Android Virtualization Framework
2022

Android Virtualization Framework

Protected computing for the next generation use cases

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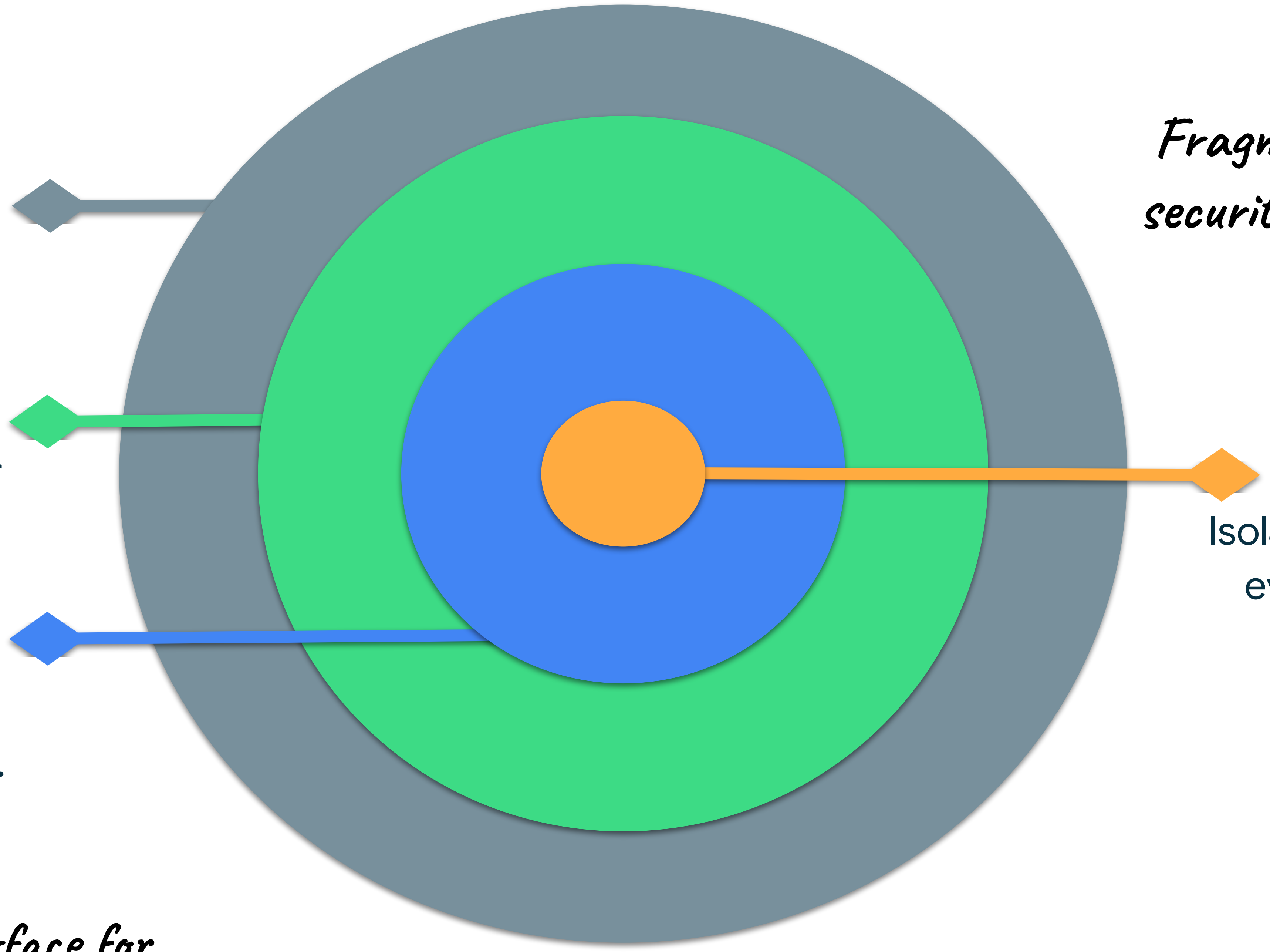
Android defense mechanisms



Google Play Store
Malware and security scanning for Android applications.

Android Application Sandbox
Isolates Android applications and their resources from each other.

Android Kernel
Enforces the application sandbox and process isolation and security policies.

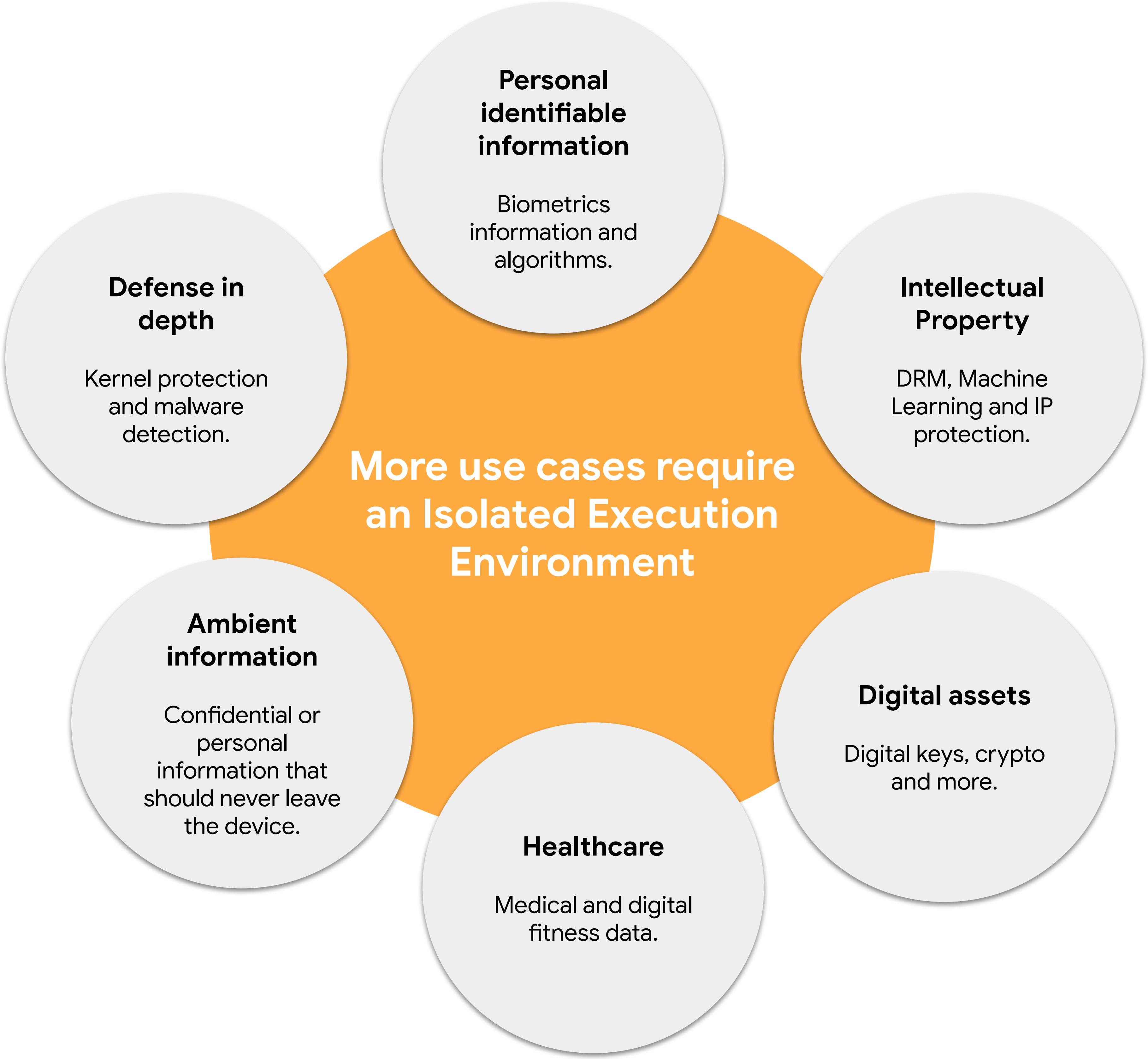
Too big of an attack surface for privacy-sensitive use cases.

