SiDi

Linux to Android: a path to becoming a secure mobile operating system

Danilo Rodrigues

$ whoami

SiDi

Cloud

Machine learning

Security

What will be discussed today?

- What exactly is Android?
- Is Android secure?
  - Linux inherited security features
  - Android's own security features
- What are the security issues on Android today?
- BONUS: How Brazilian authorities were hacked?

Meet Android

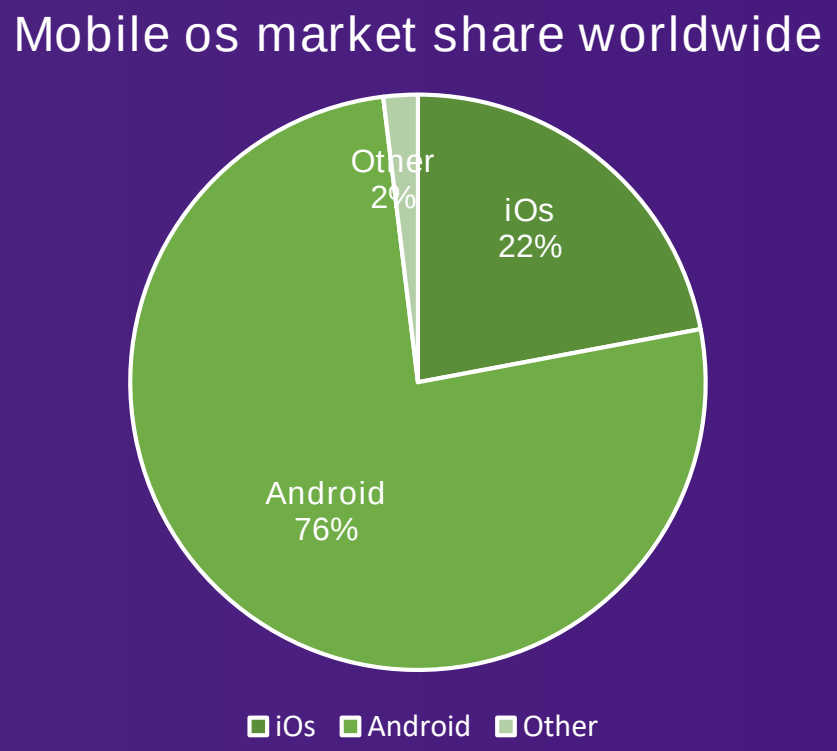
In the beginning...

The FIRST Android_

T-Mobile G1, the first Android phone sold

ANDROID today.

2.5 BILLION DEVICES
2.1 MILLION APPS
5.9 MILLION DEVELOPERS



Linux and Android

Is Android another Linux distribution?

Maybe a little bit Linux

Common Features

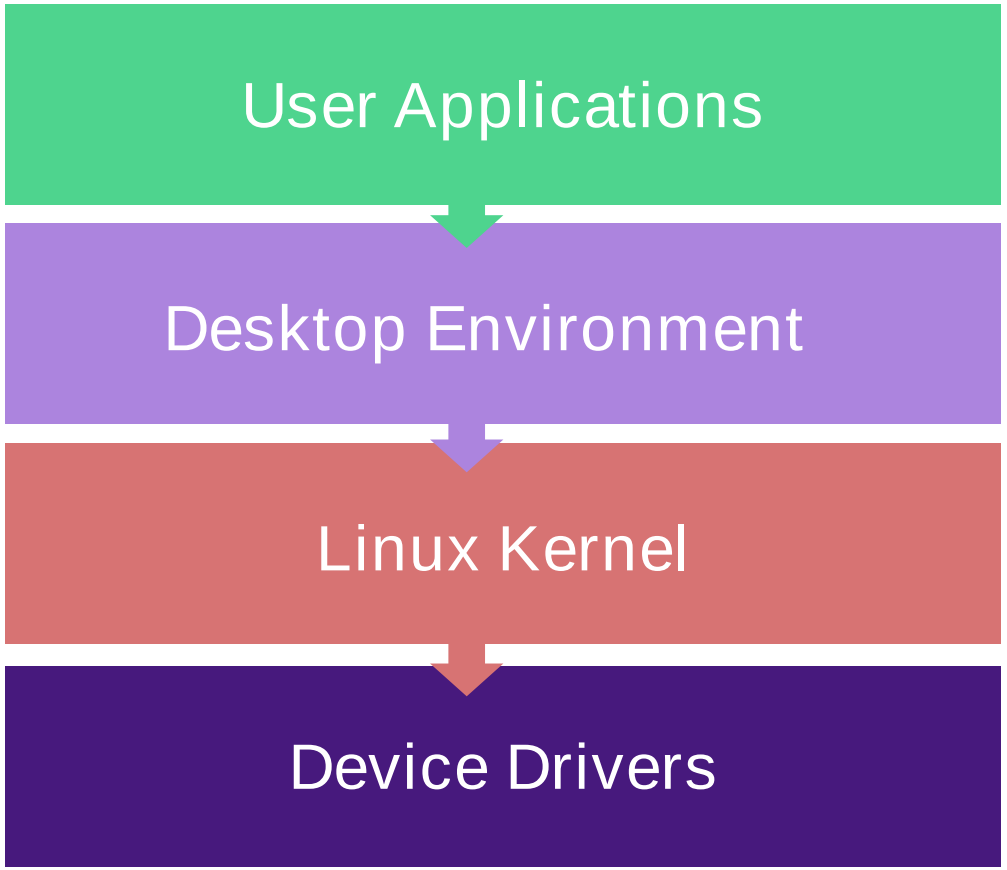
- Many native binaries
- Same process and thread behavior
- Control groups
- Low memory conditions
- Security features

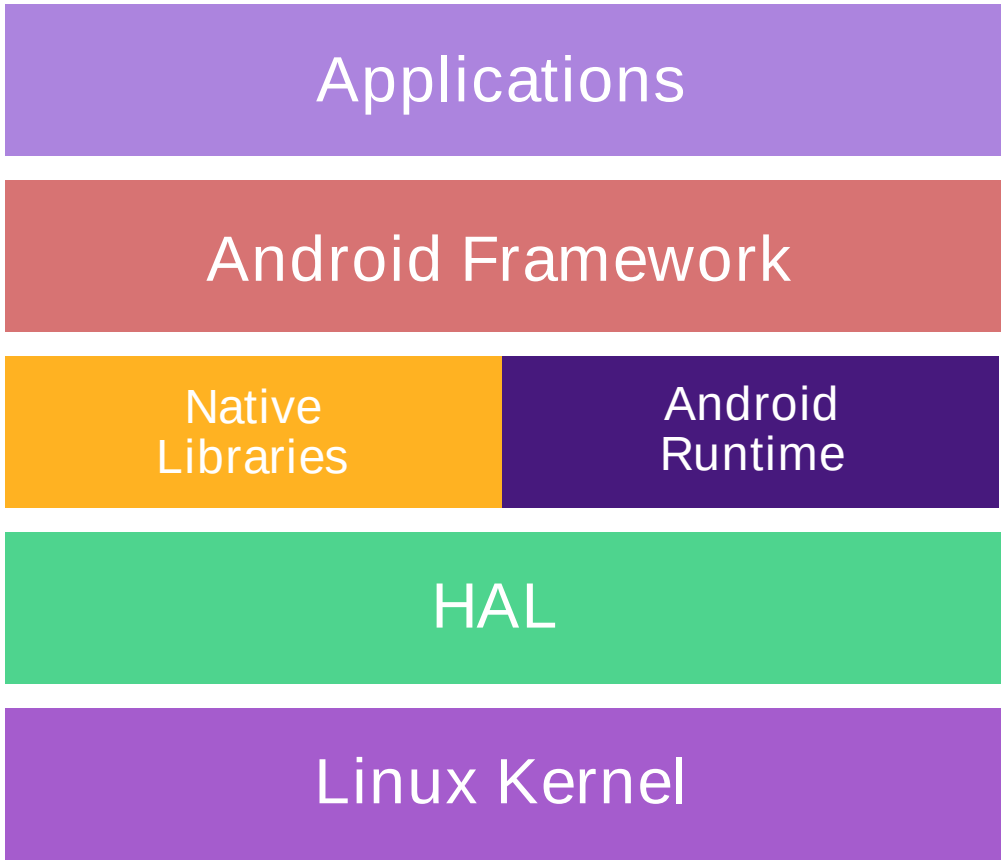
Android and Linux are about 95% equal in Kernel level!

Different problems require different solutions.

