Hardware, Apps, and Surveys at Scale: Insights from Measuring Grid Reliability in Accra, Ghana

Noah Klugman[†], Joshua Adkins[†], Susanna Berkouwer[†], Kwame Abrokwah, Ivan Bobashev[†], Pat Pannuto[ǂ], Matthew Podolsky[†], Aldo Suseno[†], Revati Thatte[†], Catherine Wolfram[†], Jay Taneja[*], and Prabal Dutta[†]

ACM COMPASS, July 4th, 2019
Accra, Ghana

Measuring electricity reliability in Accra

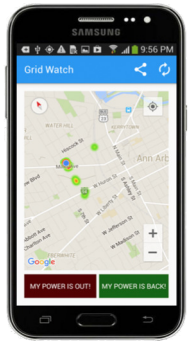
- Ghana Power Compact $498 million investment from US Federal Government
- Compact aims include reducing power outages, and stabilizing voltage
- Dumsor occurred from 2013 until 2015 due to under generation
- Current power situation could improve

Deployment Methodology

Measurements

- When does the power go out?
- Where does the power go out?
- How long is the power out?
- What equipment on the grid failed?
- Is voltage stable?
- Economic impacts?

Instruments



App

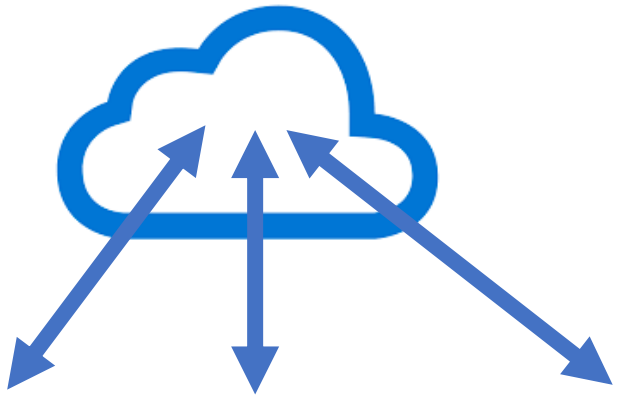
Location,
Power state,
Time

Plug Load

Location,
Power state,
Time,
Voltage,
Frequency

Survey

Supporting Services



Incentive System

Deployment Management

Data Insight System

Outline

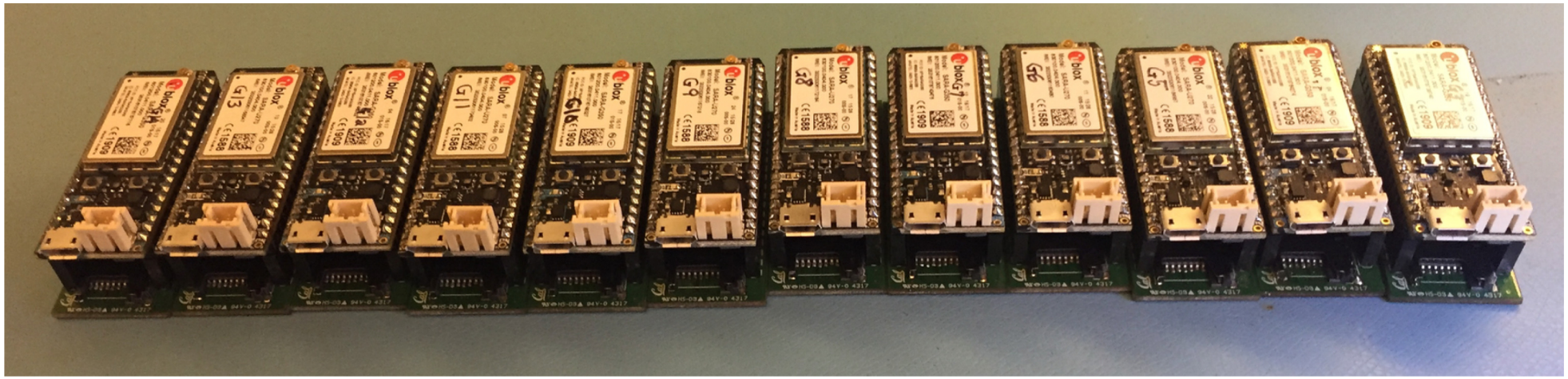
- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Small-scale: The first deployment