Fragmented, constrained APIs, limited security updates and no mutual distrust.

Isolated Execution Environment
Isolates security critical payloads even in the event of a compromised Android Kernel.

A standard deployment across the ecosystem

These use cases need isolation even in the event of a kernel vulnerability (think Dirty Pipe).



More use cases require an Isolated Execution Environment

Personal identifiable information

Biometrics information and algorithms.

Intellectual Property

DRM, Machine Learning and IP protection.

Digital assets

Digital keys, crypto and more.

Healthcare

Medical and digital fitness data.

Ambient information

Confidential or personal information that should never leave the device.

Defense in depth

Kernel protection and malware detection.

The TrustZone TEE is too privileged and fragmented to use.

Deploying there would further increase the vulnerable TCB.

The Execution Environment needed

to enable Protected Computing on Android

Isolated
from the kernel's
attack surface and other
Protected Virtual Machines.

Updatable
using the same
containers and updata
technologies as Android.

Least privilege
mutually distrusted
and isolated even in
the event of an exploit.

Android Virtualization Framework

android13-5.x branches: we’ve been very busy!

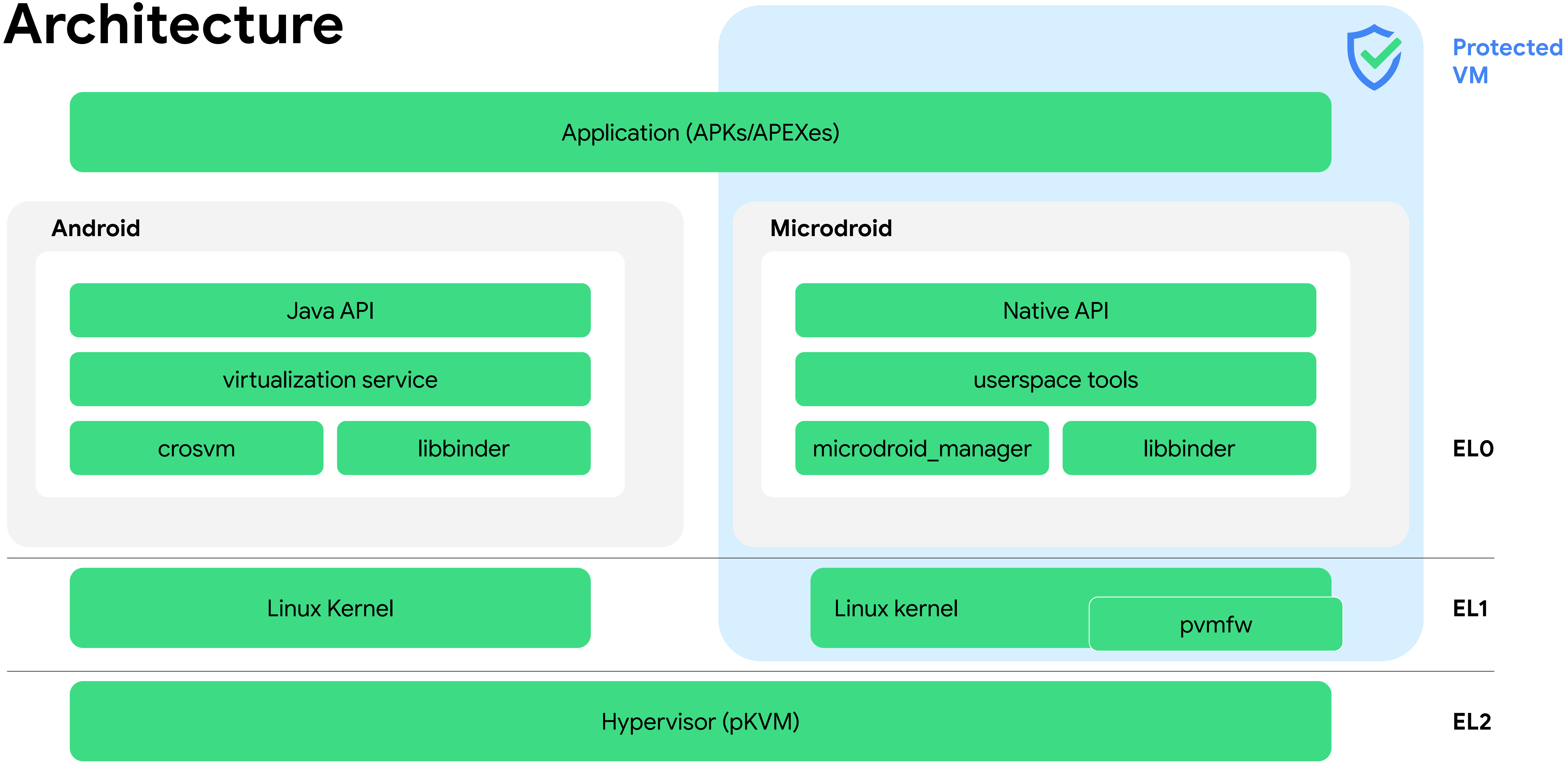
Key pKVM hypervisor features available today:

- VM state and management isolated from the host
- Guest memory isolation
  - Including some IOMMU support (S2MPU)
- Services exposed as hypercalls to the guest payload
  - Memory sharing and virtio using bounce buffers
  - MMIO guard
  - TRNG proxied to secure world
- pVM firmware loading
- Non-protected guests for debug visibility

Actively working on upstreaming all of these features!

