FoneAstra: Making Mobile Phones Smarter

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Motivation

• Low-tier mobile phones are the most prevalent in developing countries
  – Surveys in Bangalore and parts of Rawanda
• Cheap voice/SMS-only devices
  – Limited hardware capabilities
  – No programmable run-time
  – Restricts service delivery
• How do we extend capabilities of such phones?
• Initial application idea - phone logger
  – Collect extensive phone usage data at large scales
  – Correlations b/w phone usage, time and location?
  – Infer group behavior?
Phone Logger - Requirements

• Communication patterns
  – Phone calls, SMS
    • Inbound, outbound, location, time

• Key presses
  – UI navigation
  – Apps used on the phone
Phone Investigation

• Software phone logger was not an option
  – Mid/High tier phones not as prevalent
  – Would change user experience (Heisenberg)

• Needed logging on common low-tier phones
  – Nokia S30, S40 (1100,1200/3, 1650,3300 etc.)

• Can we build an external, pluggable logger?
  – External interface for accessing usage data
External Interfaces

- **FBUS protocol**
  - Serial interface on low-tier Nokia phones
  - FBUS pin-outs available on Pop-Port
  - Exposes a rich set of capabilities
    - Cell tower-IDs, communications etc
  - *Monitoring key-presses not possible*

- **GSM/CDMA AT commands over data port**
  - Similar capabilities but often not implemented on LT phones
FoneAstra: Basic Architecture

- Battery-powered microcontroller (MCU)
- MCU communicates via FBUS over serial link
- Cell tower-IDs enable location sensing.
- Memory card for persistent storage
Networked Computing Platform

• Input
  – DTMF decoder: input from phone

• Output
  – Headset/Speaker: audio output
    • Useful for semi/illiterate users
  – LCD: visual output

• Sensing via I/O ports

• Communications
  – Send/receive SMS
  – Initiate/answer voice calls
FoneAstra Hardware

- NXP’s LPC2148 processor
  - 16/32 bit ARM7-based microcontroller
  - Extended to support SD/MMC cards
- ~$15 for basic architecture in prototype scale
- Tested with Nokia 1200/3/8/9, 1650/61/62, 2660, 6020
  - Interface will continue to exist on future low-tier Nokia phones
Logging Application

• Phone notifies FoneAstra (FA)
  – Voice call initiated, answered, hung up, rejected
  – SMS sent, received
• Query cell tower-ID for location
• Events logged to SD card
• User study – MSRI support staff
Location Tracking

- MSRI-SP Road – 10 mile round trip
- FA connected to Nokia 1200
- Scan cell tower-ID every 2 minutes
- Data stored on memory card, processed offline
- “Unofficial” Google API to map cell-IDs to geo coordinates
Vaccine Cold-Chain Monitoring

- Collaboration with PATH
- Cold-boxes store vaccines
  - 2°C - 8°C
- Staff at facility manually record temperature
- Monitoring during transit is difficult
- FA enhanced with temperature sensor for monitoring
- Periodically sample sensor
  - Every 15 minutes
  - Aggregate data for 12 hrs
  - Send temperature logs to server via SMS
    - 2 SMSes per day
- SMS Alarms to notify deviation
- Location tracking in transit
- Local display for simple statistics
- FA-based solution $50
  - Commercial products > $500!
Monitor Milk Pasteurization

- Human Milk Banks for infants
- Pasteurize milk to kill HIV
  - Controlled heating
- FA enhanced with temp sensor and audio/visual output
- Real-time feedback to guide health worker
- SMS reports to remote experts
- FA-based solution <$100
  - Commercial products $2500 - $12000!
Future Work

- Extended “in-lab” deployment at PATH
  - Solar-powered Cold-box on PATH’s rooftop
- Add display and audio playback capabilities
- Field trials in Albania, South Africa
- Integrate with cell phone
  - Draw power from phone’s battery
- FoneAstra for smart phones
  - Integrate high-level sensors (e.g. ultra sound probe)
  - Healthcare delivery and point of care diagnostics in rural areas
Questions?

(And a simple demo for later, if folks are interested)