TECHNISCHE UNIVERSITÄT DRESDEN

ResUbic

QualiFune

Fakultät Informatik Institut für Software- und Multimediatechnik - Lehrstuhl für Softwaretechnologie

Energy Labels for Mobile Applications

ACSE

Claas Wilke

13.11.2012

Europa fördert Sachsen. ESF Europäischer Sozialfonds SACHSEN

DRESDEN concept Exzellenz aus Wissenschaft und Kultur


YOU ARE LOST, YOU'RE
WITHOUT A SMARTPHONE...
AGAIN...
Verkehrs-
beeinträchtigung
durch
Baustelle Bohlweg
Parkleitsystem
htc
menu

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PROBLEM

2000

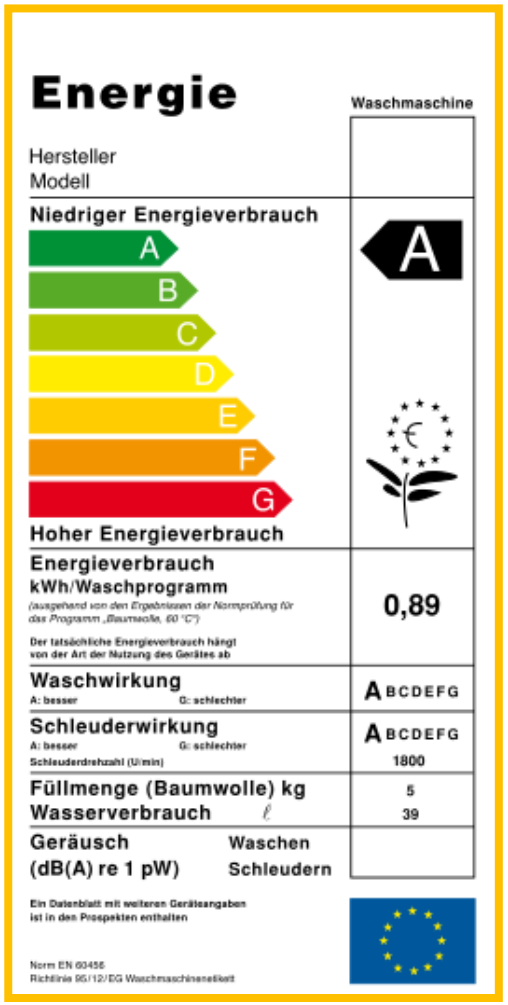
2012

http://graphjam.files.wordpress.com/2012/03/funny-graphs-gadgets-vs-gadgets.jpg
http://www.techwench.com/wp-content/uploads/2011/03/Six-Upcoming-High-End-Android-SmartPhone-on-Spring-2011-6-600x543.jpg
http://www.guide2wdw.com/images/2012%20News/iPhone-Low-Battery.jpg

PROBLEM

- Mobile devices have **limited battery** uptime
- Depending on usage, **uptime can vary** heavily
- Although providing similar services, **different applications** consume different amounts of energy
- Users **select** their applications **based on community rankings** but not on power consumption

If you buy a washing machine …



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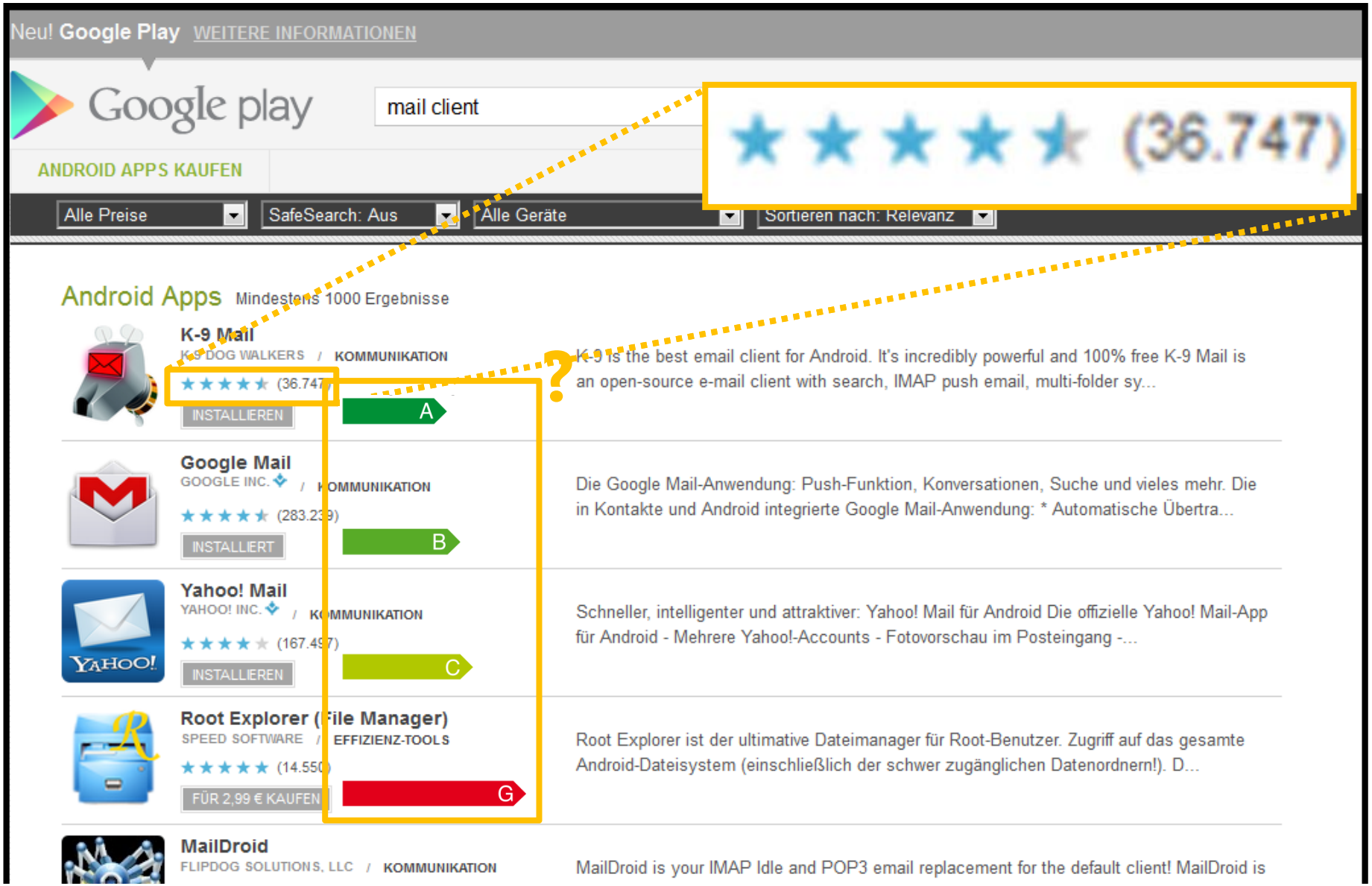
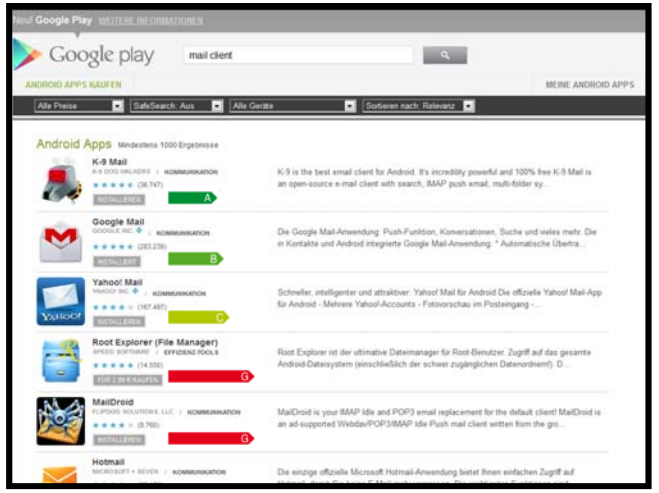
If you buy/install an app ...



