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IMS/DB2 Database Crypto Support on z/OS

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Agenda

- Crypto Functions
- IBM Crypto Hardware on System z196
- ICSF
- Tape/DASD
- Exploiting Crypto on the Host
  - Data Encryption Tool for IMS and DB2
  - DB2 UDB Built-In Functions
- Exploiting Crypto in the Network
- Summary and References

Crypto Functions

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

System z Clear Key Crypto Hardware –z196

- CP Assist for Crypto Function (CPACF)
  - DES (56-, 112-, 168-bit)
  - AES-128, AES-192, AES-256
  - SHA-1, SHA-256, SHA-384, SHA-512 (SHA-2)
  - PRNG (Pseudo Random Number Generation)
  - Protected Key

TechDoc WP100810 – A Synopsis of System z Crypto Hardware

System z Secure Key Crypto Hardware - CEX3 (z196)

- Secure Key DES/TDES
- Secure Key AES
- Financial (PIN) Functions
- Key Generate/Key Management
- Random Number Generate and Generate Long
- Protected Key Support
- Elliptic Curve Digital Signature Algorithm (ECDSA)
- SSL Handshakes

TechDoc WP100810 – A Synopsis of System z Crypto Hardware

Clear Key / Secure Key / Protected Key

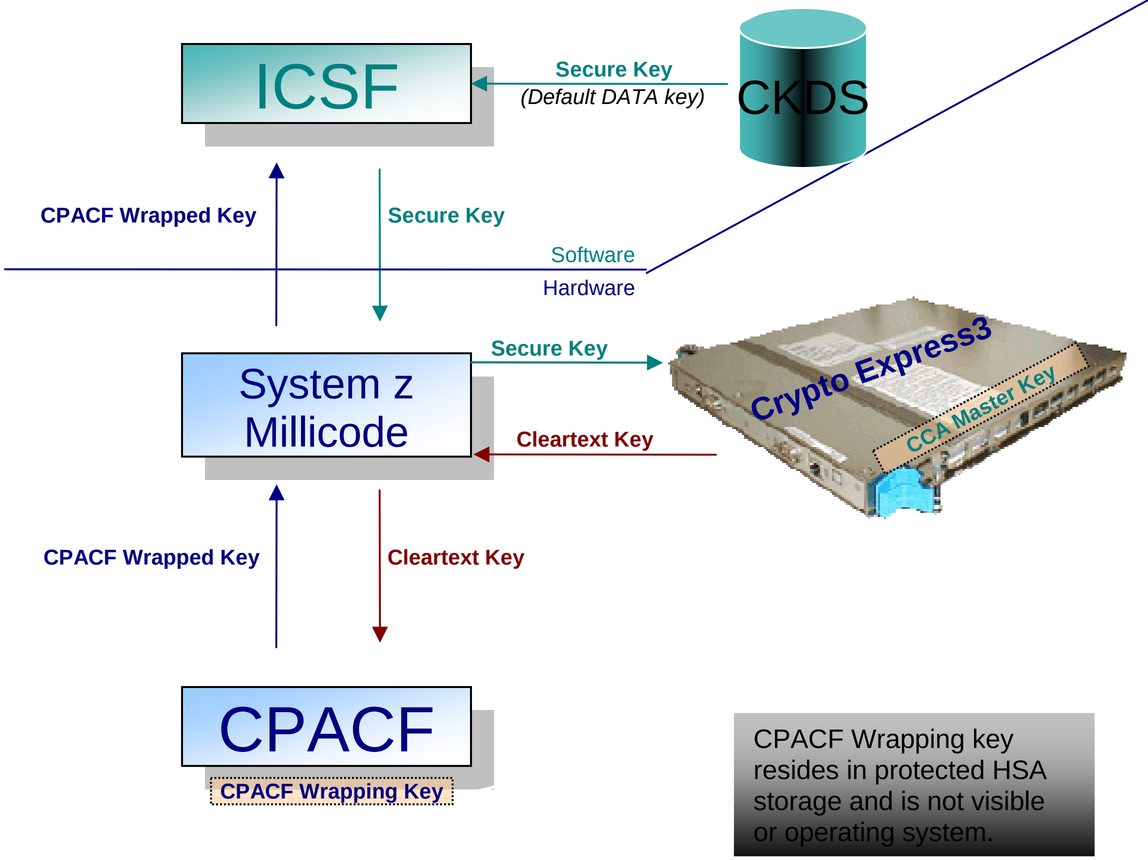
- Clear Key – key may be in the clear, at least briefly, somewhere in the environment
- Secure Key – key value does not exist in the clear outside of the HSM (secure, tamper-resistant boundary of the card)
- Protected Key – key value does not exist outside of physical hardware, although the hardware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

