MAINFRAME CRYPTO

Crypto Application Coding

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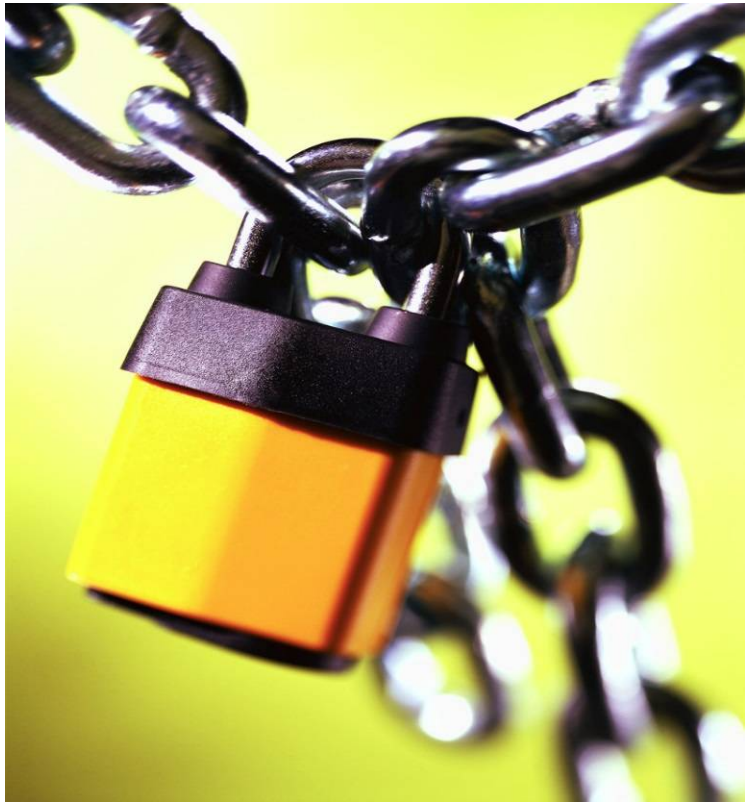
Agenda – Application Coding

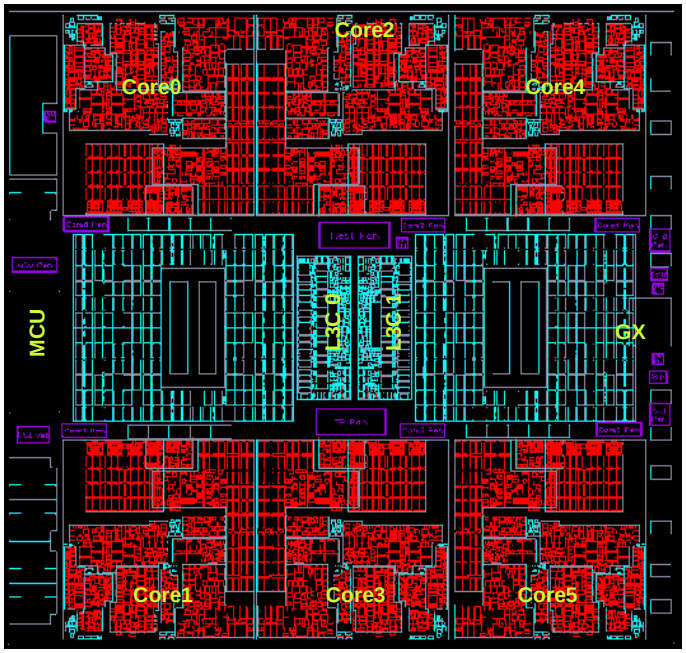
- Refresher
  - Crypto Functions
  - CPACF
  - Crypto Express cards
- Coding Native crypto instructions
- Coding APIs
  - API Naming Conventions
  - API Statistics
  - Clear key API
  - Secure key API

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



System z Crypto Hardware



CPACF

Crypto Express5S

Crypto Express4S

MSA – Message Security Assist

- MSA (z890/z990)
  - Cipher Message instruction (KM)
  - Cipher Message with Chaining instruction (KMC)
  - Compute Intermediate Message Digest instruction (KIMD)
  - Compute Last Message Digest instruction (KLMD)
  - Compute Message Authentication Code instruction (KMAC)
- MSA Extension 1 (z9) – added SHA-256, AES-128 and PRNG
- MSA Extension 2 (z10) – added AES-192, AES-256, SHA-512
- MSA Extension 3 (CEX3) – added Protected Key support
- MSA Extension 4 (z196)
  - Cipher Message With Cipher Feedback (CFB) instruction (KMF)
  - Cipher Message With Counter instruction (KMCTR)
  - Cipher Message With Output Feedback (OFB) instruction (KMO)
  - Perform Cryptographic Computation instruction (PCC)
  - Add AES Ciphertext stealing, GHASH; Enhance CMAC mode
- MSA Extension 5 (z13)
  - Perform Pseudo Random Number instruction (PPNO)

