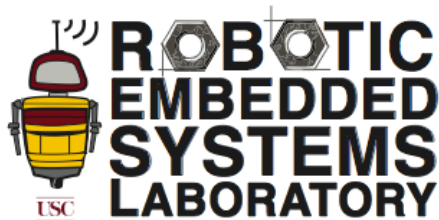


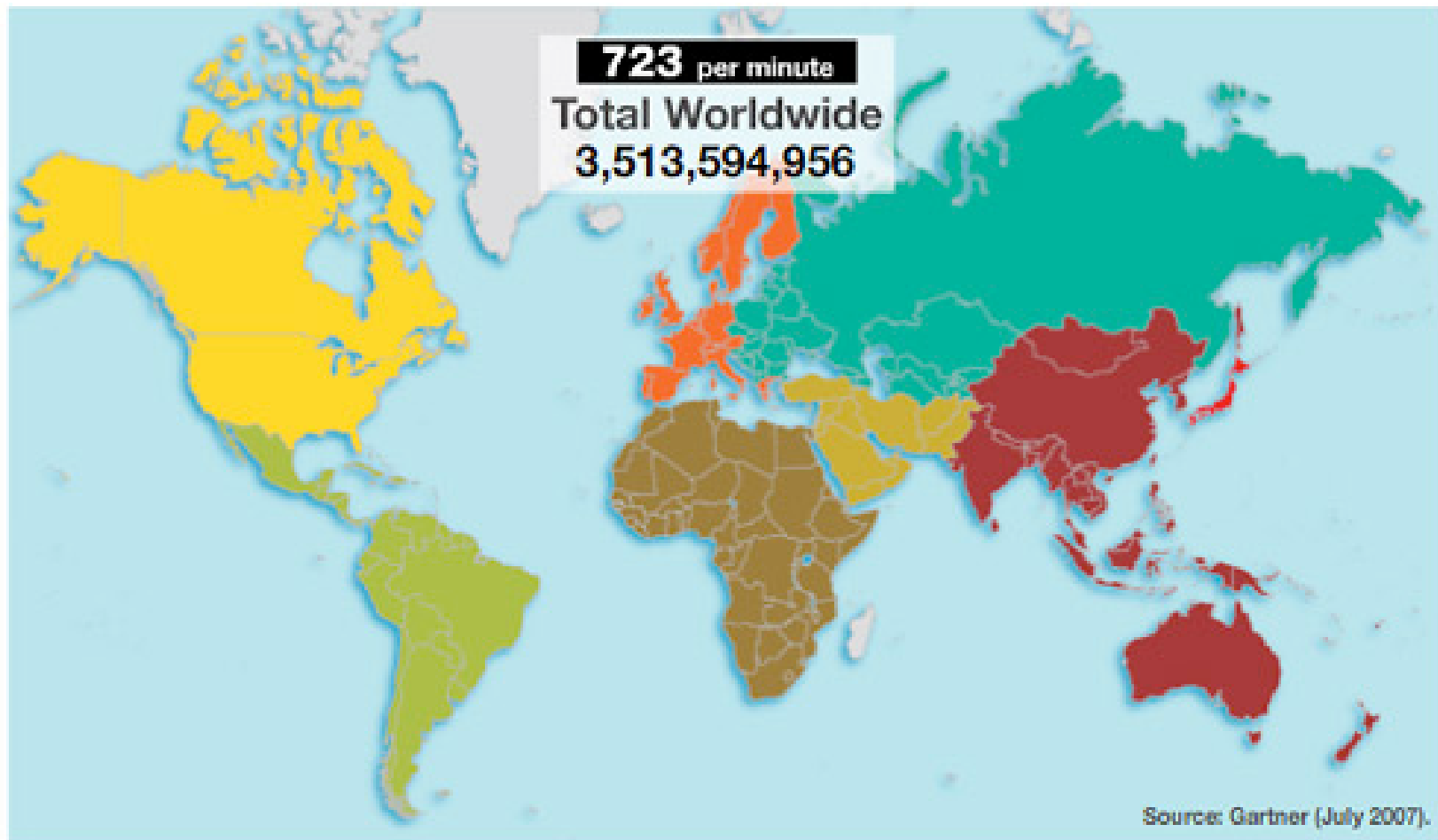
my view of
^ the mobile wave
&
SenSys paper on CenceMe

