Context-Aware Mobile Information Access

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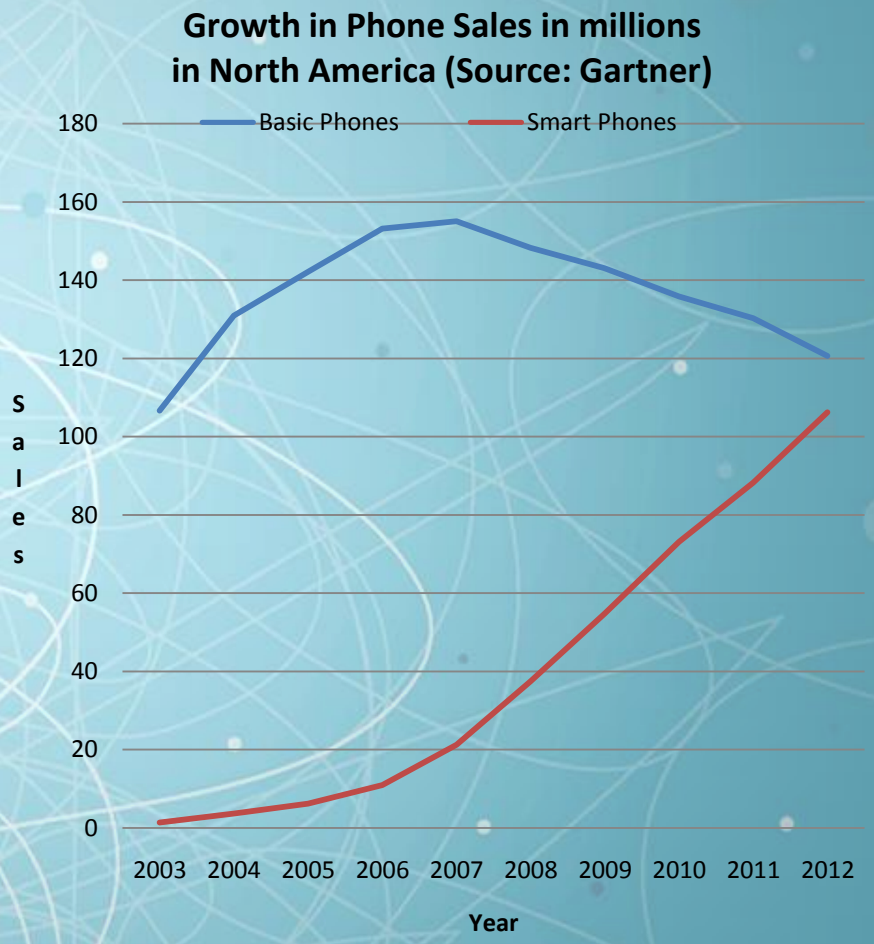
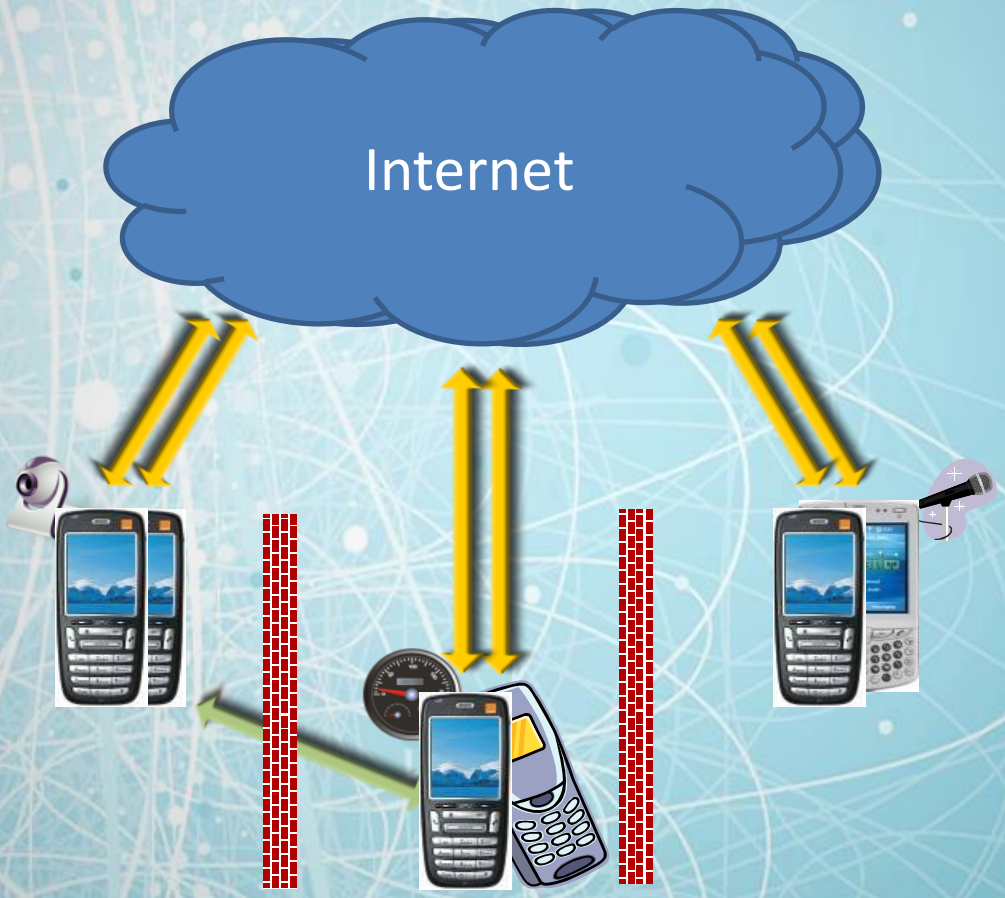
Mobile Phones

- ~4B phones worldwide, 1B sold every year
- ~300M phones in India
- 11.5% of all phones sold worldwide in 2007 were smartphones
- Smartphone market share expected to reach nearly 50% by 2012 in NA



