

Experience: Android Resists Liberation from Its Primary Use Case

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Application: Sensing AC grid reliability in Zanzibar



Michamvi, one of our two deployment sites in Zanzibar

Photo by Veronica Jacome

Challenge: get data from sensor to cloud

- Sensor: WiTenergy E110
 - Voltage, current
 - Bluetooth Low Energy
- Backend
 - node.js + influx
- Gateway: ?



Insight: Android smartphones should make the gateway as easy as writing an app

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 - Voltage, current
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- Gateway
 - Android smartphone!
 - Mature ecosystem
 - Background services
 - BLE radio, GSM radio, SD card
 - OTA updates



Insight: Android smartphones should make the gateway as easy as writing an app ...right?

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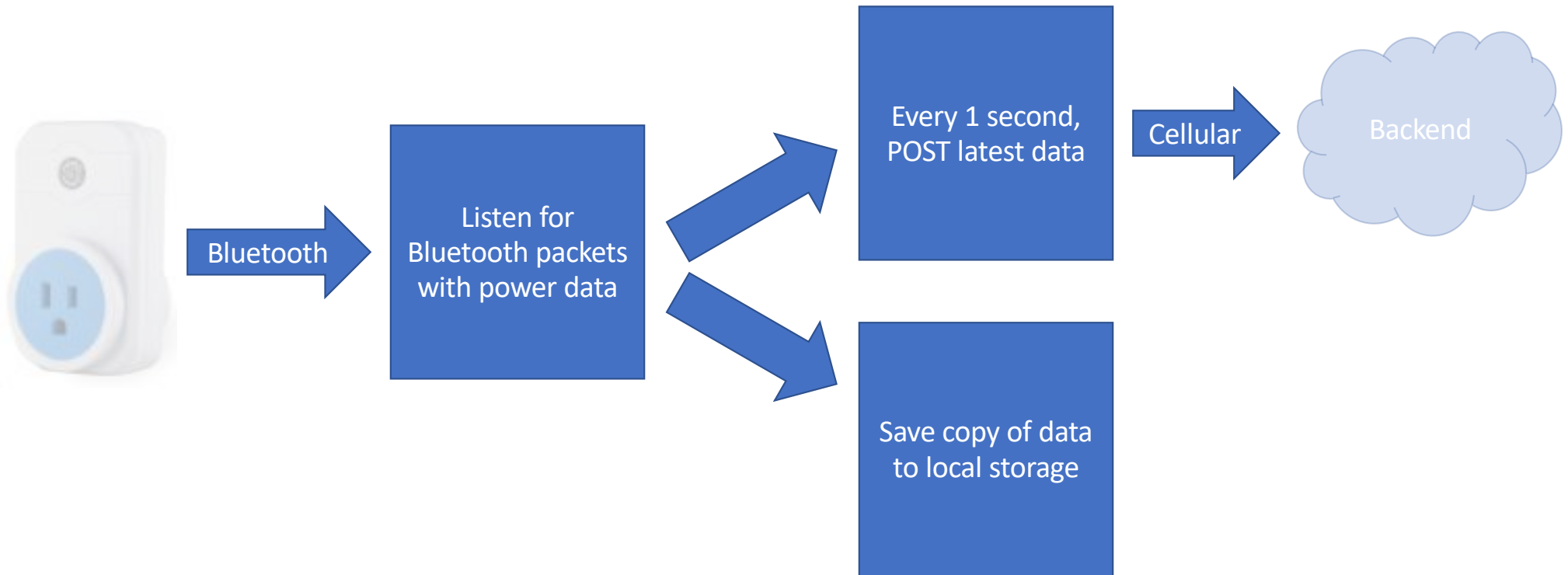


Let's start putting together a deployment...

- Pick a phone: Samsung J110H
 - Mid-range hardware
 - Low-cost (\$90)
 - Widely available in Tanzania
 - Upgraded to Android 4.4.4
 - (and eventually rooted....)



Write an app...