Assembler Instructions

- Cipher Message instructions
  - KM R1,R2
  - KMC R1,R2
  - KMF R1,R2
  - KMO R1,R2
  - KMCTR R1,R3,R2
- R1 pointer to output location
- R2 pointer to source location
- R2+1 length of source
- R3 pointer to a counter field
- Reg 0 contains Function Code
- Reg 1 pointer to parameter block

Function Codes

Bit 56 – Encrypt/Decrypt flag

Code	Function	Parm Block Size (Bytes)	Data Block Size (Bytes)
0	KM(C)-Query	16	-
1	KM(C)-DEA	8 (16)	8
2	KM(C)-TDEA-128	16 (24)	8
3	KM(C)-TDEA-192	24 (32)	8
9	KM(C)-Encrypted-DEA	32 (40)	8
10	KM(C)-Encrypted-TDEA-128	40 (48)	8
11	KM(C)-Encrypted-TDEA-192	48 (56)	8
18	KM(C)-AES-128	16 (32)	16
19	KM(C)-AES-192	24 (40)	16
20	KM(C)-AES-256	32 (48)	16
26	KM(C)-Encrypted-AES-128	48 (64)	16
27	KM(C)-Encrypted-AES-192	56 (72)	16
28	KM(C)-Encrypted-AES-256	64 (80)	16
50	KM-XTS-AES-128	32	16
52	KM-XTS-AES-256	48	16
58	KM-XTS-Encrypted-AES-128	64	16
60	KM-XTS-Encrypted-AES-256	80	16
67	KMC-PRNG	32	8

Parameter Block

KM/KMC/KMF/KMCTR/
KMO Query

Status Word 16-byte

KMC PRNG

Chaining Value 8-byte
Key 1 8-byte
Key 2 8-byte
Key 3 8-byte

KM

Cryptographic Key 8-, 16- or 24-bytes for DES/TDES 128-, 192- or 256-bits for AES
Wrapping Key VP 24-bytes for DES/TDES 256-bits for AES
XTS Parameter 128-bits

KMx Chaining

Chaining Value 8-, or 16-bytes for DES/TDES 128-, 192- or 256-bits for AES
Cryptographic Key 8-, 16- or 24-bytes for DES/TDES 128-, 192- or 256-bits for AES
Wrapping Key VP 24-bytes for DES/TDES 256-bits for AES

Some code

```
                L       R0,FUNCCODE
                LA      R1,CPARMBLK     R1 points to cipherparm block
                SR      R7,R7           zero Reg 7 for the length
                L       R7,INPUTLEN     R7 length of data
                LA      R6,INPUTDAT     R6 points @ data
                LA      R8,OUTPUTDA     R8 points to output field
DOKMC           DS      0H
                KMC     R8,R6           Do the encrypt
                BRC     1,DOKMC

FUNCCODE DC     XL4'00000014'   D'20' for Encrypt AES-256 bit
CPARMBLK  DS    0H
ICVVALUE  DC     XL8'B9D628DECEBA6B05'
          DC     XL8'C37892BD6134B48E'
KEYVALUE  DC     XL8'0B54388EDE6466BF'
          DC     XL8'9AF620DF135D47EC'
          DC     XL8'503406FFB8B1A9F6'
          DC     XL8'24F1A3BE76B26D16'
INPUTDAT  DC     XL24'My cleartext input msg '
INPUTLEN  DC     XL4'00000018'
OUTPUTDA DC      XL24' '
```

API Naming Conventions

This callable service prefix:	Identifies	
CSNBzzz / CSFzzz	31-bit	Symmetric Key Services and Hashing Services
CSNBzzz1 / CSFzzz1	31-bit ALET-qualified	
CSNEzzz / CSFzzz6	64-bit	
CSNEzzz1 / CSFzzz16	64-bit ALET-qualified	
CSNDzzz / CSFzzz	31-bit	Asymmetric Key Services
CSNFzzz / CSFzzz6	64-bit	
CSFPzzz	31-bit	PKCS #11 Services
CSFPzzz6	64-bit	
CSFzzz	31-bit	Utility Services and TKE Workstation Interfaces
CSFzzz6	64-bit	