Mobile Information Access

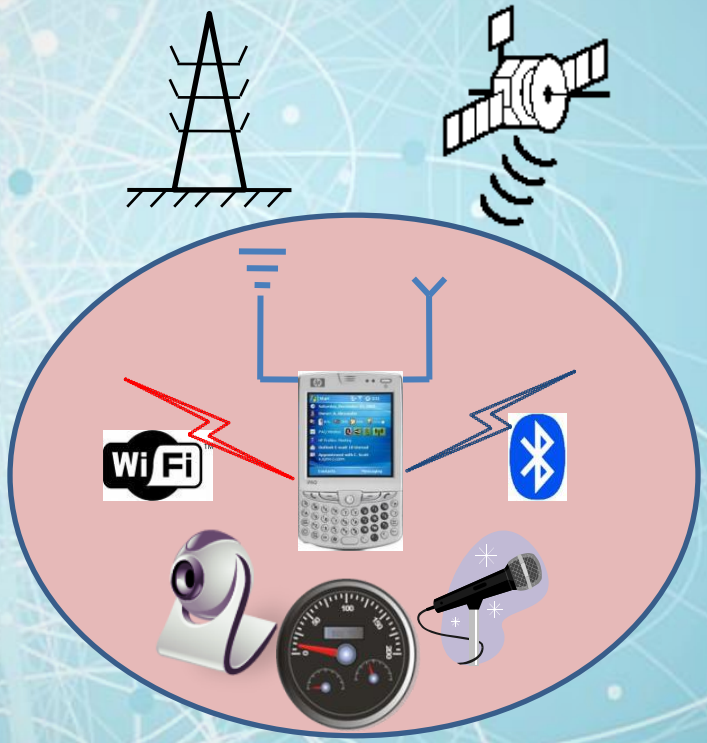


What is Context?

- Where you are $\Rightarrow$ location
- Who you are with $\Rightarrow$ neighborhood
- What resources are around you $\Rightarrow$ environment

PARCTAB, Bill Schilit et al., 1994!

Smartphone under the hood



Smartphone: Computing + Communication + Sensing

Context-Awareness using Sensors on Mobile Phones

1. Microphone ⇒ audio
2. Cell Radio ⇒ location (100m-10km)
3. Bluetooth ⇒ location (10-50m)
4. WiFi ⇒ location (25-100m)
5. GPS ⇒ location (3-10m)
6. Camera ⇒ video
7. Light ⇒ light
8. Accelerometer ⇒ motion/force
9. Gyroscope ⇒ angular motion
10. Temperature ⇒ temperature
11. Pressure ⇒ altitude
12. Carbon Monoxide ⇒ air quality
13. …

Outline

- Overview
- Location as context
- Rich Context-Aware Applications
  - Collaborative downloading
  - Road and Traffic Monitoring
  - Sensing and Social Networking
- User Interface
- Conclusion

Location as Context

- Location is a key element of user context
- Mobile devices a natural conduit for Location-based Services (LBS)
- Lots of buzz and hype around LBS

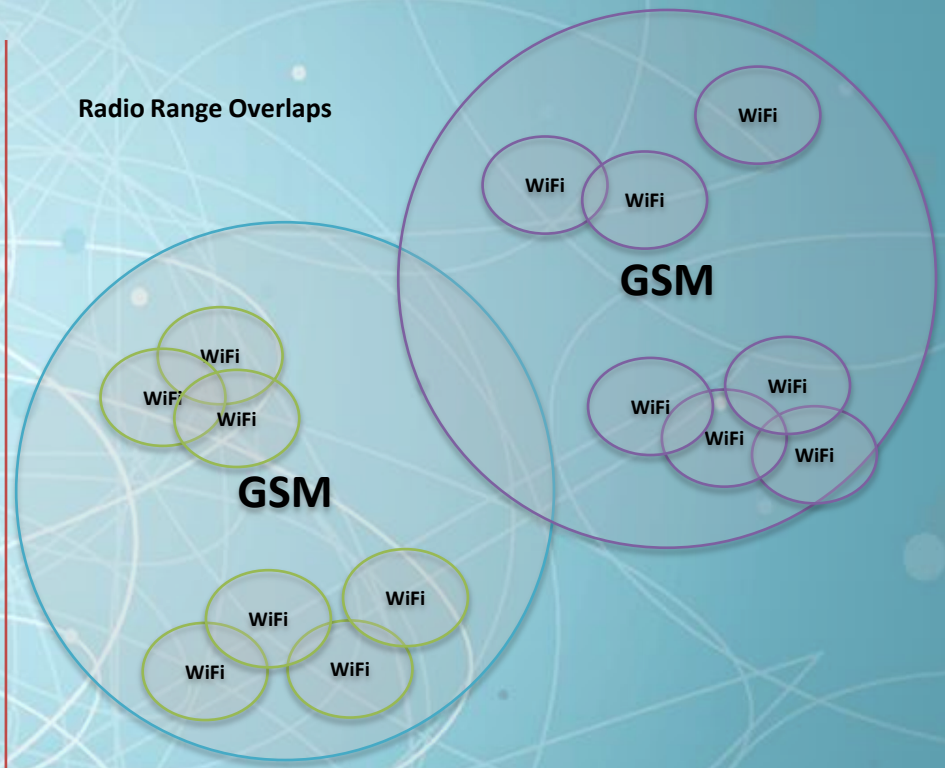
1. Many apps care only about *relative* location
   - Relative to landmarks
   - Relative to people
2. *Future* Location
   - Predicting destinations for targeted LBS

Why Relative Location?