And send it out into the field!

- Deployment of 16 systems in two villages in Zanzibar
- Plugged in at an outlet inside a household
- Phone was placed in a plastic box and screwed shut
- PlugWatch designed to run continually



PlugWatch was supposed to be easy...

- Simple system based on commercially available components
- We assumed Android would trivially act as a gateway

Phones on their own?

- Most smartphone use cases are interactive, a human holding a phone
- Tight Association^[1] :
 - Assumption of frequent interactions between the human and the phone
- Loose Association:
 - Apps are continuously-running, unsupervised, and characterized by machine-to-machine interactions

[1] Ivan Beschastnikh, Yuan Zhang, Zhengping Qian, and Lidong Zhou. 2012. Liberating Mobile Phones from their Primary Use Case.

Latent Hypothesis

- Smartphones enable unattended long-running networked sensing applications through their rich supporting environments, wireless peripheral connectivity, and physical reliability.

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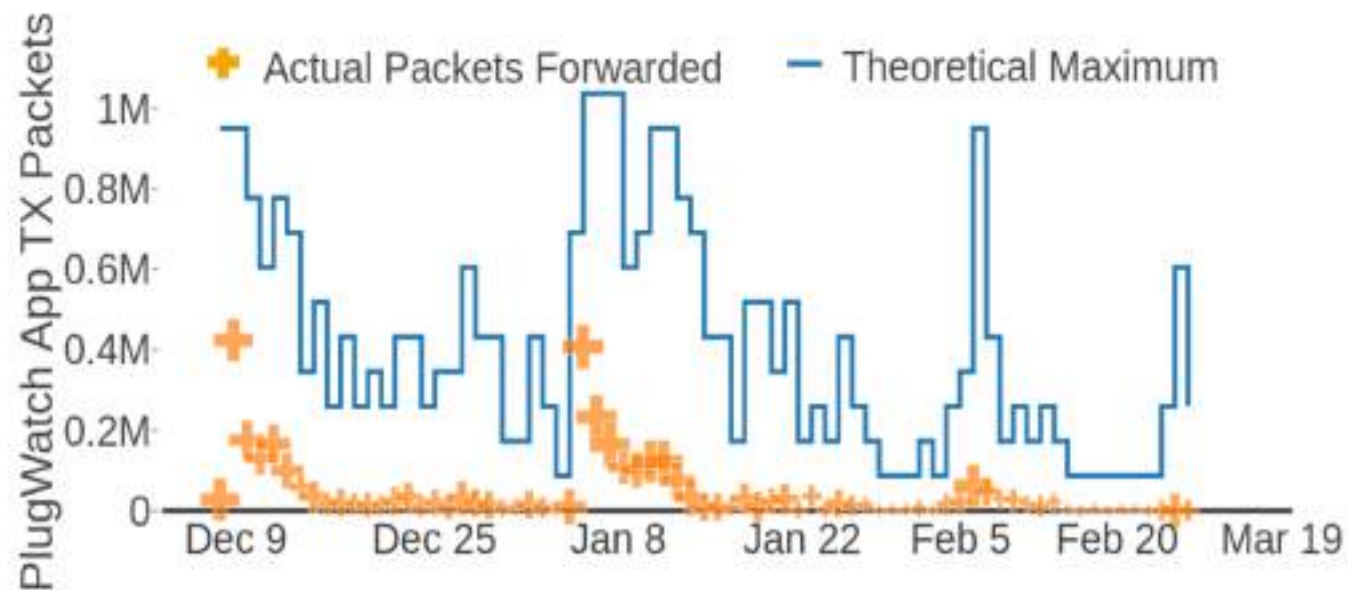
It is difficult to keep apps running without a human in the loop.