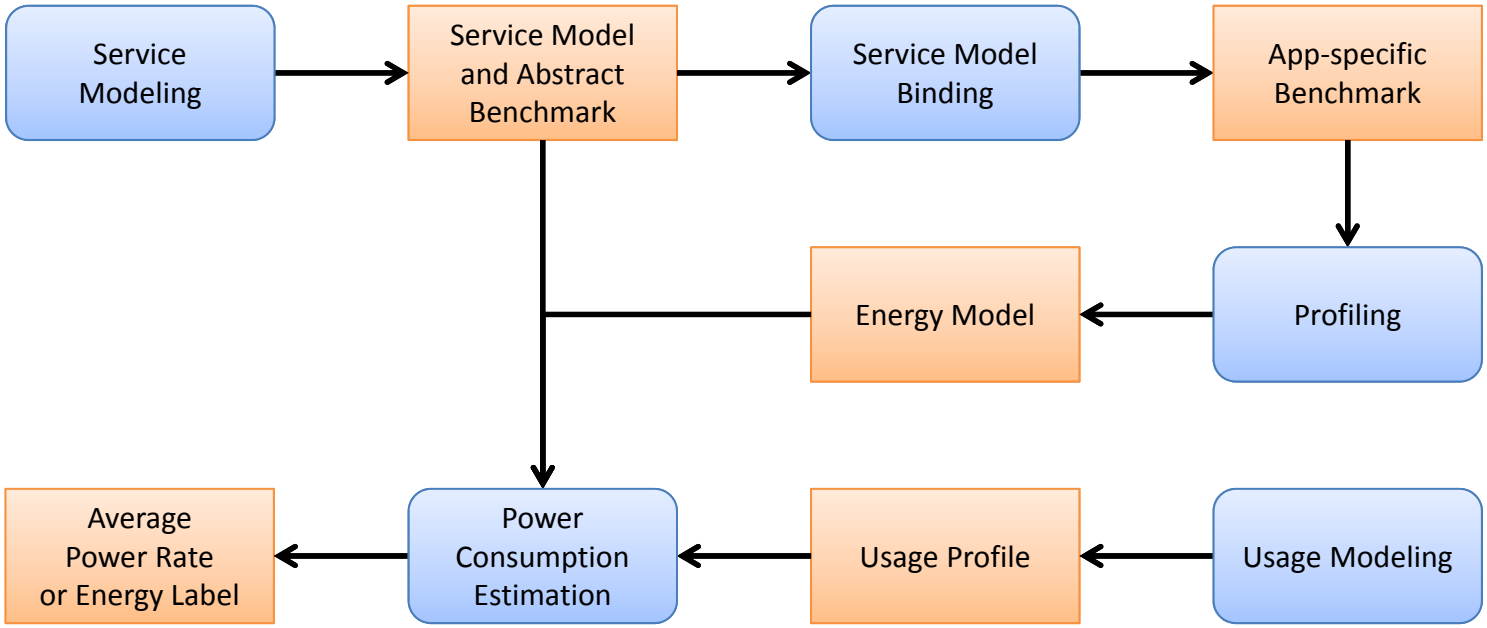
TARGET

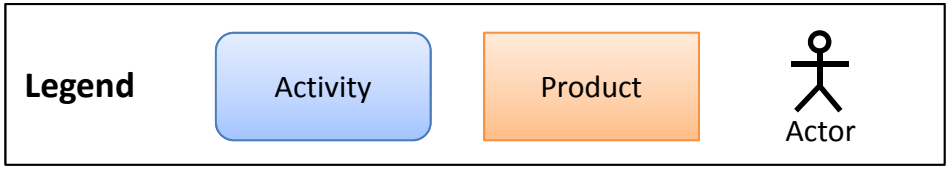
- A process to **predict power consumption** of applications based on
  - A **consumption model** and
  - A **usage profile**
- Provide **energy labels** for apps comparing their consumption w.r.t. similar functionality

