Google

Insider Attack Resistance in the Android Ecosystem

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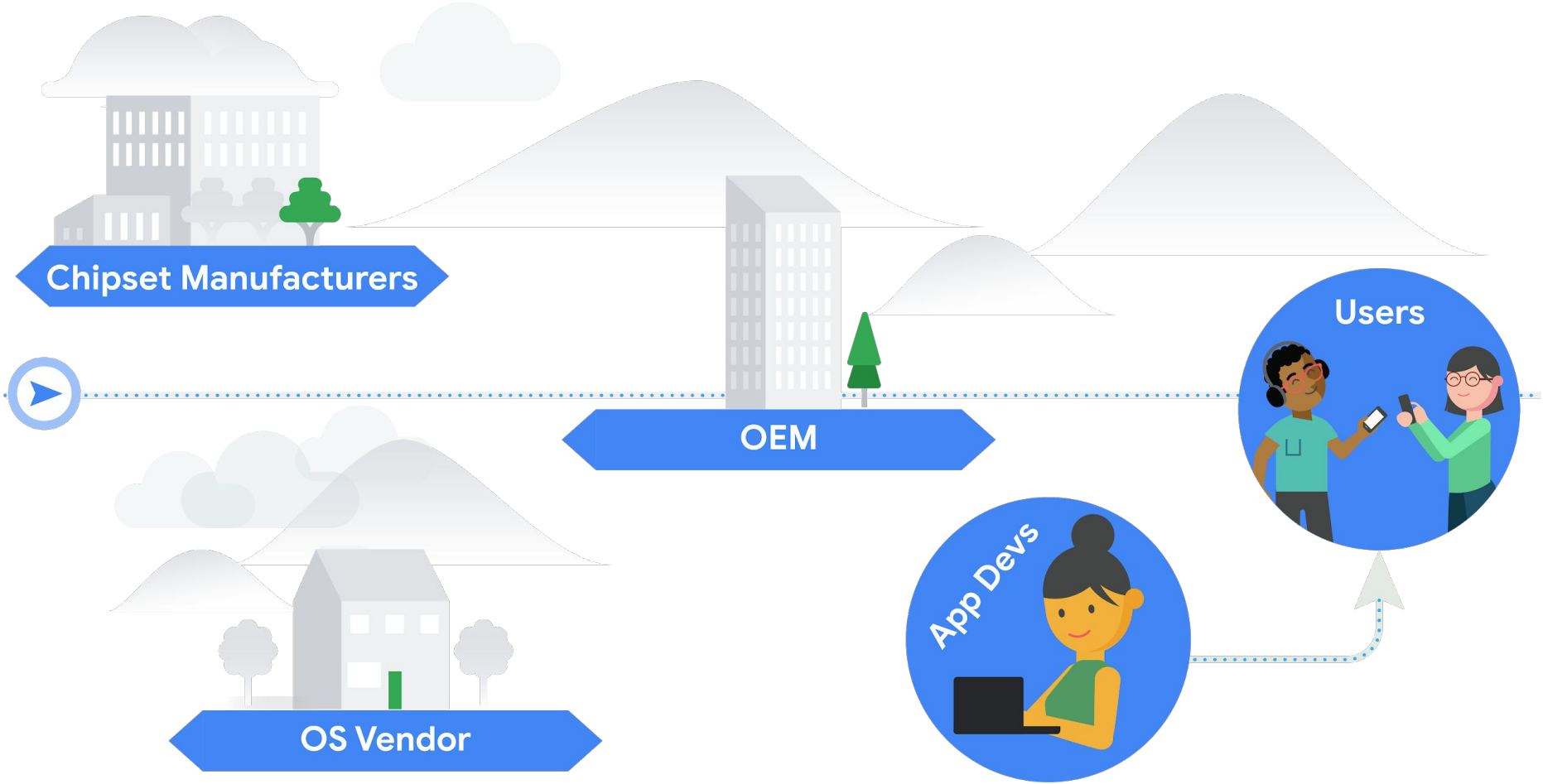
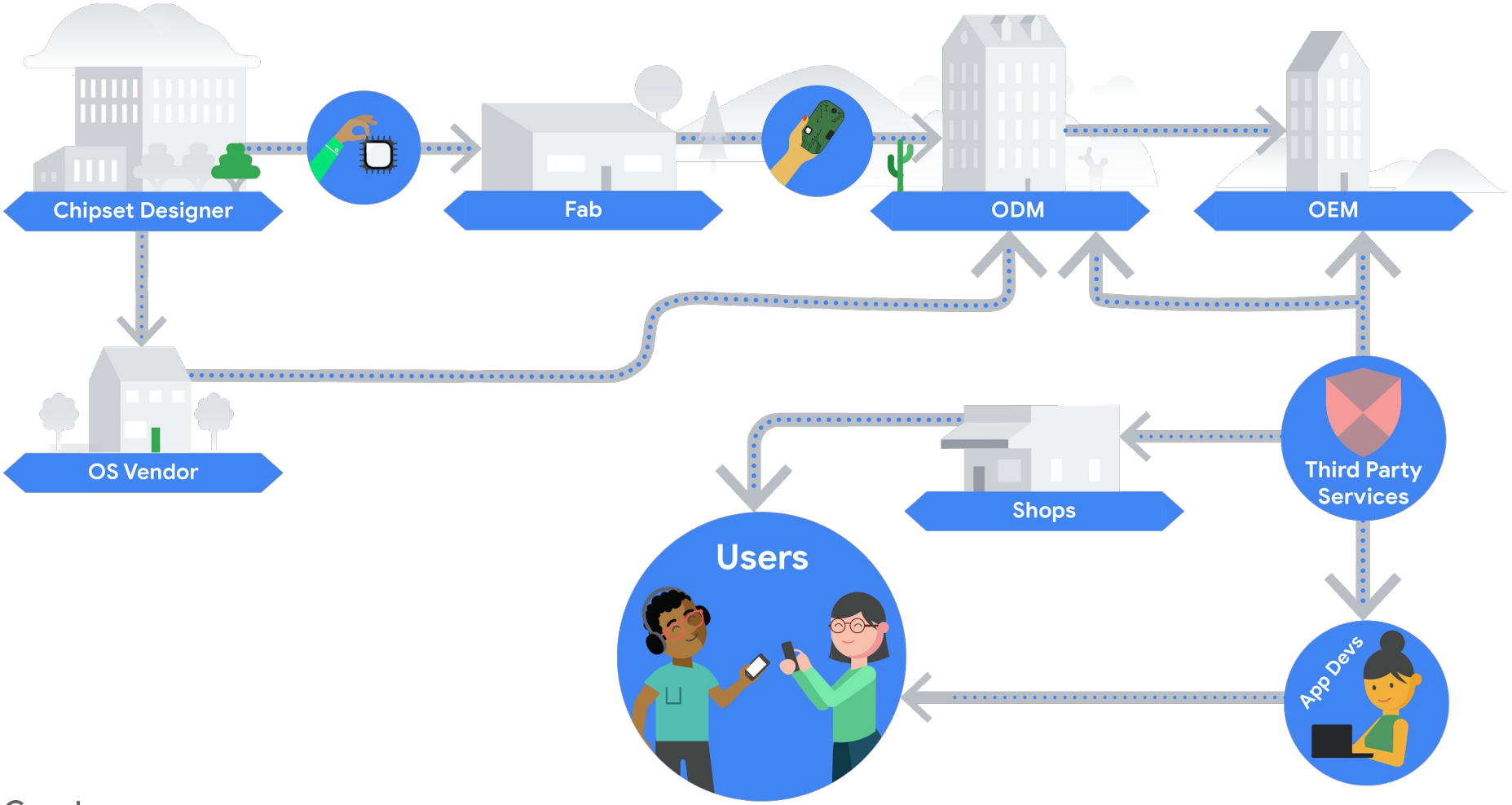
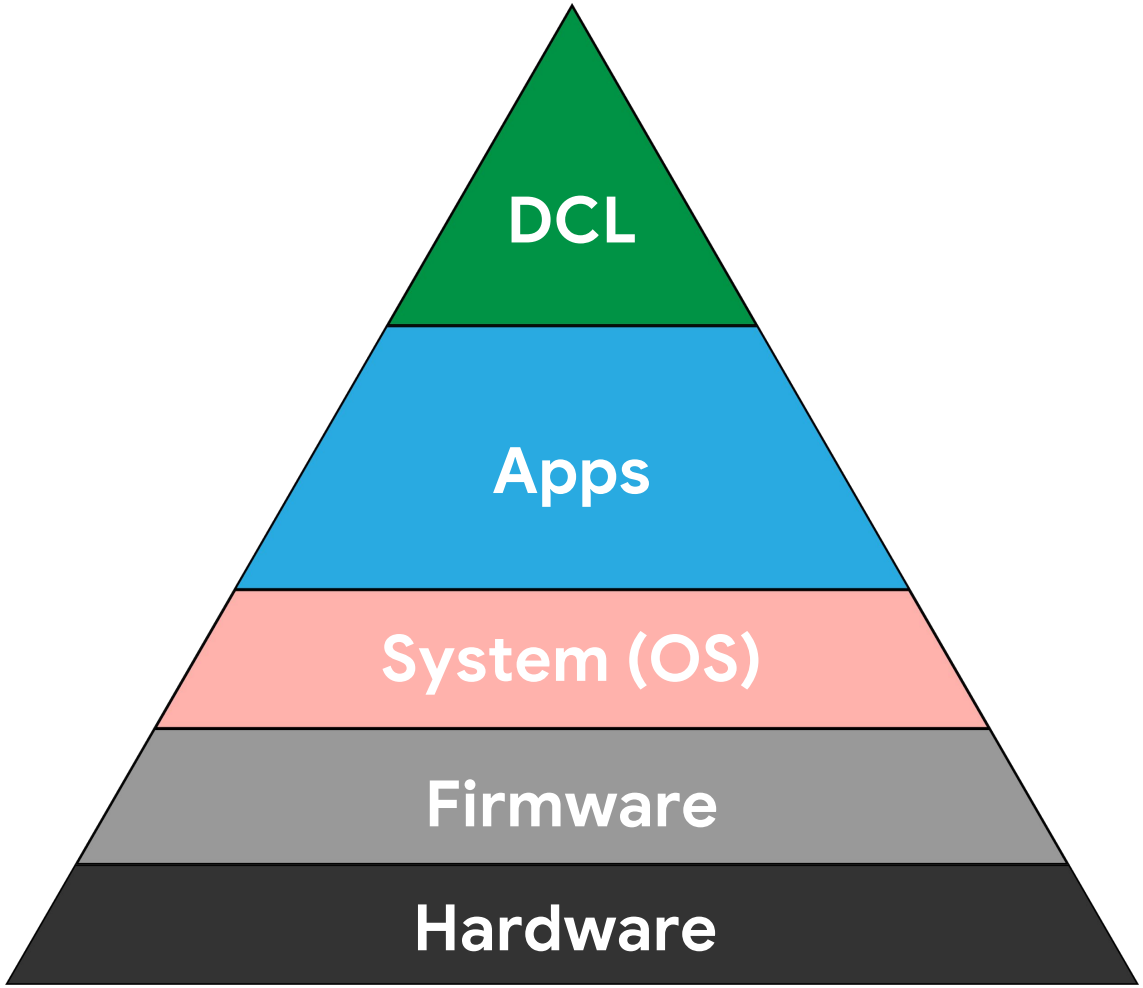
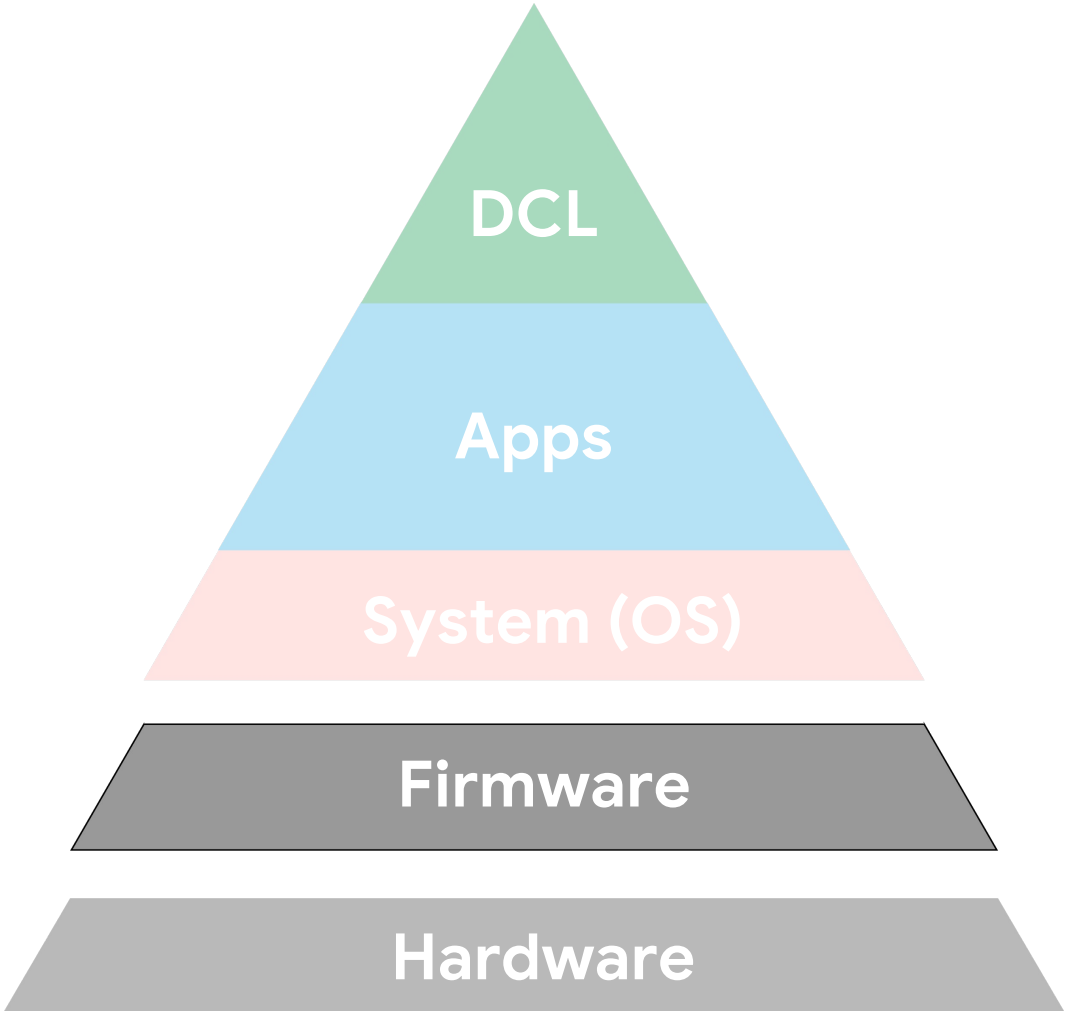
Insiders


