Reducing the Window of Opportunity for Android Malware

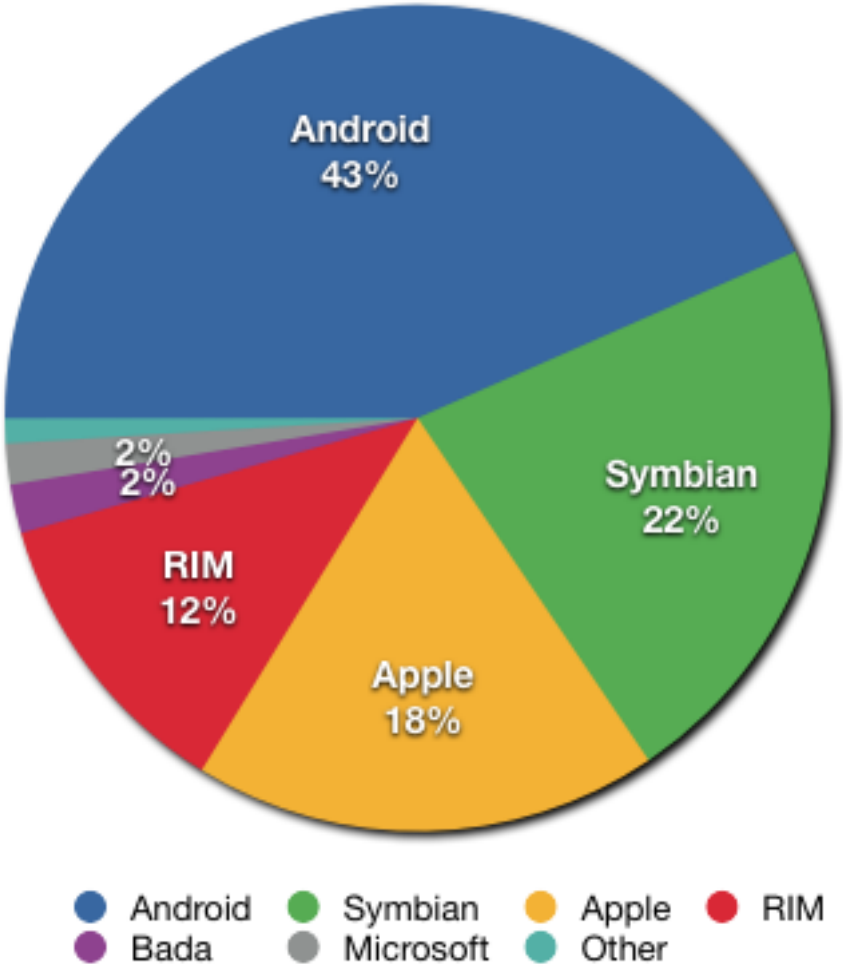
Gotta catch 'em all

Axelle Apvrille, Fortinet

Tim Strazzere, Lookout Mobile Security

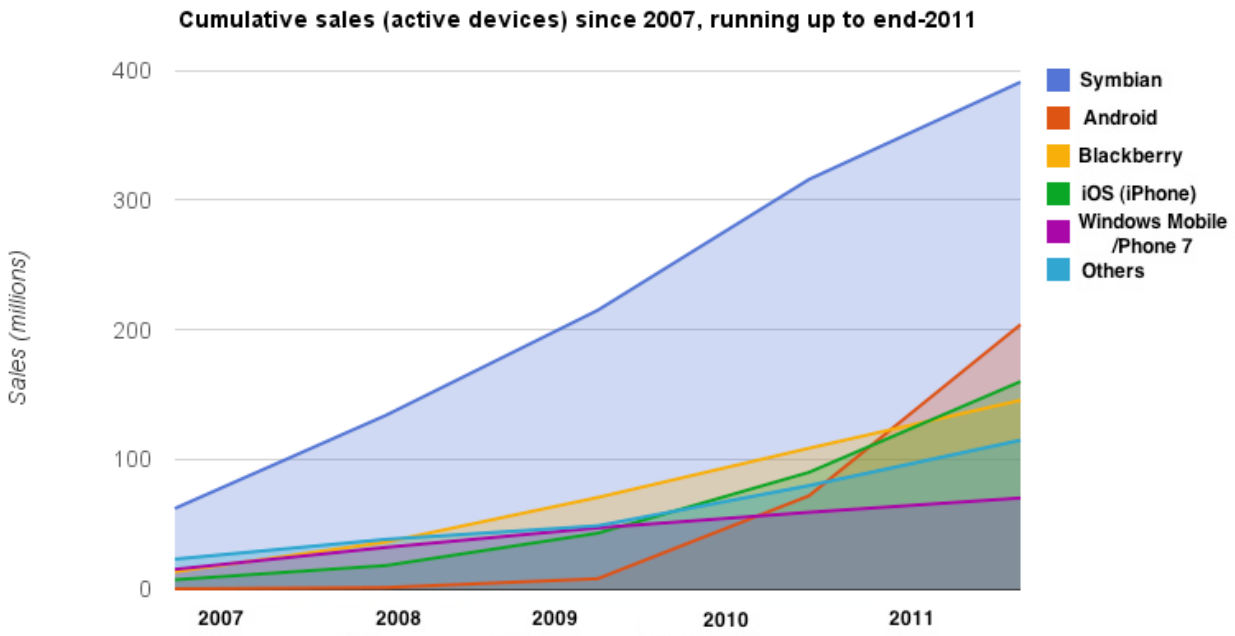
EICAR Conference, May 2012

Stats are difficult to compute



- Q2 2011 sales [Source: Gartner]

Stats are difficult to compute



- Cumulative sales [Source: David Litchfield]

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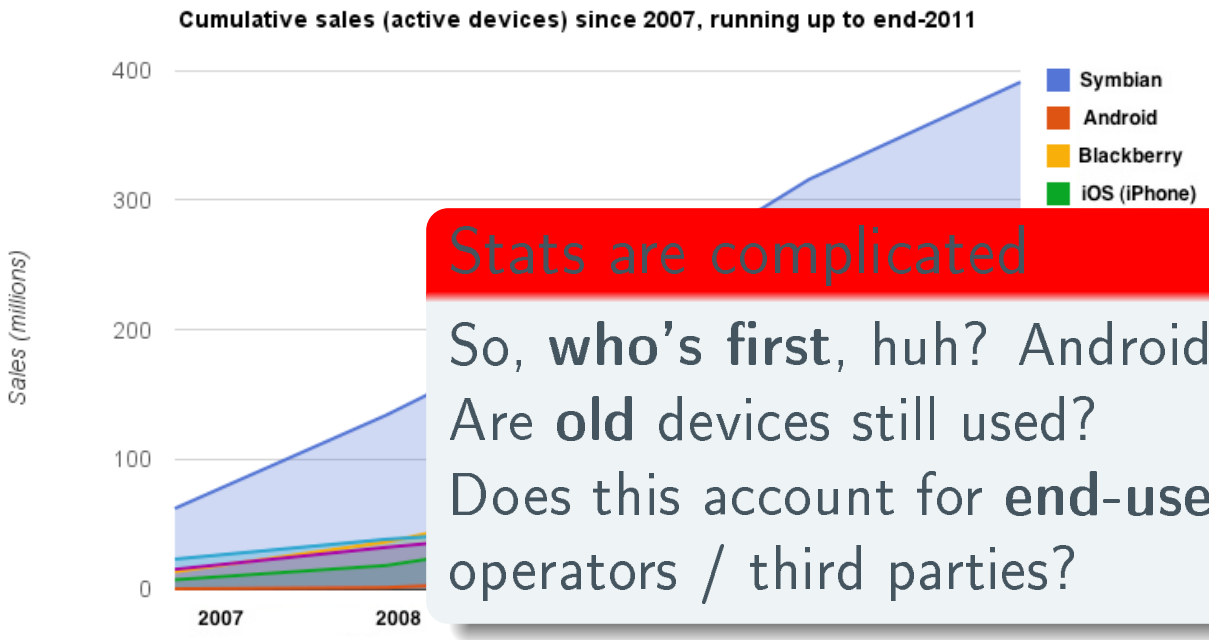
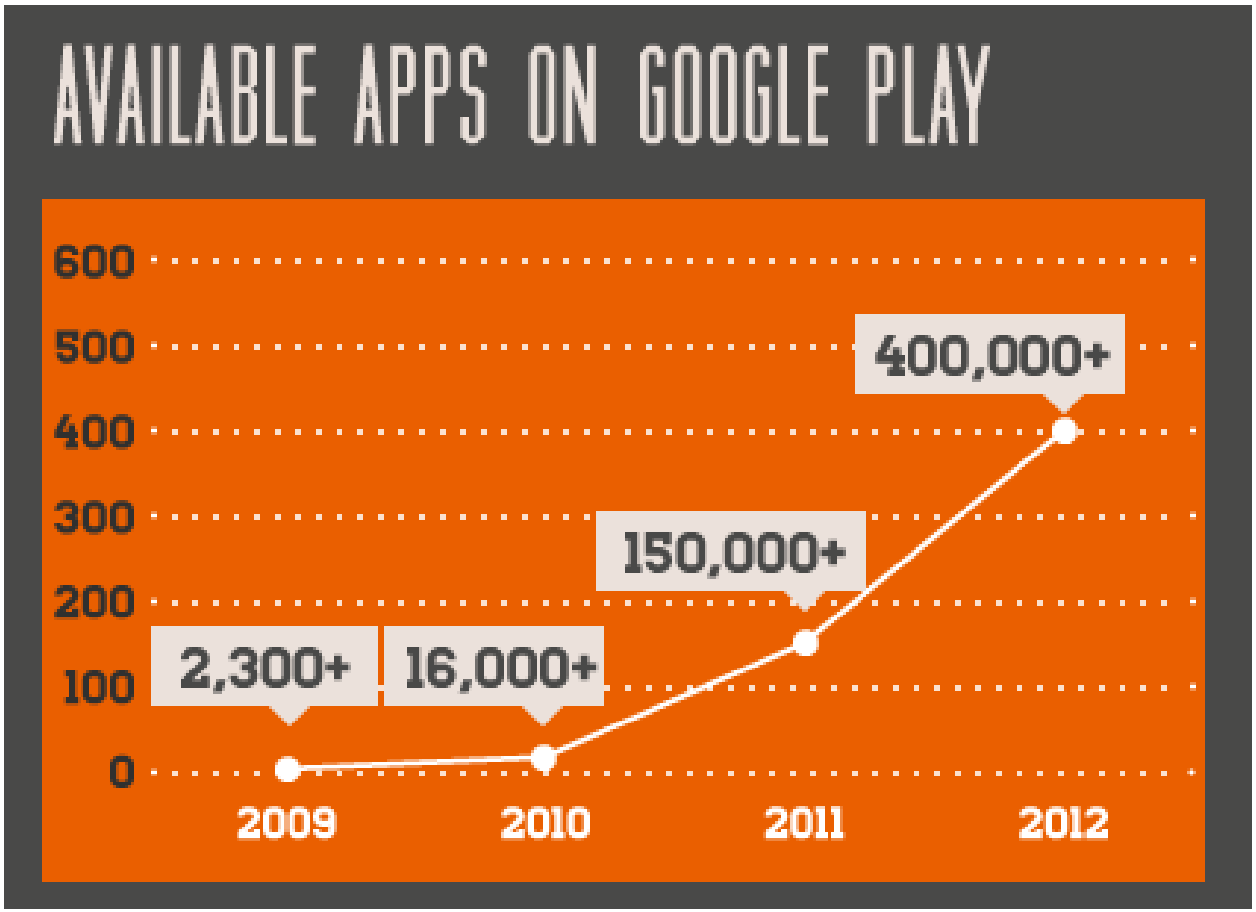


