SELF-ENCRYPTING DRIVES
Michael Willett, Seagate Technology
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Abstract

SELF-ENCRYPTING DRIVES

Data security is top of mind for most businesses trying to respond to the constant barrage of news highlighting data theft and security breaches. Combined with litigation risks, compliance issues and pending legislation, companies face a myriad of technology and products that all claim to protect data-at-rest on storage devices. However, these current solutions either fail to deliver or force compromise.

The disk drive industry has standardized and is now deploying innovative, simple and powerful technology intended to secure data where it lives – in storage. This presentation will give storage users and managers a look at emerging drive-level self-encryption technology from notebook PCs to the data center that will provide a more secure storage foundation.
Corporations spend millions to protect their networks, devices & data…

- Physical security, firewalls, intrusion detection, etc…

…But don’t always understand the risk posed by internal misplacement, re-purposing, and disposal processes.
The Problem...

Over 155,048,651 records containing sensitive personal information have been involved in security breaches in the US since 2005.

Reported Data Breaches Since February 2005 to Now

In another survey by the Ponemon Institute – corporations shelled out $14 million dollars on average to recover from a data breach.

$14 Million Per Incident
The Problem…

Over 155,048,651 records containing sensitive information have been involved in data breaches since February 2005.

The cost of a data breach is $14 million per incident.

1. **Legal**
2. **Financial**
3. **Reputation**

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Source: Privacy Rights Clearinghouse

Legal, Financial, and Reputation impacts of data breaches.
Who is demanding a solution...?

6 new bills on security breach, privacy, theft.

42+ states have passed laws on data privacy w/ encryption safe harbors

Payment Card Industry Data Security Standards (PCI DSS)

MEMORANDUM FOR THE HEADS OF DEPARTMENTS AND AGENCIES

FROM: Clay Johnson III
Deputy Director for Management

SUBJECT: Protection of Sensitive Agency Information
Why Encrypt Data-At-Rest?

- Compliance
  - 42+ states have data privacy laws with encryption safe harbors
  - New data breach bills have explicit encryption safe harbors
  - PCI DSS requires rendering stored cardholder data unreadable

- Exposure of data loss is expensive

- Data center disk drives are mobile

- Exposure of data loss is expensive ([$14 Million on average\(^1\)](www.ponemon.org))

- Obsolete, Failed, Stolen, Misplaced…
  - Nearly ALL drives leave the security of the data center
  - The vast majority of decommissioned drives are still readable

*Threat scenario: stored data leaves the owner’s control – lost, stolen, re-purposed, repaired, end-of-life, …*


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Why Encrypt Data-At-Rest?

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Threat scenario: stored data leaves the owner’s control – lost, stolen, re-purposed, repaired, end-of-life, …

Encryption can be done in a number of places…

- Host middleware
- Host HBA (h/w adapter)
- Application
- Switch
- “Bump in the wire” appliance
- Array controller
- Disk drive
Encryption can be done in a number of places...

- Network Fabric
- Application Server
- Host (middleware)
- Host HBA (h/w adapter)
- “Bump in the wire” appliance
- Switch
- Array controller
- Disk drive

Host middleware

Diverse Threat Scenarios
3 Simple reasons

- **Storage for secrets with strong access control**
  - Inaccessible using traditional storage access
  - Arbitrarily large memory space
  - Gated by access control

- **Unobservable cryptographic processing of secrets**
  - Processing unit “welded” to storage unit
  - “Closed”, controlled environment

- **Custom logic for faster, more secure operations**
  - Inexpensive implementation of modern cryptographic functions
  - Complex security operations are feasible
Trusted Storage Standardization

Published Storage Specifications
TRUSTED SEND/IN

(Protocol ID = xxxx .....)

TRUSTED RECEIVE/OUT

T10/T13 defined the "container commands"

TCG/Storage defining the "TCG payload"

Protocol IDs assigned to TCG, T10/T13, or reserved
TRUSTED STORAGE

- (Partitioned) Hidden Memory
- Security firmware/hardware
- Trusted Send/Receive Commands
- Assign Hidden Memory to Applications
Trusted Storage with Trusted Platform

Life Cycle: Manufacture, Own, Enroll, PowerUp, Connect, Use, …
Trusted Storage with Trusted Platform

Trusted Storage

Trusted Platform

TPM

Trusted Element

Manage Trusted Storage

Life Cycle: Manufacture, Own, Enroll, PowerUp, Connect, Use, ...

