News on z/VSE Security, Crypto Support and OpenSSL for z/VSE

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http://www.ibm.com/zVSE

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Notes:
Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.
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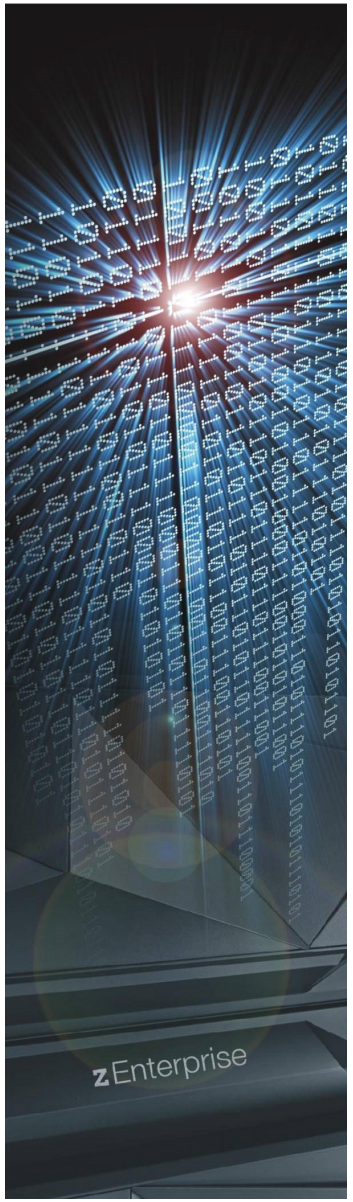
Agenda

- **Introduction**
- **Cryptography basics**
  - Encryption algorithms
  - Encryption keys
  - Diffie-Hellman versus RSA
  - Elliptic Curve Cryptography
  - Recommendations
- **Using cryptography with z/VSE**
  - Full tape encryption
  - Encryption Facility for z/VSE
  - SSL/TLS
  - SecureFTP
  - Hardware cryptography support on z Systems
  - OpenSSL
  - What's new with z/VSE V6.2

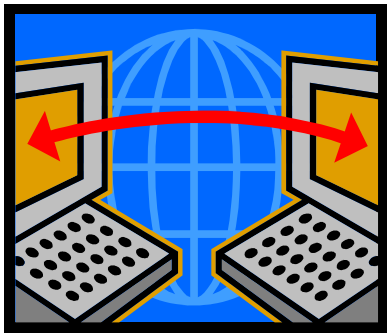


Why secure VSE ?

- **Prevent unauthorized access to VSE and data**
  - Keep secret data secret
  - Data modification by unauthorized users

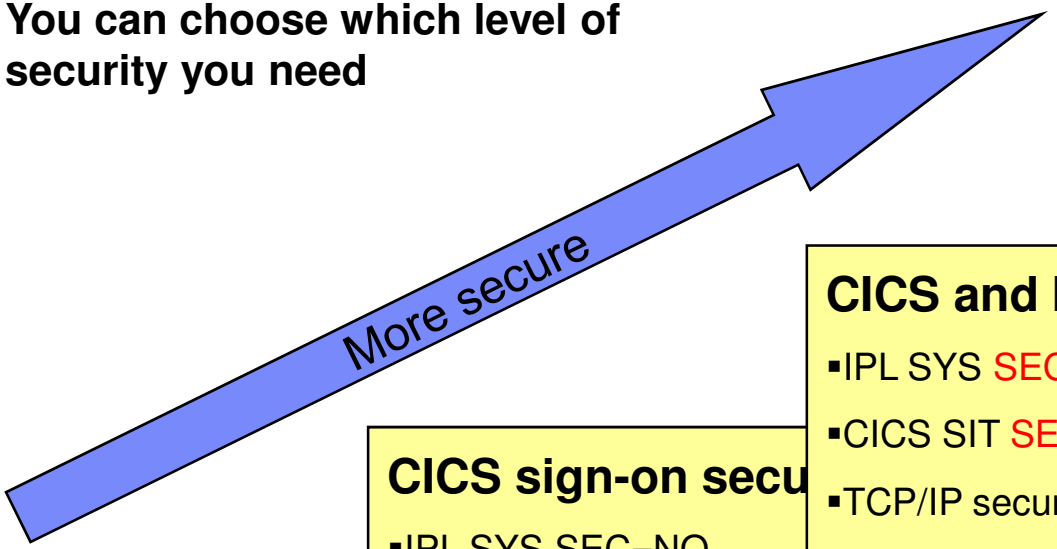
- **Prevent users from damaging the VSE system (maybe by accident)**
  - Deletion of members or entries
  - Submission of jobs

- **Prevent unauthorized remote access to VSE**
  - Today most computers are part of a network
  - Theoretically every system in the network could connect to your VSE system
  - FTP allows to access production data
    - VSAM
    - POWER entries (listings)



Securing you system – Protection levels

You can choose which level of security you need



No security or homegrown se

- IPL SEC=NO
- CICS SIT SEC=NO
- No TCP/IP security

→ No real protection from inside nor outside !

CICS sign-on secu

- IPL SYS SEC=NO
- CICS SIT SEC=YES
- No TCP/IP security

→ Only protected if signing in through CICS. No protection for batch or remote

CICS and batch s

- IPL SYS SEC=YES
- CICS SIT SEC=YES
- TCP/IP security active

→ Protected against ac
Inside (e.g. batch) and outside (CICS and TCP/IP)