- Cumulative sales [Source: David Litchfield]

Stats are complicated

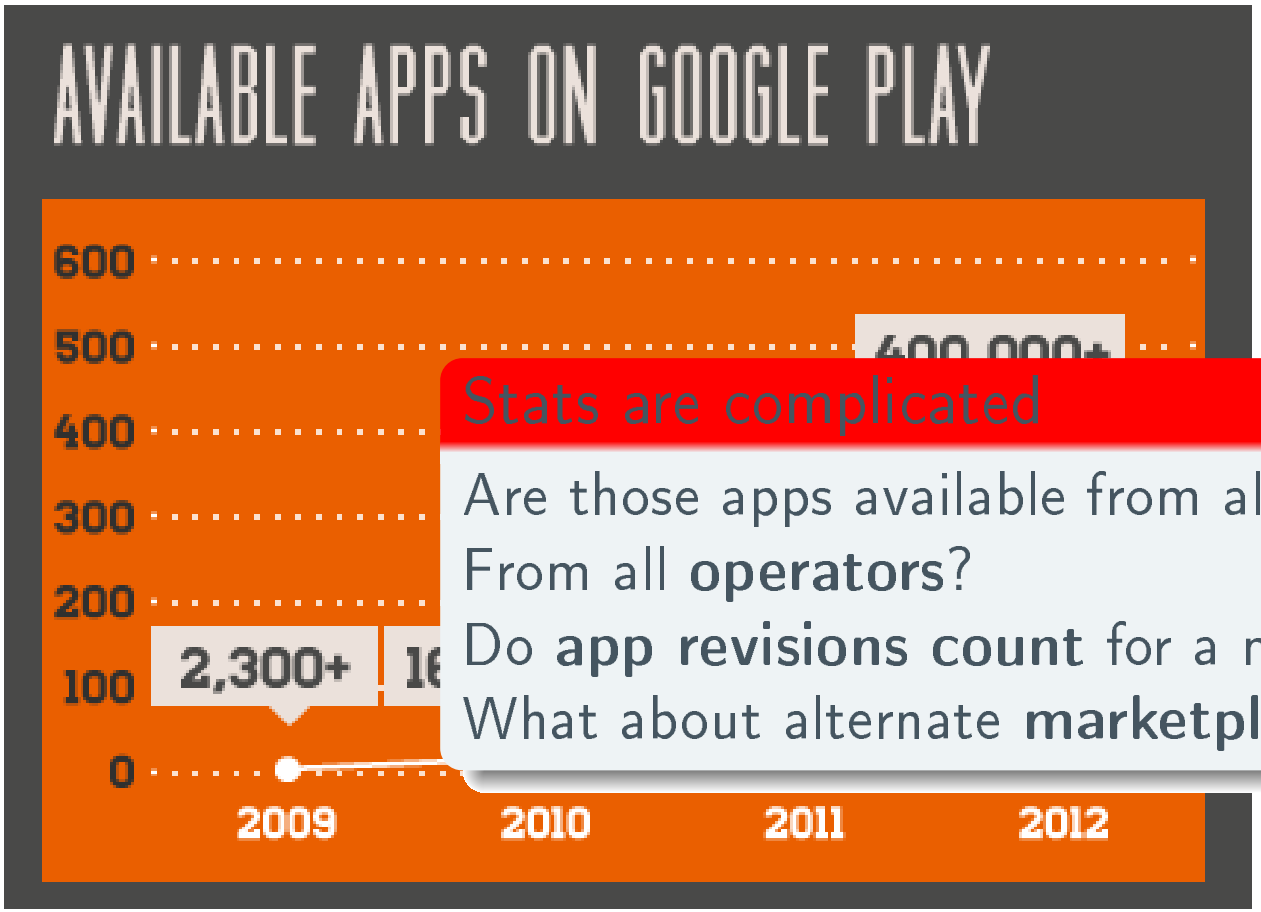
So, **who's first**, huh? Android? Symbian?
Are **old** devices still used?
Does this account for **end-user sales** or sales to operators / third parties?

Stats are difficult to compute



- Available apps [Source: Lookout]

