2015 USENIX Annual Technical Conference
usenix
JULY 8-10, 2015 • SANTA CLARA, CA

SAMSUNG

A New Paradigm for Power Management

MyungJoo Ham / Frontier Computer Science (FCS) Lab



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http://www.callcentermemes.com/wp-content/uploads/2014/10/1414512274783.jpg

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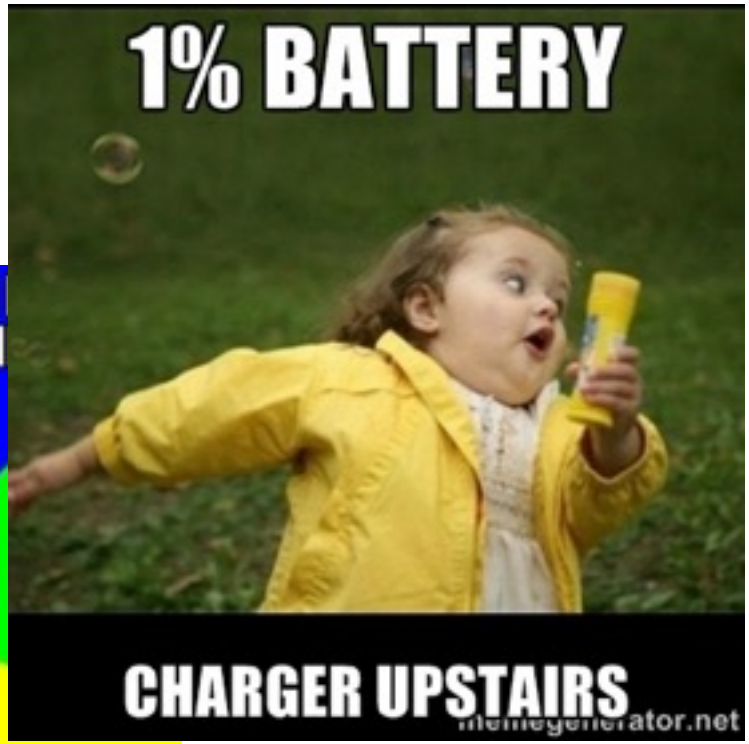
User Experience?



http://memegenerator.net/instance/60729280



http://www.abcmemes.com/meme/unplug-100-charged-iphone-and-text-someone



http://memegenerator.net/instance/14442822



http://memecrunch.com/meme/1E7CM/battery-life

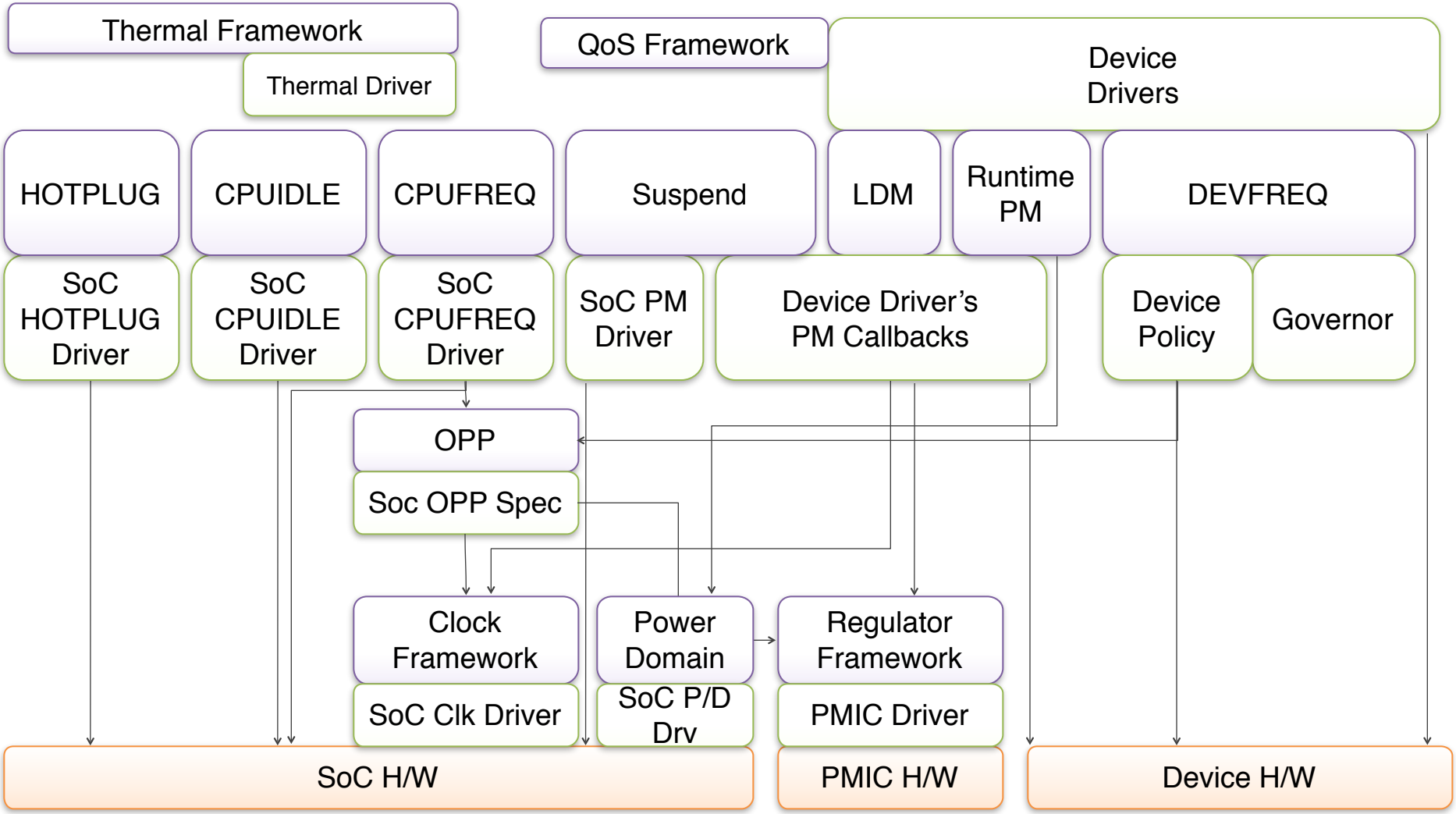
Google Image, “battery meme”

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What We Had Been Doing?

- **Power Management @ Kernel**

A Lot… Really A Lot…



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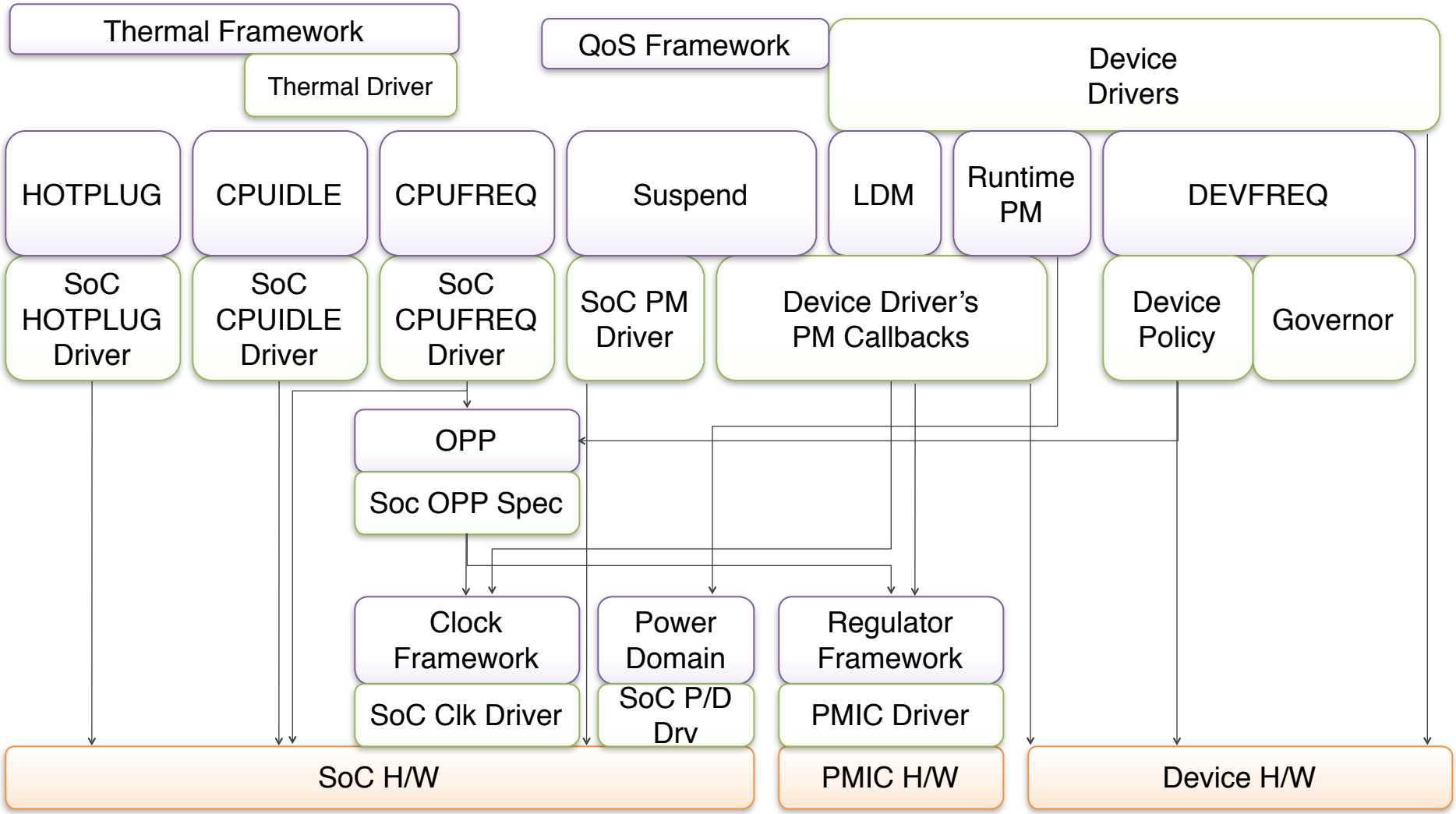


http://www.quickmeme.com/NOT-GOOD-ENOUGH-GORDON-RAMSAY

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Then, What We Have Been Doing Recently?

- **Power Management @ Kernel**

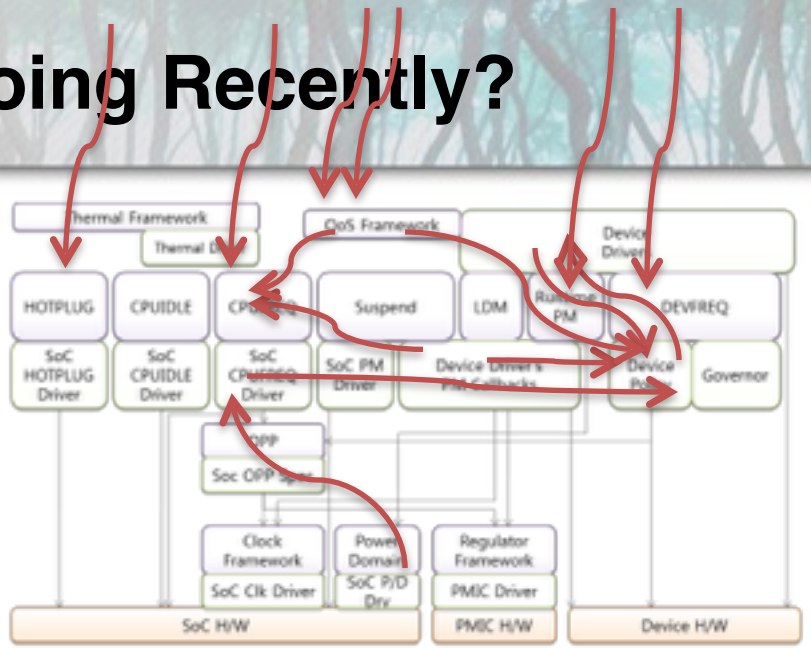


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Then, What We Have Been Doing Recently?

