IMS/DB2 Database Crypto Support

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Agenda

- **Introduction to Crypto**
  - Crypto Functions
  - IBM Crypto Hardware on System z196
  - ICSF
  - Database Encryption (DB2 and IMS)
  - Other Encryption Exploitation
- **Database Activity Monitoring with Guardium**
- **Conclusion and Reference Resources**

Crypto Functions

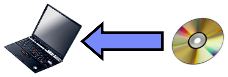
- **Data Confidentiality**
  - Symmetric – DES/TDES, AES
  - Asymmetric – RSA, Diffie-Hellman
- **Data Integrity**
  - Modification Detection
  - Message Authentication
  - Non-repudiation
- **Financial Functions**
- **Key Security & Integrity**

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**

System z Clear Key Crypto Hardware –z196

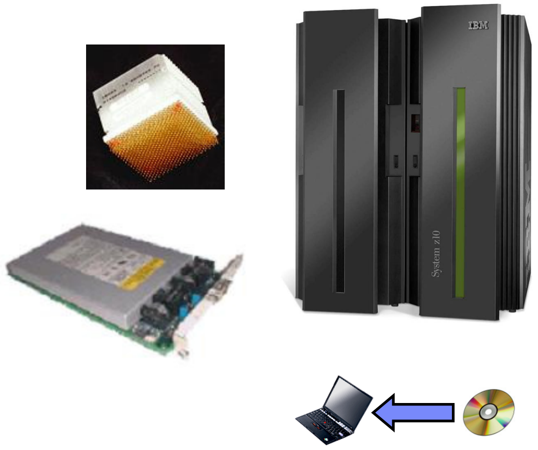
- **CP Assist for Crypto Function (CPACF)**
  - **DES (56-, 112-, 168-bit), new chaining options**
  - **AES-128, AES-192, AES-256, new chaining options**
  - **SHA-1, SHA-256, SHA-384, SHA-512 (SHA-2)**
  - **PRNG**
  - **Protected Key**



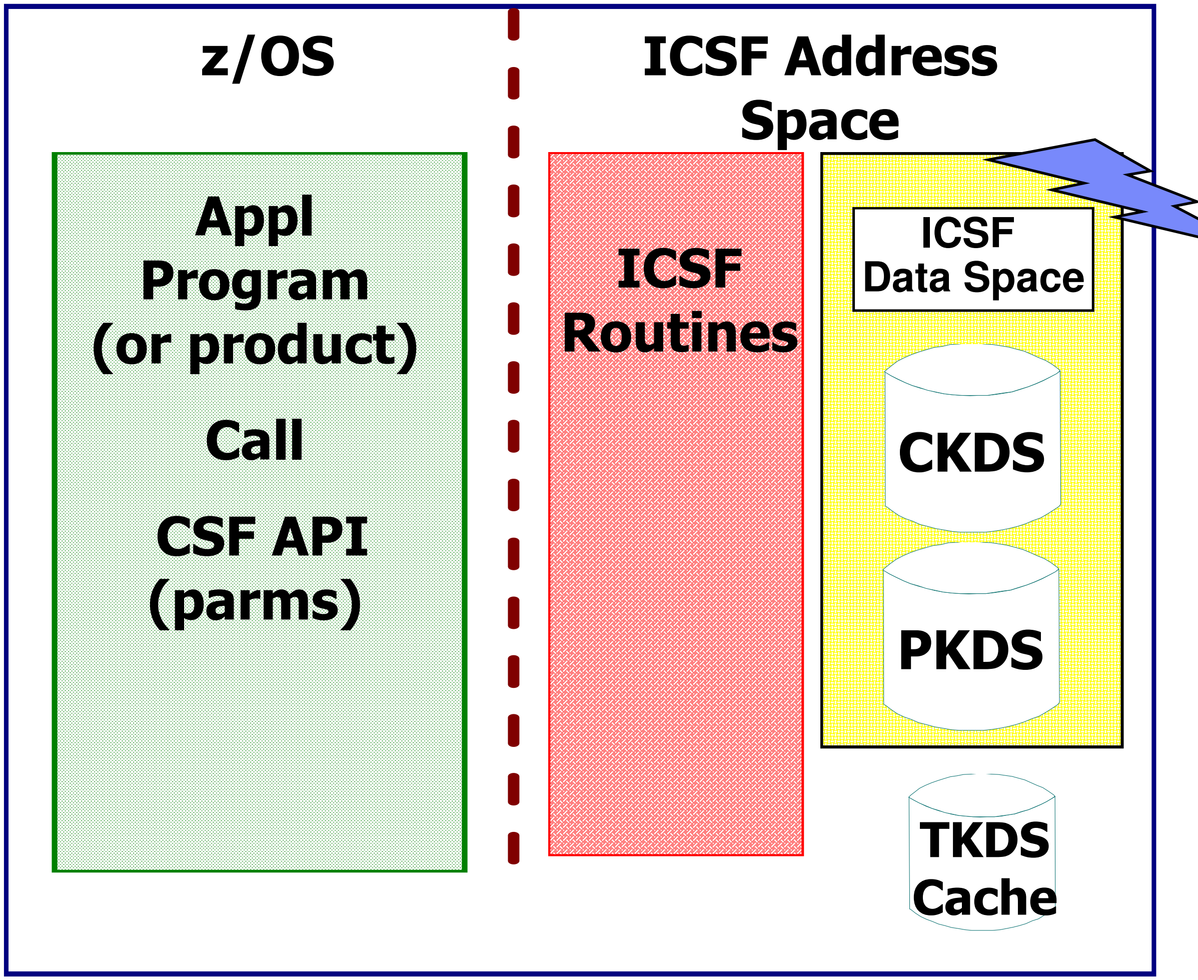
TechDoc WP100810 – A Synopsis of System z Crypto Hardware

