ManTech
International Corporation ®

CYBER SECTOR

BitLocker To Go

Jesse Kornblum

Outline

- Introduction
- While you'll see more BitLocker
- What hasn't changed
- Passwords
- Smart Cards
- Drive Layout
- BitLocker To Go
- Auto Unlock Keys
- Incident Response
- Forensics
- Operations

Introduction

- BitLocker Disk Encryption (BDE)
  - Full Volume Encryption
  - Introduced with Windows Vista
  - Protects data at rest

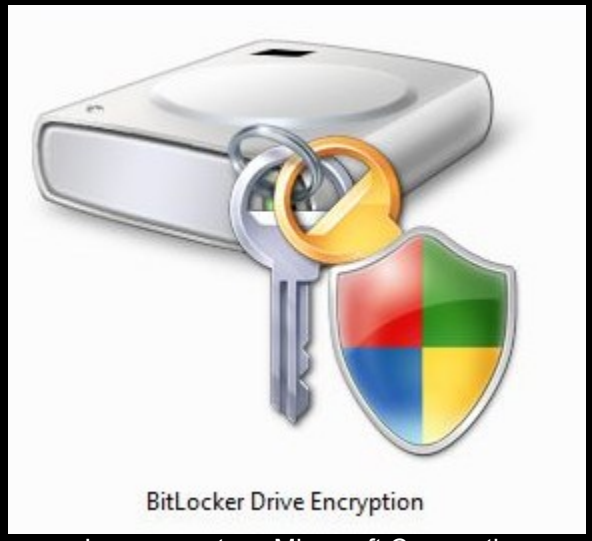


Image courtesy Microsoft Corporation.

Introduction

- Not widely adopted
  - Only came with Enterprise or Ultimate edition
  - Pain to install
    - Required hard drive repartition
    - Easy to lose data
  - Pain to use
    - Easy to lose data

