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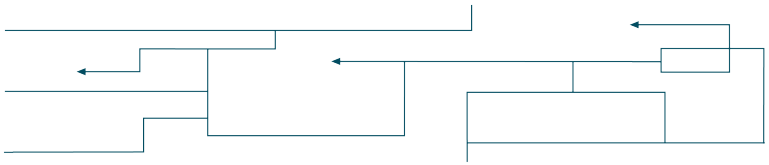

Enhancing Security of Linux-based Android Devices

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Jan Clausen, Kamer Ali Yüksel, Osman Kiraz, Ahmet Camtepe, and Sahin Albayrak




CC SEC
Security


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- Research Institute with ~100 employees
- Six core departments:
  - Agent Core Technologies
  - Next Generation Services
  - Information Retrieval
  - Cognitive Architectures
  - Education
  - **Security**

DAI-Labor Security Department

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- Works on:
  - Smartphone Security
  - Agent Security
  - Network Security Simulation
  - Critical Infrastructures
  - PKI / Cryptography
  - Next Generation Homes - Security

TOC

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- Motivation
- Android Security
- Adding Linux Security Tools to Android
- Enhancing Security with self-built IDS

Motivation

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- Smartphones getting increasingly popular
- Various smartphone malwares appeared
- Signature-based approaches only efficient for “known” malware
- Anti-Virus engines need avg. time of 48 days to get capable of detecting new malware [Oberheide08]
- More than 700,000 can be infected via MMS in about three hours [Bulygin07]

Motivation

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- Android already very popular (Java on Linux)
- Android sources will be set open-source
  - Opportunity to develop low-level security tools for commonly used smartphones the first time
- Linux security research is mature
  - A lot lessons learned
  - A lot of open source tools available

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Android Security

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- Images on emulator
  - System Image (YAFFS2, 65 MB / 21 MB free)
    - Mounted to /system
    - OS files, libraries, drivers, system bins
    - Android config files
    - Android framework
    - Android base applications (e.g. Browser)
    - +R(W)X

Android Security

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- Images on emulator
  - Userdata Image (YAFFS2, 65 MB / 40 MB free)
    - Mounted to /data
    - Used for applications, user data, DRM, ...
    - +RWX
  - Cache Image (YAFFS2, usage not specified yet)
  - SD-Card Image (no “obvious” size limitations)
    - Mounted to /sdcard
    - Files created as user and group “system”
    - +RW

Android Security

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- Applications are “location-aware”
  - Can only be executed in /data or /system
  - Any changes on file permissions succeed there
  - Changes in e.g. /sdcard do not succeed (e.g. set execute bit)
  - Most probably, (Linux) applications cannot be started via SD-Card

Android Security

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- (Java) Application signing is required
  - Linux state not clear
  - developer signs his application with own certificate at the moment
  - System might change to something similar to Symbian OS
    - Central authority for assigning certificates
    - Limited access to APIs
    - Each, Goole and T-Mobile announced application store (might include application testing and verification)

Android Security

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- File rights:
  - /data/data/<package.application_name>
  - “application land”
  - drwxr-xr-x app_14 app_14 2008-09-17 14:26 com.android.sample
- Application can access other application directories signed with identical certificates
  - “Certification land”

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Adding Linux Security Tools to Android General Information

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- Emulator is used as basis
- OHA/Google modified a lot of standard libraries and binaries
  - Reason: opportunity for business costumers to claim “intellectual property”
- Application space is limited (~40 MB)
- Common security tools were tested
  - But: special build environment needed

Creating a Build Environment for Android

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- Ubuntu 8.04
- Two toolkits can be used
  - Sourcery cross-compile toolchain
  - Scratchbox cross-compilation toolkit
    - Emulated ARM environment
    - “Common” Linux file system layout

Creating a Build Environment for Android
Important Facts

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- Files are located in:
  - System files are placed in /system
  - Binaries in /system/bin
  - Libraries in /system/lib
  - Config files in /system/etc
- System configuration in OpenBinder
- Page alignment causes changes in linking
- Only way to get available applications run is compiling them statically

Adding Tools

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- “Top 100 Network Security Tools” [Insec06]
- Tested from 5 main categories:
  - Anti-Virus: ClamAV
  - Firewall: iptables
  - Rootkit Detectors: chkrootkit
  - Intrusion Detection: Snort
  - Other useful tools: Busybox, Bash, OpenSSH, strace, Nmap