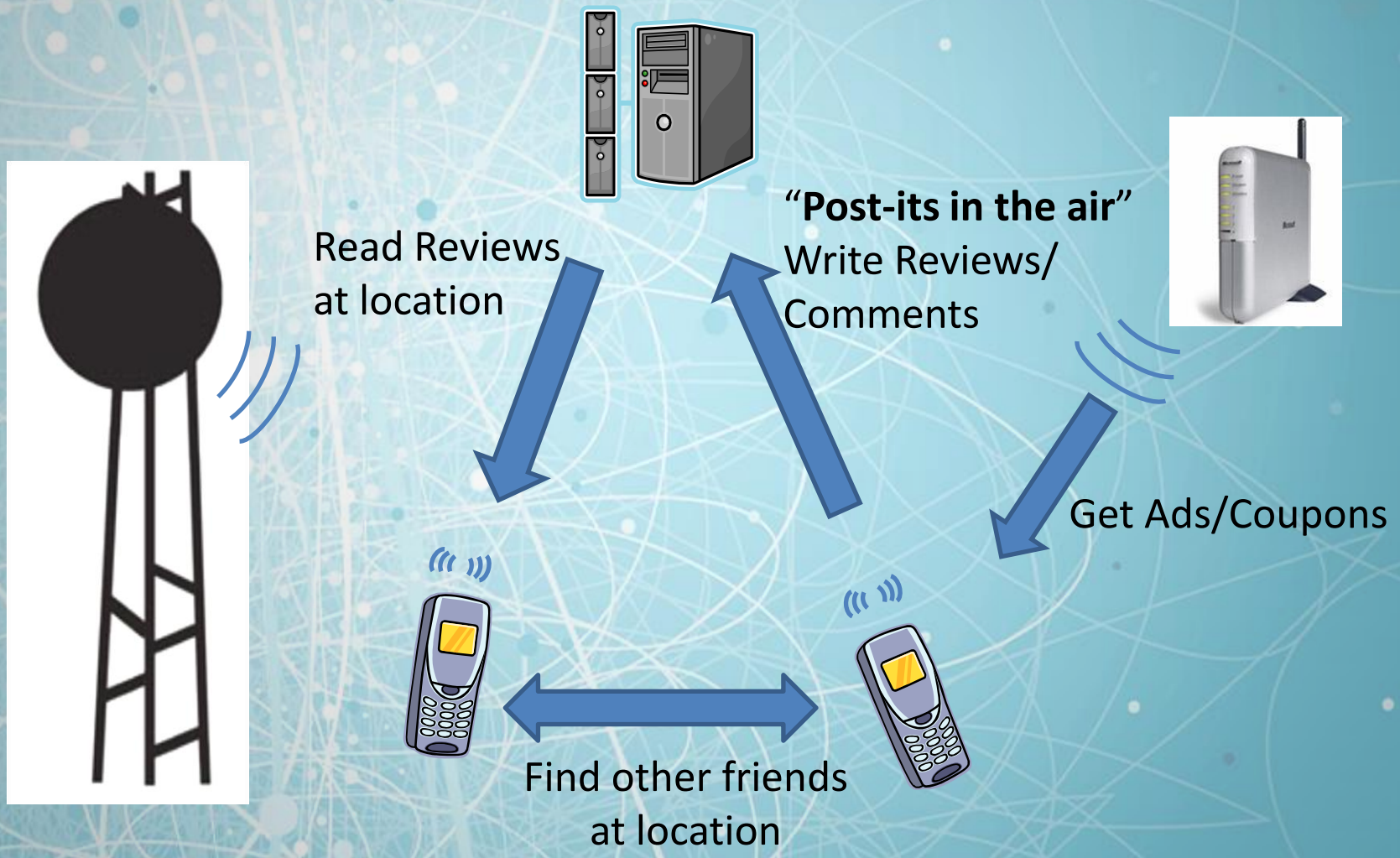
- Why not just GPS?
  - not all phones have it
  - coverage (indoors, urban canyons, inside a bus)
  - time to lock (~26 secs even with warm start)
  - energy (~600 mW on iPAQ 6965)
- No need for periodic “wardriving” (as in WiFi, GSM)

Landmarks and Neighbourhoods

- Landmarks
  - WiFi Access Points
  - GSM Towers
- Two nodes are neighbours if they see common landmark
- Overlapping neighbourhood information aggregated at server to form **radio maps**
- Proximity between nodes obtained from radio maps



Example Scenario



Applications of Relative Location

1. Location sensitive Ads
2. Comments and Reviews
3. Friends Near Me
4. **Location based Games, Game Pairing**
5. **Location based remainders**
6. **Location based profiles**
7. **Enhanced Presence**
8. **Social Networking**
9. **…**

Future Location or Where do you want to go today?

- Why predict destination?
  - Anticipatory information
  - LBS spam filter!
- How do we predict a user's destination?
  - Use both user's past history as well as history of other users to build a probability model for destination
  - Refine probability as drive progresses
- How well does it work?
  - Median error of 3km at start of trip

http://research.microsoft.com/~jckrumm

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1. Collaborative Downloading

Range-Speed Dichotomy

	Speed	Coverage
WLAN (Wi-Fi, Bluetooth)	**1 – 54 Mbps**	hotspots
WWAN (3G, GPRS)	50 – 500Kbps	**Wide-area**

How do we bridge this gap?

