TPM Keys
Creating, Certifying, and Using Them

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Day 1

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What We'll Be Covering

- Creating TPM Keys
- Certifying TPM Keys
- Using TPM Keys

Creating TPM Keys

First question: What kind of key do you need?

Key creation is split into two:[1]:

- Identity key creation
- Everything else

[1] Not *quite* true, but certifiable migratable keys are beyond the scope of this class.

Quick Review: Types of TPM Keys

- Identity (AIK): sign data from the TPM, such as quotes or certificates
  - A TPM can have many identities!
- Signing: sign user data
- Storage: encrypt data, including other keys
- Binding: decrypt data (usually from remote platforms)
- Legacy: signing or encryption
  - Lower security for backwards compatibility; not recommended
  - Only usable in some commands
  - Not creatable in FIPS mode

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Wrap keys!

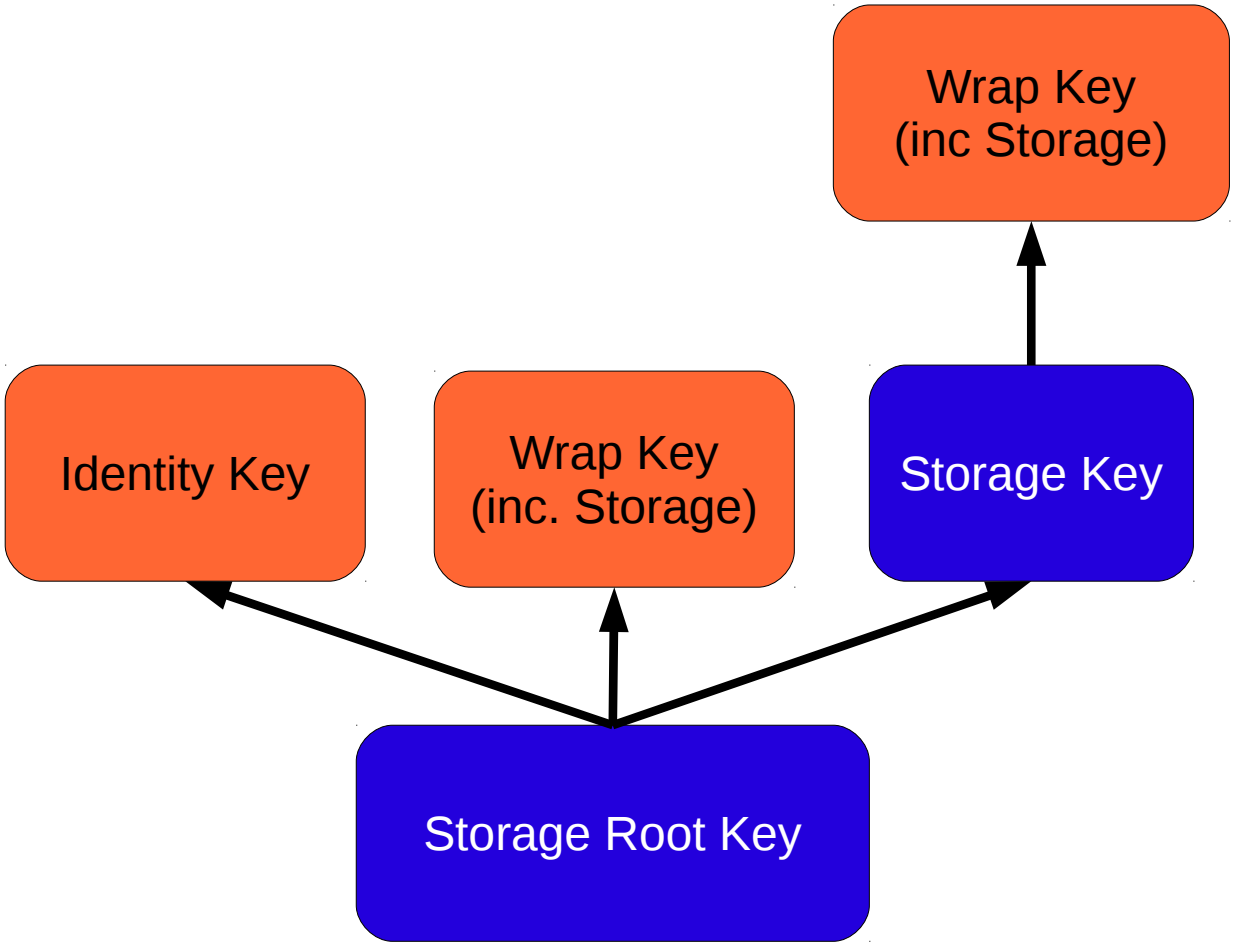
Creating Wrap Keys

- `TPM_CreateWrapKey`
- Offers many choices
  - Key type: Any except identity
  - Key size: 512-2048 bits
  - Authorization values to use, if any (key password)
  - PCR and/or locality constraints, if any
  - Migratable (can be exported) or non-migratable (this TPM only)
  - Some key-specific options
