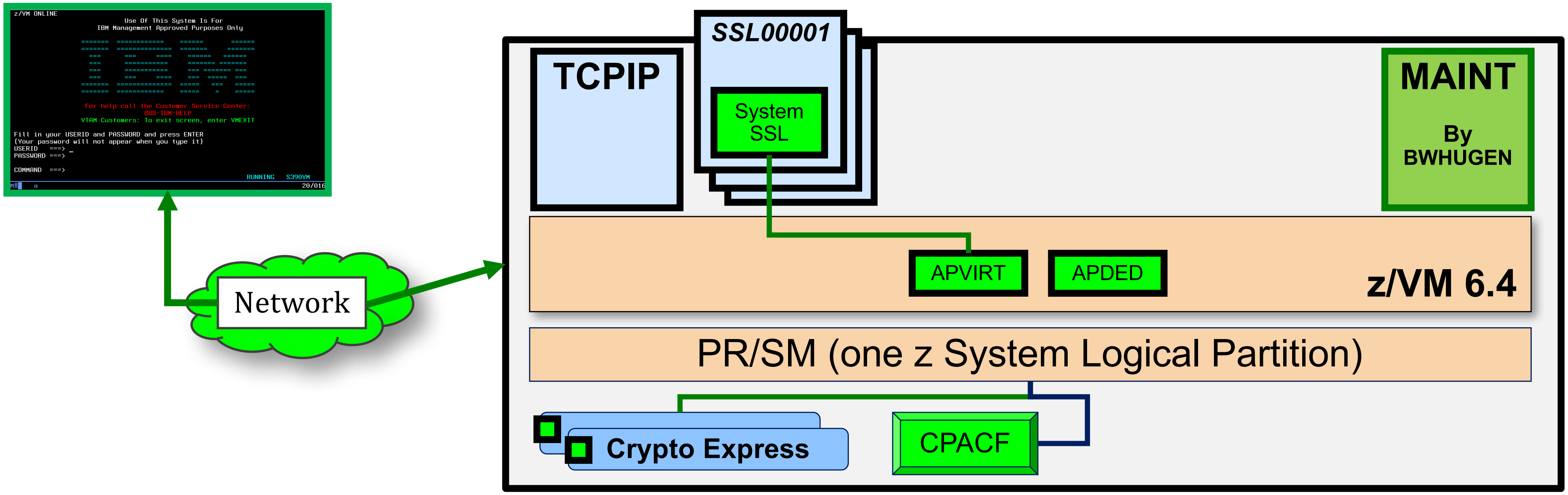
CMS Guests Running on z/VM

- CMS guests can utilize CPACF if enabled
  - Need to issue appropriate machine instructions
  - Some features (Pipelines, TLS/SSL Server) use these automatically

- The CMS environment does not have Crypto Express libraries
  - Different instructions / communication paths than CPACF
  - Nothing available yet for general system programmer use

Crypto APVIRT for the z/VM TLS/SSL Server

PTFs for APAR PI72106



```
z/VM ONLINE
                        Use Of This System Is For
                   IBM Management Approved Purposes Only

               =======  ============    ======      ======
               =======  ==============  =======    =======
                 ===      ===    ====     ======   ======
                 ===      ===========     ======= =======
                 ===      ===========     === ======= ===
                 ===      ===    ====     ===  =====  ===
               =======  ==============  =====   ===   =====
               =======  ============    =====    =    =====

               For help call the Customer Service Center:
                              888-IBM-HELP
               VTAM Customers: To exit screen, enter VMEXIT

Fill in your USERID and PASSWORD and press ENTER
(Your password will not appear when you type it)
USERID   ===> _
PASSWORD ===>

COMMAND  ===>
                                                    RUNNING   S390VM
MA    a                                                           20/016
```

- If Crypto Express domains are defined for sharing, then TLS/SSL Server will use them
  - **Clear-key RSA operations** are the primary beneficiary
    - Handshaking, rather than data transfer – **benefit will come from a lot of connections**
    - Will still use CPACF when pertinent
  - Meant as a performance enabler, not to replace key storage (still need .kdb or .p12 in BFS)
- Also works for your LDAP/VM Server!