See our talks at KVM Forum

Architecture



Protected VM

Application (APKs/APEXes)

Android

Java API

virtualization service

crosvm

libbinder

Microdroid

Native API

userspace tools

microdroid_manager

libbinder

EL0

Linux Kernel

Linux kernel

pvmfw

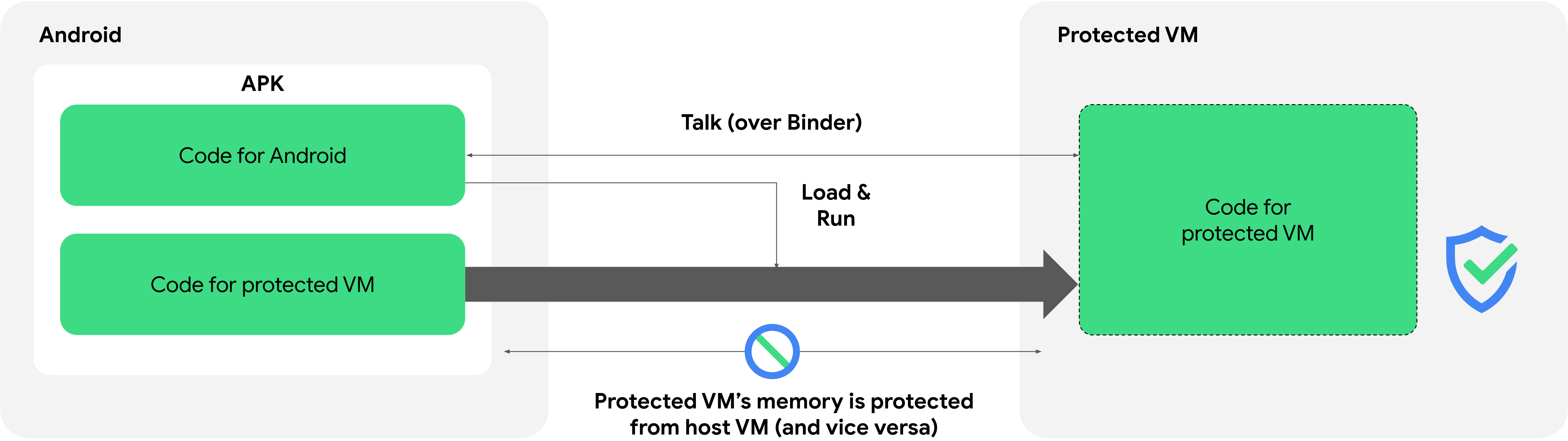
EL1

Hypervisor (pKVM)

EL2

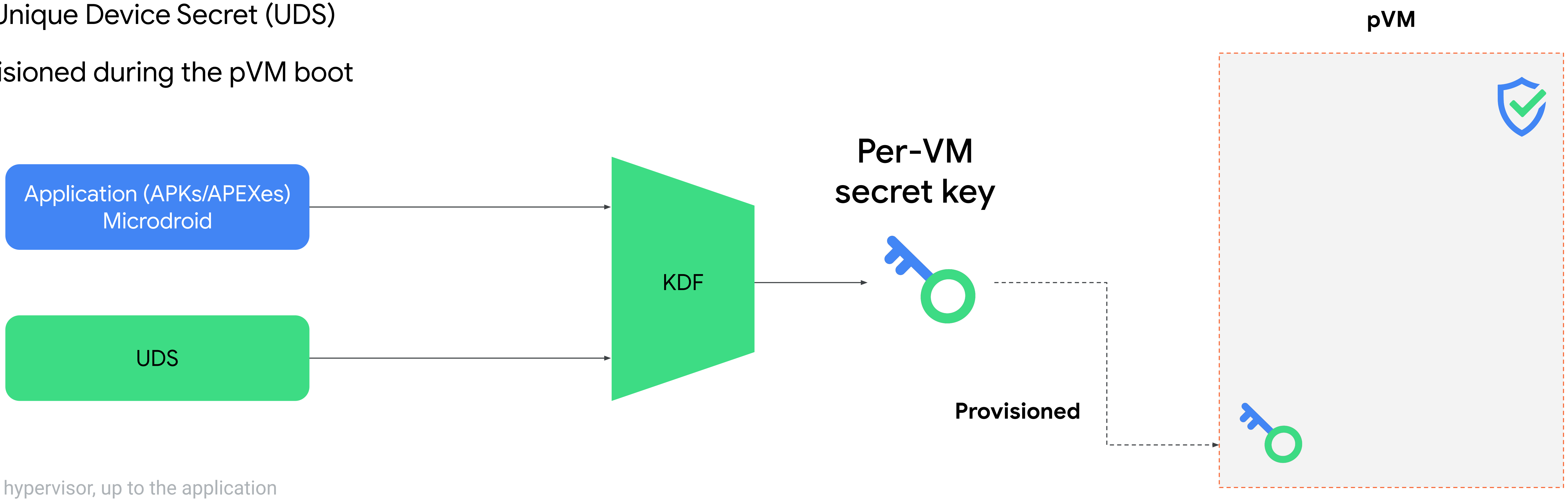
Programming Model

- Using APIs, you create a protected VM and run a native shared library in your APK there
- The library implements a Binder service
- Android app connects over Binder to send commands and get results



Secret Provisioning Using DICE

- Each pVM has its own secret key, not available to Android
- The per-pVM secret is not a random number, nor kept in a secure key store
- It is a function of
  (1) measurements of the software that defines the behavior of the pVM* and
  (2) Unique Device Secret (UDS)
- Provisioned during the pVM boot



*From bootloader, hypervisor, up to the application

Documentation

https://source.android.com/devices/virtualization

android-kvm+partner@google.com

Questions

- How do you plan to use the Android Virtualization Framework?
- What use cases do you deploy at EL2/TZ today?