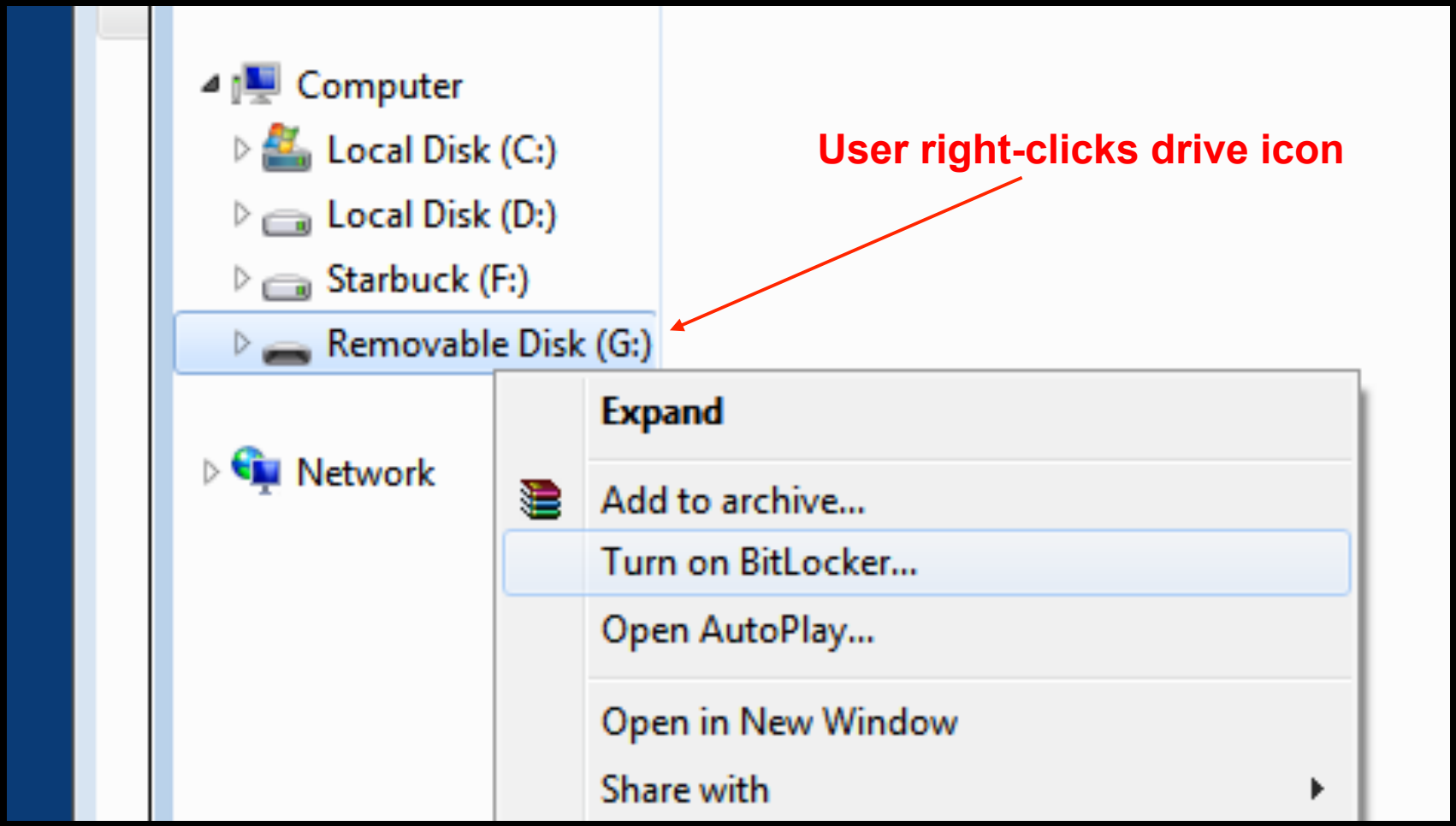
BitLocker version 2

- Introduced in Windows 7 (Fall 2009)
  - Still only in higher end versions
- Asks to upgrade existing BDE volumes
- Still painful to use for fixed disks

Why You'll See More BitLocker

- Can encrypt removable media
  - BitLocker To Go (BTG)
  - USB drives
  - Encrypts in place
- As easy as right clicking

Why You'll See More BitLocker



ManTech International Corporation ®

Why You'll See More BitLocker

- BitLocker policy options
  - Can be configured to only allow writes to BTG protected devices
- Force protection
- Ideal for deployed environments
  - USB sticks are lost, stolen
  - Prevent thief from accessing data

ManTech International Corporation ®

What Hasn't Changed

Image courtesy Flickr user shoothead and licensed under the Creative Commons

- Computationally infeasible to access protected volume without a key
  - There is no back door
- Best hope is known plaintext attack against AES-256