  → App store with energy labels

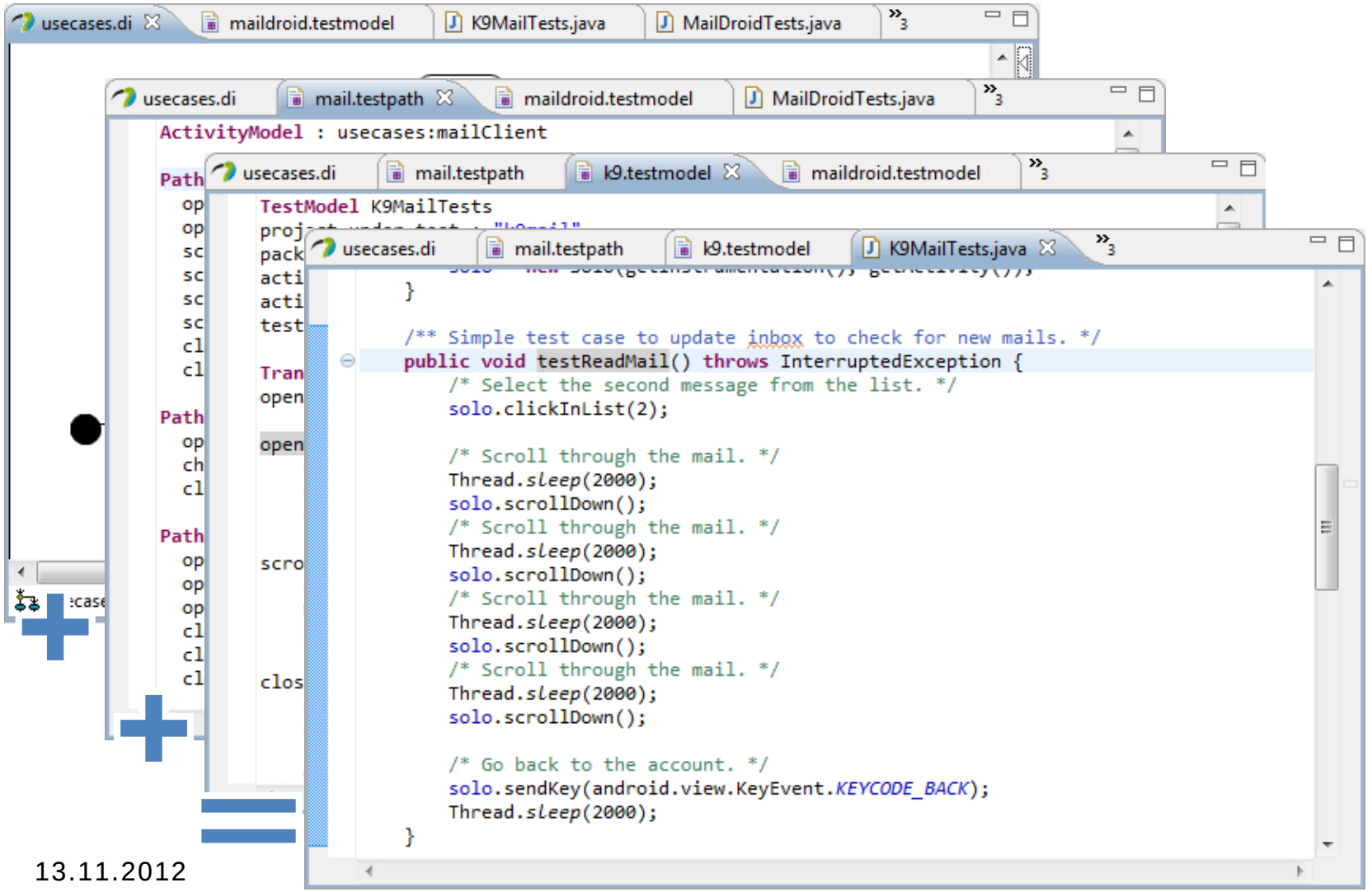


Energy Labeling Process

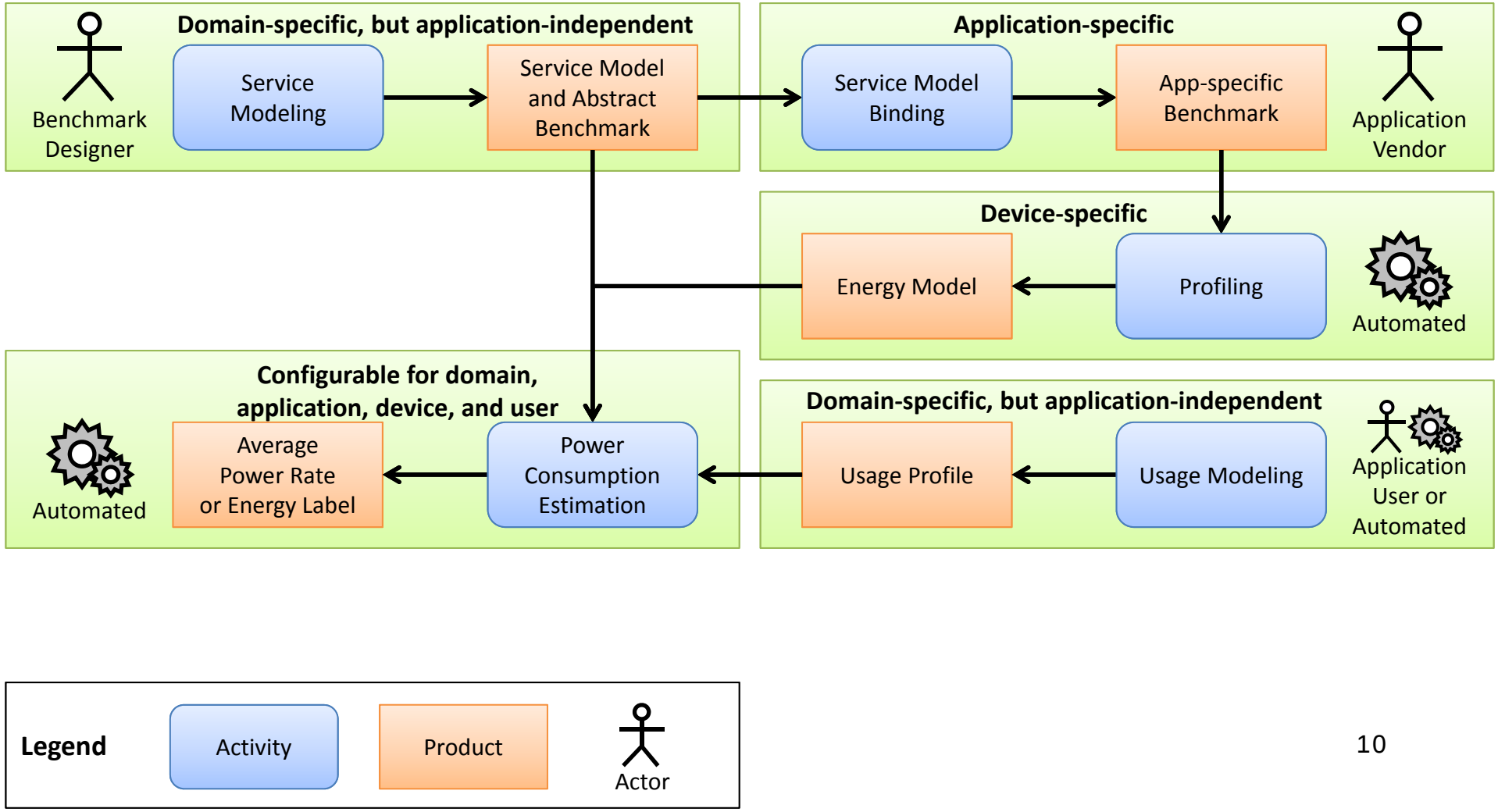




Benchmark Instatiation



Energy Labeling Process



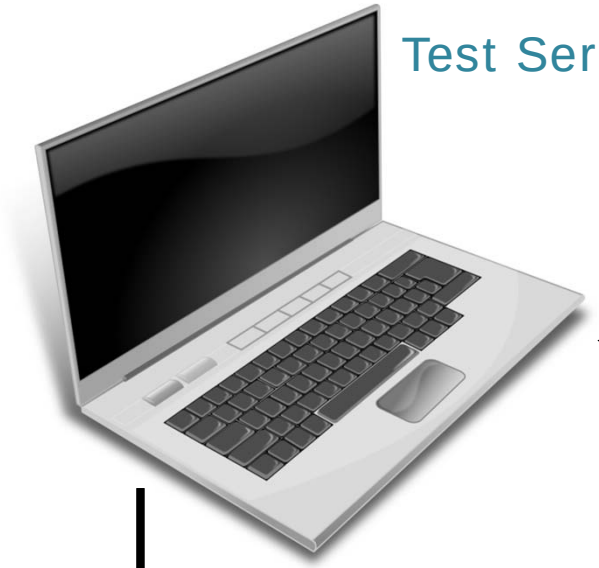
MAJOR CHALLENGES

1. **Energy profiling method**
   - How to correlate power consumption and executed services?
2. **Energy benchmarking**
   - Do apps influence the energy consumption significantly?
   - Can similar services consume different amounts of energy?
3. **User behavior profiling and modeling**
4. **Energy label computation**

PROFILING

- **Devices** as **black boxes**
- **Execution** of **workloads** represented by **unit tests**
  - **Represent user activities**
  - Click button, enter text, …
- **Power** rate **profiling** in parallel