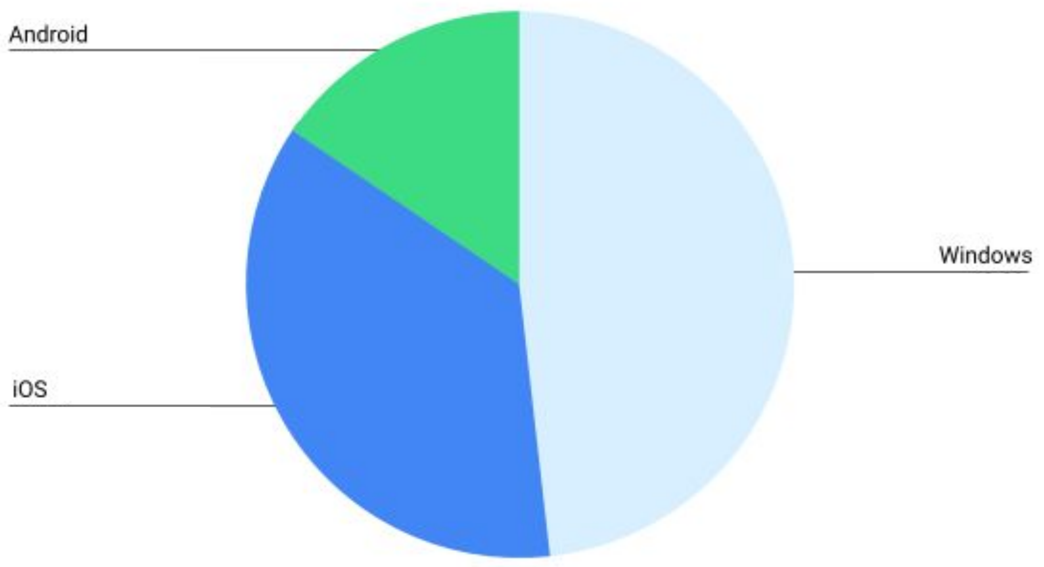
Thank you!

Backup

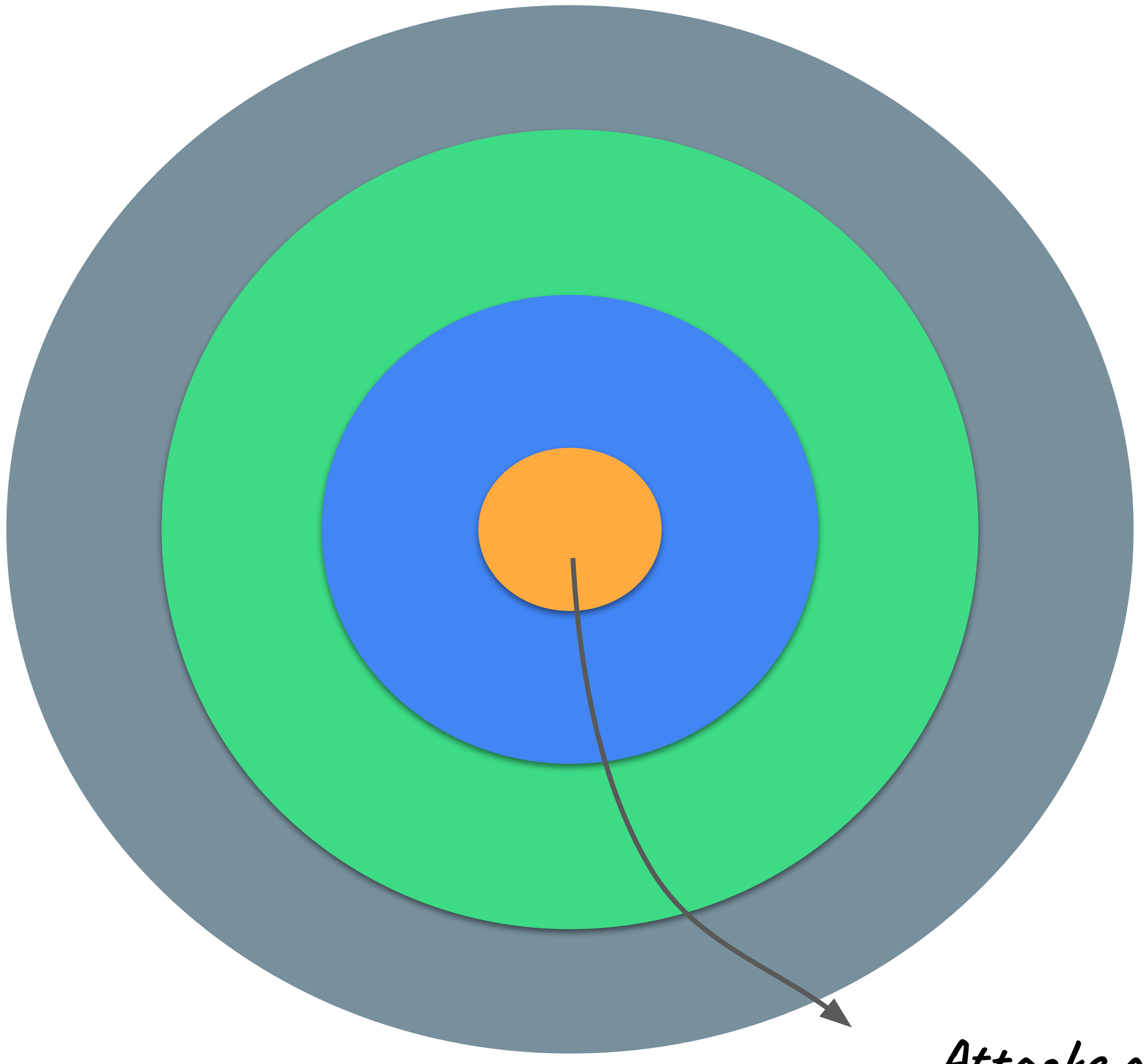
Cyber landscape

Today, more cyber attacks than ever are happening on a broader, global scale. The targets of these attacks are … but also individuals.