TechDoc WP100647 – A Clear Key / Secure Key / Protected Key Primer

CPACF Protected Key - Key Wrapping

CPACF Wrapped key cached in ICSF address space in.

Source key is stored in CKDS as a CCA MK wrapped key.



CPACF Wrapping key resides in protected HSA storage and is not visible or operating system.

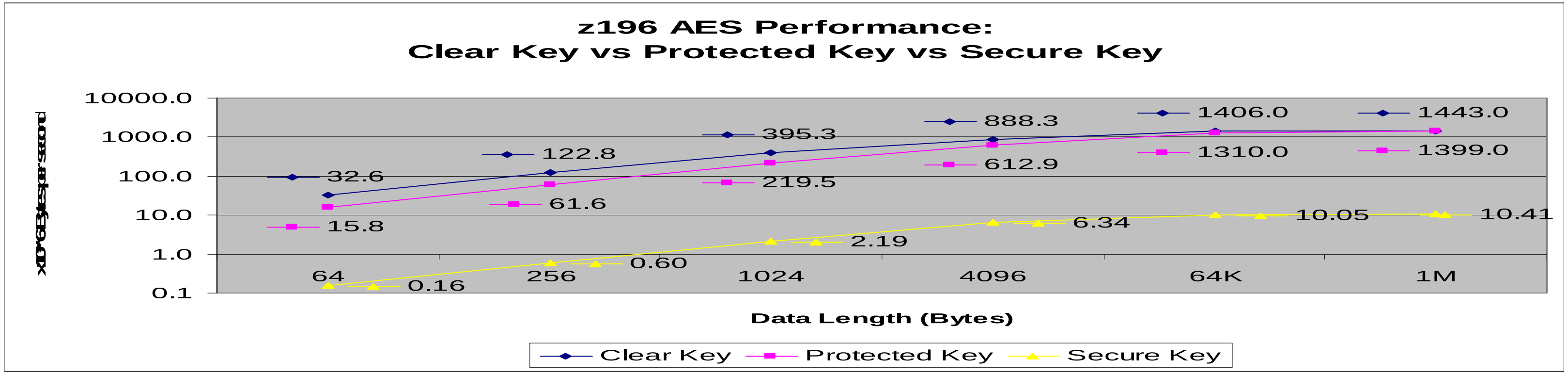
- Create a key ‘ABCD’, store as secure key (i.e. encrypted under Master Key, MK)
  - E_{MK}(x’ABCD’) => x’4A!2’
- Execute CSNBSYE (clear key API) with that key and text to be encrypted of ‘MY MSG ’
- ICSF will pass key value x’4A!2’ to CEX3, recover original key value, then wrap it using wrapping key
  - D_{MK}(x’ 4A!2’) => x’ ABCD’
  - E_{WK}(x’ABCD’) => x’*94E’
- ICSF will pass wrapped key value to CPACF, along with message to be encrypted
- In CPACF, unwrap key and perform encryption
  - D_{wk}(x’ *94E’) => x’ ABCD’
  - $E_{x’ABCD’}$(‘MY MSG ’) => ciphertext of x’ 81FF18019717D183’

