z/VM and Tape Encryption

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Agenda

- Terminology
- Overview
- z/VM Support
  - “Default Key” Encryption
  - “User Defined Key” Encryption
  - Tape Rekey

A PDF of this presentation is available at:
http://www.vm.ibm.com/devpages/farman

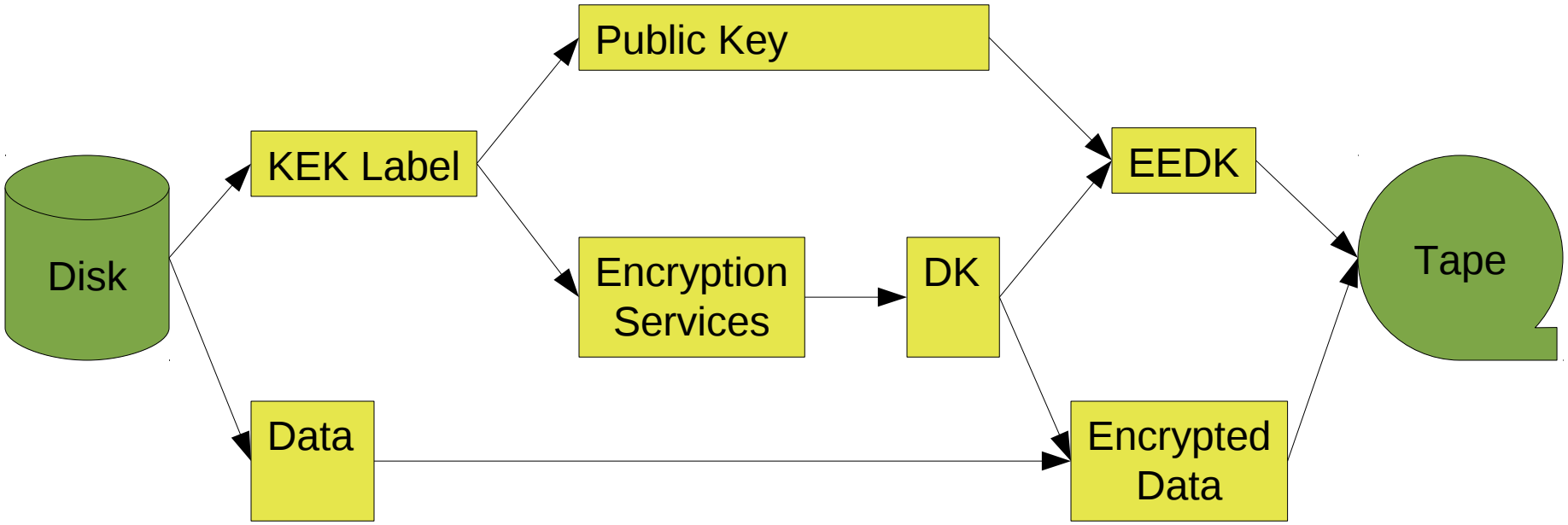
Terminology

- BOT – Beginning of Tape
- DK – Data Key
  - 256-bit AES symmetric key used to encrypt/decrypt data on tape
- EEDK – Externally Encrypted Data Key
  - DK encrypted with public key referenced by KEK Label
- EKM – Encryption Key Manager
  - Software that provides key management capabilities
- KEK – Key Encrypting Key
  - Public/private key pair used for encrypting/decrypting DK, respectively
- KEK Label – Key Encrypting Key Label
  - Human-readable representation of a KEK, defined in EKM

Overview

- Hardware-based encryption support introduced with the 3592 Model E05 tape drives (and C06 Control Unit)
- Data is sent between Operating System and Control Unit as plain text data
- CU and EKM handle key processing at the point of the first read/write I/O issued to a mounted tape cartridge
  - Communication path must be configured as “out-of-band” (TCP/IP) for z/VM
- One or two public keys can be used for a cartridge
  - Presumption is one key would be for the creator of the tape
  - A second key would be for the intended recipient of the tape