    - e.g., Signing keys have three signature scheme options
- Must provide a *parent* key, already loaded into TPM
  - Storage key that will be used to encrypt private portion
  - SRK is a storage key!
- Outputs a key blob, which user responsible for storing

Creating Identity Keys

- `TPM_MakeIdentity`
- TPM owner must authorize command!
- Only choices:
  - Authorization values to use (key password)
  - PCR and/or locality constraints, if any
  - Privacy CA to create signing request for
    - Privacy CAs in the next section
- All identity keys are created to meet minimum security requirements
  - Non-migratable
  - 2048 bits
  - SRK parent
- Outputs key blob and certificate signing request
  - Note: key blob same format as CreateWrapKey output!
  - CSR is not x.509 standard; custom AIK certification protocol

Key Storage Hierarchy Illustration



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Certifying TPM Keys

A very complex subject!

- TCG has well-designed, high-security, verifiable protocols
- Completely non-standard!
- Not supported by today's commercial CAs
- TPM keys *cannot* participate in standard certification protocols

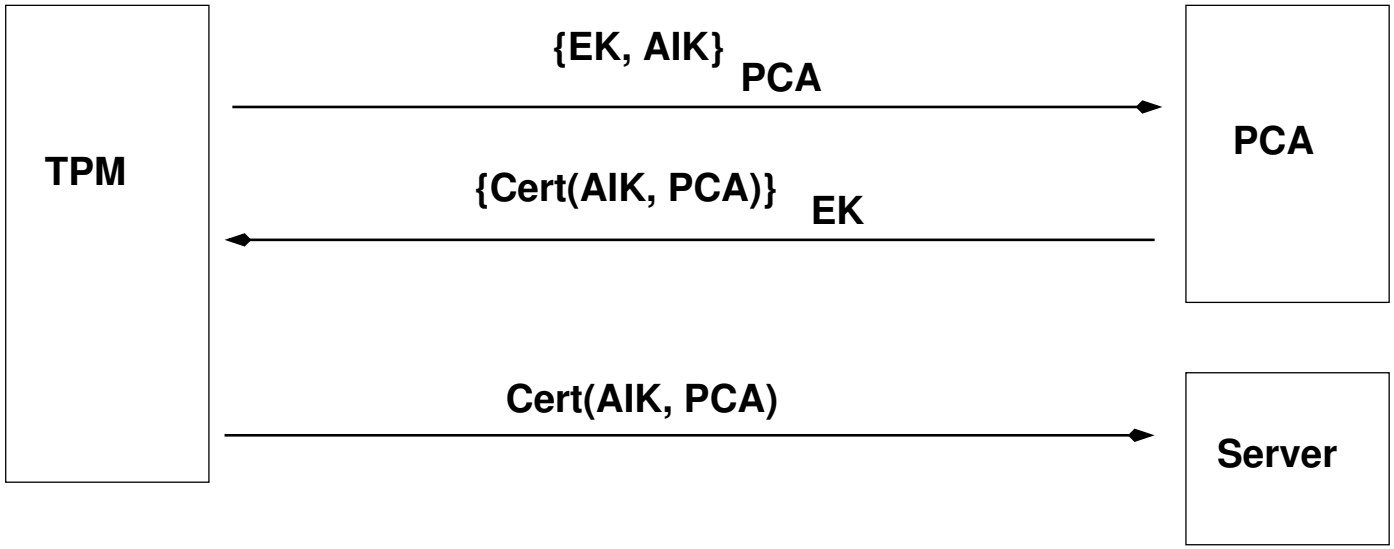
Discussing Certification

- Explore TCG's certification design
- Enterprise PKI and commercial CA expectations
- Compromises and recommendations