z196 Crypto Performance

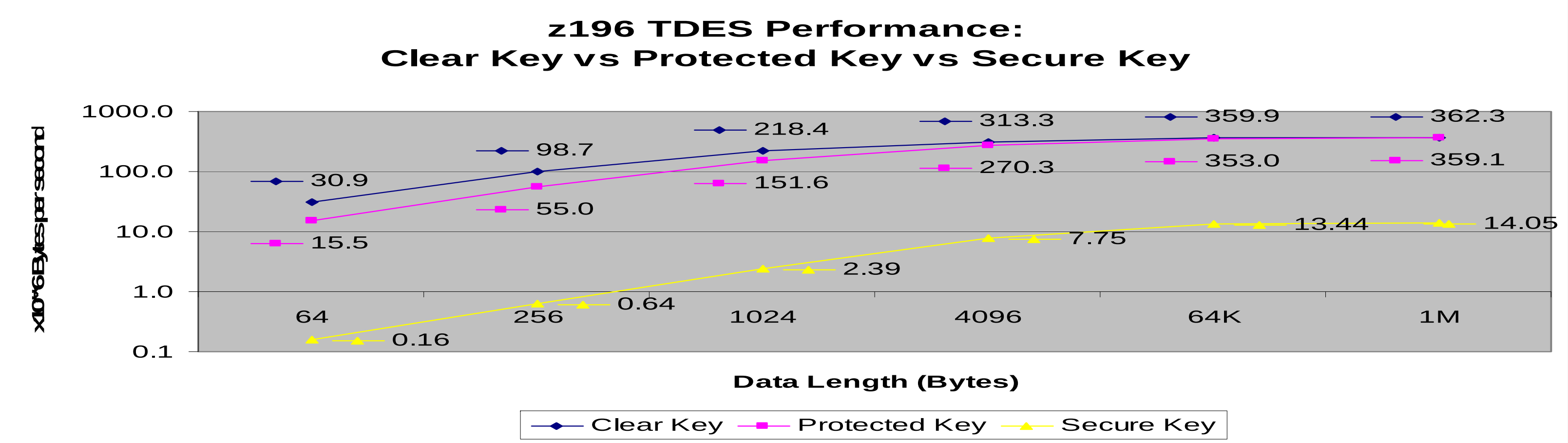
- From the Crypto Performance Whitepapers