- **Power Management @ Kernel**

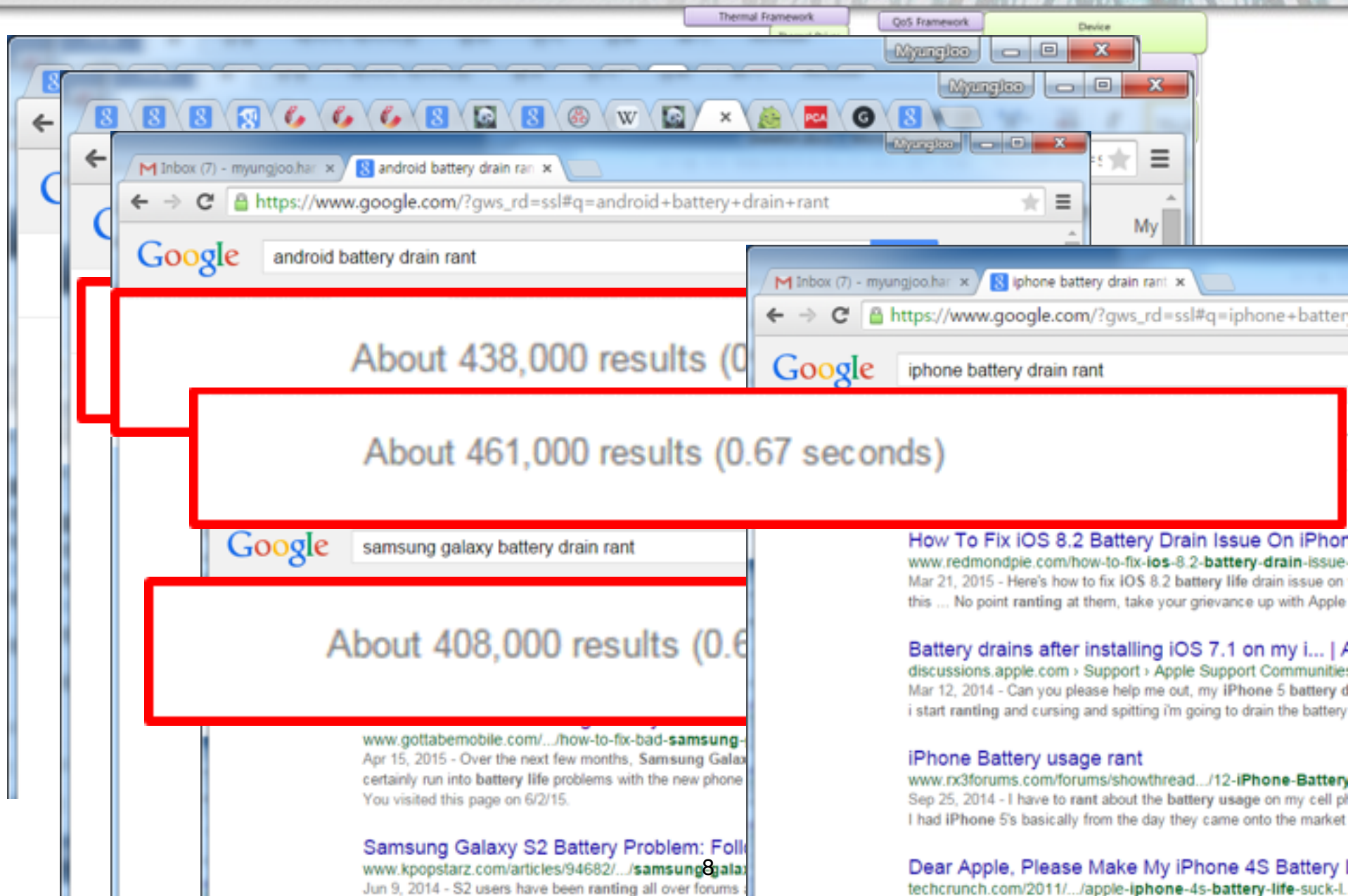
Additional Control Flows



- **Power Management @ Kernel: Device-to-Device Relations**
  - Touch Event → DVFS/Hotplug Boost
  - Video En/Decoder Enable → DVFS Boost to guarantee FPS
  - …
- **Power Management @ Userspace OS**
  - OS Service – DVFS Ties, QoS/Performance related in-OS interfaces
  - …
- **Power Management based on User Intention/Behavior Inference**
  - Smart Stay
  - Ultra Power Saving Mode
  - …



User Reaction?





http://scifi.stackexchange.com/questions/2013/which-episode-is-the-double-facepalm-image-macro-from

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Are We Missing Something?



http://scifi.stackexchange.com/questions/2013/which-episode-is-the-double-facepalm-image-macro-from

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Maybe That's Missing.



http://scifi.stackexchange.com/questions/2013/which-episode-is-the-double-facepalm-image-macro-from

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Maybe That's Missing.



APPLICATIONS!

http://scifi.stackexchange.com/questions/2013/which-episode-is-the-double-facepalm-image-macro-from

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Maybe That's Missing.



APPLICATIO

THIRD PARTY APPLICATIONS!

http://scifi.stackexchange.com/questions/2013/which-episode-is-the-double-facepalm-image-macro-from

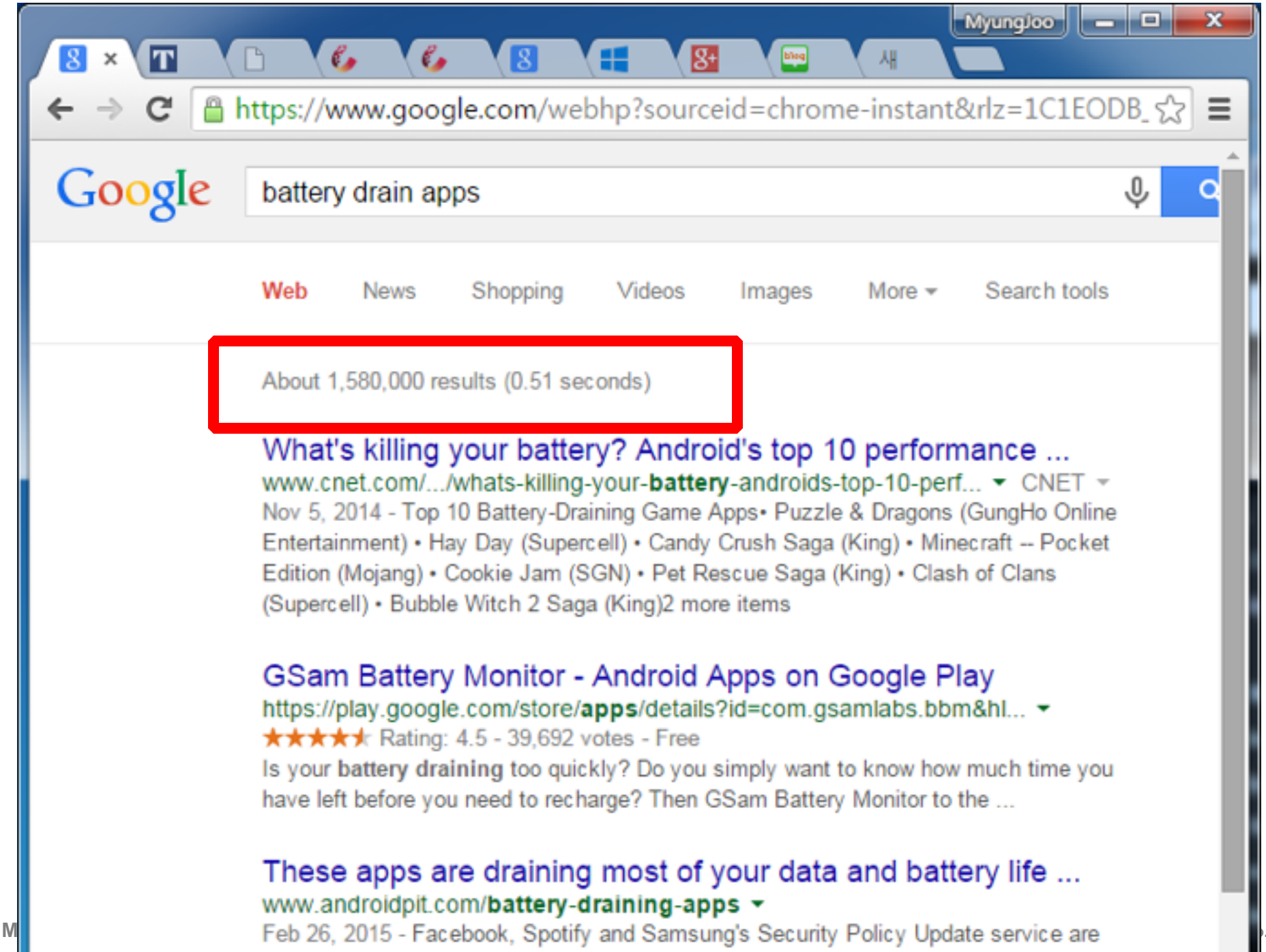
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Is It That BAD?



http://ishareimage.com/double-facepalm-animated-gif.asp

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MyungJoo
https://www.google.com/webhp?sourceid=chrome-instant&rlz=1C1EODB_
Google
battery drain apps
Web
News
Shopping
Videos
Images
More
Search tools
About 1,580,000 results (0.51 seconds)
What's killing your battery? Android's top 10 performance ...
www.cnet.com/.../whats-killing-your-battery-androids-top-10-perf... CNET
Nov 5, 2014 - Top 10 Battery-Draining Game Apps• Puzzle & Dragons (GungHo Online Entertainment) • Hay Day (Supercell) • Candy Crush Saga (King) • Minecraft -- Pocket Edition (Mojang) • Cookie Jam (SGN) • Pet Rescue Saga (King) • Clash of Clans (Supercell) • Bubble Witch 2 Saga (King)2 more items
GSam Battery Monitor - Android Apps on Google Play
https://play.google.com/store/apps/details?id=com.gsamlabs.bbm&hl...
Rating: 4.5 - 39,692 votes - Free
Is your battery draining too quickly? Do you simply want to know how much time you have left before you need to recharge? Then GSam Battery Monitor to the ...
These apps are draining most of your data and battery life ...
www.androidpit.com/battery-draining-apps
Feb 26, 2015 - Facebook, Spotify and Samsung's Security Policy Update service are



These apps are draining your Android phone's battery

POSTED 4:04 PM, JUNE 7, 2015, BY CNN WIRE, *UPDATED AT 04:06PM, JUNE 7, 2015*

U.S. smartphone users have about 30 apps on their smartphones, on average. But the most used apps — messaging, social media, and streaming entertainment — happen to be the biggest guzzlers of battery power, according to a new study of Android phones from AVG Technologies, an online security company.

Some of the worst offenders are apps that run automatically when a phone boots up, whether you open them or not. The biggest offenders in that category are Facebook, Kik, WhatsApp, Facebook Messenger and RetailMeNot. These apps are constantly running in the background, checking for updates and messages.

For apps that don't start automatically, Amazon Kindle, Snapchat, LINE, Spotify, Netflix and Amazon Shopping give battery life the biggest beating — but only when you're actively using them, unlike Facebook, which drains your battery whether you're using it or not. Surprisingly, the Wal-Mart app is the top battery drainer among U.S. Android users in this category.