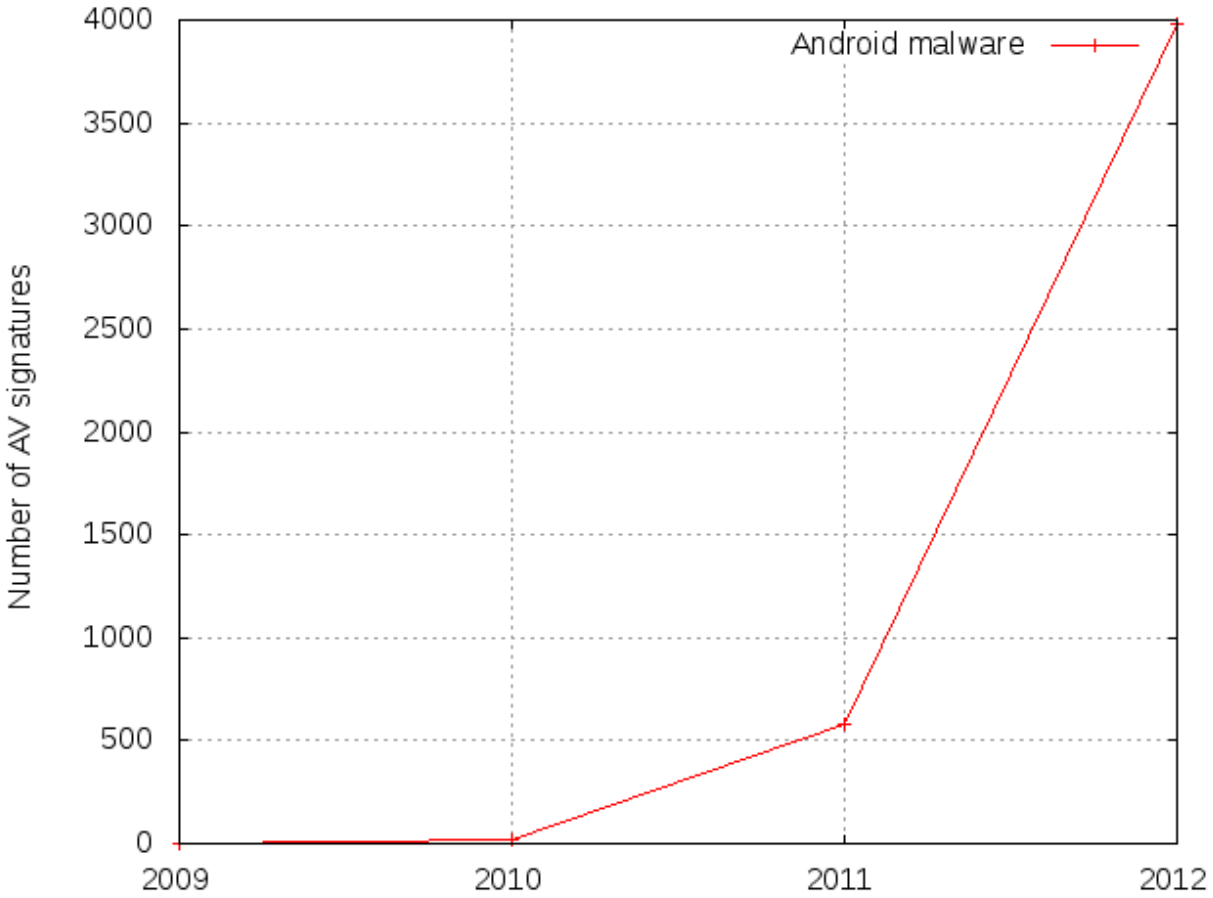
Stats are difficult to compute



Stats are complicated

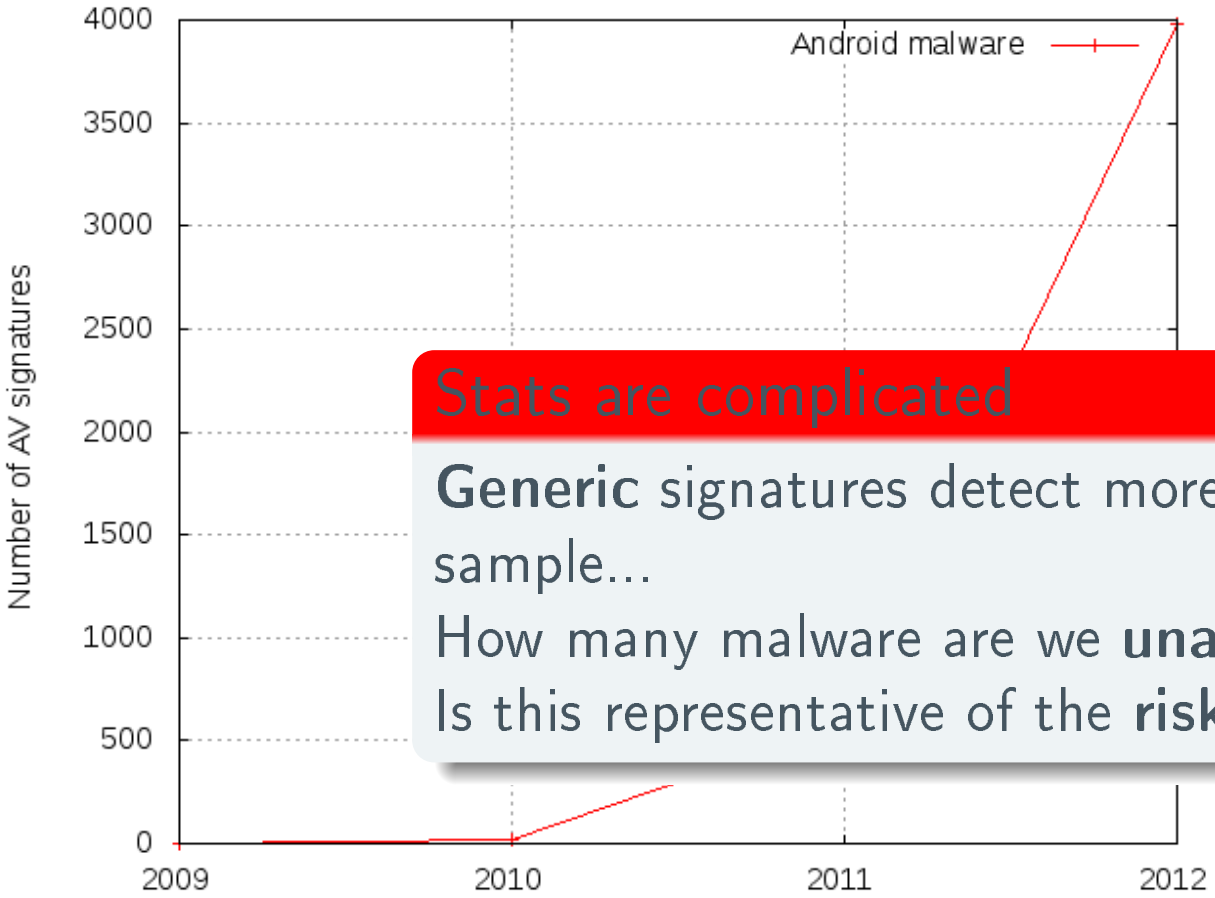
Are those apps available from all **countries**?
From all **operators**?
Do **app revisions count** for a new app?
What about alternate **marketplaces**?

Stats are difficult to compute



- Nb of signatures [Source: Fortinet]

Stats are difficult to compute



Stats are complicated

Generic signatures detect more than one sample...

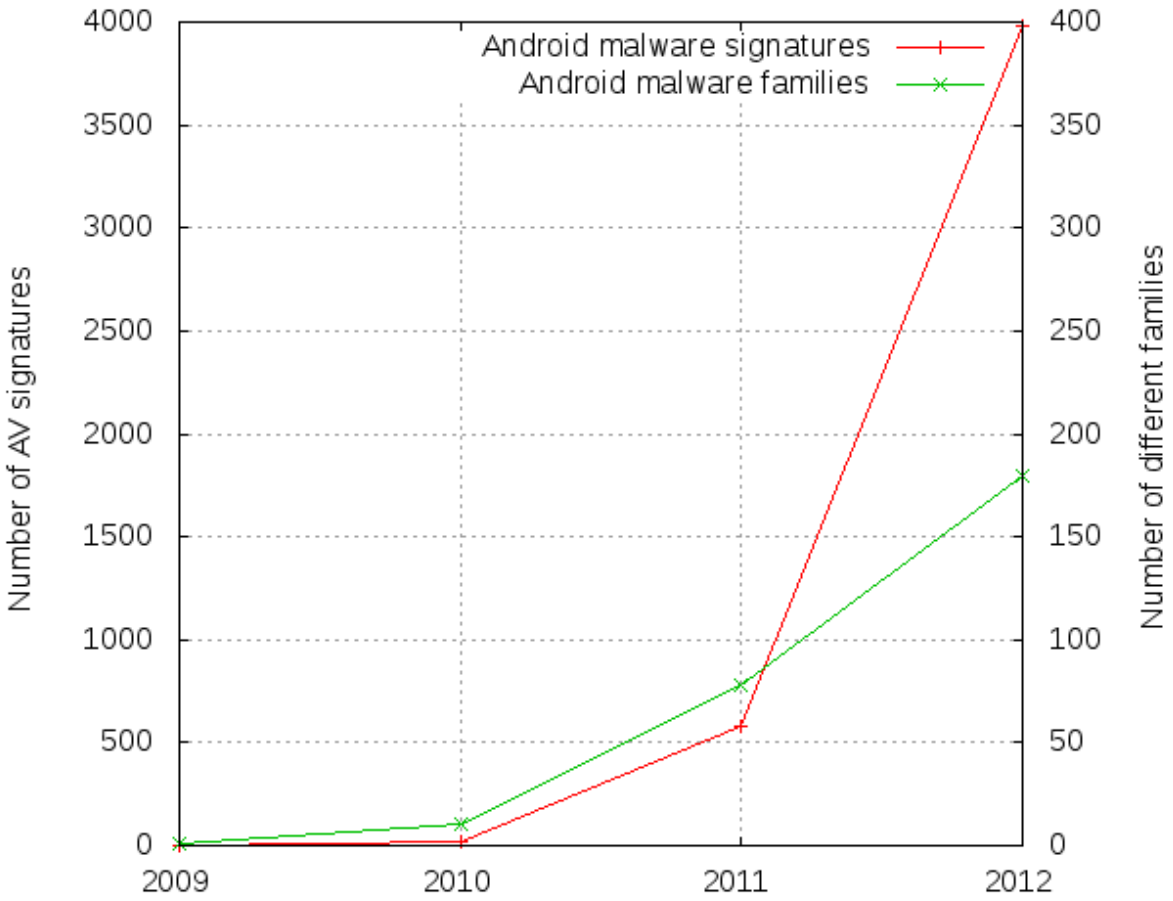
How many malware are we **unaware** of?