From the ICSF Application Programmer's Guide

APIs

- Callable Services
  - Dependency on server type
  - Dependency on Crypto card
  - Languages: C, COBOL, PL/I, Assembler, Fortran (and REXX)
  - Problem vs Supervisor State
  - Task or SRB Mode
  - 64-Bit Access (as of HCR77A0)
  - Alternate entry points (ALET-qualified)

APIs

- Symmetric Key Management (48)
  - CSNBCKI – Clear Key Import
  - CSNBCVG – Control Vector Generate
  - CSNBCVT – Control Vector Translate
  - CSNBCVE – Cryptographic Variable Encipher
  - CSNBDKX – Data Key Export
  - CSNBDKM - Data Key Import
  - CSNBDCM – Derive ICC MK*
  - CSNBDSK – Derive Session Key*
  - CSNBDKG – Diversified Key Generate
  - CSNBDKG2 - Diversified Key Generate2
  - CSNBEDH – ECC Diffie-Hellman
  - CSNBGIM – Generate Issuer MK*
  - CSNBKEX – Key Export
  - CSNBKGN – Key Generate
  - CSNBKGN2 – Key Generate2
  - CSNBKIM – Key Import
  - CSNBKPI – Key Part Import
  - CSNBKPI2 – Key Part Import2
  - CSNBKYT – Key Test
  - CSBNKYT2 – Key Test2
  - CSBNKYTX – Key Test Extended
  - CSNBKTB – Key Token Build
  - CSNBKTB2 – Key Token Build2
  - CSNBKTR – Key Translate
  - CSNBKTR2 – Key Translate2
  - CSNBCKM – Multiple Clear Key Import
  - CSNBSKM – Multiple Secure Key Import
  - CSNDPKD – PKA Decrypt
  - CSNDPKE – PKA Encrypt
  - CSNBPEX – Prohibit Export
  - CSNBPEXX – Prohibit Export Extended
  - CSNBRNG – Random Number Generate
  - CSNDRKX – Remote Key Export
  - CSNDRKA – Restrict Key Attribute
  - CSNBSKI - Secure Key Import
  - CSNBSKI2 – Secure Key Import2
  - CSNDSYX - Symmetric Key Export
  - CSNDSXD – Symmetric Key Export with Data
  - CSNDSYG – Symmetric Key Generate
  - CSNDSYI – Symmetric Key Import
  - CSNDSYI2 – Symmetric Key Import2
  - CSNDTBC – Trusted Block Create
  - CSNBT31X – TR-31 Export
  - CSNBT31I – TR-31 Import
  - CSNBT31O – TR-31 Optional Data Build
  - CSNBT31R – TR-31 Optional Data Read
  - CSNBT31P – TR-31 Parse
  - CSNBUKD – Unique Key Derive

APIs

- Protecting Data (9)
  - CSNBCTT2 – CipherText Translate2
  - CSNBDEC – Decipher
  - CSNBDCO – Decode
  - CSNBENC – Encipher
  - CSNBECO – Encode
  - CSNBSAD – Symmetric Algorithm Decipher
  - CSNBSAE – Symmetric Algorithm Encipher
  - CSNBSYD – Symmetric Key Decipher
  - CSNBSYE – Symmetric Key Encipher
- Verifying Data Integrity and Authenticating Messages (10)
  - CSNBHMG – HMAC Generate
  - CSNBHMV – HMAC Verify
  - CSNBMGN – MAC Generate
  - CSNBMGN2 – MAC Generate2
  - CSNBMVR – MAC Verify
  - CSNBMVR2 – MAC Verify2
  - CSNBMDG - MDC Generate
  - CSNBOWH – One-Way Hash Generate
  - CSNBSMG – Symmetric MAC Generate
  - CSNBSMV – Symmetric MAC Verify