Power Consumption Profiling



Test Server

Device under Test

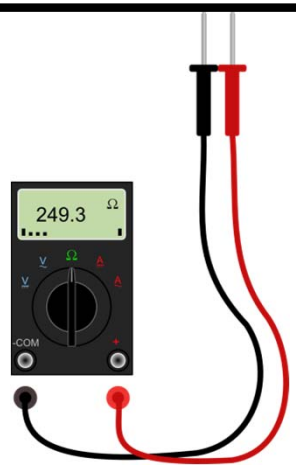
Test Execution

Events

Power Rates

Energy Profile

Use Case	Time	Rate	Cons
A	12	3.5	42.0
B	8	3.2	25.6
C	10	3.2	32.0

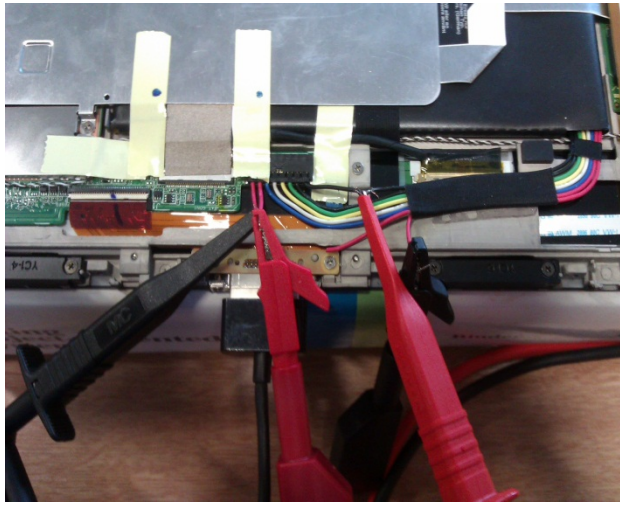


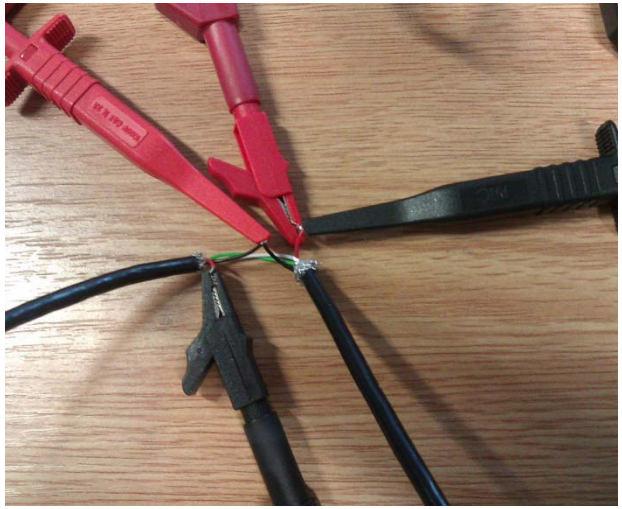
Power Meter

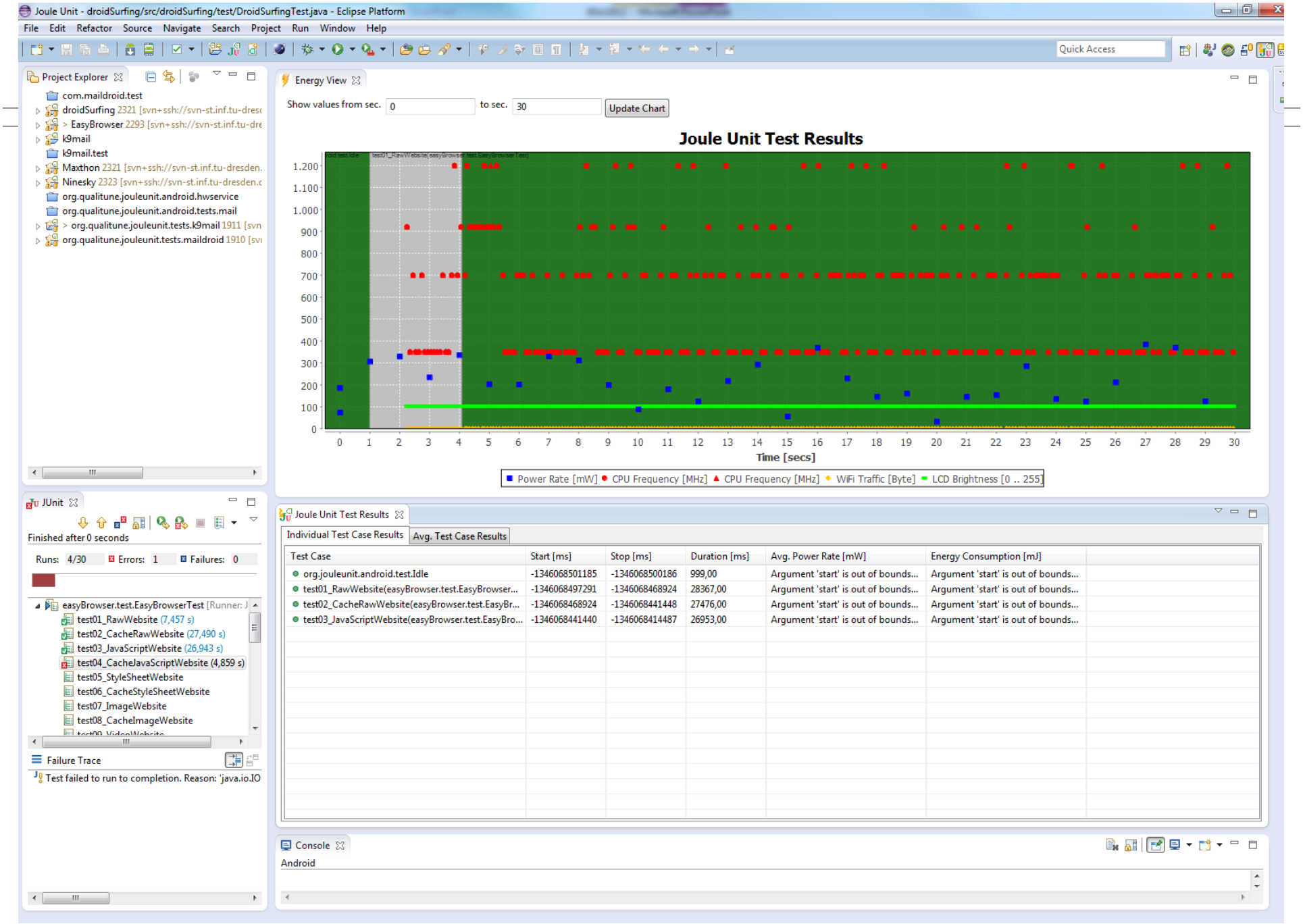
ANDROID PROFILING

- **Extension** of Android **JUnit** runner
  - **Tests** for **third party code** possible
- **Test server**
  - Integration of **external power meter** hardware
  - **Result computation** and presentation **in Eclipse**

Energy Profiling






Joule Unit - droidSurfing/src/droidSurfing/test/DroidSurfingTest.java - Eclipse Platform
File Edit Refactor Source Navigate Search Project Run Window Help
Quick Access
Project Explorer
com.maildroid.test
droidSurfing 2321 [svn+ssh://svn-st.inf.tu-dresc
> EasyBrowser 2293 [svn+ssh://svn-st.inf.tu-dre
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Maxthon 2321 [svn+ssh://svn-st.inf.tu-dresden.
Ninesky 2323 [svn+ssh://svn-st.inf.tu-dresden.c
org.qualitune.jouleunit.android.hwservice
org.qualitune.jouleunit.android.tests.mail
> org.qualitune.jouleunit.tests.k9mail 1911 [svn
org.qualitune.jouleunit.tests.maildroid 1910 [svi
Energy View
Show values from sec. 0 to sec. 30 Update Chart
Joule Unit Test Results
1.200
1.100
1.000
900