Desktop

Mobile



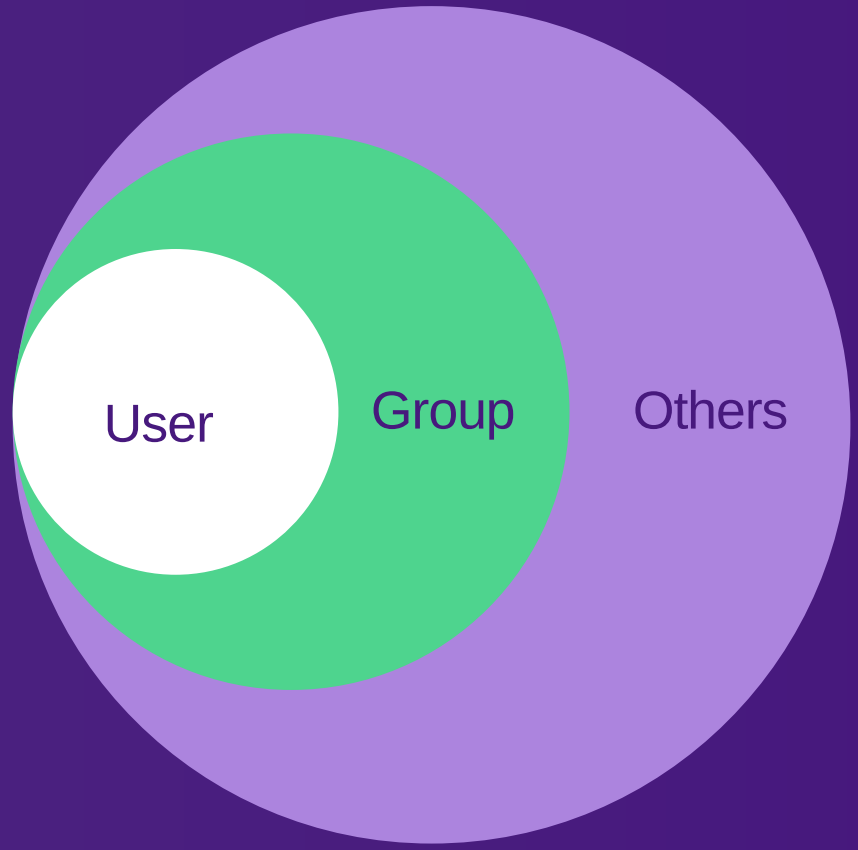


Using Linux *security* features.

Linux permissions

-rwxr-xr-x

r: Read
w: Write
x: eXecute



Application A

UID: 10209 (u0_a209)
GUID: 10209 (u0_a209)

/data/data/applicationA

Application B

UID: 10210 (u0_a210)
GUID: 10210 (u0_a210)

/data/data/applicationB

Application A

UID: 10209 (u0_a209)
GUID: 10209 (u0_a209)

/data/data/applicationA

Application B

UID: 10210 (u0_a210)
GUID: 10210 (u0_a210)

/data/data/applicationB

Application A

UID: 10209 (u0_a209)
GUID: 10209 (u0_a209)

/data/data/applicationA

Application B

UID: 10209 (u0_a209)
GUID: 10209 (u0_a209)

/data/data/applicationB

Linux permissions

“All apps are equal, but some apps are more equal than others.”

Process	UID
ROOT	0
…	…
SYSTEM SERVER	1000
RADIO	1001
BLUETOOTH	1002
GRAPHICS	1003
…	…
SHELL	2000
…	…
Regular APP 0	10000
Regular APP 1	10001
…	…