Self-Encrypting Drives
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Self-Encrypting Drive
- Laptop Loss or Theft
- Re-Purposing
- End of Life
- Rapid Erase

Drive Locking/Drive Pairing

Forensic Logging

On-board Crypto Key Management

Crypto Chip

Personal Video Recorders

DRM Building Blocks
SPs (Security Providers)
- Logical Groupings of Features
- SP = Tables + Methods + Access Controls

Tables
- Like “registers”, primitive storage and control

Methods
- Get, Set – Commands kept simple with many possible functions

Access Control over Methods on Tables
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Access Control over Methods on Tables
Home Banking (or Remote Medical, or … )

- Multi-factor authentication: password, biometrics, dongles
- Secure/hardware storage of credentials, confidential financial/medical data
- Trusted life cycle management of personal information
- Integrity-checking of application software
- Cryptographic functions for storage and communications security
- Trusted/secure computation of high-value functions (protection from viruses/etc)
Home Banking (or Remote Medical, or … )

Breadth of Applications

Trusted Platform w/

Trusted Storage

- Multi-factor authentication: password, biometrics, dongles
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TCG Storage: Document Structure

General Documents

Specific Documents

Auxiliary Documents

Core Spec

Interface

PC SSC (OPAL)

Optical SSC

Enterprise SSC

Compliance and Security Evaluation

SSC = Security Subsystem Class

Self-Encrypting Drives

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Many organizations are considering drive-level security for its simplicity in helping secure sensitive data through the hardware lifecycle from initial setup, to upgrade transitions and disposal.

Eric Ouellet
Research Vice President
Self-Encrypting Drives Solve…

Purpose

• Protect data from exposure due to equipment loss
• Enable instant, secure erase of HDD

Closed encryption device

• Dedicated engine for full interface speed encryption
• Key generated by true RNG\(^1\) in drive
• Encryption cannot be turned off
• Encryption Key never leaves the drive
• Drive exposes an open interface for management of encryption & credentials
• Only signed firmware can be loaded onto drive

2 Architectures

• Client (laptops, desktops) 3rd party software manages encryption
• Enterprise (arrays) Storage System manages encryption

\(^1\)Random Number Generator
Enterprise Management of Self-Encrypting Drives

- **Enterprise Server:**
  
  Key generation and distribution

  Key/Password archive, backup and recovery

- **Laptop (Application):**
  
  Master/User passwords, multi-factor authentication, TPM support

  Secure log-in, “Rapid Erase”

- **Trusted Drive (self-encrypting):**
  
  Disk or sector encryption, sensitive credential store, drive locking
Lessons Learned: Laptop Self-Encryption

- Continuous protection against laptop loss and theft
- Facilitates easy re-purposing, end of life, and rapid erase
- Satisfies legislative/regulation compliance obligations
- No performance degradation (with hardware encryption)
- Considered more secure than software-based solutions
Qualification received for the 1st Self-Encrypting Drive Model

The National Security Agency (NSA) has approved a vendor laptop SED hard drive for protection of sensitive and classified information in computers deployed by U.S. government agencies and contractors for national security purposes.

Other vendor SED drive qualifications expected to follow...

*More information on NSTISSP #11 is available at http://www.niap-ccrevs.org/cc-scheme/faqs/nstissp-faqs.cfm#Question_1_5.
Client Security: Pre-Boot Authentication

• Transparency: Master boot record and OS are unmodified
• Protected from malicious software: Authentication occurs before OS (and any malicious software) is loaded
• The master boot record can’t be corrupted: The entire drive, including the master boot record, is encrypted

1. BIOS attempts MBR read; drive redirects to pre-boot area
2. Drive loads pre-boot OS
3. User enters authentication credentials for drive to verify
4. If authentication successful, drive loads original MBR
5. Normal operation commences
The drive LOCKS automatically when powered OFF
The drive remains LOCKED when it is powered back ON
Authentication Key (Password) Unlocks the drive
Write and Read data normally while drive is unlocked