Extended security

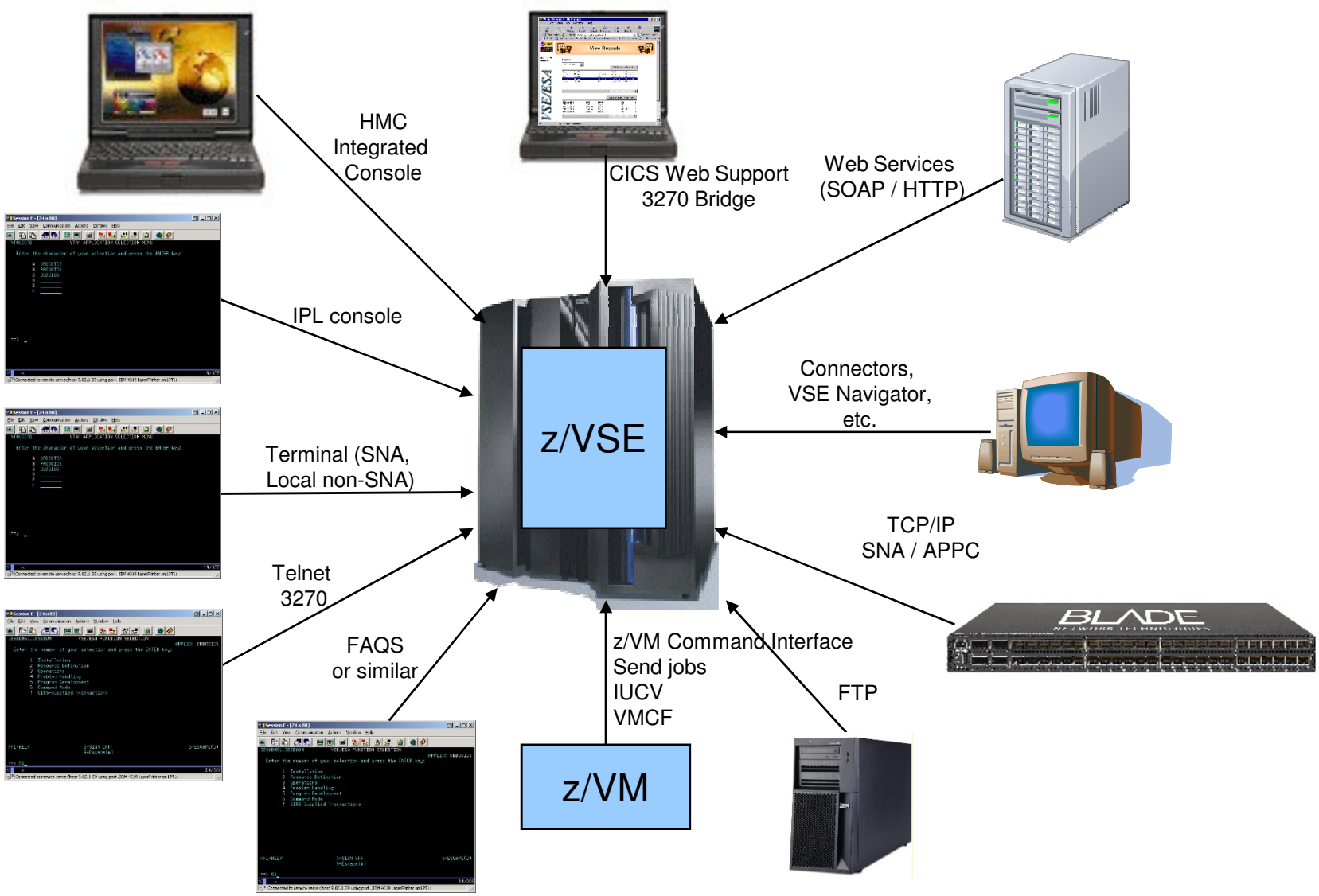
- IPL SYS SEC=YES
- CICS SIT SEC=YES
- TCP/IP security active
- Using extended security features
  - FACILITY resources
  - JCL security
  - LDAP signon
  - Data encryption & SSL
  - Auditing

Required level of protection depends on

→ What resources you want to protect

→ Against whom (inside, outside)

Ways into your z/VSE system – Are you securing them all?



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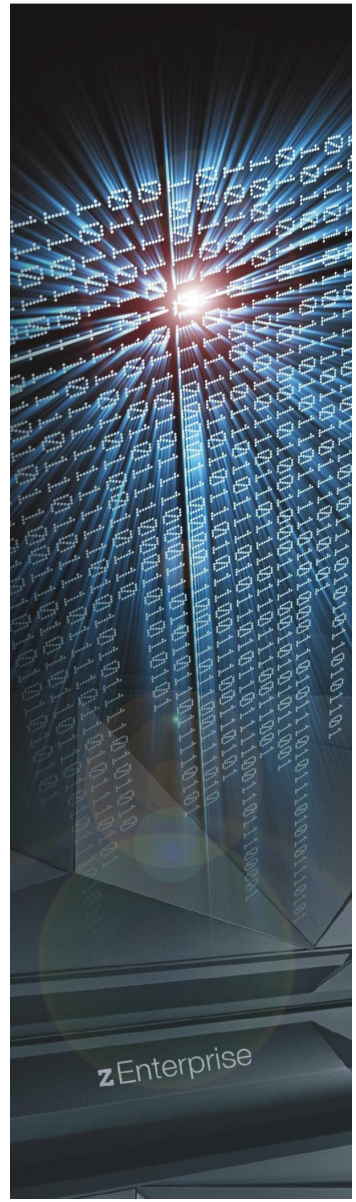
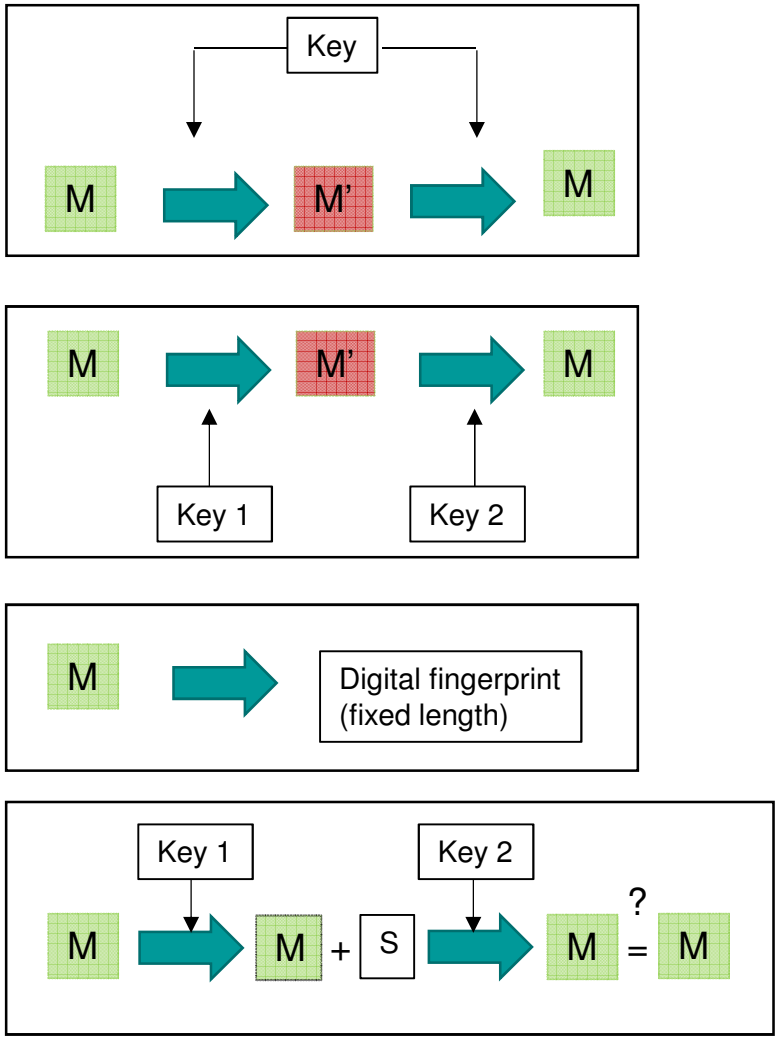