Linux capabilities

You DONT have to be root to do root stuff!

```
[mgn@lois ~]$ getcap /bin/ping                                  # Getting ping capabilities
/bin/ping = cap_net_raw+ep
[mgn@lois ~]$ sudo setcap -r /bin/ping                          # Removing ping capabilities
[mgn@lois ~]$ ping google.com                                   # Testing ping...
ping: socket: Operação não permitida
[mgn@lois ~]$ sudo ping google.com                              # Now testing as root...
PING google.com (172.217.28.78) 56(84) bytes of data.
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^C
--- google.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 11.744/12.172/12.601/0.442 ms
[mgn@lois ~]$ sudo setcap 'cap_net_raw+ep' /bin/ping            # Restoring ping capability
[mgn@lois ~]$ ping google.com                                   # Retesting ping...
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[mgn@lois ~]$
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Ping has net_raw capability

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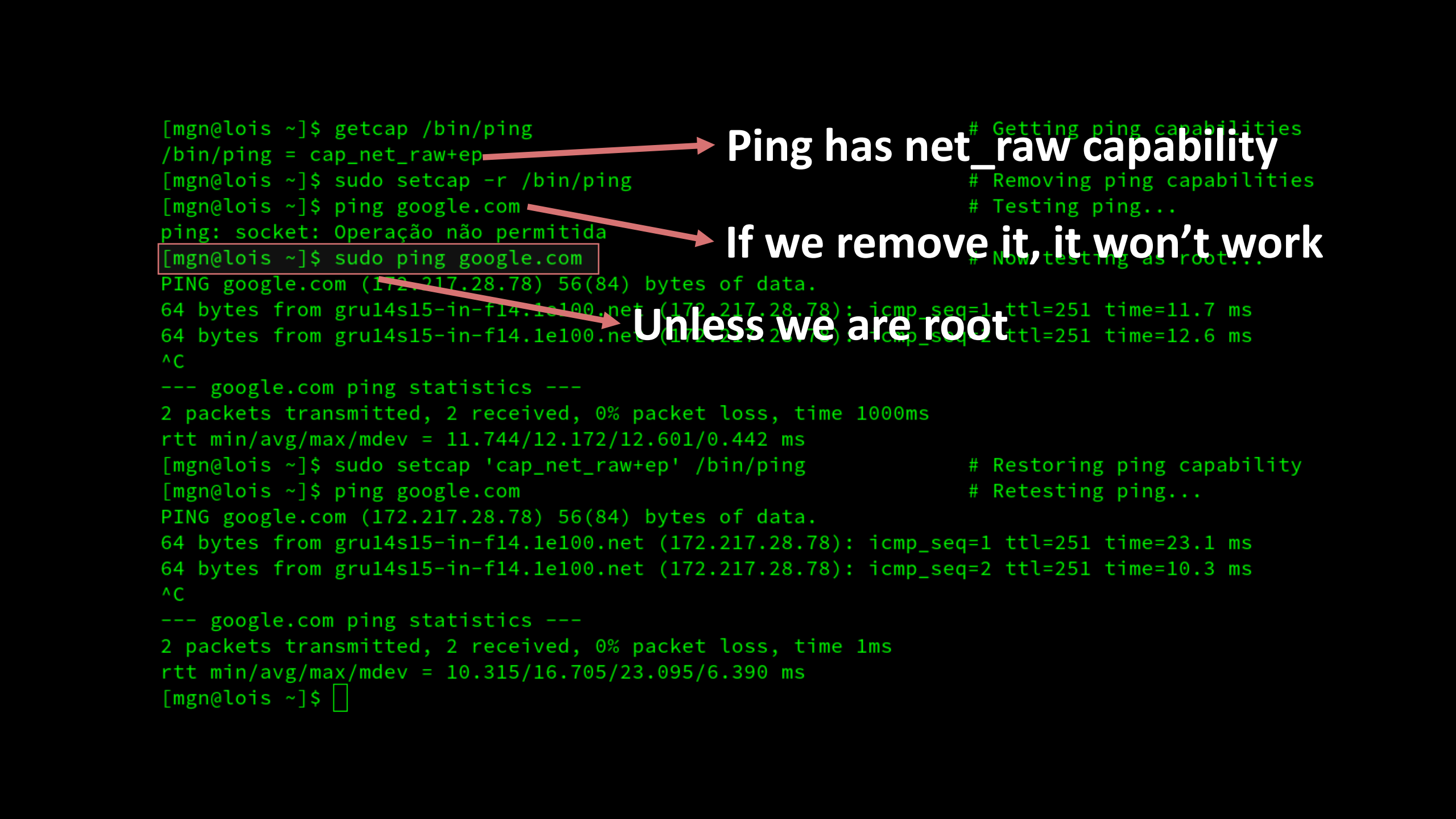
Ping has net_raw capability

If we remove it, it won't work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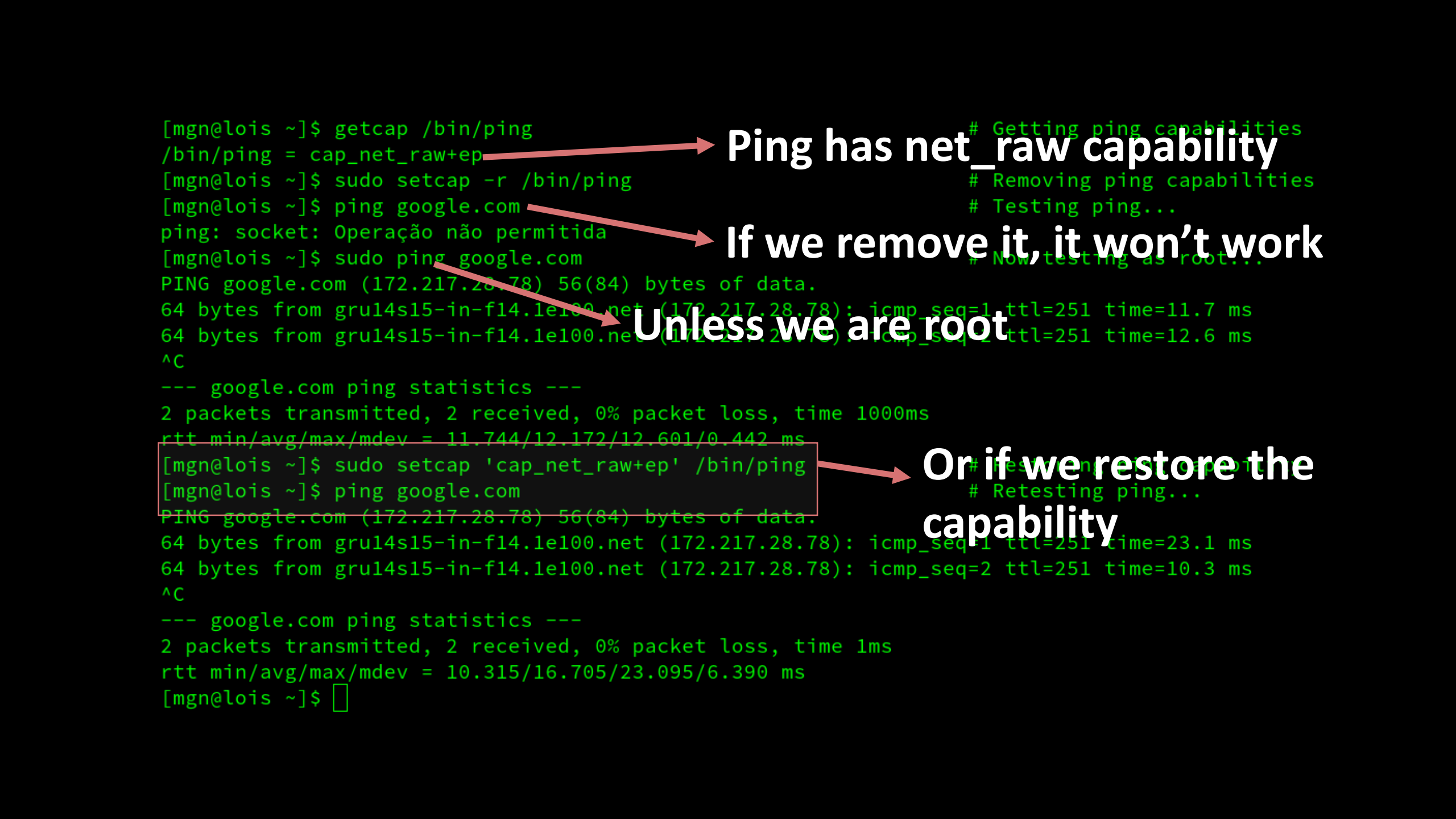
Retesting ping...
Ping has net_raw capability
If we remove it, it won't work
Unless we are root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Retesting ping...
Ping has net_raw capability
If we remove it, it won't work
Unless we are root
Or if we restore the capability

Linux capabilities_

Android's processes drop privileges before they do anything.

- Principle of least privilege
- Sandboxed capabilities
- Lower security risk

SELinux_

Discretionary Access Control

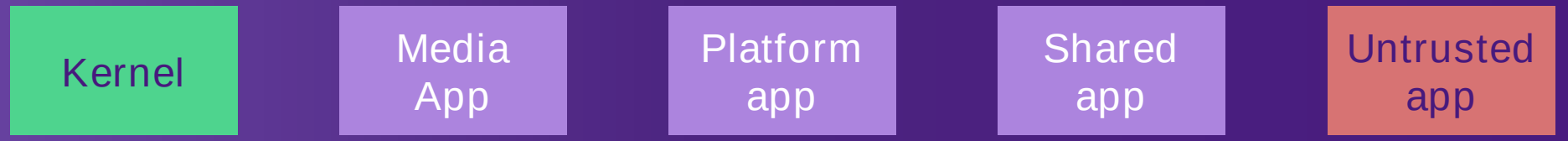
VS

Mandatory Access Control

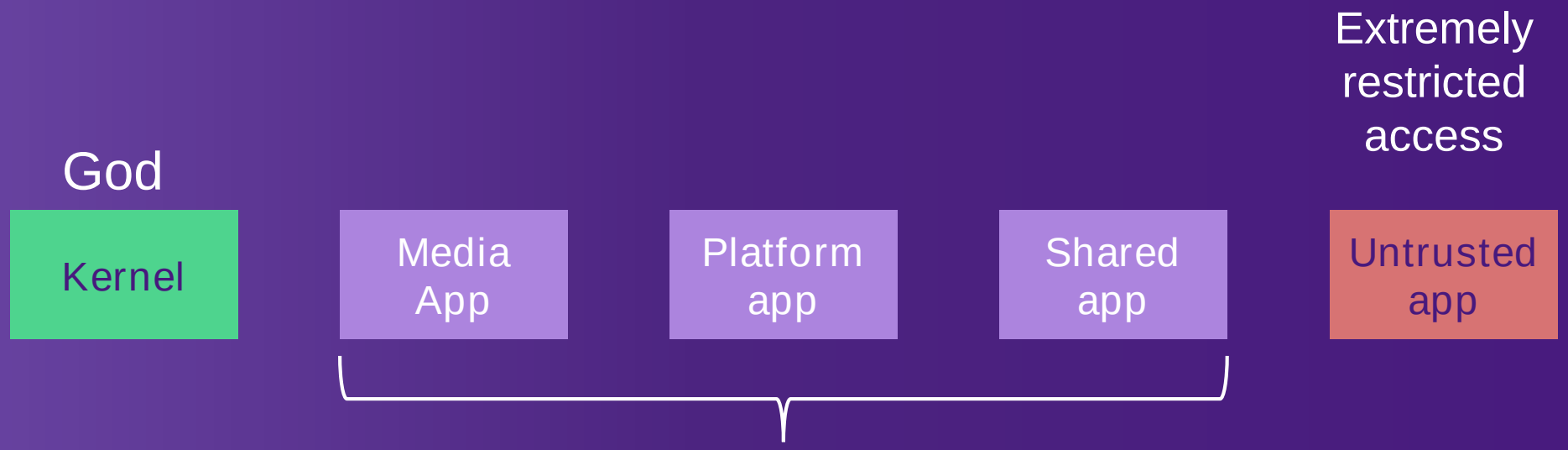
USER:ROLE:TYPE:LEVEL

~~USER~~:~~ROLE~~:TYPE:~~LEVEL~~

~~USER~~:~~ROLE~~:TYPE:~~LEVEL~~



~~USER~~:~~ROLE~~:TYPE:~~LEVEL~~