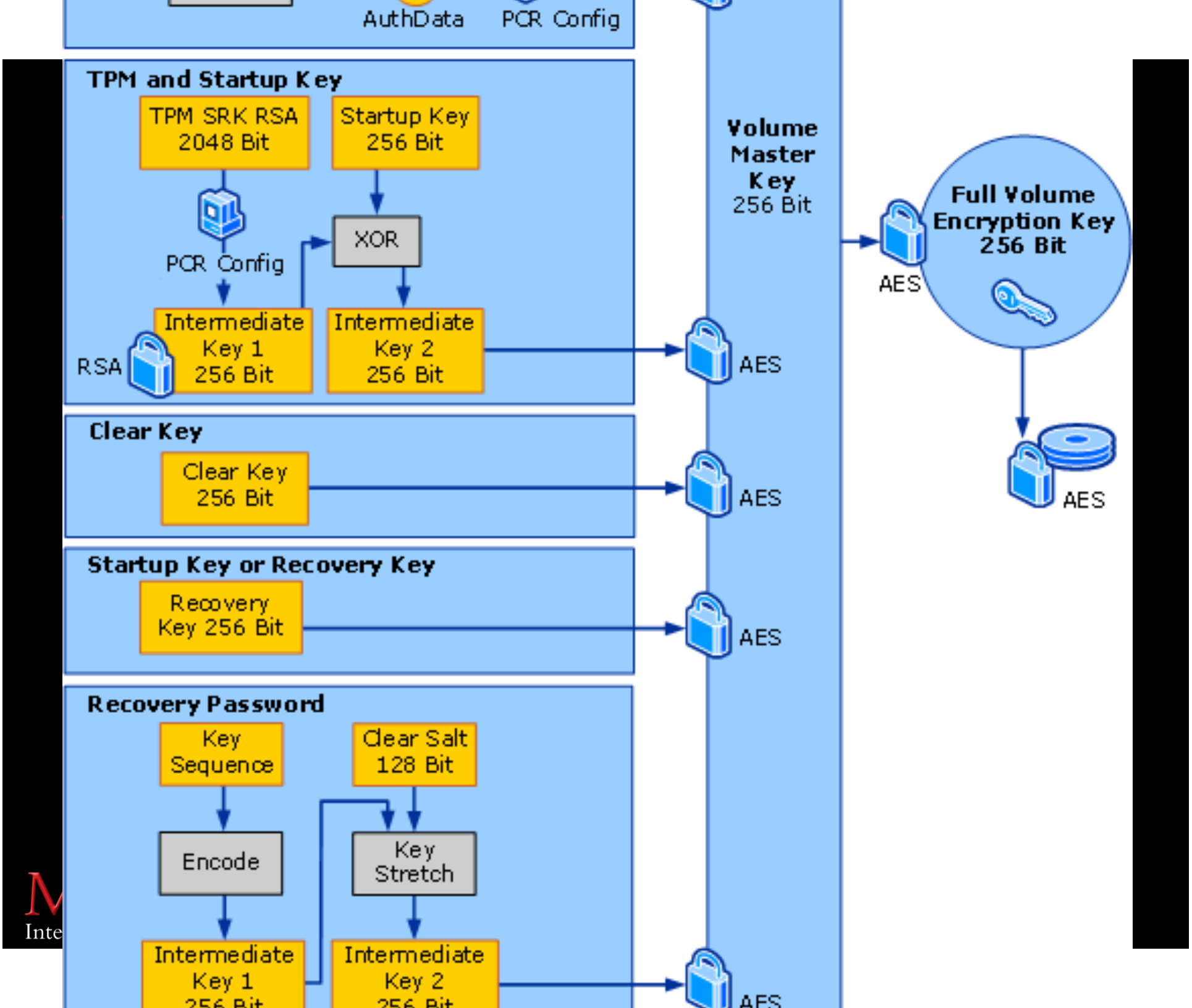
(good luck!)

What Hasn't Changed

- Data is encrypted with Full Volume Master Key (FVEK)
- FVEK is stored on disk, encrypted with Volume Master Key (VMK)
- Many copies of VMK are stored on disk, encrypted with different keys
  - TPM, Recovery, External, etc.

Image courtesy Flickr user Svadilfari and licensed under the Creative Commons

ManTech International Corporation ®


AuthData
PCR Config
TPM and Startup Key
TPM SRK RSA 2048 Bit
Startup Key 256 Bit
PCR Config
XOR
RSA
Intermediate Key 1 256 Bit
Intermediate Key 2 256 Bit
Volume Master Key 256 Bit
AES
Full Volume Encryption Key 256 Bit
AES
AES
Clear Key
Clear Key 256 Bit
AES
Startup Key or Recovery Key
Recovery Key 256 Bit
AES
Recovery Password
Key Sequence
Clear Salt 128 Bit
Encode
Key Stretch
Intermediate Key 1
Intermediate Key 2
AES

What Hasn't Changed

- Logical access to a drive is not affected
  - Programs do not need to know about BitLocker to access the drive
- Physical access to volume
  - Use \\.\C: file
  - This file handle can be imaged
- Still using AES with Elephant diffuser
- BitLocker can be disabled but still encrypt the data

What Hasn't Changed

- For each particular key k
  - Metadata contains copy of the VMK encrypted with that key
  - E(VMK, k)
- Metadata also contains copy of k encrypted with VMK
  - E(k, VMK)

- Having one key means you can get all the keys
  - Allows user to recreate an access device
  - Allows us to create an access device, too

What Hasn't Changed

- Let's suppose metadata contains:
  - E(VMK, recovery password)
  - E(recovery password, VMK)
  - E(VMK, external key)
  - E(external key, VMK)
  - E(VMK, TPM key)
  - E(TPM key, VMK)

Passwords

- Volumes can be protected with a Unicode password
  - Documentation used "password" and "passphrase" interchangeably
- Policy can control complexity requirements
  - By default, must be at least eight characters
- To get key from password:
  - Hash password using SHA-256
  - Chain hash the result, with salt, 2^{16} times
    - Repetitions makes brute force attacks more difficult
    - Salting impacts rainbow tables