Myung... ...nics Co.

battery drain apps - Goo × | Owners Complain × | These Apps Are 'Secretly × | MyungJoo

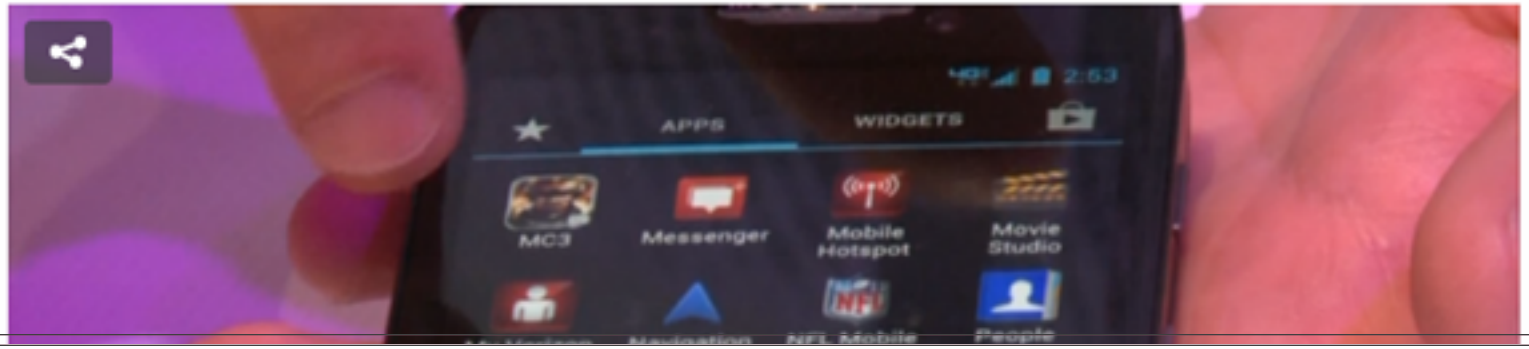
battery drain apps - Google Search

www.myfox28columbus.com/news/features/top-stories/stories/These-Apps-Are-39-Secret

These Apps Are 'Secretly' Draining Your Phone's Battery

Updated: Wednesday, June 10, 2015 | Katelyn Murphy

Like 2 Tweet 0 +1 0 Pin it



2 Like 0 Tweet 0 +1 9 Share

(Kate Murphy) -- If you feel your phone battery draining quickly, it could be running applications that are prone to power zapping.

Many of these apps, that are 'secretly' draining your battery, are messaging, social media and streaming apps.

Applications like Facebook, Kik, Whatsapp, Facebook Messenger and RetailMeNot boot up right away and are constantly running in the background looking for new messages and updates.

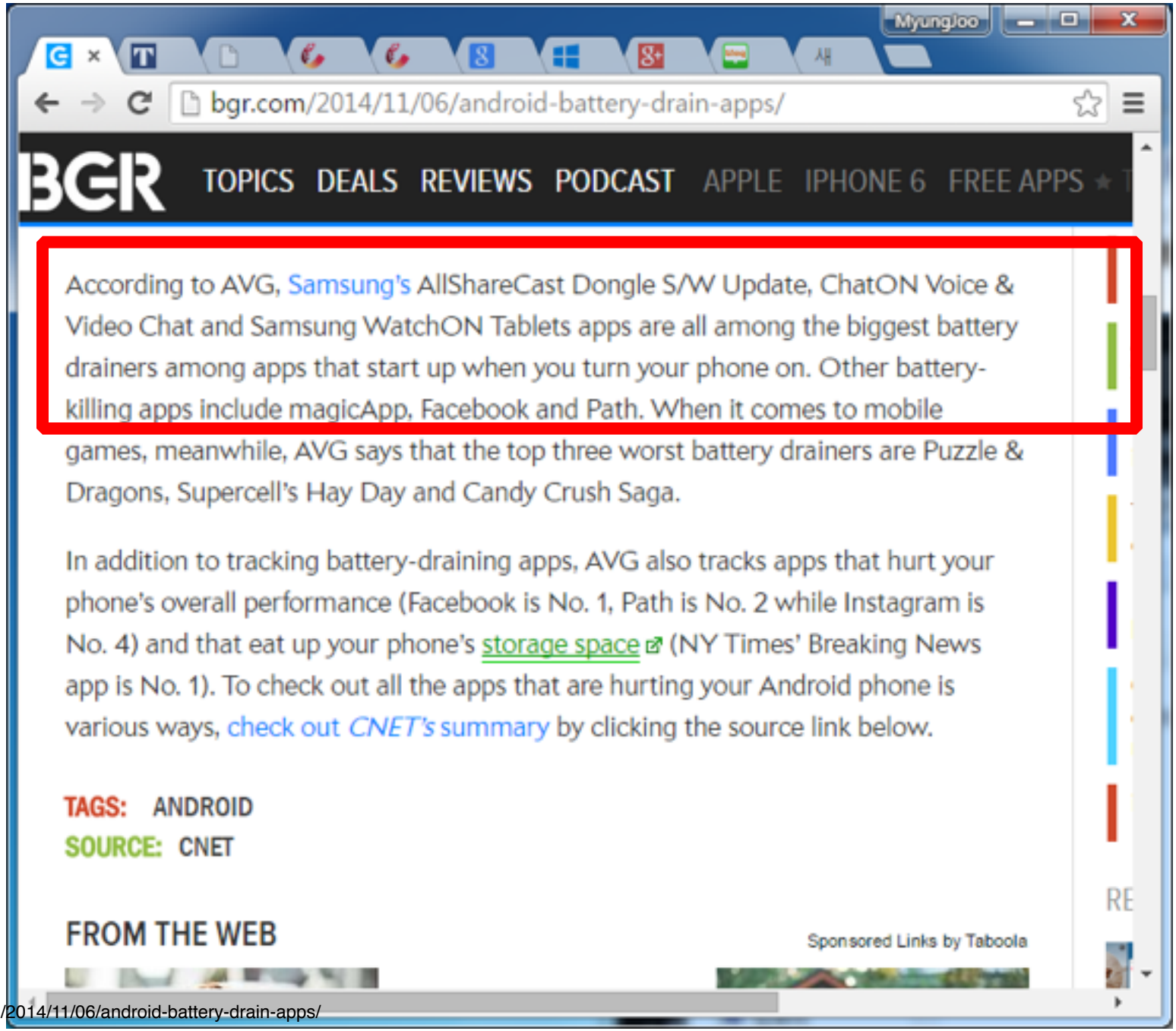
Even apps that don't start up immediately, such as Kindle, Amazon and Snapchat still burn battery power a lot of battery power -- but only when you're actively using them.

To cut down on the power drain, limit your push notifications and turn off the Wi-Fi and GPS when not using it.

http://www.myfox28columbus.com/news/features/top-stories/stories/These-Apps-Are-39-Secretly-39-Draining-Your-Phone-39-s-Battery-147255.shtml#.VXpk_fntlBc

MORE TO EXPLORE

Myung ics Co.



http://bgr.com/2014/11/06/android-battery-drain-apps/

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Examples of App Energy Bugs

- **Apps w/ Wakelock Bugs (Android)**
  - Frequency: even major apps…



1.4.8*
Installs: 5M-10M



1.1.4*
Installs: 10M-50M

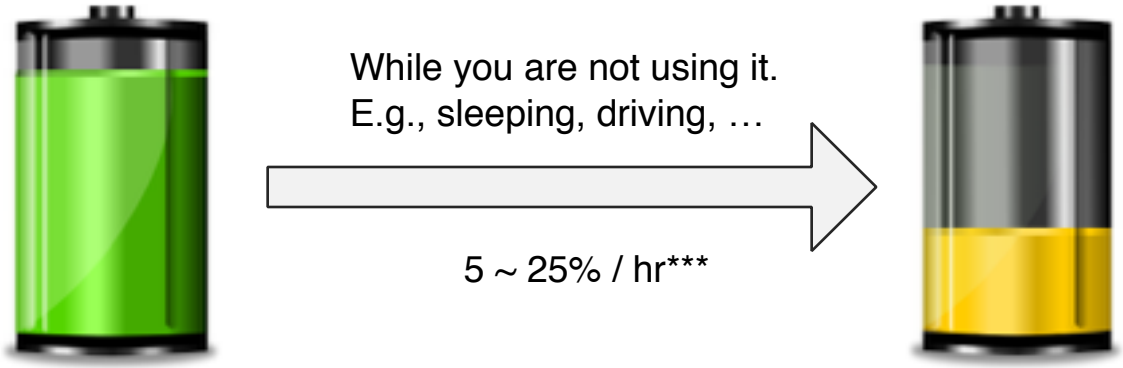


4.0.1.47928040*
Installs: 1B-5B



1.3.0**
Installs: 1B-5B

  - Severity: drains the battery while not using



* Data from http://mobed.yonsei.ac.kr/wakescope
** Data from NSDI'13, "eDoctor: Automatically Diagnosing Abnormal Battery Drain Issues on Smartphones"
*** Data from MobiSys'12, "What is keeping my phone awake?: characterizing and detecting no-sleep energy bugs in smartphone apps"

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Examples of App Energy Bugs

- **Apps w/ Wakelock Bugs (Android)**
  - Frequency: even major apps…
  - Severity: drains t

Properly optimized phone sleeping: < 10mW
Energy bug apps + phone sleeping: ~ 1W

x 100 energy usage!
Your sleepless nights to reduce 10% of sleeping energy are TOTALLY

1.4.8
Instal
-5B



* Data from http://mobed.yonsei.ac.kr/wakescope
** Data from NSDI'13, "eDoctor: Automatically Diagnosing Abnormal Battery Drain Issues on Smartphones"
*** Data from MobiSys'12, "What is keeping my phone awake?: characterizing and detecting no-sleep energy bugs in smartphone apps"
picture from https://www.youtube.com/watch?v=jeYQp0Mt2hA (GTA V screenshot)

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Examples of App Energy Bugs

- **Apps w/ Unnecessary & Excessive Peripheral Device Usage**
  - Frequency: even major apps…

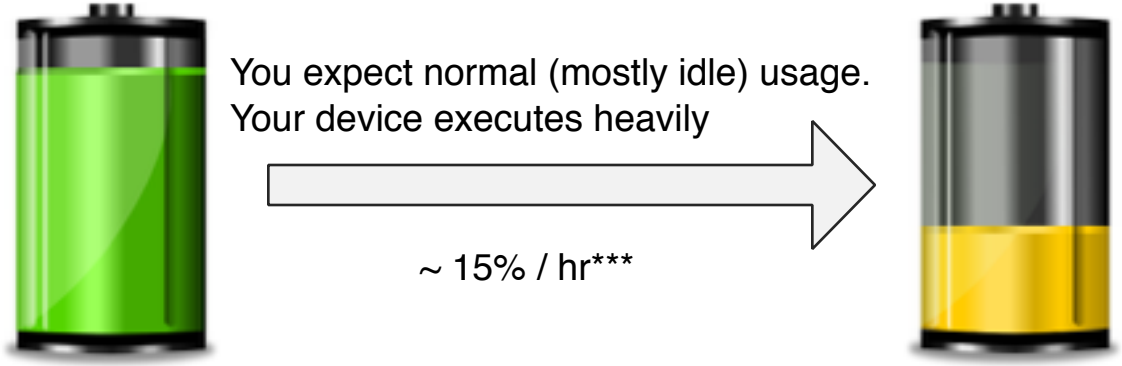


* GPS
Installs: 10M-50M



* GPS
Installs: 10M-50M

  - Severity: drains the battery fast



* Data from MobiSys'12, "What is keeping my phone awake?: characterizing and detecting no-sleep energy bugs in smartphone apps"

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Examples of App Energy Bugs

- **Apps w/ Unnecessary Loops or Immortal Apps**

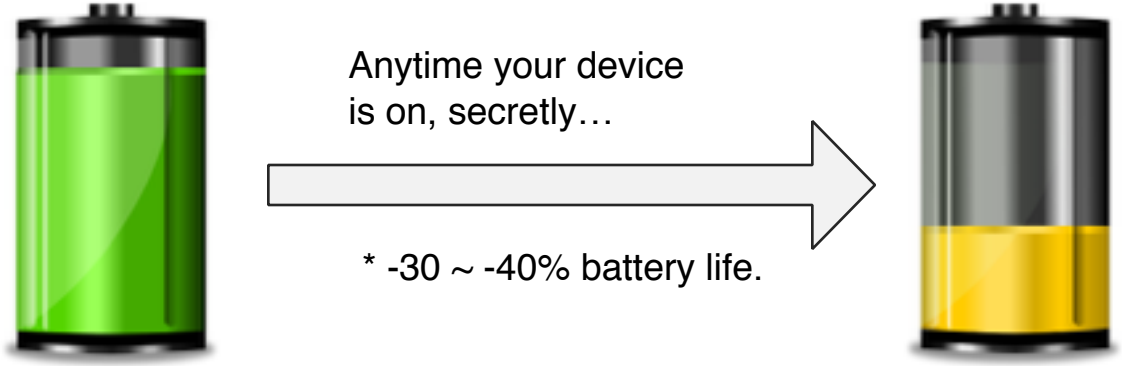


* Background Load
Installs: 100M-500M



* Background Load
Installs: 1B-5B

  - Severity: drains the battery while not using.