System z Secure Key Crypto Hardware - CEX3 (z196)

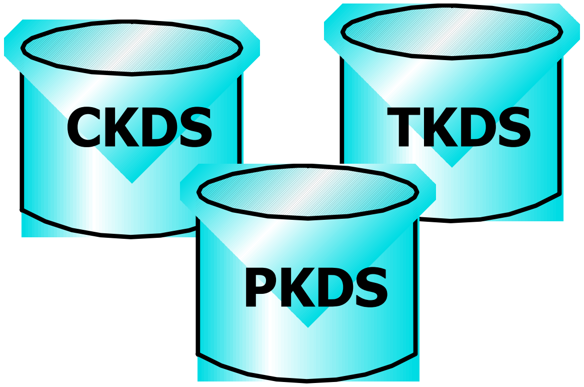
- **Secure Key DES/TDES**
- **Secure Key AES**
- **Financial (PIN) Functions**
- **Key Generate/Key Management**
- **Random Number Generate and Generate Long**
- **Protected Key Support**
- **SSL Handshakes, ECDSA support**



ICSF – Interface to the Crypto Hardware



- APIs
- Key Storage
- Load Balancing
- Security



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

Enabling Protected Key

- **Install HCR7770 or later**
  - CSFINIT replaces CSFMMAIN
- **Install Crypto Express3 on z10 with Driver 79 or on z196**
- **Install RACF (OA29193) and SAF (OA29194) APARs**
- **Create secure keys which will be used as protected keys**
- **Create/update RACF profiles for the keys, with SYMCPACFWRAP(YES)**

Encryption and “Data at Rest” Protection

- **Key requirement for most of the “popular” data protection initiatives**
- **Main requirement is to protect “data at rest” to ensure that only access if 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 controlled via RACF from direct access outside of DB2 via 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

Encryption and DB2 for z/OS

- **IBM Data Server Drivers starting in V9.5 support SSL protocol and AES encryption.**
- **Starting with Fix Pack 2, non-Java clients supports the Secure Sockets Layer (SSL) protocol. All DB2 Version 9.5 clients now support SSL. In addition, Java and CLI clients now support 256-bit AES encryption.**
- **SSL connectivity and AES user ID and password encryption requires Communication's AT-TLS configured and ICSF started.**
- **Starting with DB2 for z/OS V8, column level encryption implemented via SQL primitives is supported. TDES 128 bit support only.**
- **Row level encryption implemented for all supported releases of DB2 for z/OS using the IBM Infosphere Guardium Encryption Tool for IMS and DB2 databases**
- **DS8000 family DASD Based Encryption**
- **TS1120/TS1130 Tape Based Encryption**
  - TKLM (Tivoli Key Lifecycle Manager) Required for DS8000 and recommended for TS1120/TS1130