Sameera Poduri



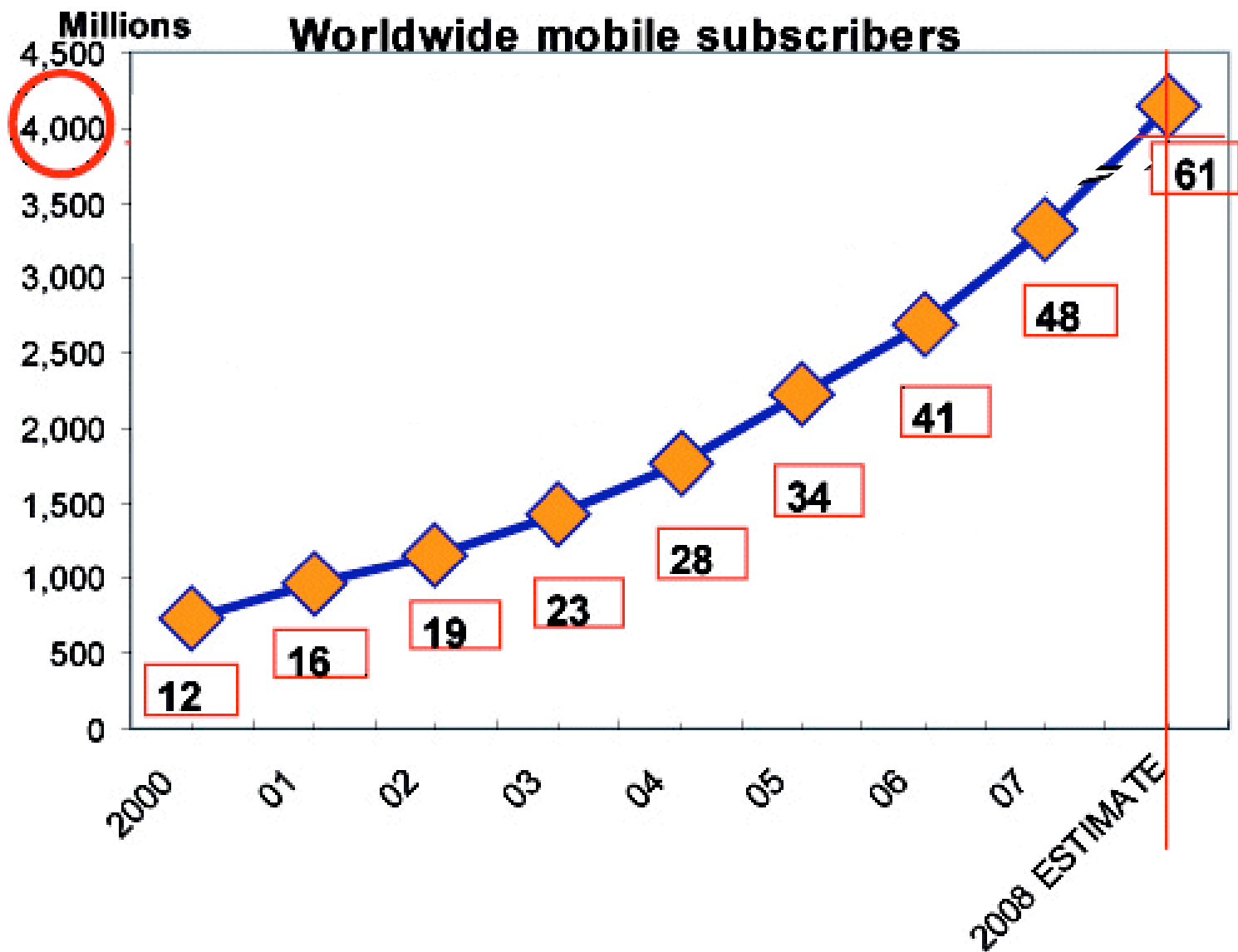
CS 546 Intelligent Embedded Systems

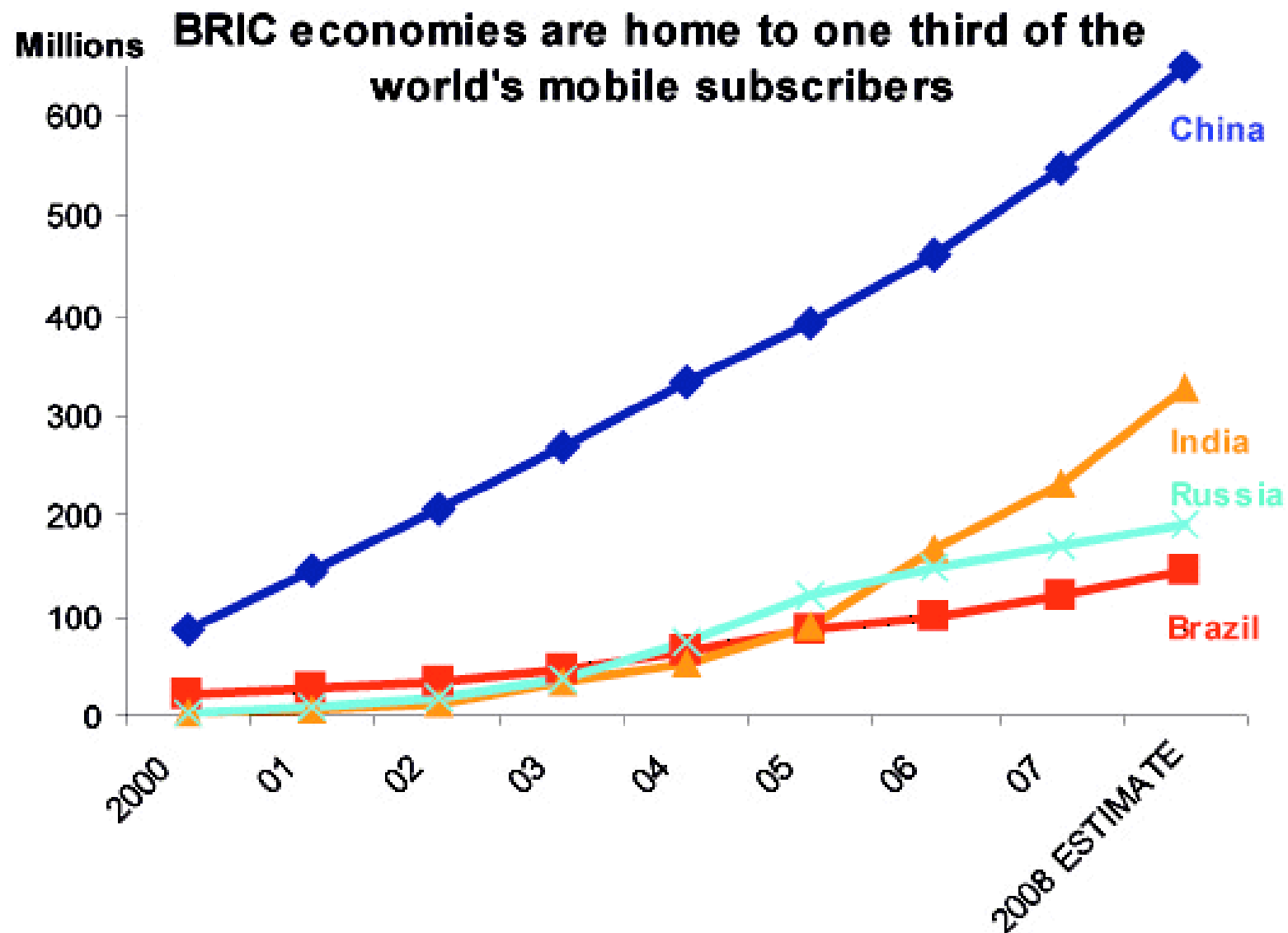
01.26.09



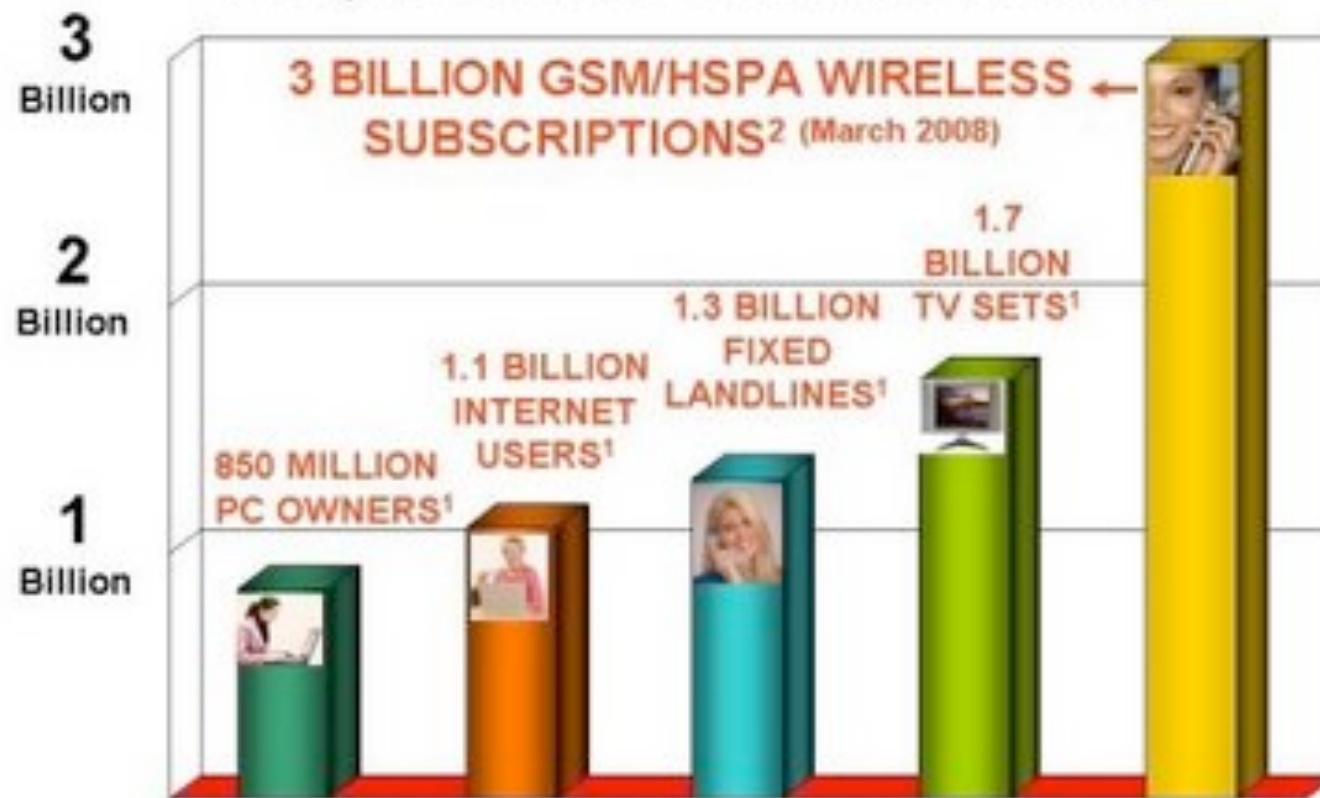
today >4 billion (60%)

[United Nations International Telecommunications Union, Sept 2008]





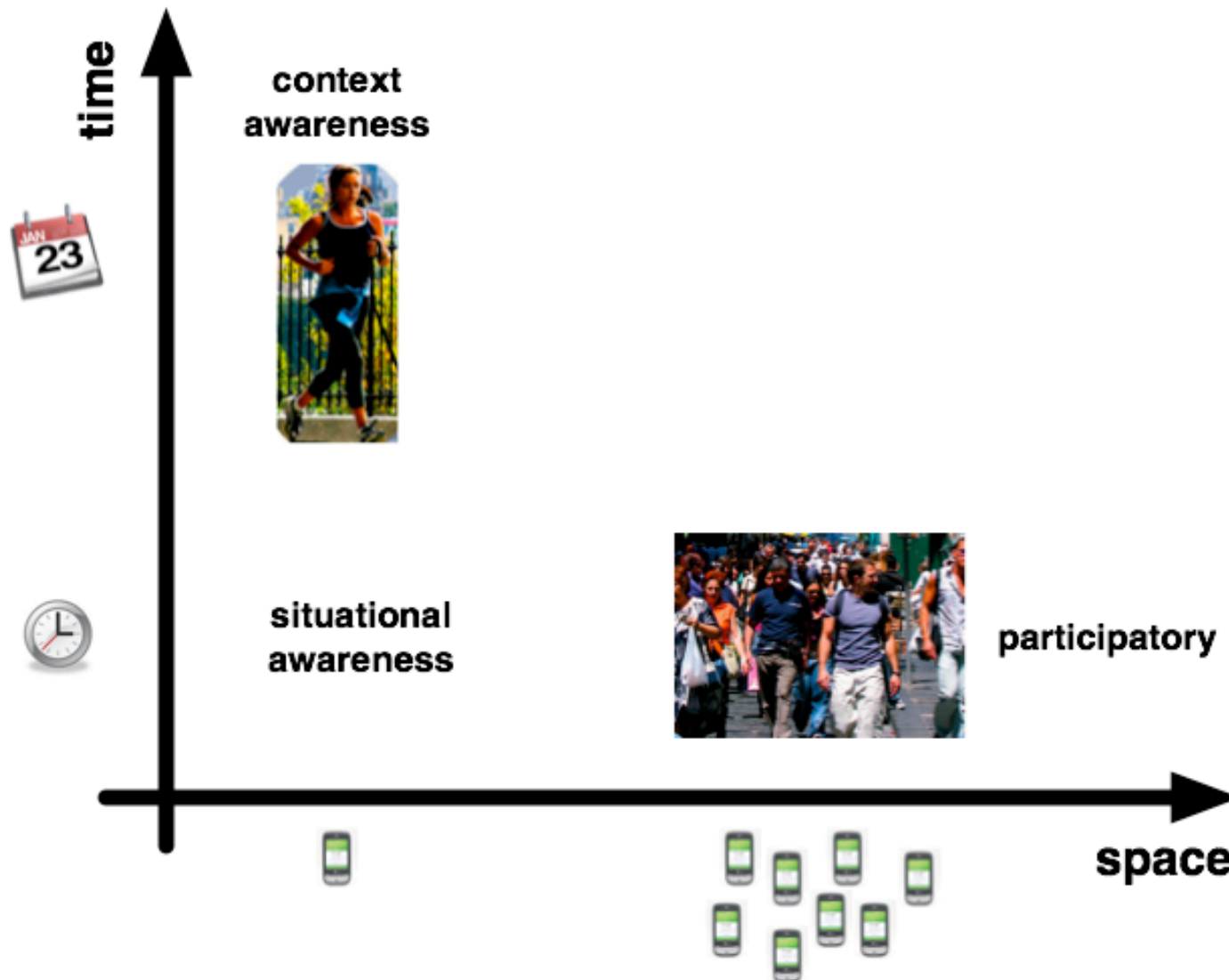
Personal Communications Technologies *Comparison of Global Market Size*