  http://www.ibm.com/systems/z/advantages/security/z10cryptography.html

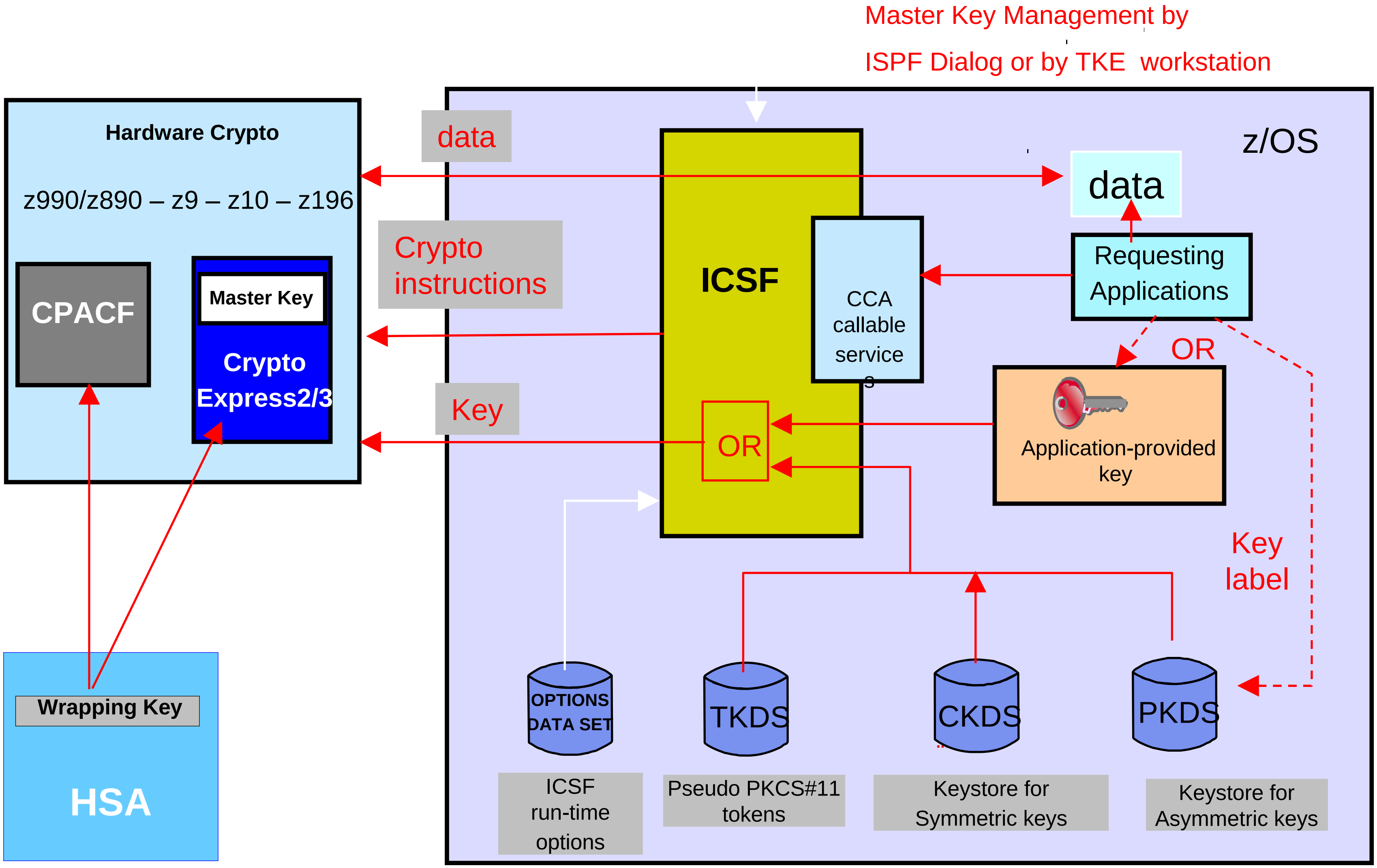
- AES Encryption



- TDES Encryption



z/OS Integrated Cryptographic Services Facility



Wrapping Key only supported on z10 or z196 with CEX3

SAF Protection

- ICSF uses SAF to protect resources
  - CSFKEYS Class
    - Protects the key by its label
  - CSFSERV Class
    - Profiles to protect the APIs
    - Profiles to protect ISPF panels
  - CSFKGUP profile to protect the Key Generation Utility Program
- Key Store Policies
  - Key Token Authorization Checking
  - Default Key Label Checking
  - Duplicate Key Token Checking
  - Granular Key Label Access Control
  - Symmetric Key Label Export Control

Refer to the z/OS ICSF Administration Guide for a list of *service_names* that can be protected

IBM Tape Based Encryption

- LTO4 and LTO5 - Open Systems
- TS1120, TS1130, TS1140 - Open Systems and Mainframe
- AES-256 bit encryption
- All files on the tape are protected using a single key
  - Which is in turn encrypted using RSA (public/private key algorithms)
- TKLM, Tivoli Key Lifecycle Manager or just announced, ISKLM IBM Security Key Lifecycle Manager is required for DS8000 and recommended for Tapes

IBM DS8000 Disk Encryption - Characteristics

- Customer data at rest is encrypted
  - Data at rest = data on any disk or in any persistent memory
- Customer data in flight is not encrypted
  - Data in flight = on I/O interfaces or in dynamic memories (Cache, NVS)
    - If you can read/write to disk, you get access to clear-text data.
- Uses Encrypting Disk
  - Encryption hardware in disk (AES 128)
  - Runs at full data rate (146/300/450 GBs 15K RPM)- No measurable performance impact
- Integrated with Tivoli Key Lifecycle Manager (TKLM) or IBM Security Key Lifecycle Manager (ISKLM)
  - DS8000 automatically communicates with TKLM when configuring encryption group or at power on to obtain necessary encryption keys to access customer data
  - Each disk has an encryption key
    - Data is always encrypted on write and decrypted on read
    - Encryption key is wrapped with access credential and maintained within the disk
    - Access credential maintained by TKLM/ISKLM
    - Establishing a new encryption key causes cryptographic erasure
- Key attack vectors prevented:
  - Disk removed (repair, or stolen)
  - Box removed (retire, or stolen)

