Crowd-Sourced Sensing and Collaboration using Twitter

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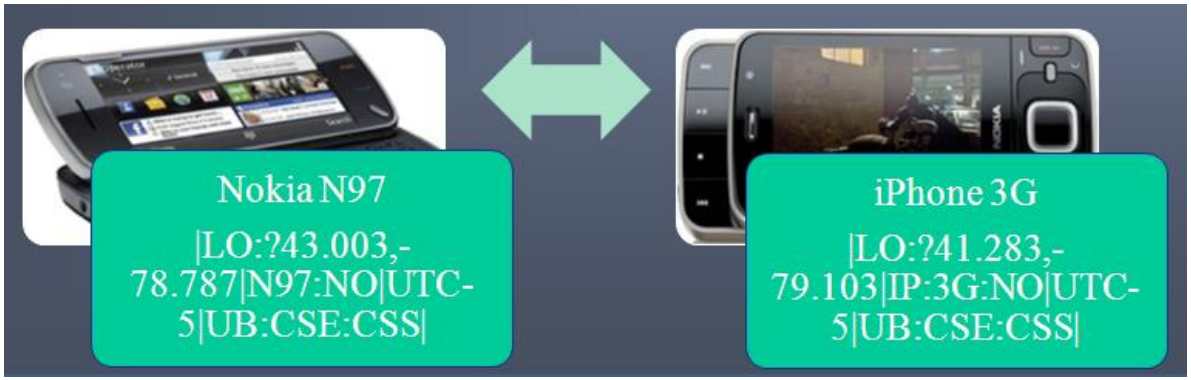
Motivations

- Mobile Phone sensing is the next BIG Thing in the next years! [1]
- We come to an exciting point in the development of people-centric sensing applications.
- Power of human motes (Human + Smartphone) can be used to answer lots of interesting questions and to build collaborative social network applications.
- Despite these ubiquitous vision, there is no infrastructure to task/utilize these devices for collaboration and coordination.



[1] Mobile Phone Sensing is the Next Big Thing!, Andrew T. Campbell, ACM MobiOpp 2010 keynote, Feb 2010, Pisa, Italy.