- Deployment goal: Do the sensors work?
  - GPS fix
  - Operated at 240v/50hz
  - Connects to cellular network



12 Plug-load sensors used in small scale deployment

Going beyond consumer needs

- Limit of 3 SIM cards due to security concerns

MTN fights simbox fraudsters

2 min read

383 16

Share on Facebook | Share on Twitter | Share on Whatsapp

MTN Ghana in collaboration with an anti-fraud team made up of the Criminal Investigations Department (CID) of the Ghana Police Service, National Communications Authority (NCA) and other telecom service providers have nabbed two suspects engaged in a SIM Box syndicate operating in Dome –Pillar 2,Accra.

CITI NEWSROOM

HOME | BUSINESS | POLITICS | SHOWBIZ | SPORTS | ODD BUT TRUE | OPINION | RELATIONSHIP | INFOGRAPHICS

Gov't to clamp down on SIM card fraudsters

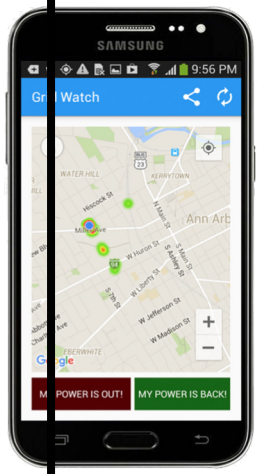
Posted by Godwin Akweiteh Allotey | Date: Apr 1, 2019 6:56am

Lesson: The deployment is the system

Instruments and Services

Sensors

Supporting Services



Sensor: App

Sensor: Plug Load

Survey

Incentive System

Deployment Management

Data Insight System

Outline

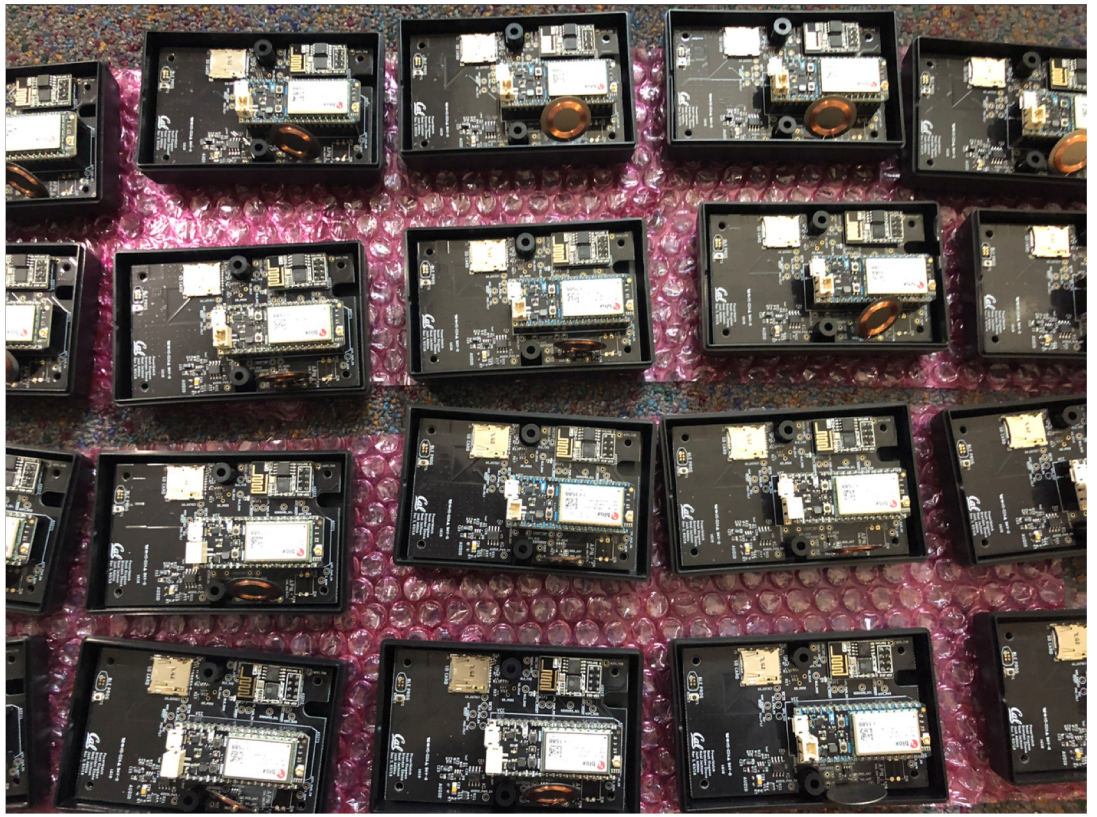
- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Medium-scale: The second deployment

