Database Procedures for Security

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Abstract

- This presentation lays out the steps needed to write a database exit to encrypt and decrypt CA IDMS data at a field level. Sample code will be provided as well as all the accompanying external updates such as Schema and SYSGEN.

Biography

- **Laura Rochon**
  Hera Evolution Inc.

  Laura has worked with CA IDMS for 30 years, including close to 7 years with Cullinet and CA. Laura is a frequent presenter at CA World and User Conferences in both North America and Europe. As a technical and application DBA, Laura has supported multiple clients in North America, by teaching classes, performing database and system reviews, installation and maintenance, and just normal DBA work. She presently works for Hera Evolution Inc, a leader in CA IDMS Support.

Agenda

- The Driver – Regulatory Requirements
- Encryption History
- Encryption Techniques
- Encryption Implementation

The Driver
Regulatory Requirements

The Driver – Regulatory Requirements

- Health Insurance Portability and Accountability Act of 1996 ("HIPAA")
- Protects "*Individually identifiable health information*"
- Individually identifiable health information
  - Includes many common identifiers (e.g., name, address, birth date, Social Security number(SSN))
- Privacy rule
  - Define and limit the circumstances in which an individual's protected heath information may be used or disclosed by covered entities

The Driver – Regulatory Requirements

- Sarbanes-Oxley Act of 2002 (SOX)
- Contains 11 titles that describe specific mandates and requirements for financial reporting
- SOX does not specifically reference encryption
- SOX Section 404: Assessment of internal control
  - Requires management and the external auditor to report on the adequacy of the company's internal control over financial reporting (includes IT department and controls)

Encryption History

Encryption History

- Cryptography - the practice and study of hiding information
  - Used as early as the ancient Greeks
  - Julius Caesar used with a shift of 3 to communicate with his generals during his military campaigns
- Encryption - used heavily in WWII (famous Enigma machine used by Germany)
- 1976 US government publishes Data Encryption Standard (DES) specification (56-bit key)
- 2002 US government publishes Advanced Encryption Standard (AES) with key size of 128, 192, or 256 bits

Encryption Techniques

Encryption Techniques
DES

- Algorithm that takes a fixed-length string of plaintext bits and transforms it through a series of complicated operations
  - Expansion
    - The 32-bit half-block is expanded to 48 bits using the expansion permutation, by duplicating some of the bits
  - Key mixing
    - The result is combined with a subkey using an XOR operation
    - Sixteen 48-bit subkeys (one for each round) are derived from the main key

Encryption Techniques
DES

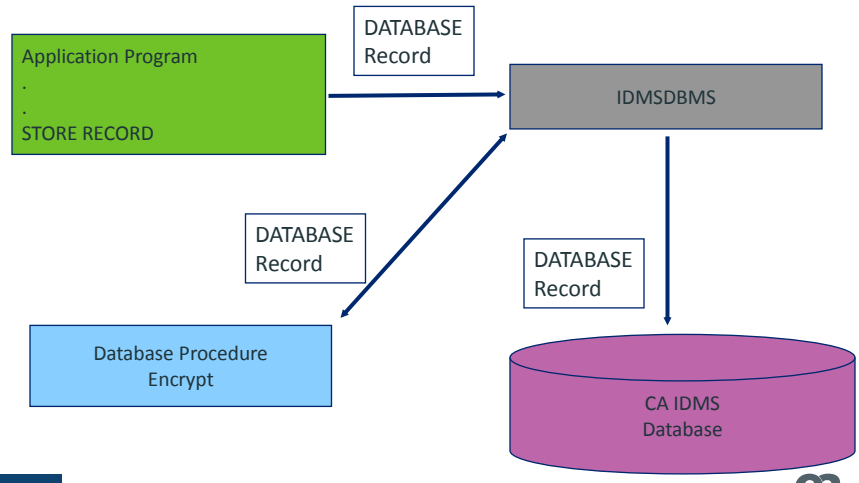
- Algorithm operations (cont.)
  - Substitution
    - After mixing in the subkey, the block is divided into eight 6-bit pieces before processing by the S-boxes, or substitution boxes
    - Each of the eight S-boxes replaces its six input bits with four output bits according to a non-linear transformation, provided in the form of a lookup table
    - The S-boxes provide the core of the security of DES; without them, the cipher would be linear, and trivially breakable
  - Permutation
    - Finally, the 32 outputs from the S-boxes are rearranged according to a fixed permutation