Chipset Manufacturers
OEM
Users
App Devs
OS Vendor


Chipset Designer
Fab
ODM
OEM
OS Vendor
Shops
Third Party Services
Users
App Devs

Simple and few trusted components


DCL
Apps
System (OS)
Firmware
Hardware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Wipe on firmware update without user involvement

[C-SR] are **STRONGLY RECOMMENDED** to provide **insider attack resistance (IAR)**, which means that an insider with access to firmware signing keys cannot produce firmware that causes the StrongBox to leak secrets, to bypass functional security requirements or otherwise enable access to sensitive user data. The recommended way to implement IAR is to **allow firmware updates only when the primary user password is provided** via the IAuthSecret HAL. IAR **will likely become a requirement in a future release**.

https://android-developers.googleblog.com/2018/05/insider-attack-resistance.html
https://source.android.com/compatibility/9.0/android-9.0-cdd Section 9.11.2. StrongBox

Insider Attack Resistance for user PIN/password/pattern

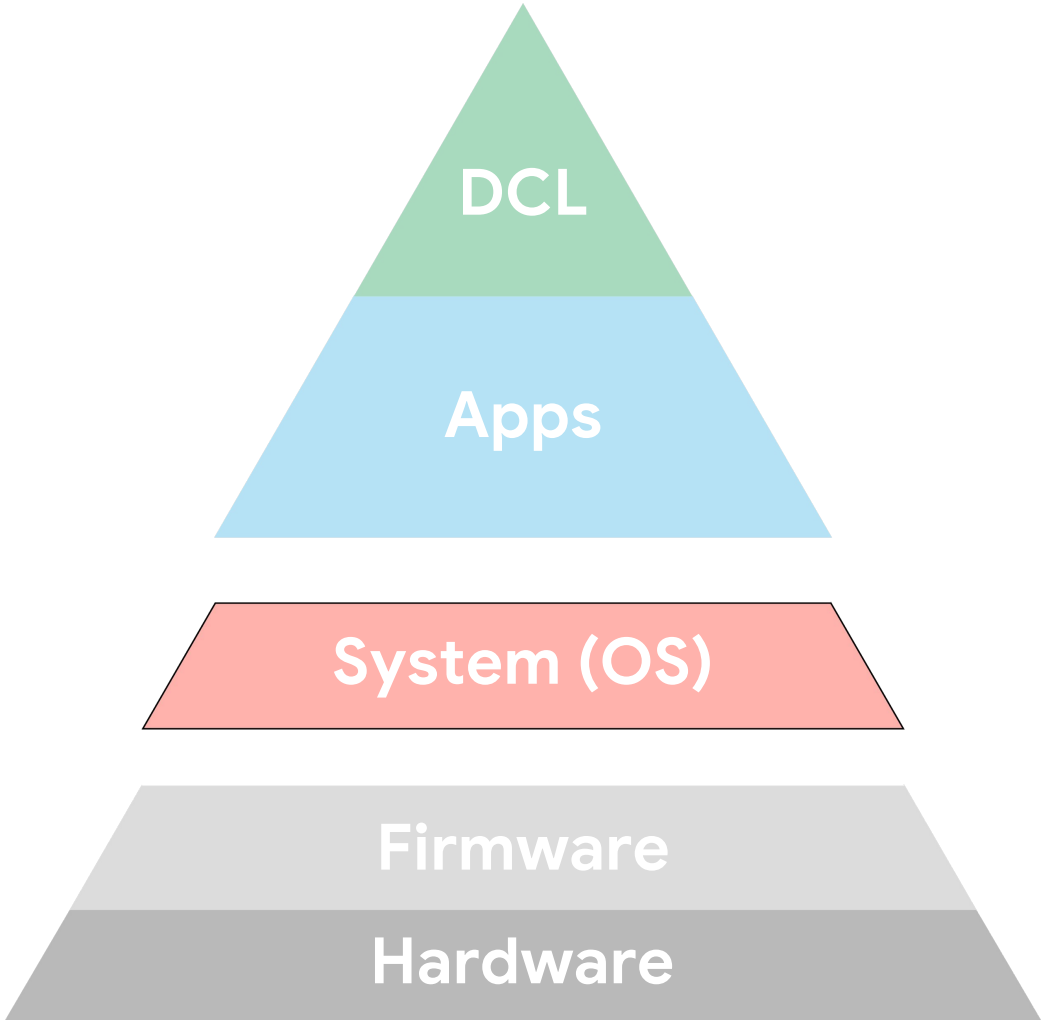
Google Pixel 2 (Weaver)