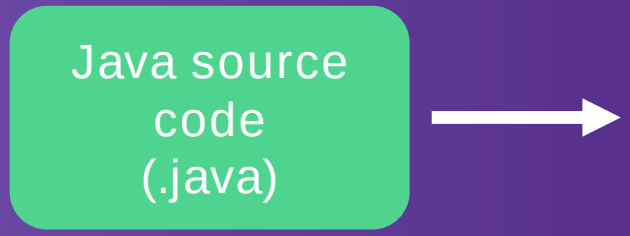
Other Linux protections_

- Address Space Layout Randomization
- Kernel hardening
- Stack protections
- Data execution prevention

Android Runtime security features_

Running Java

How it’s done in Java



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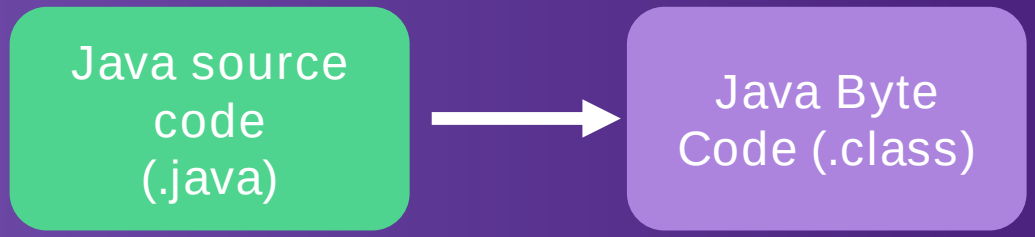

Running Java

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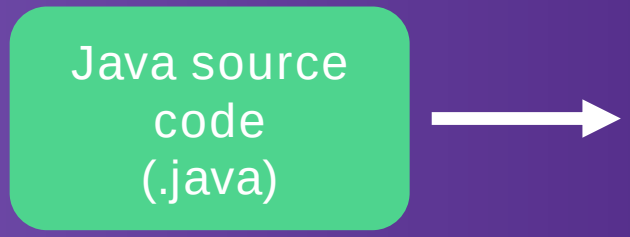
How Android did it



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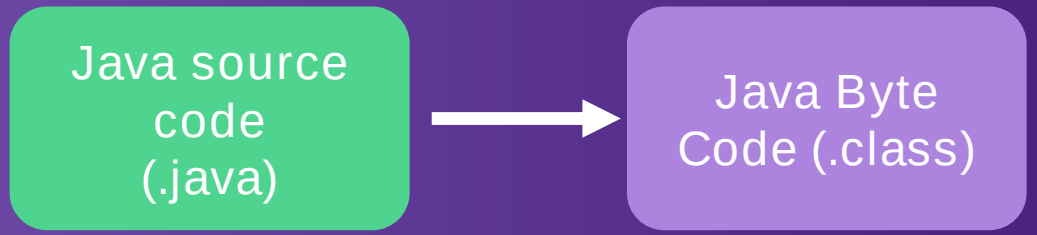

Running Java

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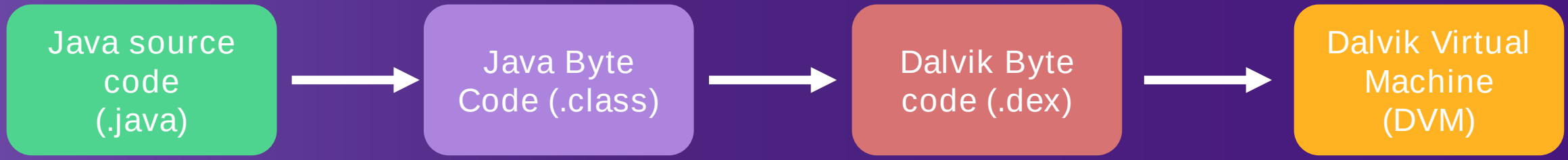

Running Java

How it's done in Java

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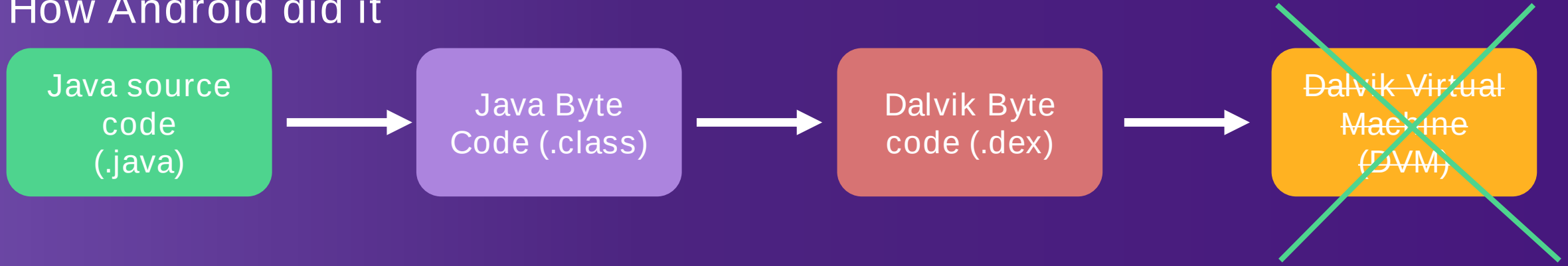

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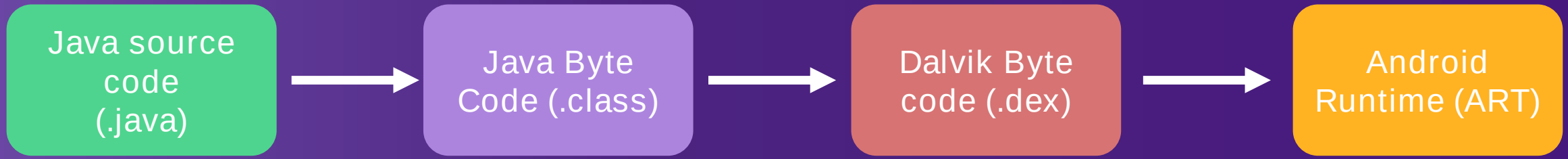

Android Runtime_

- Virtualization
- Granular permissions (AndroidManifest.xml)
- Code signing