Is this representative of the **risk** for end-users?

res

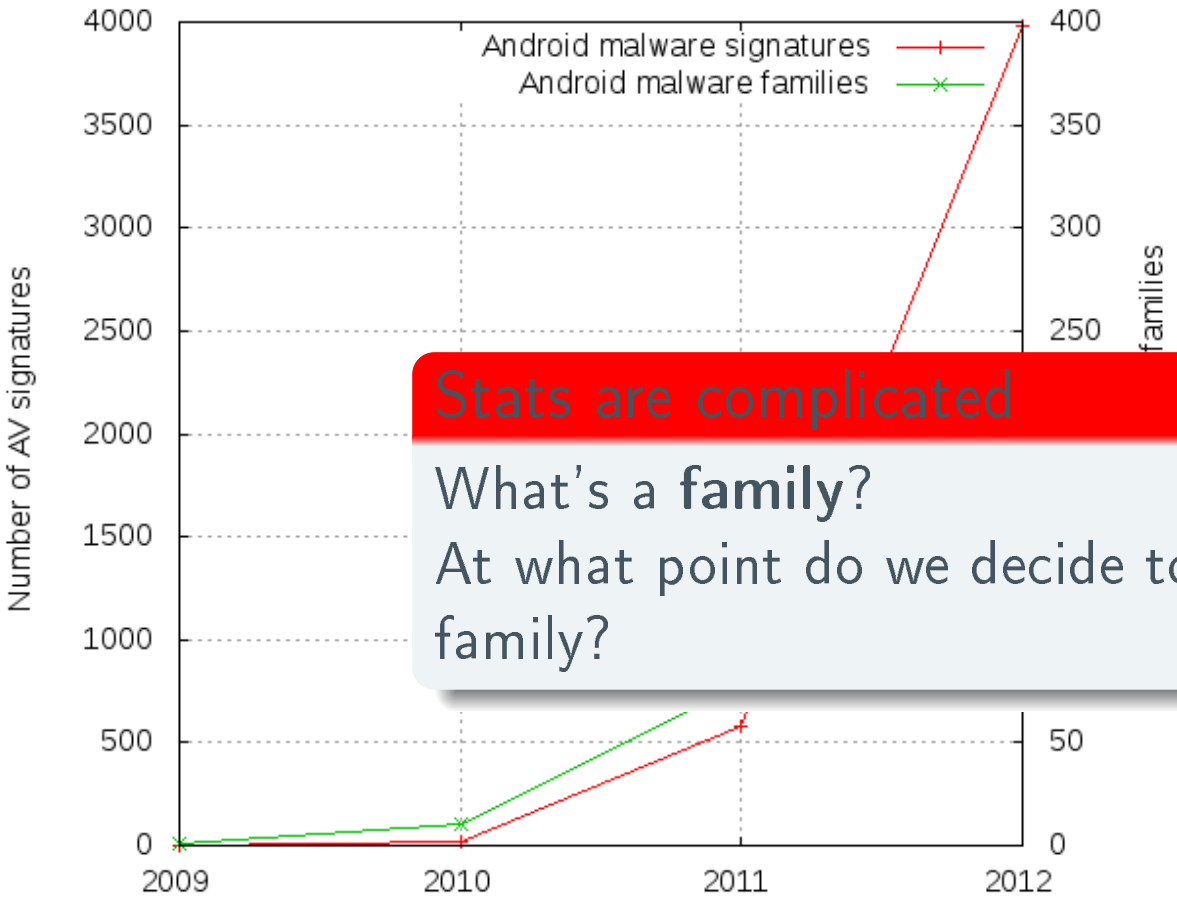
net]

Stats are difficult to compute



- Nb of different families [Source: Fortinet]

Stats are difficult to compute



Stats are complicated

What's a **family**?

At what point do we decide to create a new family?

- Nb of different families [Source: Fortinet]

Our perception of world depends on our knowledge

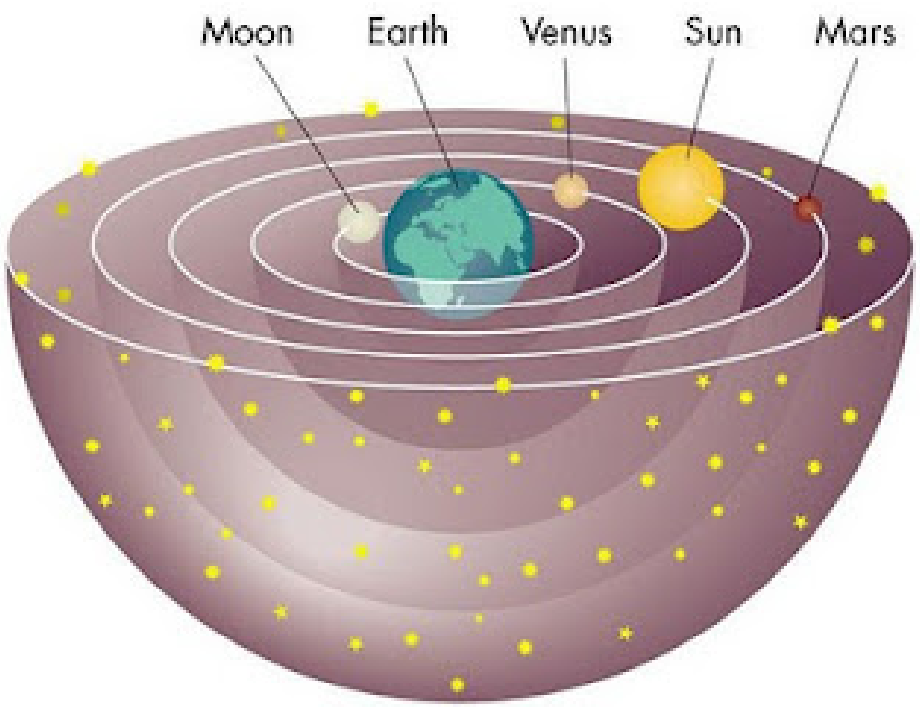


Figure: Aristotle's Universe (source: AlienCitadel)

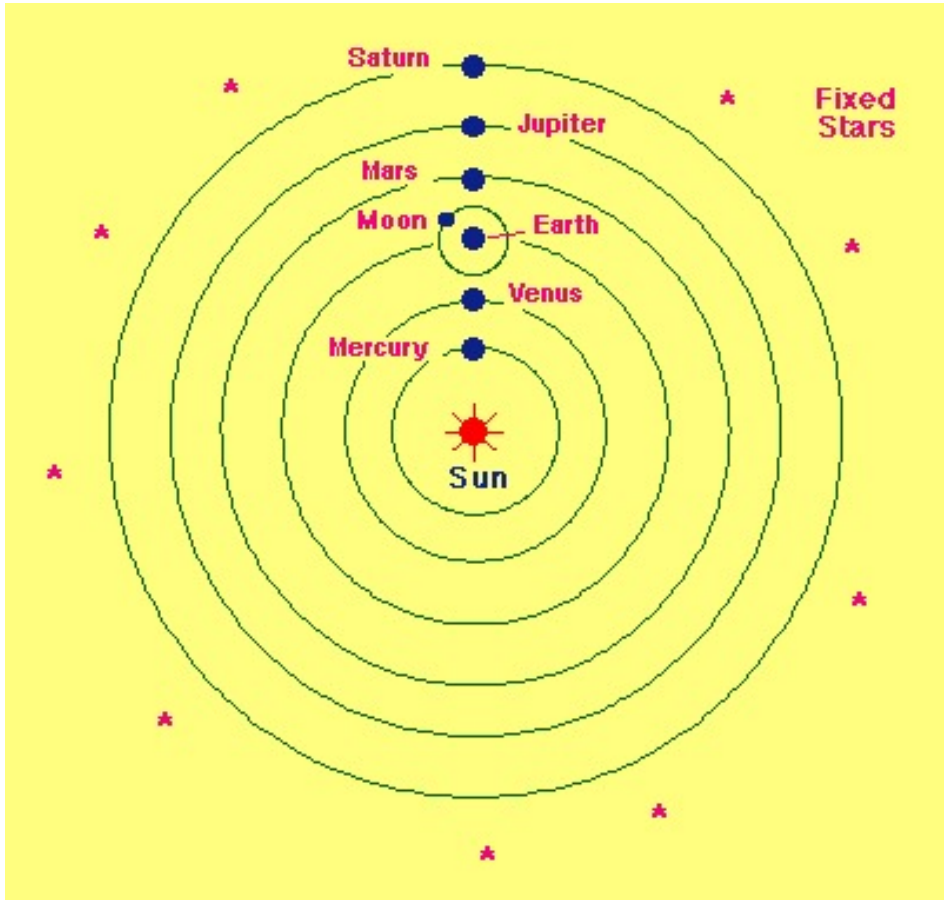
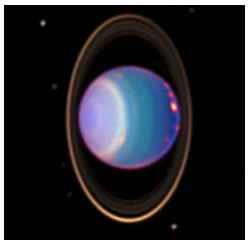
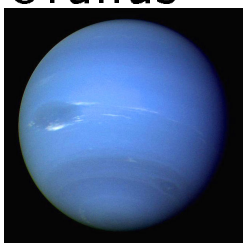
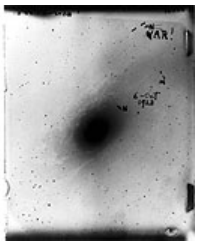


Figure: The Copernican Universe (source: Tpellk)

What are we missing?