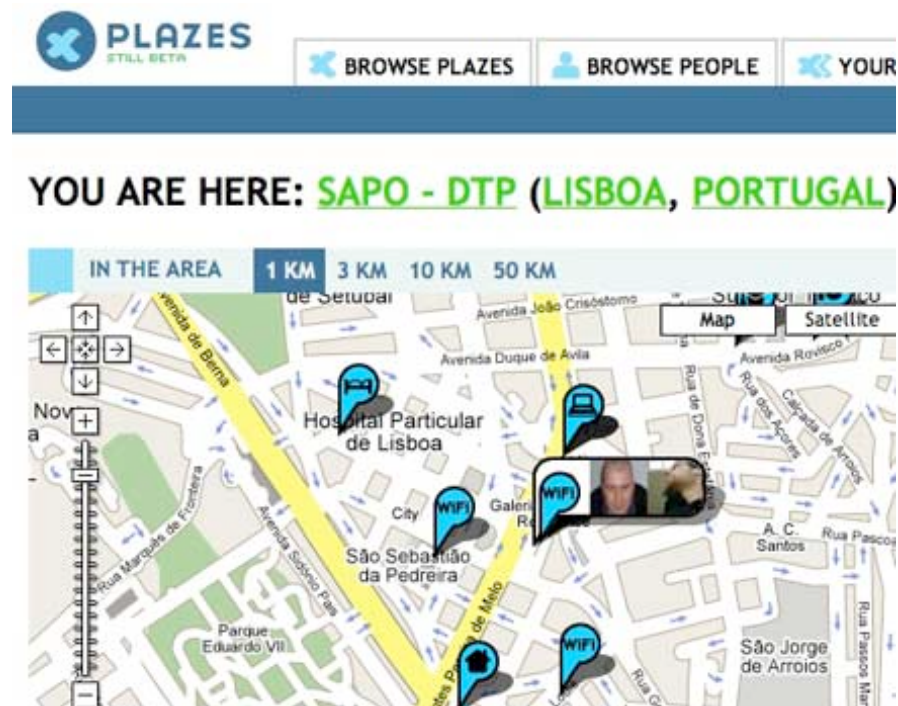


Source: ¹Tomi Ahonen, Jan 2007 ²Informa Telecoms & Media, WCIS, March 2008



application space





context awareness is more than *add GPS and stir*

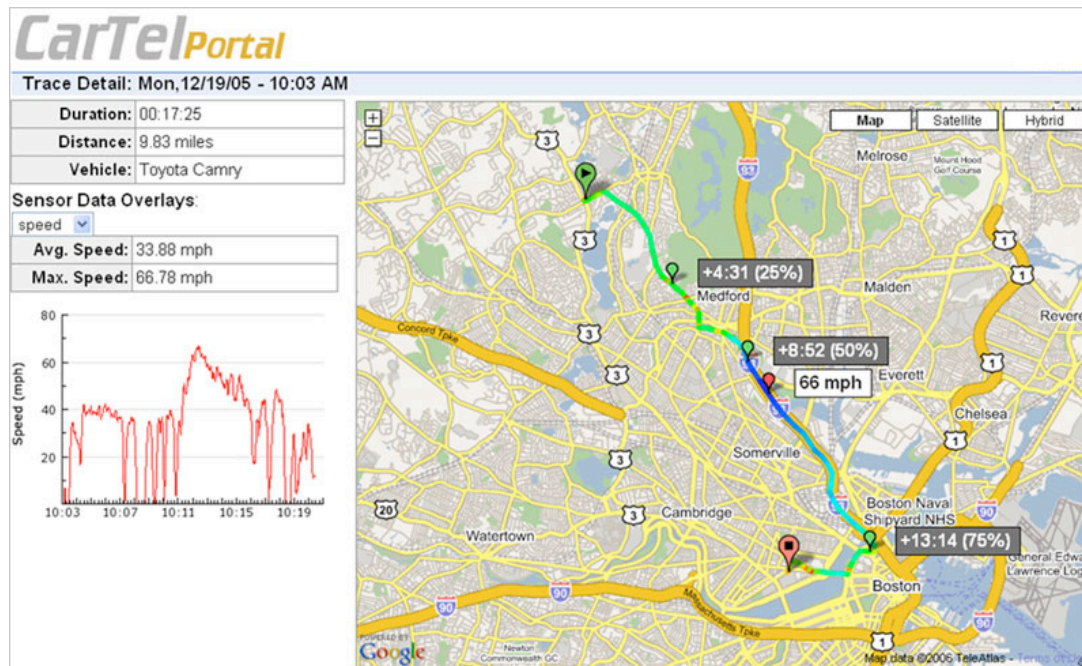
[Dawn Nafus, Intel, 2008]

algorithms - signal processing, classification, machine learning

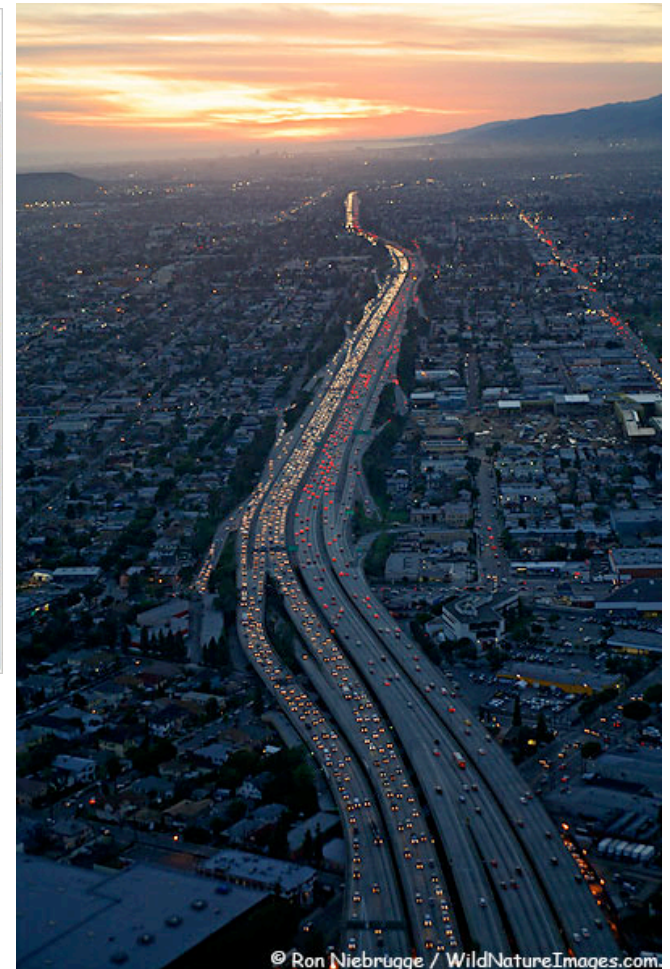
energy-accuracy tradeoff

privacy

participatory sensing



user \equiv data gatherer

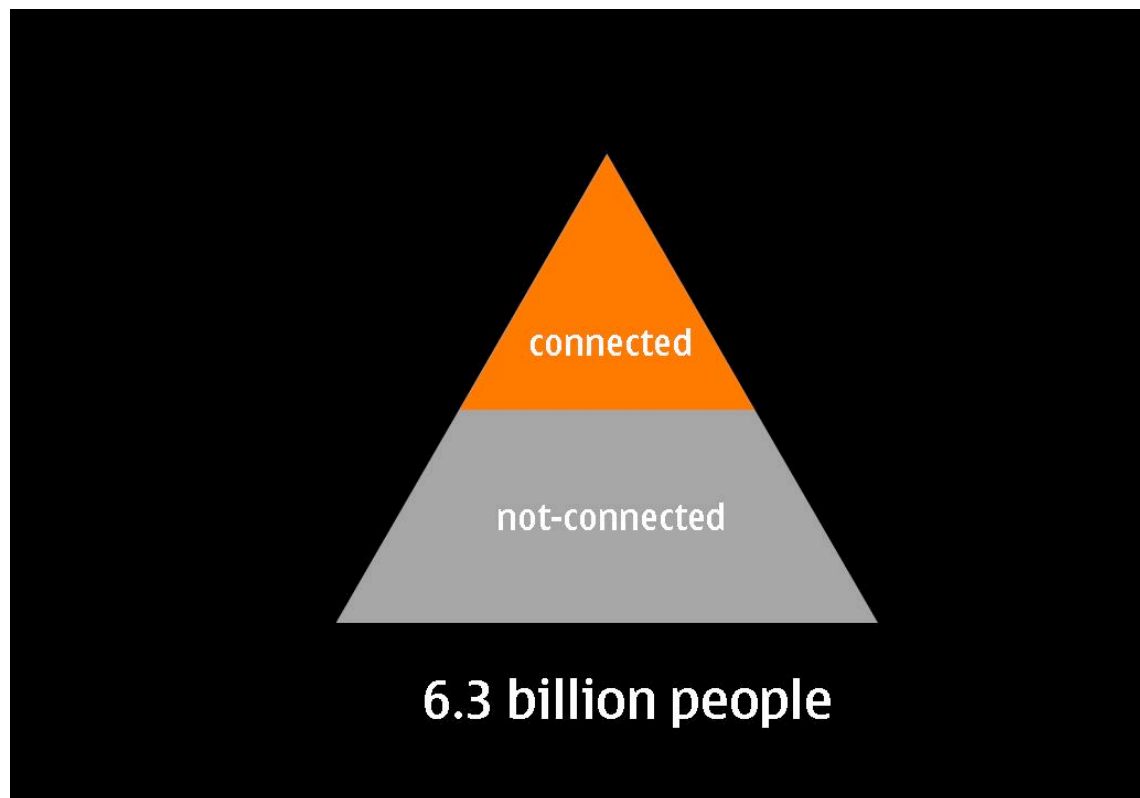


issues

- requires threshold number of users
- what is the incentive for participating?
- how to ensure privacy?
- can we trust user data?

next billion users

Emerging markets : India, China, Brazil, Africa



[Jan Chipchase]



originally designed for...