- Javacard applets on NXP secure element hold secrets and compare user knowledge factor
- Explicitly **doesn't implement data backup functionality**
- If app is updated, secrets are wiped
- NXP SE **OS upgrade itself requires app to be uninstalled**, wiping secrets.
- If a new app is needed, it's installed alongside the old, and secrets are migrated when used.

Google Pixel 3 (Weaver and Strongbox)

- Custom firmware on Google Titan M
- Firmware update is atomic with A/B (active/inactive) slots
- **Any new firmware is put into untrusted "hold" state** during installation to inactive slot
- Only providing matching **user knowledge factor transitions it into trusted active slot**
- Resetting knowledge factor (e.g. for RMA) forces wiping secrets beforehand

https://www.blog.google/products/pixel/titan-m-makes-pixel-3-our-most-secure-phone-yet/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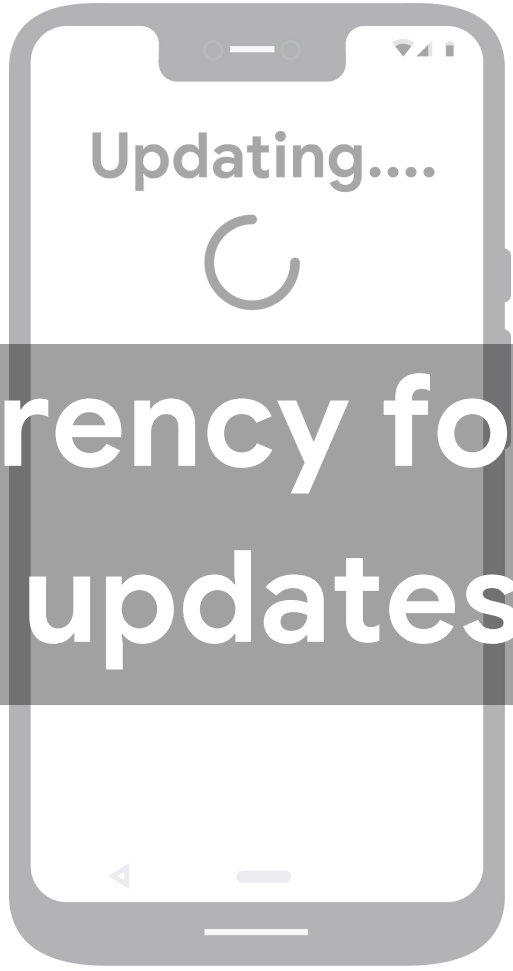
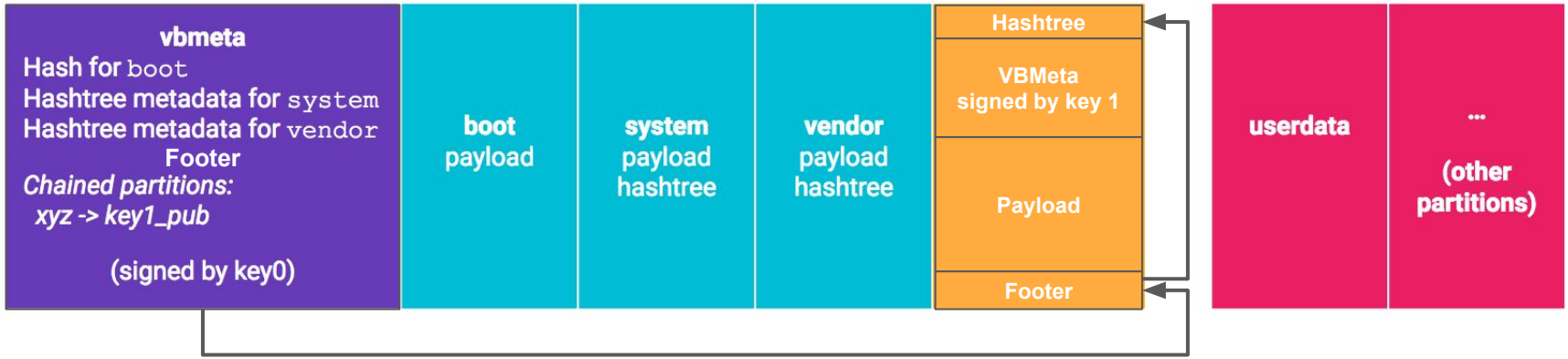


Transparency for system updates

Android Verified Boot (AVB) / VBMeta

- AVB uses VBMeta structures to describe/verify elements of the boot chain.
- Bootloader stores hash measurement of VBMeta into KeyMaster v4
- VBMeta lives either in its own partition or on chained partitions
- The hash of VBMeta can be remotely attested with Key Attestation



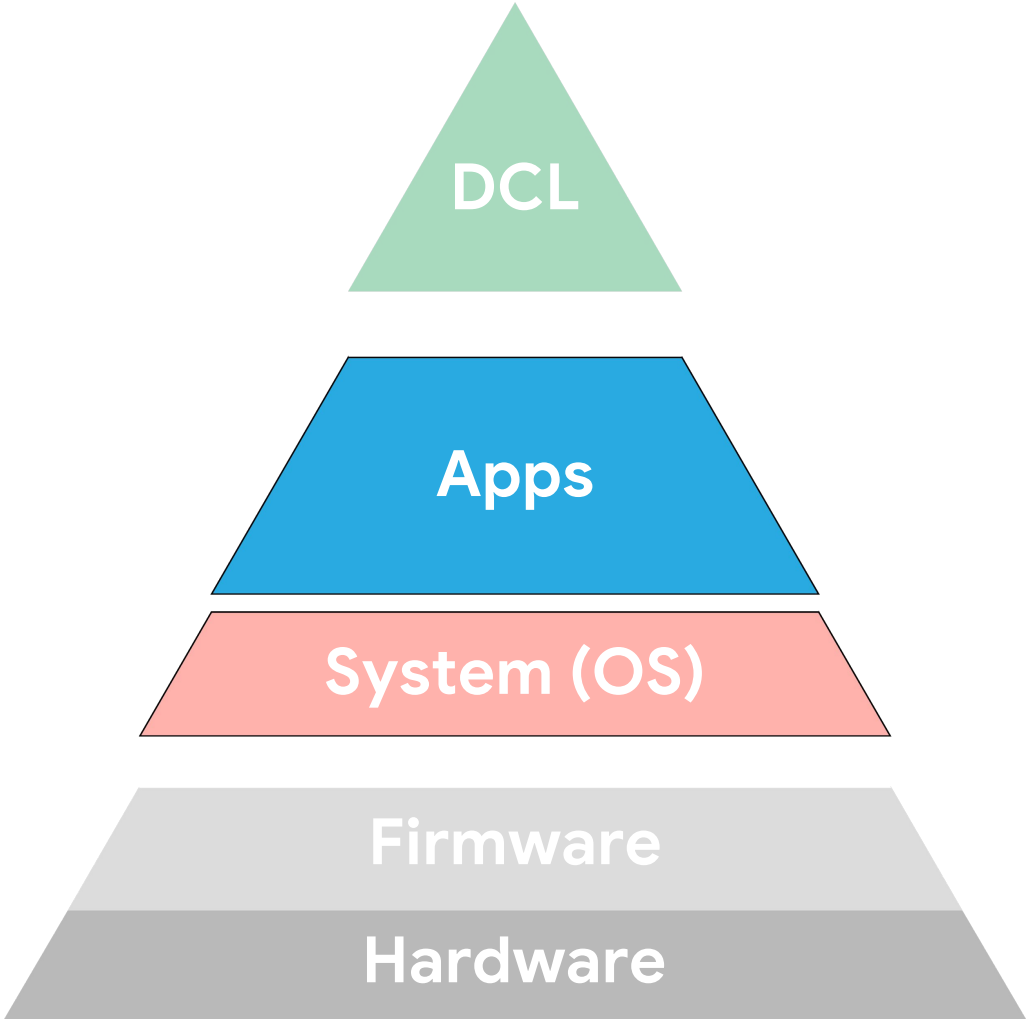
https://android.googlesource.com/platform/external/avb/
https://developers.google.com/android/images