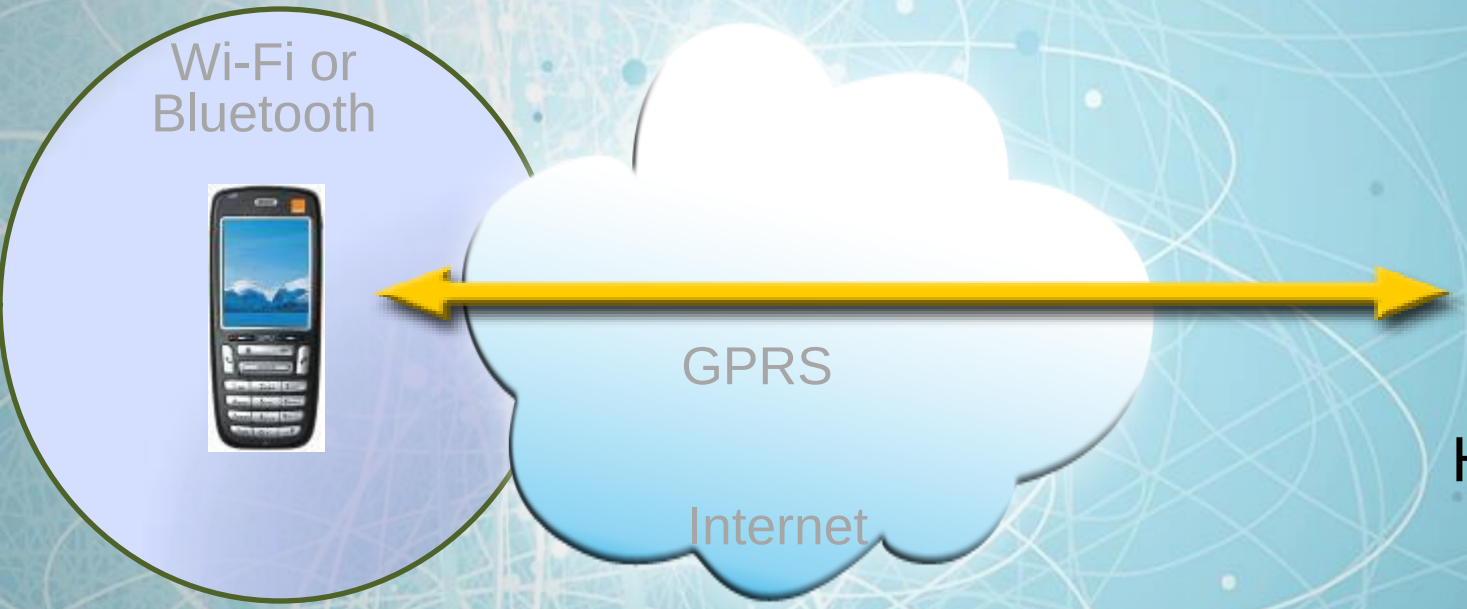
- **Identify devices near you and pool their WWAN bandwidths**

