SMD

Introduction

Lecture 1

Security of Mobile Devices

2022

Team, Schedule and Grading

Android Architecture

Application Development Overview

Security Mechanisms

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Team and Schedule

- Team
  - Laura Ruse, Costin Carabaș, Florin Mihalache, Ionuț Mihalache, Cosmin Chenaru, invited speakers
- Schedule
  - Lecture: Wednesday 8-10, on MS Teams
  - Labs: Thursday, 8-10, 18-20, 20-22, on MS Teams

Syllabus

- Android OS:
  - SDK
  - Internals
  - Security architecture
  - Network security
  - Secure booting, system updates and root access
  - Vulnerabilities and malware
- Invited speakers from industry

Resources

- Wiki: `http://ocw.cs.pub.ro/courses/smd`
  - Courses
  - Labs
  - Class registrer
  - Calendar
- Moodle: `http://curs.upb.ro/`
  - https://curs.upb.ro/2021/course/view.php?id=5419

Grading

- **0.5 points** Lecture tests and attendance
- **1 point** Lab activity
- **4 points** Assignment
- **1.5 points** Mid-term exam
- **3.5 points** Final exam
- 50% (2.5 points) from the lab activity and the assignment are required to enter the exam.
- 5p are required to pass the class.

Grading

- **0.5 points** Lecture tests and attendance
  - the test will be held at the end of the lecture, on Moodle
  - the test will consist of one simple question
  - the question will be related to what was presented at the course

Grading

- **1 points** Lab activity
  - Android Studio, Java, Kotlin (if you want to)
  - Lab allocation
  - Github Classroom
  - The lab will be solved during the lab (it may be finished after the lab)
  - Submit until Sunday 23:55 (same week)

Grading

- **4 points** Assignment/project
  - `https://ocw.cs.pub.ro/courses/smd/res/assignment`
  - Project theme registration - April 11th, 0.3p penalty
  - Intermediary project presentation - May 19th, 0.5p penalty
  - Final project presentation - June 2nd

Grading

- **1.5 points** Mid-term exam (first 4 lectures)
- **3.5 points** Final exam (next 4 lectures)
- 20 multiple choice questions
- 20 minutes
- each question has 4 choices of which only one is correct
- correct answer - 1 point
- incorrect/no answer - 0 points

Grading

- For those who retake the course, all the forms of examination except the final exam will be equivalated/scaled

Recommended Bibliography

- Embedded Android: Porting, Extending, and Customizing, Karim Yaghmour, 2015
- Android Security Internals, Nicolay Elenkov, 2015
- Android Hacker's Handbook, Joshua J. Drake, 2014
- Introducere in sistemul de operare Android - Laura Ruse, Vlad Traistă-Popescu, 2021
- Securitatea sistemului de operare Android - Laura Ruse, Vlad Traistă-Popescu, 2021
- `http://developer.android.com`