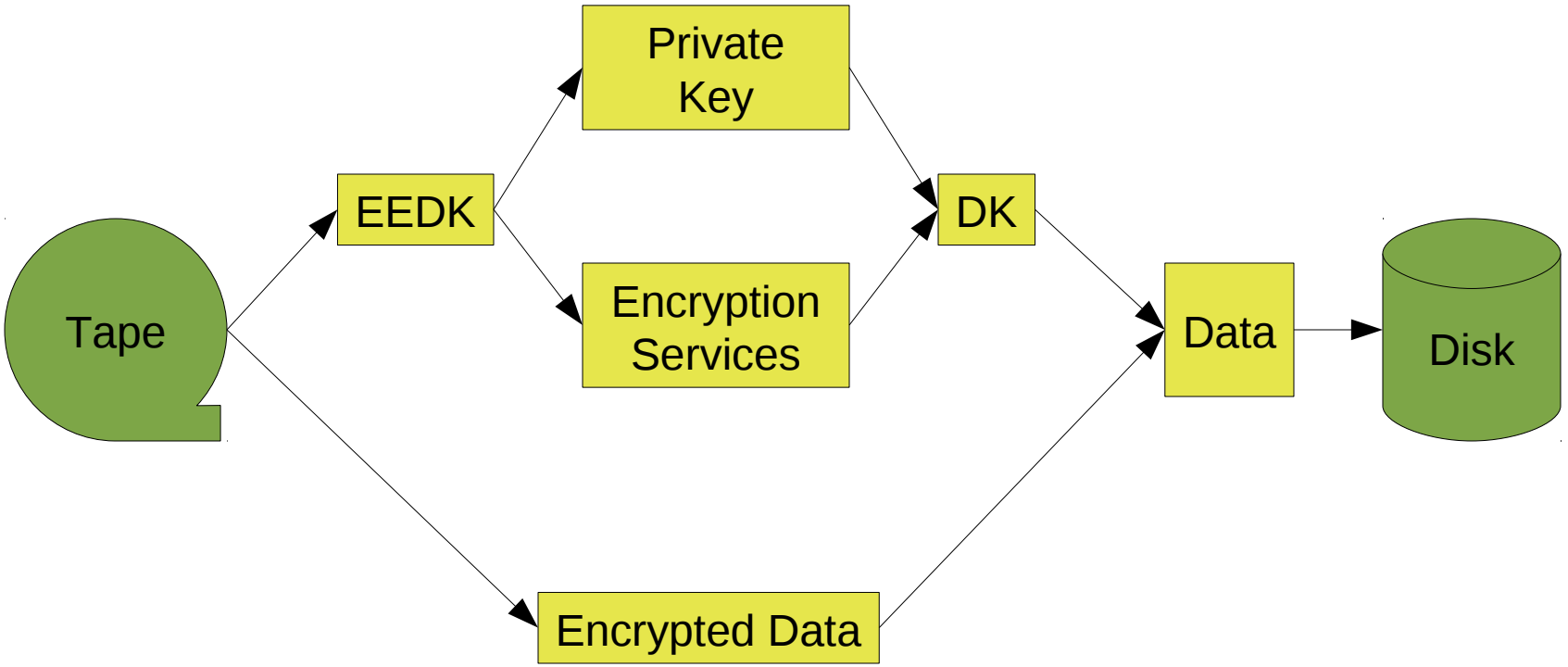
Overview – Encrypted Write to Tape (from BOT)



Overview – Encrypted Write to Tape

- OS specifies KEK Label(s) to use
  - CU and EKM negotiate with key store and cryptographic services
  - Retrieve public key(s) referenced by KEK Label(s)
  - Generate random DK
  - Use public key to encrypt DK into an EEDK
  - Store EEDK(s) on tape cartridge
- Data is encrypted with DK as it gets written to tape
  - It is written as the OS specified, if writing from BOT
  - It is written in the existing format, if the tape cartridge is moved beyond BOT before writing