Smart Cards

- Volume is protected using Smart Card and PIN
  - Something you have and something you know
  - Exact method of key generation is unknown

Image courtesy U.S. Department of Defense and is public domain

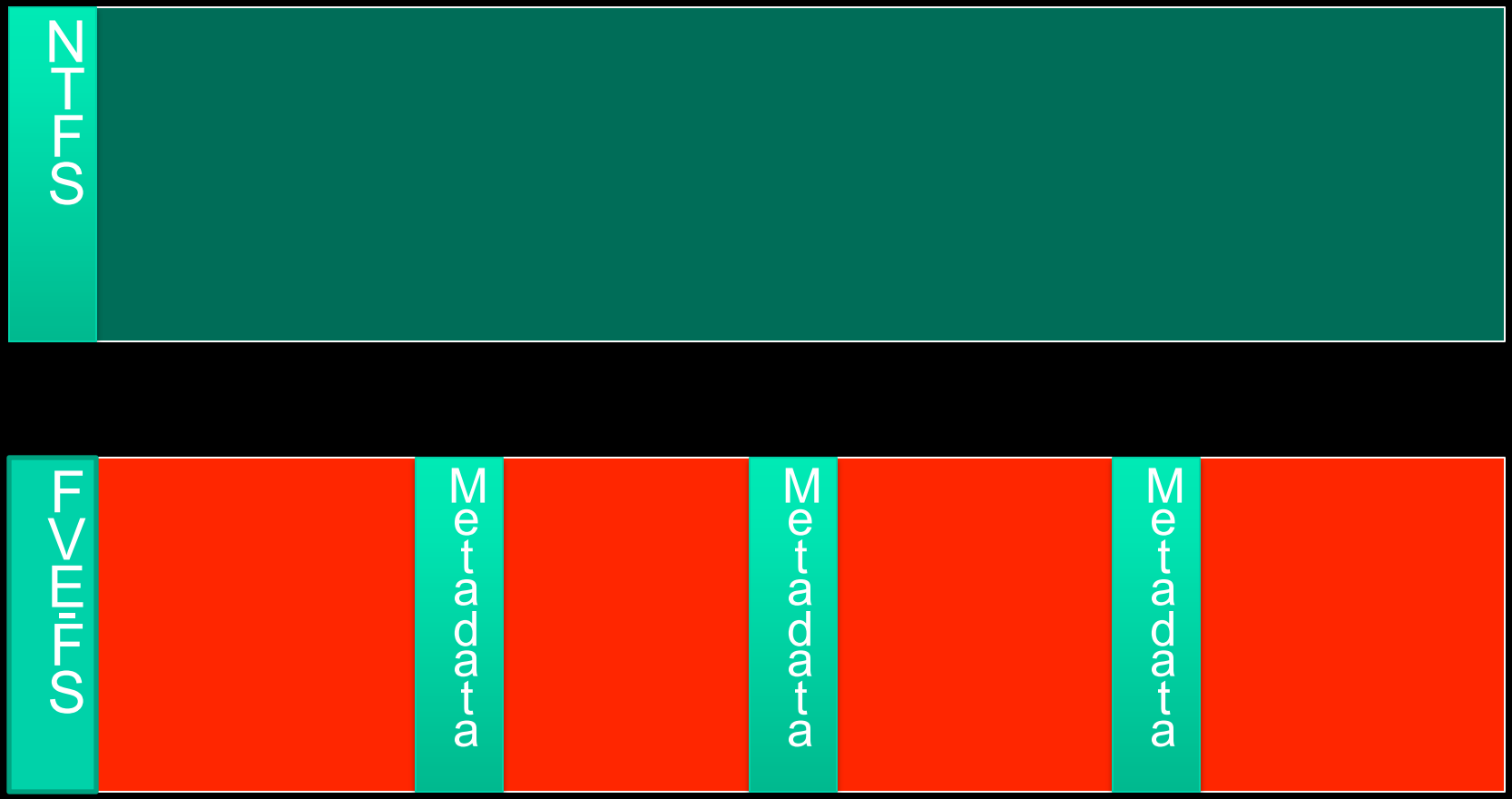
Command Line Interface

- Passwords and Smart Cards not normally used for fixed disks
- But can be added using CLI
- manage-bde.exe
  - http://technet.microsoft.com/en-us/library/dd875513%28WS.10%29.aspx