TCG Certification Vision

- TPM EK certified by manufacturer
- Identity keys tied to EK with pseudonymizing PCA protocol
- Identity keys certify other TPM keys using CertifyKey certificates
- Strong cryptographic bindings at each step!
- TPM key heirarchies can be verified without CA interaction per-key

PCA Protocol

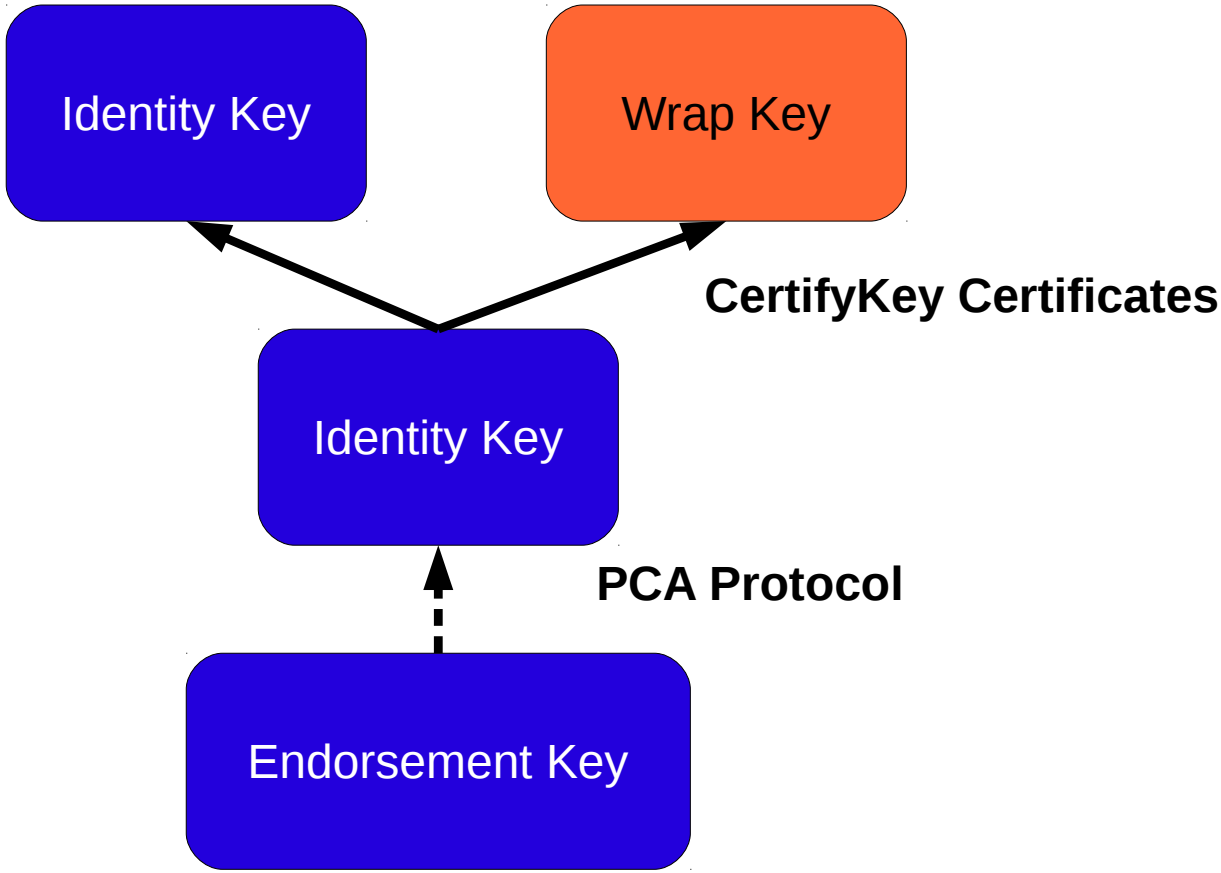


- PCA: Privacy Certificate Authority
- Issues certificate for *any* AIK if EK legitimate
  - EK will only decrypt cert if AIK actually in TPM
  - `ActivateIdentity` command decrypts certs
- Only PCA (trusted party) can associate EK and AIK
  - PCA cannot prove association unless sees cert
  - Recipients cannot associate different AIKs from same TPM
- Strong cryptographic binding between EK and AIK; pseudonymity