* Data from AVG 2014 Q4 Report, “Android App Performance Report"

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OK. Then,
What Should We Look At?



http://ishareimage.com/double-facepalm-animated-gif.asp

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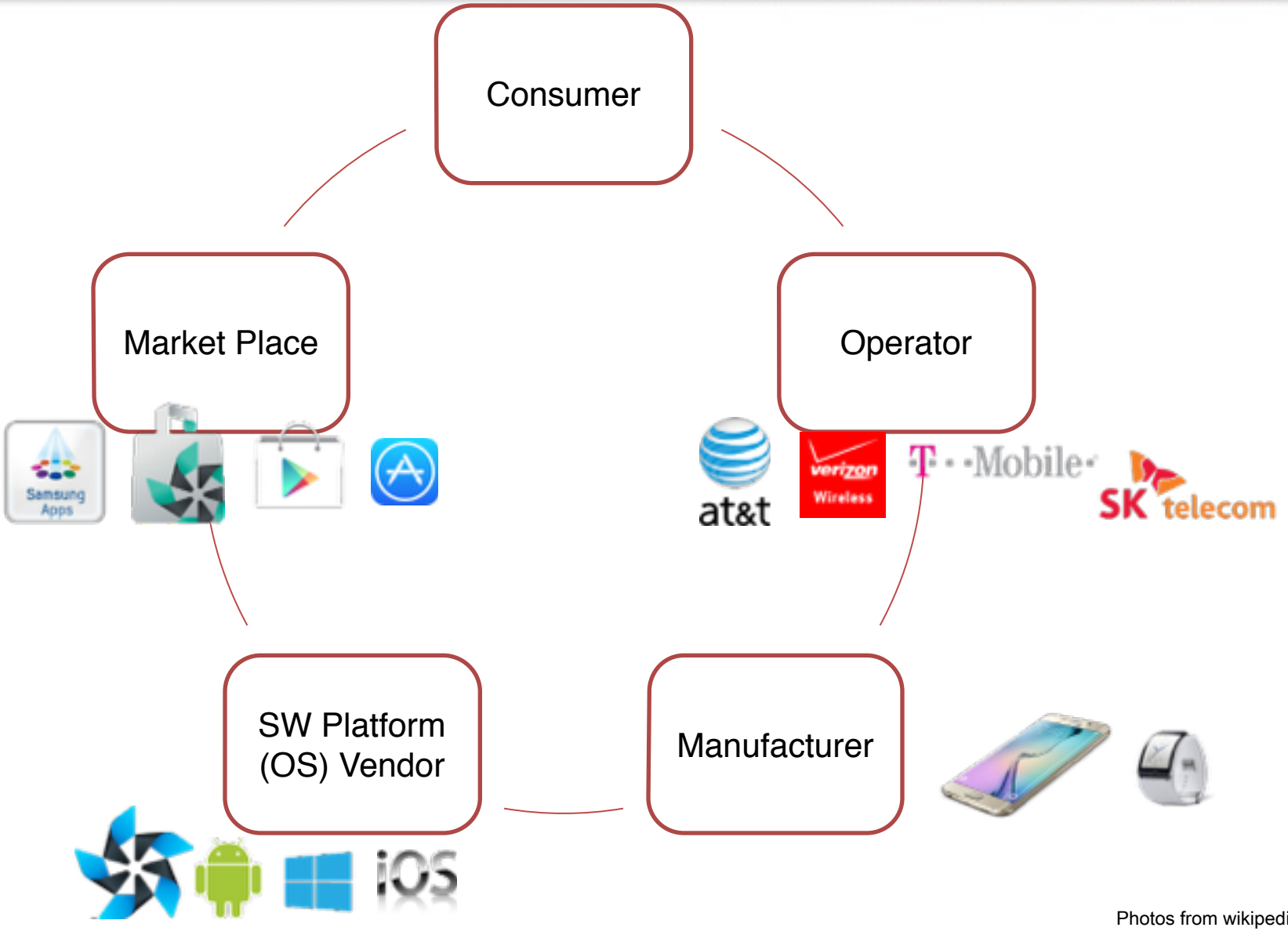


The Whole Ecosystem

Photos from wikipedia, pixabay

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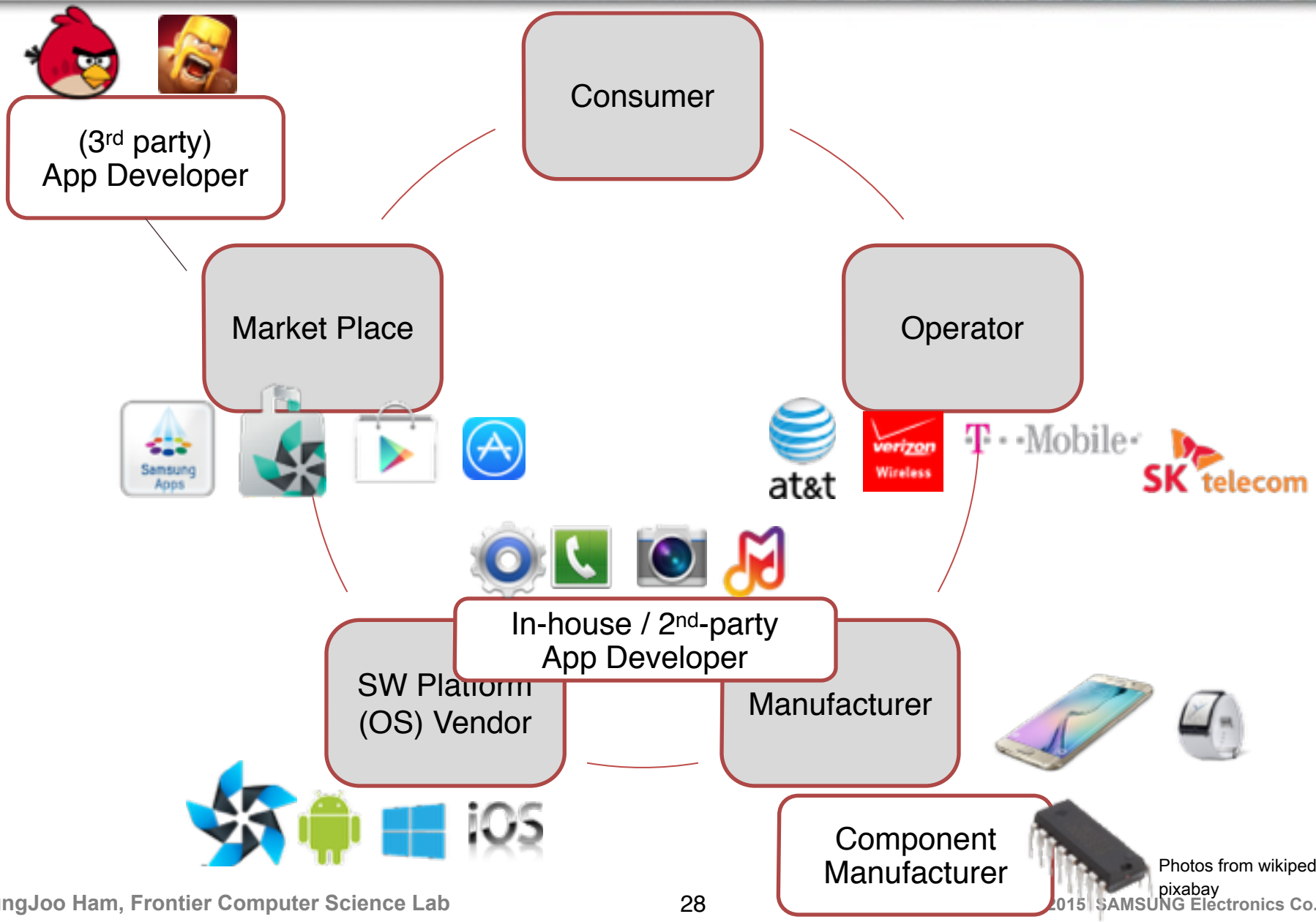
The Big Picture, The Ecosystem



Photos from wikipedia, pixabay

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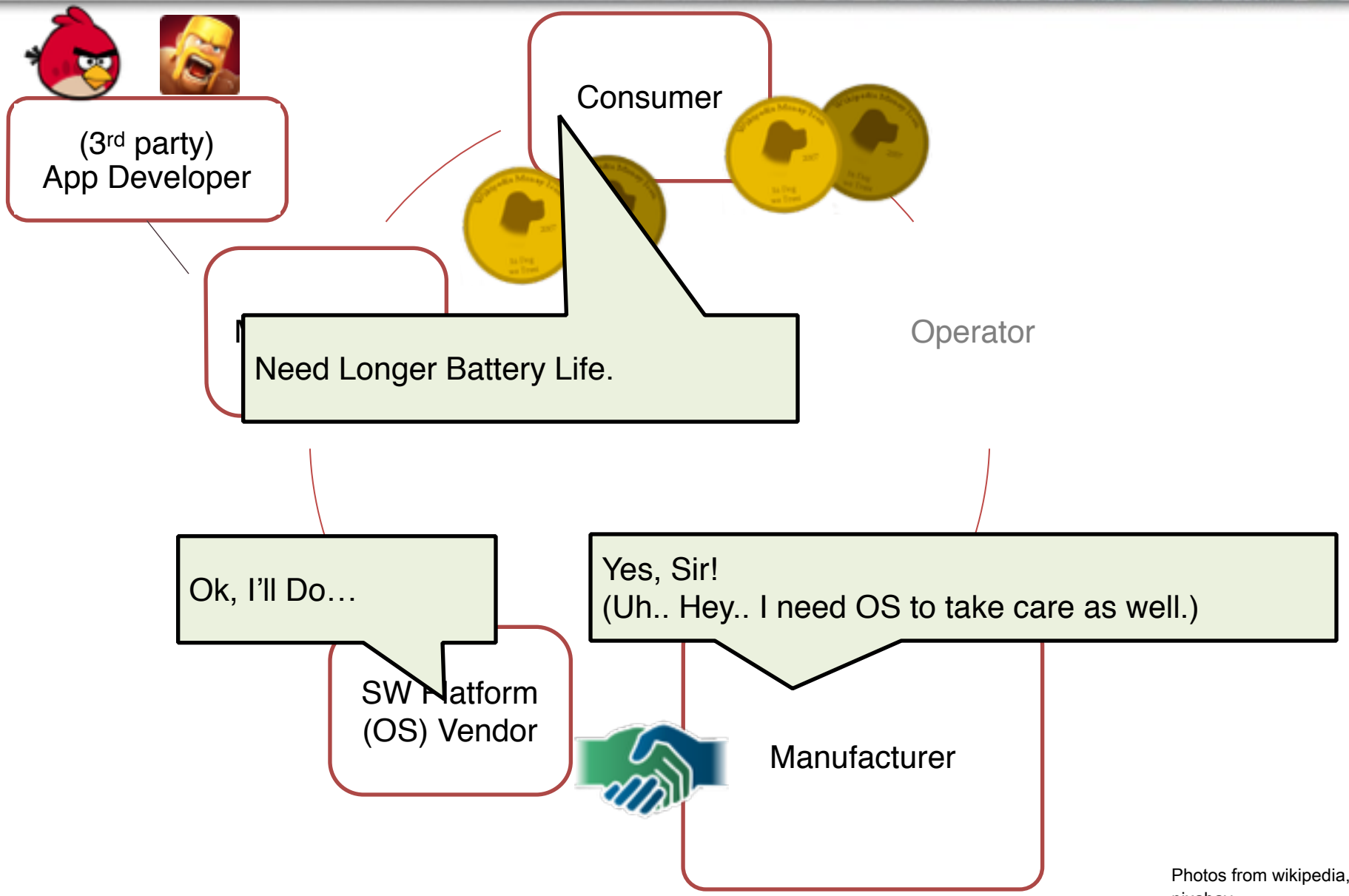
The Big Picture, The Ecosystem, Extended



Photos from wikipedia, pixabay

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The Big Picture, Relations: Money Flows



Photos from wikipedia, pixabay

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The Big Picture, Relations




(3rd party)
App Developer

Consumer

Don't know which app is bad.
(Whatever… the phone maker is bad..)