Overview – Encrypted Read from Tape



Overview – Encrypted Read from Tape

- EEDK(s) are retrieved from tape cartridge
  - CU and EKM negotiate with key store and cryptographic services
  - No OS operands need to be specified
  - Private key is located to decrypt the DK within EEDK
    - If not found, tape I/O fails with error
- Data is decrypted with DK as it gets read from tape
- Additional data that is appended to the tape is encrypted with DK

z/VM Support

- Enables dedicated device support for any guest OS that supports tape encryption (e.g., z/OS, Linux)
- Provides mechanism for z/VM to enable encryption on behalf of those guests that do not support tape encryption (e.g., CMS) or want it managed by hypervisor
- Also used by facilities of z/VM itself, such as with SPXTAPE or DDR
- DFSMS/VM FL221 supports locating encryption-capable drives in an ATL

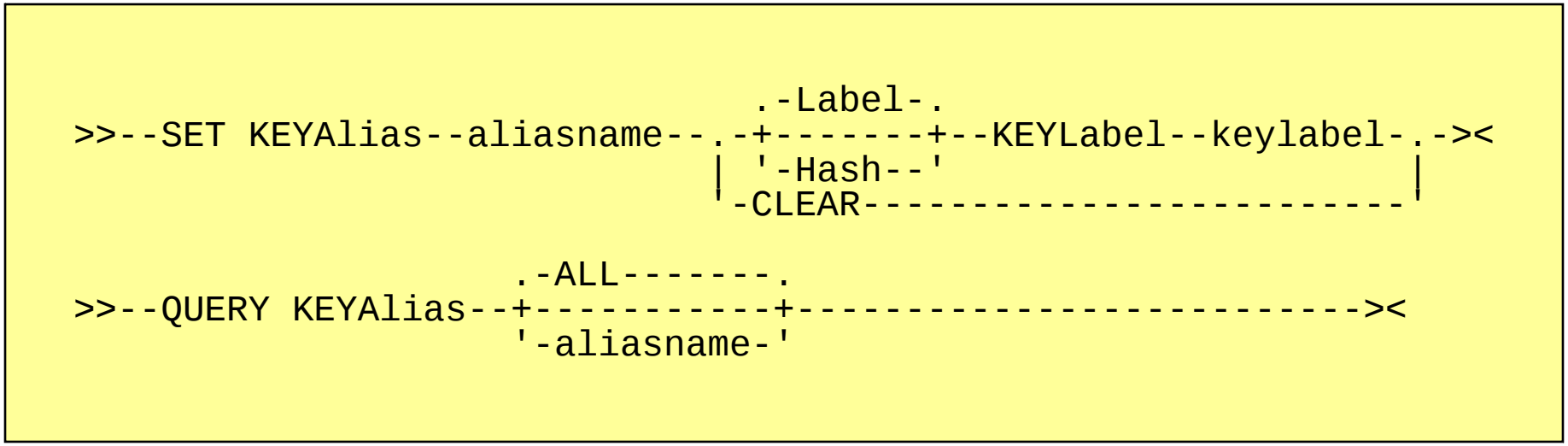
z/VM Support

- When z/VM is preparing a tape drive for use by itself or for unaware guests, encryption information needs to be provided to the drive
  - Commands permit the use of a set of “default” keys defined by the EKM
  - Alternatively, one or two key labels can be specified to use specific key pairs
    - Will also necessitate specification of an encoding mechanism
    - Expectation is one label will be owned by creator of tape, optional second label for a separate reader
- A z/VM “key alias” can be used to specify KEK Label(s) other than the EKM Default on ATTACH or SET RDEVice commands
  - Generated by the SET KEYalias command
  - Contains a KEK Label and an encoding mechanism
- KEK Label support also added to DDR
  - Since DDR can run standalone, uses a new control statement