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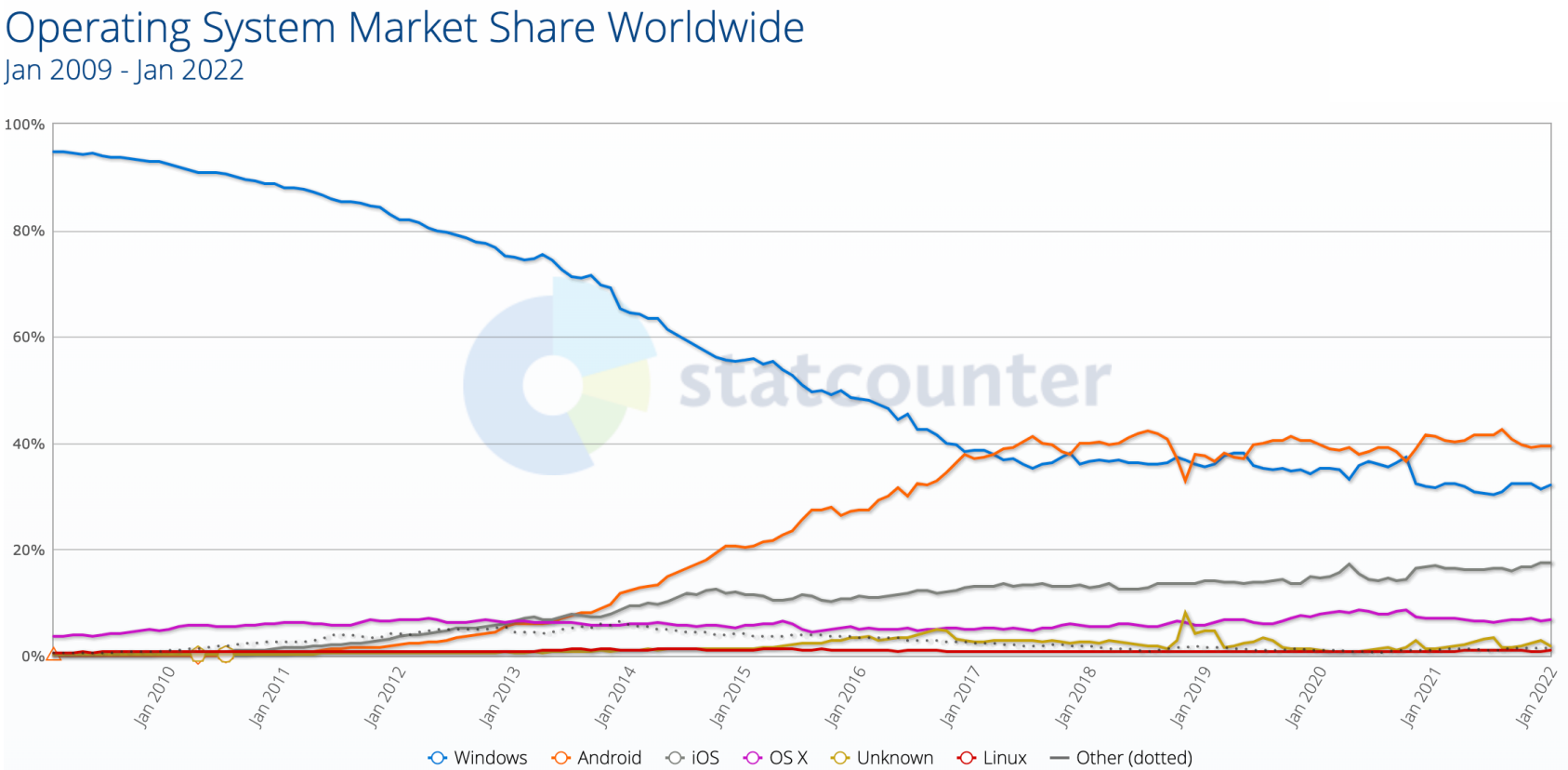
Android popularity