Encryption basics

- **Symmetric encryption**
  - The same key is used to encrypt and decrypt
  - Example: RC4, DES, 3DES, AES
- **Asymmetric encryption**
  - One key is used for encryption, another key is used for decryption (public and private keys)
  - Example: RSA, Elliptic Curve Cryptography
- **Hash Algorithms**
  - A digital fingerprint of a text
  - Example: MD5, SHA
- **Signatures**
  - To create a digital signature asymmetric algorithms are used, mainly RSA



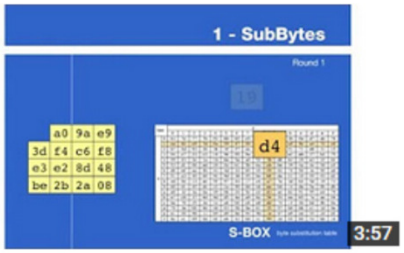
Different kinds of encryption keys

- **Keys that consist of numbers which are based on mathematical algorithms (asymmetric algorithms)**
  - RSA, Example: public key = (23,143), private key = (47,143)
    - Encryption of the number 7: 7^{23} mod(143) = 2
    - Decryption: 2^{47} mod(143) = 7

In this example, one could easily 'guess' the private key of 47 (i.e. brut force).

In reality this is done using much longer numbers, e.g. numbers of 4096 bits length

- **Keys that consist of random bit patterns (symmetric algorithms)**
  - The key consist of a bit pattern of fixed length, e.g.
    - 16 Bytes = 128 bit results in $2^{128} = 3{,}4*10^{38}$ possibilities
    - 32 Bytes = 256 bit results $2^{256} = 1{,}1*10^{77}$ possibilities
  - Example: Youtube: https://www.youtube.com/watch?v=evjFwDRTmV0



Animation of RIJNDEAL CIPHER : AES Encryption algorithm

HowTo
1 year ago • 2,497 views
This **animation** is made by Mr. Enrique Zabala. This is verison 4 made for CrypTool. This video is made for students so that they ...

Encryption key sizes

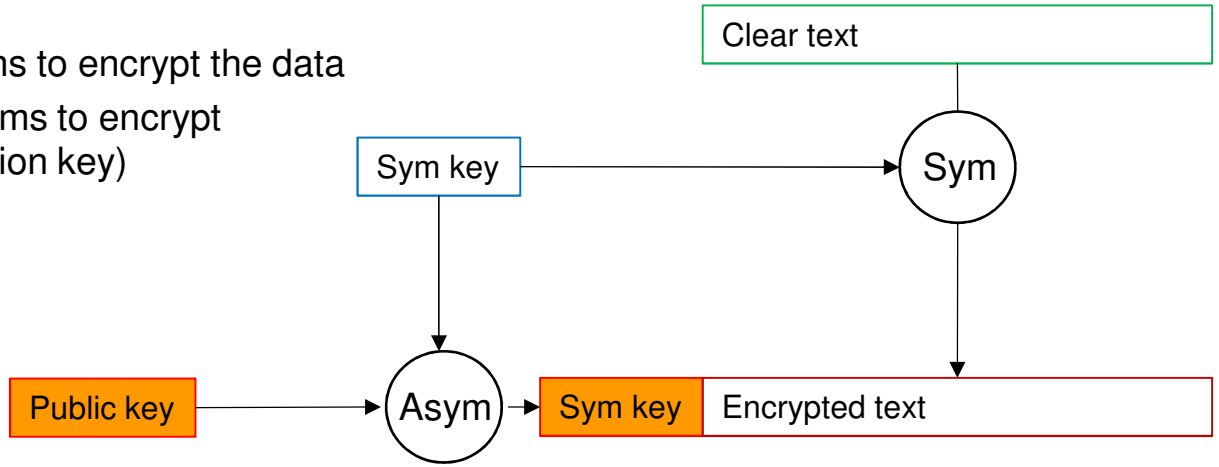
… and their security level

RSA	ECDH	Symmetric	Hash	Security (bits)
		RC4		<?
		DES	MD5	<?
			SHA-1	<80
1024	160			80
2048	224	TDES	SHA-224	112
3072	256	AES-128	SHA-256	128
4096				
7680	384	AES-192	SHA-384	192
15360	512	AES-256	SHA-512	256

This is what we normally want

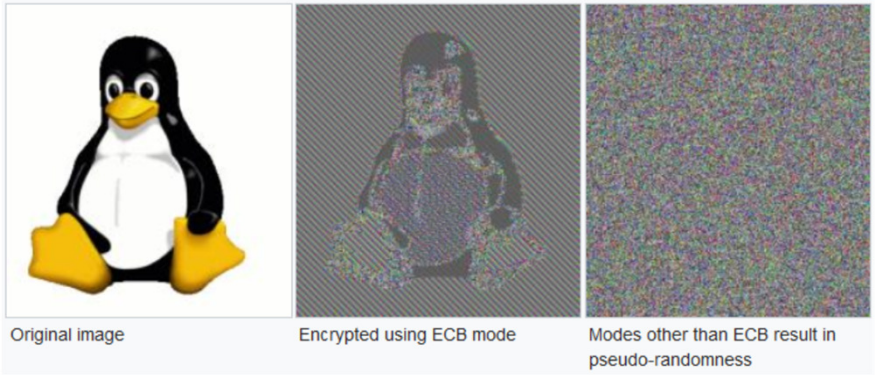
Why all these different encryption algorithms?

- **Asymmetric algorithms**
  - Are slower by factors than symmetric algorithms
  - Used to uniquely identify a communication partner
  - Can only encrypt a certain number of bytes
- **Symmetric algorithms**
  - Based on bit-shifting and logical computations (XOR, etc.)
  - Very fast
  - Can encrypt any numbers of bytes (usually in blocks of 8 or 16 bytes)
- **Idea:**
  - Use symmetric algorithms to encrypt the data
  - Use asymmetric algorithms to encrypt the symmetric key (session key)



Encryption modes (chaining)

- **ECB (Electronic Codebook)**
  - Each data block is encrypted separately



Source: Wikipedia

- **CBC (Cipher Block Chaining)**
  - The result of the encryption of one data block is fed into the encryption of the next data block

- **GCM (Galois Counter Mode)**
  - Encryption and generation of a hash (digital fingerprint) in one step
  - Most current and securest mode

AES-GCM supported in hardware on z14!

- **Others**
  - CFB - Cipher Feedback
  - OFB - Output Feedback
  - XTS - XEX-based tweaked-codebook mode with ciphertext stealing
  - ...