VBMeta digest verification

Getting reference VBMeta digest

Attestation and verification of VBMeta digest

https://android.googlesource.com/platform/external/avb/
https://developers.google.com/android/images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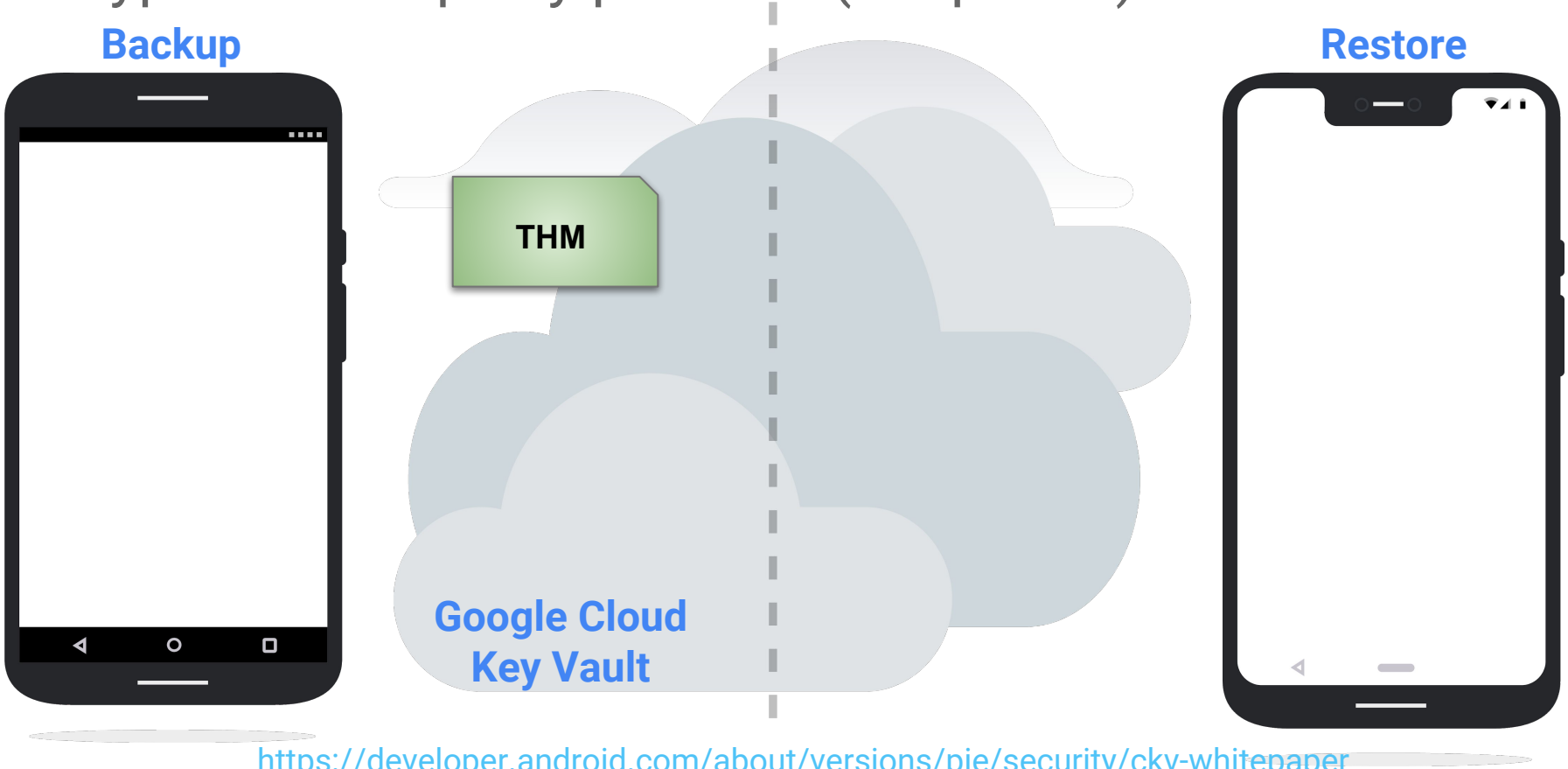
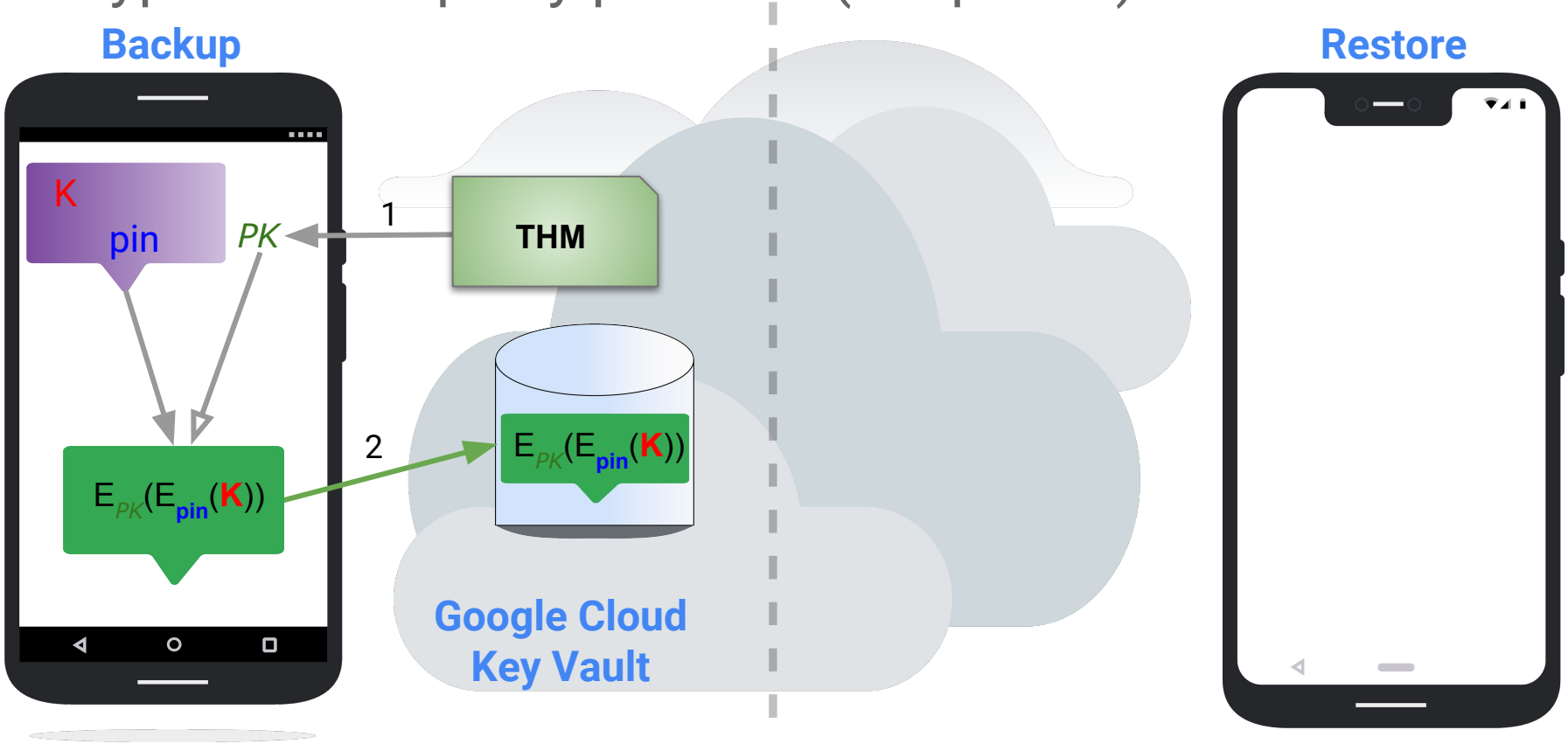
End-to-end backup encryption

Encrypted backup key protocol (simplified)



https://developer.android.com/about/versions/pie/security/ckv-whitepaper
https://security.googleblog.com/2018/10/google-and-android-have-your-back-by.html

Encrypted backup key protocol (simplified)