- App has no direct system access

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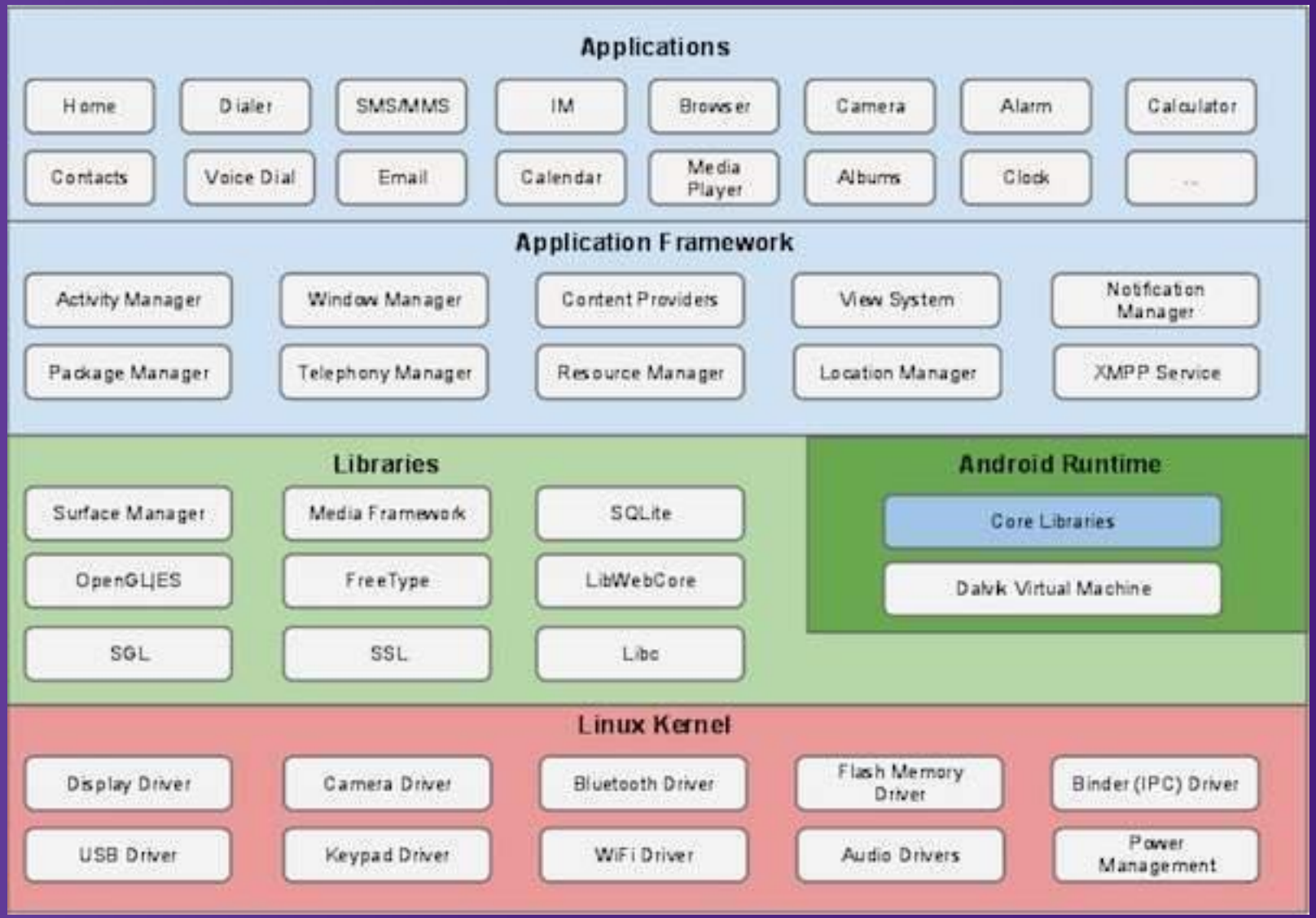
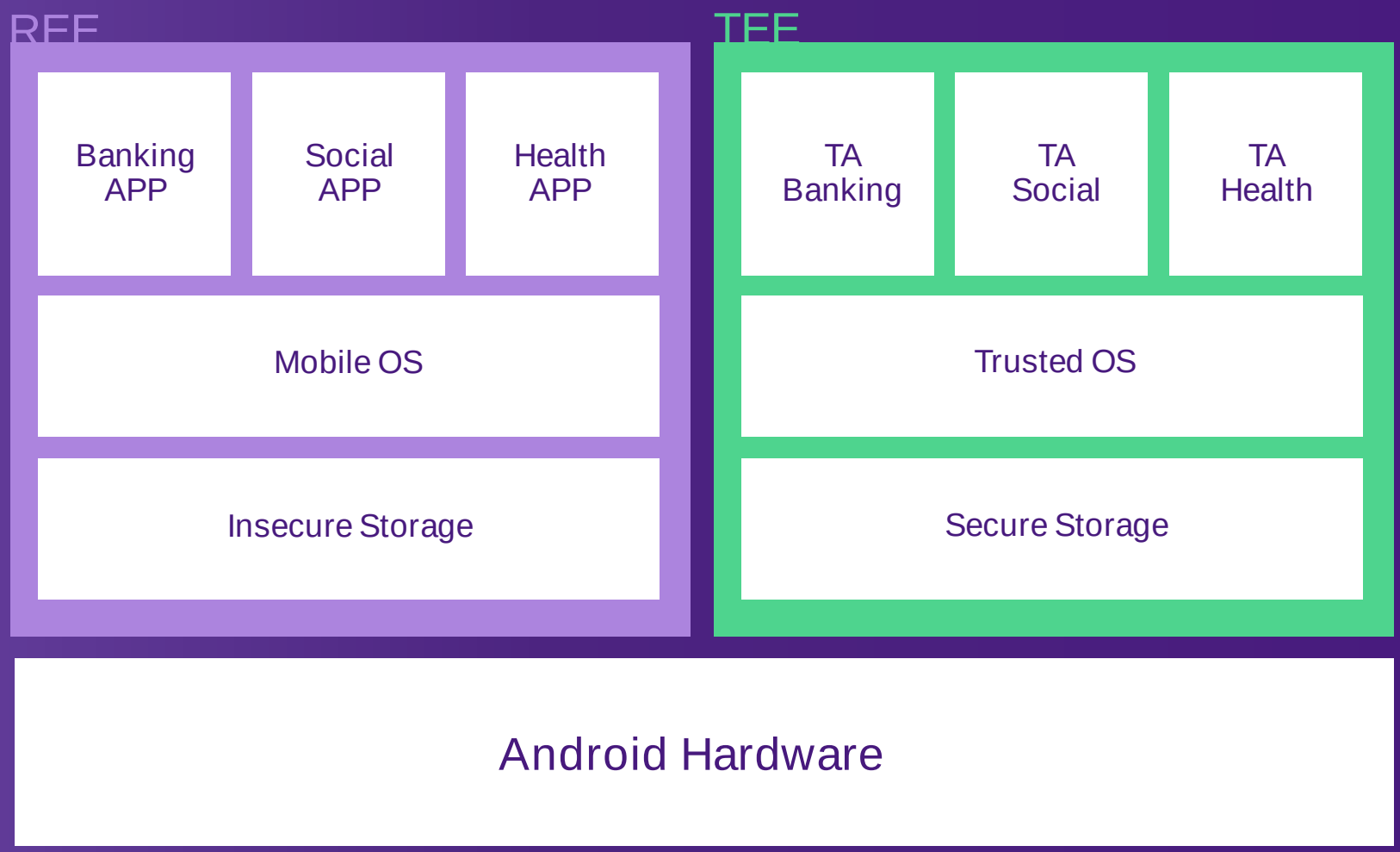
Android Framework

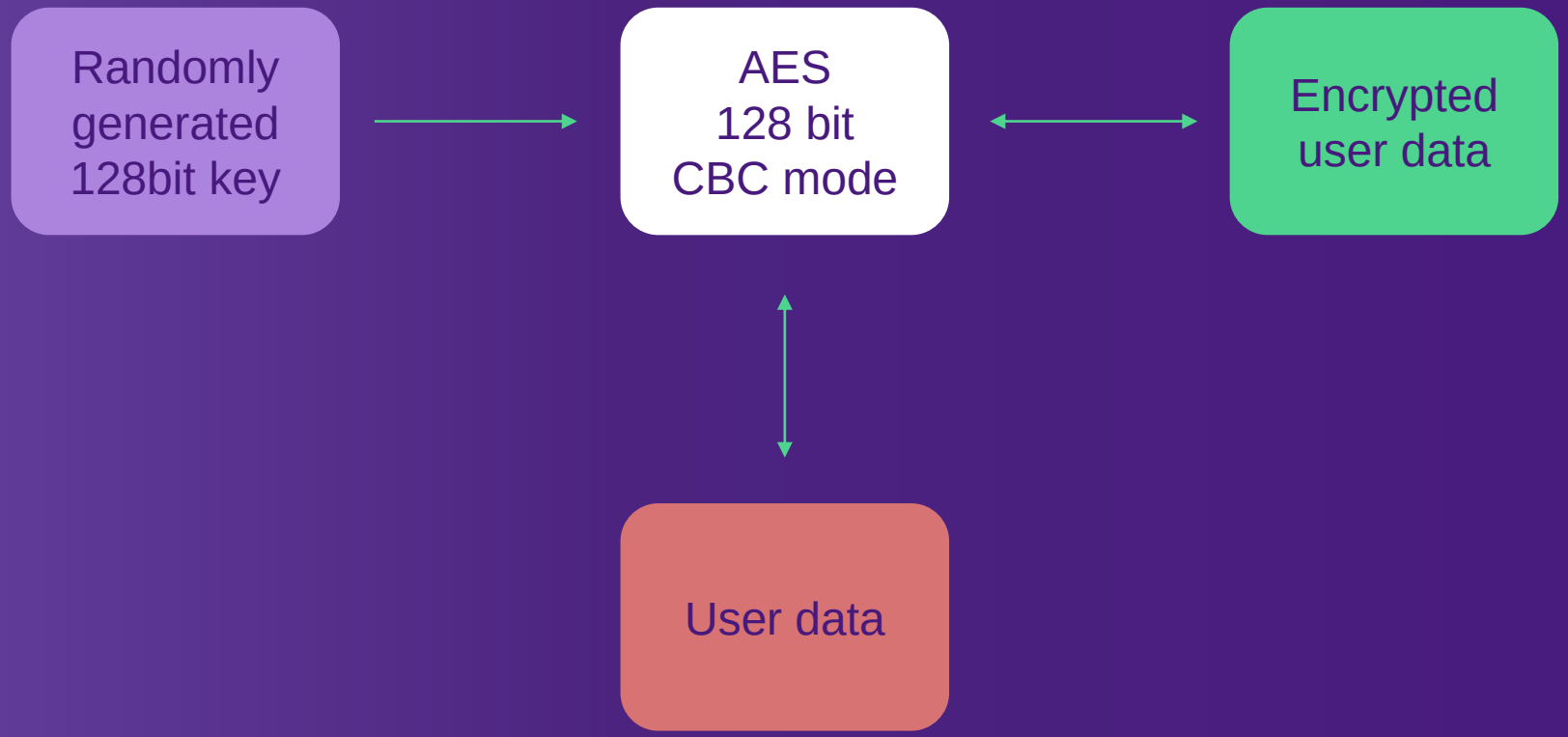


Other SECURITY features

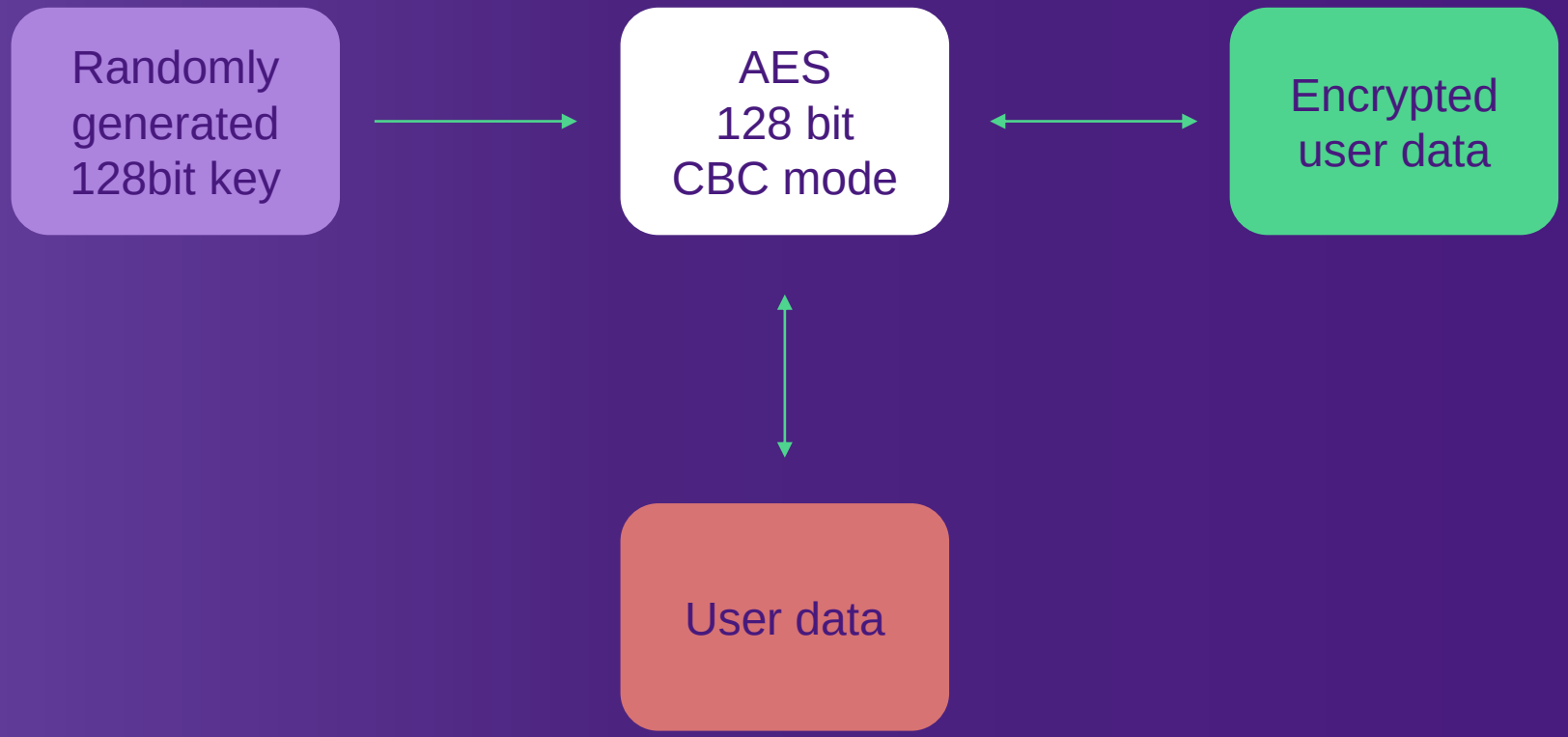
Trusted Execution Environment.



Full disk encryption_

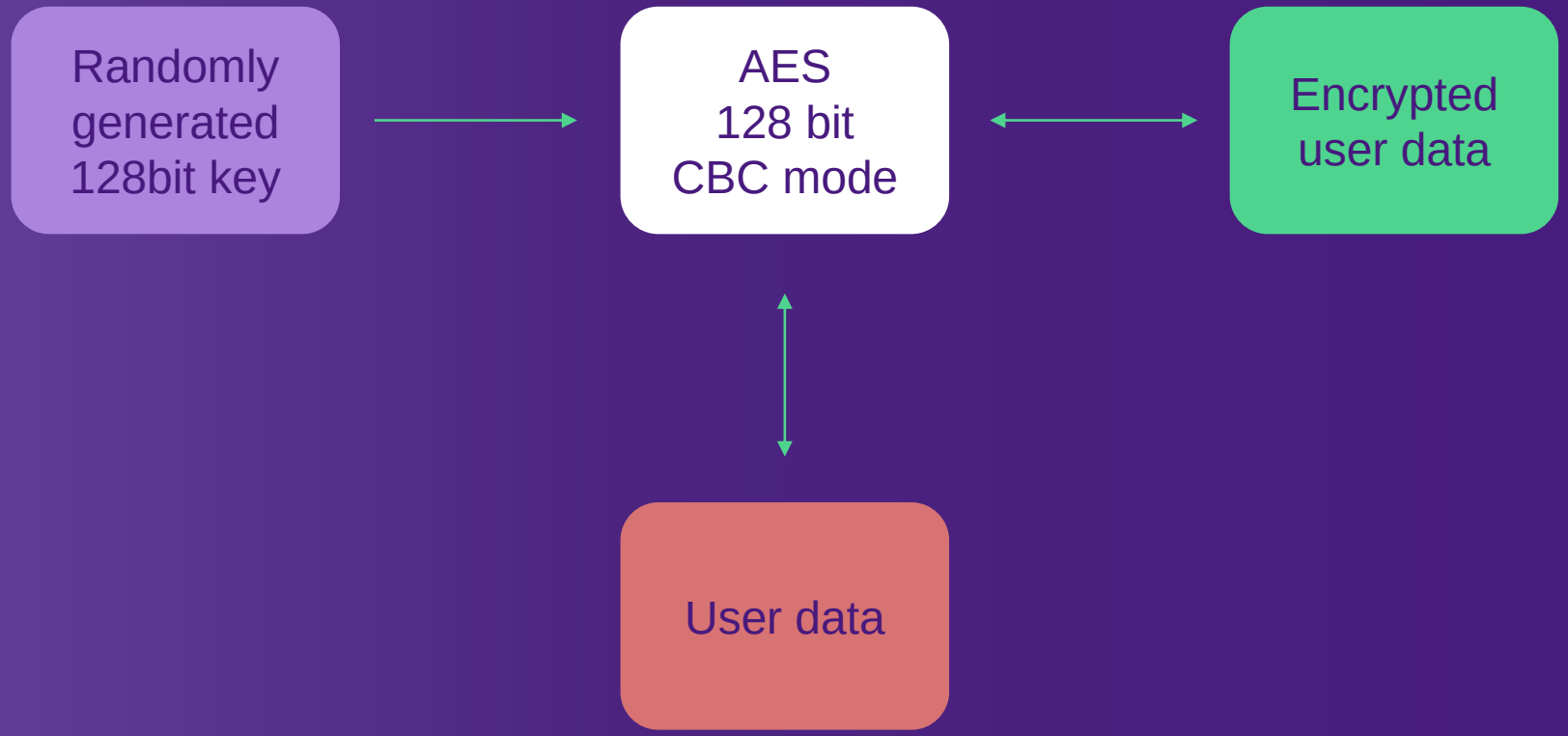


How do I securely store this key?



How do I securely store this key?

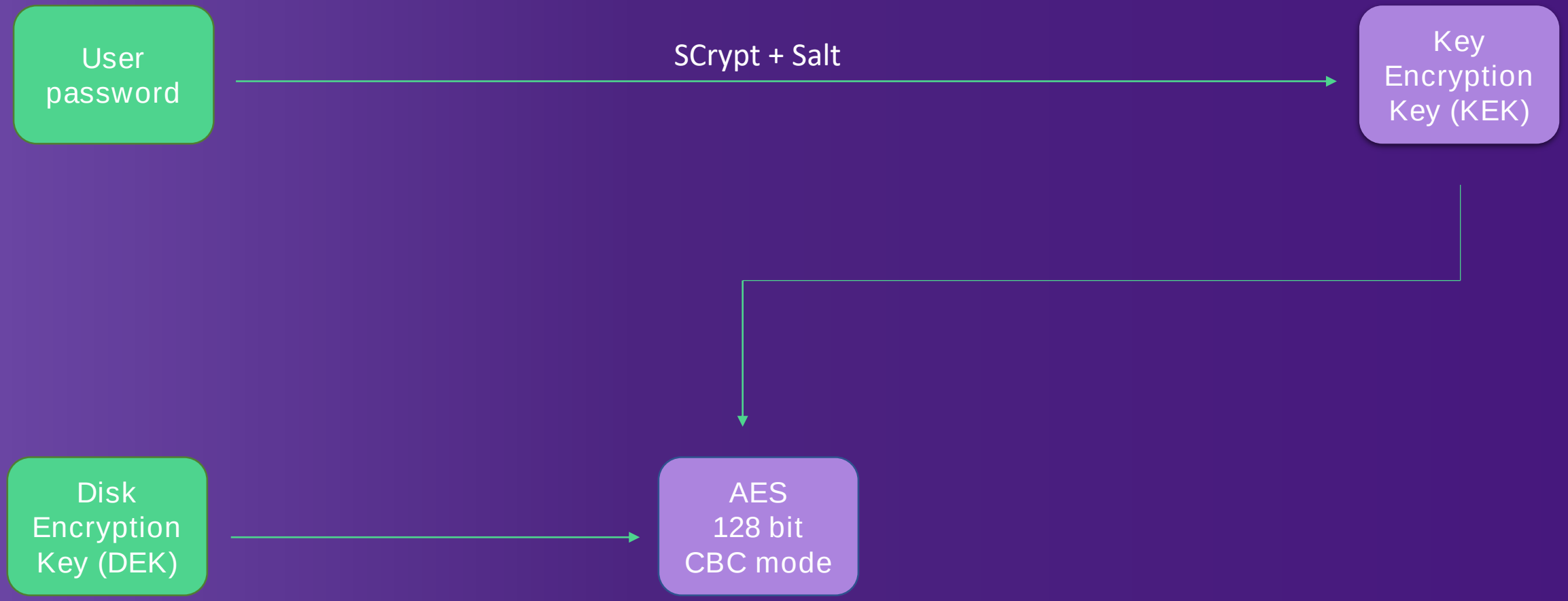
What about user pin/password?

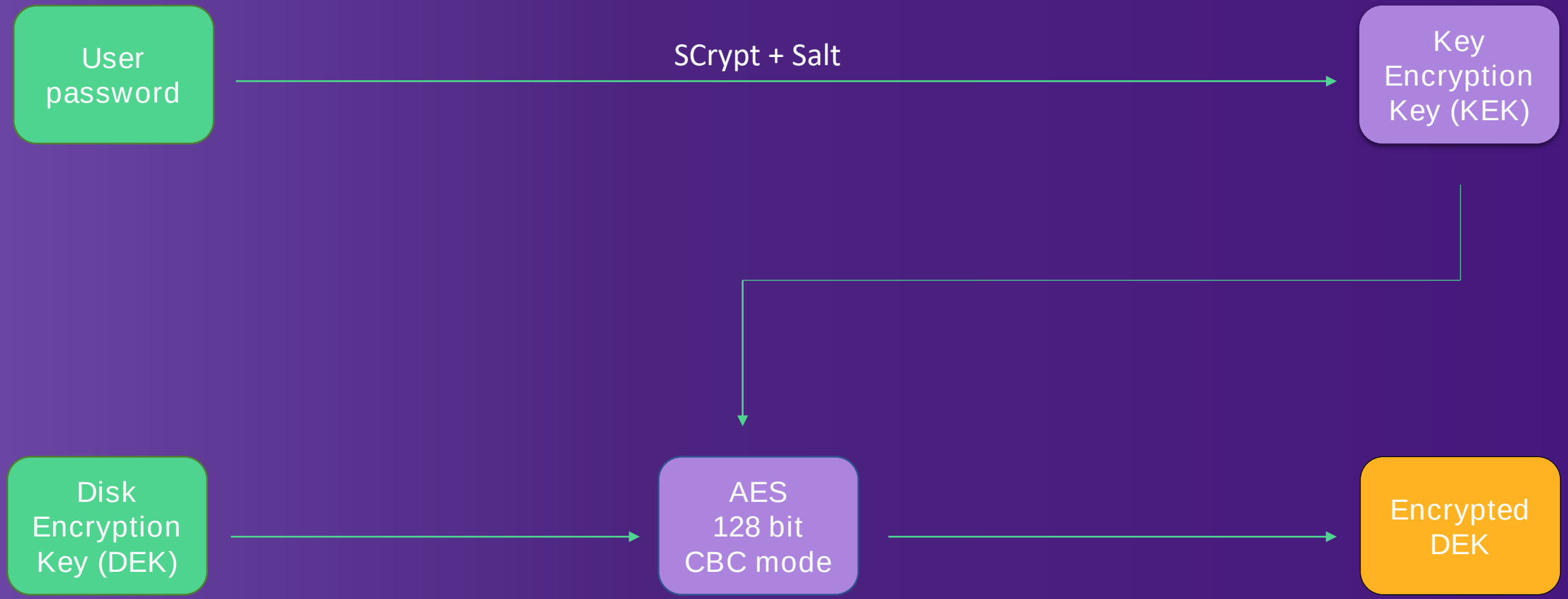


Full disk encryption_

Randomly generated 128bit key

Disk Encryption Key (DEK)


User password
SCrypt + Salt
Key Encryption Key (KEK)
Disk Encryption Key (DEK)
AES 128 bit CBC mode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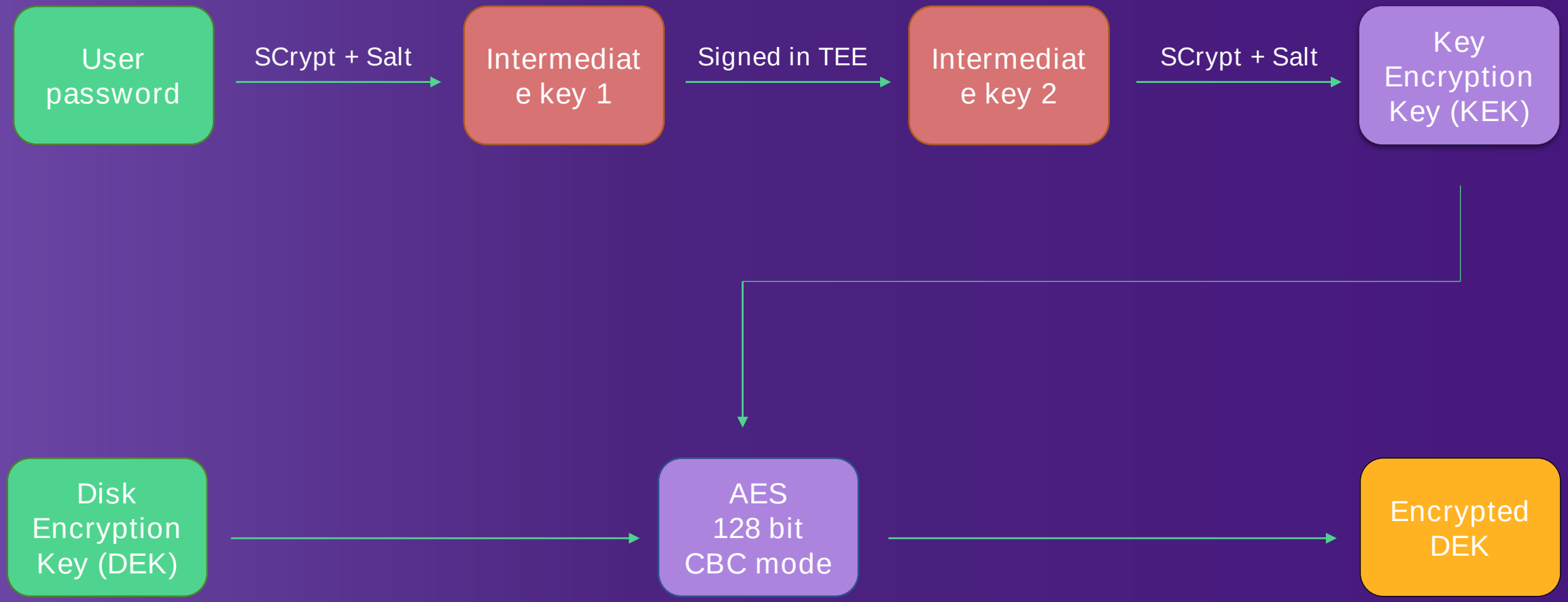
Key Encryption Key (KEK)
Disk Encryption Key (DEK)
AES 128 bit CBC mode
Encrypted DEK


User password
SCrypt + Salt
Intermediate key 1