SSL/TLS Connection establishment and key exchange

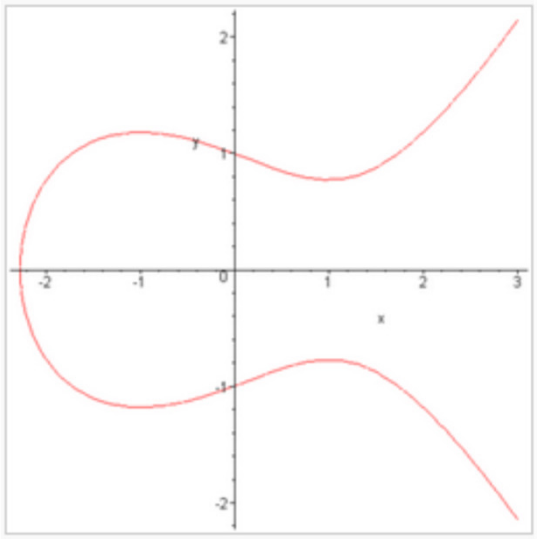
- **RSA-based:**
  - Commonly used
  - Long-term attacks are possible, because the session key is sent (encrypted) over the line

- **Diffie-Hellman based:**
  - Usage increases
  - Needs up to 30% more CPU
  - Long-term, attacks are NOT possible (forward secrecy), because the session key is not sent over the line
  - Usually used in combination with Elliptic Curve Cryptography (ECC) for better performance
  - https://www.youtube.com/watch?v=3QnD2c4Xovk

Public Key Cryptography: Diffie-Hellman Key Exchange (short version)
Art of the Problem
4 years ago • 366,437 views
Diffie-Hellman key exchange was one of the earliest practical implementations of key exchange within the field of cryptography.

Some more info on Elliptic Curve Cryptography (ECC) …

- **Elliptic Curves**
  - Described through $y^2 = x^3 + ax + b$
  - Mathematical calculation based on points on the curve

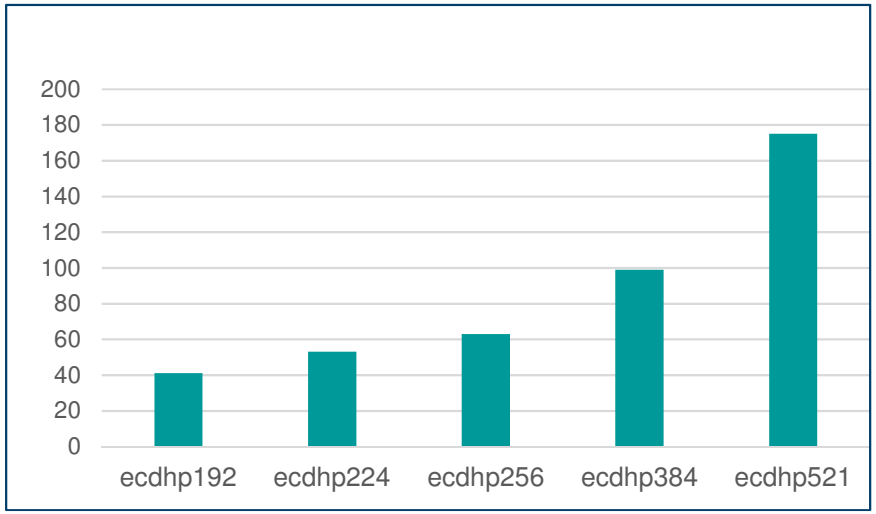


- **Two types of curves:**
  - Prime Curves (NIST)
  - Brainpool curves
    - Are being researched and provided by an working group of German governmental institutions and companies, including the German BSI (equivalent to U.S. NIST)
    - Are supported with OpenSSL 1.0.2 (and Java)
    - Also supported by Keyman/VSE
    - Refer to
      - http://www.ecc-brainpool.org/ (German website)
      - https://en.wikipedia.org/wiki/Elliptic_curve_cryptography#Implementation

- **ECC acceleration supported on CEX4C and later**
  - z/VSE 6.2: Added hardware acceleration for ECC in z/VSE and OpenSSL

Hardware support for ECC on z/VSE 6.2

- **Performance**



Requires CEX4S CCA coprocessor or later with internal CCA level of 4.2 or higher.

(x-axis: elliptic curves, y-axis: performance increase by factor)

Check card's CCA level with new z/VSE 6.2 crypto command on console:

```
msg fb,data=apstat ap=2 statcca
FB 0115 Adapter Status of AP 2 (Coprocessor)
...
FB 0115   CCA application version ................ : 4.4.59z
FB 0115   CCA application build date ............. : 20160511
FB 0115   Host application user authority ........ : DEFALT15
```

All together builds an SSL/TLS cipher suite

Example: maps.google.de

TLS_ECDHE_RSA_WITH_AES_128_GCM_ SHA_256

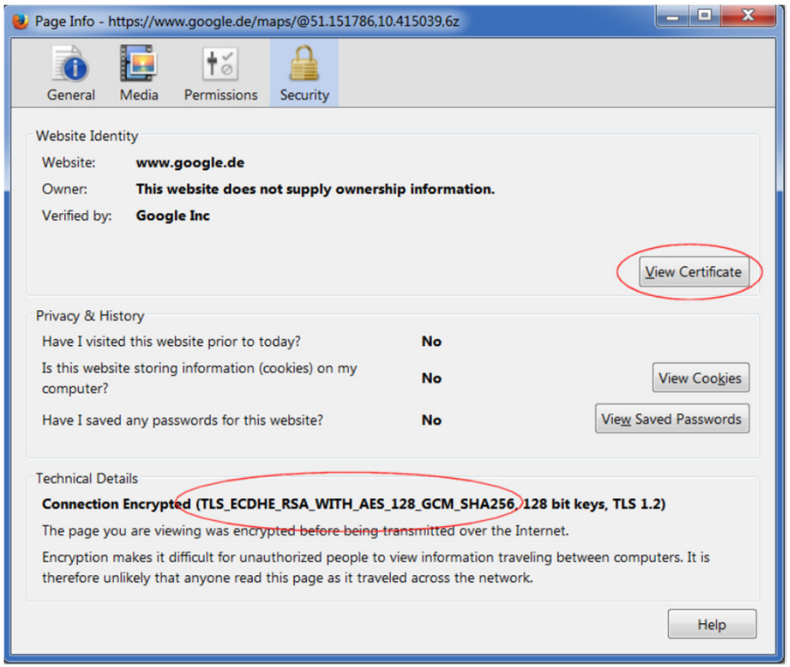
4: Hash function is SHA-256

3: Encryption with AES-128 in Galois Counter Mode (GCM)

2: Authentication with RSA

1: Key exchange with Diffie-Hellman / Elliptic Curve

Protocol Version, naming may differ



Recommendations

- **Symmetric encryption:**
  - RC4 (Ron‘s Code 4), from the 80‘s, Stream cipher → Insecure
  - DES, 3DES (Data Encryption Standard), 1977, Block cipher → also treated as insecure nowadays
  - AES (Advanced Encryption Standard), 2000, Block cipher → Recommended (AES-128/256)

- **Asymmetric encryption:**
  - RSA (Rivest, Shamir, Adleman), 1977, → Use key sizes >= 2048 bits
  - ECC (Elliptic Curve Cryptography) (from the 80’s) → Use in combination with RSA, 256-bit curve

- **Hash Algorithms („digital fingerprint“)**
  - MD5 (Message Digest 5) → Insecure
  - SHA-1 (Secure Hash Algorithm, 2001) → no longer considered secure
  - SHA-2 (224, 256, 384, 512), 2002 → Recommended hash algorithm
  - SHA-3, standardized 2015 -> Successor of SHA-2, may not be available in applications

- **SSL/TLS protocol versions**
  - SSL 3.0 → Do not use this anymore
  - TLS 1.0 / 1.1 → May be used if TLS 1.2 is not available
  - TLS 1.2 → Recommended

SHA3 supported in hardware on z14!