- Goal: Measurements power quality in a single district of Accra
- 2,000 app downloads and short surveys
- 165 plug-load installations and long survey
- Fully implemented deployment methodology



20 of the 165 plug-load sensors deployed at medium scale

Local insight is critical for participant recruitment

- Talking with local people helps understand how to legitimize our work in Accra

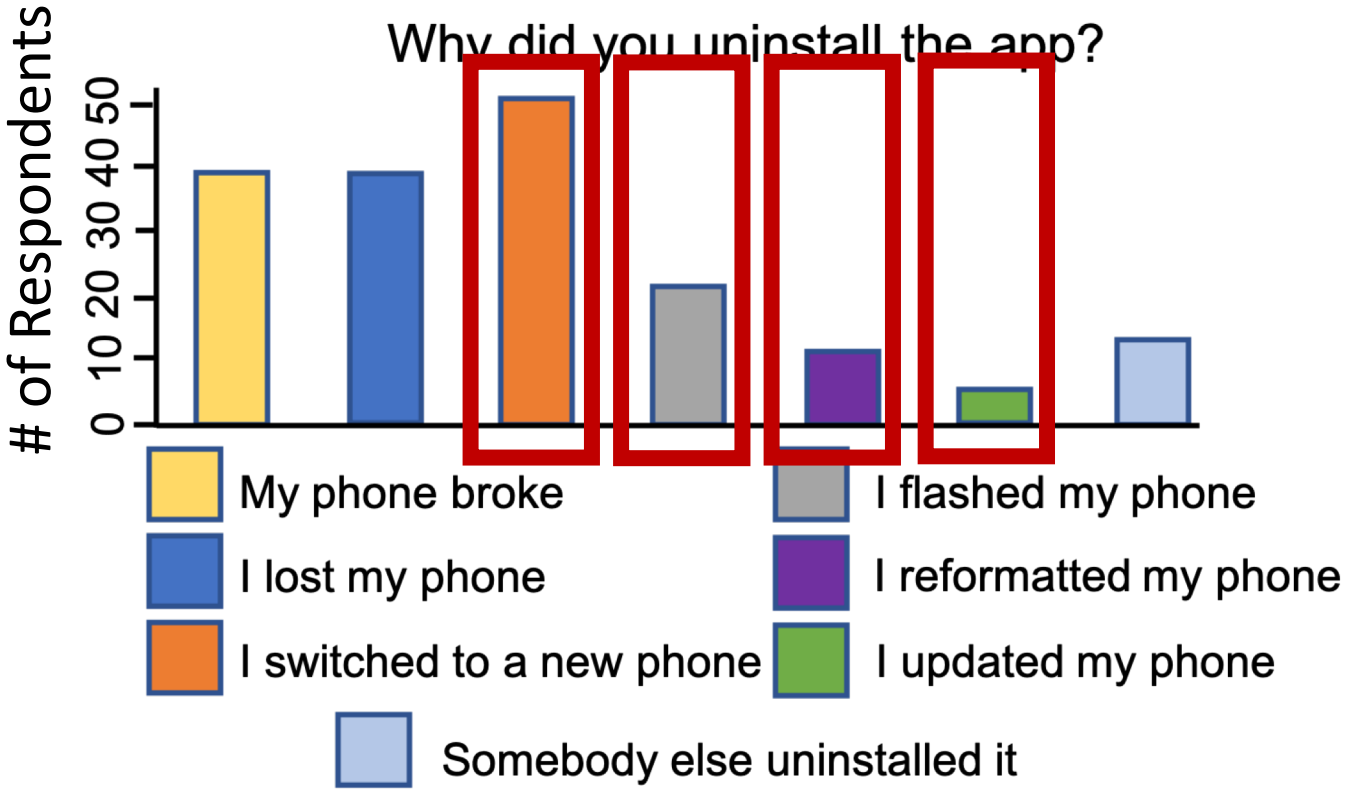
ACCRA METROPOLITAN ASSEMBLY

Assembly permission was important

Kelvin, a team lead, and the other field officers in the red, Dumsorwatch uniforms