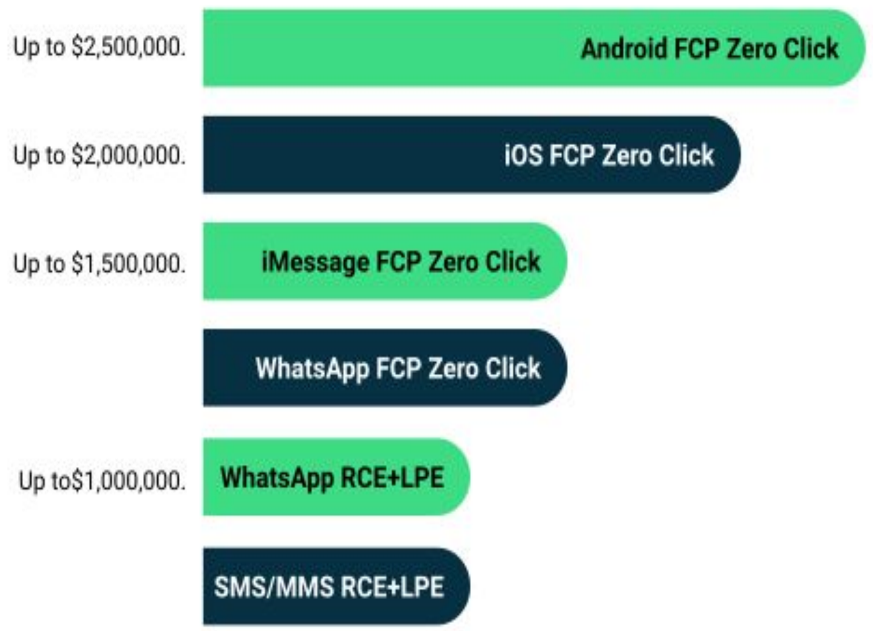
Attacks are moving to more privileged layers



Zero-day Vulnerability Database
(data)



Attacks are probably moving to more privileged layers like the TEE.



Zerodium
(data)

Android Virtualization Framework

Upstream Protected KVM
or vendor specific.

Isolated from Android,
other VMs and DMA devices.

Hypervisor , **Protected Virtual Machines** and **Framework APIs** that enable **Protected Computing** in Android.

Integrated in Android
as a first-class primitive;
standard and developer friendly.

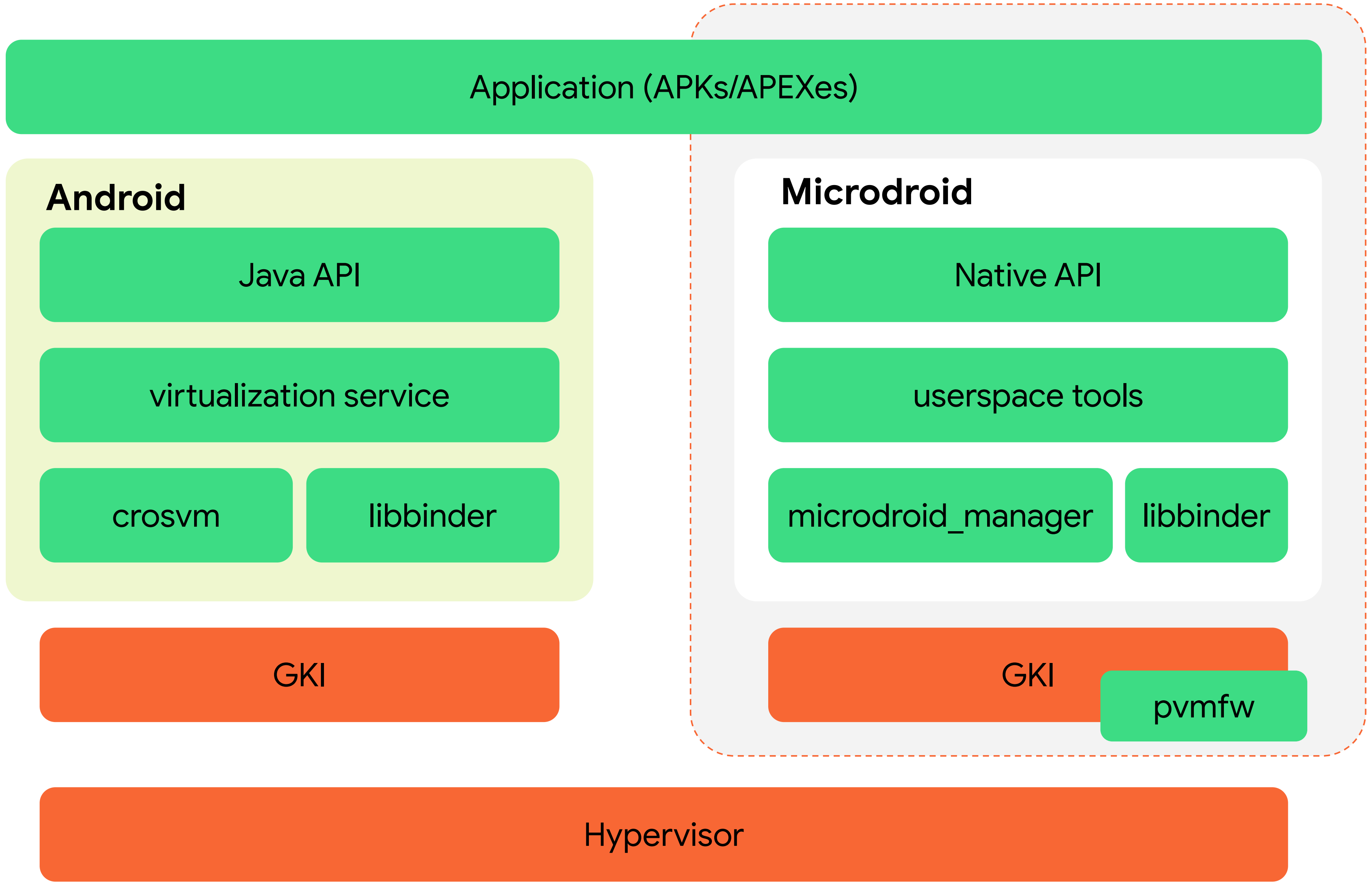
Key Components (1/3)

Hypervisor

- Must isolate VM memory from others, even from the host; enforced with stage-2 page tables and IOMMUs
- Reference implementation: KVM/arm in protected mode (pKVM)