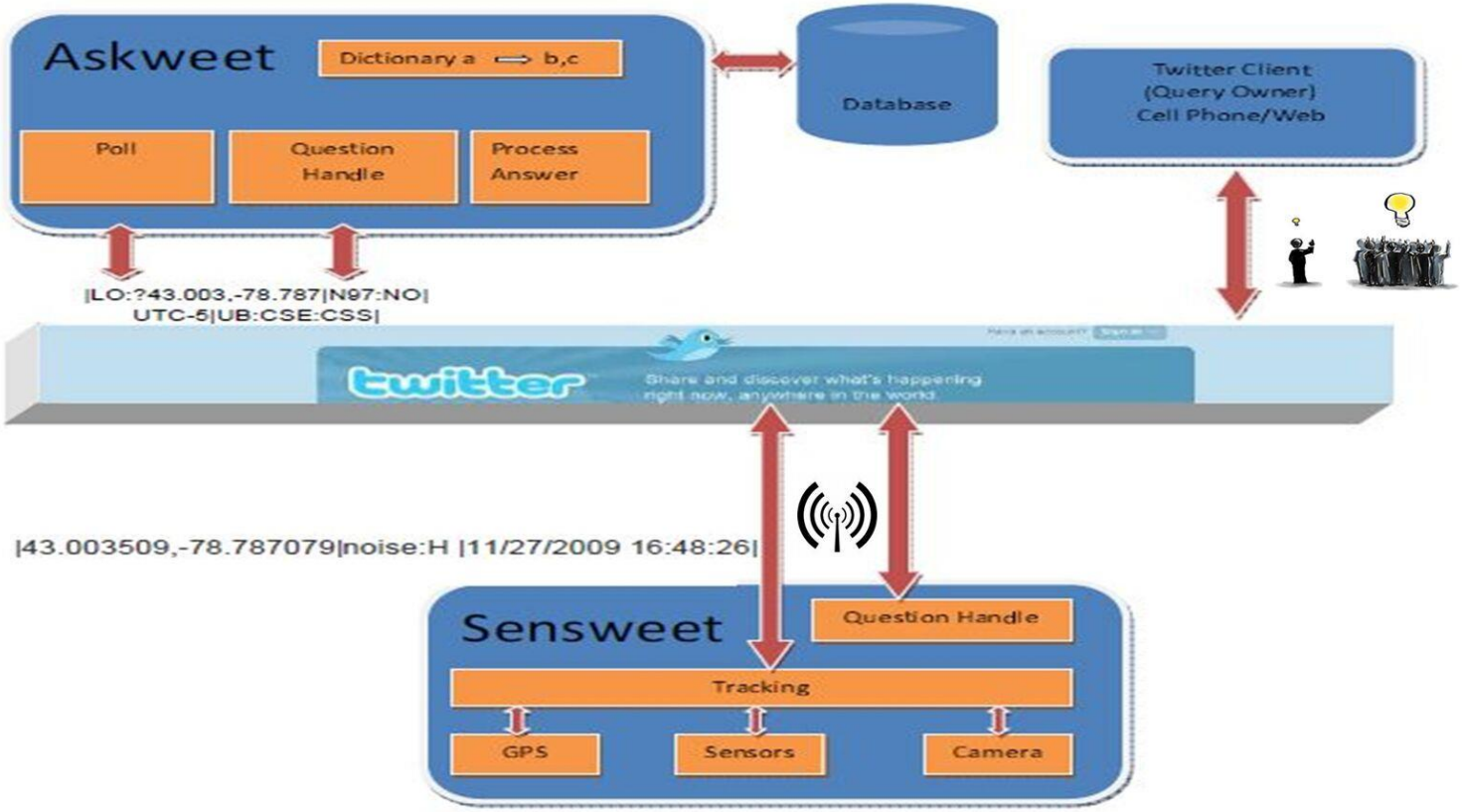
Approach

- We focused on designing location based collaborative crowd-sourced sensing system for solving real life problems with wisdom-of-crowds affect.

- We propose that Twitter can provide an “open” publish-subscribe infrastructure for sensors and smartphones and pave the way for ubiquitous crowd-sourced sensing and collaboration applications.

Architecture

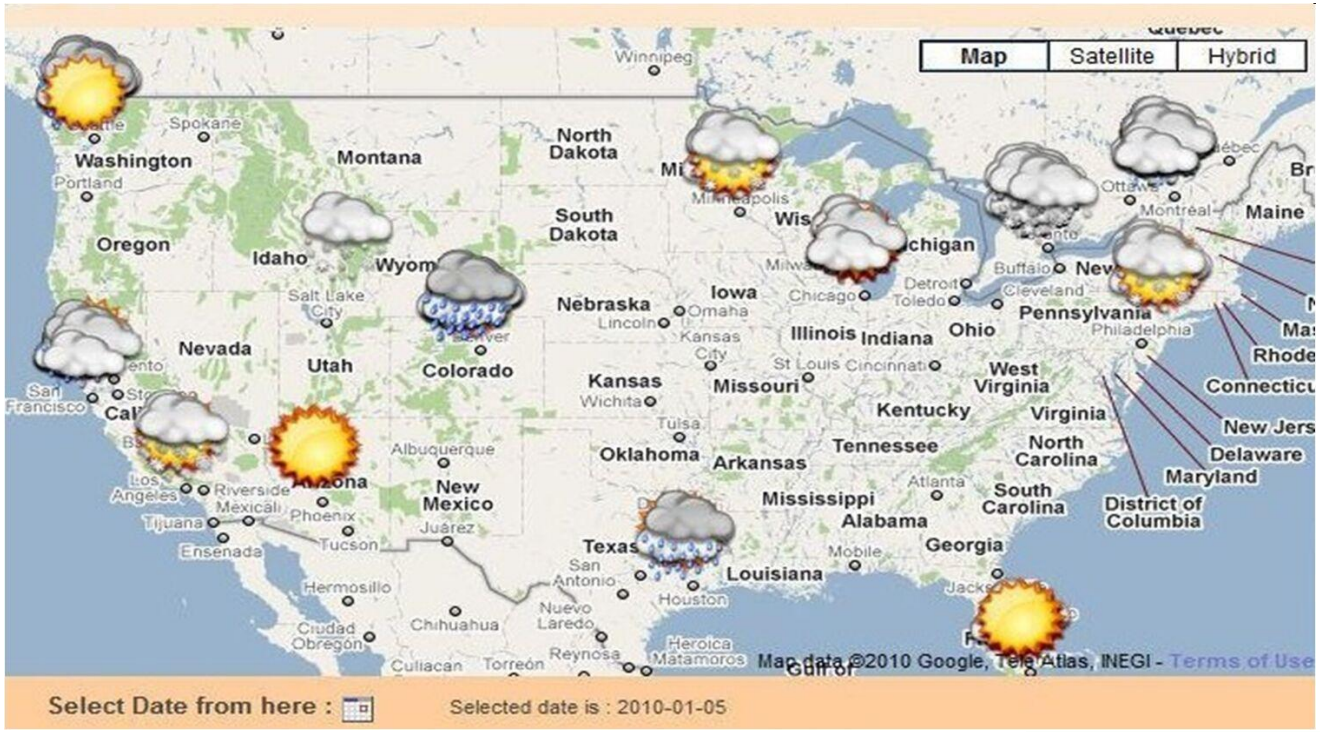
■ AskWeet: A server side application that pushes questions to Sensweets (based on their locations) and collects answers for Query owners (Twitter Clients).