[Jan Chipchase]

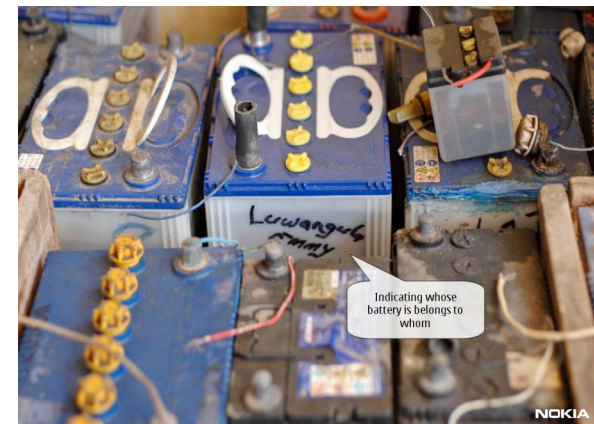
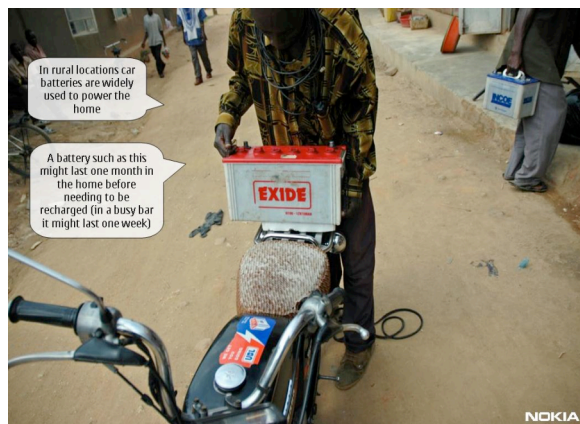


increasingly used in...

much of the growth is coming from places such as India and Africa
with much lower levels of structured learning

[Jan Chipchase]

electricity



[Jan Chipchase, Uganda, 2006]

literacy and communication

- illiteracy ~0.8 billion
- native languages

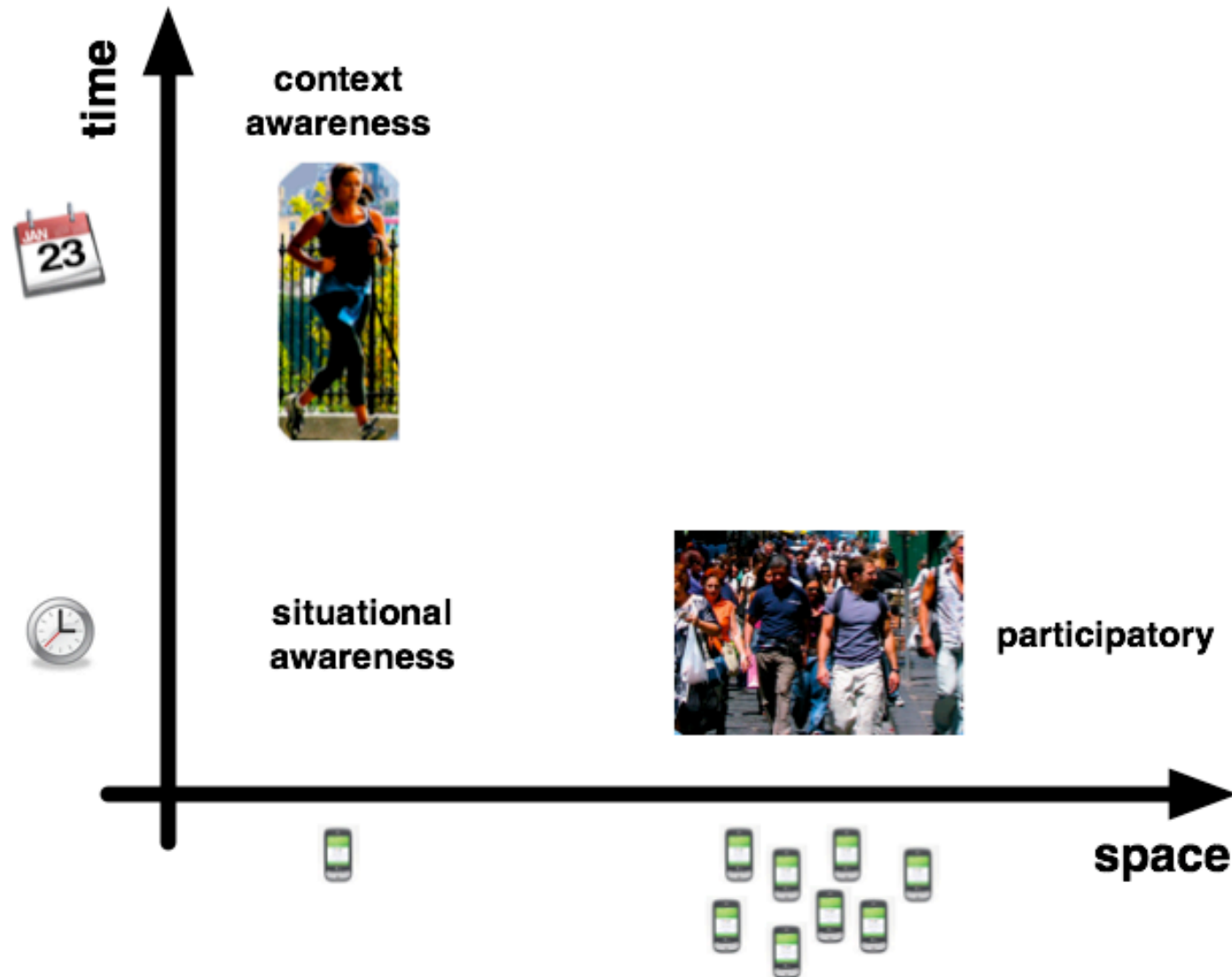
solution

- support native languages
- interface designs - audio/visual prompts vs textual

user innovation



[Jan Chipchase, Uganda, 2006]



Sensing Meets Mobile Social Networks: The Design, Implementation and Evaluation of the **CenceMe** Application

Emiliano Miluzzo, Nicholas D. Lane, Kristóf Fodor, Ronald Peterson, Hong Lu, Mirco Musolesi, Xiao Zheng, Andrew T. Campbell

Computer Science, Dartmouth College

Shane B. Eisenman

Electrical Engineering, Columbia University



ACM Conference on Embedded Networked Sensor Systems, (SenSys) 2008

Your Seventh Sense

HOME DESCRIPTION NEWS DOWNLOAD FAQ DISCUSSION

cenceme



connects with

Facebook

Want to sense your social network in real-time? Want to know what your friends are doing right now - sitting, walking, running, dancing? Want to know their social setting or fav hangouts - gym, café, meeting, party?

Ready for the next step in Web presence? CenceMe uses iPhone™ sensors to automatically discern your activity and more, and shares it with your Facebook™ buddies while respecting your privacy needs.

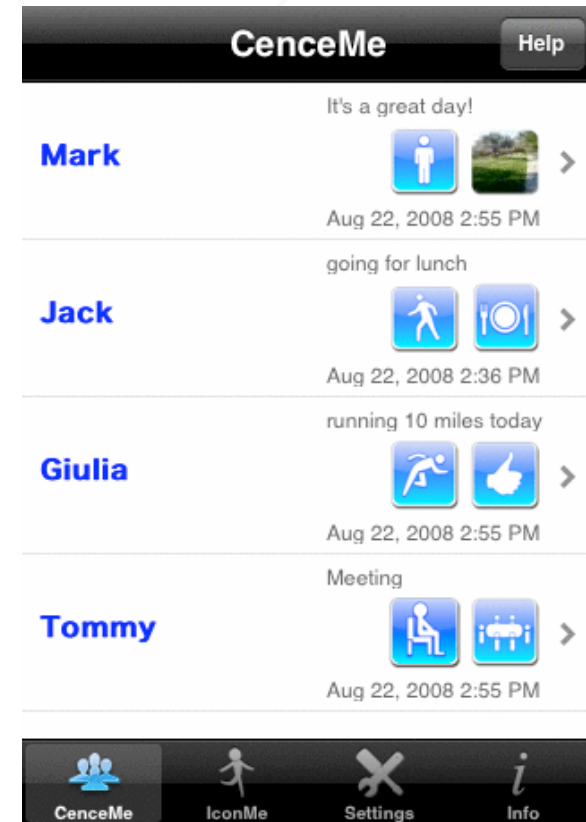
CenceMe - Your Seventh Sense on the iPhone™ and iPod touch now!





goal: infer **context**

- activity - sitting, walking, running, etc
- silent, conversation, noisy
- location on map, pictures
- surrounding - meeting, party, etc



outline

- motivation
- architectural design
- classification algorithm
- results
- conclusions

motivation

- common text messages - “where are you?”, “what are you doing?”
- your phone has a variety of sensors - camera, GPS, accelerometer, proximity sensors, microphone, ..
- let the phone answer these questions

design considerations

- Nokia N95, Symbian/ JME VM, Facebook
- challenges
 - OS - prioritizes calls over third party apps, lot of exception calls
 - JME - accelerometer functions not supported
 - security - access is controlled to file system, bluetooth, GPS, ...
 - energy - 'always on' mode wont do
- split-level operation
 - first-cut on phone - *primitives*
 - complex algorithms on backend server - *facts*
 - supports *customized tags*