Authentication Key source

Data protected from loss, disclosure
**Authentication in the Drive**

1. Correct AK? (Clear Data)

   - Hash AK
     - No
     - Yes

   - Clear AK decrypts DEK

2. Unlock HDD

3. DEK encrypts and decrypts User Data

**Key Terms**

- **AK**: Authentication Key
- **DEK**: Data Encryption Key
Cryptographic Erase

**Description**
- Cryptographic erase changes the drive encryption key
- Data encrypted with previous key, unintelligible when **Decrypted** with new key

**Benefits**
- Instantaneous “rapid” erase for secure disposal or re-purposing

```
The quick brown fox jumps over the lazy dog
```
Client SED Deployment

Drive Manufacturer
- Encryption key created
- Encryption turned on
- User password Not Initialized

System Manufacturer
- Optional cryptographic erase (generate new encryption key)
- Optionally integrate management software

SED Managers
- Change master password(s)
- Optional crypto erase before re-image
- Set a default User password
- Save new passwords

End User
- User powers on, enters PWD
- User changes PWD
- Uses system normally
- User returns system to IT for erase

IT department
- Generate new encryption key to erase drive

Customer
- System delivered to end user

System sold

Drive sold

Encryption key created
Encryption turned on
User password initialized

Change master password(s)
Optional crypto erase before re-image
Set a default User password
Save new passwords
### ‘Hurdles’ to Implementing Encryption…

<table>
<thead>
<tr>
<th>Category</th>
<th>Data Management/Key Management/Loss</th>
<th>Complexity</th>
<th>Performance</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tracking and managing encryption keys</td>
<td>Data classification</td>
<td>Performance degradation; scalability</td>
<td>Initial acquisition costs; Deployment costs</td>
</tr>
<tr>
<td></td>
<td>Tracking and managing authentication keys (passwords for unlocking drives)</td>
<td>Impact on OS, applications, databases; Interoperability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
No Performance Degradation

Encryption engine speed

Matches
Port’s max speed

The encryption engine is in the controller ASIC

Scales Linearly, Automatically

Network

Storage System

Storage System

All data will be encrypted, with no performance degradation
IT Retires Hard Drives Constantly

- All Drives are Eventually Retired
  - End of Life
  - Returned for Expired Lease
  - Returned for Repair / Warranty
  - Repurposed
- 50,000 drives leave data centers daily
- Exposure of data is expensive - $14 million on average
- 90% of retired drives are still readable (IBM study)

Needed: A simple, efficient, secure way to make retired hard drive data unreadable
How the Drive Retirement Process Works

Retirement Options
- Overwriting takes days and there is no notification of completion from drive
- Hard to ensure degauss strength matched drive type
- Shredding is environmentally hazardous
- Not always as secure as shredding, but more fun

People make mistakes

“Because of the volume of information we handle and the fact people are involved, we have occasionally made mistakes.”

People make mistakes which lost a tape with 150,000 Social Security numbers stored at an Iron Mountain warehouse, October 2007

99% of Shuttle Columbia's hard drive data recovered from crash site

Data recovery specialists at Kroll Ontrack Inc. retrieved 99% of the information stored on the charred Seagate hard drive's platters over a two day period.

- May 7, 2008 (Computerworld)


Self-Encrypting Drives
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How the Drive Retirement Process Works

Drive Retirement is:

Expensive
Time-consuming
Error-prone


People make mistakes which lost a tape with 150,000 Social Security numbers stored at an Iron Mountain warehouse, October 2007.