■ Sensweet: A smart-phone client or Sensor gateway device to publish sensed data including location information to Twitter.

Applications

- Weather Radar: Creating very fine granularity weather condition maps of cities.
- Query owner ask weather condition for specific location, Queries are handled with Askweet and forwarded to sensweet clients (Twitter users with smartphone).
- Each answer from sensweet clients include longitude and latitude information with weather condition status.



Weather Radar

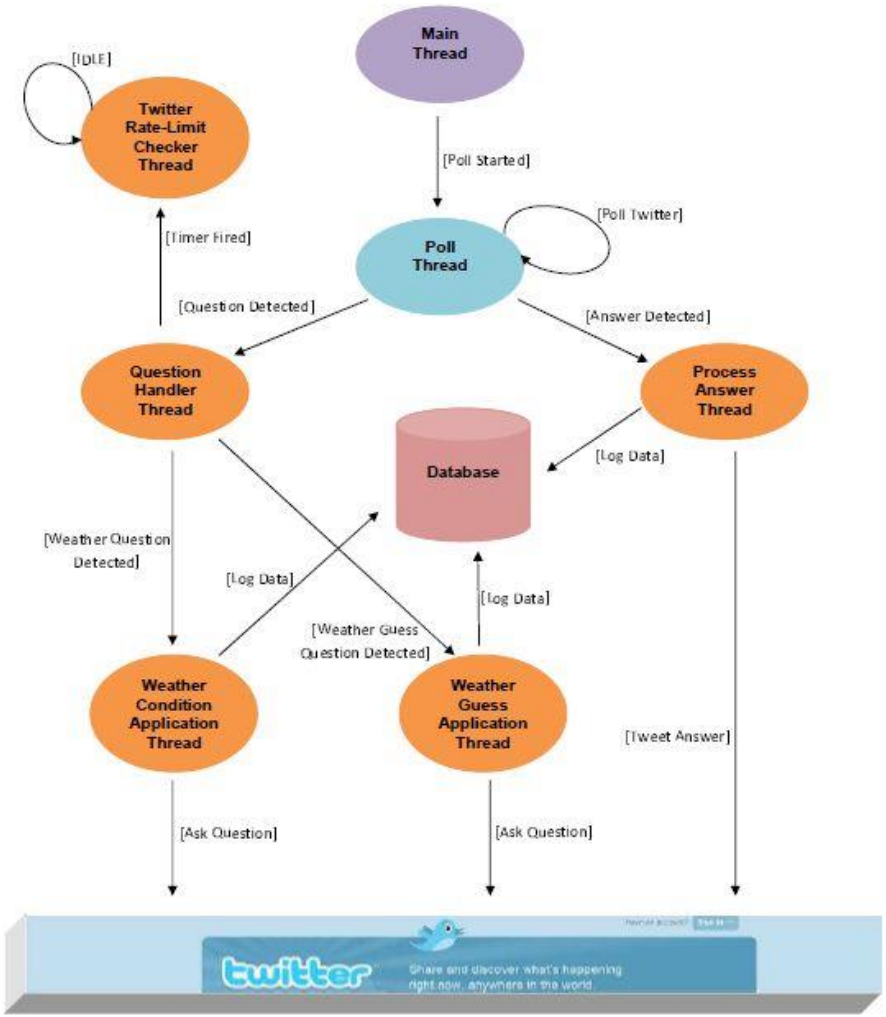
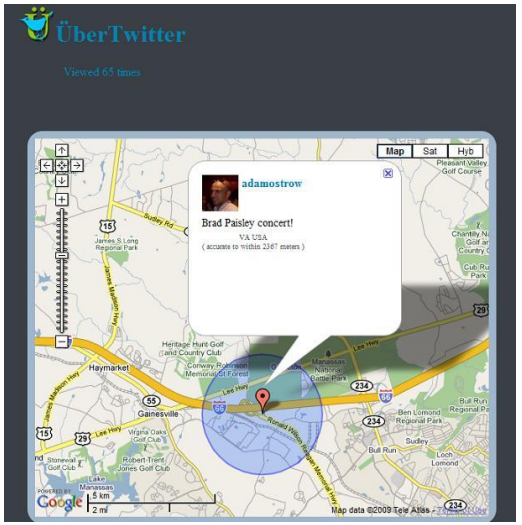
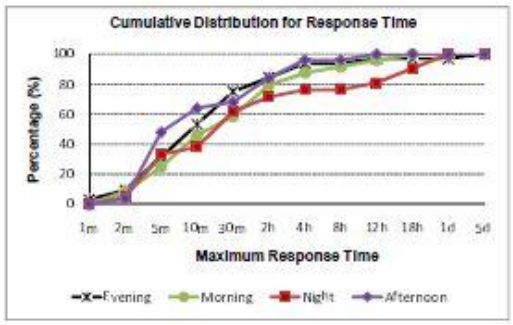