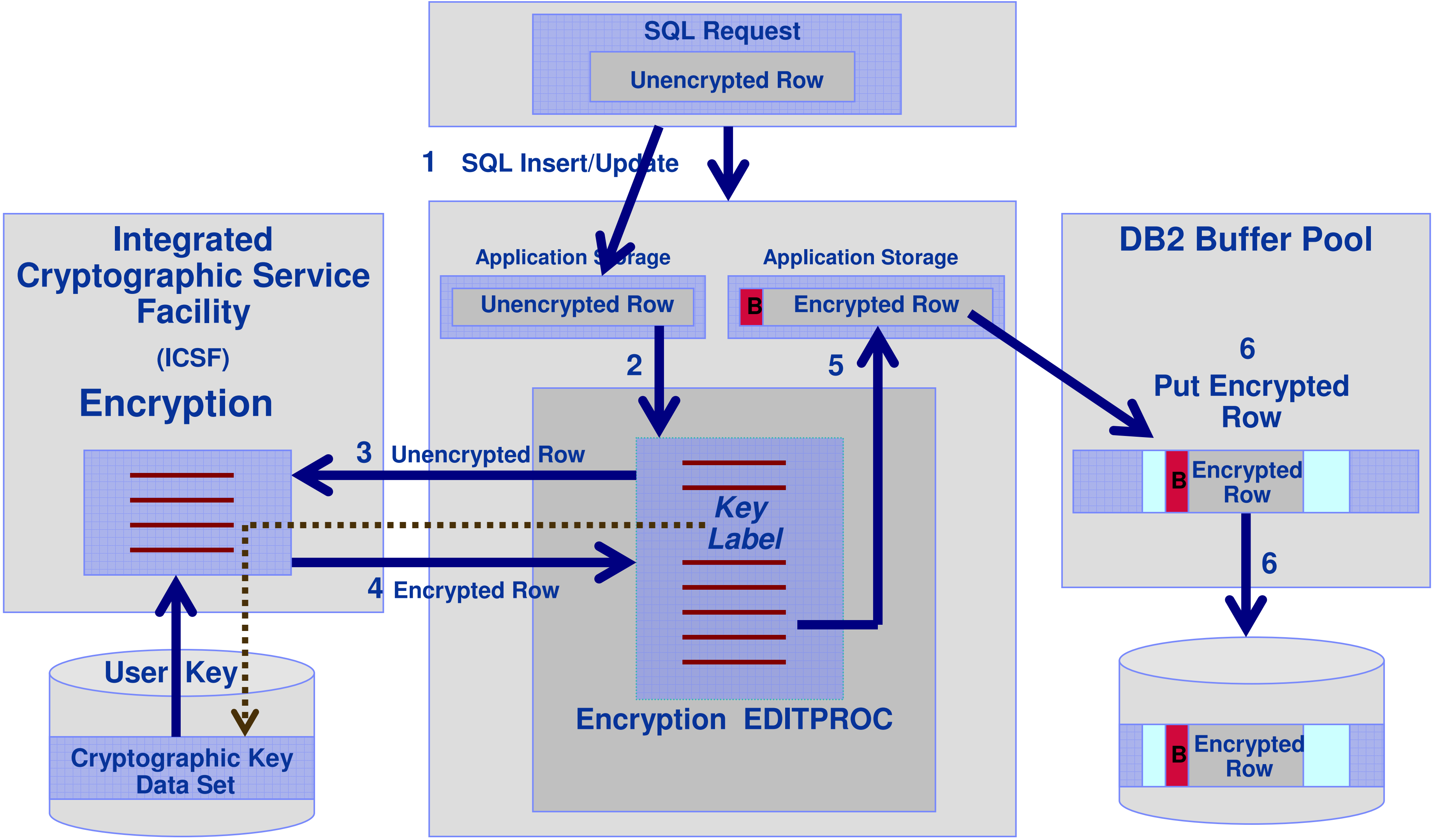
Database Encryption

- **DB2 UDB Version 8/9 Built-In Functions**
- **IMS Data Encryption Tool for IMS & DB2 Databases (5799-P03)**

How is crypto invoked with the Data Encryption Tool?

- **Via an EDITPROC, for every row processed by any SQL Utility for DB2 or IMS**
  - Encrypted row same length as clear row
  - 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

DB2 Data Encryption Flow – Insert / Update



How is crypto invoked with DB2 Built-In Functions?