Signed in TEE
Intermediate key 2
SCrypt + Salt
Key Encryption Key (KEK)
Disk Encryption Key (DEK)
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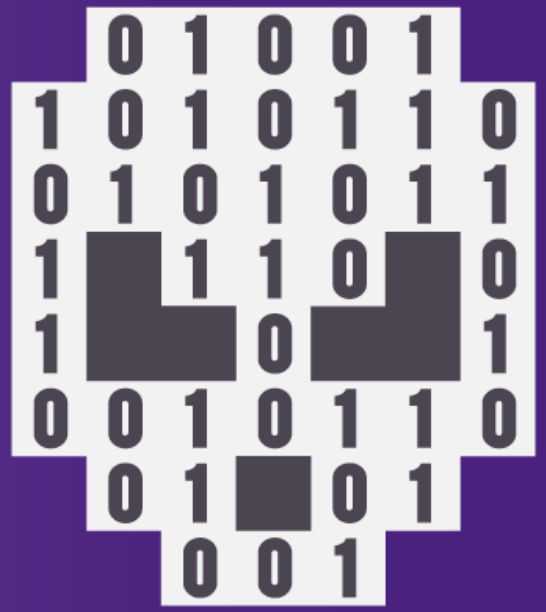
Encrypted DEK

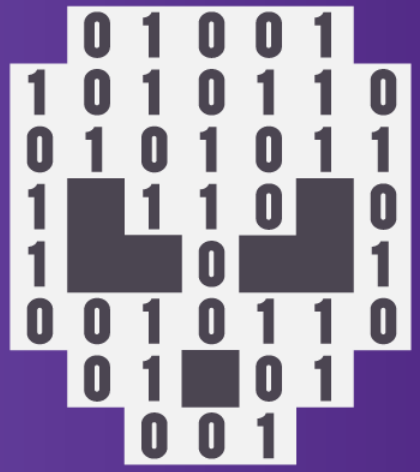
KEYSTORE

Attack surfaces_

Malicious App



Malicious App

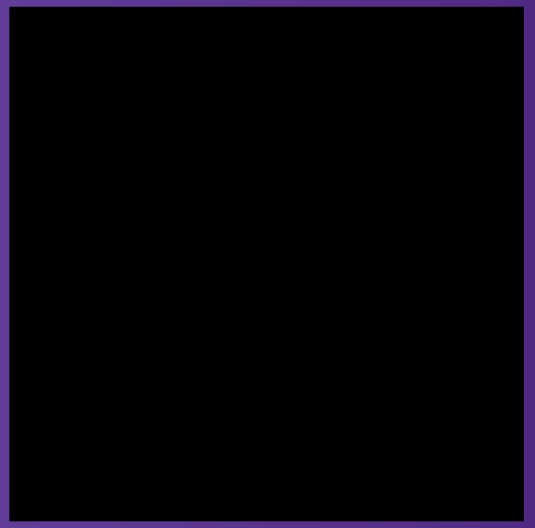


- **Android Runtime**

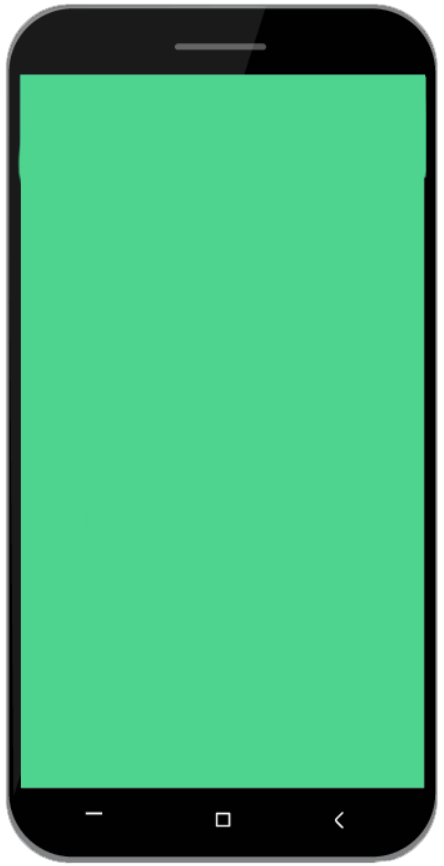
Malicious App

- **Android Runtime**
- **Linux permissions**

Malicious App



- **Android Runtime**
- **Linux permissions**
- **SELinux**



Physical attack_

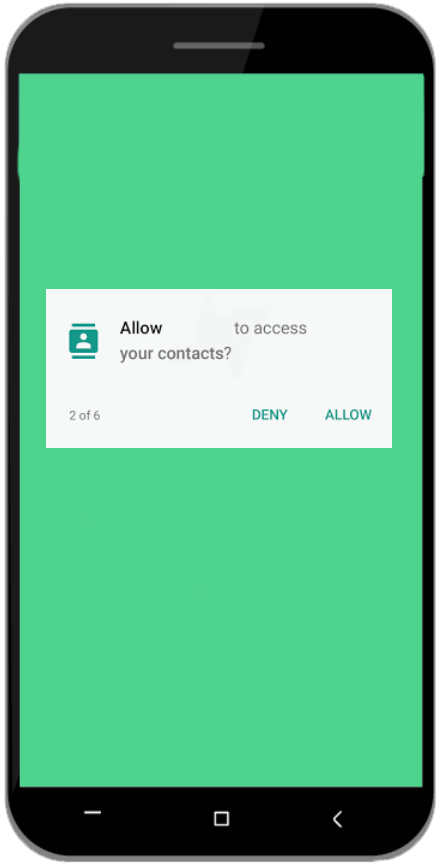
Physical attack_

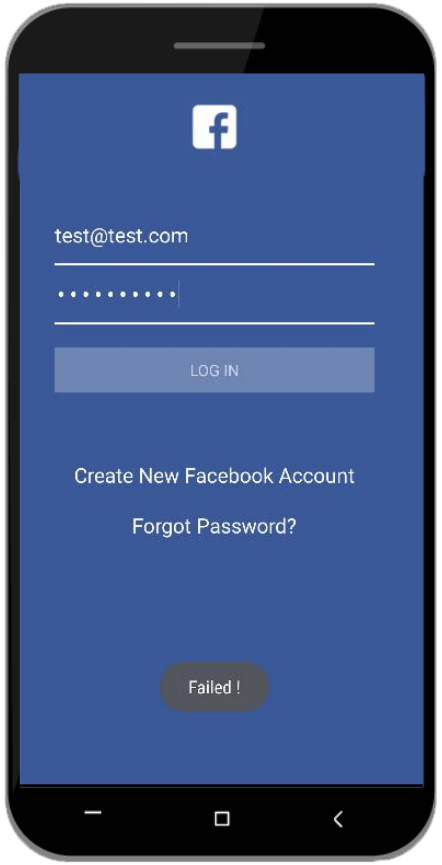
- **Full disk encryption**

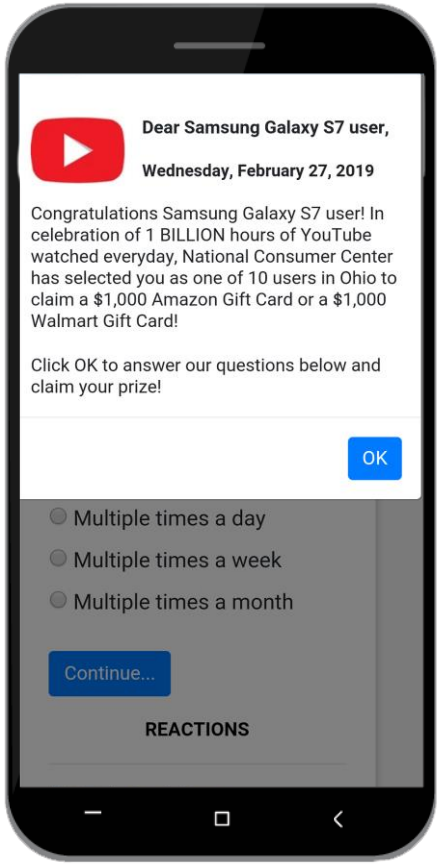
Attack surfaces are extremely reduced!

Security issues_

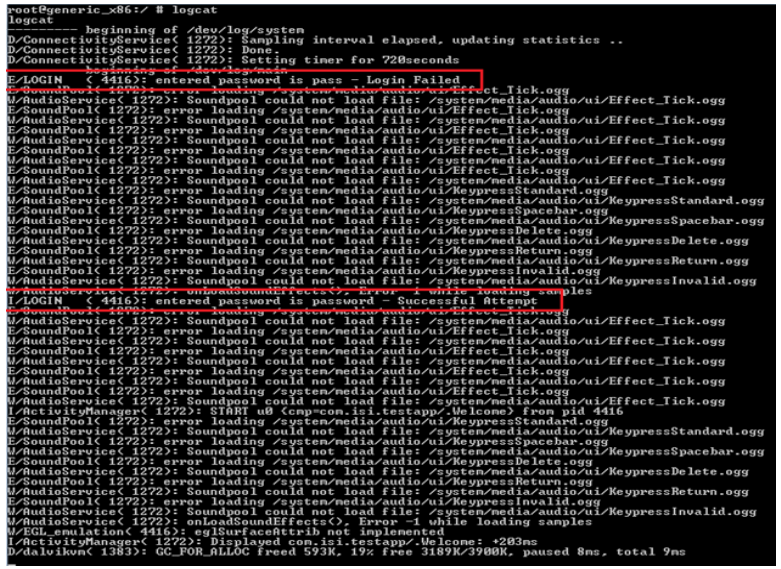
User is the weakest link







Developers often make mistakes



Too much data in logs

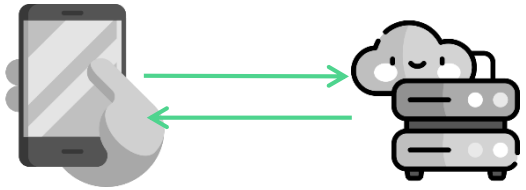
```
package com.august.util;