Encoding Mechanisms

- Method of identifying which private key would be required to decrypt a given EEDK
  - “LABEL” uses the KEK Label directly, such that the recipient must have the same KEK Label tagging the public/private key
  - “HASH” uses a hash of the public key, such that the recipient’s KEK Label need not match that of the originator
- In either case, the private key that corresponds to the public key used for encryption must be present in the key store
  - Does not provide a mechanism for fabricating the private key

z/VM Support – SET/Query KEYAlias command



z/VM Support – SET/Query KEYAlias command

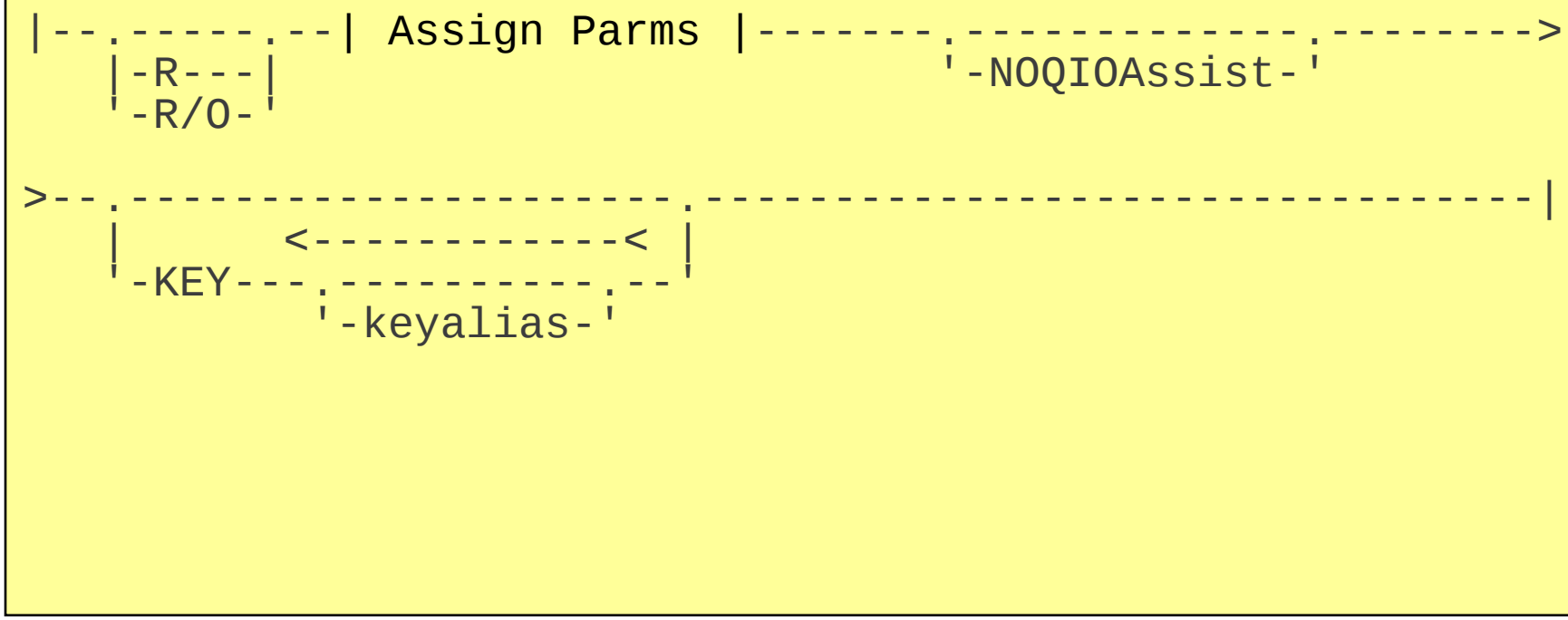
```
SET KEYA 1K1L LABEL KEYL tape_sol_tst_shr_pvt_1024_lbl_01
Ready; T=0.01/0.01 16:14:21
SET KEYA 1K1H HASH  KEYL 'tape sol tst shr pvt 1024 lbl 01'
Ready; T=0.01/0.01 16:14:28
q keya 1k1l
KEYALIAS: (L) 1K1L
        = TAPE_SOL_TST_SHR_PVT_1024_LBL_01
Ready; T=0.01/0.01 16:14:33
q keya
KEYALIAS: (L) 1K1L
        = TAPE_SOL_TST_SHR_PVT_1024_LBL_01
KEYALIAS: (H) 1K1H
        = TAPE SOL TST SHR PVT 1024 LBL 01
Ready; T=0.01/0.01 16:14:39
```