- **Within the application, for every field that contains encrypted data 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)

Crypto Keys and Indexes

- **Data Encryption Tool**
  - EDITPROC encrypts the entire row, so the data is in the encrypted, but the index is not
    - Bad for security, good for performance
    - Encryption key is stored in the CKDS, when not in use
    - When in use, the key is brought into the DB2 Address Space
- **DB2 V8/V9/V10**
  - Application encrypts the field, if that field is an index, then the index is encrypted
    - Good for security, bad for performance
    - Key value is in the DB2 Address Space

Crypto Hardware for Data Encryption Tool

- **Clear Key**

– z800/z900/G6	Requires a CCF
– z10/z9/z890/z990	CPACF (& PCIXCC, CEX2C for CKDS)*

- **Secure Key**

– z800/z900/G6	Requires a CCF
– 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

Crypto Hardware for DB2 V8/V9/V10 BIFs

- **z900/z800/G6**
  - – These machines only supported Secure Key via the CCF hardware, so all work is done using secure key APIs
- **z196/z10/z9/z990/z890**
  - – CPACF (uses MSA instructions, not the ICSF APIs), but ICSF must be started to provide hashing support
  - – TDES only

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	▪High overhead due to the amount of data encryptions
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

Who owns the data and who is responsible for it’s security?

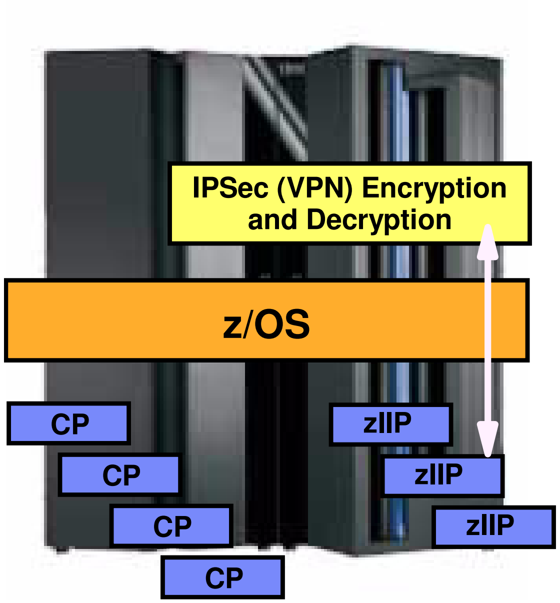
- **Data Administrator - Data Encryption Tool**
  - sets up the EDITPROC and specifies the key to be used for the entire table
  - Key must be defined to/managed by ICSF (stored in the CKDS)
- **Application - DB2 V8/V9/V10**
  - Application logic determines which key to use for each field/column
  - Password is managed by the application

Decisions, Decisions

- **Which should you implement**
  - Depends on
    - 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
  - No clear-text data on any network segments
    - Security regulations compliance
  - 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



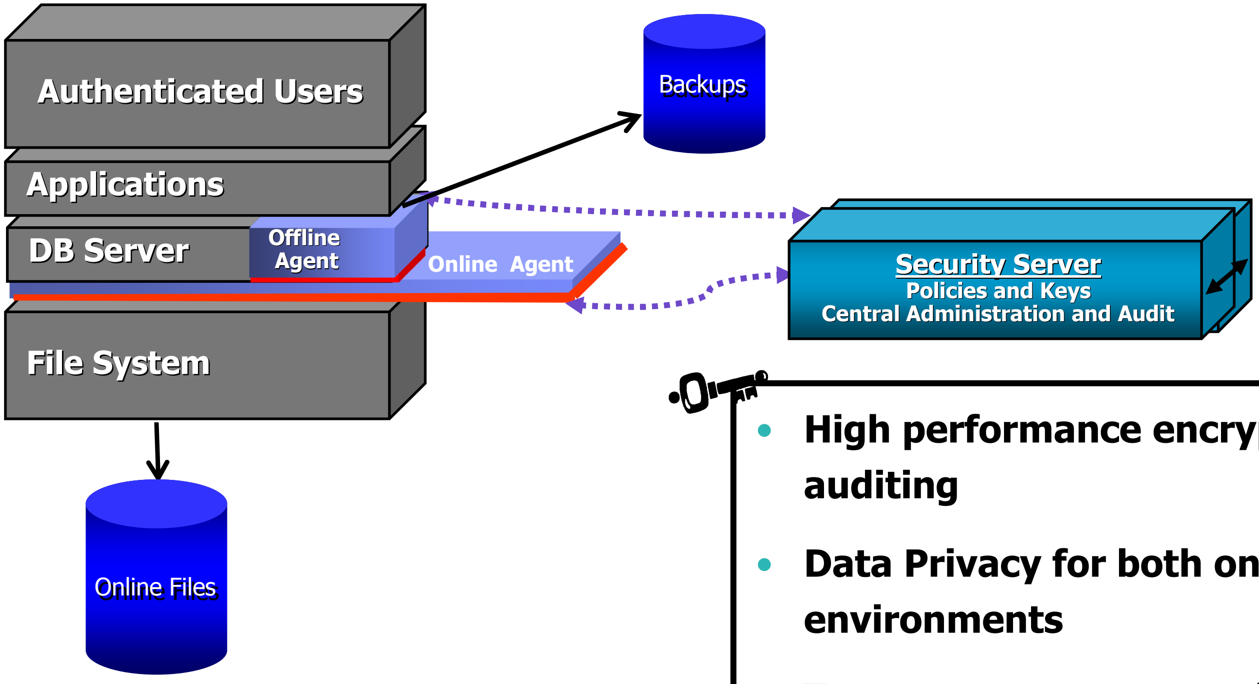
System z9 or later
z/OS CS V1R8 + PTFs
z/OS CS V1R9