What's coming next?

- **TLS 1.3**
  - First draft from 2016
  - Removes all deprecated and insecure algorithms
  - Key exchange only using Diffie-Hellmann, preferable with Elliptic-Curve
  - Data encryption with AES-GCM only
  - Already available in:
    - Google Chrome 56 (needs manual activation)
    - Firefox 52 (TLS 1.3 is activated per default)
    - OpenSSL TLS 1.3 support available with OpenSSL V1.1.1

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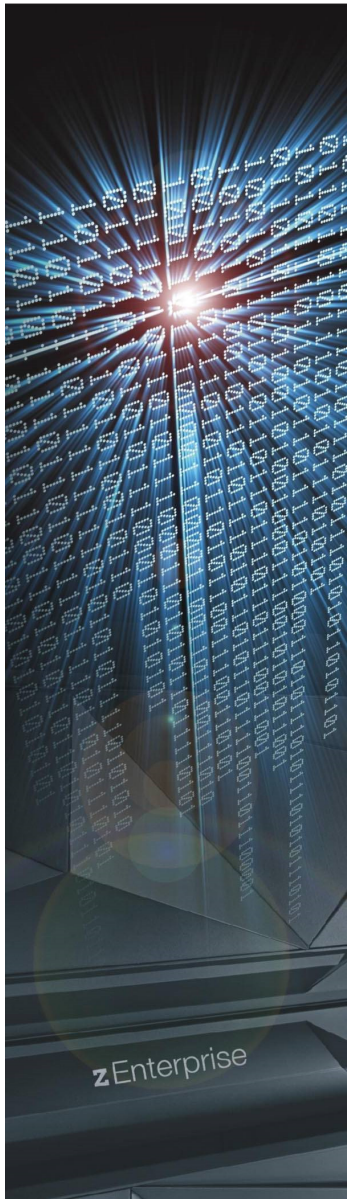
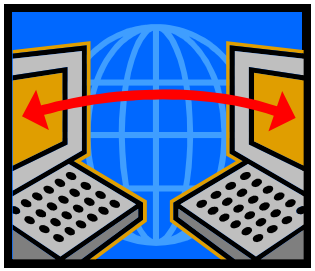


Using cryptography with z/VSE

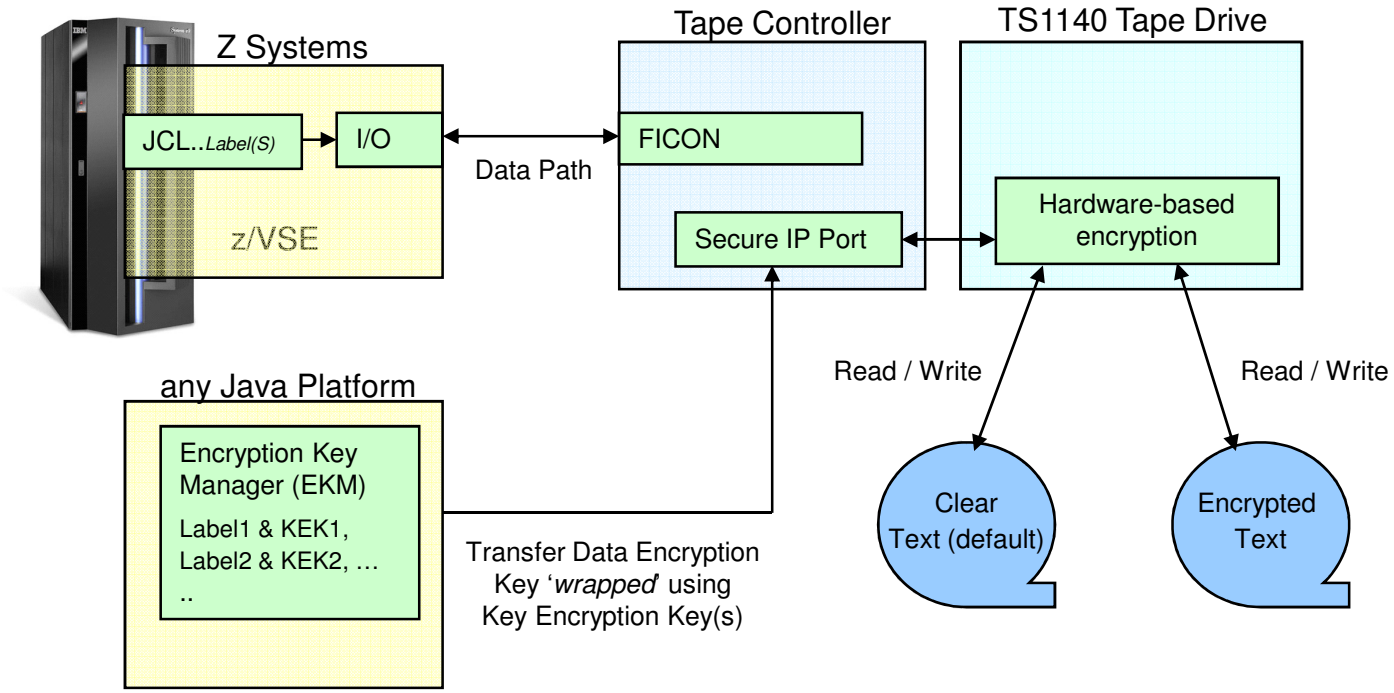
Main areas of cryptography:

- **Encryption of data transmitted over network connections**
  - SSL/TLS, HTTPS
  - SecureFTP
  - Secure Telnet / TN3270



- **Encryption of data stored on disk or tape**
  - Encryption of backups or archives
  - Exchange of encrypted and/or signed data with customers or business partners
  - TS1140 Encrypting Tape Drive
  - Encryption Facility for z/VSE

IBM Tape Encryption – TS1140



encryption mode (03=write)