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Time [secs]
Power Rate [mW] CPU Frequency [MHz] CPU Frequency [MHz] WiFi Traffic [Byte] LCD Brightness [0 .. 255]
JUnit
Finished after 0 seconds
Runs: 4/30 Errors: 1 Failures: 0
easyBrowser.test.EasyBrowserTest [Runner: J
test01_RawWebsite (7,457 s)
test02_CacheRawWebsite (27,490 s)
test03_JavaScriptWebsite (26,943 s)
test04_CacheJavaScriptWebsite (4,859 s)
test05_StyleSheetWebsite
test06_CacheStyleSheetWebsite
test07_ImageWebsite
test08_CacheImageWebsite
Failure Trace
Test failed to run to completion. Reason: 'java.io.IO
Joule Unit Test Results
Individual Test Case Results
Avg. Test Case Results
Test Case
Start [ms]
Stop [ms]
Duration [ms]
Avg. Power Rate [mW]
Energy Consumption [mJ]
org.jouleunit.android.test.Idle -1346068501185 -1346068500186 999,00 Argument 'start' is out of bounds... Argument 'start' is out of bounds...
test01_RawWebsite(easyBrowser.test.EasyBrowser... -1346068497291 -1346068468924 28367,00 Argument 'start' is out of bounds... Argument 'start' is out of bounds...
test02_CacheRawWebsite(easyBrowser.test.EasyBr... -1346068468924 -1346068441448 27476,00 Argument 'start' is out of bounds... Argument 'start' is out of bounds...
test03_JavaScriptWebsite(easyBrowser.test.EasyBro... -1346068441440 -1346068414487 26953,00 Argument 'start' is out of bounds... Argument 'start' is out of bounds...
Console
Android