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)**
  - 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
    - Establishing a new encryption key causes cryptographic erasure

- **Key attack vectors prevented:**
  - Disk removed (repair, or stolen)
  - Box removed (retire, or stolen)

Optim Encryption Expert – Data Encryption



UDB, IDS, and Others

- **High performance encryption, access control and auditing**
- **Data Privacy for both online and backup environments**
- **Transparency to users, databases, applications, storage**
  - No coding or changes to existing IT infrastructure
  - Protect data in any storage environment
  - User access to data same as before
- **Centralized administration**
  - Policy and key management
  - Audit logs
  - High Availability

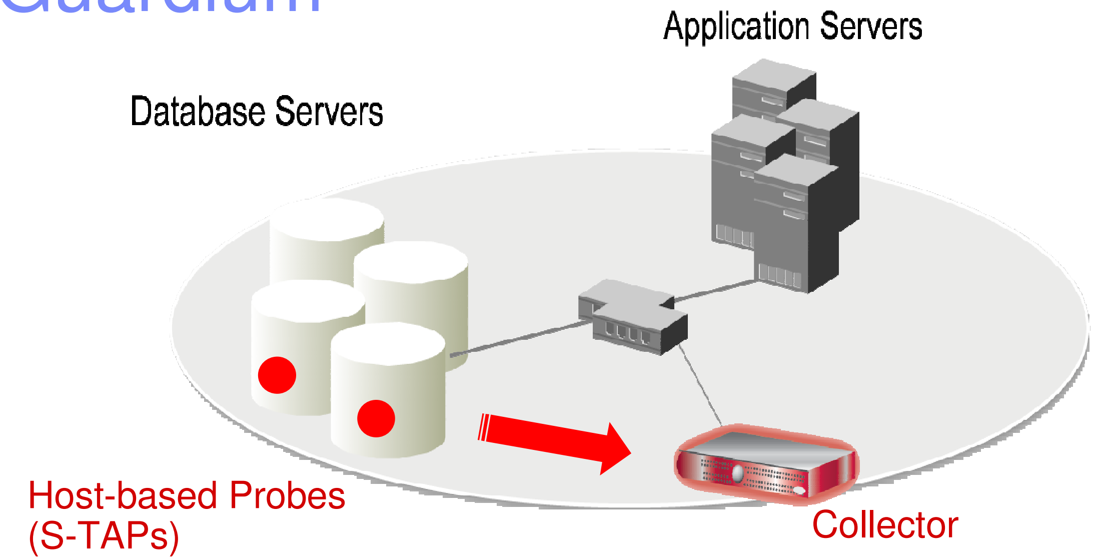
Why auditing is important in a RACF controlled environment

- **RACF provides significant controls to protect access to resources, but does little in the way of meaningful access reporting**
  - RACF does two things:
    - Prevents people from accessing a resource that is not essential or appropriate for their jobs
    - Allows people access to the necessary data to do their jobs
  - But RACF does NOT:
    - prevent a malicious update if the user has authority to the data.
    - prevent an authorized user from accessing sensitive data that is ***NOT*** within the scope of their job.E.g. a bank teller looks up the CEOs bank balance or personal customer information
    - provide meaningful information about access to protected DB2 resources (authorized or not).
- **DB2 Audit trace will do nothing to protect data, but provides data to help understand what type of access has occurred.**
    - Auditing is about ensuring that the appropriate controls are in place to identify inappropriate access and use of production data
    - You need some form of audit facility to watch your privileged users who have RACF and/or DB2 authority and users that have access to sensitive data within the scope of their job
    - Understanding how trusted (privileged) users access sensitive information is essential to ensuring that data is indeed protected