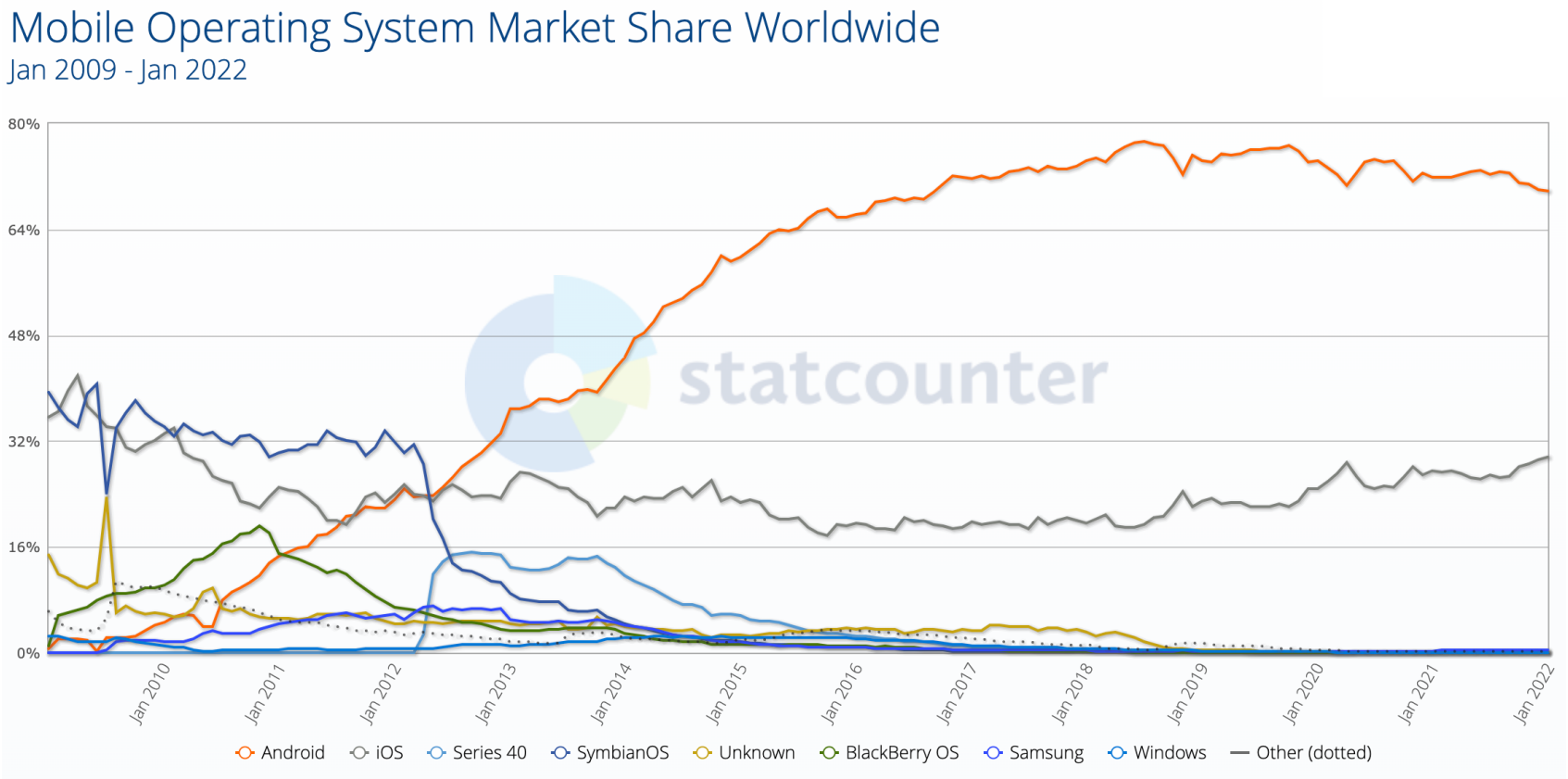
- Open-source OS for mobile devices
- 2.8 billion monthly active users (2021)
- Mobile OS market share (Jan 2022)
  - Android 69.74%
  - iOS 29.49%
- OS market share (across all devices) (Jan 2022)
  - Android 39.45%
  - Windows 32.11%
  - iOS 17.56%
  - OS X 6.74%
  - Linux 0.94%
- Source: Statcounter
- Official application market: Google Play Store