Operator

Affecting Energy Efficiency Greatly

My Product is affected by them.
But I can do nothing about it…

SW Platform
(OS) Vendor



Manufacturer

Photos from wikipedia, pixabay

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The Big Picture





(3rd party)
App Developer

What If 3rd Party App Developers

Also Address Energy Efficiency?

Market Place



SW Platform
(OS) Vendor



Manufacturer

Photos from wikipedia, pixabay, yonhapnews

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Observation? Stereotypes? OR… Paranoia?

- **It appears that App developers mostly**
  - Do NOT **care power** consumption
  - Do NOT **want to optimize** energy efficiency
  - Do NOT **know how** to optimize energy efficiency

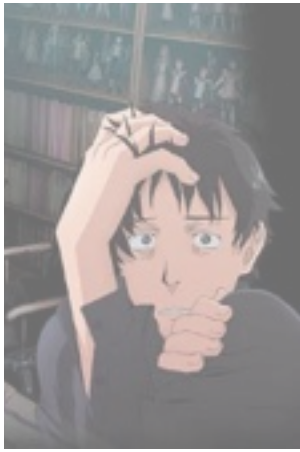


Photo from "Welcome to NHK" / Copyright(C) by GONZO

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Observation? Stereotypes? OR… Paranoia?

- **It appears that USERS mostly**
  - DO **care energy** efficiency
  - DO **blame manufacturers** for energy efficiency
  - DO **not have effective mechanisms**

    to look at the energy efficiency

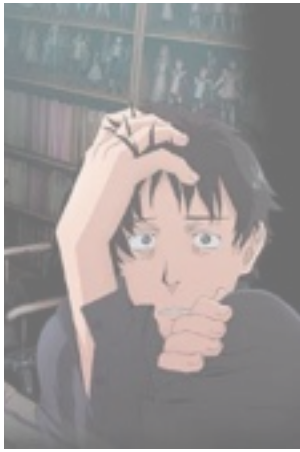


Photo from "Welcome to NHK" / Copyright(C) by GONZO

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Lou Holtz

"Ability is what you're capable of doing.

Motivation determines what you do.

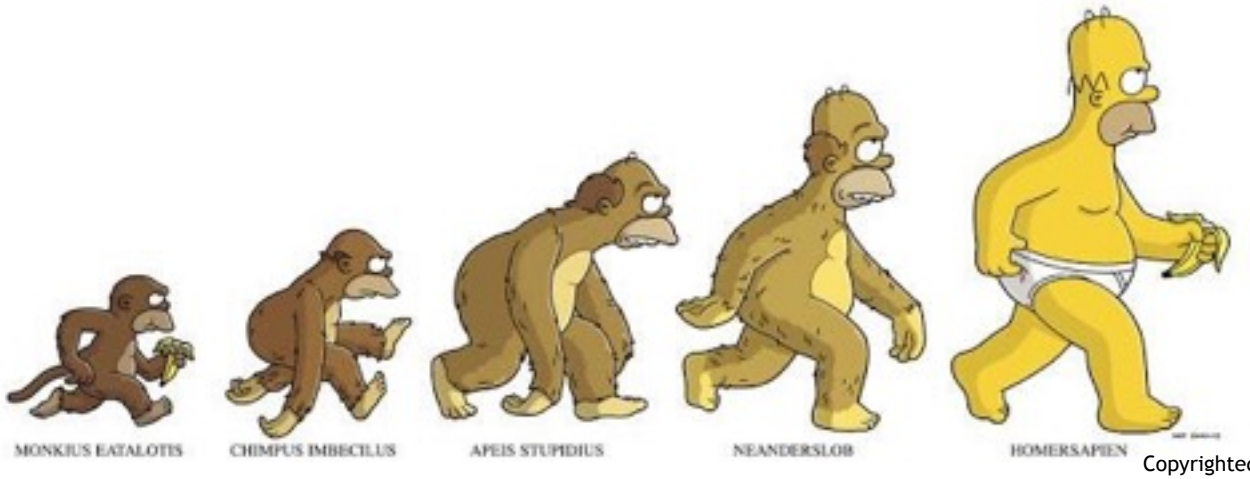
Attitude determines how well you do it."

http://en.wikipedia.org/wiki/Lou_Holtz#/media/File:Lou_Holtz_cropped.jpg

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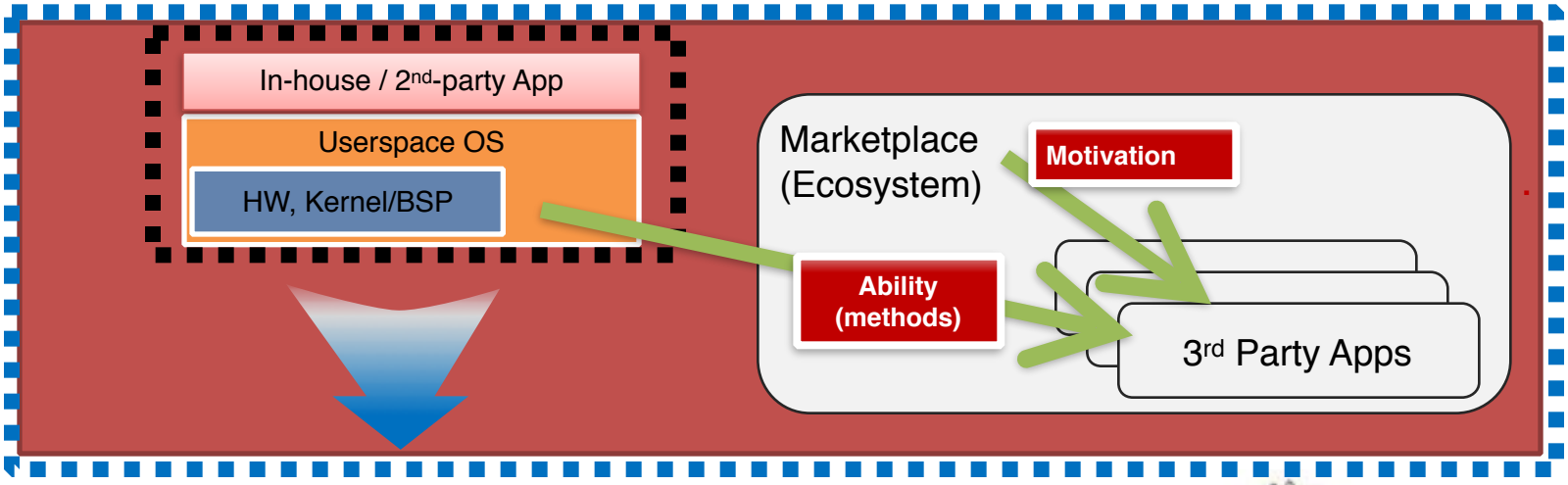
WHAT CAN WE DO

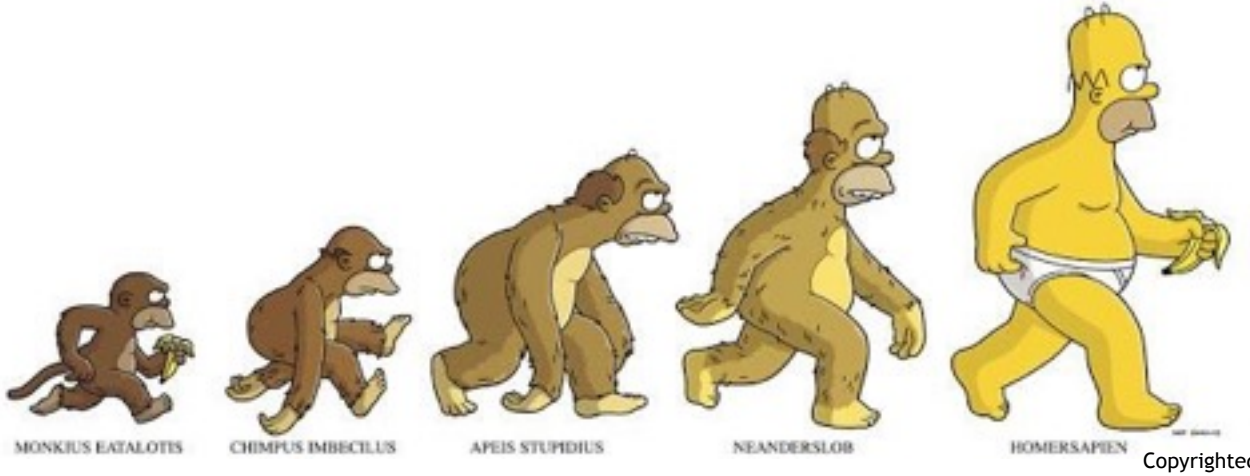


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device/user-centric to ECO-CENTRIC?





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(Third Party)
App Developers

"Working hard for energy efficiency"

Ability

Motivation

….. & Attitude



Photos from wikipedia, yonhapnews

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What Can We Do?: Ability

- **Observation**
  - Highly skilled and system-understanding app developers has the ability: RARE!

- **How Can We Let 3rd Party App Developers**

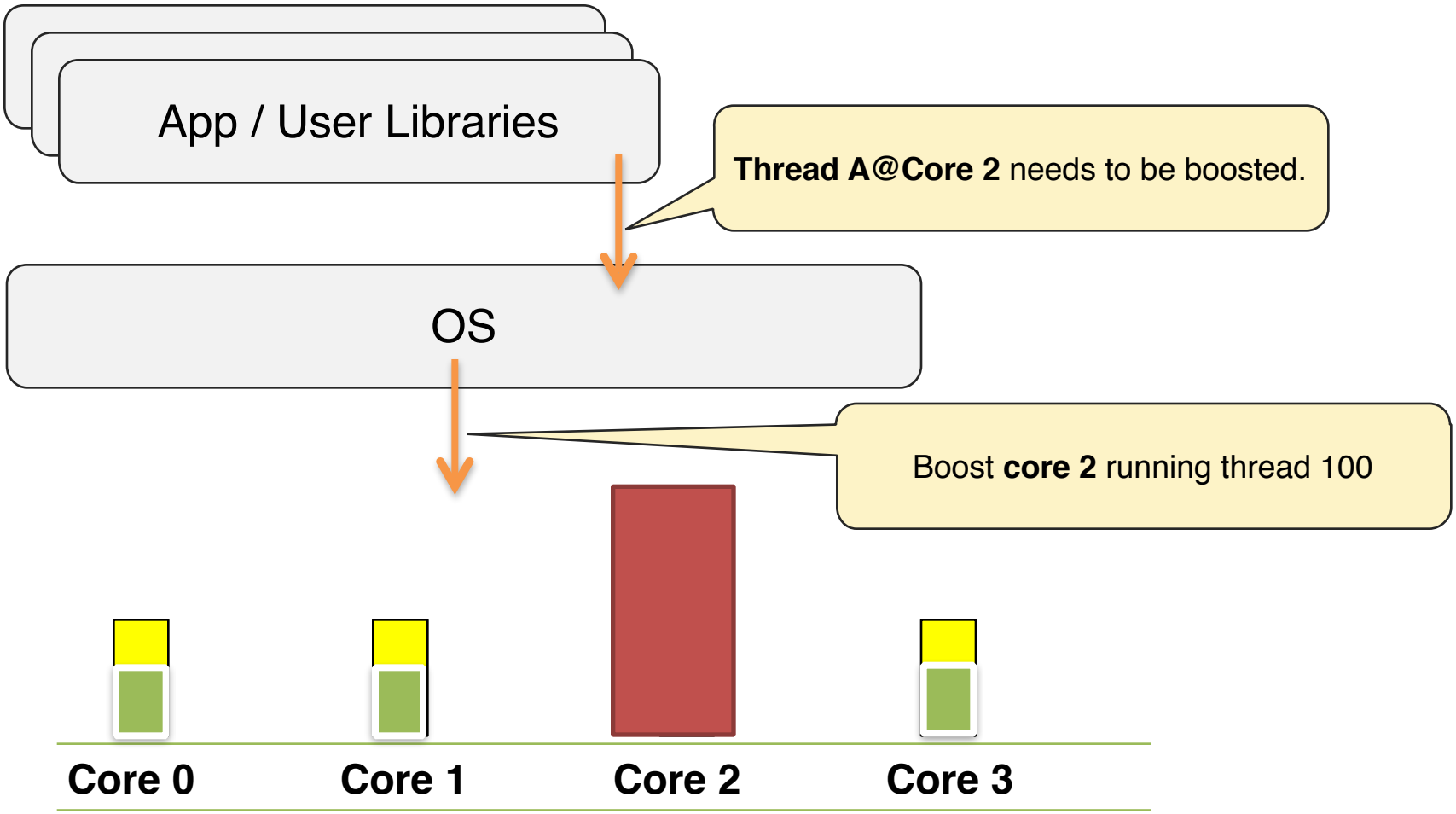
  Be Able to Improve Energy Efficiency?
  (trade off power--performance)