Encryption of Data within the Database

- Critical requirement for most of the “popular” data protection initiatives: To protect “data at rest” to ensure that the only access is for business need-to-know, and through mechanisms which can be controlled by the native security mechanisms (such as RACF)
- Consider the following scenario - DB2 Linear VSAM datasets are protected via RACF from direct access outside of DB2 using dataset access rules
    - DBA or Storage Administrator has RACF authority to read VSAM datasets in order to perform legitimate storage administration activities
    - Administration privileges can be abused to read the linear VSAM datasets directly and access clear-text data outside of DB2/RACF protections
- Now consider the above scenario, but with the underlying Linear VSAM datasets encrypted
    - When DBA or Storage Administrator uses their RACF dataset authorities in a manner which is outside of business need-to-know, the data retrieved is cybertext and thus remains encrypted and protected
    - Only way to access and obtain clear-text data will be via SQL which can be protected via DB2/RACF interface

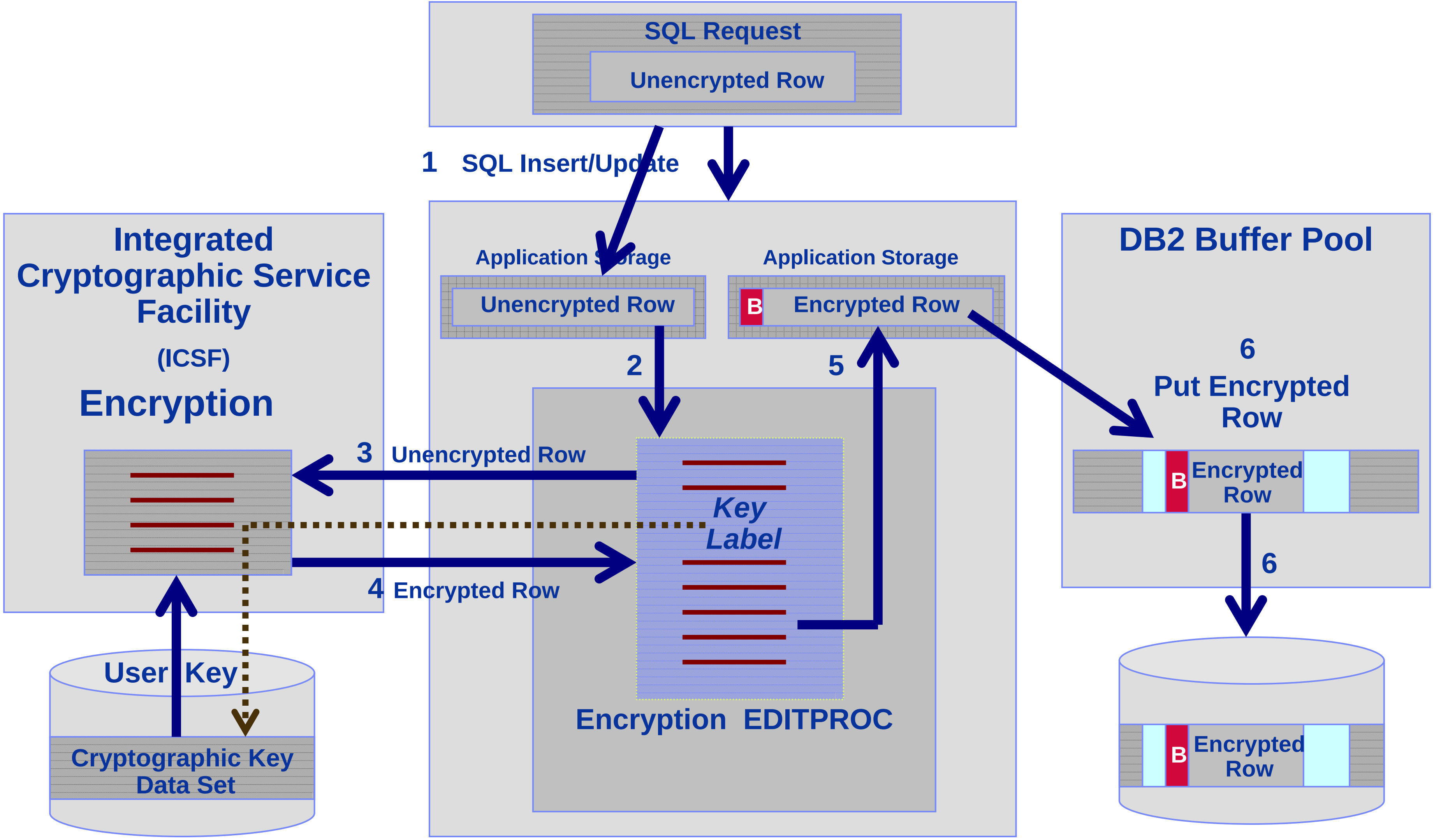
Database Encryption

- Data Encryption Tool for IMS & DB2 Databases (5799-P03)
- DB2 UDB Built-In Functions

The Data Encryption Tool – How It Works

- Via an EDITPROC, for every row processed by any SQL Utility for DB2 or IMS
  - No application changes required
  - One key per table or segment specified in the EDITPROC
  - Can use Clear Key, Secure Key or Protected Key
    - Protected key requires HCR7770 or later and CEX3
  - Encrypted row same length as clear row

DB2 Data Encryption Flow – Insert / Update



DB2 Built-In Functions – How It Works

- Under application control - for every field that must be encrypted ex. encrypt(data,'password for encryption',hint)