A FIRST CASE STUDY

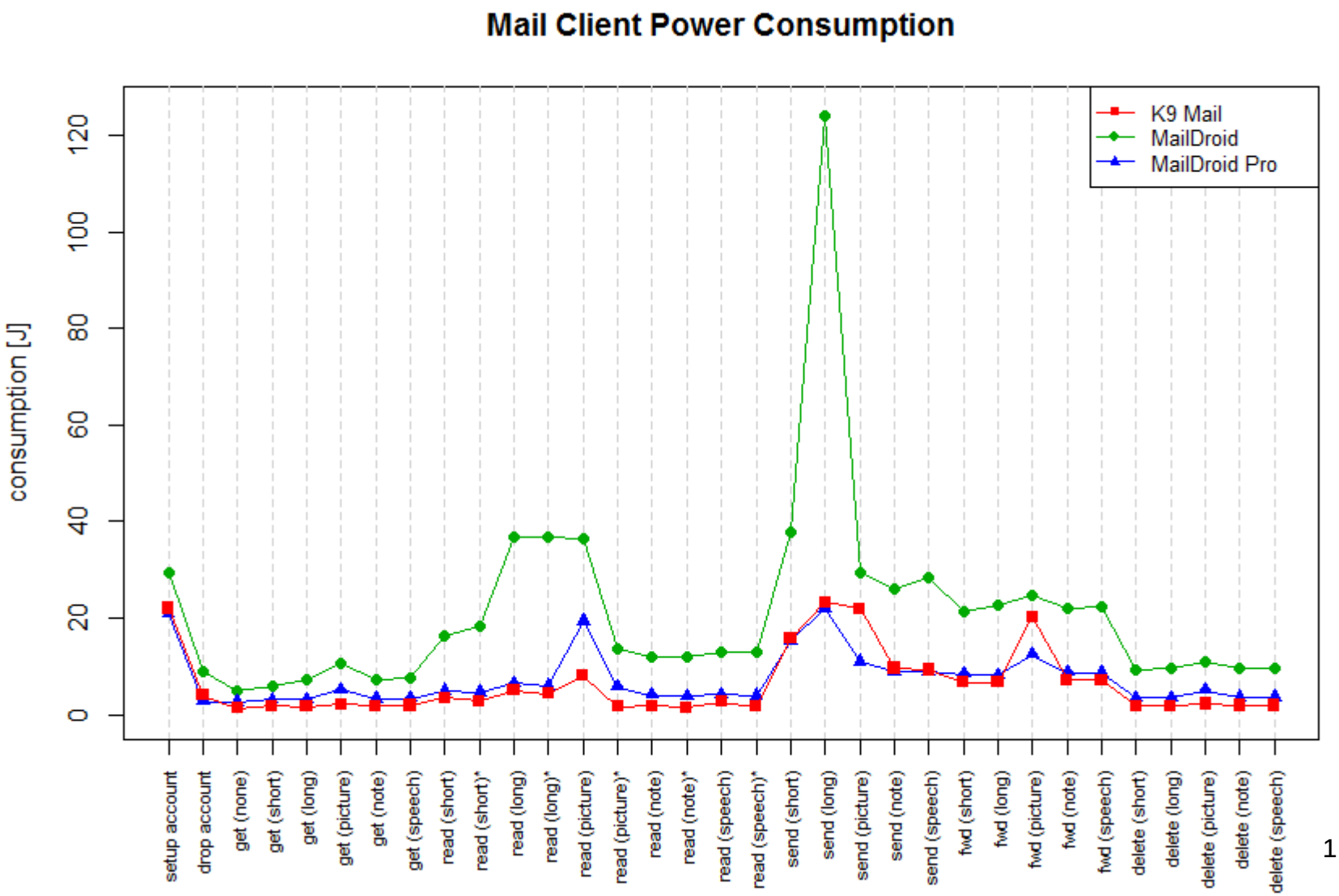
- **Comparing email clients**

K9 Mail
(> 1,000,000 downloads)

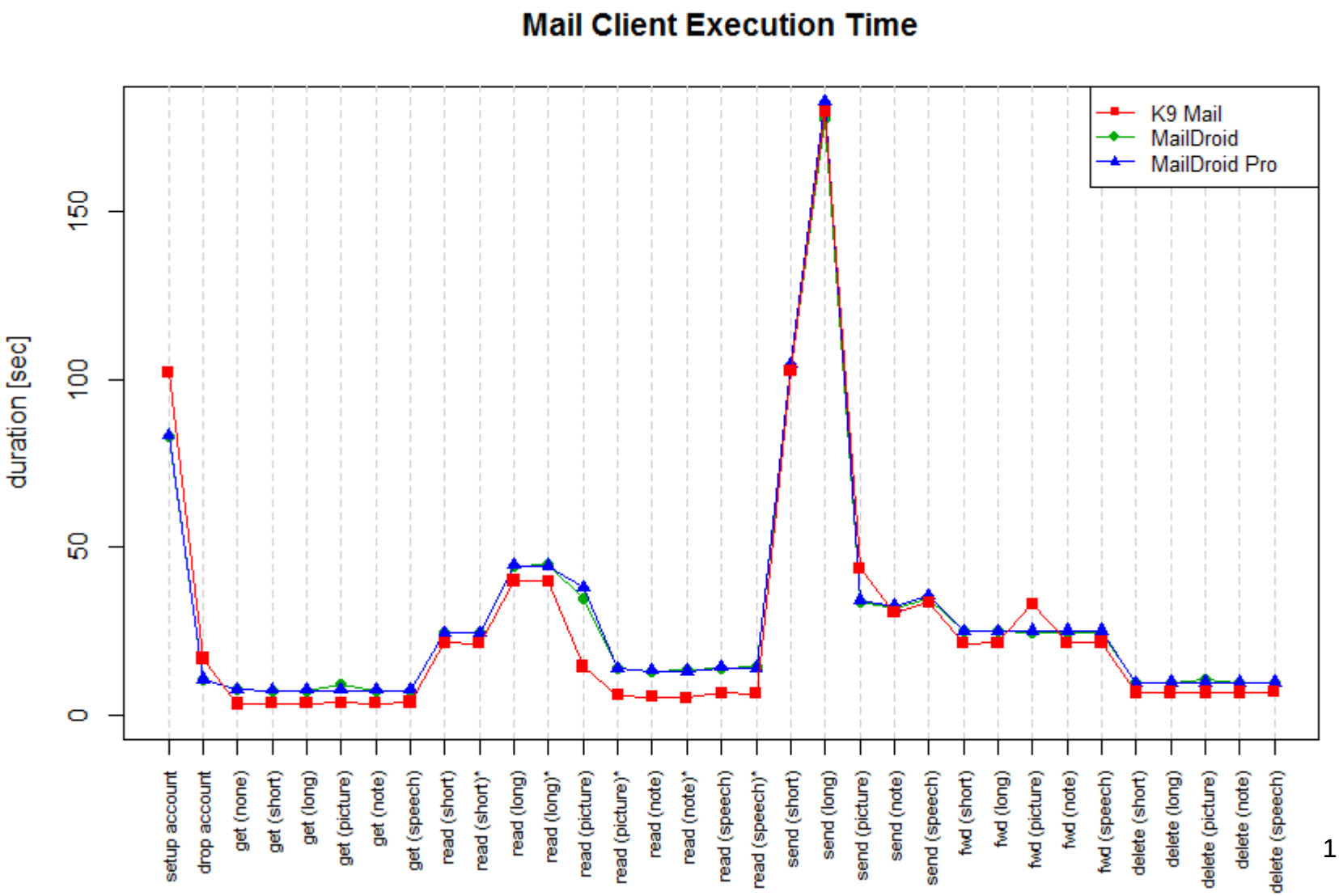
Mail Droid
(> 500,000 downloads)