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What Can We Do?: Ability – Case: TURBO Diaries

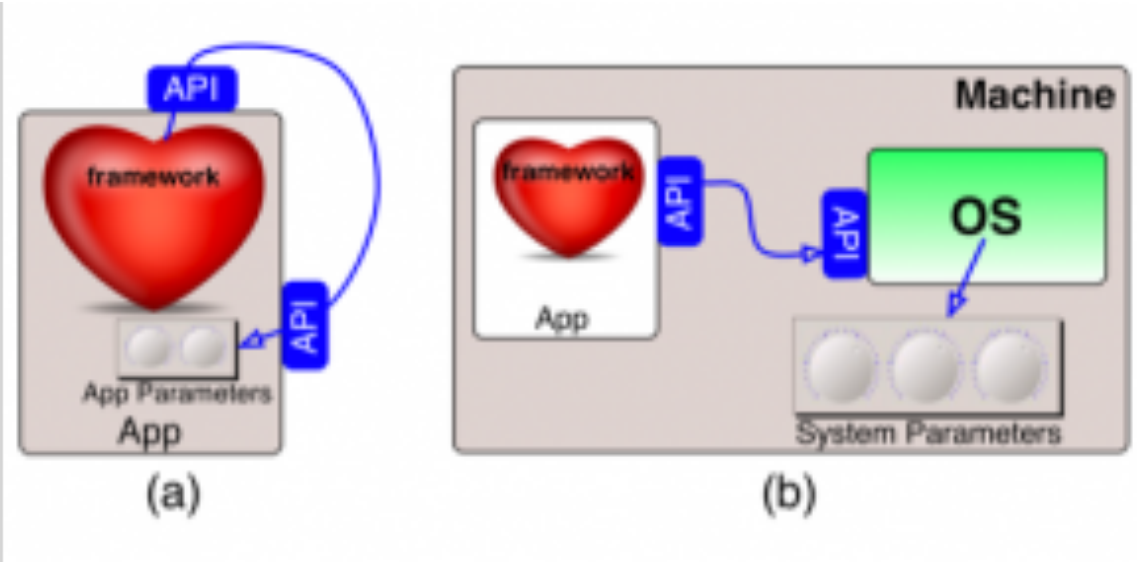
- **Wamhoff, et al., USENIX ATC 2014**
  "The TURBO Diaries: Application-controller Frequency Scaling Explained"



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What Can We Do?: Ability – Case: Heartbeat

- **Application Heartbeats (Carbon Research Group, CSAIL, MIT)**
  - App tells OS how fast the App is running: “Heartbeat”
  - OS throttles (e.g., DVFS) accordingly



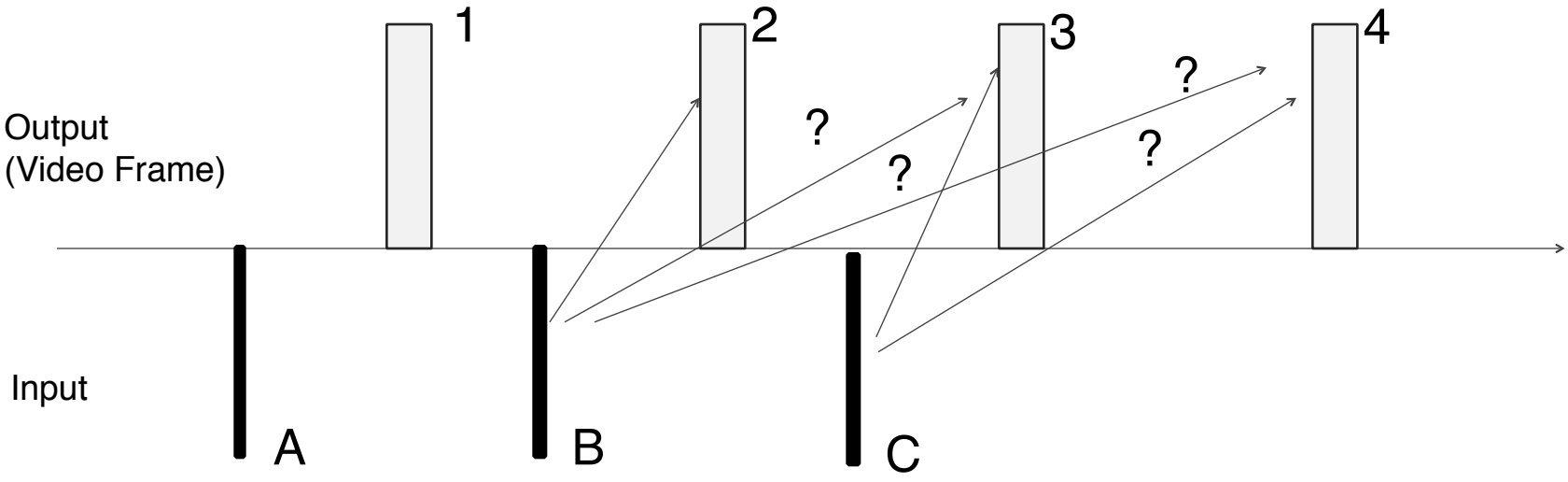
http://groups.csail.mit.edu/carbon/?page_id=94

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What Can We Do?: Ability – Case: FPS/IO-Latency

- **Generalizing Heartbeat ➔ Frame-per-second (FPS)**
  - Transparent to applications.
  - Does not require anything to app developers

- **We don't know whether INPUT-C is related to OUTPUT-3 or OUTPUT-4.**
  - Even if we have high FPS (60?), there might be input-output sluggish.
  - Unless we do "TAINT" for UI frameworks and apps?



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What Can We Do?: Ability – Case: AppScope

- **Yoon, et al., USENIX ATC 2012**
  "AppScope: Application Energy Metering Framework for Android ……"
  - Shows energy usage per device for each thread.

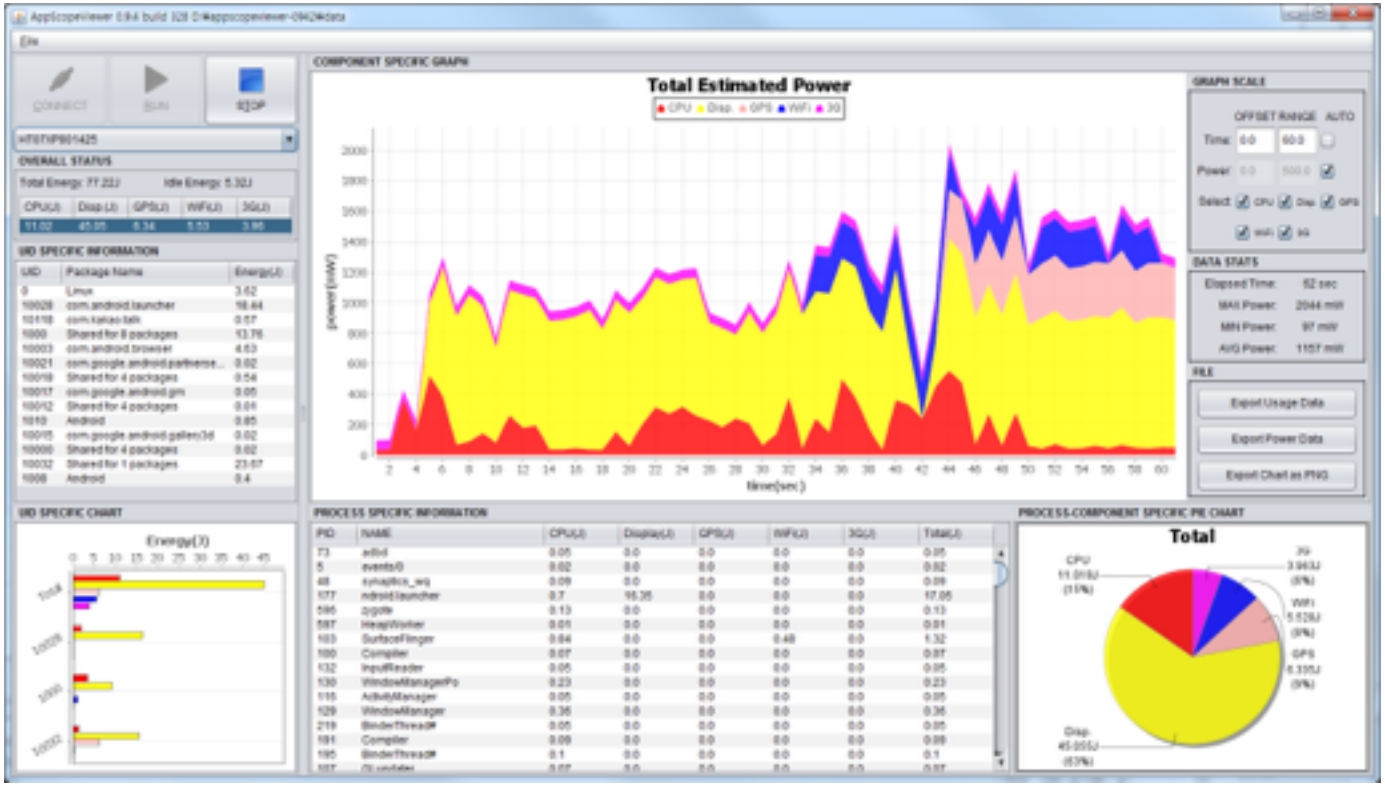


Image from http://css3.yonsei.ac.kr/appscope/attachment/wiki/AppScopeViewer/AppScopeViewer.png

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What Can We Do?: Ability – Case: 1st/2nd Party Apps

- **Privileged APIs for In-House / Contracted (2nd party) Apps**
  - E.g., DVFS_LOCK(CPU, 1000, 200);
    - For the next 200 ms, run CPU at 1000MHz or faster.
- **Solves most "performance issues",**

  allowing more aggressive energy policies.



F.S. Church, "Pandora"

https://en.wikipedia.org/wiki/Pandora

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What Can We Do?: Ability – Case: Abuse

- **App Developers (Even In-House & 2nd-party) Abuse The System!**



Dramatization - Viewer discretion is advised.

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What Can We Do?: Ability – New Requirements

- **Easy to Use**
  - Should not become another heavy burden for developers.
  - Optional features for “advanced” developers for fine tuning?

- **Abuse Prevention or Avoidance**
  - **Do NOT trust** their ability or intention.

- **Device/System Transparency**
  - App developers should not care whether it’s “Galaxy S6” or “Galaxy S2”
    “Tizen 2.3” or “Tizen 3.0”
    “On Wifi” or “On LTE”
    - This is not a simple engineering problem, but an inherent problem of computer systems:
      “How can we normalize the performance across different machines?”