APIs

- Financial Services (25)
  - CSNBAPG - Authentication Parameter Generate
  - CSNBCPE – Clear PIN Encrypt
  - CSNBPGN – Clear PIN Generate
  - CSNBCPA – Clear PIN Generate Alternate
  - CSNBCKC – CVV Key Combine
  - CSNBESC – EMV Scripting Service*
  - CSNBEAC – EMV Transaction (ARQC/ARPC) Service*
  - CSNBEVF – EMV Verification Functions*
  - CSNBEPG – Encrypted PIN Generate
  - CSNBPTR – Encrypted PIN Translate
  - CSNBPVR – Encrypted PIN Verify
  - CSNBFLD – Field Level Decipher
  - CSNBFLE – Field Level Encipher
  - CSNBFPED – FPE Decipher
  - CSNBFPEE – FPE Encipher
  - CSNBFPET – FPE Translate
  - CSNBPCU – PIN Change/Unblock
  - CSNBPFO – Recover PIN from Offset
  - CSNBSKY – Secure Messaging for Keys
  - CSNBSPN – Secure Messaging for PINs
  - CSNDSBC – SET Block Compose
  - CSNDSBD – SET Block Decompose
  - CSNBTRV – Transaction Validation
  - CSNBCSG – VISA CVV Service Generate
  - CSNBCSV – VISA CVV Service Verify
- Financial Services for DK PIN Methods (10)
  - CSNBDDPG – DK Deterministic PIN Generate
  - CSNBDMP - DK Migrate PIN
  - CSNBDPMT - DK PAN Modify in Transaction
  - CSNBDPT - DK PAN Translate
  - CSNBDPC - DK PIN Change
  - CSNBDPV - DK PIN Verify
  - CSNBDPNU - DK PRW Card Number Update
  - CSNBDPCG - DK PRW CMAC Generate
  - CSNBDRPG - DK Random PIN Generate
  - CSNBDRP - DK Regenerate PRW

APIs

- Using Digital Signatures (2)
  - CSNDDSG – Digital Signature Generate
  - CSNDDSV – Digital Signature Verify
- Managing PKA Cryptographic Keys (8)
  - CSNDPKG – PKA Key Generate
  - CSNDPKI – PKA Key Import
  - CSNDPKB – PKA Key Token Build
  - CSNDKTC – PKA Key Token Change
  - CSNDPKT – PKA Key Translate
  - CSNDPKX – PKA Public Key Extract
  - CSNDRKD – Retained Key Delete
  - CSNDRKL – Retained Key List
- Key Data Set Management (16)
  - CSNBKRC – CKDS Key Record Create
  - CSNBKRC2 – CKDS Key Record Create2
  - CSNBKRD – CKDS Key Record Delete
  - CSNBKRR – CKDS Key Record Read
  - CSNBKRR2 – CKDS Key Record Read2
  - CSNBKRW – CKDS Key Record Write
  - CSNBKRW2 – CKDS Key Record Write2
  - CSFCRC – Coordinated KDS Administration
  - CSFMPS - ICSF Multi-Purpose Service
  - CSFKDSL - Key Data Set List
  - CSFKDMR - Key Data Set Metadata Read
  - CSFKDMW - Key Data Set Metadata Write
  - CSNDKRC – PKDS Key Record Create
  - CSNDKRD – PKDS Key Record Delete
  - CSNDKRR – PKDS Key Record Read
  - CSNDKRW – PKDS Key Record Write

APIs

- Utilities (7)
  - CSNBXBC – Character/Nibble Conversion
  - CSNBXEA – Code Conversion
  - CSFIQA – ICSF Query Algorithm
  - CSFIQF – ICSF Query Facility
  - CSFIQF2 – ICSF Query Facility2
  - CSFACEE – SAF ACEE Selection
  - CSNB9ED – X9.9 Data Editing
- Trusted Key Entry Workstation Interfaces (1)
  - CSFPCI – PCI Interface Callable Service
- Using PKCS #11 Tokens and Objects (19)
  - CSFPDMK – PKCS #11 Derive Multiple Keys
  - CSFPDVK – PKCS #11 Derive Key
  - CSFPGAV – PKCS #11 Get Attribute Value
  - CSFPGKP – PKCS #11 Generate Key Pair
  - CSFPGSK – PKCS #11 Generate secret key
  - CSFPHMG – PKCS #11 Generate HMAC
  - CSFPHMV – PKCS #11 Verify HMAC
  - CSFPOWH – PKCS #11 One-way hash, sign, or verify
  - CSFPPKS – PKCS #11 Private Key Sign
  - CSFPPKV – PKCS #11 Public Key Verify
  - CSFPPRF – PKCS #11 Pseudo-random function
  - CSFPSAV – PKCS #11 Save Attribute Value
  - CSFPSKD – PKCS #11 Secret Key Decrypt
  - CSFPSKE – PKCS #11 Secret Key Encrypt
  - CSFPTRC – PKCS #11 Token Record Create
  - CSFPTRD – PKCS #11 Token Record Delete
  - CSFPTRL – PKCS #11 Token Record List
  - CSFPUWK – PKCS #11 Unwrap Key
  - CSFPWPK – PKCS #11 Wrap key