CenceMe implementation

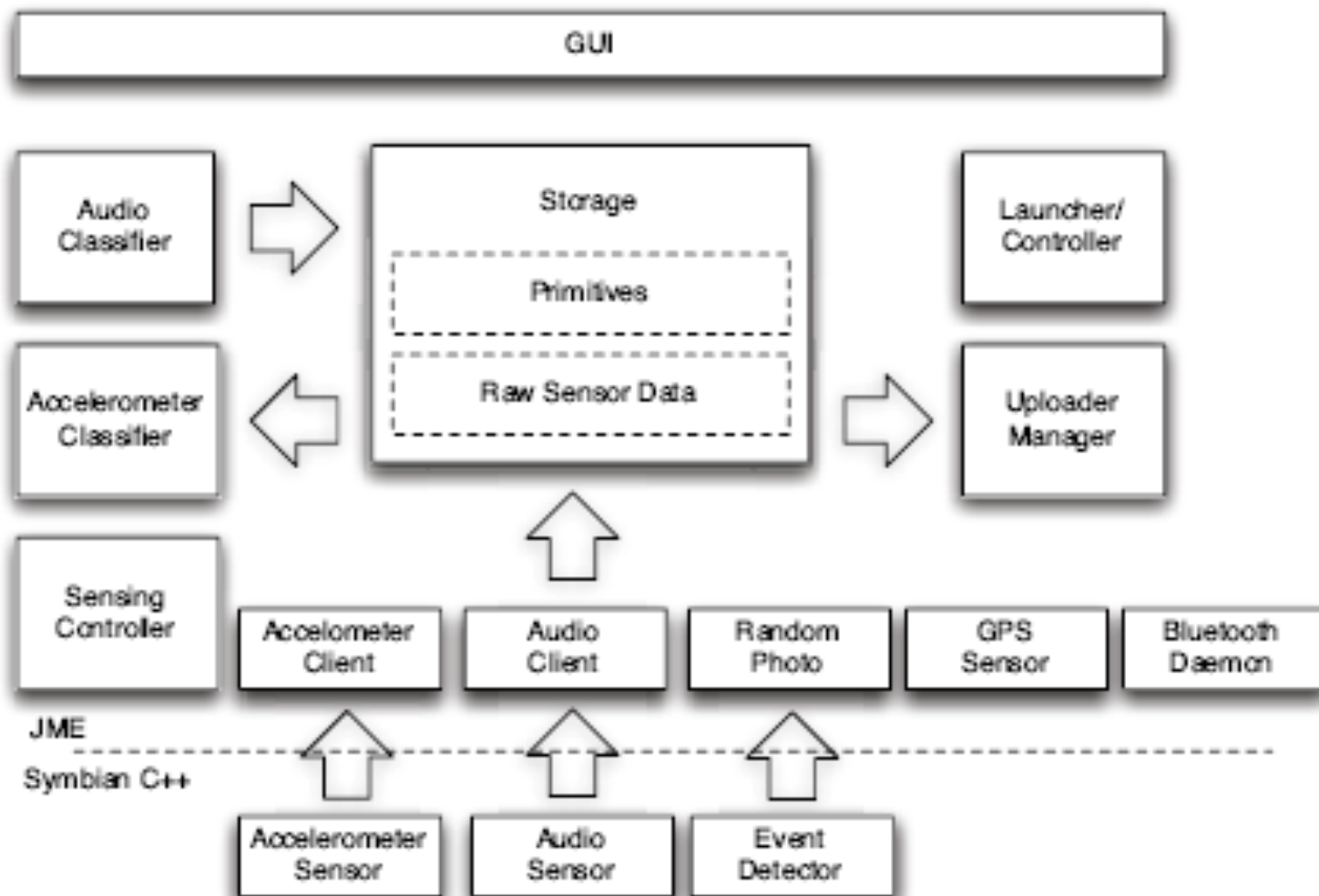
phone:

- sensing
 - basic classification - primitives
 - presentation to user
1. upload to server

backend server:

- classify audio
 - classify accelerometer
 - bluetooth/MAC scan
 - GPS
1. random photos