Drive Layout

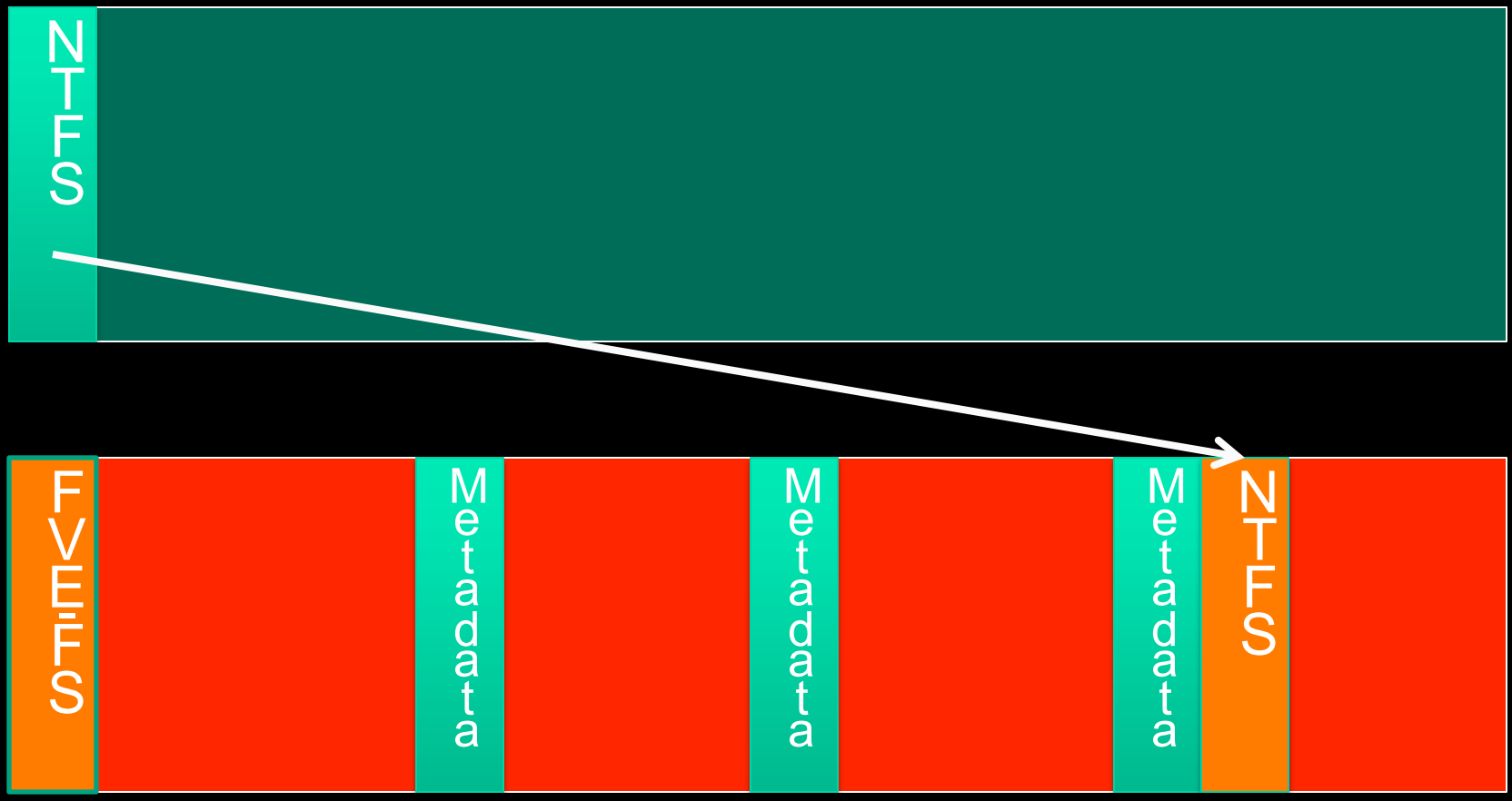
- Version one munged NTFS header
  - From NTFS to -FVE-FS-
  - Also set offset 0x38 to point to metadata
- Version two completely replaces NTFS header
  - Still has -FVE-FS- signature, but is not a valid disk header
- Contains BitLocker GUID
  - 4967D63B-2E29- 4AD8-8399-F6A339E3D001
- Appears on disk as
  - 3b d6 67 49 29 2e d8 4a 83 99 f6 a3 39 e3 d0 01