Participant behavior is unexpected

- Sensors depending on participant behavior require flexibility



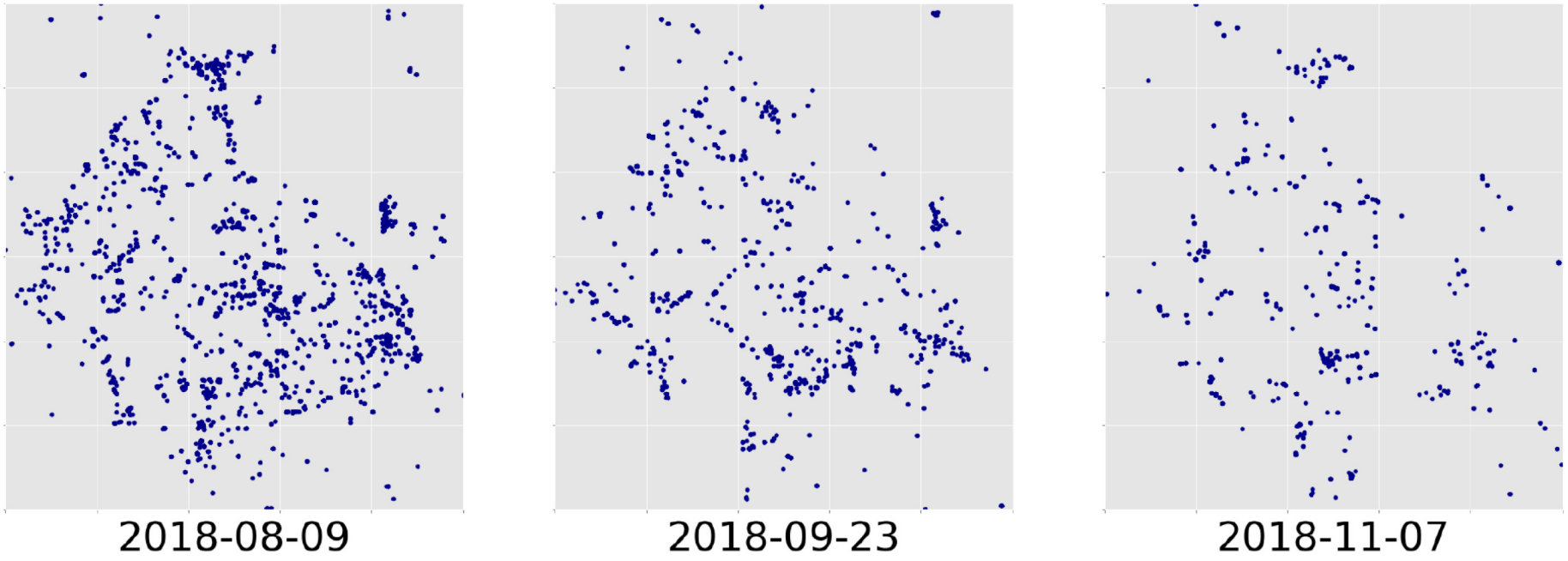
Scale doesn’t bootstrap trust

- Local resources were made available slowly
- Acquiring resources required in-country presence

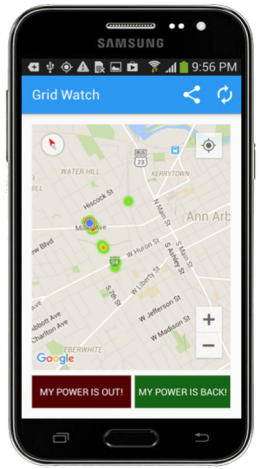
400 MTN prepaid SIM cards acquired after months of effort