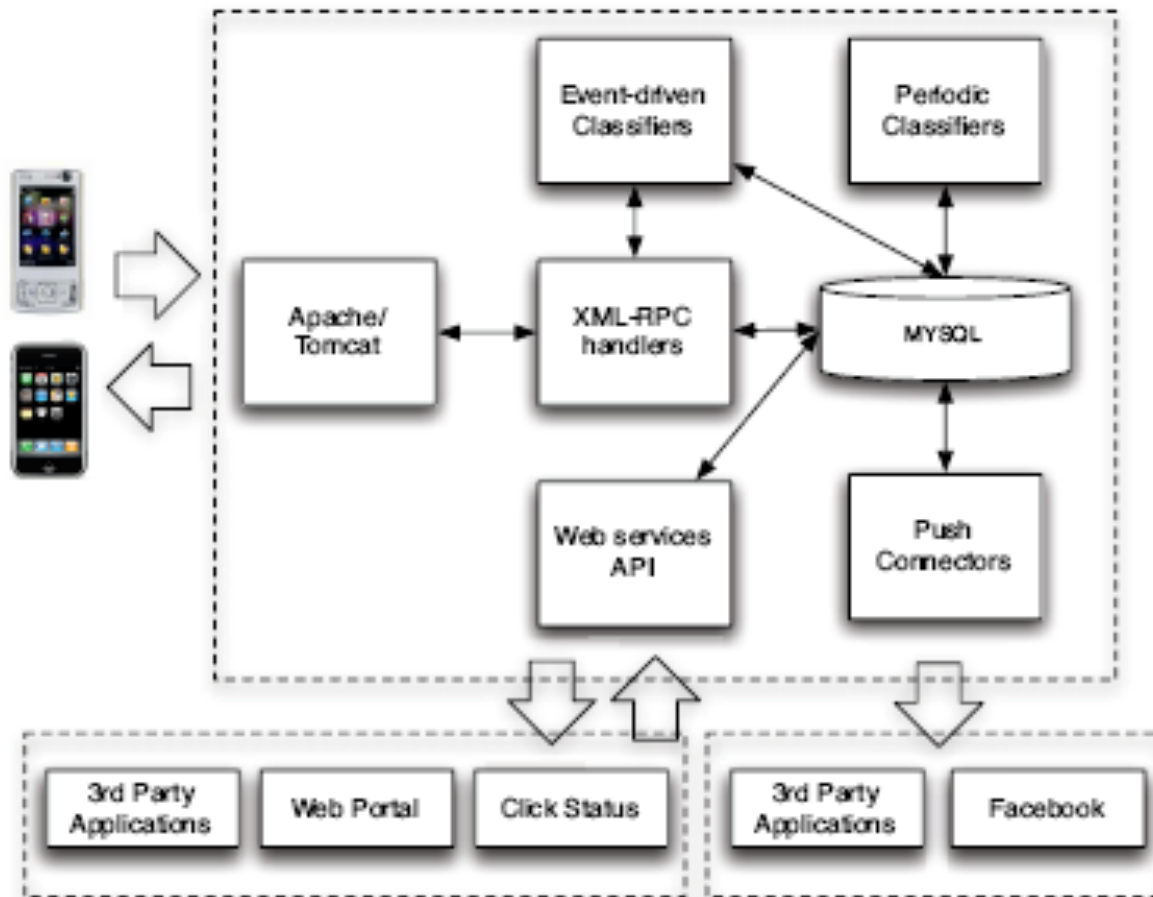
phone software



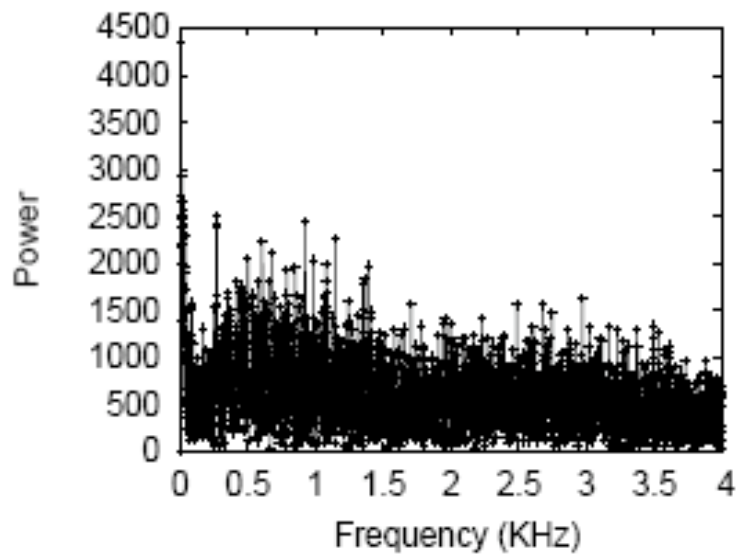
ClickStatus



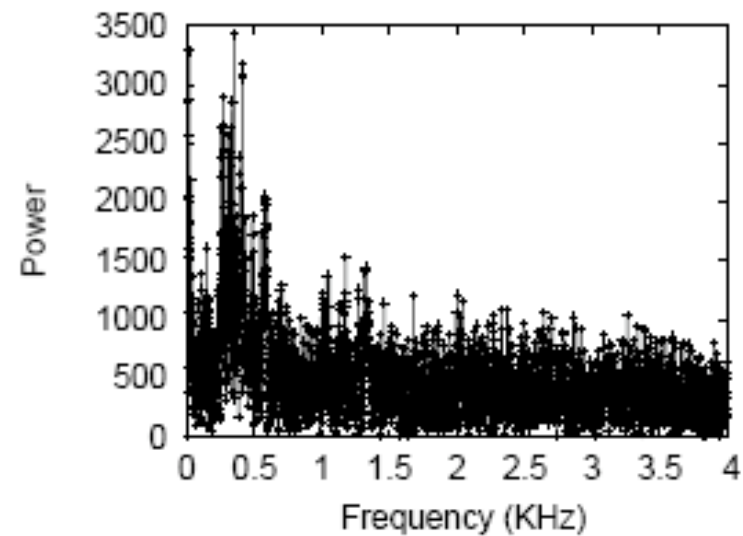
backend



audio samples

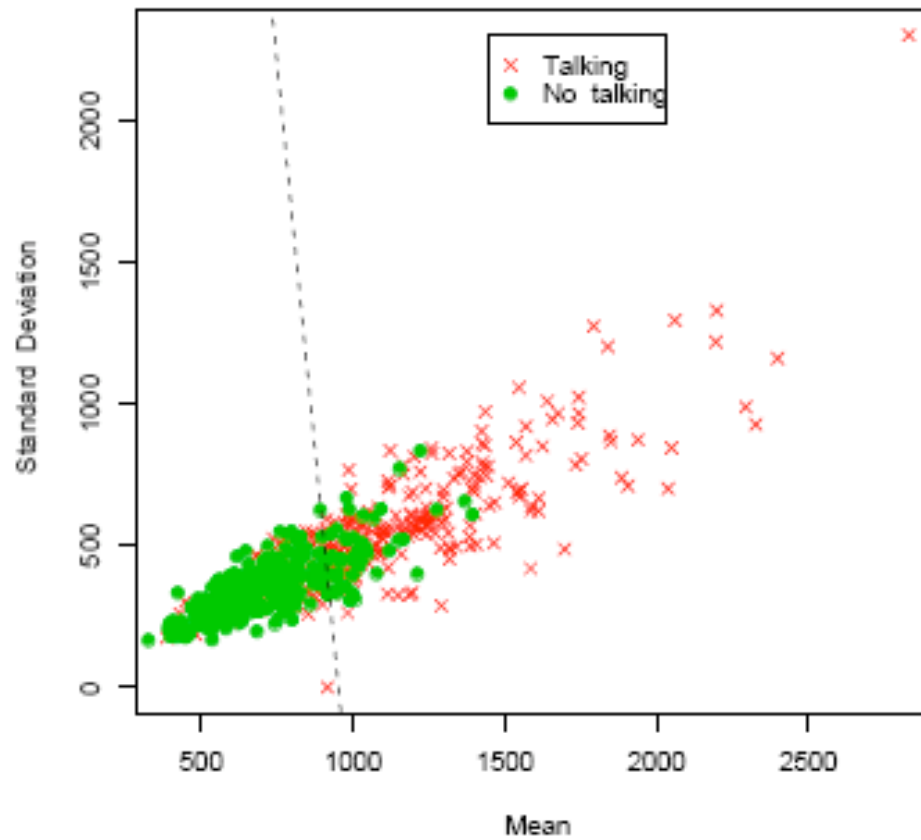


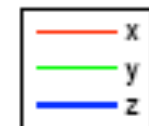
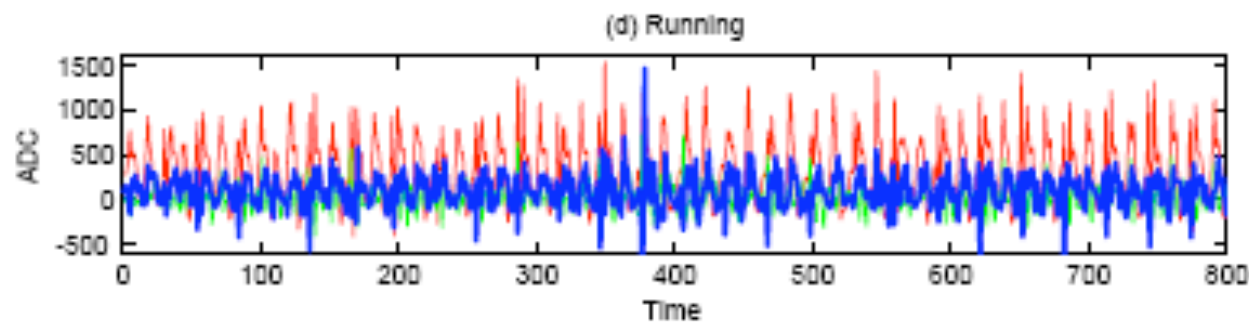
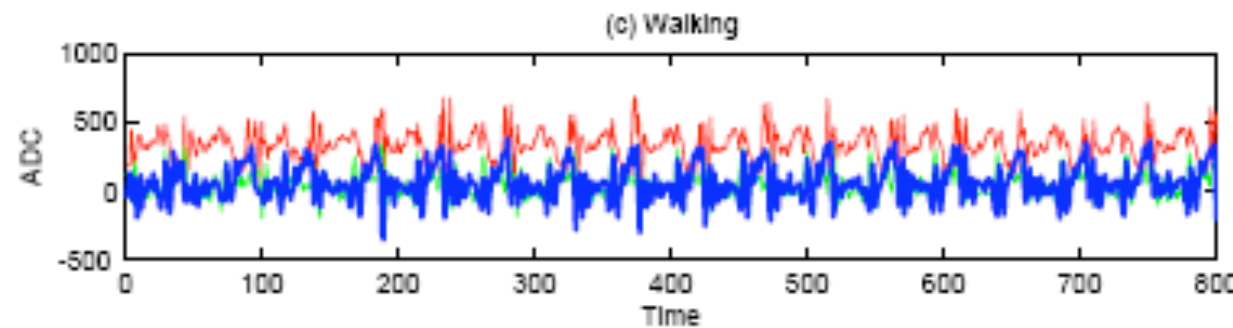
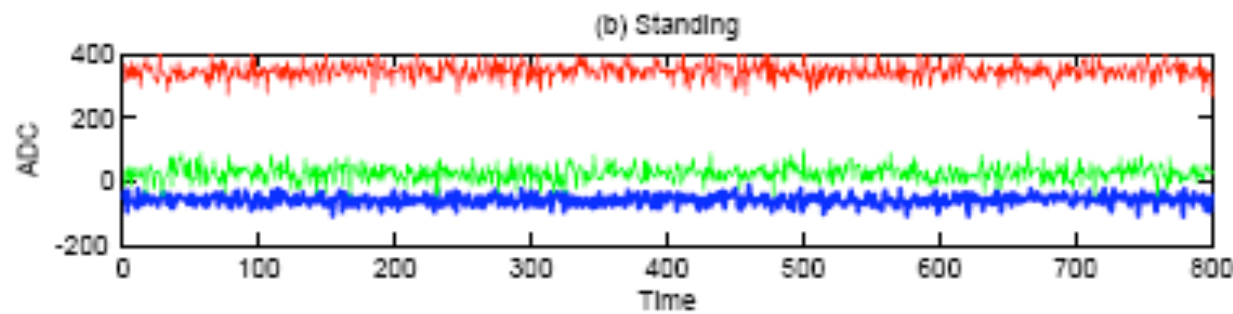
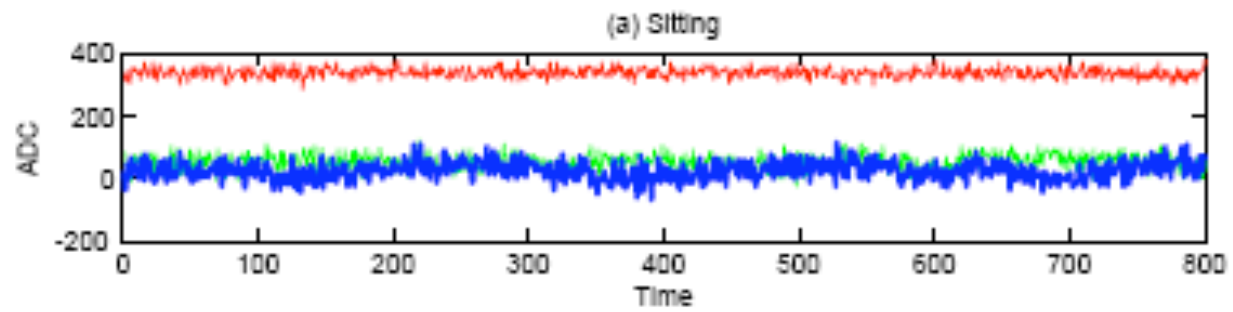
ambient noise



human voice + ambient noise

audio classification





backend classifier

- higher level context - facts
 - conversation
 - mobility mode
 - “Am I Hot”