- **Power consumption** for **simple use cases**
  (check mails, open mail, open attachment, background service)

Results


Mail Client Power Consumption
consumption [J]
0
20
40
60
80
100
120
K9 Mail
MailDroid
MailDroid Pro
setup account
drop account
get (none)
get (short)
get (long)
get (picture)
get (note)
get (speech)
read (short)
read (short)*
read (long)
read (long)*
read (picture)
read (picture)*
read (note)
read (note)*
read (speech)
read (speech)*
send (short)
send (long)
send (picture)
send (note)
send (speech)
fwd (short)
fwd (long)
fwd (picture)
fwd (note)
fwd (speech)
delete (short)
delete (long)
delete (picture)
delete (note)
delete (speech)

Results


Mail Client Execution Time
duration [sec]
0
50
100
150
K9 Mail
MailDroid
MailDroid Pro
setup account
drop account
get (none)
get (short)
get (long)
get (picture)
get (note)
get (speech)
read (short)
read (short)*
read (long)
read (long)*
read (picture)
read (picture)*
read (note)
read (note)*
read (speech)
read (speech)*
send (short)
send (long)
send (picture)
send (note)
send (speech)
fwd (short)
fwd (long)
fwd (picture)
fwd (note)
fwd (speech)
delete (short)
delete (long)
delete (picture)
delete (note)
delete (speech)

INTERPRETATION

→ ***Execution time*** *is* ***no major concern***

→ ***K9 Mail*** *is a* ***bit faster*** *(easier navigation)*

→ *The* ***major power consumer*** *in MailDroid is* ***advertisement***

→ ***K9 Mail*** *and* ***MailDroid Pro*** *behave rather* ***similarly***

→ *However,* ***MailDroid Pro costs 15 Euros*** *…*

LABELS

K9 Mail
(> 1,000,000 downloads)

Mail Droid
(> 500,000 downloads)

Mail Droid Pro
(> 10,000 downloads)

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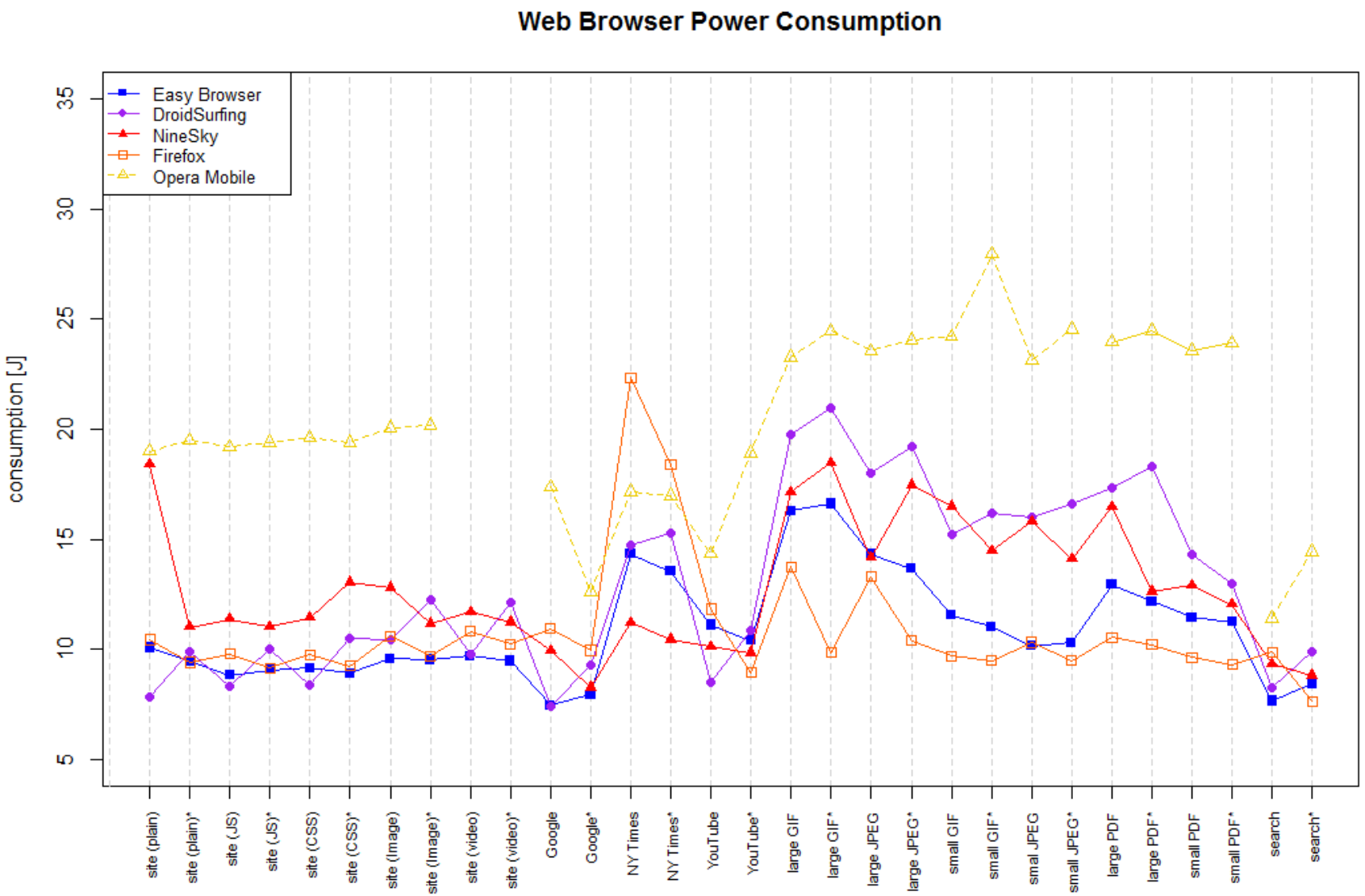
A Second Case Study