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Drive Retirement: Self-Encrypting Drives

Self-Encrypting Drives

Retire Drive
- Replace
- Repair
- Repurpose

Remove ALL drives
Send even “dead” drives through
Queue in secure area
Transport Offsite
Queue in secure area

Power Off = Locked and Encrypted = Secure

- Reduces IT operating expense
  - Eliminates the need to overwrite or destroy drive
  - Secures warranty and expired lease returns
  - Enables drives to be repurposed securely

- Provides safe harbor for data privacy laws
Key Management Simplification

Encryption keys never leave the drive. No need to track or manage …
BUT, YOU STILL MUST MANAGE THE AUTHENTICATION KEYS (drive locking),
to protect against loss or theft (for just crypto erase, no authentication key)

• To recover data from a drive:
  • Only need the Authentication Key and the drive
  • Don’t need to escrow the encryption key to maintain data recoverability
  • Don’t need to track encryption key storage separate from data storage
  • Don’t need to be concerned with interoperability of encryption key storage and data
  • One-to-One Drive-Encryption Key association. Can decommission drive by deleting it’s encryption key.
  • Less re-encryption required.
  • Backward compatibility; easy to upgrade.
Reducing Complexity for IT

- Application Developers: May need to change applications
- OS: May change if encrypting in a driver
- Encryption engine: May need separate hardware
- Network: Heavyweight encryption can impact performance
- Key Manager: Installed on server
- Storage System: Data compression & de-duplication affected

- Key Manager: Installed on server
- Storage System: Upgrade per schedule
At Initialization:
- Bring in new volume
- Set up Authentication Key

Power-up:
- Authenticate with the key source
- Pass key to the disk drive

After Power-up:
The storage system virtualizes the disk drives and provides:
- Data protection through RAID and copy services
- Availability through redundancy, failover drivers, robust error handling
- Capacity sharing through partitioning and network connectivity
- Management reporting
- Data compression and de-duplication best applied BEFORE encryption
Reducing Security Costs

✧ **Initial acquisition costs:**
  - Integrated into standard products
  - Implemented per standard storage upgrade schedule
  - Standards-based, and all hard drive vendors are participating in TCG
  - The hard drive industry has long demonstrated standards drive competition which drives cost
  - Economies of scale enable incremental logic in the ASICs to remain a small portion of drive material costs

✧ **Reduce drive decommissioning and insurance costs**

✧ **Maintain ability to compress and de-duplicate data**

✧ **Preserve drive hardware value**
  - Service, warranty, expired lease returns enabled
  - Drive repurposing enabled
### Addressing the Hurdles...

<table>
<thead>
<tr>
<th>Simplifies key management to prevent data loss</th>
<th>✔ Encryption key does not leave the drive; it does not need to be escrowed, tracked, or managed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplifies Planning and Management</td>
<td>✔ Standards-based for optimal manageability and interoperability</td>
</tr>
<tr>
<td></td>
<td>✔ Transparent to application developers and database administrators. No change to OS, applications, databases</td>
</tr>
<tr>
<td></td>
<td>✔ Data classification not needed to maintain performance</td>
</tr>
<tr>
<td>Solves Performance</td>
<td>✔ No performance degradation</td>
</tr>
<tr>
<td></td>
<td>✔ Automatically scales linearly</td>
</tr>
<tr>
<td></td>
<td>✔ Can change keys without re-encrypting data</td>
</tr>
<tr>
<td>Reduces Cost</td>
<td>✔ Standards enables competition and drive cost down</td>
</tr>
<tr>
<td></td>
<td>✔ Compression and de-duplication maintained</td>
</tr>
<tr>
<td></td>
<td>✔ Simplifies decommissioning and preserves hardware value for returns, repurposing</td>
</tr>
</tbody>
</table>
New IT policy: All future drive purchases to be self-encrypting drives when available

Beginning: SEDs for critical applications and routine storage upgrades
Ongoing: SEDs for ongoing routine storage upgrades
Eventually: All data, no matter where data resides, is stored securely

Eventually, ALL drives will be self-encrypting
Encryption everywhere!
- Ecosystem to extend from the data center/branch office to the USB drive

Standards-based
- Multiple vendors; interoperability

Unified key management
- Authentication key management handles all forms of storage

Simplified key management
- Encryption keys never leave the drive. No need to track or manage.

Transparent
- Transparent to OS, applications, application developers, databases, database administrators

Automatic performance scaling
- Granular data classification not needed
Thank You!
Q&A/Feedback

Please send any questions or comments on this presentation to SNIA: tracksecurity@snia.org

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- SNIA Education Committee

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