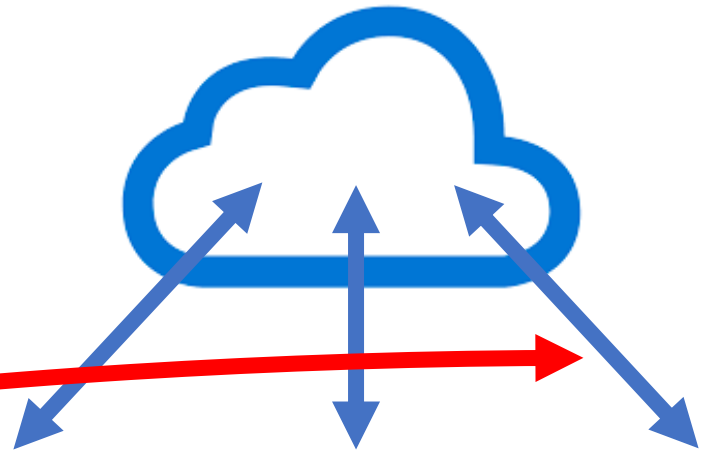
Each subsystem matters at scale

- Research systems are not deployment ready
- Software bugs, missed payments meant high attrition



Lesson: Information flow is critical

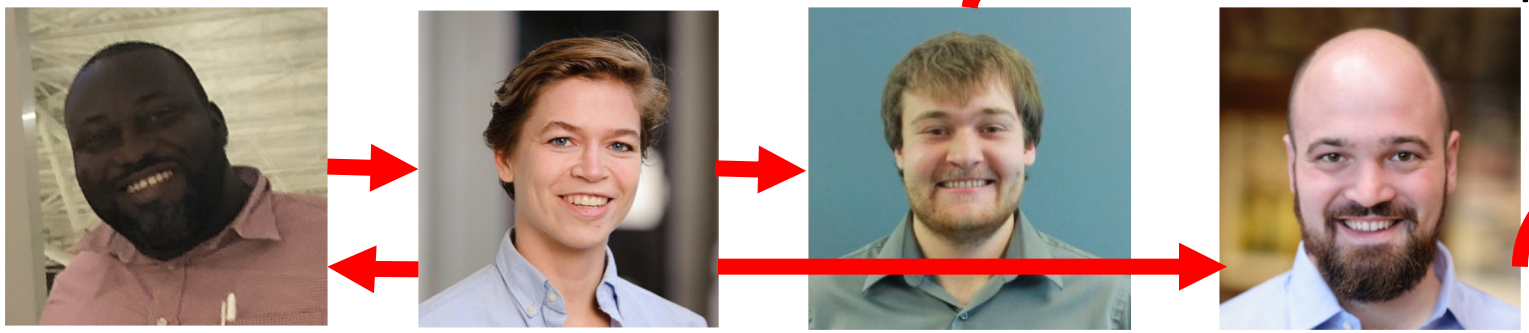




Incentive System

Deployment Management

Data Insight System



Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

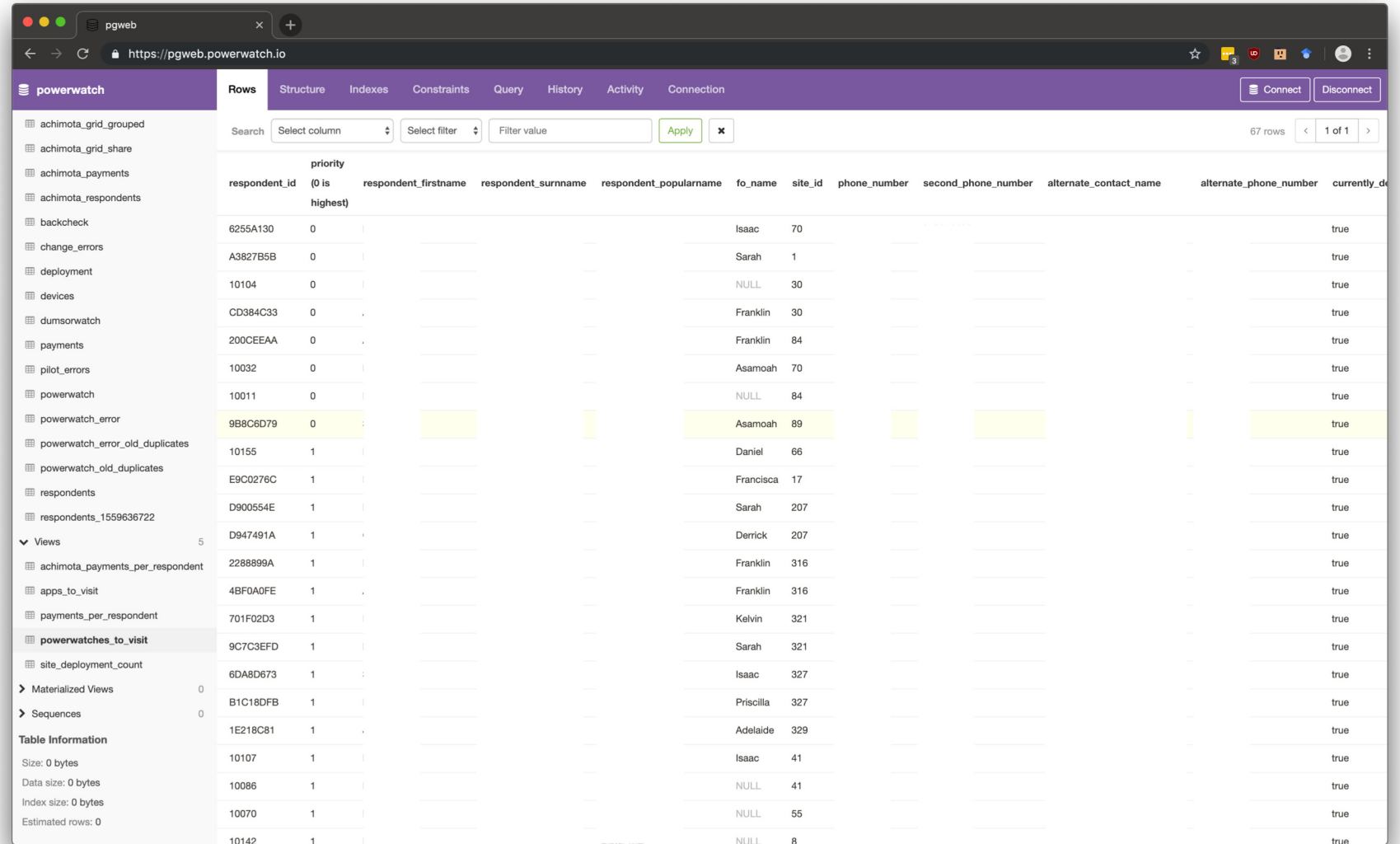
Large-scale: The third deployment

- Goal: Measurements power quality in two more districts of Accra
- 1,400 app downloads and short surveys (total 3,400)
- 292 plug-load installations and long survey
(total 457)

A shelf of assembled plug-load sensors

Automating deployment management

- At scale, lots of state is always in flux
- Input errors are more common and have a big impact
- A single, safe interface for all non-expert users



Deployment management in practice

Using the Deployment Management System in the field

Administrative hurdles at home

- Universities move slowly
- Financial agility is key
- Conforming to University policy can be hard
- Financial concerns, even with full funding, caused large delays

Laboratory as a factory