1781: William Herschel discovers Uranus


1846: Johan Galle discovers Neptune


1924: Edwin Hubble discovers new galaxies

Android malware

- How blind are we?
- Is there *something* to see and how much?
- How long have malware been in the wild?

What our paper is about

Figure: Galilei's telescope

(Well, that wouldn't be very modest, of course...)

Our goal - *Android* only

- Estimate age of malicious samples
- Preliminary tools and methods to unknown malware in the wild
- Reducing the window of opportunity of Android malware

Aging malicious samples

Certificate's begin date

```
$ keytool -printcert -file ./META-INF/CERT.RSA
...
Valid from: Wed Mar 02 19:15:44 CET 2011
...
```

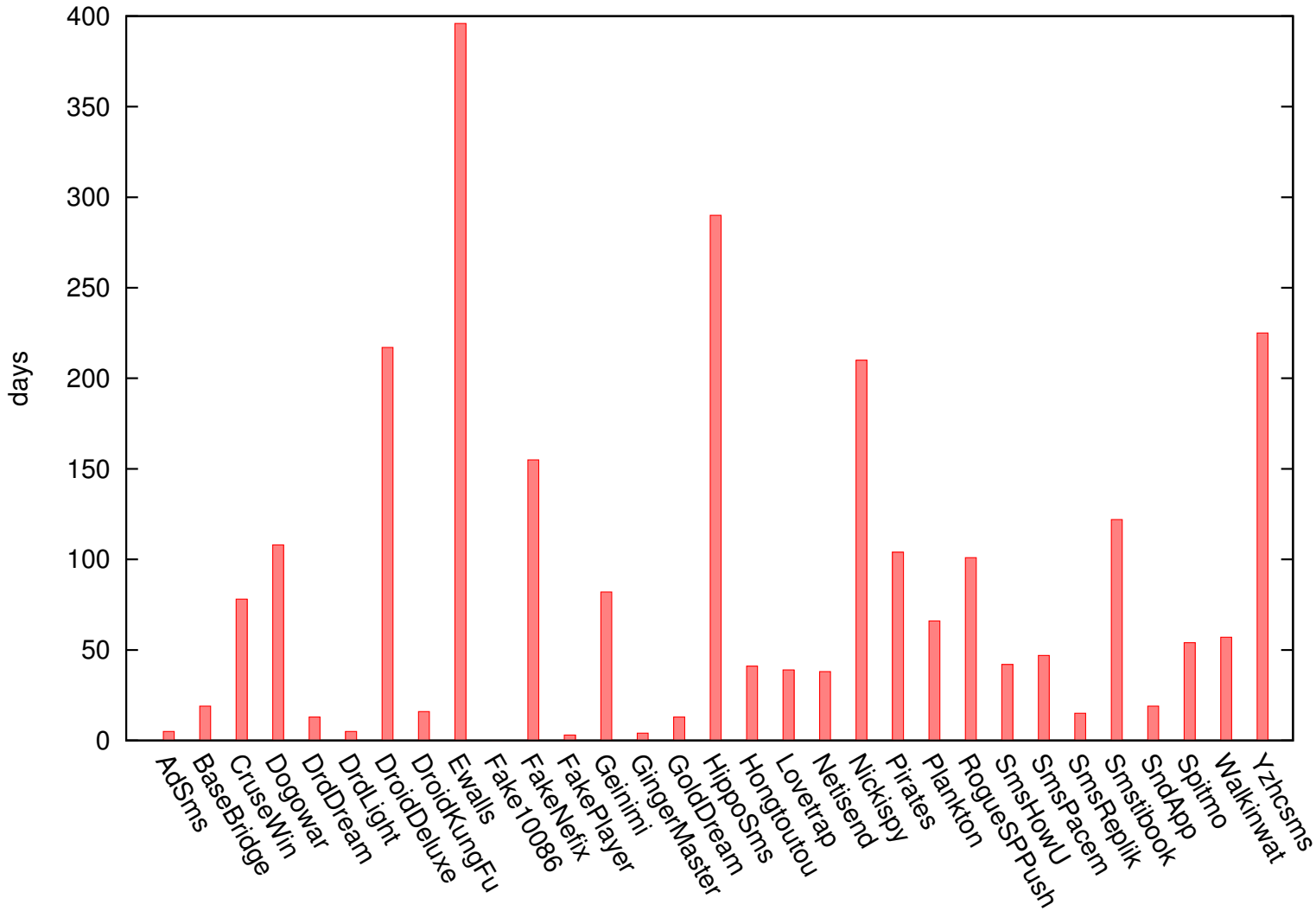
- **Approximation**. Day the certificate was created.
- Does not work for AOSP keys.

Package's zip date

```
-rw-r--r-- 1 axelle axelle  664 Dec 20 03:36 CERT.RSA
```

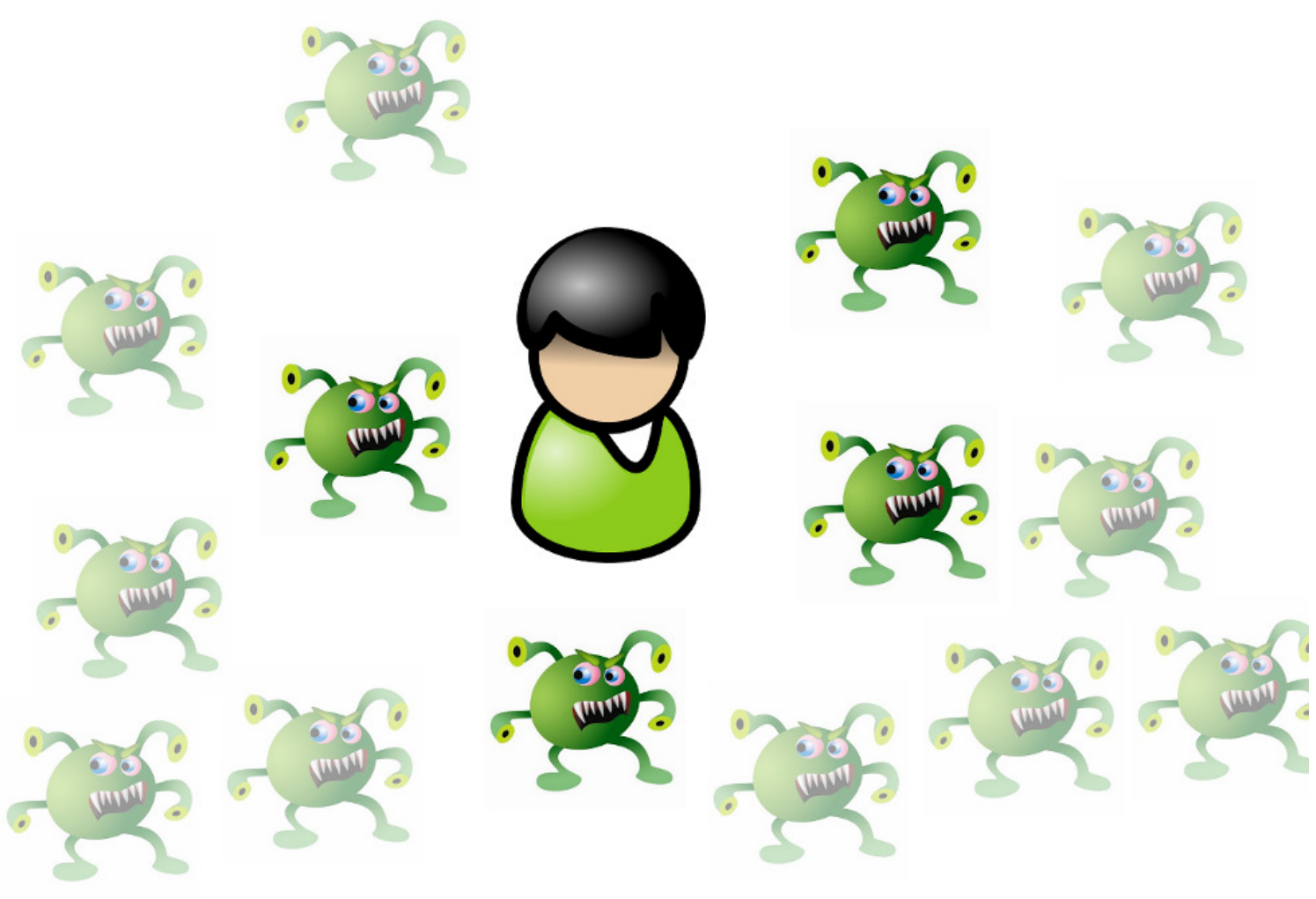
- **Dec 20** (2011): **Approximate and unsecure**.
- But... gives better results

Release date vs Detection date



Average: **80** days after release!