Fig. 2. State transition diagram for Askweet component

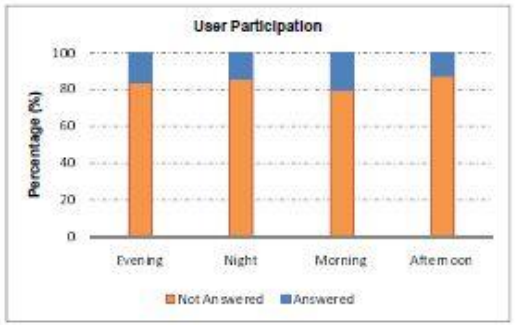
- AskWeet includes two different threads one for listening questions and one for listening answers from twitter.
- SensWeet component for weather radar application can be Twitter clients of Smartphones capable of updating GPS in Bio field in Twitter (UberTwitter, TweetDeck etc..)



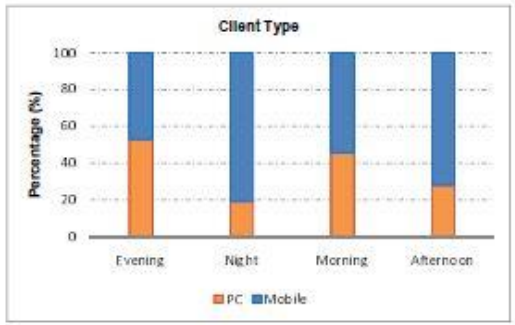
Experimental Results for Weather Radar



(a) CDF for response time

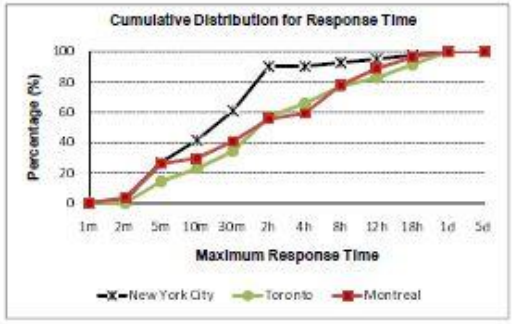


(b) User participation

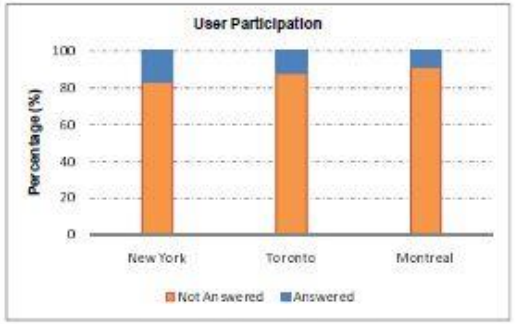


(c) Client types

Fig. 3. Experimental results for NYC in different time slices



(a) CDF for response time



(b) User participation

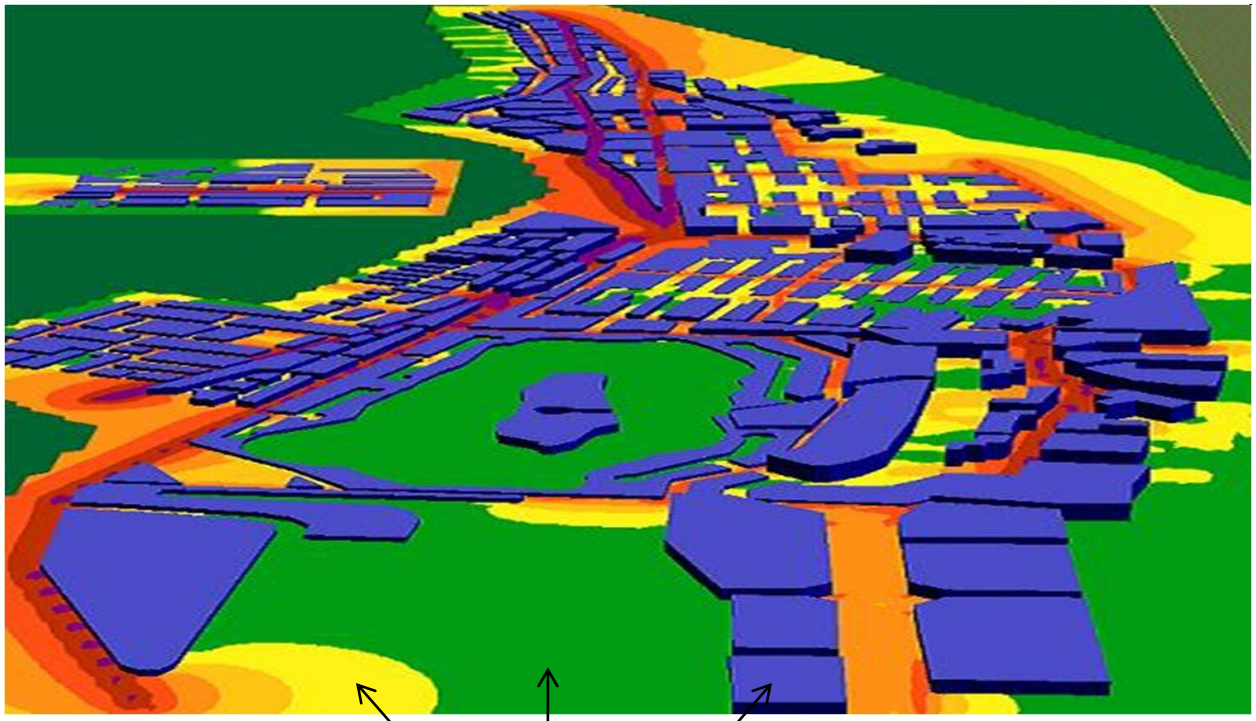
(c) Client types

Fig. 4. Experimental results for 3 cities