Crypto APVIRT for the z/VM TLS/SSL Server

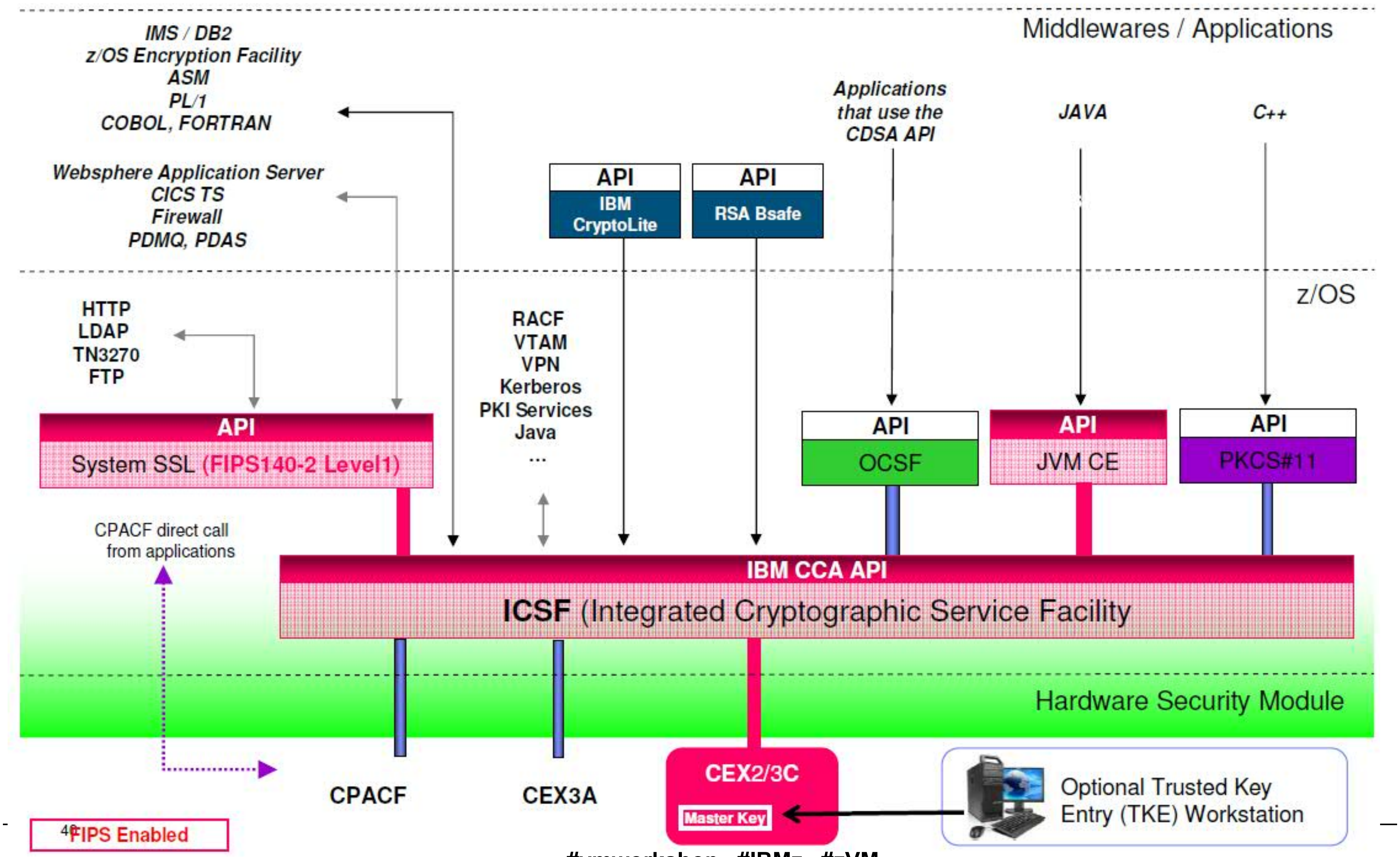
PTFs for APAR PI72106

```
PROFILE TCPSSL10
  CRYPTO APVIRTUAL
  IPL CMS PARM FILEPOOL VMSYS
  IUCV ALLOW
  LOGONBY GSKADMIN TCPMNT10 BWHUGEN
  NAMESAVE TCPIP10
  OPTION ACCT MAXCONN 1024 QUICKDSP
  POSIXINFO UID 7 GNAME security
  SHARE RELATIVE 3000
  CONSOLE 0009 3215 T
  [...]
```