OS Market Share Evolution



Source: Statcounter

Mobile OS Market Share Evolution



Source: Statcounter

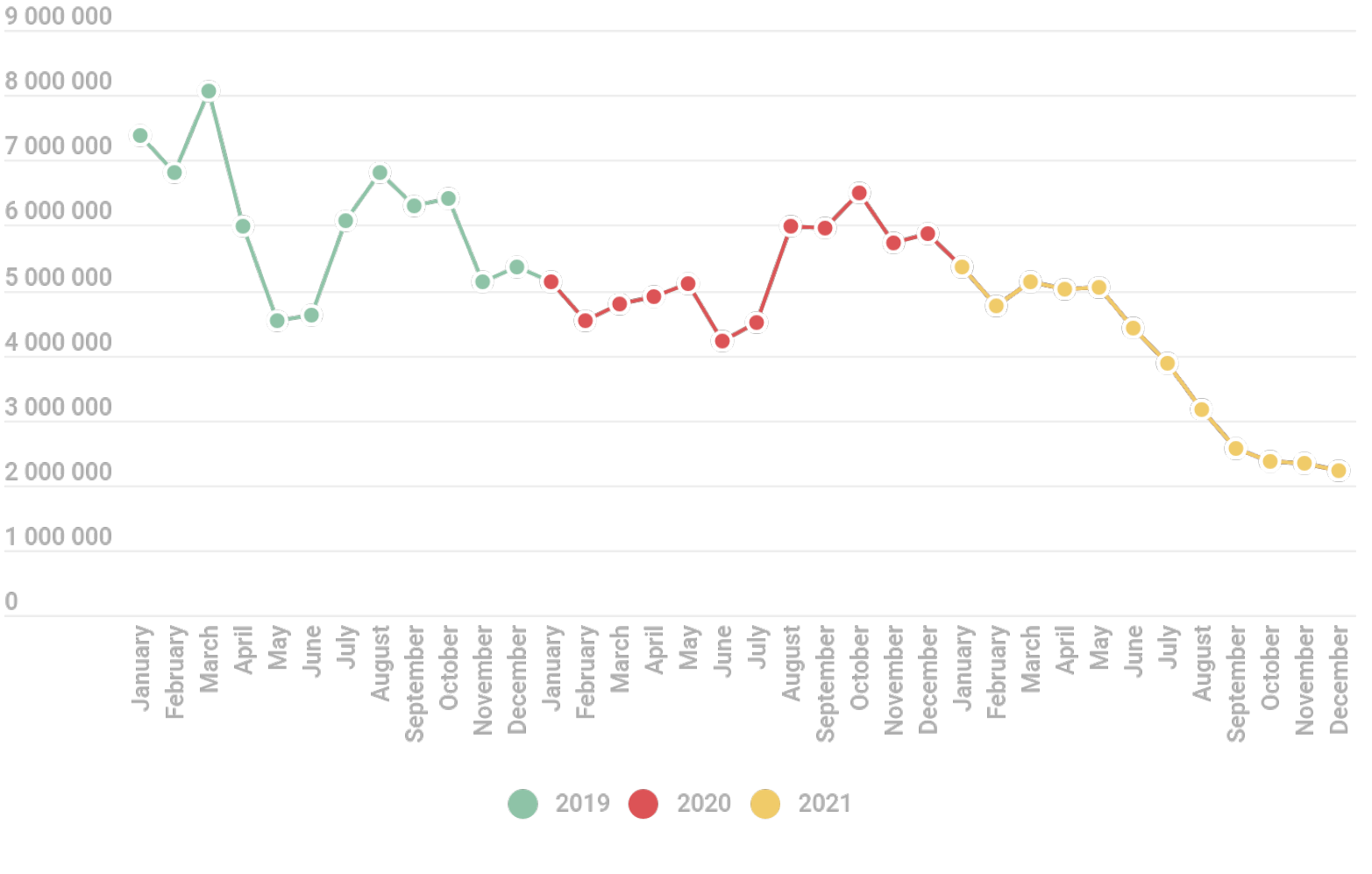
Potentially Harmful Applications (PHA)

- Apps that could put users, user data and devices at risk
- Why the keyword potentially?