- Assembly too small for traditional factory
- 10 undergraduates, 98% yield

Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Outline

- Introduction
- Small scale deployment
- Medium scale deployment
- Large scale deployment
- Conclusions

Conclusions

- Scale requires automating interfaces and information flow
- Test local assumptions early
- Deploy

Scale	Districts	Plug-load Sensors	DumsorWatch App	Deployment Date	Number of FOs
Small	0	12	5	May 2018	0
Medium	1	165	2000	Aug 2018	11
Large	2	293	1400	Feb 2019	14
Total	3	457	3400		

Thank you!

Hardware, Apps, and Surveys at Scale:
Insights from Measuring Grid Reliability in Accra, Ghana

Noah Klugman[†], Joshua Adkins[†], Susanna Berkouwer[†], Kwame Abrokwah, Ivan Bobashev[†], Pat Pannuto[ǂ], Matthew Podolsky[†], Aldo Suseno[†], Revati Thatte[†], Catherine Wolfram[†], Jay Taneja[*], and Prabal Dutta[†]

JOIN DUMSORWATCH!!!

nklugman@berkeley.edu

noahklugman.com

† **University of California, Berkeley**
Department of Electrical Engineering
Energy Institute at the Haas Business School

* **University of Massachusetts, Amherst**
Department of Electrical Engineering

ǂ **University of California, San Diego**
Department of Electrical Engineering