- OS garbage collection makes it hard to run an app for long periods
- Tricks to keep a loose association app alive:
 - Force the UI open on the screen
 - Generate notifications
 - Catch crashes and reboots to restart app
 - Close modal windows
 - Multiple watchdog processes
 - Overwrite the charging image to auto start the phone on charge restored



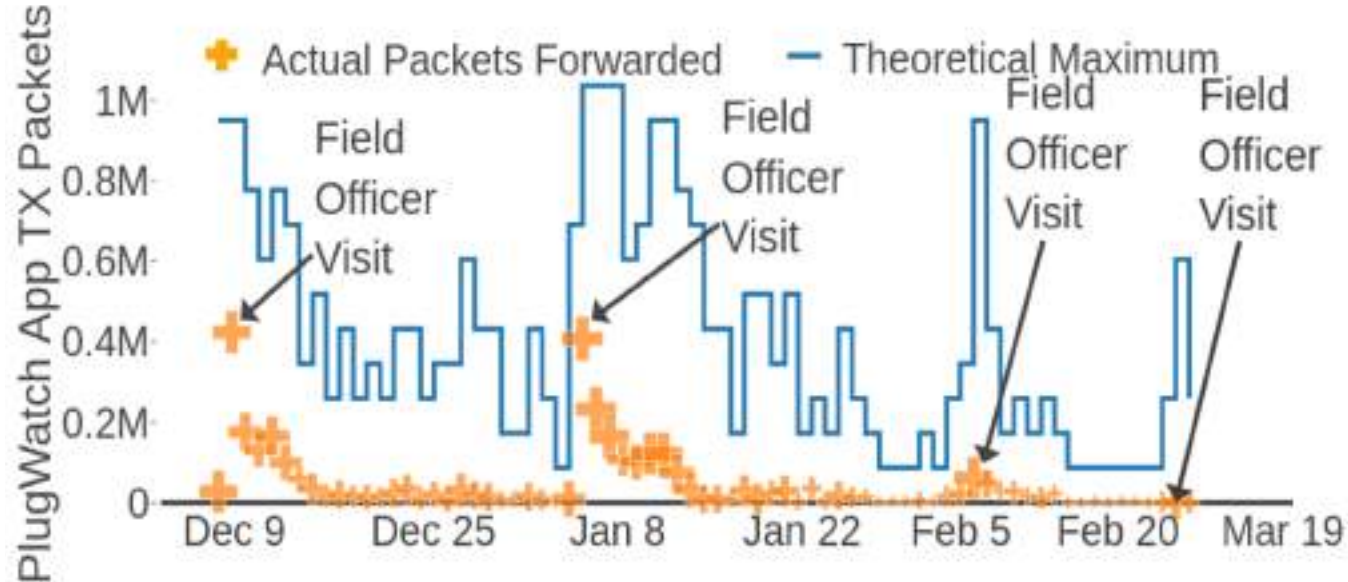
<https://news.samsung.com/global/this-is-an-unofficial-review-of-the-galaxy-note-4-apps-ultra-power-saving-mode-fast-charging-and-more>

And still... the system drastically underperformed



1 Hz data x number of seconds in day x number of phones reporting at all that day

Over long timespans phone build up residue that humans need to clear out.



1 Hz data x number of seconds in day x number of phones reporting at all that day

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Keeping multiple phones connected remotely was difficult

- SIM card data plans were non-trivial.
- Hard to diagnose connectivity problems.
 - Adding data done via scratch-off cards
 - Data had to be topped up every 30 days in-country
 - Hard to diagnose connectivity issues
- Fleet management is not well supported.



Checking value?