Mobile Malware in 2021

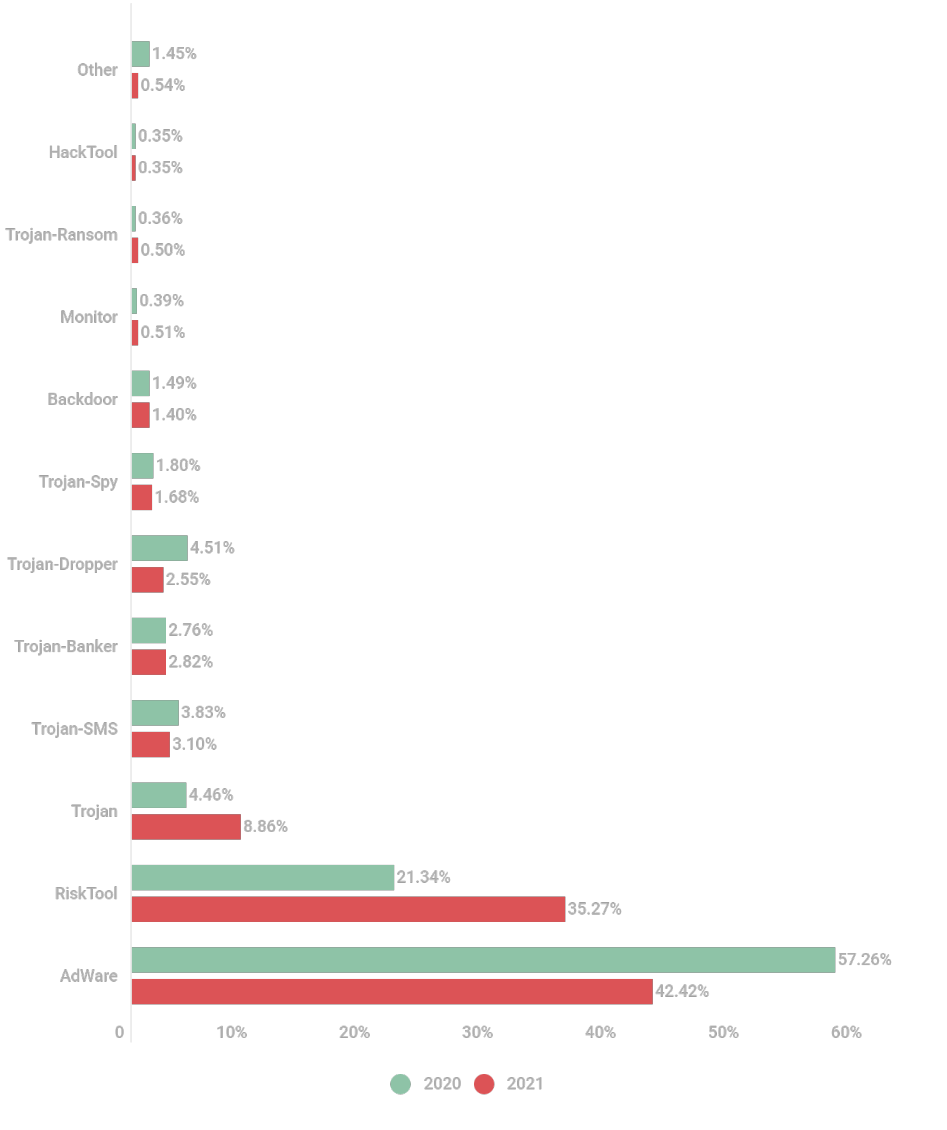
- `https://securelist.com/mobile-malware-evolution-2021/105876/`
- In 2021 Kaspersky detected:
  - 3,464,756 malicious installation packages
  - 97,661 new mobile banking Trojans
  - 17,372 new mobile ransomware Trojans

Attacks on Mobile Users



kaspersky

New Detected Mobile Threats in 2021

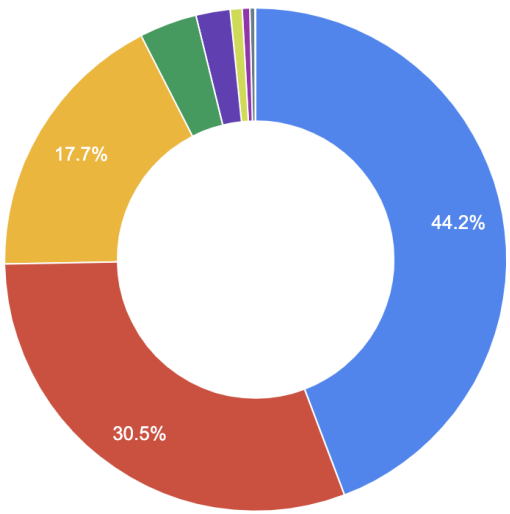


- Google Play Protect - detect and remove PHAs
- Statistics from Google:
- `https://transparencyreport.google.com/android-security/store-app-safety?hl=en`