Traditional Approach

Connections Today

COMBINE Approach

1. Search for collaborators, efficiently

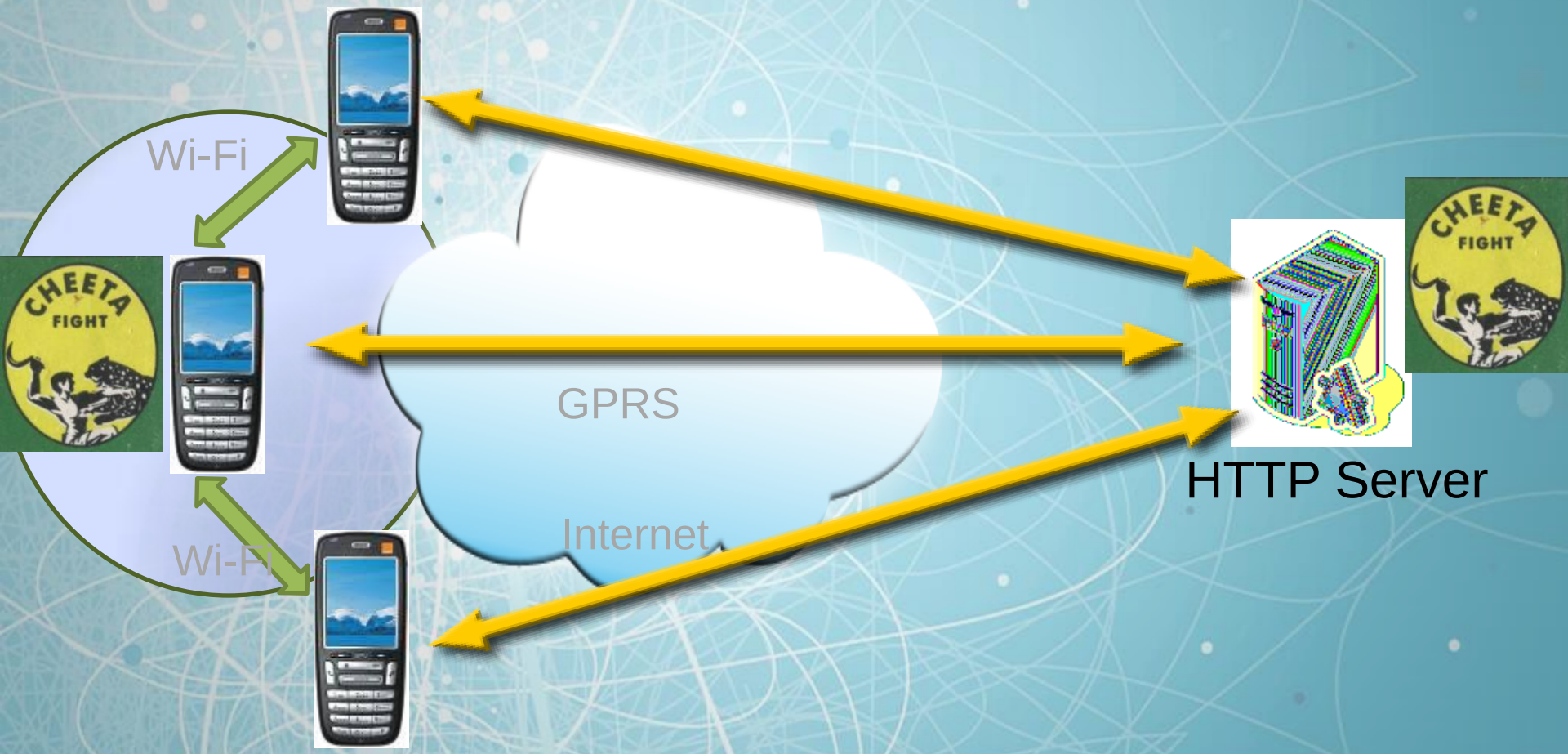


COMBINE Approach

2. Connect to collaborators over Wi-Fi

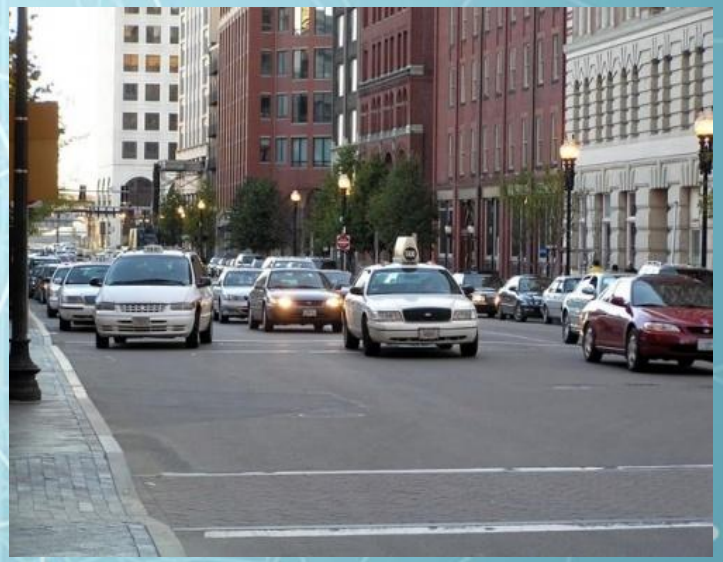
COMBINE Approach

3. Dynamically distribute over HTTP bytestream



2. Traffic Monitoring

- GPS based tracking is adequate
- Infrastructure support exists



Courtesy: FreeDigitalPhotos.net

Beyond Traffic Monitoring

- Potholes
- Road bumps
- Varied vehicle types
- Liberal honking
- Chaotic intersections
- …

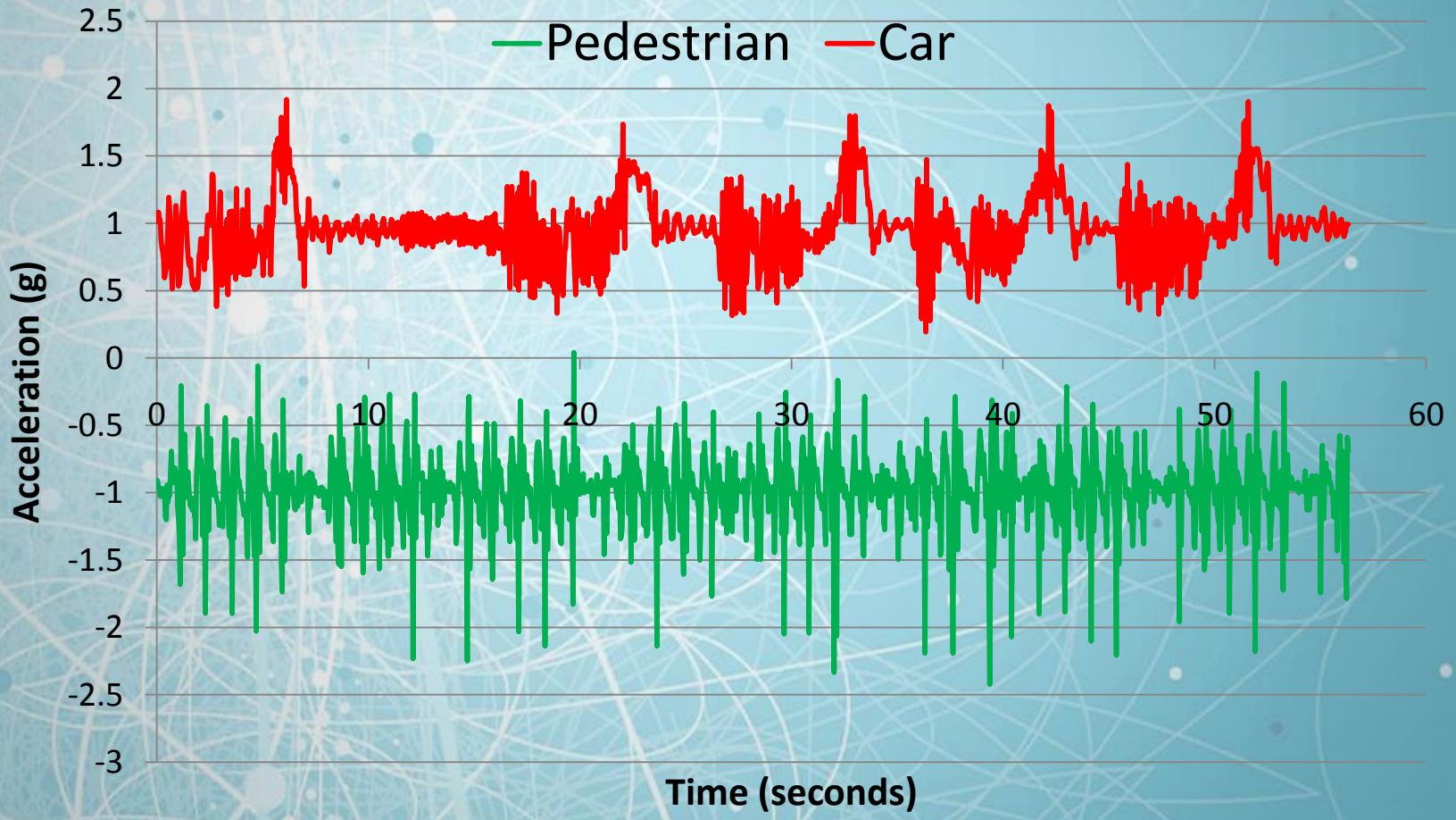
Mobile phones as both *providers and consumers* of information

- Widespread distribution of mobile phones
- Road and Traffic information without deployed infrastructure