results

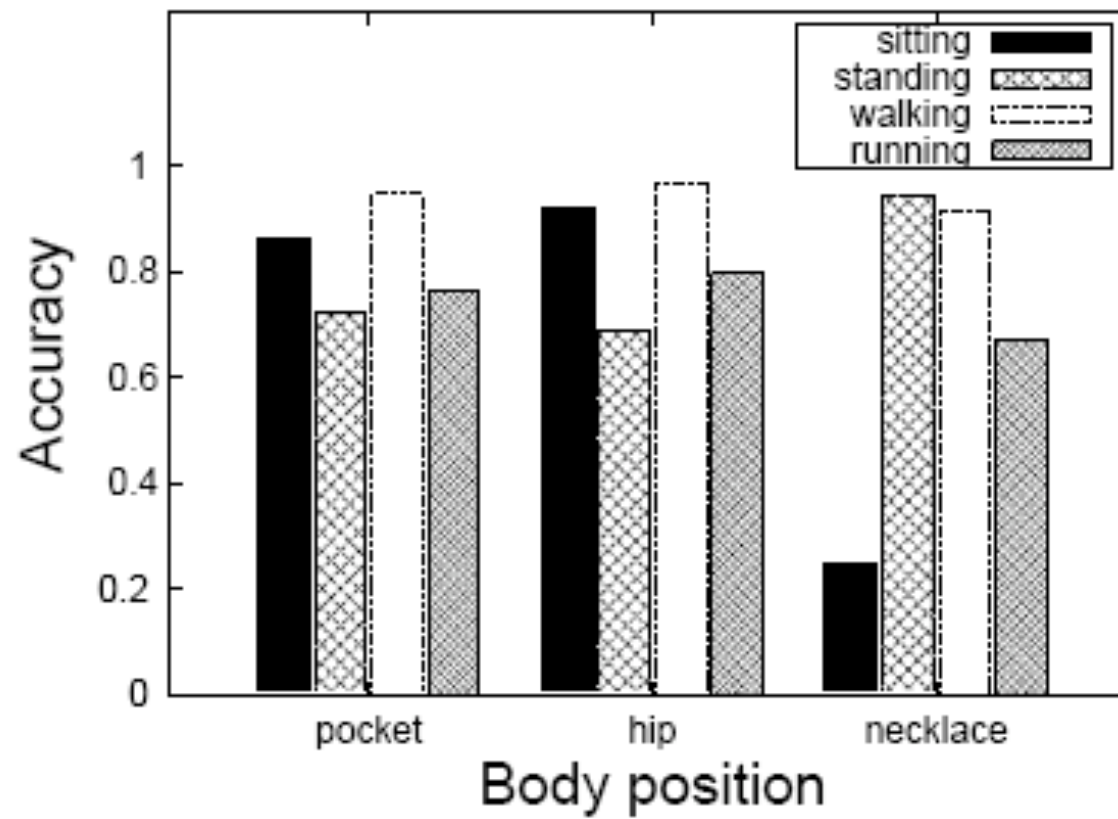
Table 1: Activity classifier confusion matrix

| | <i>Sitting</i> | <i>Standing</i> | <i>Walking</i> | <i>Running</i> |
|-----------------|----------------|-----------------|----------------|----------------|
| <i>Sitting</i> | 0.6818 | 0.2818 | 0.0364 | 0.0000 |
| <i>Standing</i> | 0.2096 | 0.7844 | 0.0060 | 0.0000 |
| <i>Walking</i> | 0.0025 | 0.0455 | 0.9444 | 0.0076 |
| <i>Running</i> | 0.0084 | 0.0700 | 0.1765 | 0.7451 |

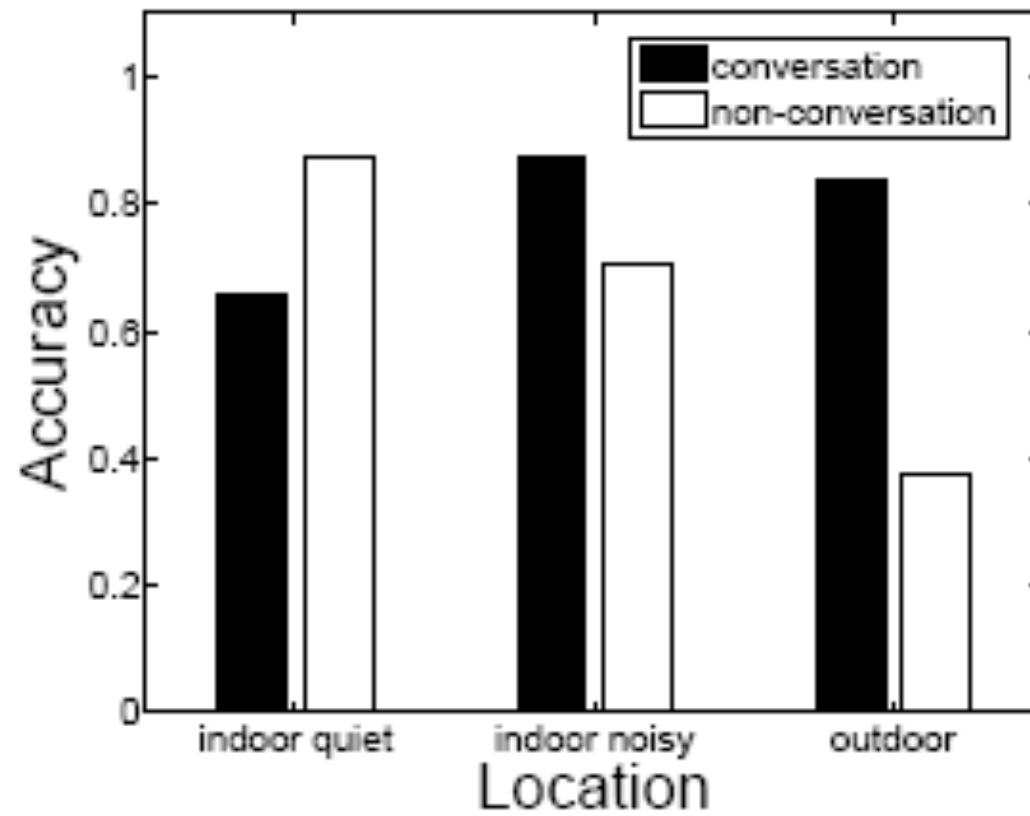
Table 2: Conversation classifier confusion matrix

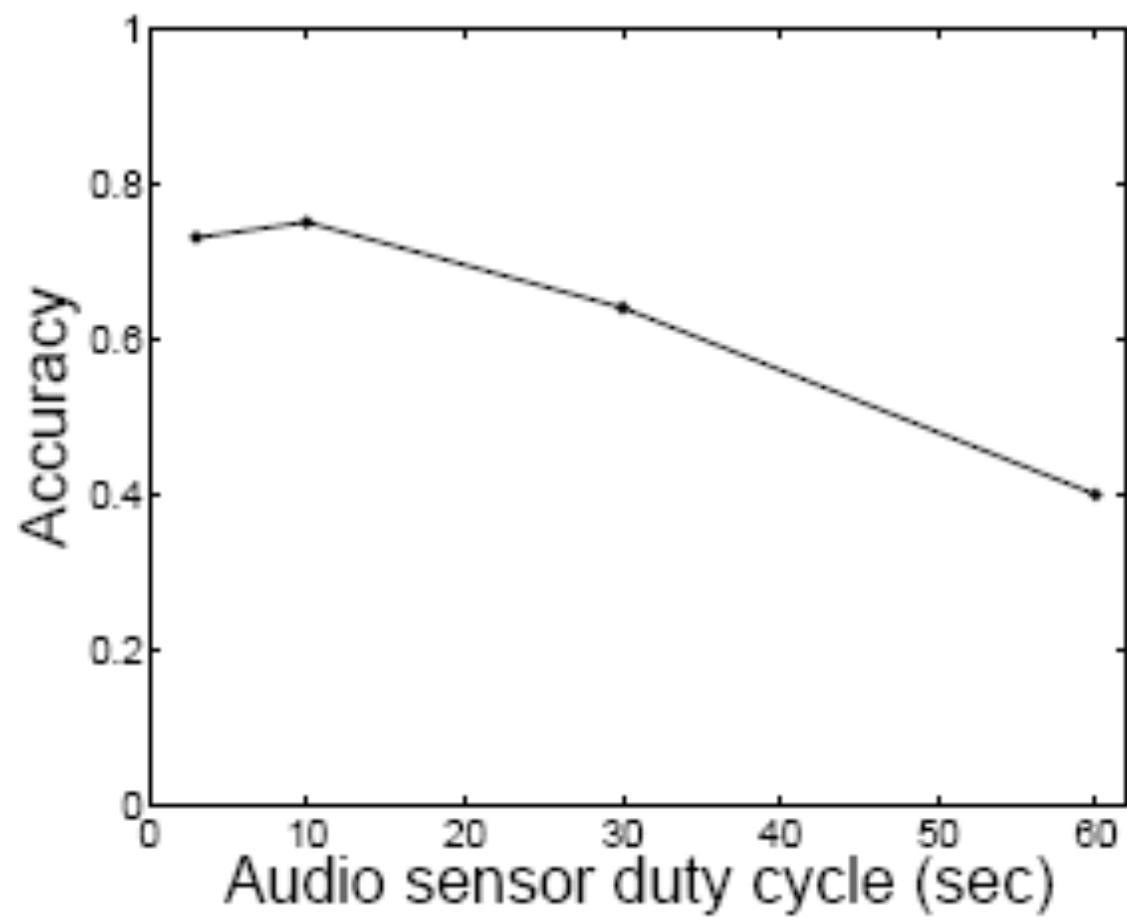
| | <i>Conversation</i> | <i>Non-Conversation</i> |
|-------------------------|---------------------|-------------------------|
| <i>Conversation</i> | 0.8382 | 0.1618 |
| <i>Non-Conversation</i> | 0.3678 | 0.6322 |