PHAs detected by Google Play Protect

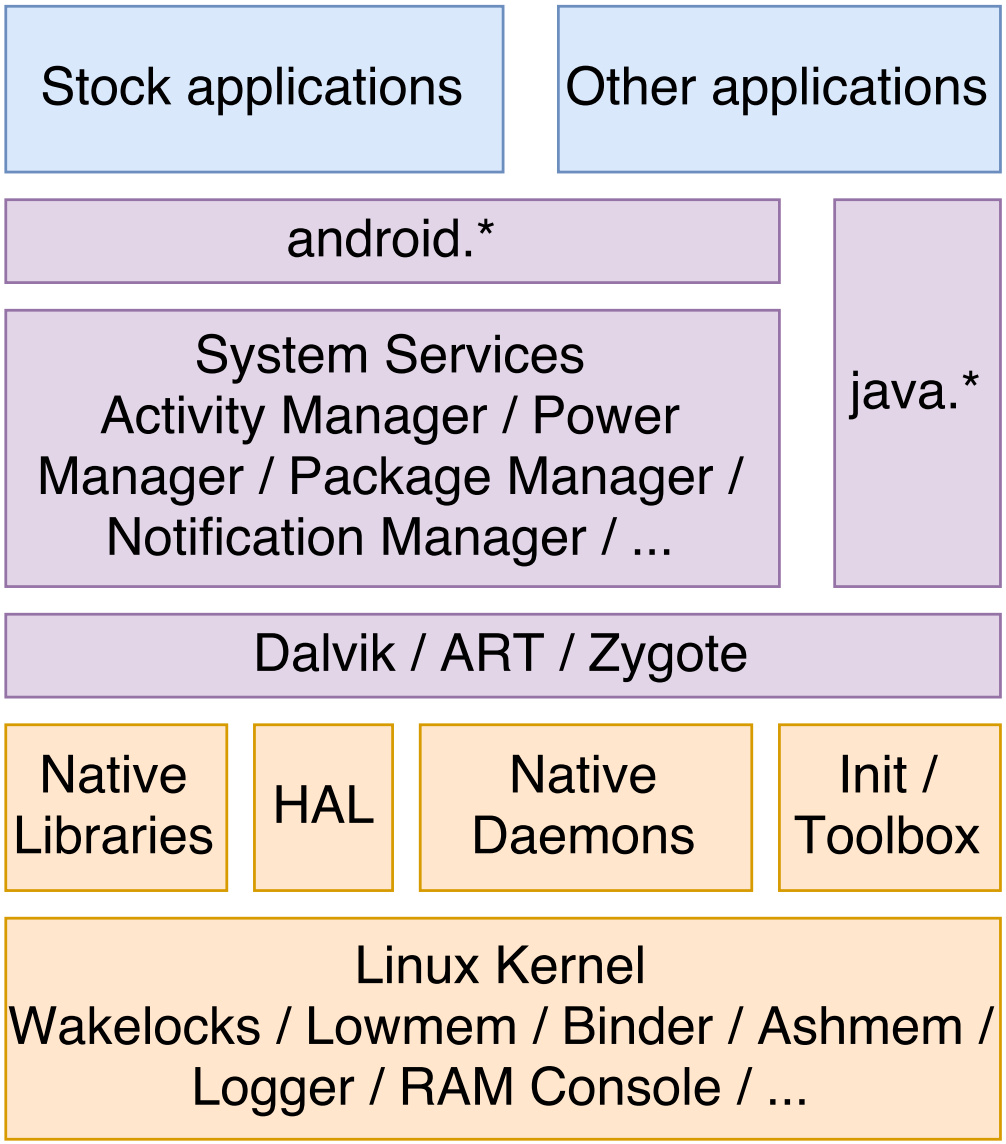
Jul 2021 – Sep 2021

Google Play



Category	PHA Install Rate
Toll fraud	0.014901969%
Spyware	0.0102640646%
Phishing	0.005973268%
Backdoor	0.001250422%
Privilege escalation	0.0007412477%
Trojan	0.0002609596%
Hostile downloader	0.0001614188%
Commercial spyware	0.0001128817%
DOS	0.0000050745%
Spam	0.0000036137%
Rooting	0.000002497%
Windows malware	0.000001482%
SMS fraud	0.0000011766%
Call fraud	0.0000000153%
Ransomware	0.0000000117%

Android Architecture



Android Architecture

- Linux kernel
  - Android Mainlining Project / Android Upstreaming
  - Androidisms
  - Advantages
- Hardware Abstraction Layer (HAL)
  - Standard interfaces
  - Multiple library modules
- Native userspace
  - init process
  - Native daemons
  - Native libraries
    - Through Java framework APIs
    - Through Android NDK

Android Architecture

- Android Runtime
  - Dalvik
  - ART
  - Ahead-Of-Time (AOT) compilation
- Java Runtime libraries
  - `java.*` and `javax.*`
  - Apache Harmony Project
  - Java Native Interface (JNI)

Android Architecture

- System services
  - Fundamental features of Android
  - Native and Java code
  - Service interface
- Android framework libraries
  - Base components for app development
  - Interaction with the hardware
  - Interaction with high level services
  - Framework APIs