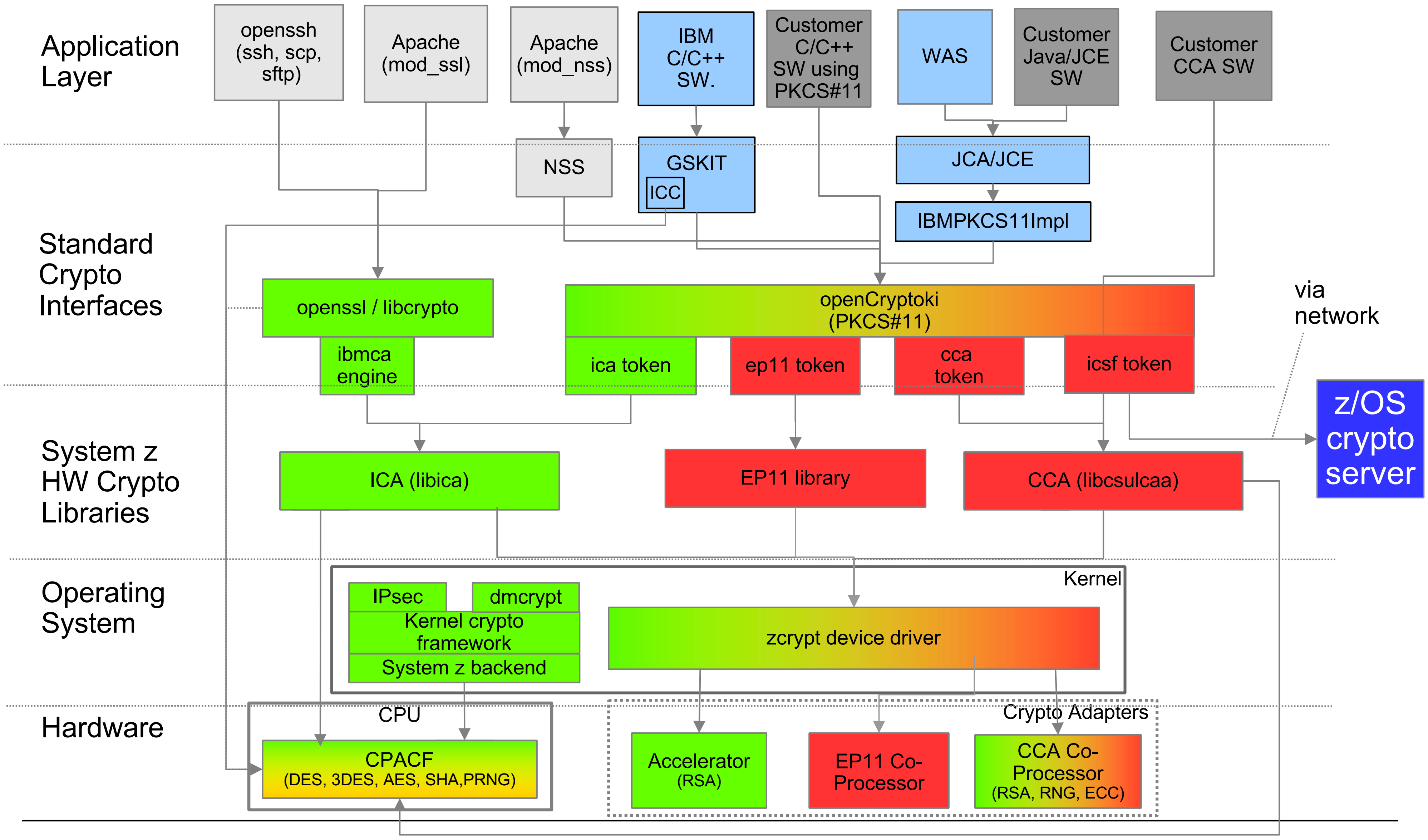
- Add `CRYPTO APVIRT` to your SSL server's PROFILE entry
  - **TCPSSLU** - the default PROFILE entry for the TLS/SSL Server
  - APDED not allowed for a POOL of userids