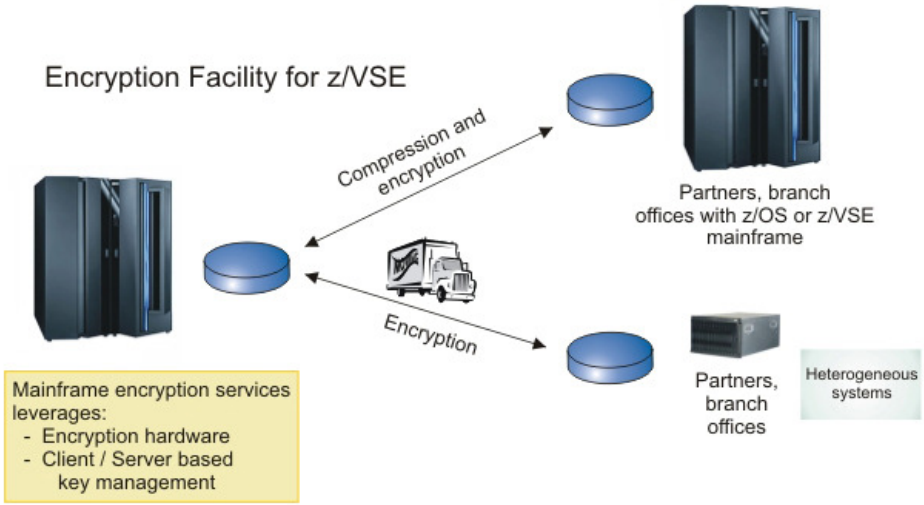
```
// JOB ENCRYPT
// ASSGN SYS005,480,03
// KEKL UNIT=480,KEKL1='MYKEKL1',KEM1=L,KEKL2='MYKEKL2',KEM2=L
// EXEC LIBR
  BACKUP LIB=PRD2 TAPE=SYS005
/*
/&
```

encoding mechanism (L=Label, H=Hash)

key label1 (name of the 1. KEK-key in EKM)

Encryption Facility for z/VSE

- Secure business and customer data
- Address regulatory requirements
- Protect data from loss and inadvertent or deliberate compromise
- Enable sharing of sensitive information across platforms with partners, vendors, and customers
- Enable decrypting and encrypting of data to be exchanged between z/VSE and non-z/VSE platforms



- The Encryption Facility for z/VSE is packaged as an optional, priced feature of VSE Central Functions V8.1 (5686-CF8-40).

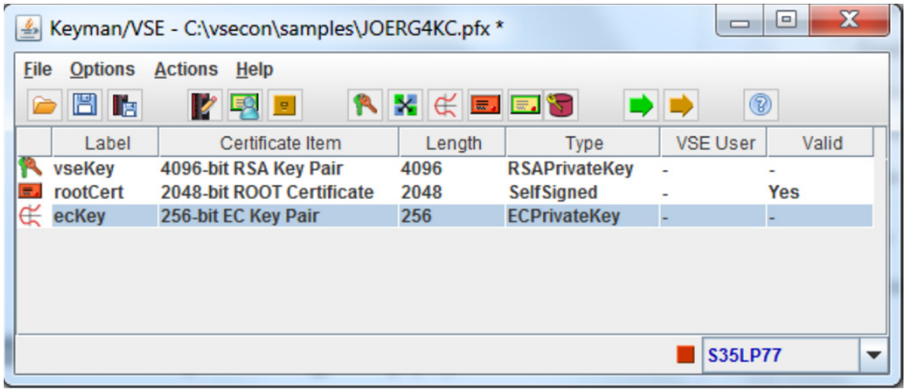
- The Encryption Facility for z/VSE V1.1 uses z Systems data format

- The Encryption Facility for z/VSE V1.2 uses the standard OpenPGP data format
  - PGP stands for „Pretty Good Privacy“, invented by Phil Zimmermann in 1991
  - Open Standard, described in RFCs 2440 and 4880
  - Compatible with Encryption Facility for z/OS V1.2 and many other OpenPGP implementations

Key & Certificate Management

Cryptography uses Keys and Certificates

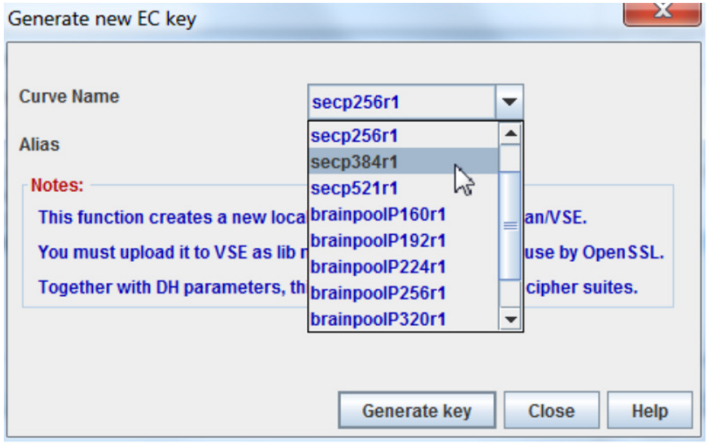
- **Key Management is not trivial**
  - Key must often be kept secure for a very long time
  - You must be able to associate the encrypted data with the corresponding key(s)
  - Encrypted data and the corresponding key(s) must be strictly separated

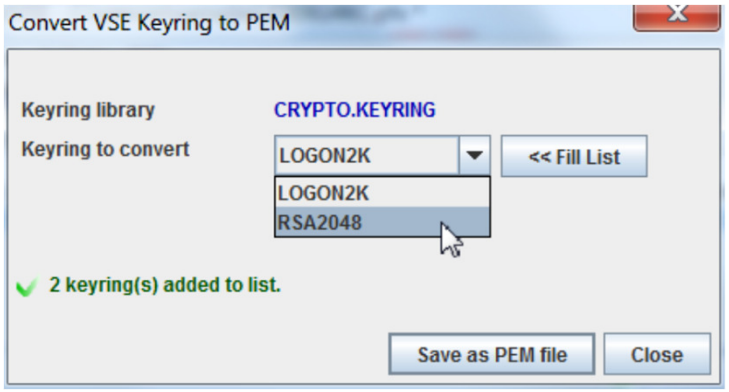


- **Keyman/VSE**
  - Creation of RSA keys and digital certificates
  - Upload of keys and certificates to VSE
  - Creation of PKCS#12 keyring files (use with Java-based connector or import into a Web browser)
  - Support for PEM files for OpenSSL
  - Download from VSE Homepage
    http://www.ibm.com/systems/z/os/zvse/downloads/#vkeyman

Keyman/VSE updates

- **ECC support**
  - Create and upload Elliptic-Curve (EC) key pairs.
- **SHA-256 support**
  - Support SHA-256 signatures in certificates.
  - This may require additional 1.5F zaps on TCP/IP for VSE.
- **Convert CSI keyrings to PEM**
  - Use existing PRVK, CERT, and ROOT members on VSE and build an equivalent PEM file for OpenSSL