Generic Kernel Image (GKI)

- pKVM distributed as part of GKI, enabled when kernel booted in EL2
- Exposes **/dev/kvm** as the control interface
- Host GKI remains in charge of scheduling
- Guests run the same GKI kernel booted in EL1



Key Components (2/3)

virtualization service

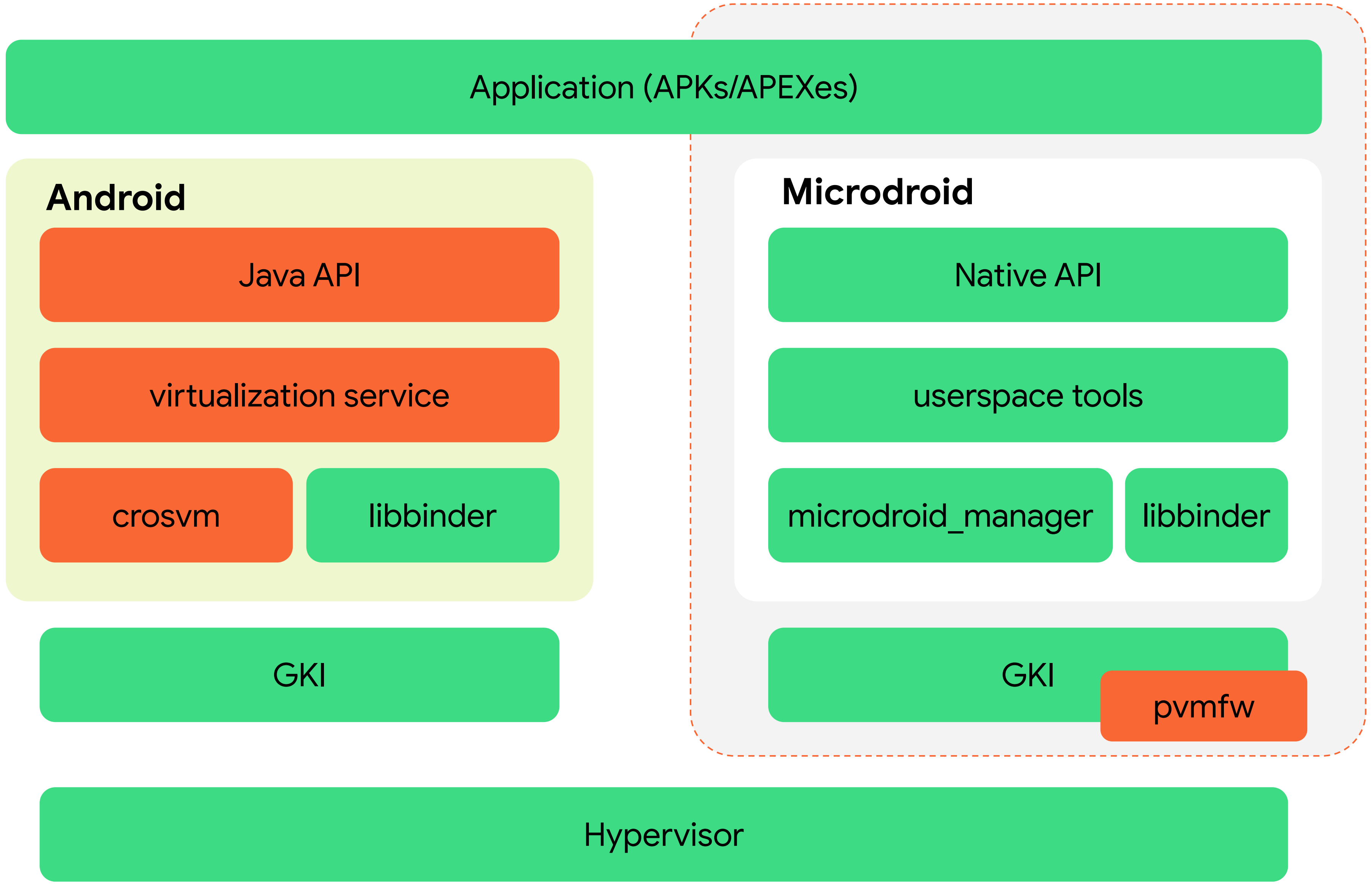
- System service managing lifecycle of VMs
- Actual creation of VM is delegated to crosvm
- Accessed via Java API (optional library)

crosvm

- Virtual machine monitor written in Rust
- Hypervisor and PV device backends
- Resource management (memory, vCPUs)

pvmfw

- First code that runs in a protected VM
- Verifies the payload, derives per-VM secret



Key Components (3/3)