Auditing the Privileged Database User

- **DB2 trace based processes are managed by DBA's**
  - The DBA's are responsible for generating audit data with which they are in turn audited, this constitutes a significant security risk and exposure
  - Trace data collection can be interfered with or turned off completely
    - DBA can issue –DSN Stop Trace
    - Use IFASMFDMP to selectively filter SMF data based on timestamp
    - Use DB2PM (Or Equivalent) filter such as DATE/TIME/EXCLUDE to filter selected records
  - Having the DBA involved in the collection of audit data is viewed as weak from a compliance and control perspective
- **Security and Auditors with system privileges**
  - Also viewed as problematic from a compliance perspective
  - Requires additional technical skills not within their core competencies
  - Misuse of privileges without coordination can result in performance and availability issues
    - Turning on traces without proper filtering to reduce overhead or quantity of trace data collected
    - Altering objects to AUDIT without ensuring that plan/package invalidation is not an issue

Real-Time Database Monitoring with InfoSphere Guardium

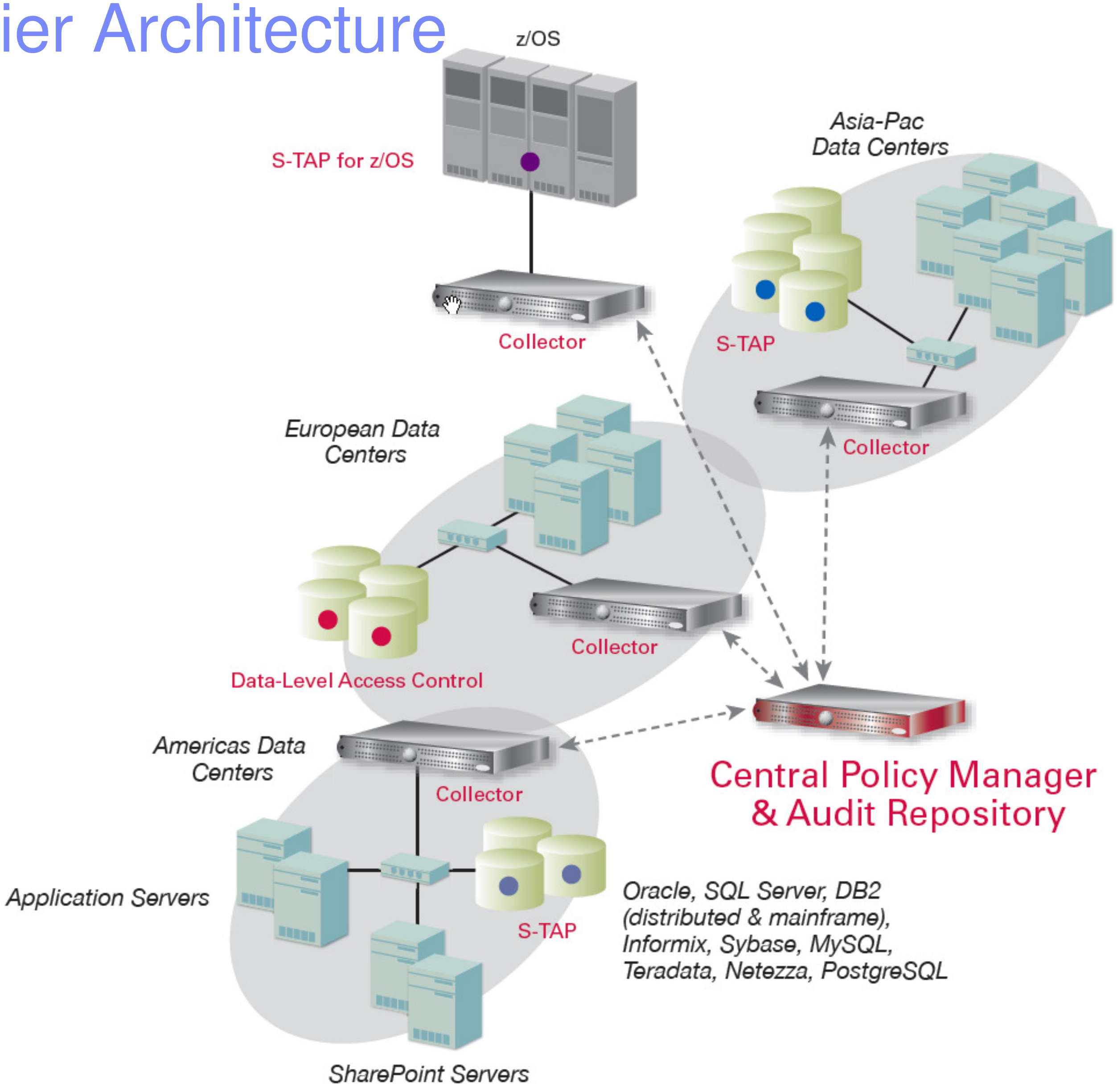


ORACLE
IBM DB2
Microsoft Office SharePoint
TERADATA
Microsoft SQL Server
PostgreSQL
NETEZZA
MySQL
IBM Informix
SYBASE

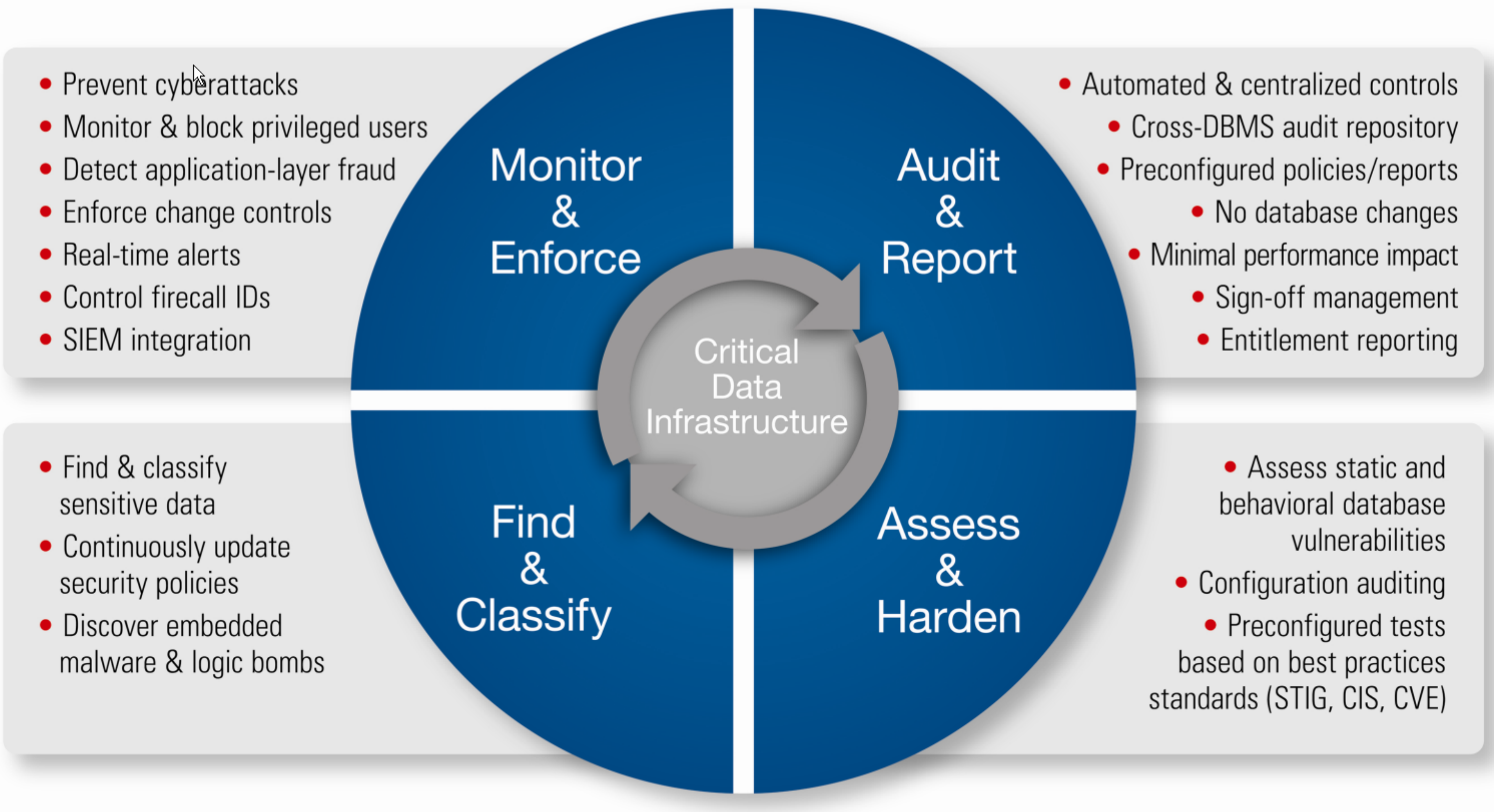
- Non-invasive architecture
  - Outside database
  - Minimal performance impact
  - No DBMS or application changes
- Cross-DBMS solution
- 100% visibility including local DBA access