- Insert directly into VM definition for:
  - **LDAPSRV** - uses its own System SSL calls
  - **GSKADMIN** - for certificate creation / management
  - A **stand-alone TLS/SSL server** (non-POOL)

z/OS Cryptographic Infrastructure



Linux on z Systems Crypto Infrastructure



🟩 clear key 🟨 protected key 🟥 secure key

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Linux Kernel and Cryptography

- **The Linux kernel provides a set of cryptographic functions**
  - Generic, platform-independent implementations of cryptographic algorithms
  - Support for platform-optimized algorithms that are automatically used if available

- **The Linux on z Systems kernel includes support for**
  - Exploiting CPACF to optimize and accelerate symmetric cryptographic functions
  - Managing Crypto Express cards with the ***zcrypt*** device driver

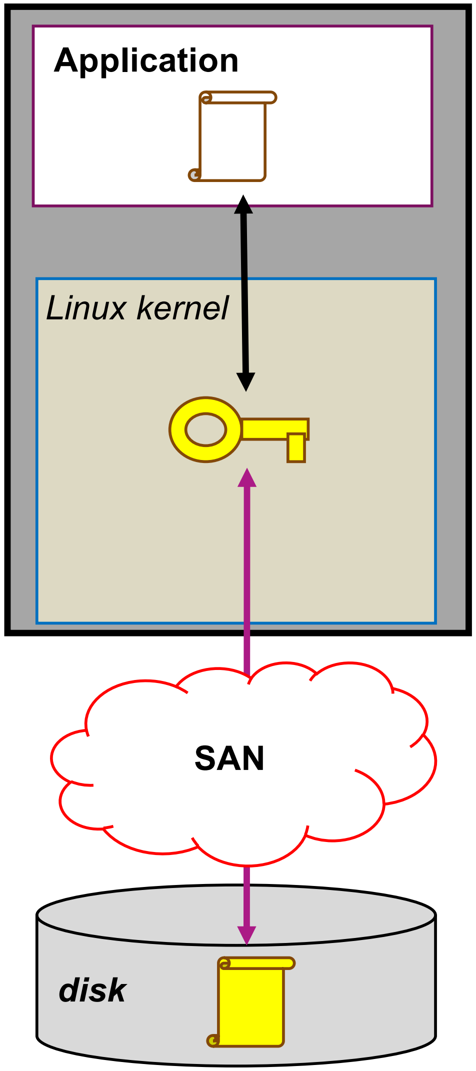
- **Which applications can benefit from accelerated in-kernel cryptographic functions?**
  - IPsec and ssh (from the beginning of the presentation, remember?)
  - Linux device-mappers – for example, **dm-crypt** or **eCryptFS**

File Systems Encryption (dm-crypt)

- **dm-crypt** (transparent disk encryption subsystem)
  - Inserts layer of crypto between block device & accessing file systems or apps
  - Positioned between file system and device mapper

- Administration done through `cryptsetup`
  - Uses LUKS (Linux Unified Key Setup)
  - Choose cipher/hashing algorithms from `/proc/crypto/procfs`
  - HW crypto (AES-CBC, XTS-AES)

- Can also set up encrypted filesystems during init
  - `/etc/crypttab` (referenced before `/etc/fstab`)
  - Bear in mind, though, interactive password prompts will still wait for you



Linux Support for Crypto Express5S

Today: Toleration Support

- Linux kernel recognizes CEX5S adapter and treats it as CEX4S adapter
- New **sysfs** attribute shows its real identity under `/sys/bus/ap/raw_hwtype`
- Supported Distributions
  - SLES 11 SP3 + maintenance
  - SLES 12 + maintenance
  - RHEL 7.1
  - RHEL 6.6 + maintenance
  - RHLE 5.11
- Some Restrictions Apply
  - http://www.ibm.com/developerworks/linux/linux390/distribution_hints_z13.html