Microdroid

- Lightweight headless Android for pVM

microdroid_manager

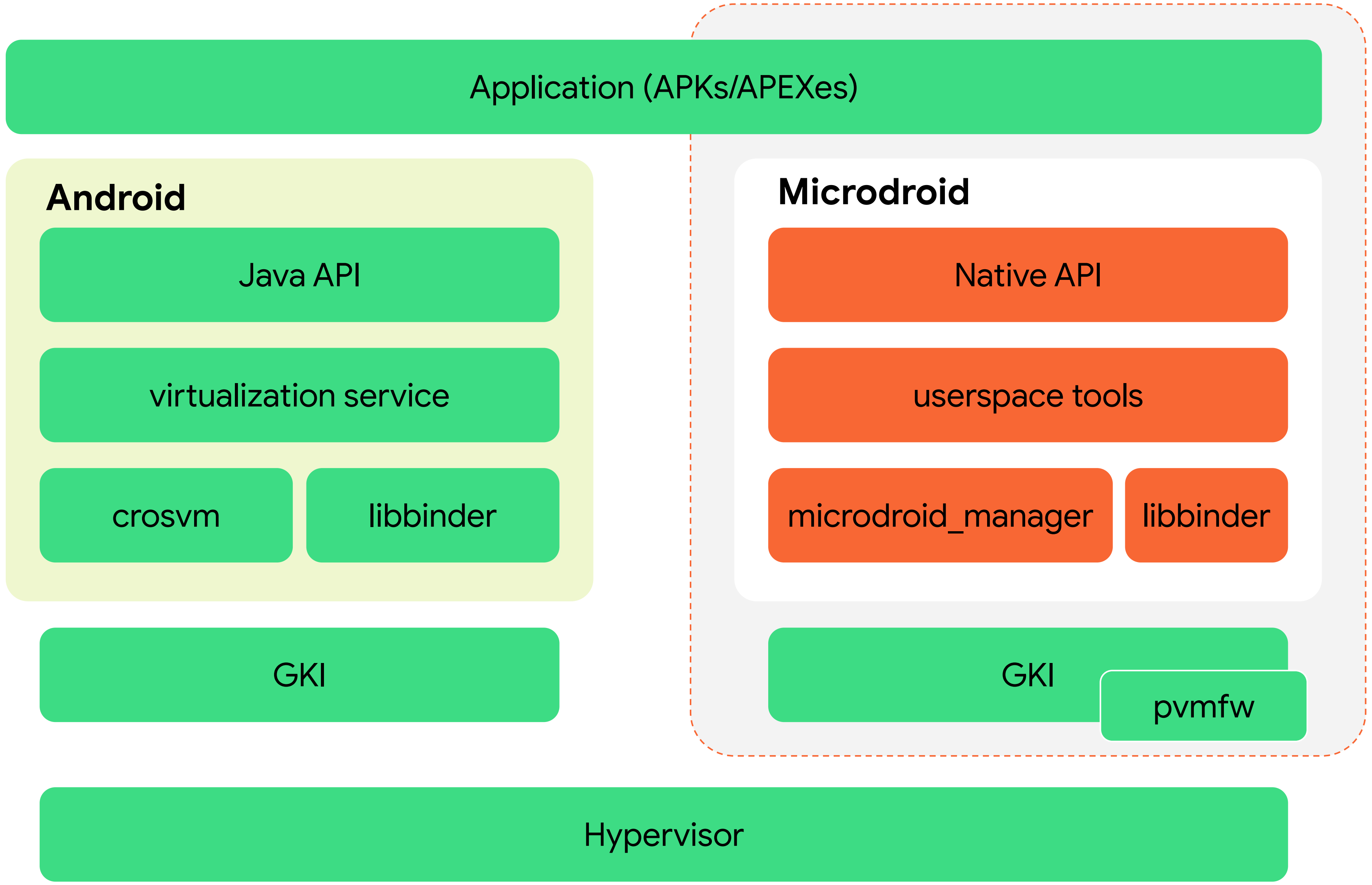
- Manages application inside the VM
- Securely mounts APK/APEXes from host
- Provides access to per-VM secret

libbinder

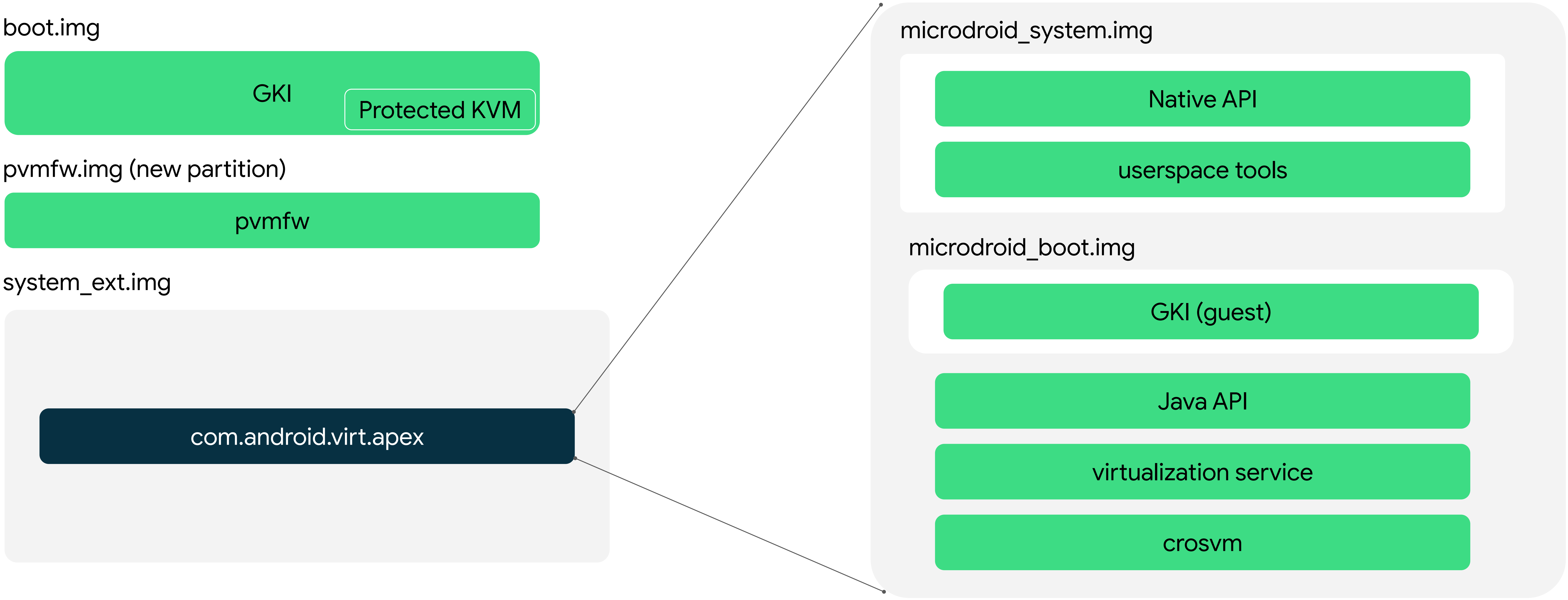
- Extended to work over vsock
- Primary means of inter-VM communication