results

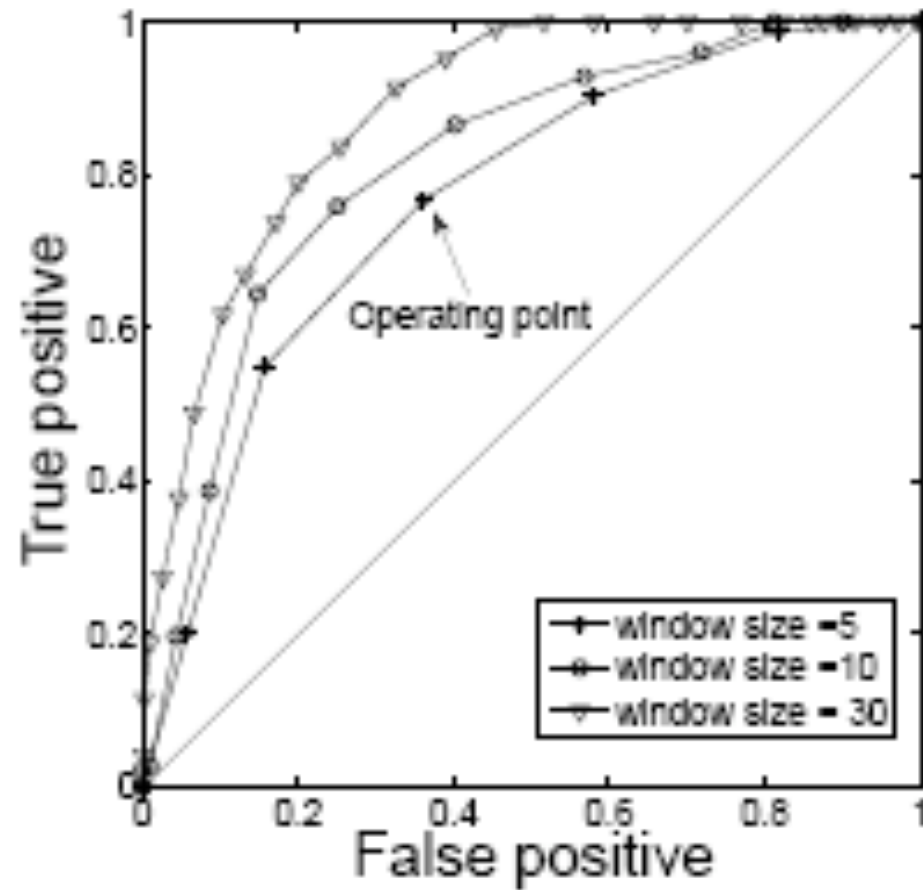


results

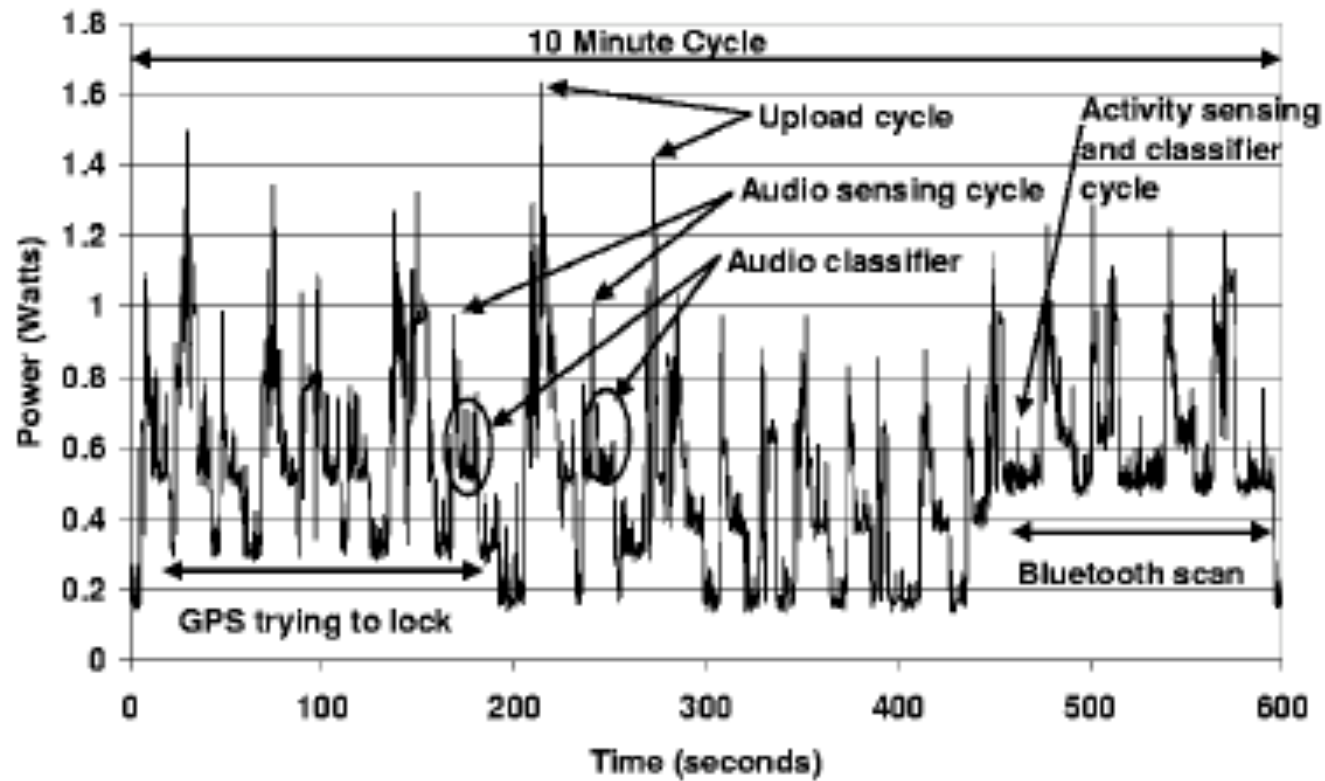




backend results



power consumption

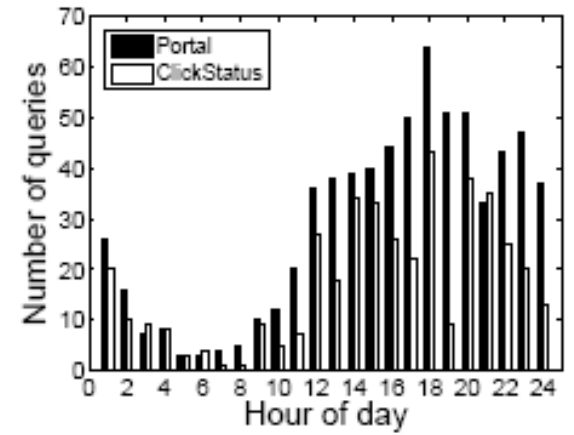
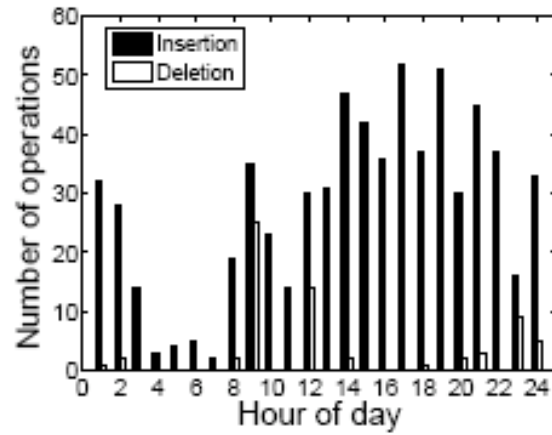
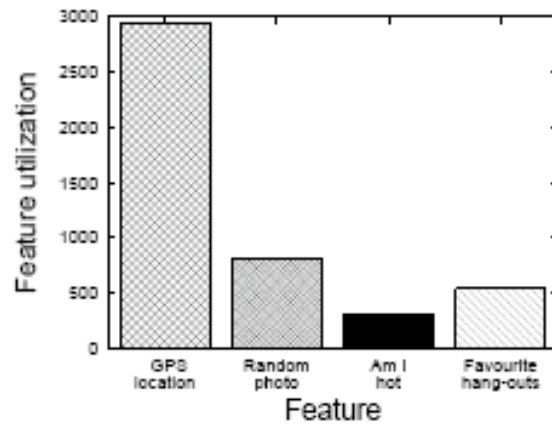


memory and CPU benchmarks

Table 4: RAM and CPU usage

| | <i>CPU</i> | <i>RAM (MB)</i> |
|-------------------------------------|---------------|-----------------|
| <i>Phone idle</i> | 2% (+/- 0.5%) | 34.08 |
| <i>Accel. and activity classif.</i> | 33% (+/- 3%) | 34.18 |
| <i>Audio sampling and classif.</i> | 60% (+/- 5%) | 34.59 |
| <i>Activity, audio, Bluetooth</i> | 60% (+/- 5%) | 36.10 |
| <i>CenceMe</i> | 60% (+/- 5%) | 36.90 |
| <i>CenceMe and ClickStatus</i> | 60% (+/- 5%) | 39.56 |

user studies



conclusions

- complete system - retrieve and publish sensor information
- addresses energy consumption, computation, security
- uses off-the-shelf devices
- detailed user study for future research

review

liked

- fully functional mobile sensor system, first of its kind
- thorough evaluation and analysis
- clear presentation

would have liked

- more details about the classifier

extensions

- richer context information
- applications beyond social networking
- implementation challenges will change (vanish?) with new phone models

Facebook | Shane Eisenman - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://columbia.facebook.com/profile. | Google

reservoir Gmail TinyURL! Google Bookmark NZ Herald NY Times Facebook

cenceMe Facebook | Shane Eisen...

facebook Profile edit Friends Networks Inbox (1) home account

Search

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Hot Stock Alert - OXFD Profit From Mortgage Meltdown. Value Stock Investment Opportunity. [www.OxfordFun...](#)

LasikPlus Vision Centers 0% interest for 12 months. Schedule your free LASIK vision exam! [www.LasikPlus...](#)

Do You Know Your Credit Score? The average U.S. credit score is up to 692. See yours for \$0. [www.freecredi...](#)

GEICO Car Insurance

I am online now.

Friends

Buddy SP

updated Tue Feb 05 21:09:18 EST 2008 powered by CenceMe

Friends in Other Networks

Networks with the most friends

Dartmouth (3)
Cornell (1)

Show All Networks | View All Friends

Shane Eisenman

is running with Nicholas.
Updated just a moment ago edit

Networks: Columbia Grad Student '08
Birthday: November 6, 1976

Mini-Feed

Displaying 6 stories.

Yesterday

Shane is sitting.
Shane is walking.
Shane is walking.
Shane is walking.
Shane is walking.
Shane is walking.

Information

Sensor Presence

activity social context location

sitting quiet work

updated Tue Feb 05 21:09:17 EST 2008 powered by CenceMe

The Wall

Education

Education Info [edit]
Grad School: Columbia '08

Done