z/VM Support – Enable Encryption

- ATTACH Command (Class B)
  - Defines the encryption settings to be used for a guest that is unaware of tape encryption
  - An unmodified ATTACH will inherit any encryption settings already associated with the tape drive
    - e.g., ATTACH MULTIUSER, DETACH LEAVE
  - Can be used with shared tape, provided each guest uses the same encryption settings
  - Drive must not contain a tape cartridge, or the mounted cartridge must be positioned at BOT
    - Ensures all data on a cartridge is consistent

ATTACH Command Syntax

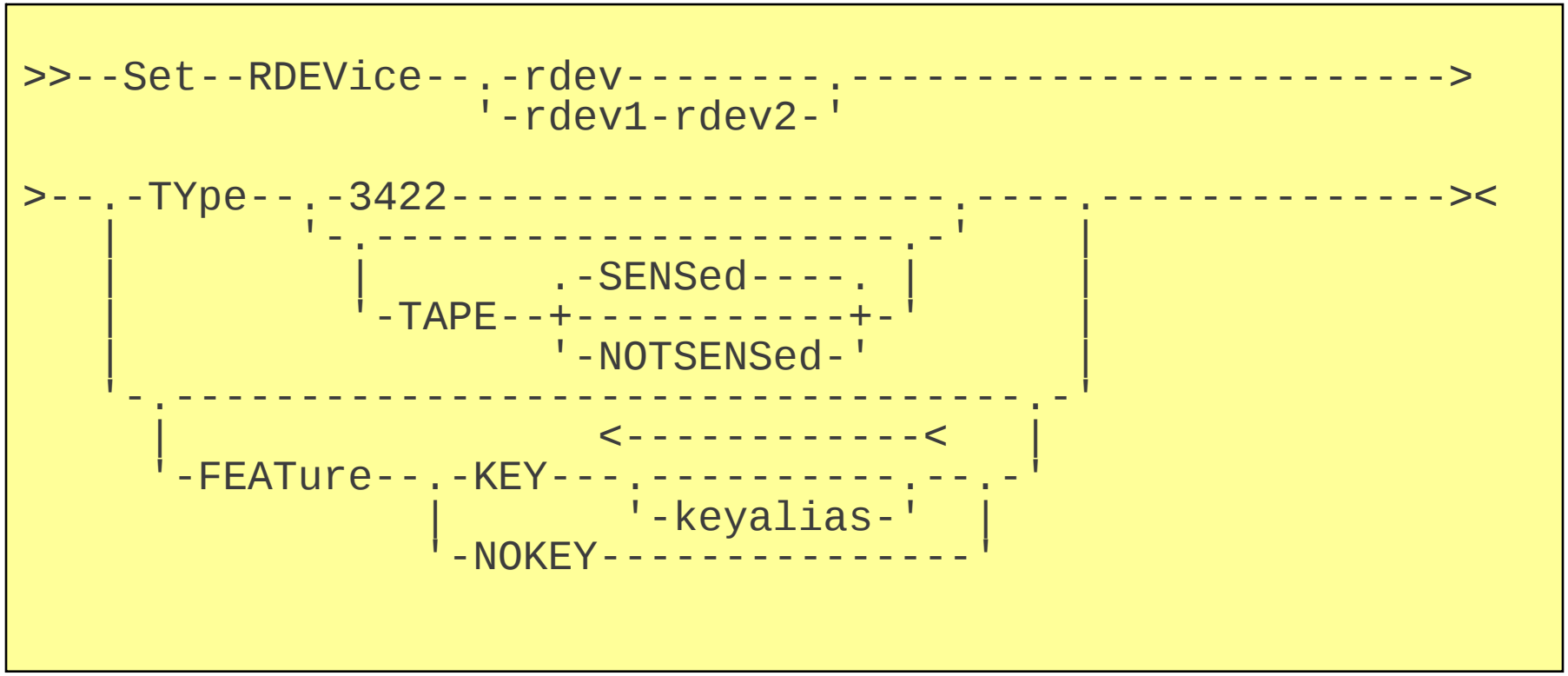
Options for Shared/Dedicated Tape Device:



z/VM Support – Enable Encryption

- SET RDEVice Command (Class B)
  - Defines the encryption settings to be used for a guest that is unaware of tape encryption, while permitting ATTACH to be issued without any changes
    - Will be superseded by encryption options on the ATTACH command, if any are specified
  - Target RDEV must be free and online
    - This differs from the existing SET RDEVice command, which expects the specified rdevice(s) to be varied offline

SET RDEVice Command Syntax



z/VM Support – Disable Encryption

- DETACH Command
  - Cleans up encryption settings on a device
  - SET RDEVice encryption settings are not affected
    - Rather, they are removed by a SET RDEVice command with the NOKEY option
  - If DETACH is issued with the LEAVE option, the encryption settings will not be removed since the cartridge is not being ejected from the drive
    - Subsequent ATTACH should not specify any encryption settings

z/VM Support – Query Encryption

- DIAGNOSE x210
  - The Virtual/Real Device Characteristics block that is returned on a Diagnose x210 code has been updated to return a new underlying device type, x13, that indicates a 3592 Model E05 drive that has been enabled for encryption

```
d210 181
DEVNUM =>0181<
VRDCBLOK =>0181005F 08830100 08831008 13000000
           35920635 90100190 4EDC0000 B4D7FD5C
           69E00000 00000000 35920635 92140013
           0E001001 00000100 46838000 04000000
           04000011 22C00000 00000000 00000000
           00000000 00000000 00000000 000000<
Good Condition code from diagnose
Ready; T=0.01/0.01 17:14:12
```

z/VM Support – Query Encryption

- Query TAPe DETails Command (Class B)
  - Displays encryption capability
  - Shows active (ATTACH) and/or inactive (SET RDEVICE) KEK Label information
    - “DEFAULT” is displayed if encryption was enabled but no KEK Labels were specified
- Query Virtual Commands (Class G)
  - Query Virtual TApes displays encryption capability
  - Query Virtual <device> DETAILS displays active (ATTACH) and/or inactive (SET RDEVICE) KEK Label information
    - “DEFAULT” is displayed if encryption was enabled but no KEK Labels were specified

z/VM Support – Query Encryption

- “DETAILS” commands have been updated
  - ACTIVE heading now shows what is currently being used on the tape drive, regardless of what was specified on ATTACH
  - New ATTACHED heading will display that information, if different
  - Provides information about encryption environment
    - When tape is not written immediately after initial mount, or
    - When tape is rekeyed

z/VM Support – Query Encryption

```
q tape details 7e2
TAPE 07E2 SEQUENCE NUMBER E0010 LIBPORT 1 ENCRYPTION CAPABLE
  ACTIVE KEY LABEL(S):
    (H) Erics Public Key
    (L) MAHNA MAHNA
  INACTIVE KEY LABEL(S): DEFAULT
Ready; T=0.01/0.01 01:32:41
q v tapes
TAPE 0181 ON DEV  07E2 3590 R/W SUBCHANNEL = 0008 ENCRYPTION CAPABLE
Ready; T=0.01/0.01 01:43:28
q v 181 details
TAPE 0181 ON DEV  07E2 3590 R/W SUBCHANNEL = 0008 ENCRYPTION CAPABLE
  ACTIVE KEY LABEL(S):
    (H) Erics Public Key
    (L) MAHNA MAHNA
  INACTIVE KEY LABEL(S): DEFAULT
Ready; T=0.01/0.01 01:44:09
```