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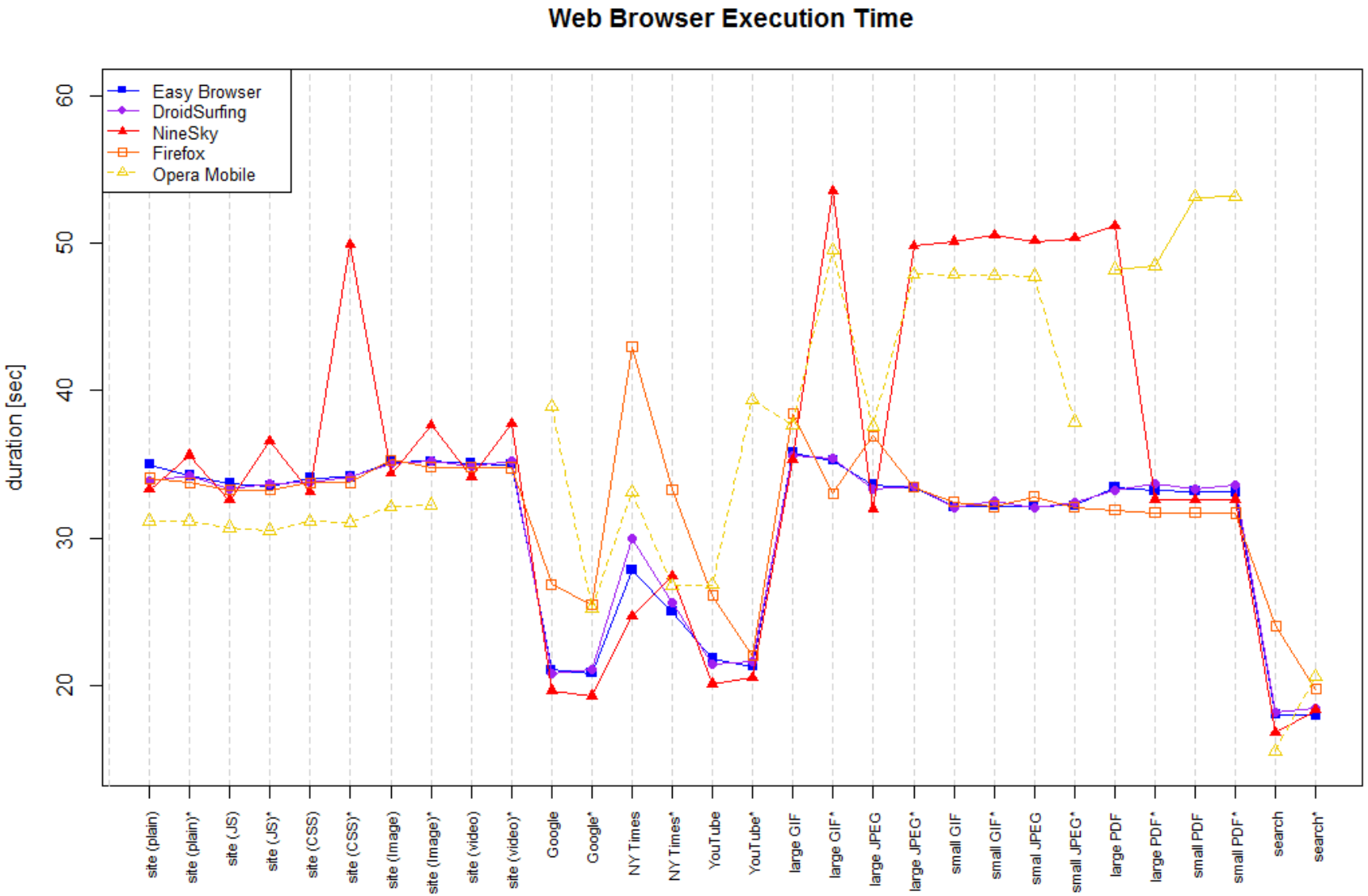
A Second Case Study



COMPARING APPLES AND ORANGES?

- **Apps including** both, **similar and different functionality**?
- Of course, **only similiar features** can be **compared**
- Different features are excluded by **setting** their **usage rate to 0**
  → **Comparison of similar features only**
- Only sensible, **if user is not interested** in these features

ONGOING RESEARCH

- **Further case studies**
  - Browsers
  - MP3 players
- Realization of **energy labeling process**

RELATED WORK

ZHANG et al.

- A **model** for smart phones **power consumption based on** their **hardware utilization**
  - Linear regression model
- **Android app** for applications' **power consumption** approximation
  - **Live approximation based on regression model**
- Identification of **major consumers**
- **No systematic comparison** of similar applications

[ZTQ+10] Zhang, L.; Tiwana, B.; Qian, Z.; Wang, Z.; Dick, R.; Mao, Z. & Yang, L.: *Accurate online power estimation and automatic battery behavior based power model generation for smartphones*. In: Proceedings of the eighth IEEE/ACM/IFIP international conference on Hardware/software codesign and system synthesis, 2010, 105-114.

PALIT et al.

- **Similar profiling** infrastructure
- **Average power consumption** for **typical application use cases**
- Different **devices vary in power consumption** for similar use cases
  - E.g., **energy** consumed **by WiFi** during **Internet browsing**
- **Focus on platforms**, not on applications

[PANS11] Palit, R.; Arya, R.; Naik, K. & Singh, A.: *Selection and Execution of User Level Test Cases for Energy Cost Evaluation of Smartphones.* In: Proceeding of the 6th international workshop on Automation of software test, 2011, 84-90.

[APNS12] Abogharaf, A.; Palit, R.; Naik, K. & Singh, A.: *A Methodology for Energy Performance Testing of Smartphone Applications.* Proceedings of the ICSE-AST 2012, Zurich, Switzerland, June 2-3, 2012., 2012.

PATHAK et al.

- Profiling and identification of **energy bugs**
  - **Approximation method** based on FSMs expressing the phone's energy behavior and system call traces
- Investigation of **several popular Android apps**
  - **Up to 75%** of free app's energy is spent for **advertisement**
  - **I/O operations** consume the most energy
- **Static analysis** tool to find **energy bugs**

[PHZ+11] Pathak, A.; Hu, Y.; Zhang, M.; Bahl, P. & Wang, Y.: *Fine-grained power modeling for smartphones using system call tracing*. In: Proceedings of the sixth conference on Computer systems, 2011, 153-168.

[PHZ12] Pathak, A.; Hu, Y. & Zhang, M.: *Where is the energy spent inside my app?: fine grained energy accounting on smartphones with Eprof*. In: Proceedings of the 7th ACM European conference on Computer Systems, 2012, 29-42.

CONCLUSION

- Mobile **applications consume too much** energy
- **Apps influence power consumption** significantly
- Different apps for **similar services can** significantly **vary in** their **power consumption** (e.g., advertisement)
- **Energy labels** can help **to guide users** to the „green“ apps
- **Comparison** can also **identify major drawbacks** in specific apps‘ implementation

THANK YOU!

- Summing up this talk in 4 minutes: **http://is.gd/energyLabel**
- More information on our project: **http://www.qualitune.org/**
- Contacting me: **claas.wilke@tu-dresden.de**