Linux Kernel

- Modified to work on mobile devices
- Patches on top of mainline Linux
- Android Mainlining Project / Android Upstreaming
- Wakelocks (also added to Linux 3.5)
- Low-Memory Killer (3.10)
- Binder (3.19)
- Alarm (3.20)
- Logger (3.20)
- Only suspend to memory

Android Runtime - Dalvik VM

- Default until Android 5.0
- Runs Dalvik-specific byte-code
- Dalvik Executable Format (DEX)
  - Runs .dex files instead of .jar files
  - .dex is 50% smaller than corresponding .jar
- Just-In-Time compilation
  - From Android 2.2
  - Short segments of bytecode translated into native machine code at runtime
  - Improves performance

Android Runtime - ART

- From Android 5.0
- More advanced runtime architecture
- Ahead-Of-Time compilation
  - Just once, at installation
  - Entire DEX file -> executable for target device
  - Instead of JIT compilation and Dalvik interpretation
  - More efficient, reduced power consumption
  - More space to store the executables
- Improved memory allocation, GC, debugging and profiling

Native Libraries

- bioniC (libc)
  - Much smaller and faster than glibc
- SQLite
  - Managing SQL databases
- OpenGL ES
  - Standard software interface for 3D processing hardware
- WebKit
  - Display web pages
  - Android, Apple iOS, BlackBerry, Tizen
- SSL
  - Securing the communication over Internet

Application Framework

- System Services and Managers
  - Telephony
  - Location
  - Activity
  - Package
  - Notification
- System Content Providers
  - Calendar
  - Dictionary
  - Contacts
  - Settings

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Application components

- User interaction
  - Activities
- Background functionality
  - Services
  - Broadcast Receivers
  - Content Providers
- Intents

Binder

- Lightweight RPC
- Remote object invocation
- In process and interprocess
- Transmit parcels of data
- Synchronous calls (blocking)

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Sandboxing

- Linux kernel security
  - Isolate user resources (file permissions)
  - Process runs with user's UID/GID (SUID, SGID)
- In Android UIDs are used to identify applications
  - Isolate applications
  - Basis for sandboxing

Sandboxing

- Unique UID assigned to each application at installation time
- Dedicated process running as that UID
- Dedicated directory - only that UID has read/write/execute permissions
- Process-level and file-level sandbox
- Kernel level sandbox - all applications (native and VM)

UIDs

- Well-defined UIDs for system apps and daemons
- Very few daemons under root UID 0
- UIDs for system services start at 1000
- User *system* has UID 1000
  - Special priviledges
- App UIDs start at 10000

Application Files Permissions

- Each app - dedicated data directory
- rwx permissions only for that app UID/GID
- MODE_WORLD_READABLE, MODE_WORLD_WRITEABLE flags
  - Deprecated from Android 4.2

Shared UID

- Apps with the same UID
- Share files
- Run in the same process
- Frequently used by system apps
- Apps signed with the same code singining key
- Deprecated since Android 10

Application Permissions

- Operations outside sandbox
- Declared statically in the Manifest file
- Before Android 6
  - Granted at installation time
  - Cannot be revoked
- From Android 6
  - Granted at runtime
  - Revoked and granted from settings

Enforce Permissions

- Access to lower-level resources
  - Enforced by the Linux kernel
  - Check UID/GID vs resource's owner
- Access to high-level Android components
  - Enforced by Android OS or a certain component

Code Signing Key

- All apps signed by their developer
- Apk signing is based on jar signing
- Same origin policy
  - App updates from the same developer
- Platform keys for signing system apps
  - Shared resources, same process
  - Generated and controlled by the entity that compiled the Android OS

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- https://securelist.com/mobile-malware-evolution-2021/105876/
- https://transparencyreport.google.com/android-security/store-app-safety?hl=en
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- https://developer.android.com/guide/components/services
- https://developer.android.com/guide/components/broadcasts
- https://developer.android.com/guide/topics/providers/content-provider-basics
- https://developer.android.com/guide/components/intents-filters
- Android Security Internals, Nicolay Elenkov, 2015
- Android Hacker's Handbook, Joshua J. Drake, 2014

Keywords

- PHA
- Linux kernel
- Android Runtime
- Dalvik
- ART
- Native libraries
- Application framework
- Activities
- Services
- Broadcast receivers
- Content providers
- Binder
- Sandboxing
- Permissions
- Code signing