  - 'Password for Encryption' is hashed to generate a unique key
  - Hint can be used as a prompt for remembering the key
  - Encrypted field must be defined as VARCHAR (since it will contain binary data once its encrypted) and the encrypted field will be longer (next multiple of 8 bytes + 24 bytes of MetaData + 32 bytes for optional hint field)
    - Password is hashed via MD5 to create 128 bit key
    - Password + data is then encrypted using TDES with 128 bit key

Cryptographic Keys

- Data Encryption Tool
  - Clear Key or Secure Key or Protected Key
  - Key must be stored in the CKDS
  - When the table with an EDITPROC is in use, the key is available in the DB2 address space
- DB2 BIF
  - Clear key only (it’s calculated from the password for encryption in software)
  - Keys are not stored in a dataset, but the password for encryption is stored in the table

Cryptographic Key Changes

- Data Encryption Tool
  - Unload, change EDITPROC to reference new key, reload
  - Unload, change current key, DB2 restart, reload
- DB2 BIF
  - Under application control

Database Indexes

- Data Encryption Tool
  - EDITPROC encrypts the entire row, so the data is encrypted, but the index is not
    - Bad for security, good for performance
- DB2 BIF
  - Application encrypts the field, if that field is an index, then the index is encrypted
    - Good for security, bad for performance

Crypto Hardware for Data Encryption Tool

- Clear Key

z196/z10/z9/z890/z990	CPACF (& PCIXCC or CEXnC for CKDS*)

- Secure Key

z890/z990	Requires a PCIXCC or CEX2
Z9	Requires a CEX2C
z10	Requires a CEX2C or CEX3C
z196	Requires a CEX3C

- Protected Key

z10/z196	Requires a CEX3C**

*Prior to HCR7750, a CEXnC is required to create and use a CKDS, beginning with HCR7751 ICSF supports a clear key only CKDS