Anti-Virus: ClamAV

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- Android Compatibility: Works
- Problems, solutions, and size:
  - Static compilation (linking) required
  - Dependent on static compiled version of "zlib" (zlib-1.2.3)
  - Total size of all ClamAV relevant files (approx. 28MB) exceeds available size in System image
  - (21MB). ClamAV virus signature database needs to be placed in a different location.
  - Size (approx.): 11140 KB libraries and binaries (/opt), 17324 KB database (/data)

Anti-Virus: ClamAV Results

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```
----------- SCAN SUMMARY -----------
Known viruses: 407205
Engine version: 0.94
Scanned directories: 0
Scanned files: 106
Infected files: 0
Data scanned: 5.12 MB
Time: 107.236 sec (1 m 47 s)
#
```

Firewall: iptables

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- Problems:
  - Kernel needs to be recompiled from source. Sources can be freely downloaded from Android Project website. Enable NETFILTER in kernel configuration and recompile!
  - “iptables” cannot be compiled due to linker issues: It requires statically compiled parts of libc which Android does not provide.

Rootkit Detector: Chkrootkit

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- Android Compatibility: Works with minor dependencies
- Problems, solutions, and size:
  - Static compilation (linking) required
  - Requires "netstat" (provided by "busybox")
  - Requires standard directories (/lib, /etc, etc.) provided by symbolic links pointing to the correct Android directories
  - Size (approx.): 588 KB

Rootkit Detector: Chkrootkit Results

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```
# ./chkrootkit
[: gid: unknown operand
ROOTDIR is `/'
Checking `amd'... not found
Checking `basename'... INFECTED
Checking `biff'... not found
Checking `cron'... not infected
Checking `echo'... INFECTED
Checking `egrep'... not infected
Checking `env'... INFECTED
Checking `find'... not infected
Searching for common ssh-scanners default files... nothing found
Searching for suspect PHP files... find: /var/tmp: No such file or
directory
nothing found
Searching for anomalies in shell history files... nothing found
chkproc: Warning: Possible LKM Trojan installed
chkdirs: Warning: Possible LKM Trojan installed
Checking `sniffer'... ./chkrootkit: ./ifpromisc: not found
```

Intrusion Detection: Snort

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- Problems:
  - Dependencies to libpcap, libdnet, libnet, pcre and iptables (all as statically compiled/linked solutions)
  - Requires statically compiled/linked libc parts which are not available on Android

Other Useful Tools: Busybox, Bash, OpenSSH, strace, Nmap

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- Busybox: works
- Bash: works
- OpenSSH: Can be executed but is not fully functional (requires users that do not exist in the android environment)
- strace: works
- Nmap: works with minor dependencies