Traffic Speed

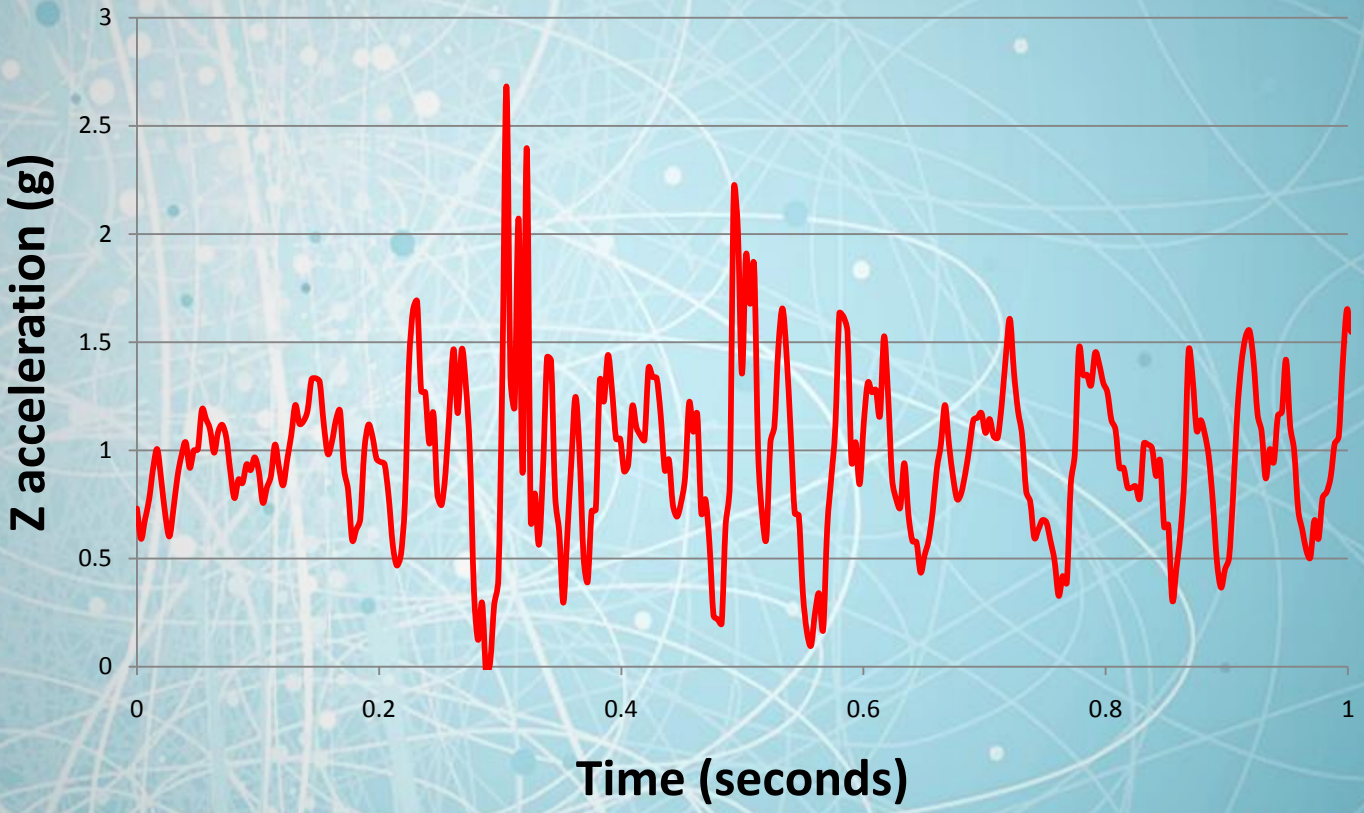
- GPS if available
  - coverage (indoors, urban canyons, inside a bus)
  - not all phones have it
- GSM tower based localization
  - widely accessible, fast, “zero” energy
  - Location: median error: **130m**
  - Speed: median error: **3.4 Kmph**

