SystemSens: A Tool for Monitoring Usage in Smartphone Research Deployments

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MobiArch
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What was going on?
What was going on?

We need a “black box” on smartphones in research deployments.
Unexpected behavior

![Battery Level Graph]

- Battery Level (%)
- Time (hour)

Thursday, August 18, 11
Unexpected behavior

We assumed batteries would only charge or discharge
Unexpected behavior

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We assumed batteries would only charge or discharge
Unexpected problems
Unexpected problems

![Graph showing battery level over time](image-url)
Unexpected problems

![Battery Level vs Time Graph](image)
Unexpected problems

![Graph showing battery level and temperature over time with a question mark indicating an anomaly at around 12 hours.](image-url)
Unexpected problems

Time (hour)

Battery Level (%)

# Interactions

Time (hour)

Thursday, August 18, 11
Unexpected problems
Unexpected problems

This was a bug in the GPS driver
Need for a generic tool
Need for a generic tool

1. Developers might miss information and dependencies

2. Avoiding deploying multiple logging tools on the same phone (wasting power and resources)
Need for a generic tool

1. Developers might miss information and dependencies

2. Avoiding deploying multiple logging tools on the same phone (wasting power and resources)

- Design & Architecture
- Evaluation
- Demo
Client Architecture

Polling Sensors
- WiFi Scan Info
- /Proc info
- Memory info
- Network info
- External Apps

Event-based Sensors
- Net State Sensor
- Screen Sensor
- Message Sensor
- Call Sensor
- Battery Sensor

SQLite DB

SystemSens DB Adaptor

SystemSens Uploader

HTTPS Post/JSON

SystemSens Server
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SystemSens Service

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SystemSens Server

Main Thread
Client Architecture

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Net Thread
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  - SystemSens DB Adaptor
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- SQLite DB

- Main Thread
- DB Thread
- Net Thread

- HTTPS Post/JSON

- SystemSens Server

App I
App II

Thursday, August 18, 11
Record Size

- Memory
- Activity Log
- Screen
- Call
- Message
- Network
- Call State
- Wi-Fi Scan
- Call Forwarding
- Cell Location
- Data Connection
- System Sensors
- GPS State
- Network Location
- Battery
- Service State
- Network Log
- Cpu
- Service Log
- Memory Info
- Network Log
- App Resources

Median Record Size (Bytes)

Thursday, August 18, 11
Records per hour

CDF

Number of records

User 1
User 2
Records per hour

CDF

Number of records

User 1

User 2
Records per hour

Between 0.75 MB and 5.5 MB of data per day
Power Consumption

- Phone: 24 mW
- SystemSens: 43 mW
- w/o Writing: 41 mW
- w/o Proc: 39 mW
- Zero Sensors: 36 mW
Power Consumption

- Phone: 24 mW
- SystemSens: 43 mW
- w/o Writing: 41 mW
- w/o /Proc: 39 mW
- Zero Sensors: 36 mW

Total difference: 19 mW
Power Consumption

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone</td>
<td>24</td>
</tr>
<tr>
<td>SystemSens</td>
<td>43</td>
</tr>
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</tr>
<tr>
<td>Zero Sensors</td>
<td>36</td>
</tr>
</tbody>
</table>

- 2 mW
- 19 mW
Power Consumption

- Phone: 24 mW
- SystemSens: 43 mW
- w/o Writing: 41 mW
- w/o Proc: 39 mW
- Zero Sensors: 36 mW

2 mW

9 mW
Power Consumption

- Phone: 24 mW
- SystemSens: 43 mW
- w/o Writing: 41 mW
- w/o Proc: 39 mW
- Zero Sensors: 36 mW

Power (mW)
Power Consumption

- Phone: 24 mW
- SystemSens: 43 mW
- w/o Writing: 41 mW
- w/o Proc: 39 mW
- Zero Sensors: 36 mW

Doing all the work

19 mW

2 mW
2 mW
3 mW

7 mW
Power Consumption

- Phone: 24 mW
- System Sens: 43 mW (2 mW, w/o Writing, 2 mW, w/o /Proc, 3 mW, Zero Sensors)
- Power consumption:
  - Doing all the work: 7 mW
  - Waking up the phone: 12 mW

Graph showing power consumption across different scenarios.
When the phone is woken up the marginal cost of extra sensors is insignificant.

Doing all the work

Waking up the phone

Power Consumption

Phone: 24 mW
SystemSens: 43 mW
w/o Writing: 41 mW
w/o Proc: 39 mW
Zero Sensors: 36 mW

Power (mW)

19 mW

12 mW

2 mW

3 mW
Battery Life

Battery Level (%)

Time (hour)

- Default
- SystemSens

Worst case
Conclusions

• Research deployments should log usage and context more broadly

• Minimize battery cost by minimizing waking up the phone
SystemSens users

1. Aruna Balasubramanian, University of Washington
2. Jiang Zhu, CMU Silicon Valley
3. Martin Lukac, NexLeaf Analytics
4. Tingshao Zhu, Chinese Academy of Sciences, Cyber Psychology
5. Murtuza Chhatrriwala, Qualcomm
6. Birjodh Tiwana, University of Michigan, Ann Arbor
7. Hamed Soroush, University of Massachusetts, Amherst
8. Hakbong Kim, Seoul National University
9. Zohair Ihsan, University Technology Malaysia
10. Marwan Omar, Colorado Technical University
11. Byeong-Gyu Park, Sungkyunkwan University, Korea
12. Hao Liu, Tsinghua University, China
13. Mohd Fikri Azli, Chonnam National University, Korea
14. Rui Guo, University of California, Irvine
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