- Covers 1 week period and 3 cities
- Even without an incentive structure, we have around 15% reply rates
- Latency are low (40-50% replies arrive in 30 minutes and 60-80% replies arrive in 2 hours).

Applications

■ Noise Map: Constructing the noise map of a city by aggregating readings from city habitants (human motes). The noise maps can be used to improve living conditions in urban life.



Different noise levels

Noise Map

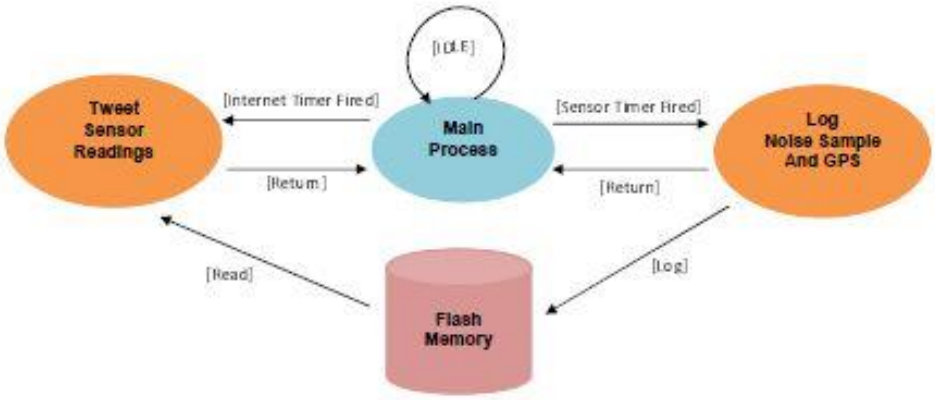


Fig. 7. State transition diagram for Sensweet client

- AskWeet is similar to one in Weather radar, it includes two different threads one for listening questions and one for updating most recent locations of its sensweet clients.
- Once query is pushed, the most recent noise sample reading value of closest sensweet client is returned (with its location and timestamp).