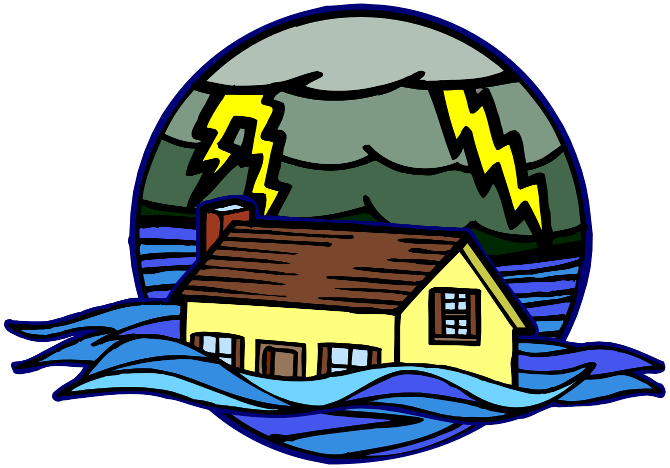
**Protected Key support requires HCR7770 or higher

Crypto Hardware for DB2 BIFs

- z196/z10/z9/z990/z890
  - CPACF (uses MSA instructions, not the ICSF APIs), but ICSF must be started to provide hashing support
  - TDES only

Disaster Recovery Considerations

- The major requirement is that the appropriate crypto hardware be available at the DR site
  - Clear Key / Secure Key / Protected Key
  - Key lengths
- Master keys must be available at the DR site



Side-by-side Comparison

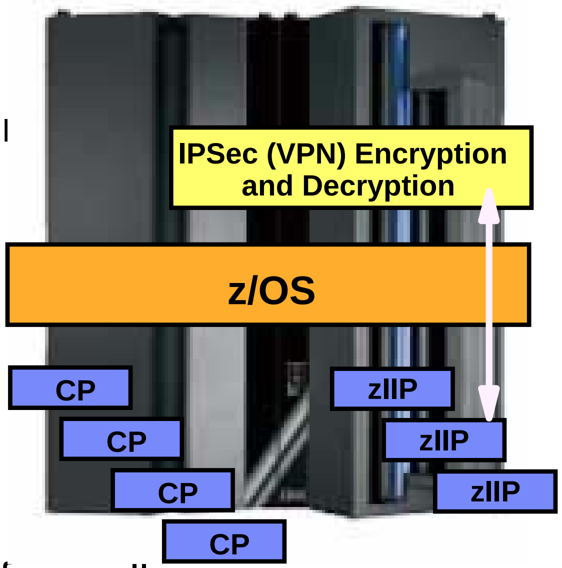
	Column (DB2 Built-In Functions)	Row/Table (IBM Encryption Tool for IMS and DB2)
DB2 Support	▪V8, V9, V10 ▪Data in indexes is encrypted ▪Does not work w/DB2 Load Utility ▪Data type of encrypted columns must be FOR BIT DATA	▪V7.x, V8.x, V9.x, v10.x ▪DB2 index data is not encrypted. ▪Works with all DB2 utilities
Application Change Required	▪Application must change to invoke the BIFs for the columns that will be encrypted	▪No application change, but each table will need to be recreated with an EDITPROC
Transaction Processing Overhead	▪The cost overhead depends on hardware, DB2 and application access	▪Each row individually encrypted
Key Management	▪Application has responsibility for the encryption key	▪Keys are managed by and accessed through ICSF
Pre-Reqs	▪ICSF must be active ▪CPACF hardware	▪ICSF must be active ▪Secure PCI card, unless running HCR7751 or later and clear key only CKDS