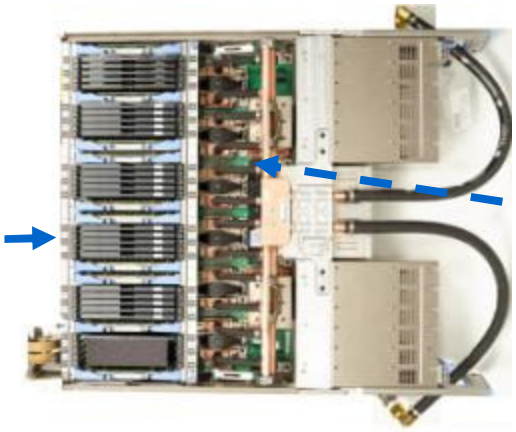




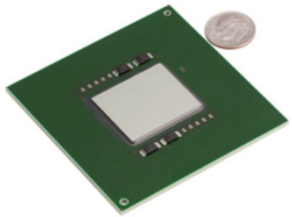
Hardware Crypto Support on z Systems

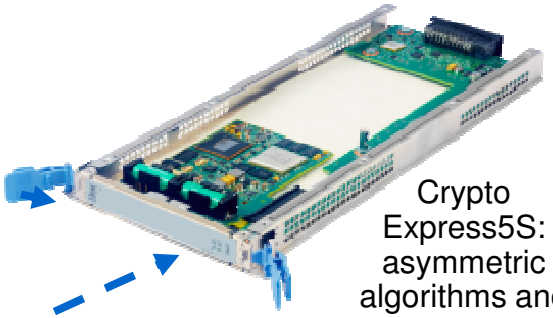
PCIe I/O drawers

CPC Drawer



CPACF Chip: symmetric algorithms and hashing





Crypto Express5S: asymmetric algorithms and secure key

TKE for management of the card: secure key entry and EP11

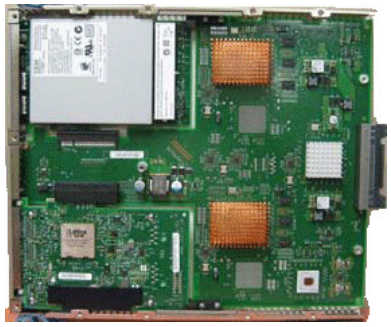
Crypto Express6S

- Exclusive to IBM z14
- One-port card, i.e. one AP (adjunct processor) per physical card
  - 2 cards min, 16 cards max per machine
- Seneca I/O cage (the 'S' in the name)
- Can be configured in one of three ways:
  - CEX6A: Accelerator
  - CEX6C: IBM Common Cryptographic Architecture (CCA) coprocessor
  - CEX6P: IBM Enterprise Public Key Cryptography Standards (PKCS) #11 (EP11) coprocessor
- Form factor comparison CEX3 / CEX6S:

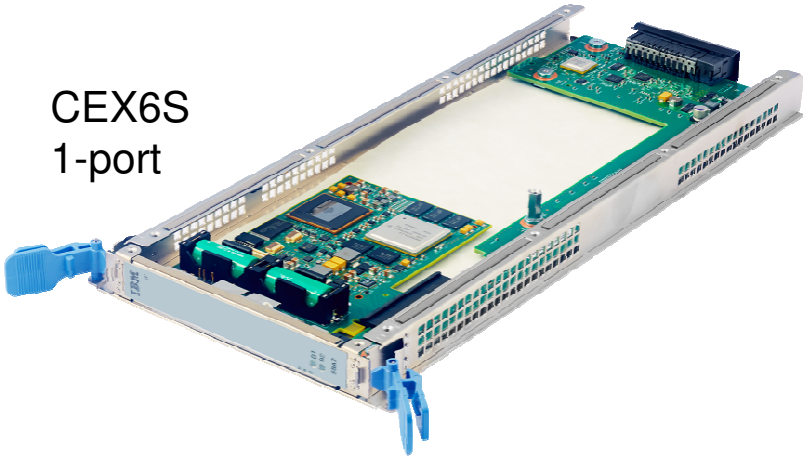
Support for Crypto Express6S
- Included in z/VSE 6.2 GA version
- APAR DY47715 for z/VSE 5.2
- APAR DY47716 for z/VSE 6.1

NEW!

CEX3
2-port



CEX6S
1-port



z/VSE Hardware Configuration

- **z/VSE hardware configuration not necessary for crypto hardware**
  - No IOCDS definition in VSE
  - No device type
  - No ADD statement
  - You may have to define the devices in the HMC (LPAR) or z/VM directory
- **Use of crypto hardware is transparent to end users and applications**
  - But use of crypto hardware can be disabled via option
- **How to setup cryptographic hardware for VSE:**
  - http://www.ibm.com/systems/z/os/zvse/documentation/security.html#howto

```
FB 0095 1J054I FOUND A CRYPTO EXPRESS5S CARD AT AP 0
FB 0095 1J054I FOUND A CRYPTO EXPRESS5S CARD AT AP 3
FB 0095 1J005I HARDWARE CRYPTO DEVICE DRIVER INITIALIZED SUCCESSFULLY.
FB 0095 1J006I USING AP QUEUE 79
```

Using crypto cards under z/VM

- **There are two ways for assigning cards to a z/VM guest**
  - CRYPTO APVIRT
    - z/VM assigns a virtual crypto domain (AP Queue) to the z/VM guest and shows only one AP to the guest
    - z/VM hides CCA coprocessors in favor of accelerators
    - Virtualized cards don't have all features of dedicated cards
  - CRYPTO APDEDICATE
    - Assignment of cards like in LPAR mode
    - Requests from guest system are directly forwarded to the hardware

- **Recommendation**
  - APDEDICATE wherever possible
    - Otherwise CCA coprocessor functions may get lost (e.g. random number generation, used in Encryption Facility and OpenSSL)
    - Load Balancing done by VSE is better
  - Optimal is one accelerator and one CCA coprocessor

OpenSSL Support

- **What is OpenSSL?**
  - OpenSSL is an Open Source project providing an SSL/TLS implementation and key management utilities
  - Available for most Unix-style operating systems, MAC, Windows, and IBM System i (OS/400)
  - For details on OpenSSL refer to http://www.openssl.org/

- **Why OpenSSL on z/VSE?**
  - The TCP/IP stack from Connectivity Systems, Inc. has an own SSL/TLS implementation
  - What about the other two stacks:
    - IPv6/VSE from Barnard Software, Inc.
    - Linux Fast Path (LFP) provided by IBM
  - All stacks could use one single SSL/TLS implementation: **OpenSSL**
  - OpenSSL is widely used in the industry
  - Latest RFC's implemented
  - One central place for access to crypto hardware, software updates, migration to higher versions

OpenSSL Support

- **What is available on z/VSE?**
  - OpenSSL 1.0.2h runtime library (with PTF UD54224)
  - New component: z/VSE cryptographic services, 5686-CF9-17-51S
  - Available on z/VSE 5.1 plus PTFs, or newer z/VSE releases
  - Software implementations for all algorithms with all key lengths
  - Hardware Crypto Support (Crypto Express cards and CPACF)
  - Programming APIs:
    - OS390 / z/OS compatible SSL API (gsk_initialize(), gsk_secure_soc_init(), etc.)
    - Subset of the OpenSSL API (LE/C)

- **OpenSSL Exploitation**
  - IPv6/VSE product exploits OpenSSL
    - **SSL Proxy Server** (BSTTPRXY)