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Android ecosystem necessitates careful thinking

- Not all Android is created equal
 - Ecosystem does not equally support all APIs
- Automatic App Updates?
 - ~~Android Profiles~~ (req 5.0+)
 - Non-deterministic Google account logouts make orphans
- Bug fixes don't reach down into old API's
 - And OS updates always require human intervention

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We encountered significant bugs in the Bluetooth Low Energy stack

Row	Error Message	Reports
1	watchdog2 rebooting due to dead process	257,547
2	gridwatch.plugwatch.wit. PlugWatchService:bluetooth stack died	108,653
3	gridwatch.plugwatch.wit. PlugWatchService:unable to start scanning	40714
4	restarting due to timeout	30,898
5	service disconnected	28,211
6	An error occurred while executing doInBackground()	18,643
7	watchdog rebooting due to dead process	3,981
8	gridwatch.plugwatch.wit. ConnectionCheckService:restart rebooting due to max timeout	3,836
9	Exception thrown on Scheduler.Worker thread. Add 'onError' handling.	1,680
10	[memory exhausted]	398

“stack died”

“failed to scan”

“max timeout”

Android's design makes recovery from subsystem bugs a high-cost operation

- When the bug is in the OS, applications don't have a great recovery strategy
- Other computing platforms can power cycle peripherals
- Android cannot reboot just the BLE stack
 - Had to restart app
 - Had to reboot phone
 - And the app doesn't always come back...

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**Exploding Batteries Get
Samsung Galaxy Note 7 Barred
from Airplanes**

**Samsung reveals why new Galaxy
Note 9 will definitely not explode or
catch fire**



Batteries failed catastrophically



Not much data available on the effects of unsupervised long-running applications on batteries

- We baked phone running app in an oven at 120°F for 18 hours, did not reveal issues

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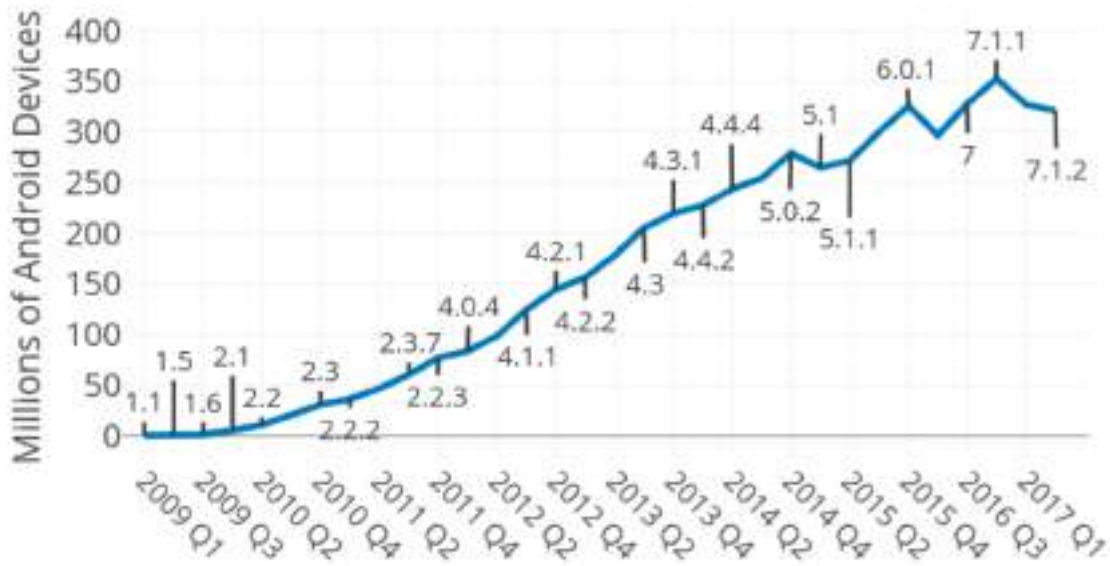
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Phone reuse is a huge opportunity to enable compute and reclaim e-waste.



Loose association requires future work

- Android is doubling down on tight association (as they should)
- A loose association version of Android
- A solution for heterogeneity
- Recycling centers



The PlugWatch is dead. Long live the PowerWatch.

- Custom hardware solution developed and deployed in Ghana
- Hundreds of sensors and millions of data points



PowerWatch: Noah Klugman, Josh Adkins, Pat Pannuto, Matt Podolsky, Neal Jackson, Branden Ghena, Jay Taneja, Prabal Dutta



PowerWatch devices being prepared for deployment

Thank you!

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