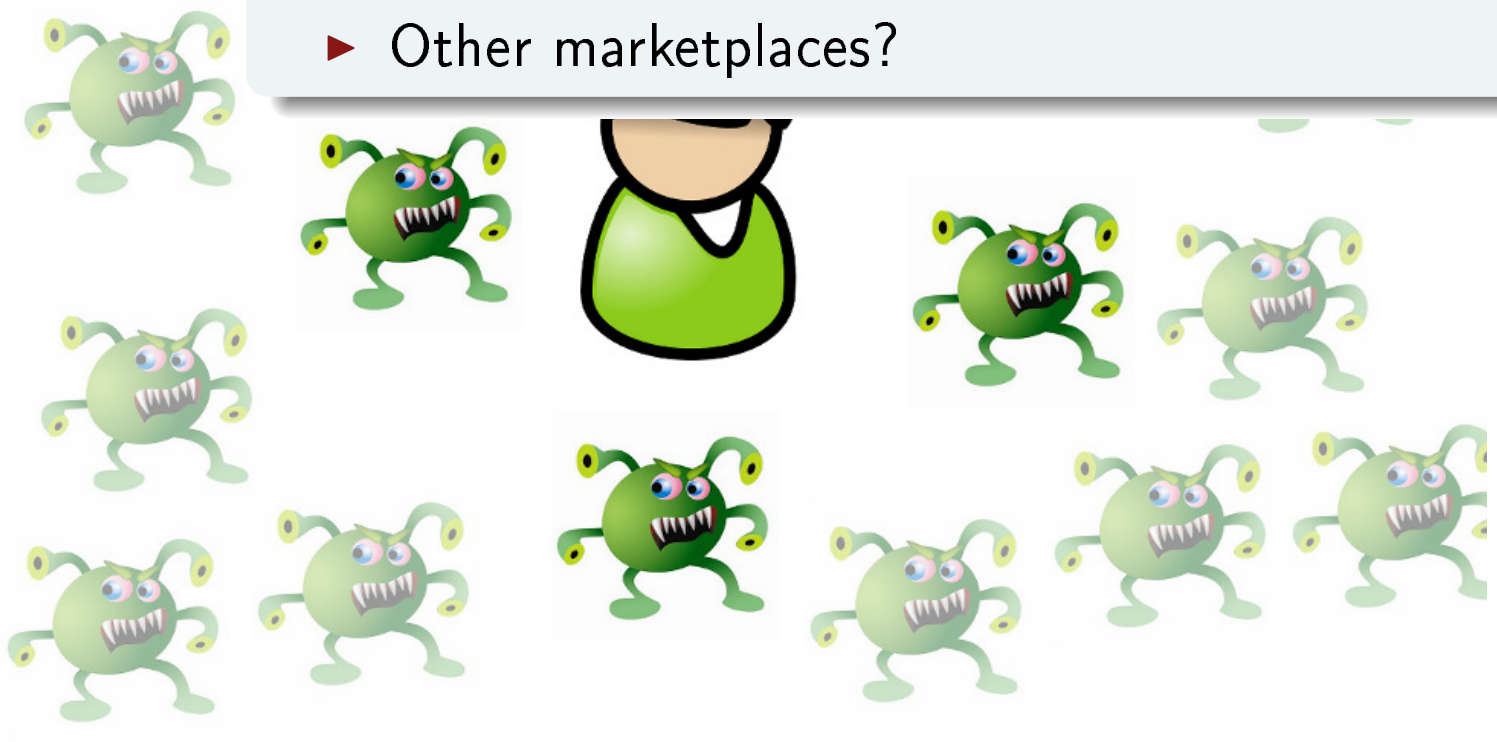
Why are we missing malware?



Why are we missing malware?

Difficult to make an inventory of Android apps

- 400,000 apps in Google Play
- 199,917 in 10 other marketplaces
- No count for 37 other marketplaces
- Other marketplaces?



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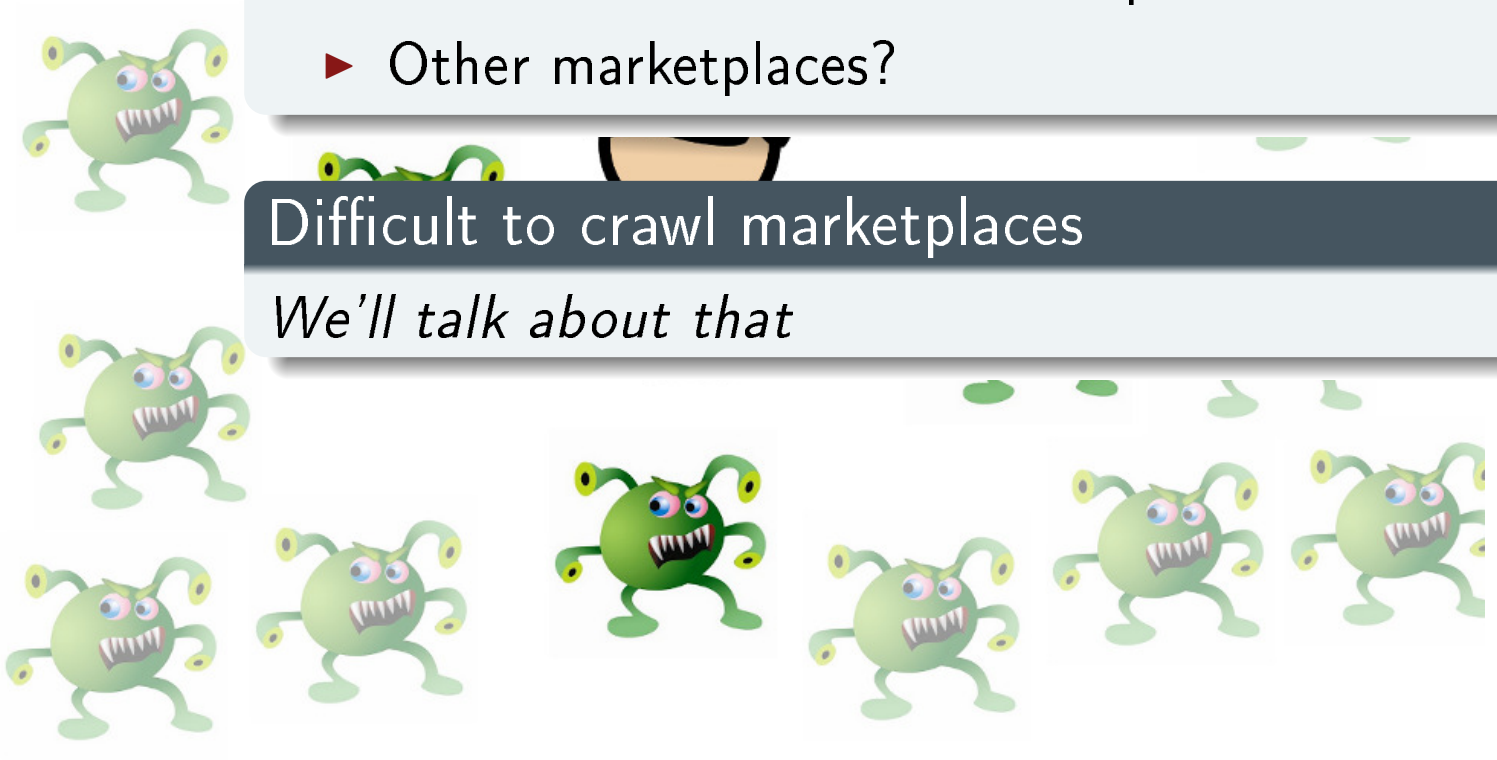
Difficult to crawl marketplaces

We'll talk about that



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+ classical failures

Did not spot the malicious parts etc

Google Play (Android Market) Crawling

Once a crawler - always a crawler, right?