Version 1 Drive Layout



ManTech International Corporation ®

Version 2 Drive Layout



Drive Layout

- Metadata format changed slightly

Offset	Size	Description
0x00	8	Signature FVE-FS-
0x08	2	Unknown
0x0A	2	Version, must be 2
0x0C	2	Unknown
0x0E	2	Unknown
0x10	8	Volume size, in bytes
0x18	4	Unknown
0x1C	4	Size of volume header, in sectors
0x20	8	First Metadata offset
0x28	8	Second Metadata offset
0x30	8	Third Metadata offset
0x38	8	Offset of volume header
0x40	4	Metadata length
0x44	4	Unknown
0x48	4	Unknown
0x4C	4	Metadata length 2
0x50	16	Volume GUID
0x60	4	Next nonce
0x64	4	Volume algorithm
0x68	8	Timestamp

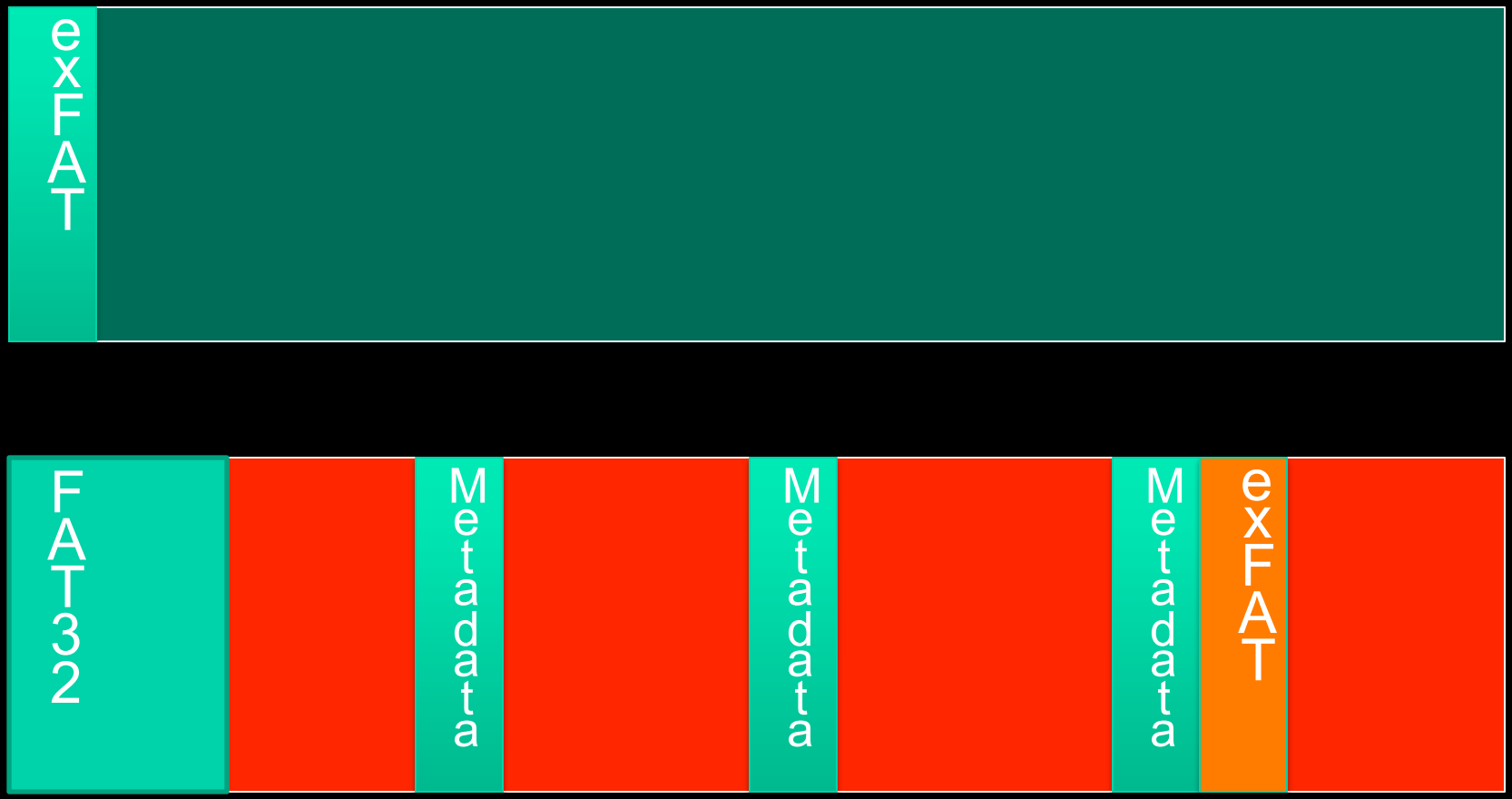
BitLocker To Go

- Right-click easy for USB devices
- Can also be enabled from Control Panel and CLI

BitLocker To Go

- Default protection is password or smart card
  - Can add others using CLI
  - Only one password per device, sorry
- Encrypts in place
  - Doesn't disturb underlying FAT12, FAT32, NTFS or exFAT
  - User can work during encryption
- If space available, adds FAT32 file system with 'reader' application
  - More like a 'copy' application, really
  - Takes about 5MB
  - Works on Windows XP and Vista

BitLocker To Go Drive Layout



BitLocker To Go

- When using GUI, user must create a recovery key file
  - Series of eight groups of six digits
- Saved to a file on the disk
  - Default name is GUID of the recovery key
  - Default save location is user's home directory
  - BUT! Key must be on a removable device to be used
  - Can also be typed manually