import android.content.SharedPreferences;

public class Settings
{
  private static final String ENC_KEY = "[redacted]";
  private static final LogUtil LOG = LogUtil.getLogger(Settings.class);
  public static final String SIZE_SUFFIX = "*size*";
  public static final String STR_ACCESS_TOKEN = "API_ACCESS_TOKEN";
  public static final String STR_DEBUG_SETTINGS = "DEBUG_SETTINGS";
  public static final String STR_INSTALL_TOKEN = "API_INSTALL_TOKEN";
  public static final String STR_PUSH_ALERTS = "PUSH_ALERTS";
  public static final String VERSION_SUFFIX = "_v1";
  static Settings _instance = null;
  DebugSettings _debugSettings = new DebugSettings();
  Properties _encryptedProps = null;

  public static Settings init()
  {
    if (_instance == null) {
      _instance = new Settings();
```

Hardcoded keys



Insecure data transfer

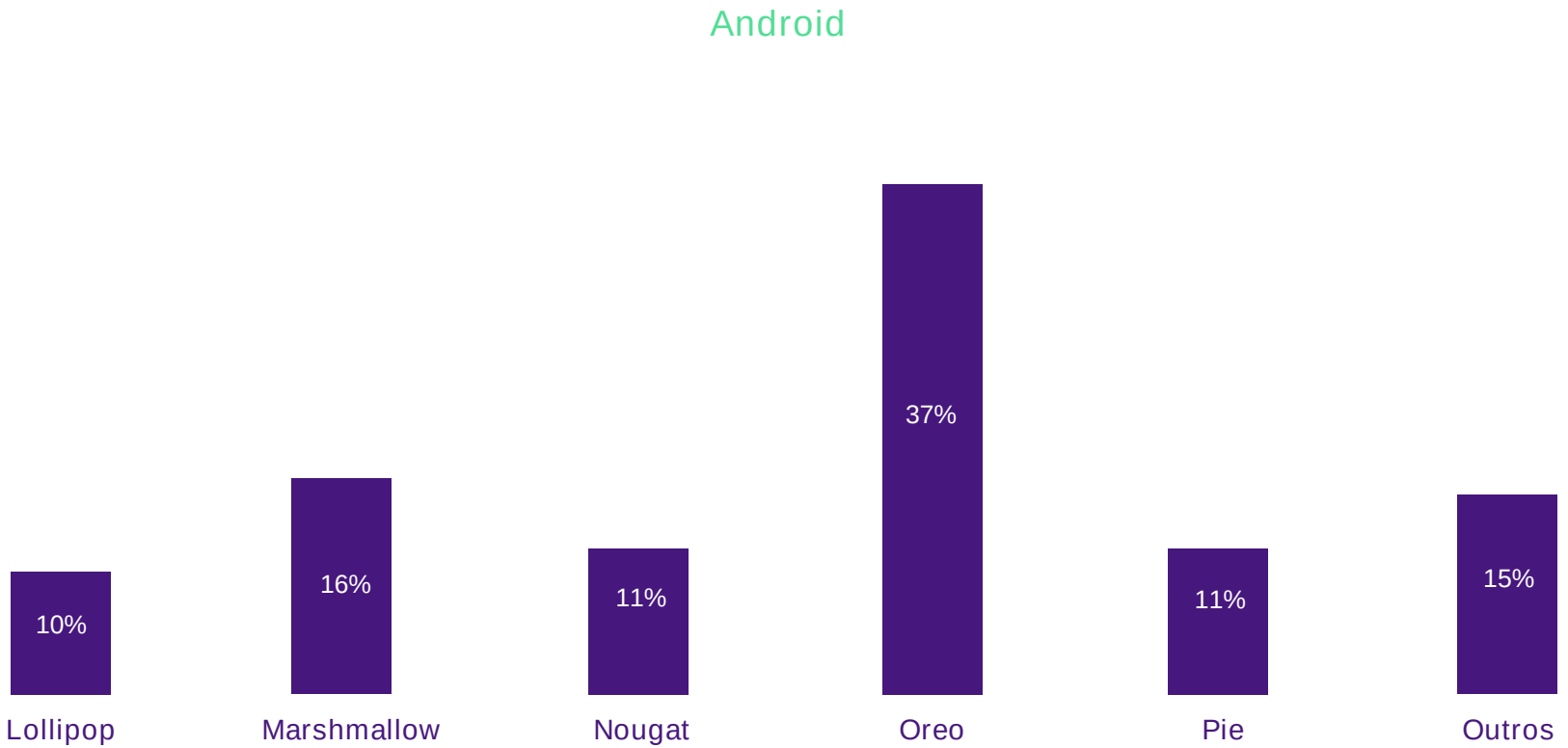
Insecure storage

Android is safe, not perfect.

782

Number of critical vulnerabilities found on Android between 2011 and 2018

Updates are necessary!



BONUS:

How Brazilian authorities were hacked?