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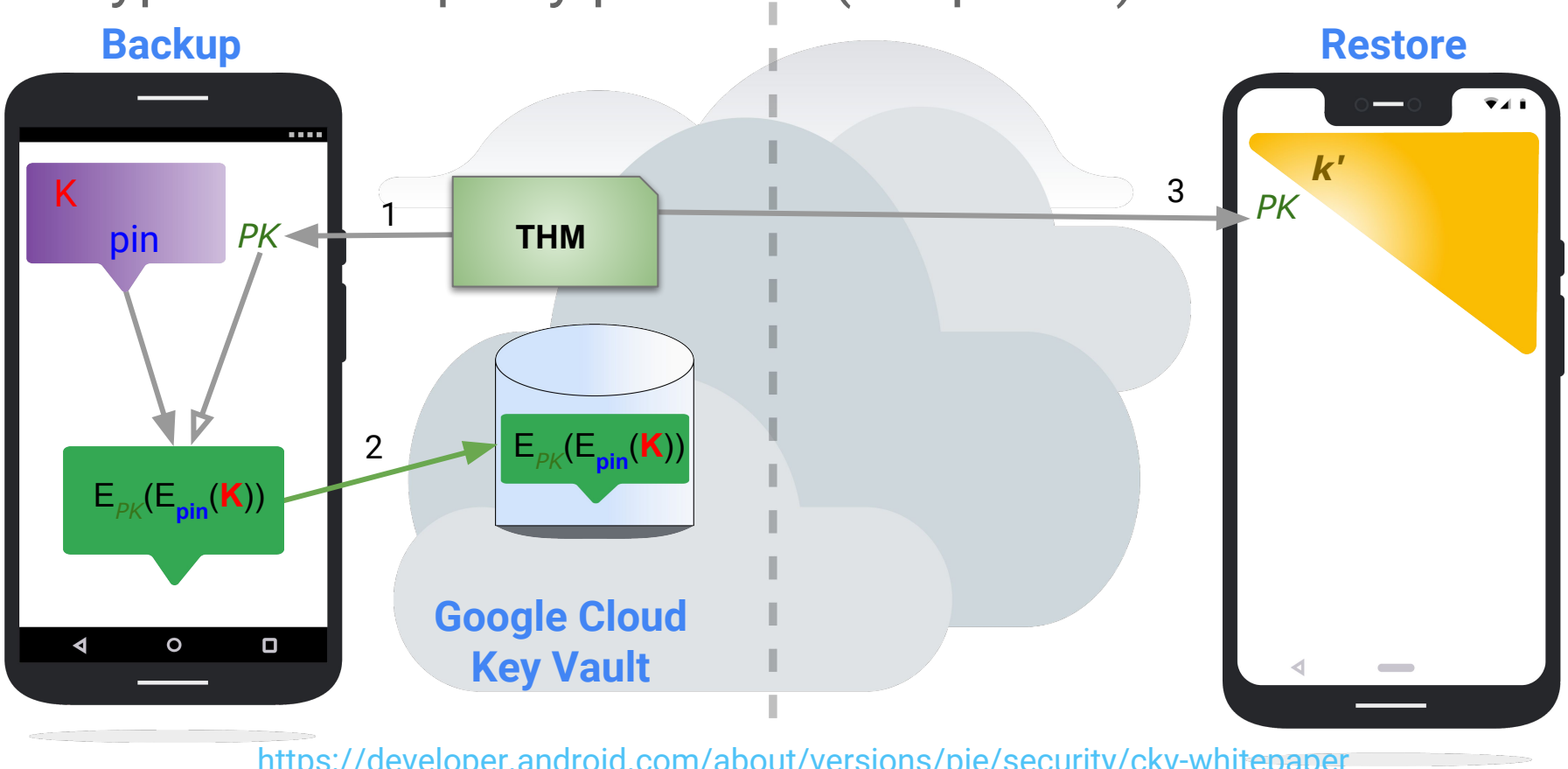

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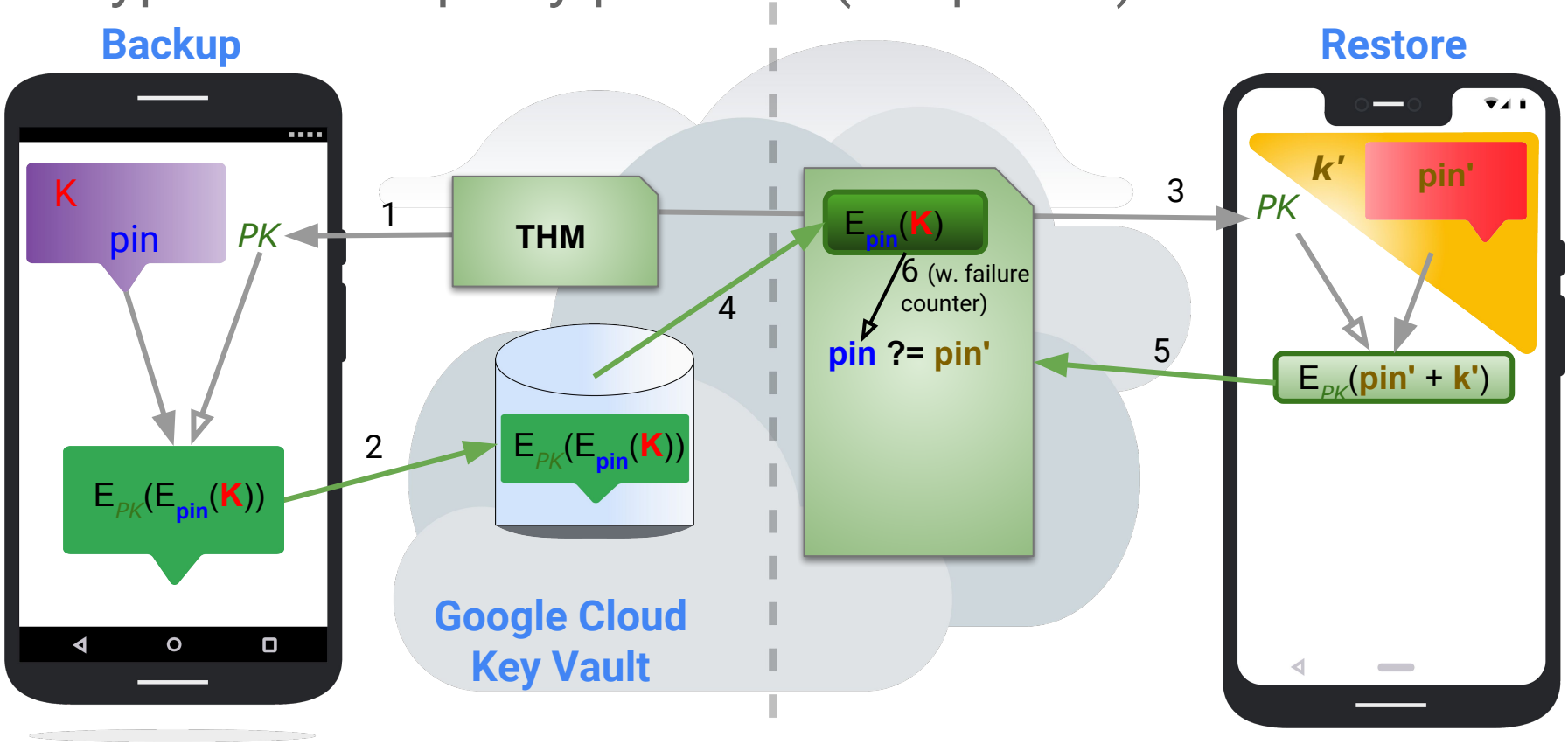
Encrypted backup key protocol (simplified)



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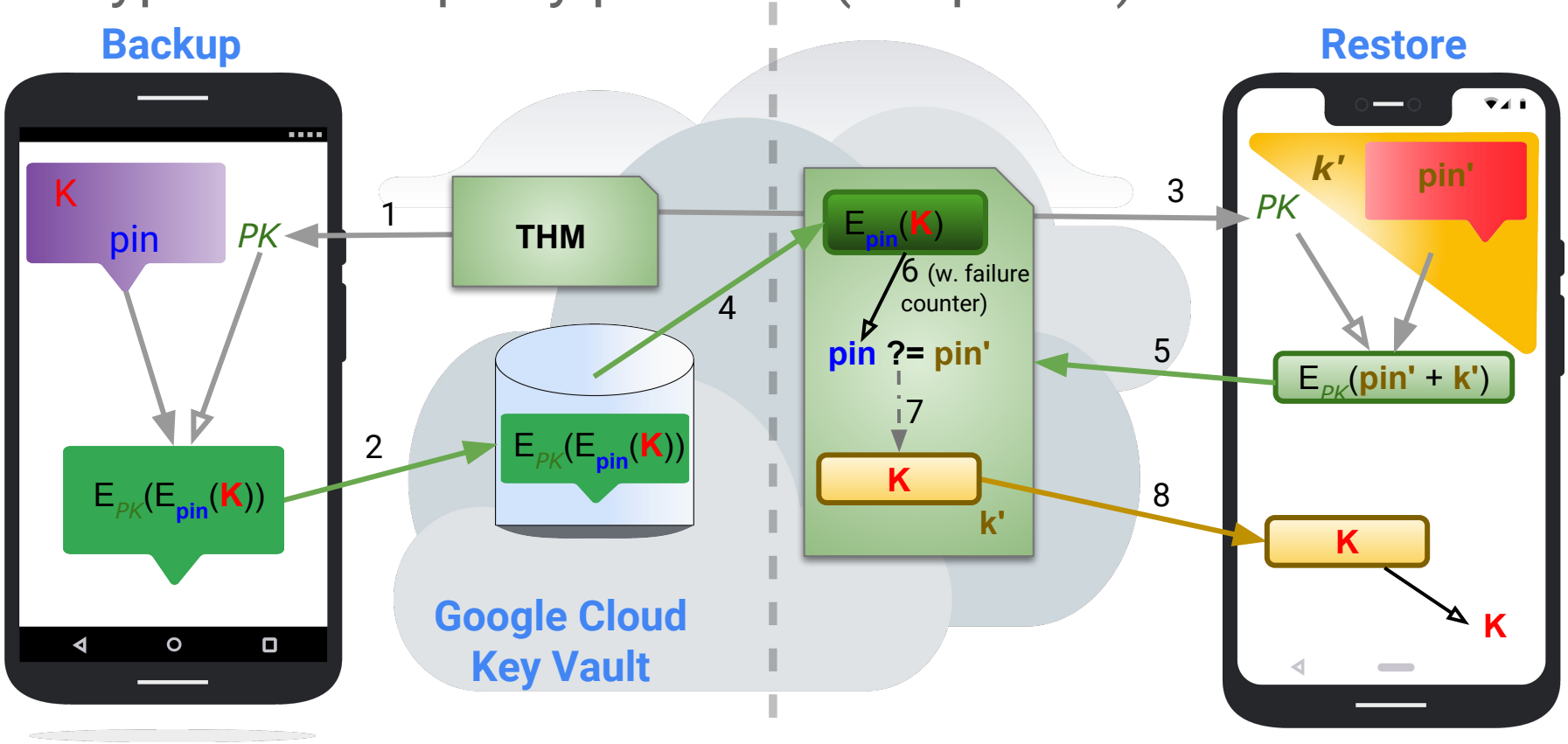
Encrypted backup key protocol (simplified)