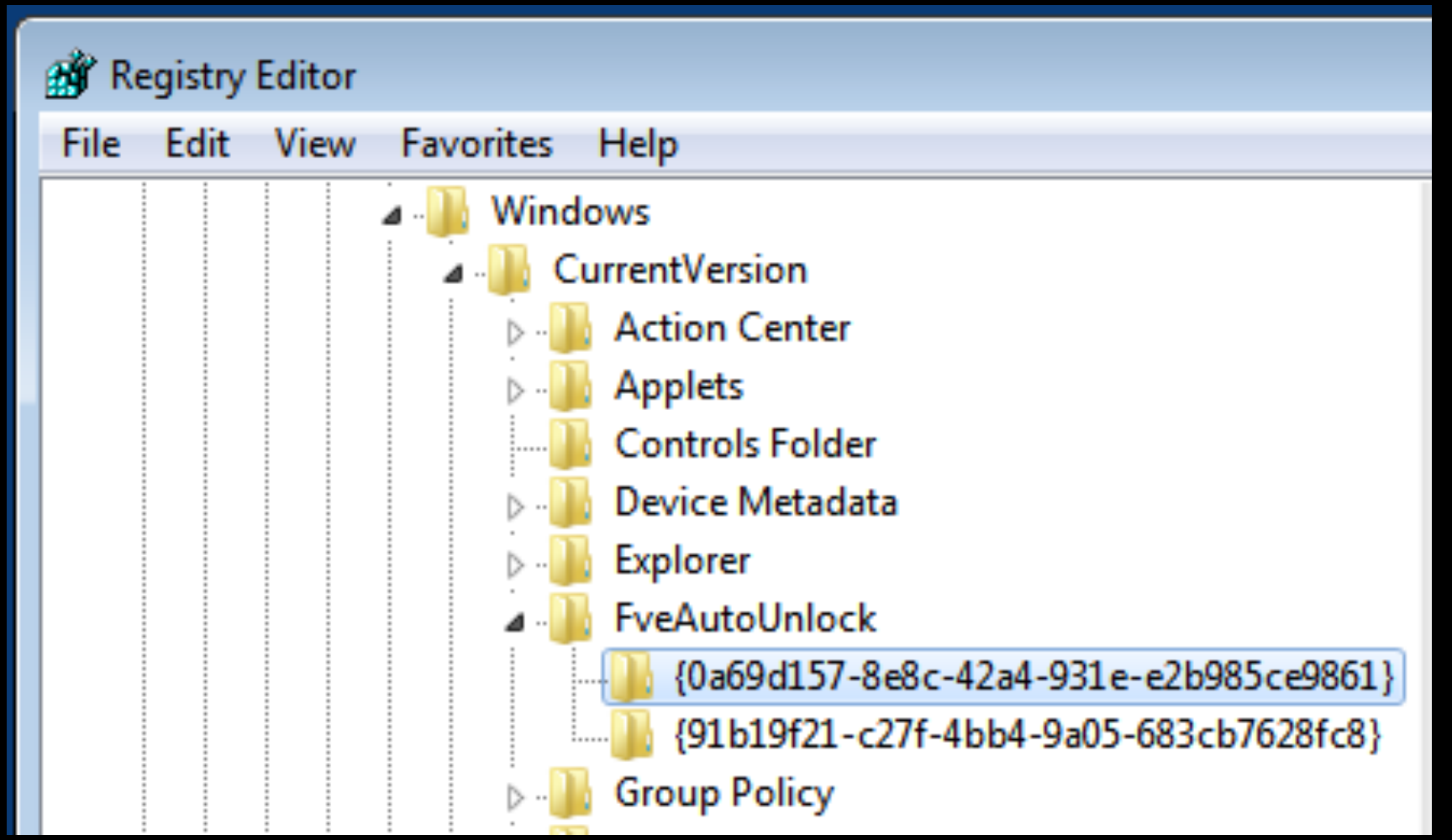
Policy Settings

- Stored in Registry
- Control complexity, writing to unprotected devices
- HKCU\Software\Policies\Microsoft\FVE

Auto Unlock Keys

- User can configure system to automatically unlock a volume
  - BitLocker External Key stored in registry
- HKCU\Software\Microsoft\Windows\CurrentVersion\ FveAutoUnlock\ {GUID}
- Key and metadata encrypted using CryptProtectData function
  - Uses login credentials and 3DES
  - Can be decrypted on the same machine

Auto Unlock Keys



Auto Unlock Keys

- Unfortunately GUIDs in the registry correspond to auto unlock keys, not the USB device itself
  - Can't correlate to list of USB devices seen by a machine

Incident Response

- Need the Full Volume Encryption Key
- Kept in RAM when drive unlocked
  - Capture RAM
- Search memory image for AES keys
  - See "Cold Boot" attack
  - Really searching for not AES key schedules

Image courtesy Flickr user mape_s and used under the Creative Commons

Incident Response

- Need a physical image of the drive
- If the drive is mounted, can image decrypted drive!

Incident Response

- Want the auto unlock keys in the registry
- Grab contents of
  - HKCU\Software\Microsoft\Windows\CurrentVersion\FveAutoUnlock
  - Decrypt using user credentials

Incident Response

- Look for written down/printed out recovery key
  - Eight groups of six digits
  - Each group is a multiple of 11
- Look for Recovery key files
  - Unicode text