- **(Additional) Maintainability**
  - Compatible with conventional OS

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(Third Party)
App Developers

"Working hard for energy efficiency"

Ability

Motivation

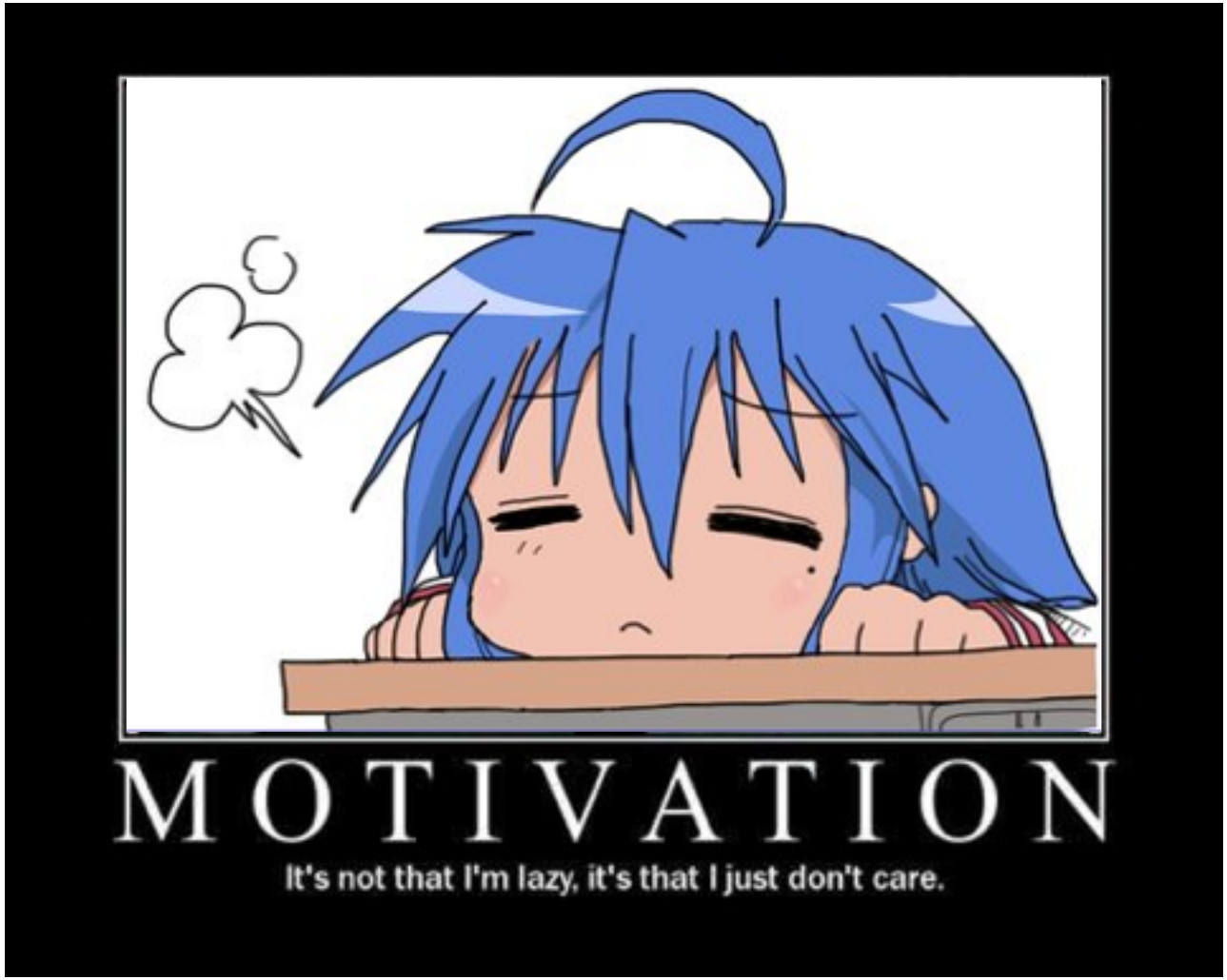
….. & Attitude



Photos from wikipedia, yonhapnews

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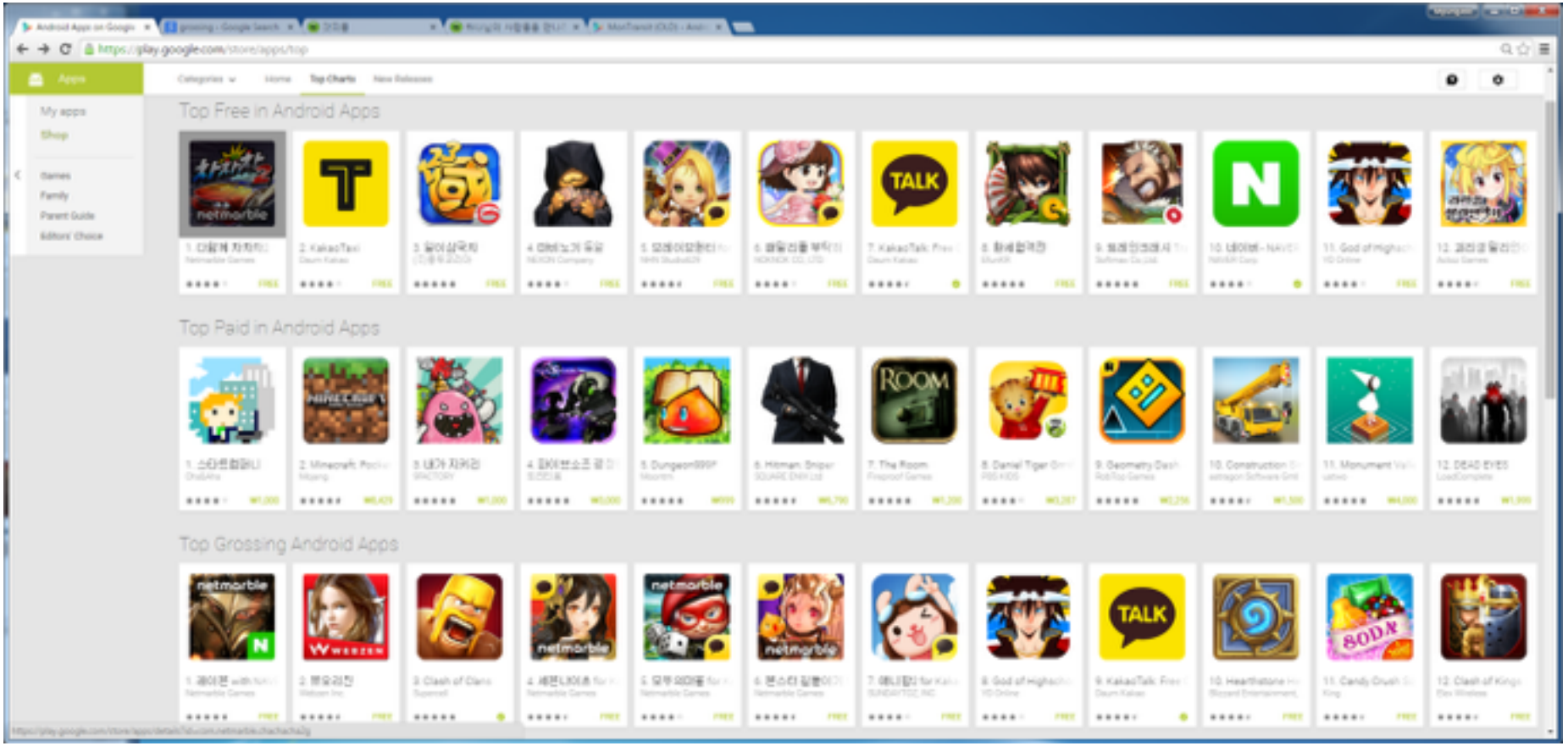
What Can We Do?: Motivation



Picture from http://cuotez.com/tag/no-motivation-to-work-out-anymore/
Quoted from http://startupbros.com/killing-the-7-motivation-murderers/

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What Can We Do?: Motivation, Hint

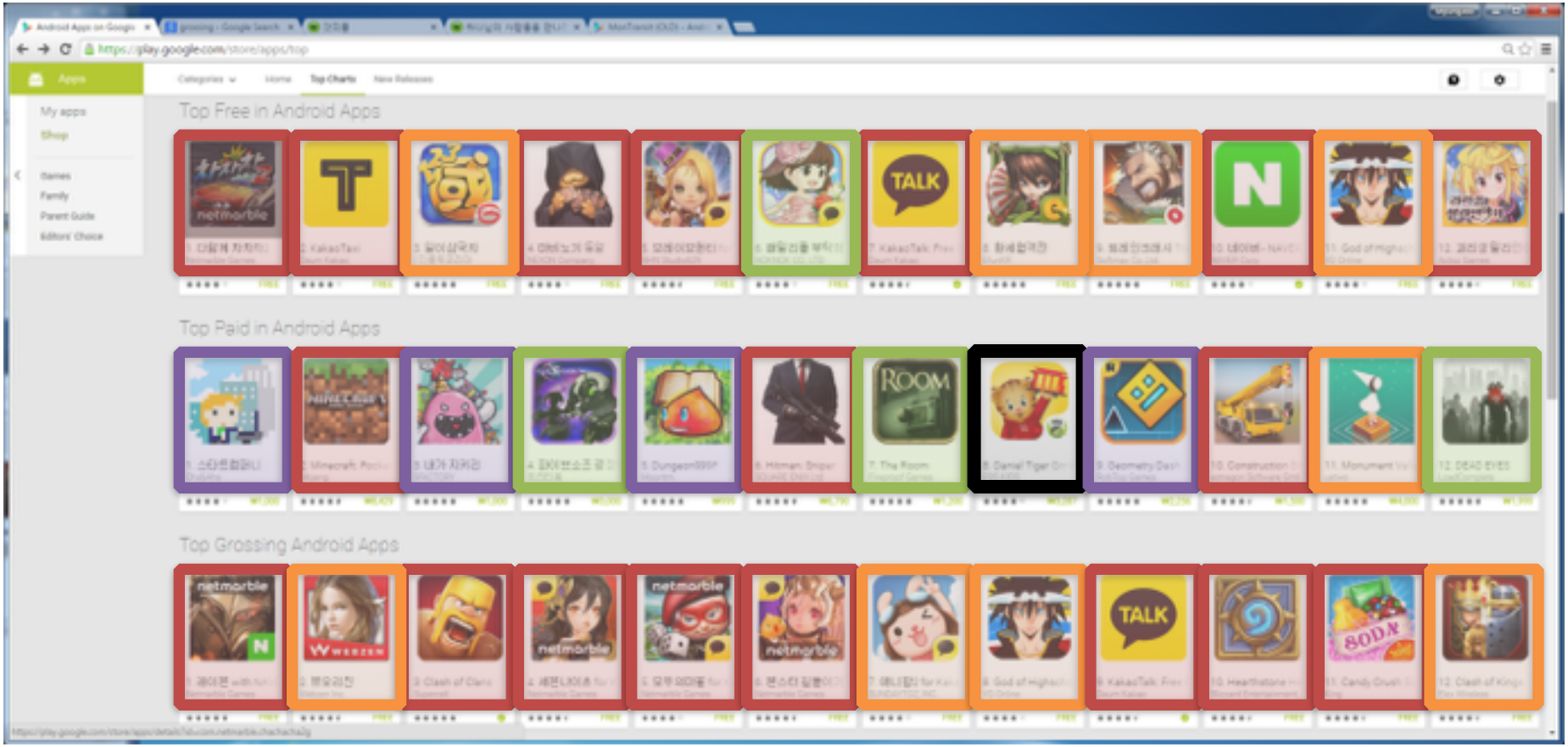


Top 12 Free Apps / Top 12 Paid Apps / Top 12 Grossing Apps (For Galaxy S4 Active @ SKT)

Picture from http://cuotez.com/tag/no-motivation-to-work-out-anymore/
Quoted from http://startupbros.com/killing-the-7-motivation-murderers/

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What Can We Do?: Motivation, Hint