- Not as simple as a normal crawler
- Requires reversing of Vending.apk $\rightarrow$ No official public API
- v1 = Base64(Protobuf (commands)) $\rightarrow$ return Base64(Protobuf (results))
- v2 = RESTFUL $\rightarrow$ return of Base64(Protobuf (results))

Different Contexts

Normal Crawler Context

- Sign in (optional)
- Enumerate all apps, collecting meta data → Often new apps are highlighted/easy to find
- Download all new APKs
- Rate limit along the way to prevent bans

Google Play Contexts

- Must mock an actual device → Only see applications viewable to the device
- Enumerate applications (limited to 500 per category/search
- No more "just-in" category anymore
- Emulate only a few contexts for each account to prevent bans

What makes a Google Play context?

So many different details!

- 1,312+ devices accessing the market
- 136+ countries officially accessible
- 109+ carriers officially supported
- 20+ languages supported
- 12+ device SDK levels
- Lucky we can get most of the apps by targeting the majority of devices

Who cares?

Why so many contexts?

- Most (malware) devs have been targeting the bulk, getting the largest ROI
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- They also want to target a specific country since they can only use premium SMS on a specific carrier?

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- Devs can target the device specifically, the country and even the carrier - generic crawlers could easily miss this

Creating accounts

Building a crawling robot army

- Create a new account
- Allow the account to only access a few contexts
- Initial sync with Google Play $\rightarrow$ Receive device specifics
- Get an auth-token $\rightarrow$ refresh every two weeks
- Store accounts in DB for later use in metadata / download retrieval

Catching' em all

Ensure rate-limiting (different limits for each part)

Getting Metadata

- Select context to search
- Enumerate apps from all 24 app categories / 6 game categories
- Repeat the enumeration for free / paid and trending (500 max for each)
- Save metadata and context, if was new, to DB/storage
- Enqueue for download if binary appears new

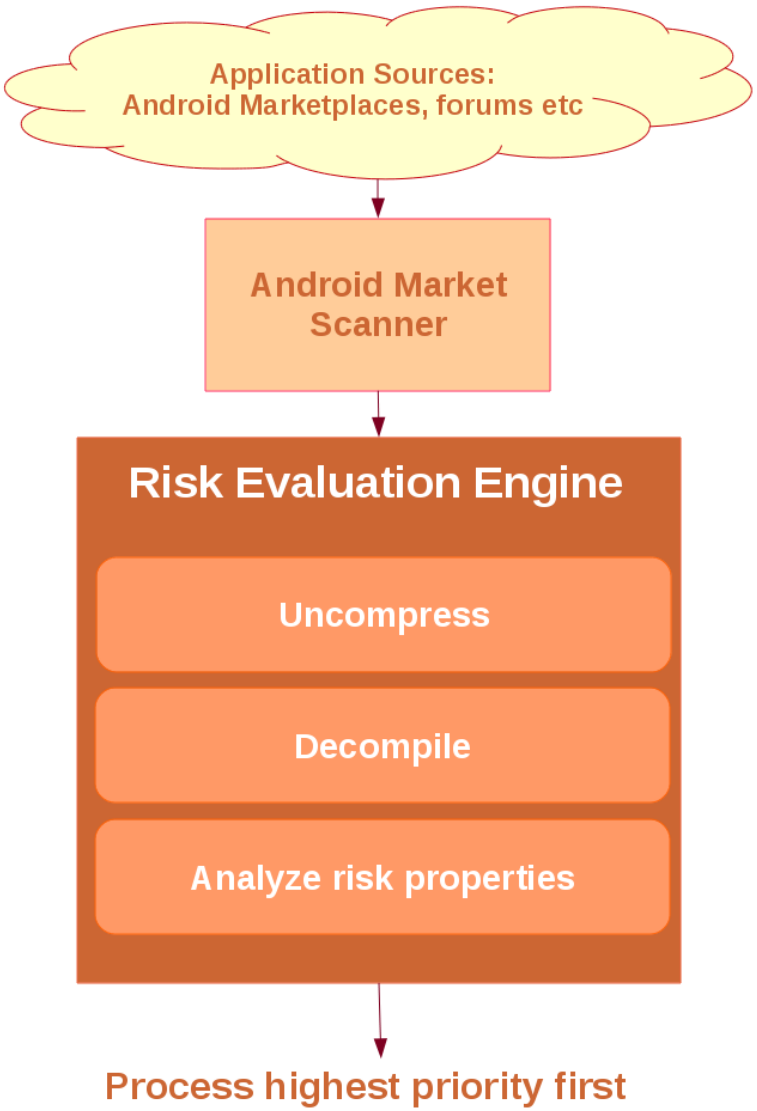
Downloading the APKs

- Retrieve new metadata results, load the context used
- Issue download request (follow redirect)
- Store binary

Maintaining this beast of a crawler

- Make sure rate limiting steady, otherwise bans occur to accounts or IP address
- Keep accounts "healthy", should attempt to look like real accounts
- Monitor ROI for contexts (enable more accounts if necessary)
- Monitor for protocol changes, backwards compat. seems good, but can always break

Risk Evaluation Engine - Heuristics



- Unpack APK, ZIP
- Disassemble using APKTool or Baksmali
- Test package properties
- Help analyst: dex2jar, unzip, unjar
- Manifest properties
- Signing certificate properties
- Search for embedded executables and inspect
- Code's properties
- Search for given combinations

Property detectors

What is a property detector?

- Detect risky situations
- Static check against the package
- (Relatively) simple test
- States a tendancy, never guarantees clean/malicious

Detector examples

- Use of AOSP signing certificate $\rightarrow$ Risk for users with custom ROM
- Call to `Runtime.exec()` $\rightarrow$ Run Unix commands, e.g `pm install`

40+ property detectors

Type	Example	Location
Permissions	SEND_SMS, RECEIVE_SMS ...	Manifest

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URL detectors	C&Cs	Executabes
Package properties	Size, AOSP platform cert	Package
Combinations	LOCATION + INTERNET	Manifest, code

Writing property detectors

Make a call

In AndroidManifest.xml:

```
<uses-permission android:name="android.permission.CALL_PHONE">
```

```
Intent callIntent = new Intent(Intent.ACTION_CALL);
callIntent.setData(Uri.parse("tel:1234"));
```

To consider...

- CALL_PRIVILEGED permission
- ACTION_DIAL: does not call, but enters the phonenumber
- `Uri.parse("content://contacts/people/1")`
- Beware PROCESS_OUTGOING_CALLS
- Advertisement libs use it (e.g Admob)

Properties are never trivial

```
$grep = `egrep -rl 'KeySpec|SecretKey|Cipher'
  "$location/smali"`;
@grep_list = split( /\n/, $grep );
if (@grep_list) { foreach my $grep (@grep_list) {
if ($grep !~ /com\/google\/ads/ &&
    $grep !~ /mobileads\/google\/com/ &&
    $grep !~ /com\/android\/vending\/licensing/ &&
    $grep !~ /openfeint/ &&
    $grep !~ /gameloft/ &&
    $grep !~ /javax\/microedition\/io\/SecurityInfo/ &&
    $grep !~ /oauth\/signpost\/signature/ &&
    $grep !~ /org\/apache\/james\/mime4j\// &&
    $grep !~ /com\/google\/android\/youtube\/core/ ) {
    $self->{sample}->report2file("Use of encryption:");
    $self->{sample}->{encryption} = true;
} ...
```

Weight

Context

- A subset of 97 malware + 217 clean files
- Assign weights: difference of percentages

Statistics (see paper)

Malware send or receive SMS more than clean files

59% of malware send SMS against 6% of clean files

Other things malware like:

- Use HTTP POSTs (68% - 25%)
- Request both SMS and INTERNET permission (46% - 6%)
- Retrieve phone's IMEI (63% - 20%)
- Use encryption (34% - 10%)
- List installed packages (33% - 5%)

Automatic Analysis Report

Thu Apr 19 14:32:34 2012

light grayed italic lines indicate samples this script was unable to analyze successfully
Internet = does sample connect to Internet?
SMS = does sample send/receive SMS?
MMS = does sample send/receive MMS?
Install = does sample install other applications?
Store = can the sample be downloaded from an AppStore/Android Market?
Enc = does sample use encryption
GPS = does sample use phone GPS
Version = which OS version does the sample require