  - Contain string "Full recovery key identification:"
- Look for External key files
  - Should be stored on USB devices
  - .BEK extension

Forensics

- Look for clear key
  - Indicates BitLocker has been disabled

Forensics

- Password cracking
  - About 0.8 seconds per guess
  - Time spent in chain hashing
  - Makes brute force generally infeasible
- Key guessing
  - Easiest attack is against FVEK
  - Known plaintext attack against AES-256
  - 2^{128} possible keys, all equally likely
    - Good luck!

Forensics

- Try it out!
- There's a BTG protected volume in the 2010 DC3 Forensics Challenge
  - http://dc3.mil/challenge/2010/

Image courtesy U.S. Department of Defense and is public domain

Interrogation

(this slide intentionally left blank)

Forensics

- Look for evidence of use on XP and Vista systems
  - Prefetch files for BitLockerToGo.exe

Operations

- Can add an access device
  - Remember, only one password per device
  - But external keys or recovery keys are fair game
- Can recreate an access device
  - Use stored copies of the VMK
- Can copy auto unlock keys from one computer to another
  - Have to be decrypted and re-encrypted

Outline

- Introduction
- While you'll see more BitLocker
- What hasn't changed
- Passwords
- Smart Cards
- Drive Layout
- BitLocker To Go
- Auto Unlock Keys
- Incident Response
- Forensics
- Operations

Questions?

Image courtesy Flickr user ella_marie and licensed under the Creative Commons

Jesse Kornblum
jesse.kornblum
@mantech.com