Linux Support for Crypto Express5S

Toleration Support

- Linux kernel recognizes CEX5S adapter and treats it as CEX4S adapter
- support domains 0 - 84
- new sysfs attribute shows its real identity under **`/sys/bus/ap/raw_hwtype`**
- new syfs attribute shows max ID of adapter domains: **`/sys/bus/ap_max_domain_id`**
- supported distributions
  - SLES 11 SP3 + maintenance
  - SLES 12 + maintenance
  - RHEL 7.1
  - RHEL 6.6 + maintenance
  - RHLE 5.11 (only 16 domains)
  - KVM 1.1.1
- Requires appropriate z/VM service

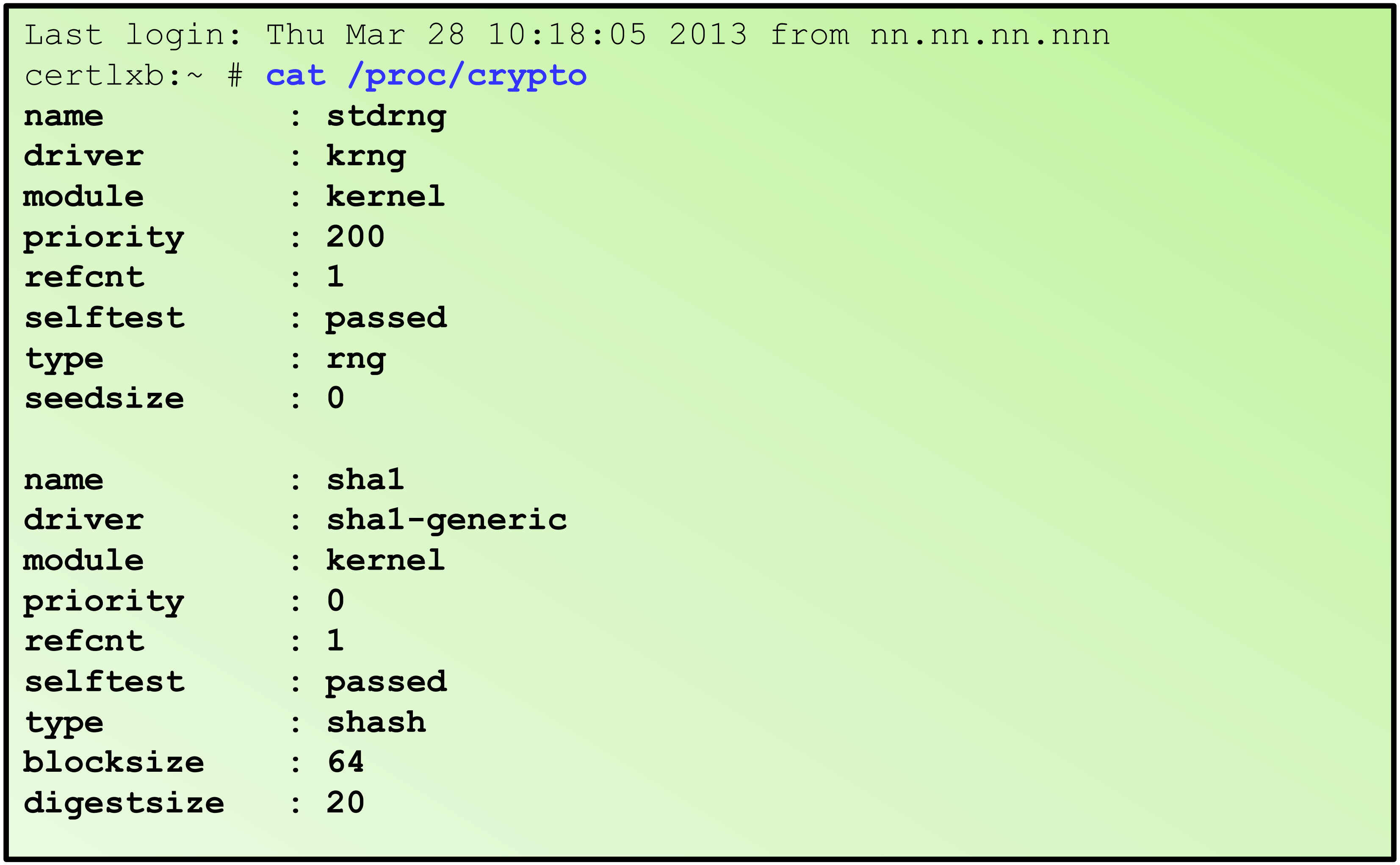
Exploitation Support

- Displays a CEX5S adapter as “CEX5A“, CEX5C” or “CEX5P”
- supported distributions
  - SLES 12 SP1
  - RHEL 7.2
  - Ubuntu 16.04

Validating Linux and z/VM Configuration

```
certlxb:~ # cat /proc/driver/z90crypt
zcrypt version: 2.1.1
Cryptographic domain: 6
Total device count: 1
PCICA count: 0
PCICC count: 0
PCIXCC MCL2 count: 0
PCIXCC MCL3 count: 0
CEX4C count: 0
CEX4A count: 1
requestq count: 0
pendingq count: 0
Total open handles: 0
```

Validating Linux and z/VM Configuration



```
Last login: Thu Mar 28 10:18:05 2013 from nn.nn.nn.nnn
certlxb:~ # cat /proc/crypto
name         : stdrng
driver       : krng
module       : kernel
priority     : 200
refcnt       : 1
selftest     : passed
type         : rng
seedsize     : 0

name         : sha1
driver       : sha1-generic
module       : kernel
priority     : 0
refcnt       : 1
selftest     : passed
type         : shash
blocksize    : 64
digestsize   : 20
```

Validating Linux and z/VM Configuration

```
certlxb:~ # icainfo


The following CP Assist for Cryptographic Function
  (CPACF) operations are supported by libica on this
  system:

SHA-1:     yes
SHA-256:   yes
SHA-512:   yes
DES:       yes
TDES-128:  yes
TDES-192:  yes
AES-128:   yes
AES-192:   yes
AES-256:   yes
PRNG:      yes
```

Validating Linux and z/VM Configuration