API Syntax

- All ICSF APIs start with same 4 parms
  - Return Code — INTEGER, HEX PIC 9(8) COMP
  - Reason Code — INTEGER, HEX PIC 9(8) COMP
  - Exit Data Length — INTEGER, HEX PIC 9(8) COMP
  - Exit Data — STRING, CHAR, PIC X()
- Followed by specific positional parms, unique to the API
- RULE_ARRAY
  - Array of positional parms, specific to the API
  - 8-byte keywords, left-justified, blank padded

CSNBSYE/CSNBSYD

- ICSF API for clear key encryption/decryption

CALL CSNBSYE(

return_code,
reason_code,
exit_data_length,
exit_data,
rule_array_count,
rule_array,
key_identifier_length,
key_identifier,
key_parms_length,
key_parms,
block_size,
initialization_vector_length,
initialization_vector,
chain_data_length,
chain_data,
clear_text_length,
clear_text,
cipher_text_length,
cipher_text,
optional_data_length,
optional_data)

CSNBSYE/CSNBSYD rule_array

- Rule_array(Algorithm, Processing rule, Key rule, ICV selection)
  - Algorithm: AES, DES
  - Processing rule: CBC, CBC-CS, CFB, CFB-LCB, CTR, CUSP, ECB, GCM, GCM-LG, IPS, OFB, PKCS-PAD, X9.23)
  - Key Rule: KEY-CLR, KEYIDENT
  - ICV Selection: INITIAL, CONTINUE, FINAL, ONLY
- Positional parameters, required/optional
- 8-character, padded

CSNBSYE Example - variables

```
api_rc                  = 'FFFFFFFF'x ;
api_rs                  = 'FFFFFFF0'x ;
api_exit_data_length    = '00000000'x ;
api_exit_data           = '' ;
sye_rule_array_cnt      = '00000004'x ;
sye_rule_array          = 'AES     CBC     KEYIDENTINITIAL ' ;
sye_keyid_length        = '00000040'x ;                  /* decimal 64 */
sye_keyid               = 'MYKEYLBL';
sye_keyparms_len        = '00000000'x ;  /* Ignored with CBC mode */
sye_keyparms            = '' ;           /* Ignored with CBC mode */
```

CSNBSYE Example - variables

```
sye_blksize          = '00000010'x ;       /*  Decimal 16 for AES */
sye_icv_len          = '00000010'x ;          /* same as blksize     */
sye_icv              = '00112233445566778899AABBCCDDEEFF'x;
sye_chaindat_len     = '00000020'x ;       /* must be 32 for AES  */
sye_chaindata        = copies('00'x,32) ;
sye_clear_text_len   = '00000020'x ;
sye_clear_text       = 'Our 32 char message with padding' ;
sye_cipher_text_len  = '00000020'x ;
sye_cipher_text      = copies('40'x,32) ;       /* our output field */
sye_optdata_len      = '00000000'x ; /* ignored except for GCM */
sye_optdata          = '' ;
```

CSNBSYE - Invocation

```
address linkpgm 'CSNBSYE' ,
                'api_rc',
                'api_rs',
                'api_exit_data_length' ,
                'api_exit_data' ,
                'sye_rule_array_cnt',
                'sye_rule_array',
                'sye_keyid_length',
                'sye_keyid',
                'sye_keyparms_len',
                'sye_keyparms',
                'sye_blksize',
                 'sye_icv_len',
                 'sye_icv',
                 'sye_chaindat_len',
                 'sye_chaindata',
                 'sye_clear_text_len',
                 'sye_clear_text',
                 'sye_cipher_text_len',
                 'sye_cipher_text',
                 'sye_optdata_len',
                 'sye_optdata'
```