Encryption Techniques
AES

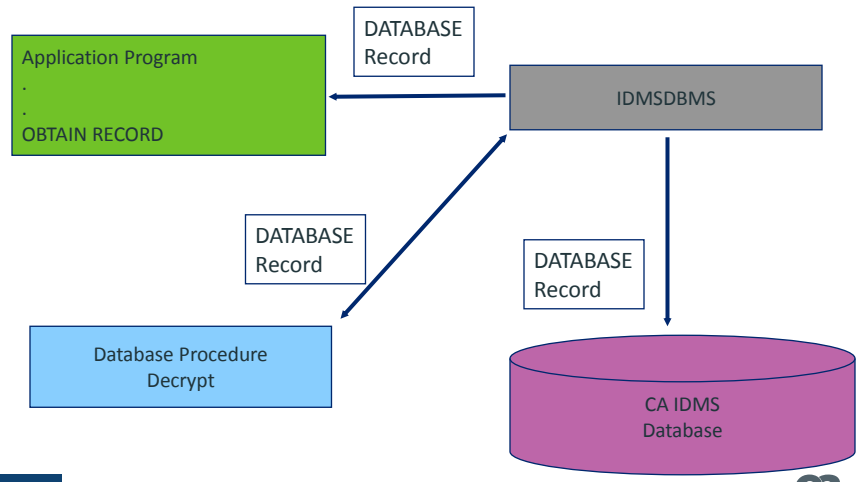
- Four Rounds
  - SubBytes — a non-linear substitution step where each byte is replaced with another according to a lookup table
  - ShiftRows — a transposition step where each row of the state is shifted cyclically a certain number of steps
  - MixColumns — a mixing operation which operates on the columns of the state, combining the four bytes in each column
  - AddRoundKey — each byte of the state is combined with the round key; each round key is derived from the cipher key using a key schedule

Encryption Implementation

Encryption Implementation
Database Procedures - Encrypt



Encryption Implementation
Database Procedures - Decrypt



Encryption Implementation

- Field level encryption/decryption
- Calc keys can be encrypted (extra code required)
- Encrypting fields involved in index keys – not pretty
- Multi-step implementation

Encryption Implementation

- Database Procedures
  - Specified as part of the schema definition
  - NO DML commands are allowed
  - CA strongly recommends that all database procedures be written in fully reentrant assembler code
  - When running in multi-tasking mode REENTRANT database procedures are REQUIRED

Encryption Implementation

- Record Procedures
- Data passed to procedure
  - Procedure control block (20 bytes)
  - Application control block (236 bytes)
  - Application program information block
  - Record control block (56 bytes)
  - Record occurrence block (length specified in schema)

Encryption Implementation

- Table Driven

```
FLTABLE  DS    0CL24
         DC    F'2084'          RECORD ID
         DC    F'0'             FIELD DISPLACEMENT
         DC    F'9'             FIELD LENGTH
         DC    F'2221'          RECORD ID
         DC    F'182'           FIELD DISPLACEMENT
         DC    F'9'             FIELD LENGTH
```

*** Schema record changes require a change to the table

Encryption Implementation
Register Usage

```
START    LM     R3,R7,0(R1)     LOAD PROCEDURE PARMS.
         USING  PRCBLK,R3       R3-->PROCEDURE CONTROL BLOCK
         USING  APPBLK,R4       R4-->APPLICATION CONTROL BLOCK
*                               R5-->COMM BLOCK NOT USED.
         USING  RECBLK,R6       R6-->RECORD CONTROL BLOCK.
*                               R7-->SCHEMA RECORD.
```


Encryption Implementation
Reason for Area Call – Free Storage

```
         BZ     RTN             NO...NO WORK TO DO
         LH     R0,PRVERBN      R0 = CURRENT VERB.
         CH     R0,FCN02              FREE STORAGE IF FINISH
         BE     FREESTO
.....
FREESTO  LR     R1,R11
         BAL    R8,FREESTG
         ST     R1,PRUSER             CLEAR ADDR OF WORK
         B      RTN
```

Encryption Implementation
Check DML Command

```
NOTAREA  CLC   ERRMIN,STAT00       EXIT IF BAD IDMS STATUS.
         BNE   RTN
         CLC   PRVERBC(2),STORCDE  IS VERB A STORE?
         BE    TIMEBFOR            YES,  GO CHECK TIME
         CLC   PRVERBC(2),MODCDE   IS VERB A MODIFY
         BNE   RTN                 NO, WRONG VERB TYPE
```