Native API

- A subset of NDK provided to application
- libc/m/dl, **no libandroid.so**

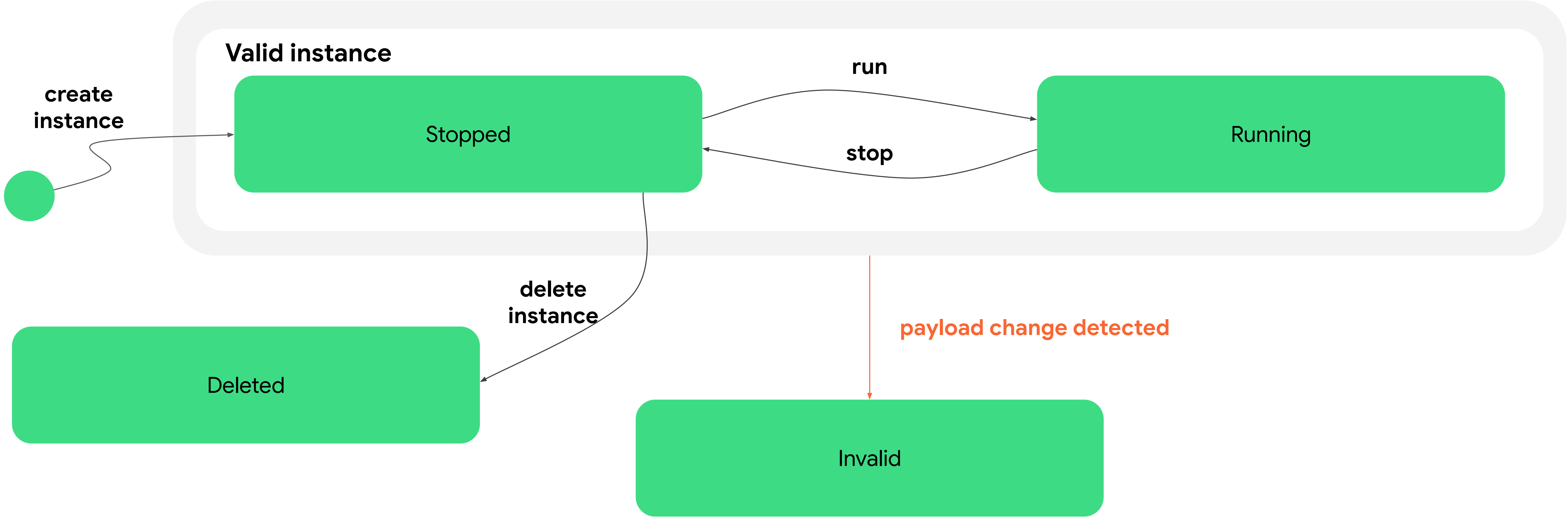


Packaging


boot.img
GKI
Protected KVM
pvmfw.img (new partition)
pvmfw
system_ext.img
com.android.virt.apex
microdroid_system.img
Native API
userspace tools
microdroid_boot.img
GKI (guest)
Java API
virtualization service
crosvm

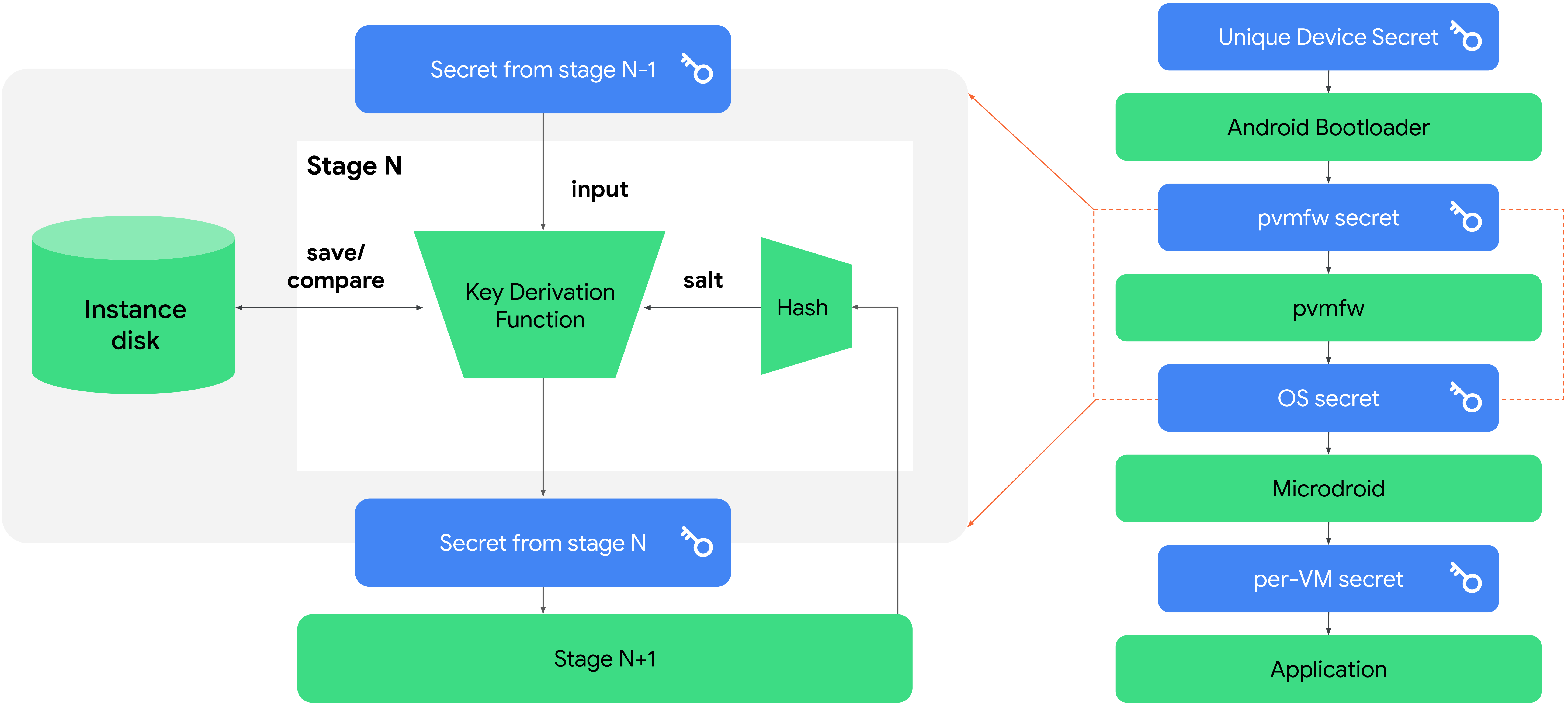
Lifecycle of a pVM

Once created, a pVM instance can be repeatedly started and stopped, as long as the software running inside the pVM remains the same. Future changes will allow to update forward without invalidating the instance.



Secret Provisioning Using DICE

- **Each stage in boot sequence derives a secret for the next stage**


Secret from stage N-1
Stage N
input
save/
compare
Instance disk
Key Derivation Function
salt
Hash
Secret from stage N
Stage N+1
Unique Device Secret
Android Bootloader
pvmfw secret
pvmfw
OS secret
Microdroid
per-VM secret
Application