Lecture 4

L4Android: A Generic Operating System Framework for Secure Smartphones

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Context

- Ubiquity of smartphones
- Need for secure apps
  - Near Field Communication
  - SIM cards
- Inherent lack of security in smartphone software

Security issues: delayed updates

- Mainline Android development: done by Google
- Phone vendors deploy customized Android versions
- “Maintenance nightmare”:
  - Provide periodic updates that fix vulnerabilities
  - Or no updates at all (that would cost too much)

Security issues: Linux kernel

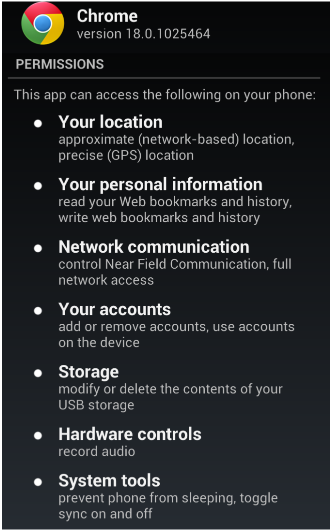
- Monolithic kernels are difficult to verify
- Device drivers run with full privileges
- Kernel components aren't isolated
- Device manufacturers develop custom (often proprietary) drivers

Security issues: rooted phones

- Root privileges allow full access to:
  - all the user data
  - manufacturer settings
  - the kernel
- "Rooted" phones are more vulnerable
  - Android phones don't allow root access by default
- Root access can be obtained
  - manually by the user
  - by malicious software (via exploits)

Security issues: Android permission system

- Permissions in Android
  - based on Mandatory Access Control (MAC)
    - “all or nothing” paradigm
  - too coarse-grained
    - e.g.: grant access to Internet and Address Book
    - → software can send user Address Book to any remote location



Chrome
version 18.0.1025464

PERMISSIONS

This app can access the following on your phone:

- **Your location**
  approximate (network-based) location, precise (GPS) location
- **Your personal information**
  read your Web bookmarks and history, write web bookmarks and history
- **Network communication**
  control Near Field Communication, full network access
- **Your accounts**
  add or remove accounts, use accounts on the device
- **Storage**
  modify or delete the contents of your USB storage
- **Hardware controls**
  record audio
- **System tools**
  prevent phone from sleeping, toggle sync on and off

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A solution

- Isolate OS inside a **virtual machine**
- Run secure apps outside the OS
- Use a **microkernel**-based framework
  - ”extended hardware”
  - small Trusted Computing Base (TCB)
  - drivers as userspace services

A solution: L^4Android

- Framework for developing secure smartphone apps
- Components:
  - microkernel: Fiasco.OC μkernel
  - services: L4Re runtime environment
  - kernel: L^4Android
  - userspace: Android libraries, apps, ...

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Fiasco.OC: Overview

- Based on Jochen Liedtke's L4 microkernel
- Implements basic OS primitives
  - Address Spaces
  - Threads
  - Scheduling
  - Inter-Process Communication
  - Interrupt Delivery (via Asynchronous IPC)

Fiasco.OC: Protection Domains

- Protection Domains:
  - equivalent to Linux namespaces/containers
  - run as tasks on top of the microkernel
  - provide isolation
    - among virtual machines
    - between VMs and the TCB

Fiasco.OC: Capabilities

- Capabilities provide access to:
  - kernel objects
    - address spaces
    - threads
    - communication channels
  - interrupts
- Fine-grained control over resources

Fiasco.OC: Verification

- Microkernel exposes minimal interface
  - small number of system calls
- Code base is small (~20,000 lines of code)
- Kernel is formally verifiable

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L4 Runtime Environment

- Software layer on top of the microkernel
- Simplifies development in microkernel userspace
- Consists of:
  - basic functionality: allocators, data structures etc.
  - user libraries: C, C++, pthread etc.
  - servers providing access to I/O devices

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L^4Android

- L^4Linux: Linux kernel modified to run paravirtualized
  - on top of Fiasco.OC + L4Re
  - with fine-grained access to devices via I/O servers
    - an L^4Linux instance can run without any access to peripherals
    - or it can be used as a driver provider
- L^4Android Kernel
  - based on L^4Linux
  - contains Android patches (wakelocks, binder etc.)
  - therefore it is able to run the Android user stack

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Evaluation: Overview

- Four proposed scenarios
  - Software Smartcard
  - Mobile Rootkit Detection
  - Hardware Abstraction Layer
  - Unified Corporate and Private Phone
- Last scenario implemented as a demo
- Runnable on ARM and x86 architectures
  - Freescale iMX.51 (Cortex-A8)
  - Aava Mobile developer phone (Moorestown)