Encryption Implementation
Check Record ID

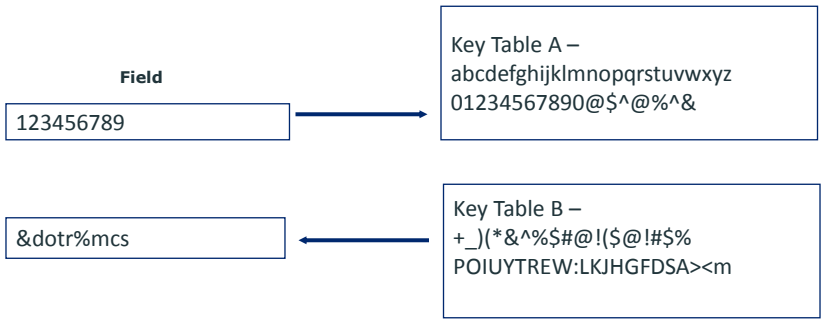
```
CHKRECID LH    R15,RECID          RECORD ID OF PASSED REC
         L     R14,FRECID         RECORD ID IN THE TABLE
         CR    R15,R14            RECORD IN THE TABLE ?
         BNE   NXTTABLE           NO GO CHECK NEXT TABLE
         BAL   R14,ENCRYPT        YES! GO ENCRYPT THE FIELD
NXTTABLE LA    R2,12(R2)          GO TO NEXT TABLE ENTRY
         BCT   R8,CHKRECID        OUT OF TABLE ENTRIES?
```

Encryption Implementation
Point to Field

```
ENCRYPT     ST     R14,REDHOLD
            L      R9,FLDLEN      LENGTH OF FIELD TO ENCRYPT
            LR     R5,R7          POINT TO SCHEMA RECORD
            MVI    COMPSW,ONSW    ON FOR ODD BYTES
            L      R1,FLDDISP     DISP OF FIELD IN REC (REL TO 0)
            SR     R0,R0
            CR     R1,R0          LENGTH 0?
            BE     NEXTCHAR       NO WE START WITH 1ST BYTE OF REC
            AR     R5,R1          ADVANCE TO DISPL OF FIELD
```


Encryption Implementation

- Encryption Options – Simple One Key
  - Look up character in Table A
  - Use Displacement to get character from Encrypt Table B



Encryption Implementation

- Decryption Module
  - Exact same code as encryption in reverse
  - Check for GET verb

    CLC PRVERBC(2),GETCDE IS VERB A MODIFY
  - Must use same key tables as encryption module

Encryption Implementation

- Insert in Schema

```
MOD
AREA NAME IS VENDOR-A
   ESTIMATED PAGES ARE 0
   CALL HSLDATE BEFORE FINISH
   CALL IMMSDCRP BEFORE FINISH
   CALL IMMSECRP BEFORE FINISH
   .
```

Encryption Implementation

- Insert in Schema

```
MOD RECORD NAME IS D084-VENDPAY-R
   SHARE STRUCTURE OF RECORD D084-VENDPAY-R VERSION 1
   RECORD ID IS 2084
   LOCATION MODE IS VIA APVENDOR-VENDPAY SET
   CALL IMMSDCRP AFTER GET
   CALL IMMSECRP BEFORE STORE
   CALL IMMSECRP BEFORE MODIFY
   WITHIN AREA VENDOR-A OFFSET 0 PERCENT FOR 100 PERCENT
```


Encryption Implementation

- Process to Implement
  - Liberally backup databases
  - Modify schema for STORE and MODIFY only
  - Run area sweep on records – OBTAIN NEXT then MODIFY
  - Modify Schema for GET
  - Modify AREA(s) for FINISH

Encryption Implementation

- Challenges
  - Testing – Used batch program and copy of area due to abending online task hazardous to your health
  - One field was in an index and had to get customer to accept less functionality
  - Run the original encrypt twice and you encrypt encrypted values.. start over….
  - Print page is your testing friend

Encryption Implementation

- Business Challenges
  - Where to keep source code for encryption tables?
  - Keep source modules in a separately secured library?
  - Removed SSN's from inquiry screens but still need on update screens

Encryption Implementation

- Performance
  - Equivalent area sweeps run with and without decryption
  - 560,579 records read in both runs
  - Buffers set at 500 and PREFETCH on in both runs
  - Jobs run multiple times to validate results
  - Calculation – Milliseconds of CPU divided by # records

Encryption Implementation

- Performance
  - Without Decryption - .01017 milliseconds per read
  - With Decryption - .01605 milliseconds per read
  - 36.6 percent more CPU time per read
  - Total 3.3 additional CPU seconds for the 560,579 records read

Summary

- Reasons for Encryption
- Using Database Procedures for Encryption
- Performance
- Challenges

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Questions and Answers