- Enforces separation of duties
- Does not rely on DBMS-resident logs that can easily be erased by attackers, rogue insiders
- Granular, real-time policies & auditing
  - *Who, what, when, how*
- Automated compliance reporting, sign-offs & escalations (SOX, PCI, NIST, etc.)

Scalable Multi-Tier Architecture



Addressing the Complete Database Security and Compliance Lifecycle



- Prevent cyberattacks
- Monitor & block privileged users
- Detect application-layer fraud
- Enforce change controls
- Real-time alerts
- Control firecall IDs
- SIEM integration

Monitor & Enforce

Audit & Report

- Automated & centralized controls
- Cross-DBMS audit repository
- Preconfigured policies/reports
- No database changes
- Minimal performance impact
- Sign-off management
- Entitlement reporting

Critical Data Infrastructure

Find & Classify

- Find & classify sensitive data
- Continuously update security policies
- Discover embedded malware & logic bombs

Assess & Harden

- Assess static and behavioral database vulnerabilities
- Configuration auditing
- Preconfigured tests based on best practices standards (STIG, CIS, CVE)

Closing Thoughts

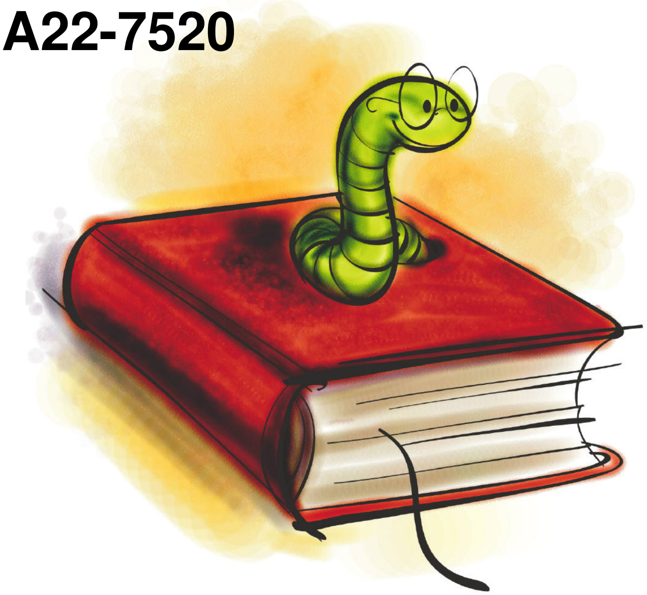
- **Encryption has a cost**
  - Crypto hardware more efficient with large blocks of data
- **Secure Key on a PCI Card – longer pathlength**
- **Clear Key exists in the DB2 Address Space, Protected Key and Secure Key are too, but they are stored encrypted under the Wrapping Key or Master Key**

References

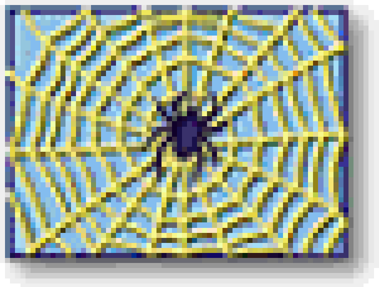
- **Cryptography Books**
  - Bruce Schneier, 'Applied Cryptography Second Edition: Protocols, Algorithms, and Source Code in "C"', Addison Wesley Longman, Inc., 1997
  - Simon Singh, 'The Code Book', Anchor Books, 1999
  - Niels Ferguson, Bruce Schneier, 'Practical Cryptography', Wiley Publishing, Inc. 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 System z10 Enterprise Class Technical Guide, SG74-7516
  - IBM System z10 Enterprise Class Configuration Setup, SG24-7571
  - IBM System z10 Business Class Technical Overview, SG24-7632
- **ATS TechDocs Web Site www.ibm.com/support/techdocs (Search All Documents for keyword of ‘Crypto’)**
  - WP100810 – A Synopsis of zSeries 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