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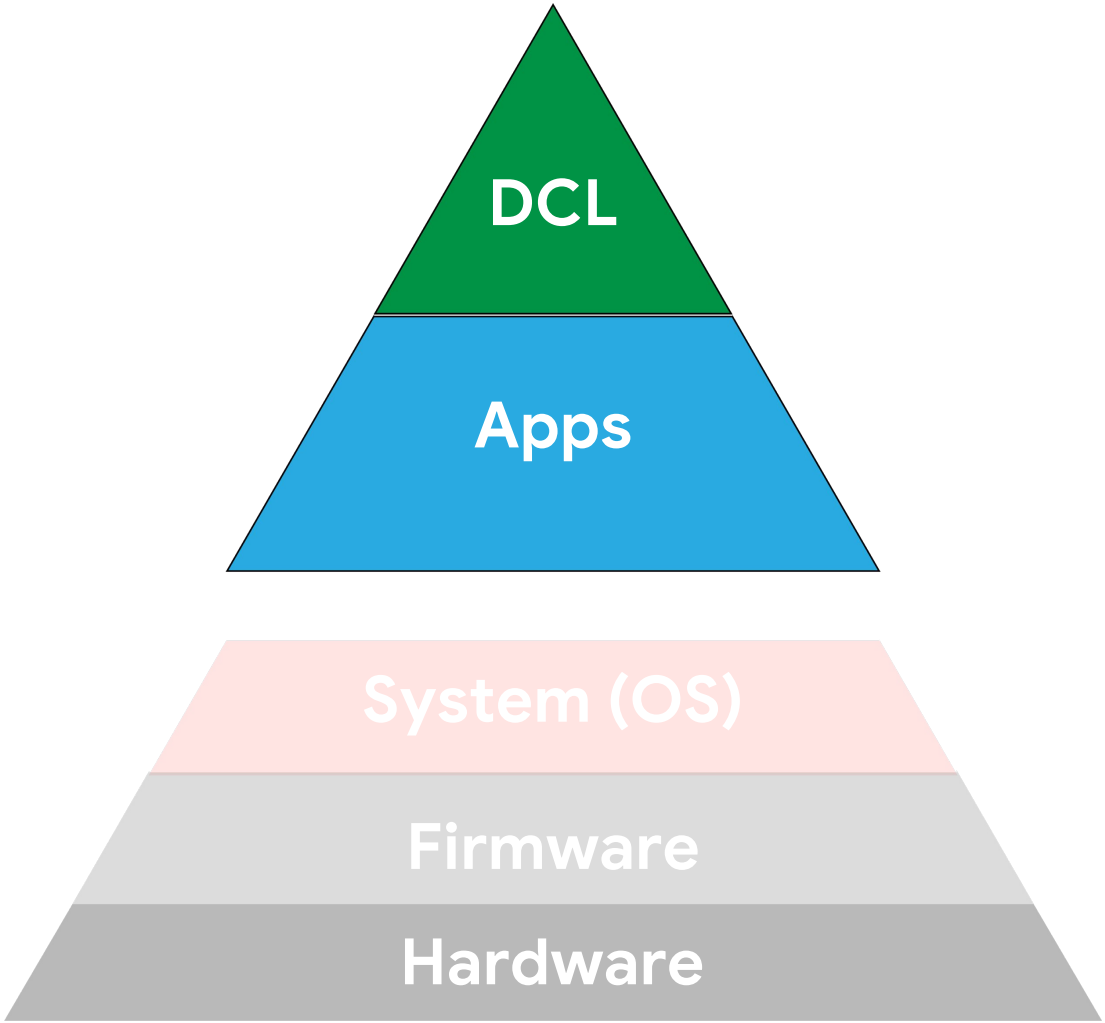
DCL
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Auditability is a key defense against insider attacks

Don’t take my word for it

Appendix

Calculating VBMeta Digest from Factory Image

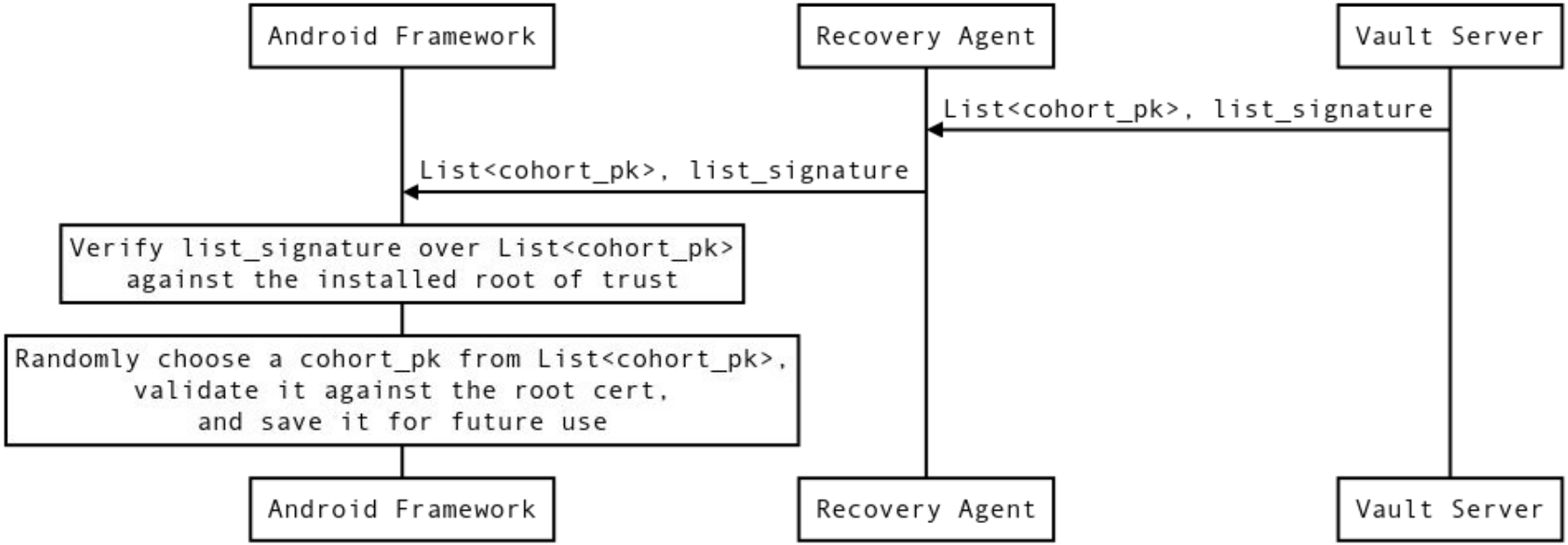
- Build avbtool from AVB 2.0 AOSP.
- Download and unzip factory image for Pixel 3.
- Validate that VBMeta structures match up with referenced partitions.
  - `avbtool verify_image --image vbmeta.img --follow_chain_partitions`
- Calculate VBmeta Digest
  - `avbtool calculate_vbmeta_digest --image vbmeta.img`

Attesting VBMeta Digest

- DevicePolicyManager.generateKeyPair() to get AttestedKeyPair
- AttestedKeyPair.getAttestationRecord() to get Key Attestation Cert Chain
- Validate the chain up to the Google root certificate
- Extract extension OID 1.3.6.1.4.1.11129.2.1.17 from leaf certificate
- RootOfTrust sequence contains verifiedBootHash field with VBMeta Digest

```
RootOfTrust ::= SEQUENCE {
    verifiedBootKey  OCTET_STRING,
    deviceLocked  BOOLEAN,
    verifiedBootState  VerifiedBootState,
    verifiedBootHash OCTET_STRING,
}
```

Encrypted backup key protocol (Details)