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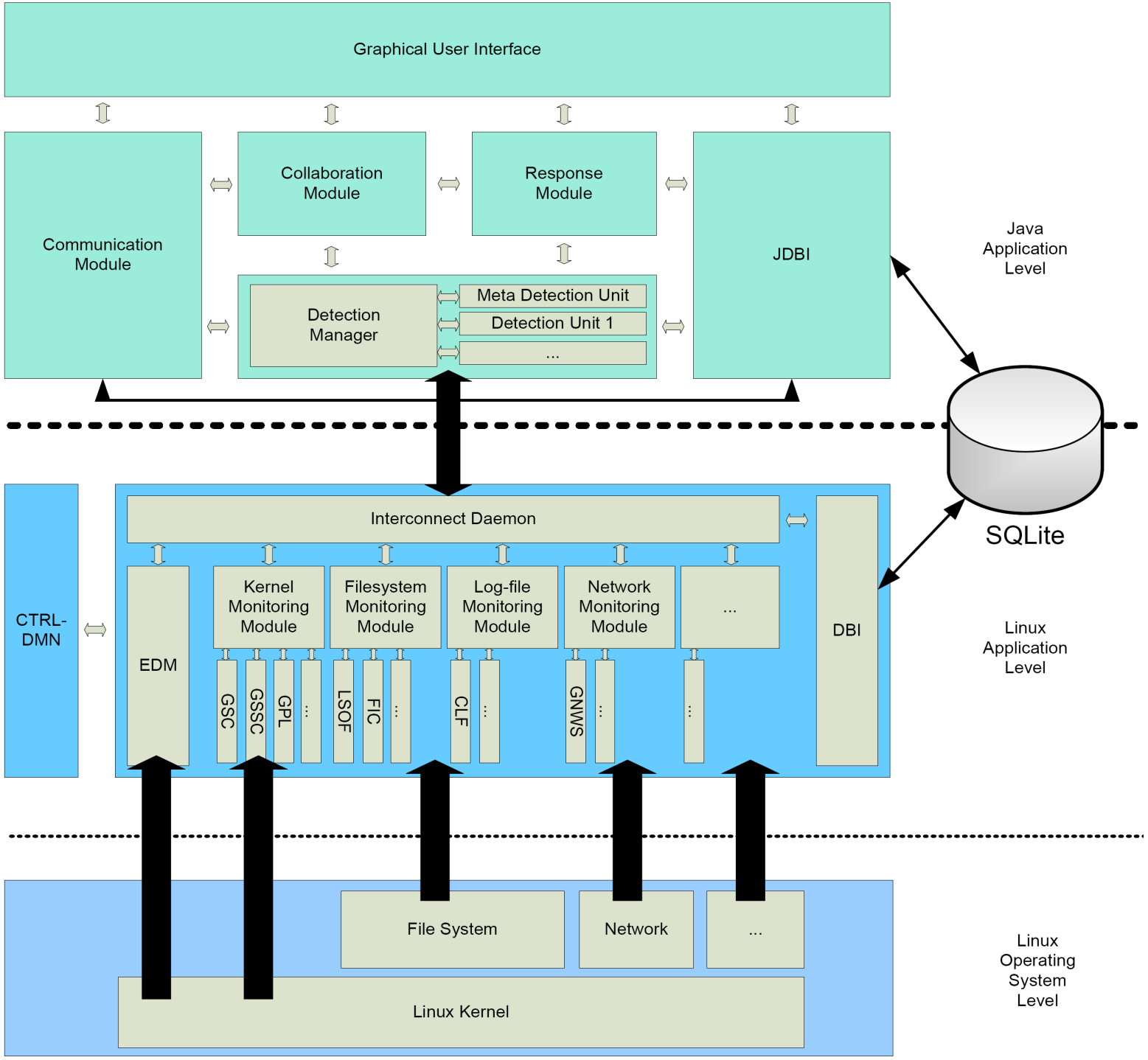
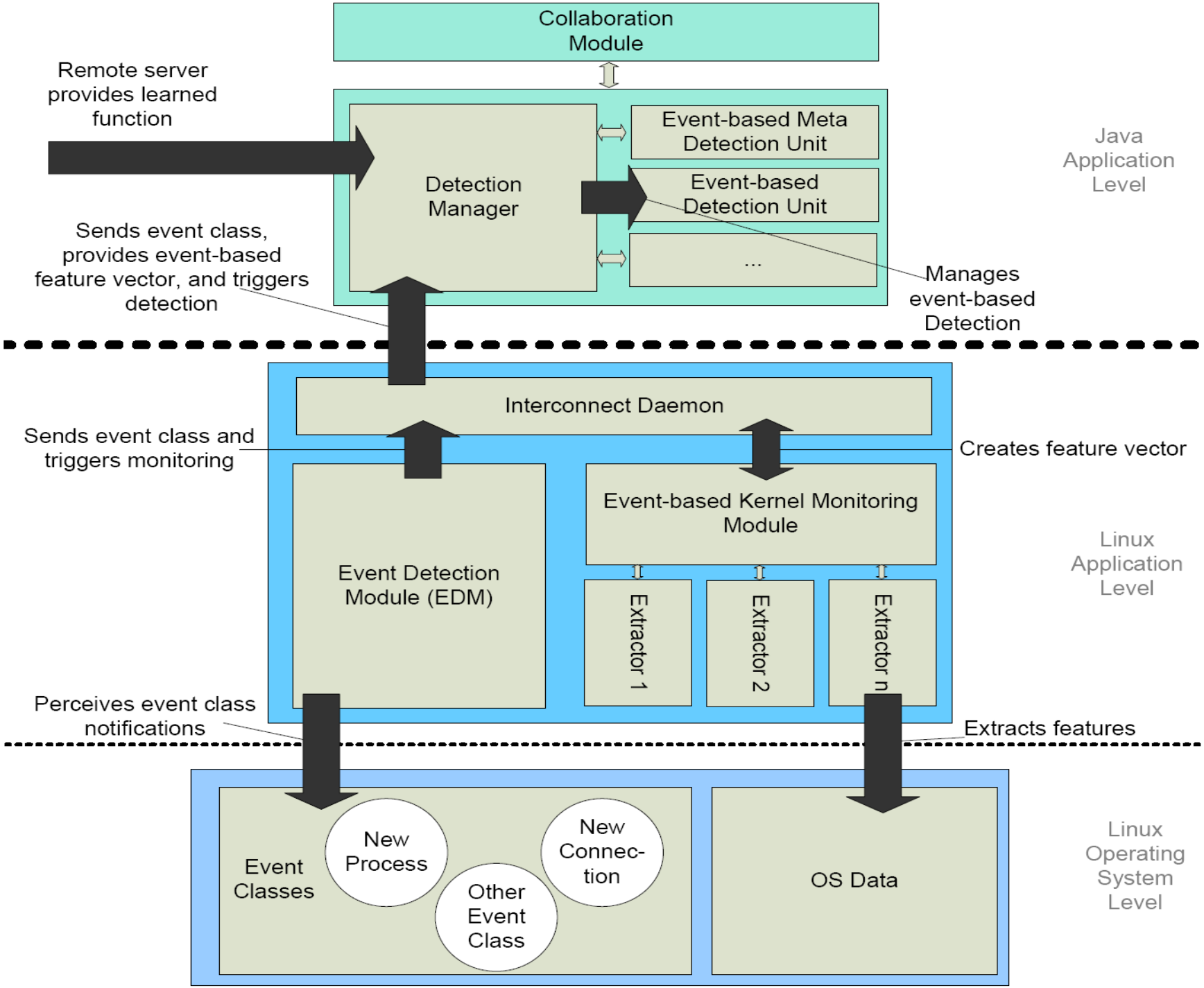

