Demo: Android Resists Liberation from Its Primary Use Case

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ABSTRACT

Network connectivity is often one of the most challenging aspects of deploying sensors. In many countries, cellular networks provide the most reliable, highest bandwidth, and greatest coverage option for internet access. Repurposing smartphones as gateways could extract value from hundreds of millions of devices currently considered to be e-waste. While these factors make smartphones a seemingly ideal platform to serve as a gateway between sensors and the cloud, we find that a device designed for multi-tenant operation and frequent human interaction becomes unreliable when tasked to continuously run a single application with no human interaction, a somewhat counter-intuitive result. Further, we find that economy phones cannot physically withstand continuous operation, resulting in a surprisingly high rate of permanent device failures in the field. If these observations hold more broadly, they would make mobile phones poorly suited to a range of sensing applications for which they have been rumored to hold great promise.

CCS CONCEPTS

• **Hardware** → **Sensor applications and deployments; Energy metering; Sensor devices and platforms;**

KEYWORDS

Smartphones; Sensor Deployment; Gateways; Android; E-Waste

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(a) Swollen batteries.

(b) Screen burn in.

Figure 1: PlugWatch Hardware problems discovered.

(a) A battery and a phone with its battery after deployment. Both demonstrate swelling, and the battery in the phone has unseated the plastic backing of the phone. (b) Screen burn-in from a device frozen in an invalid and unrecoverable state. Notice that the burn-in is from the home screen, not the PlugWatch app which should have been in the foreground.

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1 PLATFORMS

This demo complements the paper "Experience: Android Resists Liberation from Its Primary Use Case" to be presented at MobiCom'18 [2]. We introduce two platforms to collect AC plug-load measurements in the cloud and describe their architectures and supporting cloud infrastructure.

1.1 PlugWatch

The PlugWatch platform is comprised of a commercial plug-load monitor (WiTenergy E110) [6] and an unmodified Android phone (Samsung J1 Ace) [5] acting as a gateway. The smartphone is placed in a black plastic box. The system architecture is shown in Figure 2. PlugWatch did not perform well in a deployment where the system was left unattended. Failures stemmed from the multi-tenant design of Android and features in Android intended to support the user experience (most commonly garbage collection of long running services and privacy protections), bugs in the Android BLE stack, and implementation errors [2].

Figure 2: PlugWatch System Architecture. A commercial off-the-shelf plug-load power meter connects over Bluetooth Low Energy to an unmodified Android phone running a gateway app. The gateway app forwards power measurements over the cellular network to a cloud server after appending metadata such as GPS, system time, sensor ID, and gateway software version. The system runs unattended.

1.2 PowerWatch

The PowerWatch platform is comprised of a custom sensor front-end that collects power measurements and metadata such as GPS location and sensor ID and a Particle Electron [4] that serves as the primary microcontroller and cellular modem. The system architecture is shown in Figure 3.

1.3 Cloud Infrastructure

Both PowerWatch and PlugWatch have cloud end-points at InfluxDB [1] instances. The data in these databases are visualized as time series graphs using Grafana [3].

2 DEMO

This demonstration is in two parts: a showcase of the PlugWatch hardware previously deployed in Tanzania and described in our work being presented at MobiCom 2018 [2], and a live presentation demonstrating the increased performance and reliability enabled by the PowerWatch system after abandoning efforts to repurpose Android smartphones as gateways.

We display the PlugWatch hardware previously deployed in Tanzania. Attendees will see swollen batteries, screen burn-in, and physical wear resulting from the deployment. Some of these can be seen in Figure 1. Attendees will interact with the PlugWatch gateway app and observe efforts made to keep the app always running without human interaction and to limit unsolicited participant interference. They will most likely observe PlugWatch experiencing run-time errors due to either OS actions or BLE stack errors. Finally, attendees can manually add cellular data to the PlugWatch system through scratch-cards to get a sense of how poorly this scales.

Figure 3: PowerWatch System Architecture. A custom system collects power measurements and metadata such as GPS, system time, sensor ID, and firmware version and sends this data over the cellular network to a cloud server.

We visualize in real time the performance variance between the PlugWatch and PowerWatch platforms. Attendees will see a live time-series graph of AC power measurements taken from each platform. The Android based PlugWatch platform will be able to forward less information than the custom-hardware-based PowerWatch platform, which will be clearly observable in the time-series graphs. Time series graphs displaying the error states from both platforms will also be visualized in real time.

2.1 Logistics

This demonstration requires no special equipment. The demonstration relies on cellular connection, and would do best if placed in a low-interference area. Additionally, the demonstration requires Internet access, a computer monitor, and a single AC power connection with an extension chord. The demonstration should take less than 15 minutes to set up. The authors will provide their own power adapters.

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REFERENCES

- [1] InfluxData, Inc. 2018. InfluxDB: Time Series Database Monitoring & Analytics. <https://www.influxdata.com>. (2018). (Accessed 03/13/2018).
- [2] Noah Klugman, Veronica Jacome, Meghan Clark, Matthew Podolsky, Pat Pannuto, Neal Jackson, Aley Soud Nassor, Catherine Wolfram, Duncan Callaway, Jay Taneja, and Prabal Dutta. 2018. Experience: Android Resists Liberation from Its Primary Use Case. In *Proceedings of the 24rd Annual International Conference on Mobile Computing and Networking*. ACM. To appear.
- [3] Grafana Labs. 2018. Grafana – The open platform for analytics and monitoring. <https://grafana.com>. (2018). (Accessed 03/13/2018).
- [4] Particle Industries, Inc. 2018. Particle - Welcome. <https://www.particle.io>. (2018). (Accessed on 07/17/2018).
- [5] Samsung. 2018. Samsung Galaxy J1 Ace – Price, Specs & Features. <http://www.samsung.com/in/smartphones/galaxy-j1-ace-j110h>. (2018). (Accessed on 03/11/2018).
- [6] WiTenergy. 2018. WiTenergy – A cost saving system. <http://wittech.net/WiTenergy.html>. (2018). (Accessed 03/11/2018).