CertifyKey

- `TPM_CertifyKey` command: issue cert for TPM key
- Non-migratable keys only!
- Claim: "This is a genuine TPM key with the following properties"
- Certificate includes:
  - Key type
  - Key length
  - PCR and locality constraints
  - . . . i.e., anything a remote party would need to know to trust!
- Signed by AIK
  - Can be signed by signing or legacy key, but not trustworthy

Key Certification Hierarchy Illustration



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What Enterprises Generally Expect

- x.509!
  - Certificate Signing Requests are self-signed
  - Certificates are public; CAs often publish them directly
- World divided into CAs, which certify all keys; and other entities, which may not certify anything
- Standard protocols, supported by commercial CAs

Where Problems Arise

- Most TPM keys are incapable of creating a self-signed CSR
  - Breaks x.509 request protocols
- CA-published certificates would break PCA protocol entirely
  - Security relies on the secrecy of the certificate until TPM decrypts
  - A simple CSR format module isn't sufficient to fix
  - PCA protocol only way to reliably certify AIKs post-provisioning!
- TPM CertifyKey certificates break the model
  - AIKs are CAs, but only for this TPM
  - Completely non-standard format to boot: apps won't recognize

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Solving Certification: Temporary Patch

- Keys of any type can be certified during provisioning
  - Modular CA update: non-self-signed CSRs
  - Some CAs support variations already
- Must be implemented regardless, for certifying EKs!
- Equally trustworthy, if done at same time in same environment

Solving Certification: Longer Term

- Add extensions to commercial CAs to support PCA protocol
  - Or separate CA operating in non-standard mode
- Add CA extension that treats CertifyKey certs as special CSRs
  - Issue x.509 certs based on verified CertifyKey certs
  - Include CertifyKey info or even full cert
  - Aware apps can utilize; legacy apps can ignore

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Using TPM Keys

- We will *not* be covering what to use each key for yet.
  - Specialized per key; we'll cover in detail tomorrow
- This section just covers common techniques for using any TPM key

Quick Review: Key Storage

- The EK is stored in the TPM permanently
  - Never used directly
- The SRK is stored in the TPM permanently
  - Predefined location in key storage
- Other keys (identity, wrap) are stored in partially-encrypted blobs on disk
  - "Disk" is generalization– anywhere outside the TPM will work
  - For some apps, might not even be local to machine!

Loading Keys (1/2)

In order for a key to be used, it must first be loaded into the TPM.

- Loading decrypts the private half and places it in volatile storage
- User receives a *key handle* pointing to the key's location
- Handle can be provided for any future commands using the key
- *Handles are volatile*.
  - Keys may be removed from storage on reboot
  - Keys cycled out if key storage filled
- Most TPM services do behind-the-scenes key and handle management, but keys must still be explicitly loaded to use
  - As a result, handle manipulation is a potential attack
  - Recommend not reusing authorization values for high-value keys

Loading Keys (2/2)

- `TPM_LoadKey2`[2]
- Two arguments: the key (blob) to be loaded, and the parent
  - Parent is handle of an already loaded key (often SRK)
  - Used to decrypt private half
- TPM performs integrity and sanity checks, then loads key and returns handle
- Important note: This counts as using the **parent**, not the key being loaded
  - Constraints on keys, like PCR values, are checked on use
  - A key can be loaded if constraints are violated; just can't do anything

[2] LoadKey deprecated

Using Keys

- Once a key is loaded, the handle may be provided to other TPM commands
- Many TPM commands will only accept certain kinds of keys
  - Cannot sign with a storage key, or use signing key as parent
- Every time a key is used:
  - Any PCR constraints must be met
  - Any locality constraints must be met
  - Any authorization data must be provided

For the rest of the class, when we say "Use a X key", we mean "Have an X key, load it, and provide it to the relevant command".

Questions?