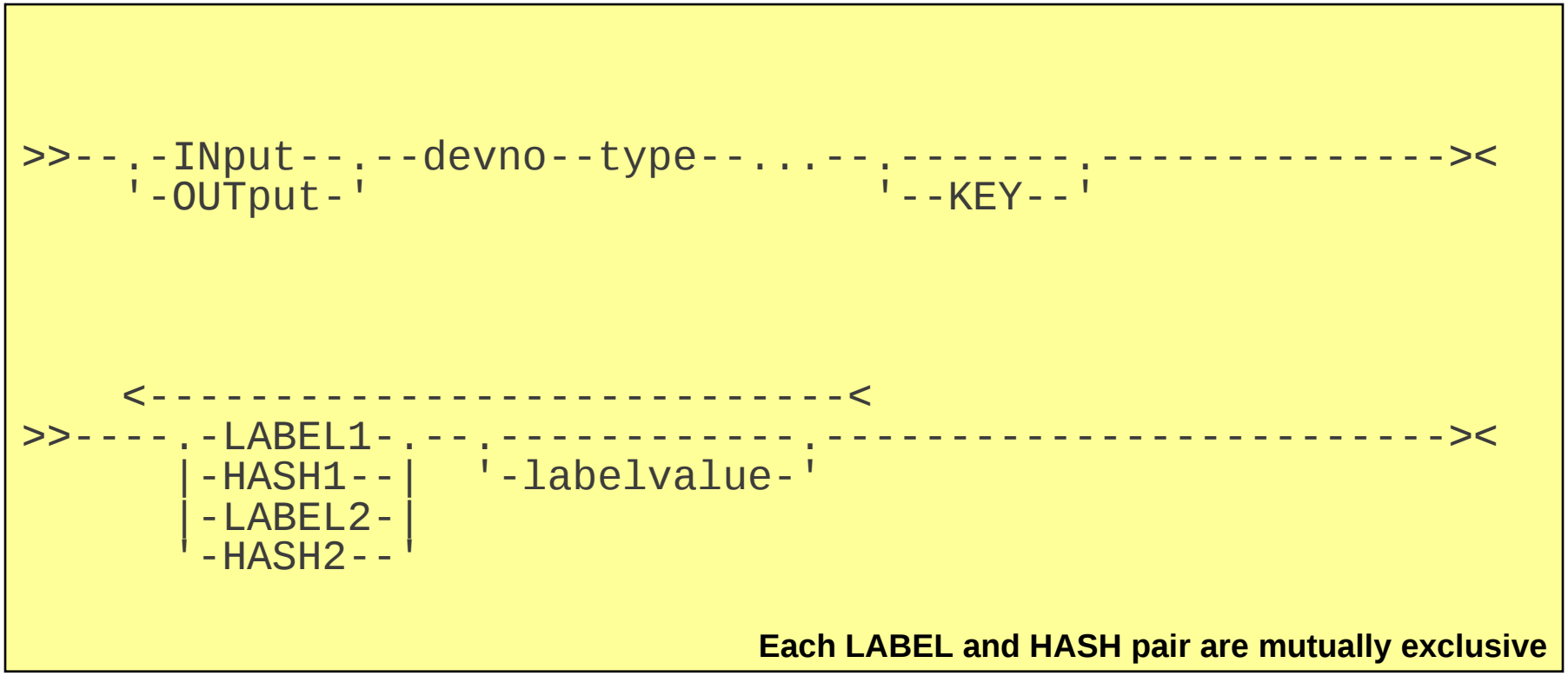
z/VM Support – Query Encryption (alternate keys)

```
q tape details 7e2
TAPE 07E2 SEQUENCE NUMBER E0010 LIBPORT 1 ENCRYPTION CAPABLE
  ACTIVE KEY LABEL(S):
    (H) Erics Public Key
    (H) Temporary Public Key
  ATTACHED KEY LABEL(S):
    (H) Erics Public Key
    (L) MAHNA MAHNA
  INACTIVE KEY LABEL(S): DEFAULT
Ready; T=0.01/0.01 04:17:22
```