Filename	Risk	Internet	SMS	MMS	Install	Store	Enc	GPS	Version
./3Banana.notes.apk	11	**Yes**						**Yes**	1.5
./47_32590_11073013120108667jng9o1.apk	22	**Yes**	**Yes**					**Yes**	
./AdvancedTaskManager-3.7-.apk	4								1.5
./DroidBreakout_v1.-.4.apk	0								
./DungeonHunter.working.apk	3	**Yes**							2.0

Risk Evaluation Engine Output

Automatic Analysis Report

A fair dataset

- **947** samples, checked to be *clean*
- **107** *malicious* samples, taken from Contagio's dump and exchange with NetQin
- Do not re-use samples used for weight
- Do not use our own malicious samples

									ersion
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./DungeonHunter.working.apk	3	**Yes**							2.0

Highest scores

Sample	Score	Name
7734626341799e6ec8c3db21722b	61	Android/DroidKung-Fu.B!tr
0f2375e7c3239b569a0b0322261b	58	Android/Pjapps.B!tr
com.swampy.sexpos.apk	58	Android/Geinimi.A!tr
Andr_PJApps-Gen_f051eeab57e42d5...apk	57	Android/Pjapps.A!tr
jeecalendar.apk	56	Android/CrazyVampire-.A!tr
0091556ed96b3b5aa0af62e70751	54	Android/DroidKungFu-.D!tr
BatterySaver.apk	52	Android/FakeDoc.A!tr
6_35228_1c0a6b1c5d24cbba9b1	51	Android/DroidCoupon-.A!tr
golddream_sample.apk	51	Android/GoldDream.A!tr

Detailed output for Android/PJapps

./steamy-PJAPPS-iNFECTED.apk	52	**Yes**	**Yes**		

```
URL: http://ads.dt.mydas.mobi/getAd.php5?asid=
URL: http://www.latest.androidpickup.appspot.com/request
URL: http://androidpickup.appspot.com/signup?..
URL: http://xxxxxxxxx9:8618/client/android/a.apk
Trying to download an APK (1)
..
Uses HTTP (3)
Probably does HTTP POSTs (7)
Probably connects to Internet (10)
Permission to write/send SMS (15)
Permission/Action filter to receive SMS/WAP Push (19)
Requesting permission to install packages (20)
Package signed on Feb 29 2008
```

Detailed output for Android/PJapps

./steamy-PJAPPS-iNFECTED.apk	52	**Yes**	**Yes**		

```
Certificate info:
Owner: EMAILADDRESS=android@android.com ..
Serial no: 936eacbe07f201df
Uses Android Dev Certificate (21)
..
Code sends SMS: sendTextMessage|
  sendMultipartTextMessage spotted (30)
Code probably reads SMS: SMS stuff spotted (35)
Reads phone IMEI: getDeviceId spotted (39)
Reads phone IMSI: getSubscriberId spotted (42)
Gets carrier: getNetworkOperator spotted (43)
Gets phone number: getLine1Number spotted (45)
getSimSerialNumber spotted  (47)
..
Possibly sending email. (50)
Listing installed packages spotted ...
RISK SCORE:  52
```

Android/PJapps: How accurate?

Raising the alarm	YES

Android/PJapps: How accurate?

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Sends SMS	YES

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Retrieves IMEI, IMSI, operator, phone number	YES

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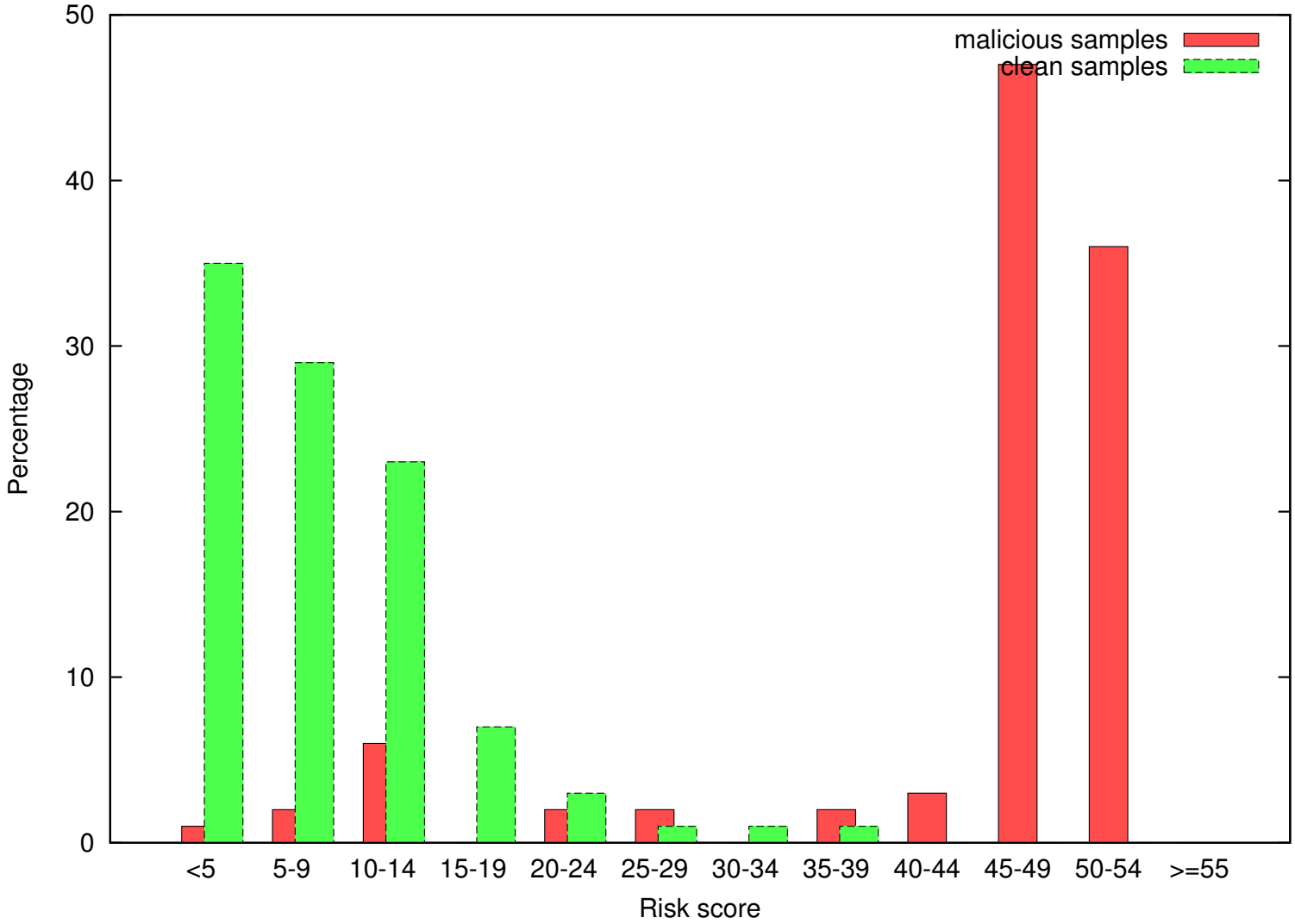
Lists installed packages	YES
Sends emails	Yes, but not used in the malicious part

Why does it work?



Limitations... by design?

False positives / negatives depend on threshold.

Score too high (false positive)

Prepay Widget - display plan's balance - risk score: *36*

- sends USSD commands: call property detector
- read incoming SMS for operator's reply to USSD commands: SMS receiver detector
- Russian certificate: geographical detector
- Test if rooted (dialer in background): Runtime.exec() detector

Typically also for hacking, rooting, system tools.

Score too low (false negative)

- Fail to disassemble: code property detectors not run. Solution: use another tool.
- Very simple malware: triggers only few detectors

Limits Example: Android/SndApp

Android/SndApp

Collects IMEI, phone number, network country, operator's name, email address of the victim.
Sends this to a remote web site.

- Retrieve IMEI, operator and phone number: DETECTED

Reads phone IMEI: getDeviceId spotted
Gets carrier: getNetworkOperator spotted
Gets phone number: getLine1Number spotted

- Retrieve network country: Not detected, but not sensible?
- Retrieve email addresses: TO DO
- URL information is sent to: DETECTED

Risk score: 12

Not enough detectors are raised.
Raise weight of these detectors?
Create combination detector for sending private data?

Future Work

- Performance: search in parallel or apply pre-filtering etc
- Adding / improving new detectors (e.g use of AccountManager)
  - Searching for commands in executables (chmod, execve, mounting system partition) - NEW
  - Detect executables in ./lib - NEW
  - Detecting AOSP certificate - NEW
  - Combinations: concealing SMS with `abortBroadcast`, AOSP & INSTALL_PACKAGES NEW
  - Improve malicious URL detection: use prior work and apply to mobile world?
- Data mining to compute weights
- Test against larger sets

Thank You !

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Slides edited with LOBSTER=LaTeX+*Beamer* + *Editor*