- Sensweet component is implemented for Nokia 97 and publishes Noise sensor readings in three different levels [Low, Medium, High] with location information.

Noise Map

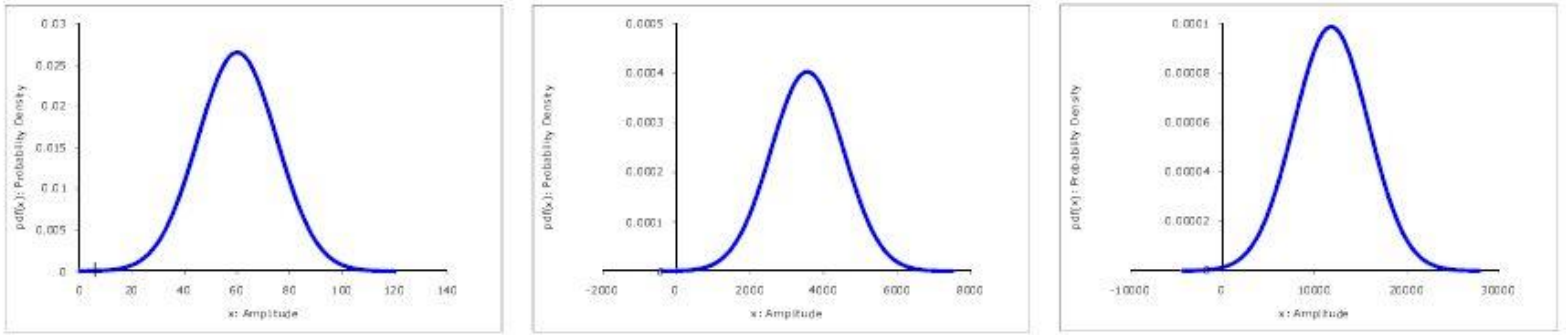
- SensWeet client record 1 second noise sample via Nokia N97 Microphone (in Wav File).
- Temporary WAV file is parsed and each sample is represented by average amplitude of signals.
- After that probability density value function value (Normal Distribution Format) of average amplitude is calculated for each class {Low, Medium, High}

$$pdf(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp(-\frac{(x-\mu)^2}{2\sigma^2})$$

- And current sample is assigned to Noise Level with highest PDF value.

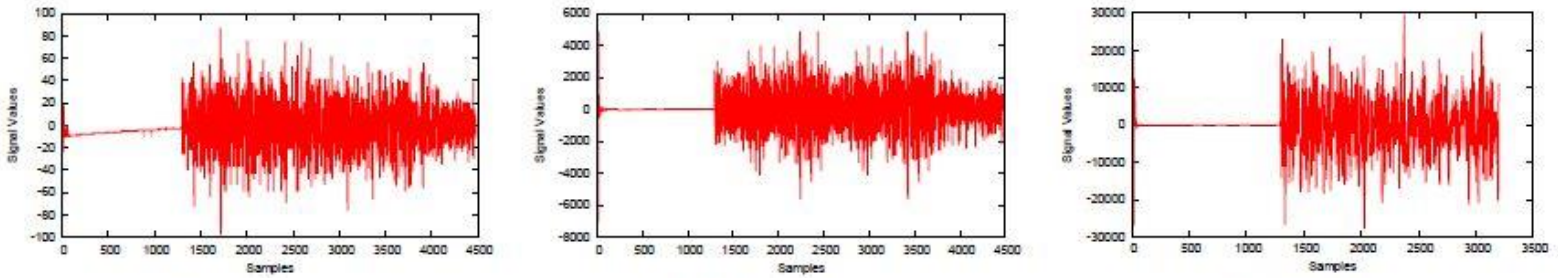
|43.003509,-78.787079|noise:H |11/27/2009 16:48:26|