z/VM Support – DASD Dump Restore

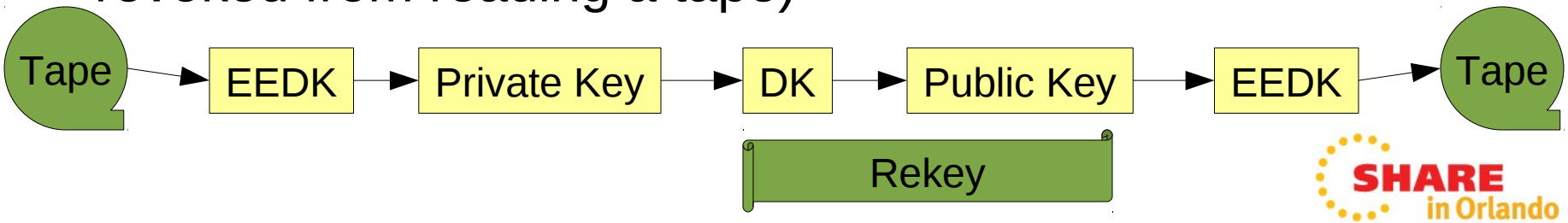
- DDR, used for backing up volumes to tape, has been updated to encrypt data via new control statements
  - If being run from within CMS virtual machine, can take advantage of same ATTACH parameters as any other guest, without changing the control statements that are issued
- INPUT/OUTPUT control statement has a “KEY” option to enable encryption with the use of the EKM “default”
  - “KEY” option is only valid on OUTPUT statement when target device is an encryption-capable tape drive

z/VM Support – DASD Dump Restore syntax



z/VM Support – Rekey operation

- Provides the ability to re-encrypt (“rekey”) a given tape cartridge with a different set of KEK Labels, without having to duplicate the tape
  - Requires hardware microcode to use this function
- Eases management of encrypted tapes if the KEK certificates expire after a given time period, or have been compromised
- Tapes originally destined for one user can be made readable by third-parties (conversely, users can be revoked from reading a tape)



z/VM Support – Initiate Rekey

- SET TAPE Command (Class B)
  - Defines the encryption settings that are to replace those defined on the specified tape device's mounted cartridge
  - Target RDEV must be mounted with an encrypted tape cartridge

```
>>--Set--TAPE--.-rdev--------.--REKEY--keyalias1--.-----------.--><
               '-rdev1-rdev2-'                     '-keyalias2-'
```

FIN

Backup Charts

You don't have to take my word for it

- Additional information
  - Redbook “IBM System Storage TS1120 Tape Encryption: Planning, Implementation, and Usage Guide”
    - Order Number SG24-7320
  - “IBM Encryption Key Manager component for the Java platform Introduction, Planning, and User's Guide”
    - Order Number GA76-0418

Other z/VM stuff that changed

- SPXTAPE, GIVE
  - No changes to code, but will honor encryption settings associated with the affected device
- Monitor
  - MRMTRDEV (Monitor Domain: Device Configuration Data)
    - New bit in MTRDEV_CALFLAGS
  - MRIODVON (I/O Domain: Vary On Device)
    - New bit in IODVON_CALFLAGS
  - MRIODDEV (I/O Domain: Device Activity)
    - New bit in IODDEV_CALFLAG1