Differentiating pedestrians from stop-and-go traffic



Pothole Detection

Pothole Detection

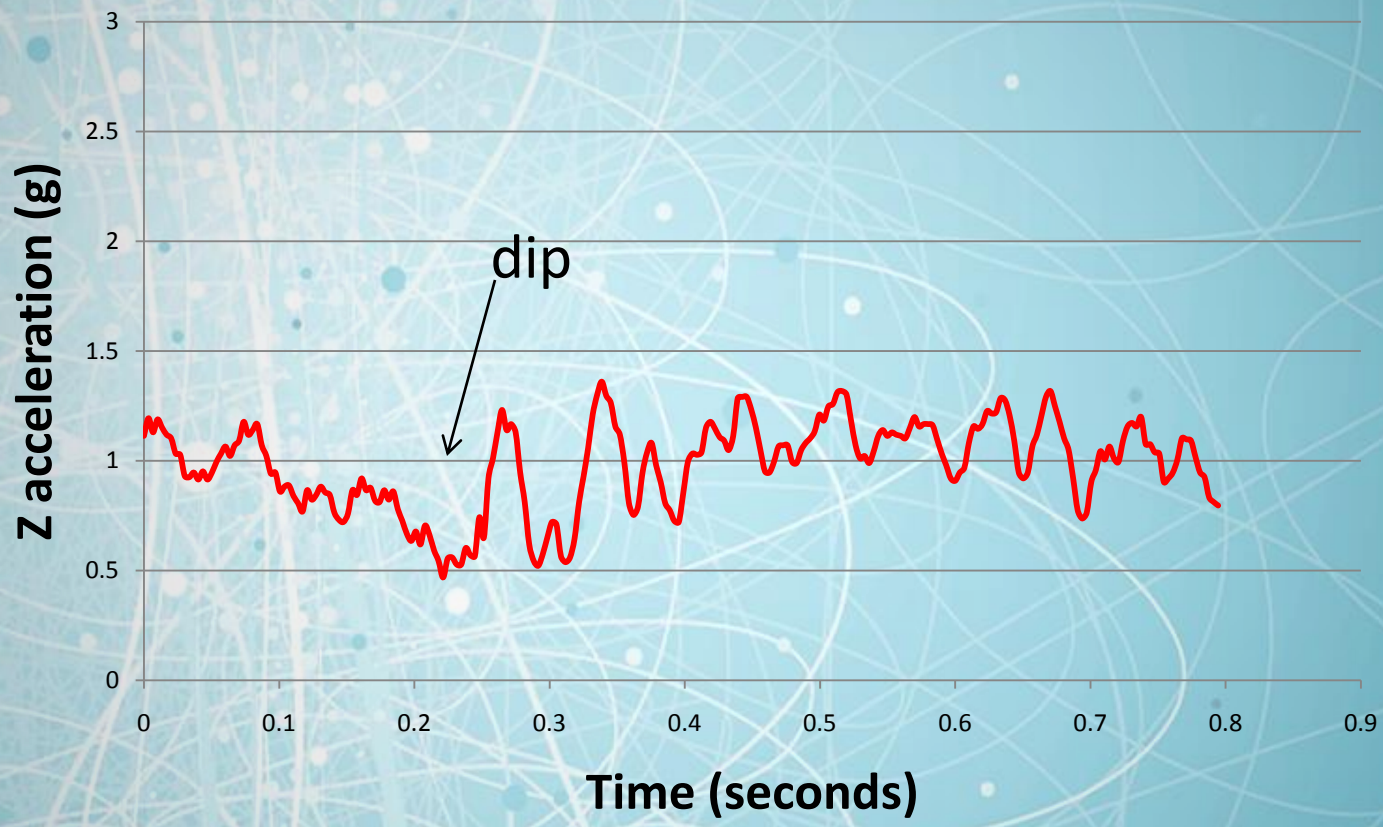


High speed (≥ 25 kmph)

z-peak: look for significant spike

Pothole Detection

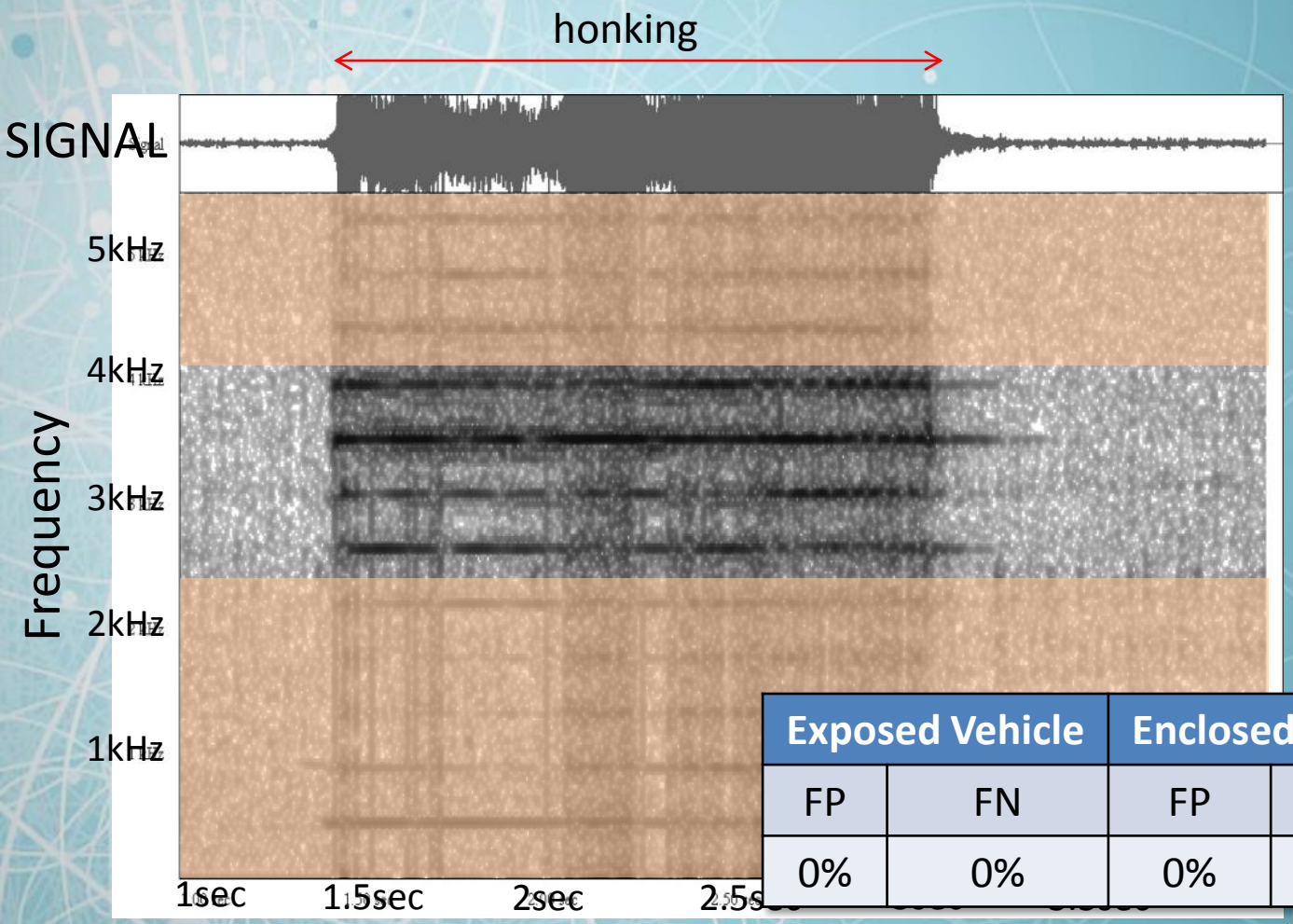
Pothole Detection



Low speed (< 25 kmph)

