Using the TPM: Data Protection and Storage

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Day 2

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What We'll Be Covering

- The TPM's Tamper Resistance
- Using Storage Keys
- Using Binding Keys
- NVRAM

Revisiting the TPM's Tamper Resistance

My most frequently asked question about TPMs:
"I can use it to protect my data if the machine is stolen, right?"

- Reminder: TPM is *tamper-resistant*, not tamper-proof
  - Not up to government standards
  - Not designed for nation-state adversaries!
- Far better than software protection, but keys *can* be removed
  - Expensive to break: $100,000+ for the publicized attack
  - High failure rate: destroyed a dozen to remove keys from one
  - **Still not sufficient for sponsor high-value data with high theft risk**

TPM's Storage Protection Scenarios

- Evil Maids
  - Can't copy hard drive and pull keys out at leisure
  - Combined with PCRs, can't reboot into evil OS and steal secrets
- Software data theft
  - Can't freely vacuum data and send off machine
  - Combine TPM keys and user passwords for best security
  - Note: At-rest protection, not during use!
- Casual physical theft
  - Not good enough for nation-states, plenty good against even competent thieves

What This Means For Use

- The TPM is strongest when protecting data at rest...
- ...therefore, protecting data in bulk less effective than small, focused chunks
- Storage most effective when used in multi-part security:
- TPM as thing you have; authorization value as thing you know
- State verification one of the most powerful tools for data protection...
- ...and can also cause self-inflicted DoS. Use with care.

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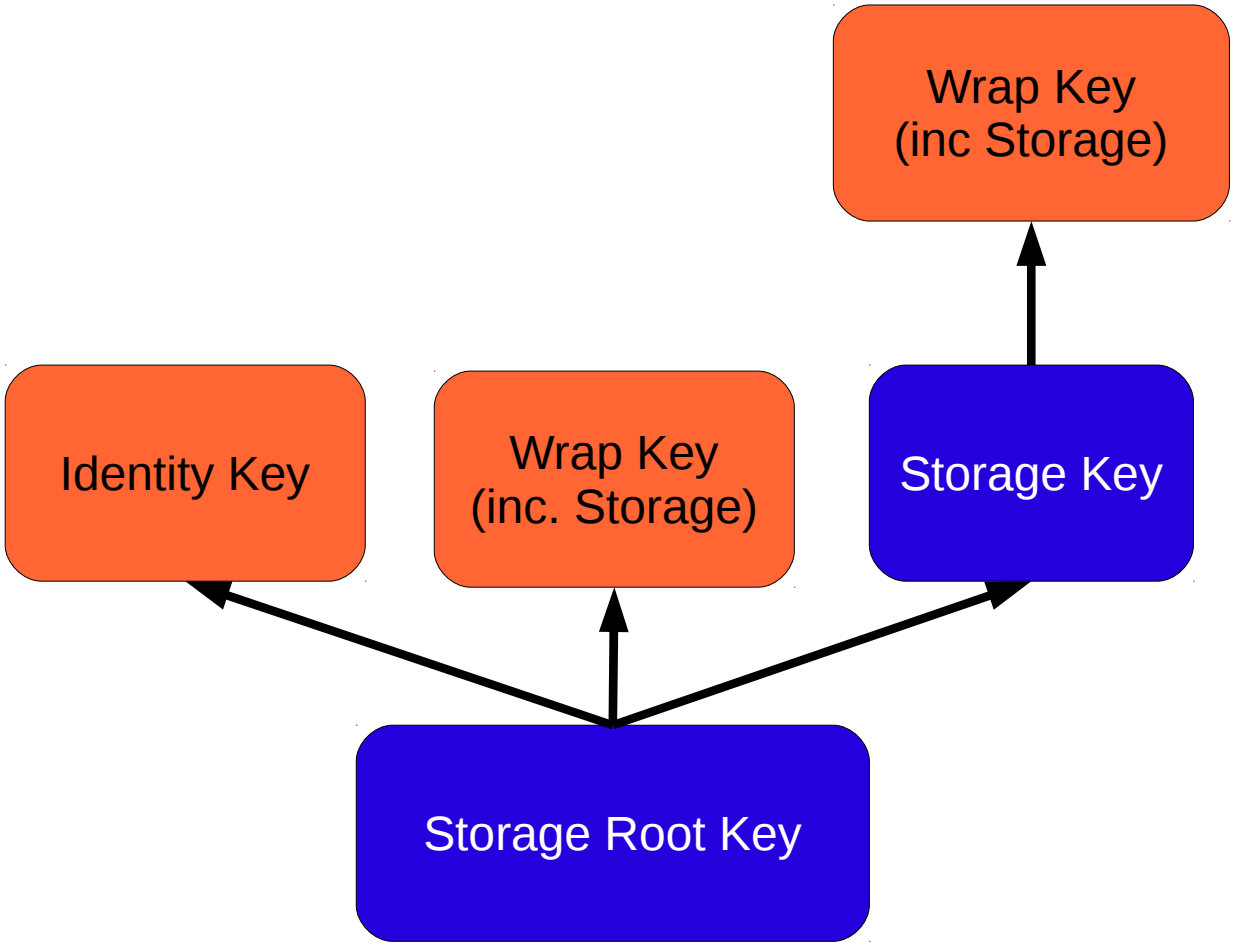
Using Storage Keys