      Proxies a clear text connection into an SSL/TLS connection and vice versa
    - **Automatic TLS Facility** (BSTTATLS)

      Automatically converts any application into SSL/TLS application
  - **User applications and z/VSE Connectors** (using LE/C Socket Interface)
    - Via LE/C Socket API Multiplexer

News with z/VSE 6.2

- **Hardware crypto operator interface for ESM customers**
  - The z/VSE crypto device driver runs as a subtask (IJBCRYPT) in the BSM security server partition (FB by default)
  - Customers using an ESM (CA TopSecret, BIM Alert, etc.) had to start phase IJBCRYPT in a partition to start the device driver
  - IJBCRYPT does not provide an operator interface.
    - No influence on behavior of device driver possible
    - No status information of device driver visible
  - New with z/VSE 6.2: Phase IJBHCOPR
    - Start in any partition, full control via operator interface

```
S1 0045 // JOB IJBHCOPR - OPERATOR INTERFACE FOR CRYPTO
        DATE 09/07/2017, CLOCK 10/50/39
S1 0115 1J022I CPU CRYPTOGRAPHIC ASSIST FEATURE AVAILABLE.
S1 0045 Crypto device driver running (MSG nn,DATA=? for help)
S1 0115 1J054I FOUND A CRYPTO EXPRESS4S CARD AT AP 0
S1 0115 1J054I FOUND A CRYPTO EXPRESS4S CARD AT AP 1
S1 0115 1J054I FOUND A CRYPTO EXPRESS4S CARD AT AP 2
S1 0115 1J005I HARDWARE CRYPTO DEVICE DRIVER INITIALIZED SUCCESSFULLY.
S1 0115 1J006I USING AP QUEUE 15
```

News with z/VSE 6.2

- **OpenSSL component of z/VSE enhancements:**
  - The OpenSSL component of z/VSE (z/VSE Cryptographic Services) will be upgraded to benefit from newer SSL/TLS functions
  - The OpenSSL component will transparently use hardware acceleration for Elliptic Curve Cryptography (ECC), if available

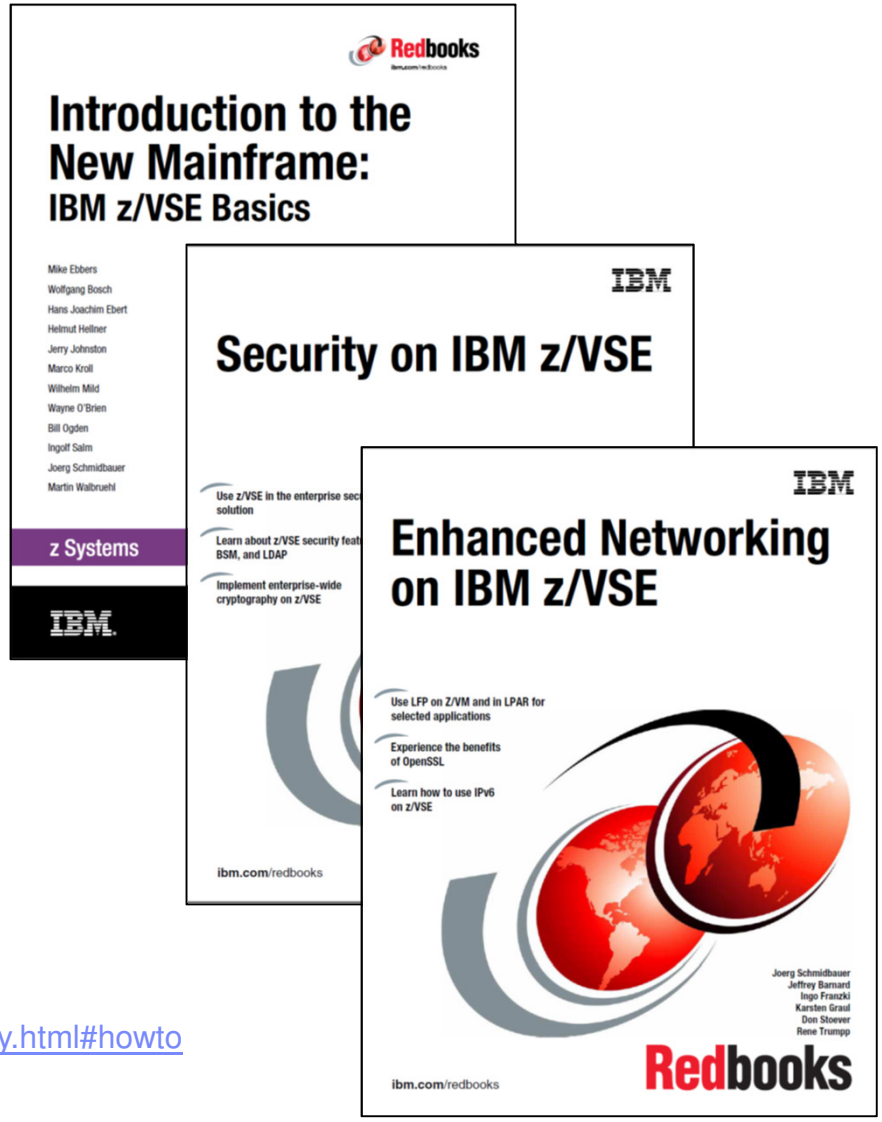
- **CICS TS V2.2 security enhancements:**
  - OpenSSL support for CICS Web Support will give clients more flexibility and allow them to take advantage of the OpenSSL security

- **EZA API enhancements:**
  - The EZA 'Multiplexer' and the EZA OpenSSL support will simplify the use of the EZA interface with any TCP/IP stack and allow to transparently use OpenSSL with EZA SSL-applications

- **VTAPE enhancements:**
  - Clients can use SSL/TLS connections for remote VTAPEs (virtual tapes) to protect sensitive data during network transfer

Important books

- **z/VSE Administration, SC34-2692**
  - Everything on encryption and SSL/TLS
  - Encryption Facility for z/VSE
  - TS1140 tape encryption
- **z/VSE TCP/IP Support, SC34-2706**
  - Overview on TCP/IP stacks
  - OpenSSL
- **Redbook: Enhanced Networking on IBM z/VSE, SG24-8091**
  - Focus on IPv6/VSE and OpenSSL
- **Redbook: Security on IBM z/VSE, SG24-7691**
  - Focus on CSI TCP/IP for VSE
- **Redbook: IBM z/VSE Basics, SG24-7436**
  - VSE in general
  - New chapter 18 on encryption
- **z/VSE e-business Connectors, User's Guide**
- **CICS Enhancements Guide, GC34-5763**
- **Technical articles on the z/VSE web page:**
  http://www.ibm.com/systems/z/os/zvse/documentation/security.html#howto



Thank You

Please forward your questions or remarks to
zvse@de.ibm.com

More Information

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- Requirements: https://www-03.ibm.com/systems/z/os/zvse/contact/requirement.html
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