Decisions, Decisions …

- Ownership (i.e. politics)
  - Data Administrator - Data Encryption Tool
    - sets up the EDITPROC and specifies the key to be used for the entire table
    - Key must be defined to/managed by ICSF (stored in the CKDS)
  - Application - DB2
    - Application logic determines which key to use for each field/column
    - Password is managed by the application
- Security requirements
- Performance requirements
- Application/production support
- Space considerations
- Crypto hardware available

zIIP Assisted IPSec (VPN) on z/OS

- **Benefits of having secure channel end-point on z/OS**
  - Security regulations compliance - No clear-text data on any networ segments
  - End-to-end authentication of secure channel end-points
    - Both end-point authentication and message authentication
  - Key management and storage done on System z by z/OS
  - Compliance with end-to-end security regulations
- **System z CPU cost is a concern**
  - Encryption/decryption CPU cost can be a significant percentage of overall CPU cost for a given application
  - Especially the case for streaming workloads (file transfer type of workload)
- **zIIP processors**
  - Specialty processor on System z9 or later hardware
  - zIIPs priced lower than general purpose processors
  - No IBM software charges on zIIPs
- **zIIP Assisted IPSec**
  - Use zIIP processors for most IPSec encryption/decryption
  - Lower the cost of doing IPSec processing on z/OS



System z9 or later
z/OS CS V1R8 + PTFs
z/OS CS V1R9

Closing Thoughts

- Encryption has a cost
  - Crypto hardware more efficient with large blocks of data
- Secure Key on a PCI Card – longer pathlength
- Clear Key exists in the DB2 Address Space; Protected Key and Secure Key as well, but they are encrypted under the Wrapping Key or Master Key

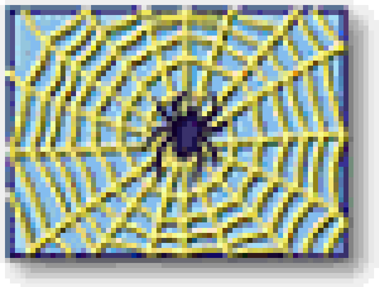
References

- Cryptography Books
  - Bruce Schneier, ‘Applied Cryptography Second Edition: Protocols, Algorithms, and Source Code in “C”’, Addison Wesley Longman, Inc., 1997
  - Simon Singh, ‘The Code Book’, Anchor Books, 1999
  - Niels Ferguson, Bruce Schneier, ‘Practical Cryptography’, Wiley Publishing, Inc. 2003
- Standards
  - www.ietf.org – Internet Engineering Task Force
  - www.csrc.nist.gov – Computer Security Resource Center of NIST
  - www.rsasecurity.com/rsalabs - Research site for RSA Security
- Free Stuff
  - www.scmagazine.com - SC Magazine
  - www.counterpane.com – Bruce Schneier web site with monthly newsletter

IBM Pubs

- ICSF Overview, SA22-7519
- ICSF Administrator’s Guide, SA22-7521
- ICSF Application Programmer’s Guide, SA22-7522
- ICSF System Programmer’s Guide, SA22-7520

IBM Resources (on the web)



- Redbooks – www.redbooks.ibm.com ‘Crypto’
  - z9-109 Crypto and TKE V5 Update, SG24-7123
  - IBM zEnterprise System Technical Introduction, SG24-7832
  - IBM zEnterprise System Technical Guide, SG24-7833
  - IBM zEnterprise 196 Configuration Setup, SG24-7834
- ATS TechDocs Web Site www.ibm.com/support/techdocs (Search All Documents for keyword of ‘Crypto’)
  - WP100810 – A Synopsis of System z Crypto Hardware
  - WP100647 – A Clear Key/Secure Key/Protected Key Primer
- Web Download Site
  - http://www.ibm.com/systems/z/os/zos/downloads/

Data Encryption for DB2 - Reference Materials

- SC18-9549 IBM Data Encryption Tool for IMS and DB2 Databases User Guide
  - Includes an appendix on activating crypto on your hardware
- ICSF Manuals
  - SA22-7520 ICSF System Programmer’s Guide
  - SA22-7521 ICSF Administrator’s Guide
- Redbooks
  - DB2 UDB for z/OS Version 8 Performance Topics – SG24-6465
- Articles
  - IMS Newletter article: “Encrypt your IMS and DB2 data on z/OS” - ftp://ftp.software.ibm.com/software/data/ims/shelf/quarterly/fall2005.pdf

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