Evaluation: Software Smartcard

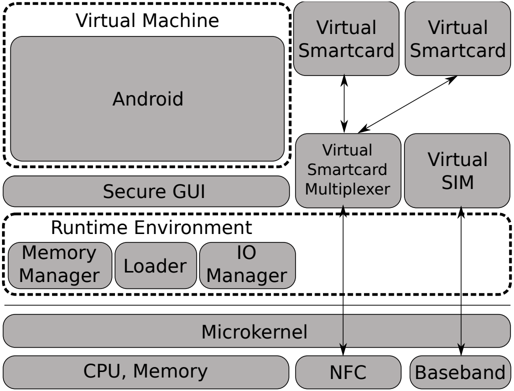
- Smartcard:
  - processor and memory integrated on a plastic card
  - cryptographic coprocessor smarcards for:
    - mobile phones (SIM, NFC)
    - credit cards
    - USB tokens
- "Software smartcard":
  - performing the same computations in software
  - cheaper and more flexible than a physical smartcard
  - usually unfeasible due to high security demands

Evaluation: Software Smartcard (2)

- the Fiasco.OC provides a secure computing base
  - the smartcard operations run on top of the microkernel
  - L4Re and microkernel syscalls offer a trusted interface
  - isolation from the L^4Android domain is achieved
- timing attacks are deflected by secure scheduling
- vendors can implement various virtual smartcard configurations

Evaluation: Software Smartcard

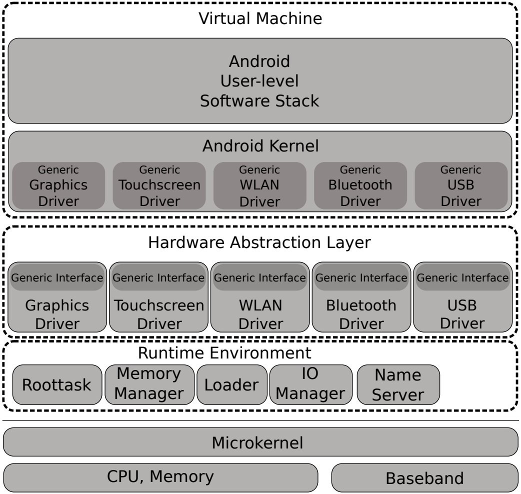
Possible Smartcard setup:



Evaluation: Hardware Abstraction Layer

- HAL: proposed L4-based development model for Linux drivers
- move driver logic to a layer between L4Re and the guest kernel
- develop generic driver stub in the guest OS
    - easier to port drivers to new kernel versions
        - by updating the Linux-HAL interface
    - driver faults are isolated from the rest of the system

Evaluation: Hardware Abstraction Layer



Evaluation: Dual Android Phone

- Corporate smartphones contain sensitive information
- Employees routinely carry two smartphones:
  - a company-provided smartphone configured according to the company's security policy
  - a personal, unrestricted phone

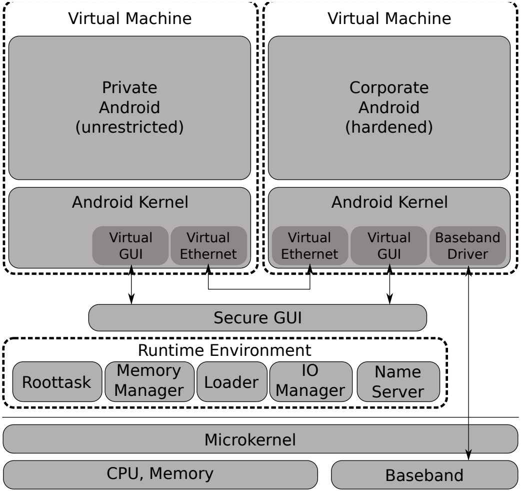
Evaluation: Dual Android Phone (2)

- Solution: a single phone running two Android virtual machines
  - private Android: can even be rooted
  - secure Android: implements corporate security policies
- User can easily switch between instances at runtime

Evaluation: Dual Android Phone (3)

- Access to devices is multiplexed between instances
  - Stub drivers in the guest kernels
  - Driver servers in the L4 Runtime Environment
- Virtualization requirements:
  - secure GUI server
  - virtual Ethernet interfaces
  - mobile telephony, hardware graphics/sound acceleration
    - drivers are binaries in the Linux kernel or Android userspace
    - difficult to virtualize

Evaluation: Dual Android Phone



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- smartphones
- operating system security
- Mandatory Access Control
- protection domain
- capability
- Trusted Computing Base
- paravirtualization
- microkernel
- L4
- I/O server

- http://l4android.org
- http://l4linux.org
- http://os.inf.tu-dresden.de/L4/
- http://users.sec.t-labs.tu-berlin.de/~steffen/papers/spsm03-lange.pdf
- Jochen Lietdke: On μ-Kernel Construction

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