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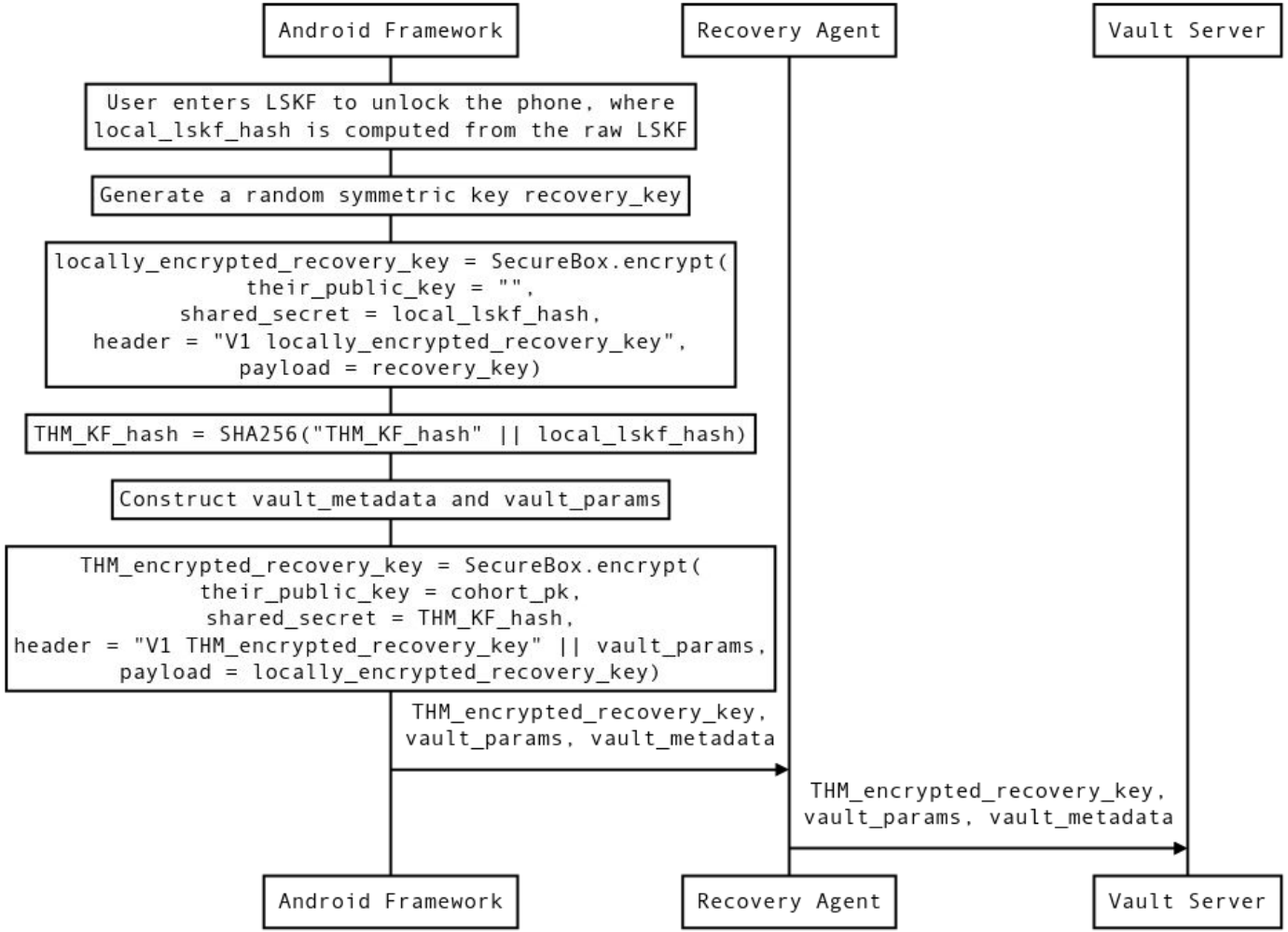
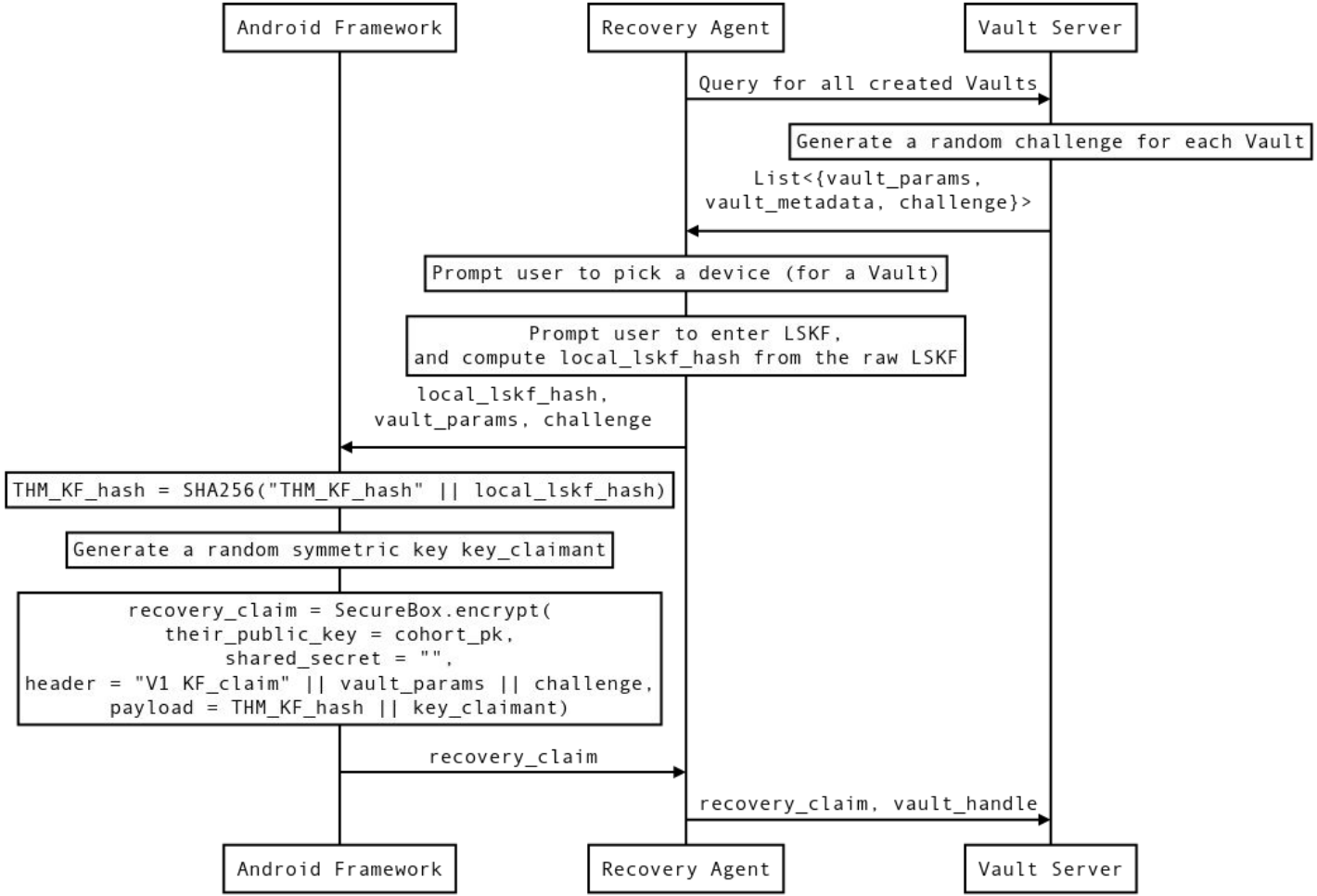
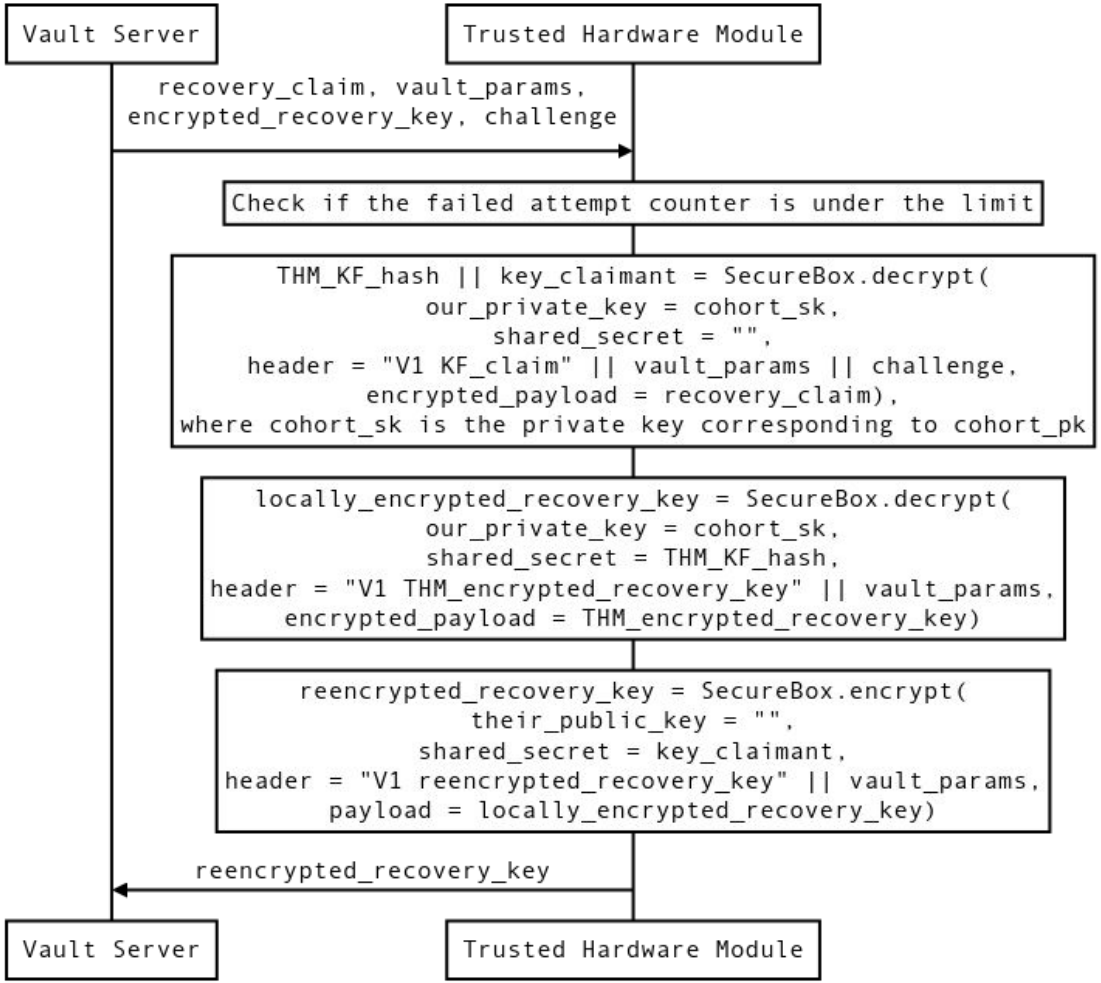
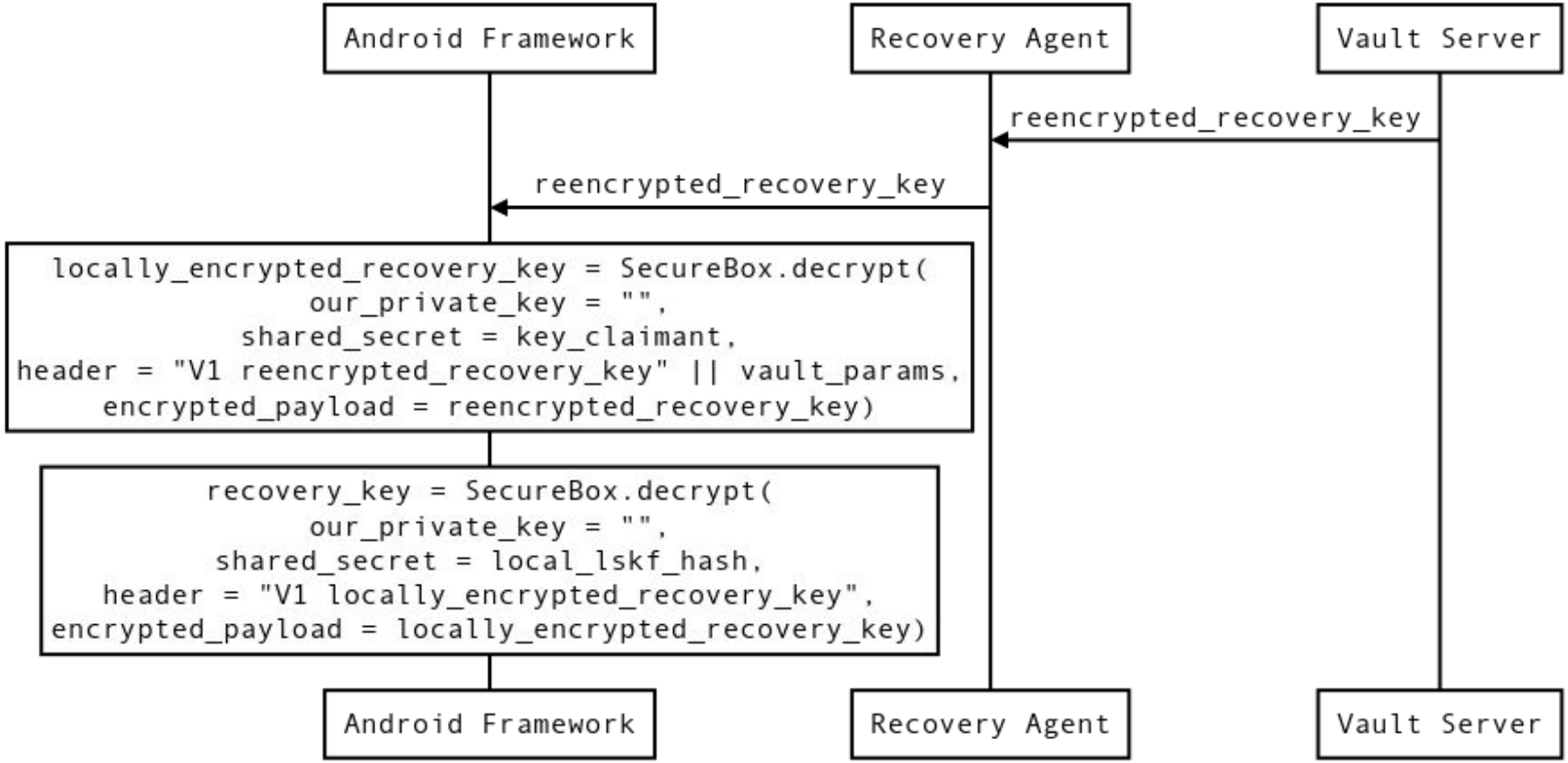
https://security.googleblog.com/2018/10/google-and-android-have-your-back-by.html
Cohort public keys: https://www.gstatic.com/cryptauthvault/v0/cert.xml