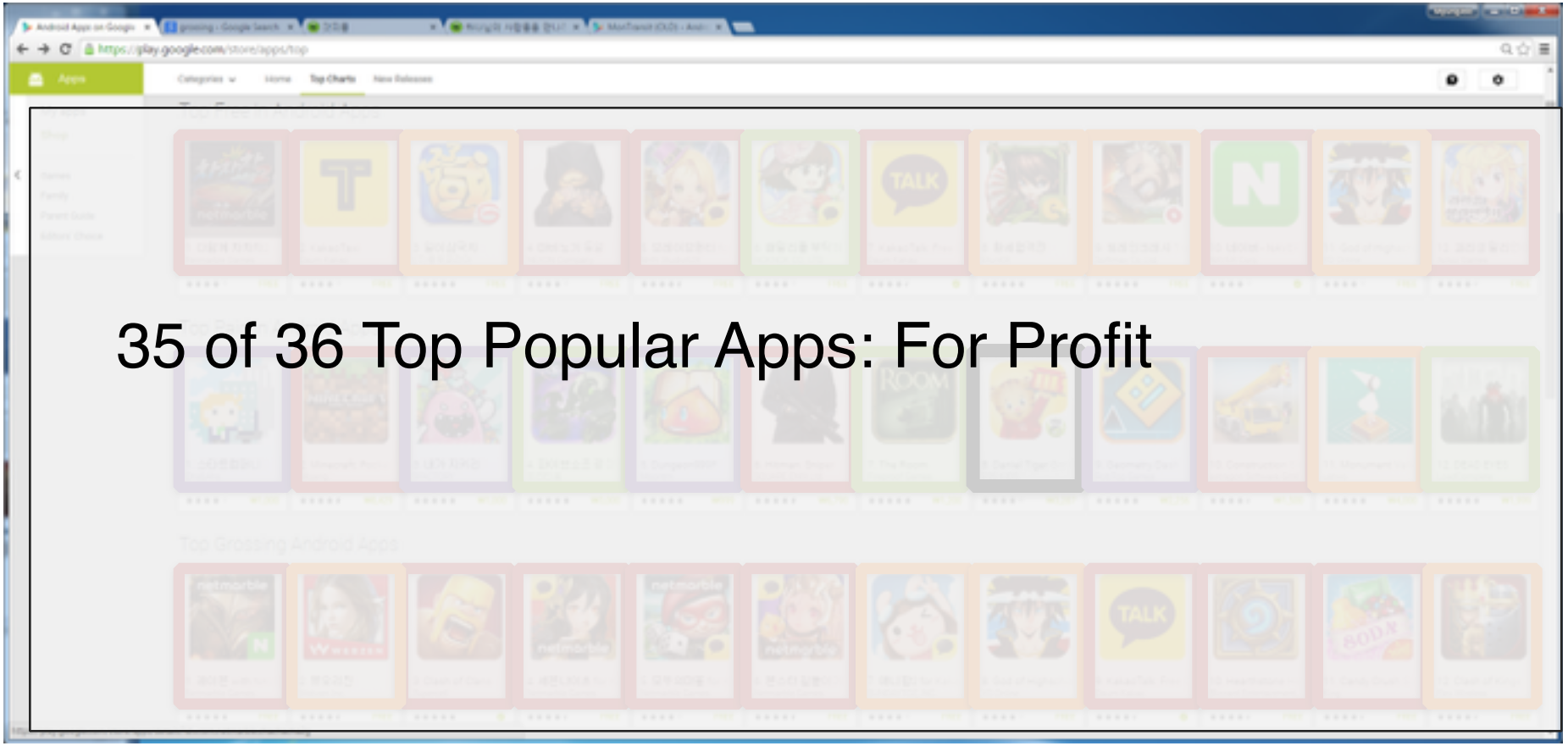


Top 12 Free Apps / Top 12 Paid Apps / Top 12 Grossing Apps (For Galaxy S4 Active @ SKT)

Big (>1000 employees or >$1B revenue)	Mid (>100)	Small (>5)	Self-Employed	Public/NPO/Hobbyist
18	**9**	**4**	**4**	**1**

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What Can We Do?: Motivation, Hint

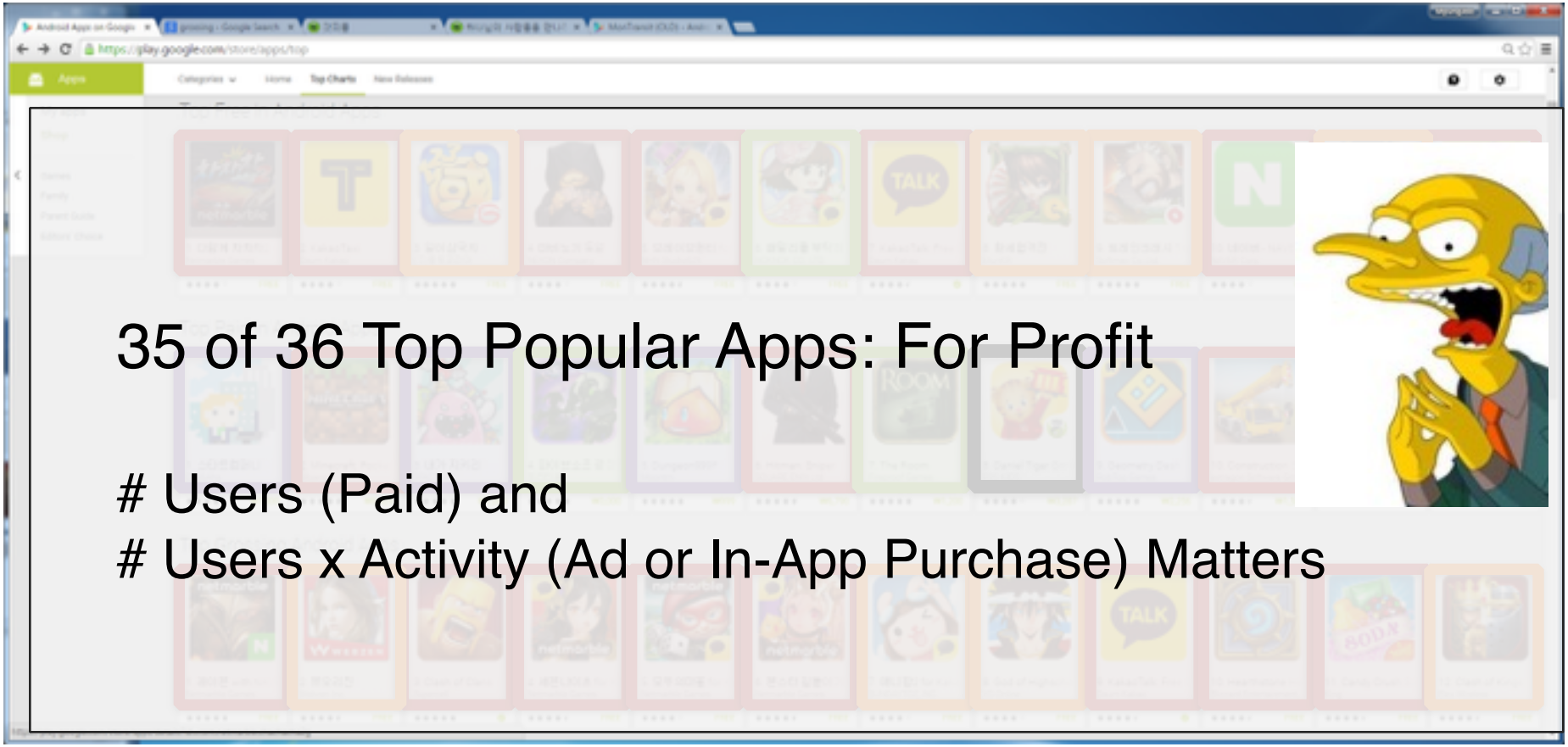


Top 12 Free Apps / Top 12 Paid Apps / Top 12 Grossing Apps (For Galaxy S4 Active @ SKT)

Big (>1000 employees or >$1B revenue)	Mid (>100)	Small (>5)	Self-Employed	Public/NPO/Hobbyist
18	**9**	**4**	**4**	**1**

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What Can We Do?: Motivation, Hint

- Motivate App Developers by Ensuring
  - Energy Efficiency DIRECTLY Affects

    #DOWNLOADS (#users)
  - Energy Efficiency DIRECTLY Affects

    User Activities (usage hours/user, …)

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What Can We Do?: Motivation.



Image from Need For Speed (EA)

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What Can We Do?: Motivation.

Roadblock Ahead

- **Energy efficiency of an APP affects INDIRECTLY!**



  - Hard to identify who's at fault & how bad it is.
  - Hard to know beforehand

Image from Need For Speed (EA)

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What Can We Do?: Motivation. How?



Image from Need For Speed (EA)

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What Can We Do?: Motivation. How?

- **Making it Direct & Transparent**
  - Assess & Publish the App Energy Rating

➔ Won't download or use inefficient apps

Image from Need For Speed (EA)

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What Can We Do?: Motivation. Open Problems.

Assess App Energy Rating

Publish App Energy Rating

- Problem 2-1.
  - "App B" served "App A".
  - Is it App A's energy usage? Or B's? Or partially?
- Problem 2-2.
  - Get user's attention
  - Without bloating the interface
  - What if we need to merge with traditional rating system?
- Problem 2-3.
  - Each user has his/her own usage pattern
- Problem 2-4.
  - A New Device is just released.
  - We do not have enough data for it.
- Problem 2-5.
  - Customize results per device
  - Customize results per user
- Problem 2-6.
  - Prevent abuses & exploits?
  - Won't we get a backlash from angry developers?
- How Are We Going To Rate Them?
- Need to be totally ordered?

- Problem 3-1.
  - Get user's attention
  - Without bloating the interface
  - What if we need to merge with traditional rating system?
- Problem 3-2.
  - Give enough information for both developers and users
  - Only when required.
- Problem 3-3.
  - Customize results per device
  - Customize results per user

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What Can We Do?: Attitude? "Determines how well you do it"

- **Tools: "PoCoMon"**
  (Power Consumption Monitor, embedded in Tizen mainline, tizen.org)
  - Gorelkina et al., "Power consumption profiling and optimization", ELCE 2013
  - Monitors energy usage w/ dynamic instrumentation: energy per function call

#	Function	mAh	Ncalls	CPU, %	Read, %	Write, %
#1: **bzip2 -c random.data > random.data.bz2** (1.79 mAh/82.98%)						
1	mainSort	0.82	117	100.00	0.00	0.00
2	BZ2_compressBlock	0.81	117	100.00	0.00	0.00
3	handle_compress	0.09	41945	100.00	0.00	0.00
4	BZ2_bzWrite	0.03	20972	60.65	0.00	39.35
5	compressStream	0.02	1	66.90	33.10	0.00
6	add_pair_to_block	0.01	407361	100.00	0.00	0.00
System power consumption				**est: 2.16**	**real: 2.28**	**err: 5%**
#2: **bzip2 -dc random.data.bz2 > test.out** (0.72 mAh/82.06%)						
1	BZ2_decompress	0.35	21183	100.00	0.00	0.00
2	BZ2_bzDecompress	0.31	42037	100.00	0.00	0.00
3	uncompressStream	0.04	1	75.55	0.00	24.45
4	BZ2_bzRead	0.02	20972	74.17	25.83	0.00
System power consumption				**est: 0.88**	**real: 1.05**	**err: 15%**

  - Not Easy for App Developers. (Integrating with SDK)
  - Not (Yet) Working for Web Apps (W.I.P.)

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What Can We Do?: Attitude? "Determines how well you do it"

- **Tools: AppScope (Energy per thread x device)**
  - Low overhead, Peripheral usage tracking.
  - Shows fine-grained energy usage.



- **Tools: XCode energy impact tools**
  - iOS only….
  - Shows coarse-grained energy usage.

    (not in "J" or "W", but in "#packets", "%CPU".)



- **What will be future requirement?**
  - Fine-grained & user friendliness
  - Useful: Off-loaded cost tracking, Energy-bug pointing, Per-function/module profiling

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Besides…

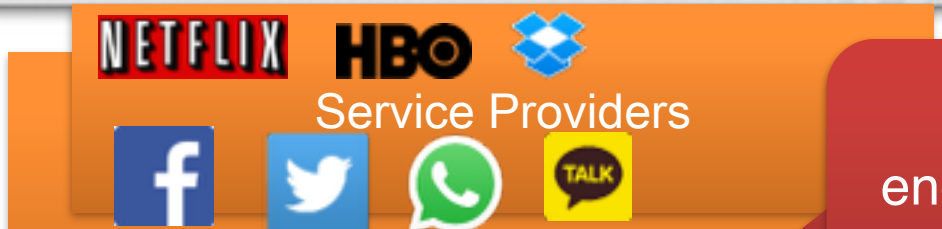
- **Extend the scope to UX/UI design as well!**
  - Example: LPD, Low Power Display Mechanism for Mobile and Wearable Display
    - **Presenting Friday.**
- **Energy-Aware Programming Language?**
- **How do we encourage cross-layer optimization where each layer has different entities with different interest.**
  - E.g., hobbyist, app vendor, device manufacturer, accessory manufacturer, OS vendor,



Have a Poster Session As Well.

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Eco-Centric Power Management



We **also** work **hard** for energy efficiency with *strong* **Ability & Motivation**





Market Place

Consumers



(In-House / Preloaded / Second Party)
App Developers

SW Platform (OS) Developers



Device Manufacturers



Component Manufacturers



Operators



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