CSNBSYE - Results

```
/* check the return and reason codes */
if (API_rc = '00000000'x & API_rs = '00000000'x)
   then do;
       say 'SYE OK, rc=' c2x(API_rc) 'rs =' c2x(API_rs) ;
      end ;
   else do ;
      say 'SYE failed, rc =' c2x(API_rc) 'rs =' c2x(API_rs) ;
      exit;
   end ;

say 'sye_clear_text(ch) = 'sye_clear_text';' ;
say 'sye_cipher_text(ch) = 'sye_cipher_text';' ;
say 'sye_cipher_text(hex) = 'c2x(sye_cipher_text)';' ;
```

ENCIPHER/DECIPHER API

- CALL CSNBENC (
  - return code,
  - reason code,
  - exit data length,
  - exit data,
  - key identifier,
  - text length,
  - clear text,
  - initialization vector,
  - rule array count,
  - rule array,
  - pad character,
  - chaining vector,
  - cipher text)

- CALL CSNBDEC (
  - return code,
  - reason code,
  - exit data length,
  - exit data,
  - key identifier,
  - text length,
  - clear text,
  - initialization vector,
  - rule array count,
  - rule array,
  - chaining vector,
  - cipher text)

See the ICSF Programmer's Guide for all of the APIs including the parms for each API

Rule Array (for CSNBENC/CSNBDEC)

- Position 1 (required)
  - CBC
  - CUSP
  - IPS
  - X9.23
  - 4700-PAD

  Has to do with blocking and chaining

- DES Algorithm (optional)
  - DES
  - TOKEN

  Can override some of the CCA bit settings related to how keys are used (encrypting data vs other keys)

- ICV Selection (optional)
  - CONTINUE
  - INITIAL

  INITIAL says to use initialization vector, not the chaining vector

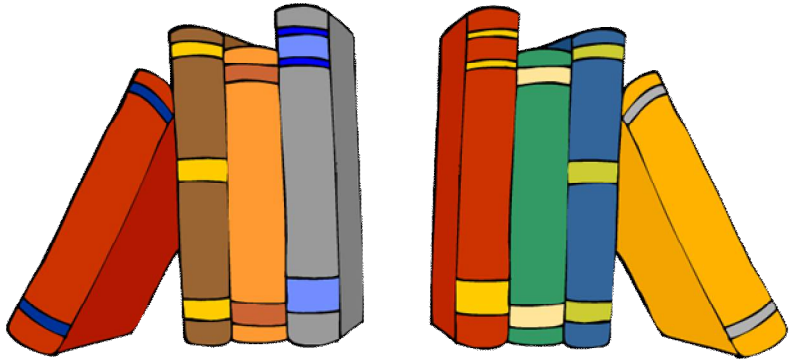
ICSF SAF Security – CSFSERV Class

- RACF
  RDEFINE CSFSERV service_name UACC(NONE)
  PERMIT service_name CLASS(CSFSERV) ID(userid) ACCESS(READ)

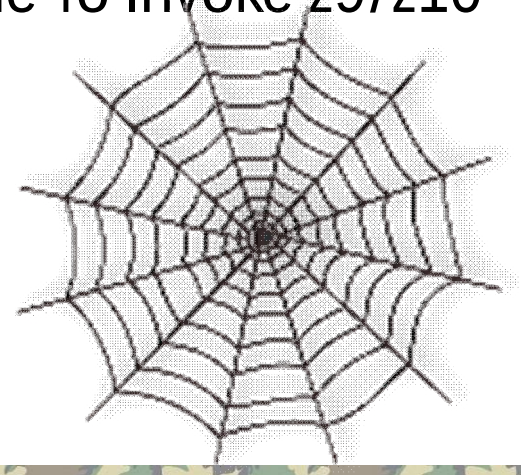
- CA TopSecret®for z/OS
  TSS ADD(owner) CSFSERV(service_name)
  TSS PERMIT(userid/profile) CSFSERV(service_name) ACCESS(READ)

- CA ACF2™ for z/OS
  SET RESOURCE(SAF)
  COMPILE
  $KEY(service) TYPE(SAF)
  UID(userid) SERVICE(READ) ALLOW
  STORE

References



- IBM Pubs
  - SA22-7832 Principles of Operations (-10 z13)
  - SC14-7508 ICSF Application Programmer's Guide (z/OS V2)
  - SA22-7522 ICSF Application Programmer's Guide (z/OS V1)
- Techdocs – www.ibm.com/support/techdocs
  - PRS2669 – CPACFZ9S – How to Use The z9/z10 CPACF Crypto Functions
  - PRS822 – CALCPACF: Callable z/OS Routine To Invoke z9/z10 CPACF Crypto Functions
  - Or search on 'crypto'



Questions