Experimental Results for Noise Map



(a) Low level noise (b) Medium level noise (c) High level noise

Fig. 5. Normal distributions for different noise levels



(a) Low level noise (b) Medium level noise (c) High level noise

Fig. 6. Representative samples for different noise levels

We train normal distribution of 3 noise level classes in different locations

- At least 2 locations are used for each class and At least 200 samples are used in each Location.
- (Silent lab, Silent home) -> Low Noise
- (Lab Meetings, Student Union) -> Medium Level
- (Loudly Music at Home, DownTown Bars) -> High Level

Related Work

Participatory Sensing [11] and People Centric Sensing [12] projects propose frameworks for collecting data from privately held smart phones. However these projects does not include how to coordinate and collaborate smartphones to solve real time Question&Answering or Crowd-Sourced Sensing problems.

Recent Similar work to our project is MicroBlog project [13] that includes design and implementation of location based question & answering for real time sensing. However this work does not utilize social networking web sites for user participation. It's closed system and needs user registration, they don't focus on crowd-sourced sensing.

[11] Burke, Jeff, Estrin, Deborah, Hansen, Mark H., Parker, Andrew, Ramanathan, Nithya, Reddy, Sasank, and Srivastava, Mani B. Participatory sensing. In ACM Sensys World Sensor Web Workshop (2006).

[12] Emiliano Miluzzo, Nicholas D. Lane, Kristóf Fodor, Ronald A. Peterson,Hong Lu, Mirco Musolesi, Shane. B. Eisenman, Xiao Zheng, Andrew T. Campbell, "Sensing Meets Mobile Social Networks: The Design, Implementation and Evaluation of the CenceMe Application", In Proc. of 6th ACM Conference on Embedded Networked Sensor Systems (SenSys '08), Raleigh, NC, USA, Nov. 5-7, 2008.

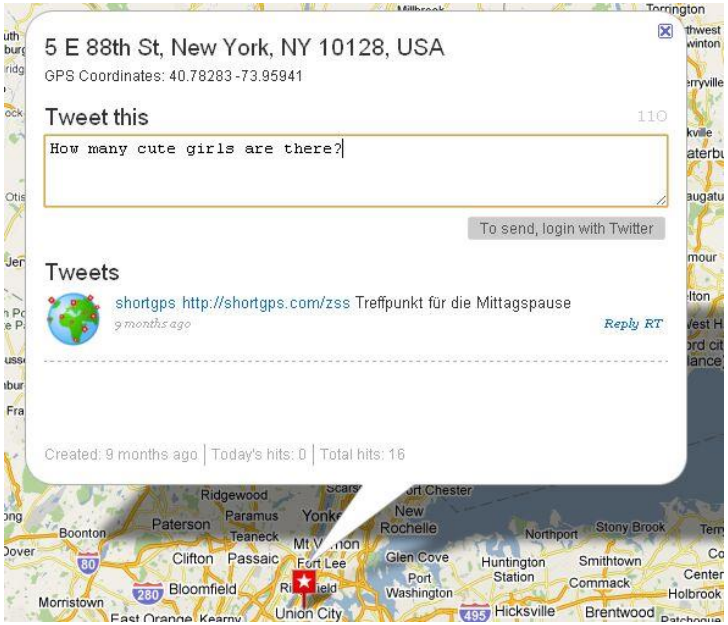
[13] Gaonkar, Shravan, Li, Jack, Choudhury, Romit Roy, Cox, Landon, and Schmidt, Al. Micro-blog: sharing and querying content through mobile phones and social participation. In MobiSys (2008), pp. 174–186.

Conclusion

- Our experiments with crowd-sourcing on Twitter are promising, For weather Radar:
  - Even without an incentive structure, we have around 15% reply rates
  - Latency are low (40-50% replies arrive in 30 minutes and 60-80% replies arrive in 2 hours).
  - Another promising finding is that a majority of replies were tweeted from smartphones.
- With Noise Map:
  - We showed that it is feasible to use sensor capacity of smartphones for location based crowd-sourced sensing applications.

Future Directions

- Future Directions:
  - Use of Mobility Profiles for client availability and continuous query assignment
  - Queries to the sparse regions can be improved by using location prediction. These queries not only routed users physically at that location (during query), but also forwarded to users that are more likely visit query location in near future.
  - Continuous queries can be assigned to specific clients by considering their mobility profiles. .



Conclusion

End of Presentation