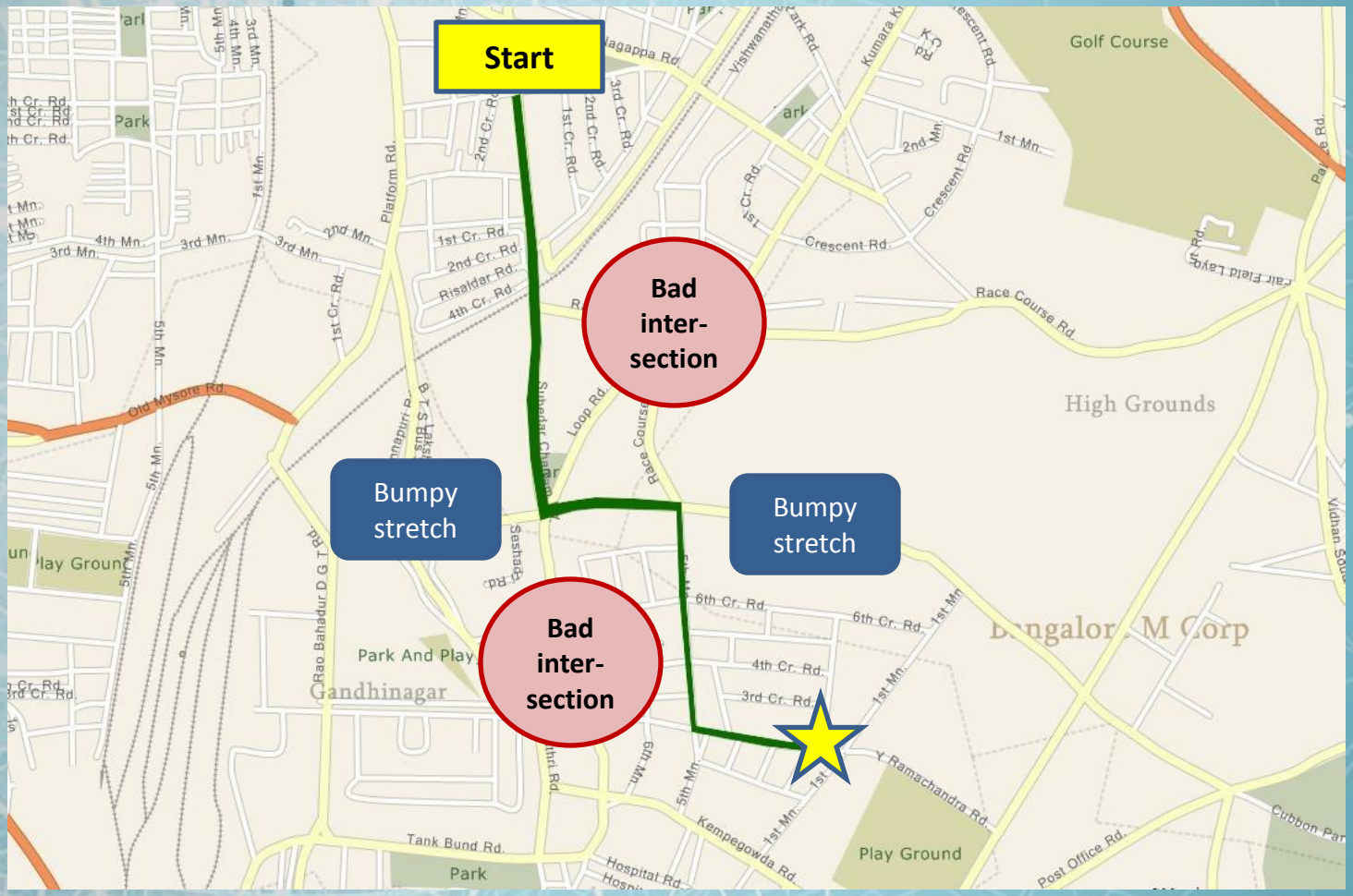
z-sus: look for sustained dip

Honk Detection



Exposed Vehicle		Enclosed Vehicle	
FP	FN	FP	FN
0%	0%	0%	23%

Rich Monitoring Application



Find least stressful route!

3. Mobile Sensing + Social Networking

- Friends can know “if you are busy in a conversation or dancing at a party!”
- Sensors
  - Accelerometer (Static/walk/run/bike/golfing!)
  - Audio (ambient noise/voice recognition/music)
  - GPS/WiFi (indoors or outdoors)
- User study: seeing online friends active (walk/run) made others more health conscious!

http://cenceme.org

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Mobile Data Access: Today

A Facet-Based Interface for Mobile Search

Data Type:

Save

Search terms

Problem:

Navigates

Keypad Mapping

- Continuous Feedback Immediately Updates Results
- Dynamic Queries

http://research.microsoft.com/fathumb

Using Audio as UI

- Humans can speak > 120 words/minute but type only at ~ 40 words/minute (On phones, even lower)
- Voice-based dialing has been around for a while
- Richer speech-based interface a matter of time
- E.g. Nuance
  - Mobile Messaging: speak SMS or email
  - Mobile Search: “find me the nearest Café”
- Spouse’s complaint:

  “talking **on** the phone” $\Rightarrow$ “talking **to** the $#%% phone!”

Using Audio as UI

- Audio can also serve as context
- E.g. Shazam
  - Hear an interesting song or tune
  - Record it using mobile phone
  - Upload
  - Get back song/artist details, reviews, link to buy!

Using Video as UI

- Camera is little more problematic since it needs careful pointing and adequate lighting
- E.g. SnapTell
  - See an interesting book, DVD, Ad
  - Snap its picture using mobile phone
  - Upload
  - Get back item details, reviews, link to buy/coupon!
  - Seamless way to link up old media ads and advertisers!

Conclusion

- Smartphone: Computing + Comm. + Sensing
- Mobile smartphone based sensing for context:
  - WiFi + BT + GSM + GPS ⇒ Location
  - Accelerometer ⇒ Walking, Running, Potholes, …
  - Microphone ⇒ Voice, Music, Honks, …
  - Camera ⇒ Books, DVDs, Ads,…
- Context-awareness using mobile phone sensors key to richer information access

http://research.microsoft.com/~ramjee