- **`icastats`** – data from the libica crypto library
  - SLES 12 and RHEL 7.1

- **`cpacfstats`** – data about CPACF on-chip usage
  - On s390tools
  - Works for Linux running in an LPAR directly
  - CPUMF data (authorization required)

- **`lszcrypt`** – statistics on Crypto Express requests

Validating Linux and z/VM Configuration

```
certlxb:~ # sudo vmcp QUERY VIRTUAL CRYPTO
AP 01 CEX4A Queue 01 shared
```

- Remember that **QUERY VIRTUAL CRYPTO** is a Class G command
- This indicates the virtual AP number and virtual Domain number provided to the guest and the type of crypto feature being shared.

Questions?

Summary

- z Systems **hardware** cryptography accelerates the hard math of crypto
  - Saves **time**, saves CPU processing **power**, saves MIPS **cost**
  - Secure Key operations are FIPS 140-2 Level 4 certified

- z/VM **virtualizes** z Systems hardware cryptography
  - Architectural fidelity in all things z
  - A "shared" flavor as well as dedicated domain use

- **Guests** that understand cryptography can utilize z Systems cryptography
  - May require configuration of the guest to exploit
  - Different guests provide different options

- Don't let cryptography (or its terminology) scare you away
  - Security is meant to enhance business, not impede it
  - Cryptography protects your data, whether at rest or in flight

For More Information …

- z/VM Security: http://www.VM.ibm.com/security
- z Systems Security: http://www.ibm.com/systems/z/advantages/security/
- ***Security for Linux on System z*** (SG24-7728), IBM RedBooks
  http://www.redbooks.ibm.com/redbooks/pdfs/sg247728.pdf
- *z/VM Secure Configuration Guide*: http://publibz.boulder.ibm.com/epubs/pdf/hcss0b30.pdf
- IBM z13: http://www-03.ibm.com/systems/z/hardware/z13.html
- IBM z Systems Crypto Express Features:
  http://www-03.ibm.com/security/cryptocards/pciecc/overview.shtml