Graphical User Interface
Communication Module
Collaboration Module
Response Module
JDBI
Detection Manager
Meta Detection Unit
Detection Unit 1
...
Java Application Level
SQLite
CTRL-DMN
Interconnect Daemon
EDM
Kernel Monitoring Module
Filesystem Monitoring Module
Log-file Monitoring Module
Network Monitoring Module
...
GSC
GSSC
GPL
...
LSOF
FIC
...
CLF
...
GNWS
...
...
DBI
Linux Application Level
File System
Network
...
Linux Kernel
Linux Operating System Level


Collaboration Module
Remote server provides learned function
Detection Manager
Event-based Meta Detection Unit
Event-based Detection Unit
...
Java Application Level
Sends event class, provides event-based feature vector, and triggers detection
Manages event-based Detection
Interconnect Daemon
Sends event class and triggers monitoring
Creates feature vector
Event Detection Module (EDM)
Event-based Kernel Monitoring Module
Extractor 1
Extractor 2
Extractor n
Linux Application Level
Perceives event class notifications
Extracts features
Event Classes
New Process
Other Event Class
New Connec-tion
OS Data
Linux Operating System Level

Detecting Intrusions and Malware
Static Function Call Approach

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- Planned to present metric for weighing suspiciousness of function/system calls
- Solution far more easier on Android
- Simple decision tree can achieve 95% detection rate
  - Tested with Linux malware
    - Some of them were recompiled for Android, but only minor differences
- Still has to be tested on real device!

Detecting Intrusions and Malware
Static Function Decision Tree

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```
__bss_start = y
|   gethostbyname = y
|   |   sigaction = y: normal
|   |   sigaction = n: malicious
|   gethostbyname = n
|   |   fork = y
|   |   |   strerror = y
|   |   |   |   getgrgid = y: malicious
|   |   |   |   getgrgid = n: normal
|   |   |   strerror = n: malicious
|   |   fork = n: normal
```

continued on the right side

... continued

```
__bss_start = n
|   printf = y: malicious
|   printf = n
|   |   fprintf = y: malicious
|   |   fprintf = n
|   |   |   execv = y: malicious
|   |   |   execv = n
|   |   |   |   memmove = y: malicious
|   |   |   |   memmove = n
|   |   |   |   |   perror = y: malicious
|   |   |   |   |   perror = n: malicious
```

Summary

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- Android Security
- How to enhance security
  - Add Linux security tools
  - Light weight IDS

References

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Thank you for your patience!

Q&A

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