- `TPM_Seal`: Encrypt data for later decryption with `TPM_Unseal`
  - Local platform only!
- Storage keys are also used to protect TPM keys
  - Every `TPM_CreateWrapKey` operation must provide a storage key parent
  - When migrating keys, encrypted to storage key: new parent
- Note: The SRK is a storage key!

Key Storage Hierarchy Review



Sealing

- When sealing data, several options:
  - Which storage key to use
  - Whether to require authorization data (password)
  - Whether to provide PCR constraints for decryption
  - Whether to provide locality constraints for decryption
- Sealed data always contains unique TPM internal value
  - Locked to this TPM even if the key migrates
- Sealing also records the current PCR state
  - Ensure that decrypted data can be trusted
- Returns "sealed blob"

Unsealing

- Use same storage key to decrypt
- Verifies authorization, current PCRs, current locality against blob
  - Note: two authorizations may be required! One for key, one for blob
- Verifies creation data to ensure real creation value matches public value
- Returns decrypted data
- Note: blob can be unsealed multiple times

Note: Once unsealed, data is in the clear!

- Use PCR values and authorization to minimize risk of loss during use

Storage Key Summary

- Utility key for protecting secret data, including keys
- Directly protect user data with Seal
  - Optionally additionally protect with password, PCR constraints
  - Local system only
- Decrypt with Unseal

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Binding Keys

- Another utility key for data protection
- Different paradigm than storage
- Anyone on any platform can Bind data
- Only TPM can decrypt, using `TPM_Unbind`
- No fancy options– just decryption
  - PCR constraints and authorization still possible, but on key not blob

Storage vs. Binding Key Summary

Storage	**Binding**
Local use only	Local or remote use
Seals user data, optional extra constraints	*Binds* user data, constraints only on key
Can be used as key parent	Encrypts user data only
Only authenticates local data	Usable for machine authentication

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NVRAM Summary

- Storage area inside TPM
- Very limited in size: only 1280 bytes required, though can be bigger
  - No hard data on actual implementations
- Controlled by owner; permissions can be delegated
- Some sections reserved for specific purposes (e.g., root credentials)
- Customizable constraints per region for read or write access
  - PCR contents
  - Locality
  - Authorization data
- Limited number of writes; can be burned out
  - Order of 10,000; only a minor DoS issue for most applications

Why NVRAM is Useful

- Stores data that can serve as reference
  - Much harder to modify than data on disk!
  - Hashes for integrity checking
  - Owner or trusted authority public key
  - Very powerful for system sanity checking!
- Stores high-value data that should not be accidentally deleted
  - Keys
  - Certificates

NVRAM Use Case Examples

- Storing user-chosen pictures for 'trusted boot'
  - If correct picture retrieved, PCR values in known state
- Preventing attacks which replace trusted authority
  - IT-approved CA key or DNS server in read-only NVRAM
- Integrity reference for software
  - Put hash of file in write-limited NVRAM
  - Current AV definitions? Most recent save file? Policy approved by owner? Approved OS list for boot loader?
  - If file is public key, can use to verify owner signature.
- Resources for early boot, DRTM
  - Limited space, but easy to constrain access

Using NVRAM– Quick Summary

- Establish a region of NVRAM with desired size and permissions
  - `TPM_NV_DefineSpace`
  - Owner only, unless permissions delegated
- Separate commands for owner, non-owner access
  - `TPM_NV_WriteValue`, `TPM_NV_ReadValue` for non-owner
  - `TPM_NV_WriteValueAuth`, `TPM_NV_ReadValueAuth` for owner
- **Note: Access control enforcement on NVRAM is not automatic!**
  - Manufacturers need ability to write certs into NVRAM without being owner
  - Supposed to set flag enabling access control afterwards
  - Don't always!
  - How to check and set flag in next section.

Problems with NVRAM

- Space is *very* limited
  - For one application, not a problem; if commonly used, potentially serious
  - Many hashes; very few certificates or keys
- Limited number of writes in lifetime
  - How many? Good question!
  - Not suitable for applications with frequent updates

TPM Data Protection Review

- TPM designed for protection of data at rest
- Storage keys protect data on this platform
  - Many protection options
- Binding keys protect data from anywhere
- NVRAM protects limited, high-value data
  - Good for integrity verification and system checks

Questions?