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@Bwhugen

RECOGNIZED SPEAKER/PRESENTER
IBM
Imparting knowledge
IBM PROFESSIONS

Dank u
Dutch

Merci
French

Спасибо
Russian

Gracias
Spanish

شكراً
Arabic

감사합니다
Korean

Tack så mycket
Swedish

धन्यवाद
Hindi

תודה רבה
Hebrew

Obrigado
Brazilian Portuguese

谢谢
Chinese

Dankon
Esperanto

Thank You

ありがとうございます
Japanese

Trugarez
Breton

Tak
Danish

Danke
German

Grazie
Italian

நன்றி
Tamil

děkuji
Czech

ขอบคุณ
Thai

go raibh maith agat
Gaelic

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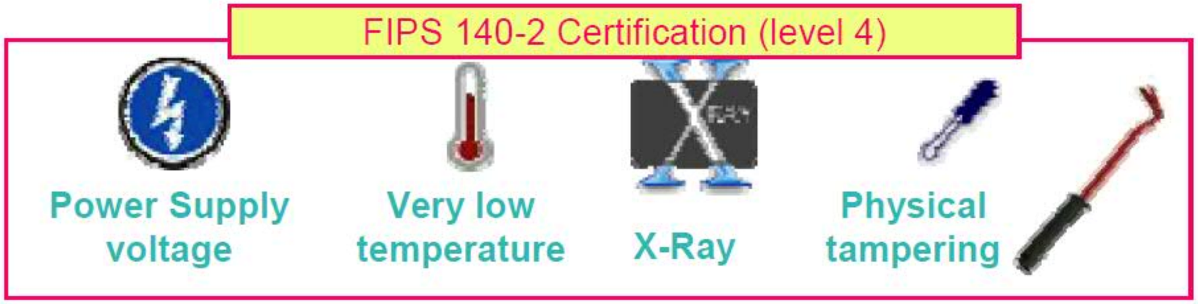
Frequently Asked Questions

Frequently Asked Questions

Do these crypto features meet any particular industry standards?

Answer: The Crypto Express cards are certified to the Federal Information Processing Standard (FIPS) 140-2 at Level 4. The **secure-key protection** not only meets HSM requirements, but is confirmed as zeroizing Master Keys in case of physical tampering, x-rays, power-supply interruption …



FIPS 140-2 Certification (level 4)

+ Master Key zeroization in case of tampering attempt

Frequently Asked Questions

- **Terminology question – is it a *domain?* or a *queue*? or an *AP?***

- **Answer**: In this context, “domain” and “queue” are mostly synonymous.

  z/VM’s QUERY CRYPTO command (as of z/VM 6.2) documents the sub-structures associated with the Crypto Express features as “domains.” APQS (short for ‘Adjunct Processor Queues’) is still accepted as an operand, and the terminology of ‘queues’ may still appear in documentation related to other IBM products.

  'Domain' may also refer to a paritucl ar queue number across multiple features – for example, "Domain 2 on cards 1, 2, 3, and 4."

  The ‘AP’ in abbreviations like ‘APDED’ and ‘APVIRT’ refers to ‘Adjunct Processor’ … which is another term of the Crypto Express features (CEX2 and onward).

Frequently Asked Questions

- **What happens if two z/VM guests have the same domain DEDicated to them on the CRYPTO statement?**

- **Answer**: The domain is considered “Reserved for Dedication” until one of the guests IPLs. At that time, the domain is considered dedicated. If the second guest IPLs at that time, the virtual machine will not receive that domain for use.

- **Update for z13**: Not only will the second guest not receive the conflicting domain, but it will not be able to access any of the domains it's reserved on that entire AP.

- ***Final Answer**: Be careful in your domain assignments*. Your guests should not swap dedicated domains!

Frequently Asked Questions

- **Bonus Question! Explain the following statement:**

```
CRYPTO DOMAIN 0 1 APDED 14 15
```

- **Answer**: The guest receives dedicated access to the following domains:

```
[0, 14]     [0, 15]      [1, 14]      [1, 15]
```

  – Domain assignation is a **union** of the AP queues and specific domains listed; be careful about assigning too many domains when configuring your z/VM virtual machines.