Android Framework
Recovery Agent
Vault Server
User enters LSKF to unlock the phone, where local_lskf_hash is computed from the raw LSKF
Generate a random symmetric key recovery_key
locally_encrypted_recovery_key = SecureBox.encrypt(their_public_key = "", shared_secret = local_lskf_hash, header = "V1 locally_encrypted_recovery_key", payload = recovery_key)
THM_KF_hash = SHA256("THM_KF_hash" || local_lskf_hash)
Construct vault_metadata and vault_params
THM_encrypted_recovery_key = SecureBox.encrypt(their_public_key = cohort_pk, shared_secret = THM_KF_hash, header = "V1 THM_encrypted_recovery_key" || vault_params, payload = locally_encrypted_recovery_key)
THM_encrypted_recovery_key, vault_params, vault_metadata
THM_encrypted_recovery_key, vault_params, vault_metadata
Android Framework
Recovery Agent
Vault Server


Android Framework
Recovery Agent
Vault Server
Query for all created Vaults
Generate a random challenge for each Vault
List<{vault_params, vault_metadata, challenge}>
Prompt user to pick a device (for a Vault)
Prompt user to enter LSKF, and compute local_lskf_hash from the raw LSKF
local_lskf_hash, vault_params, challenge
THM_KF_hash = SHA256("THM_KF_hash" || local_lskf_hash)
Generate a random symmetric key key_claimant
recovery_claim = SecureBox.encrypt(their_public_key = cohort_pk, shared_secret = "", header = "V1 KF_claim" || vault_params || challenge, payload = THM_KF_hash || key_claimant)
recovery_claim
recovery_claim, vault_handle
Android Framework
Recovery Agent
Vault Server


Vault Server
Trusted Hardware Module
recovery_claim, vault_params,
encrypted_recovery_key, challenge
Check if the failed attempt counter is under the limit
THM_KF_hash || key_claimant = SecureBox.decrypt(
our_private_key = cohort_sk,
shared_secret = "",
header = "V1 KF_claim" || vault_params || challenge,
encrypted_payload = recovery_claim),
where cohort_sk is the private key corresponding to cohort_pk
locally_encrypted_recovery_key = SecureBox.decrypt(
our_private_key = cohort_sk,
shared_secret = THM_KF_hash,
header = "V1 THM_encrypted_recovery_key" || vault_params,
encrypted_payload = THM_encrypted_recovery_key)
reencrypted_recovery_key = SecureBox.encrypt(
their_public_key = "",
shared_secret = key_claimant,
header = "V1 reencrypted_recovery_key" || vault_params,
payload = locally_encrypted_recovery_key)
reencrypted_recovery_key
Vault Server
Trusted Hardware Module


Android Framework
Recovery Agent
Vault Server
reencrypted_recovery_key
reencrypted_recovery_key
locally_encrypted_recovery_key = SecureBox.decrypt(
our_private_key = "",
shared_secret = key_claimant,
header = "V1 reencrypted_recovery_key" || vault_params,
encrypted_payload = reencrypted_recovery_key)
recovery_key = SecureBox.decrypt(
our_private_key = "",
shared_secret = local_lskf_hash,
header = "V1 locally_encrypted_recovery_key",
encrypted_payload = locally_encrypted_recovery_key)
Android Framework
Recovery Agent
Vault Server