Frequently Asked Questions

- **Question: How do I determine how many instructions are being offloaded to CPACF or the Crypto Express features?**

- **Answer**: Depends upon your authority over the system.

- If you're operating at the hypervisor administrator level, you can use CP Monitor Records to determine the number of instructions executed. Use your application of choice to examine them.
  - **MRPRCAPC** – Crypto Performance Counters (Domain 5, Record 9)
  - **MRPRCAPM** – Crypto Performance Measurement Data (Domain 5, Record 10)

- Linux commands such as ***lszcrypt*** can be used to determine basic per-guest utilization, numbers of requests processed, etc..

Frequently Asked Questions

- **Question: I just overhauled my USER DIRECT, and suddenly my guests can't use their shared crypto domains. What happened??**

- **Answer**: On z/VM 5.4 (and on z/VM V6 before z13 support), there is no way for the system administrator to assign APVIRT domains specifically for system use. Instead, APVIRT domains are assigned at system IPL and are managed by CP.

  If you've rearranged your User Directory and reserved a previously shared domain for dedicated use, you may see errors related to availability. You may need to restart your z/VM LPAR to regain specific domains.

  Note: This will continue to be the default behavior for z/VM V6 for any system where a CRYPTO APVIRT statement is not specified in your System Configuration file.

Frequently Asked Questions

- **Question: what are those restrictions on migrating guests with crypto domains assigned to them?**

- **Answer**: For APVIRT, the target system must have Crypto Express domains available for APVIRT which match the same mode as what was available on the source system. So, if **SYSTEMA** is using CEX3A for APVIRT, then CEX3A must similarly be available on **SYSTEMB**.

  Additionally, the domain on the target system must provide the same level of *function*.

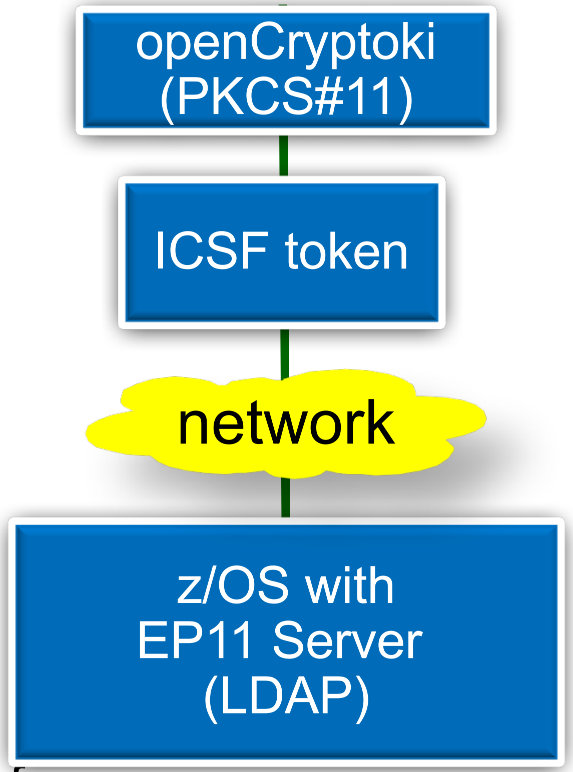
  Relocation of a Linux guest with dedicated use of a domain is not permitted.

*__Reminder__: Consult the *CP Planning and Administration Guide* or *Getting Started With Linux* manuals for more details!

Frequently Asked Questions

- **Can Linux on z crypto tie into my z/OS crypto?**

- **Answer**: Yes it can. ICSF Token Support has enabled a Linux client to tie into the z/OS Crypto-as-a-Service mechanisms (such as EKMF or ACSP)
- Available with z/OS 2.1 and RHEL 7.0
- Crypto requests are forwarded to ICSF on z/OS
  - Using LDAP protocol
  - Simple and SASL authentication
- Key objects are stored under z/OS
- Requires LDAP client set-up on Linux
- `pkcsicsf` utility for configuration
- token directory `/var/lib/opencryptoki/icsf`
- token configuration file to be referred to in opencryptoki.conf


openCryptoki
(PKCS#11)
ICSF token
network
z/OS with
EP11 Server
(LDAP)