

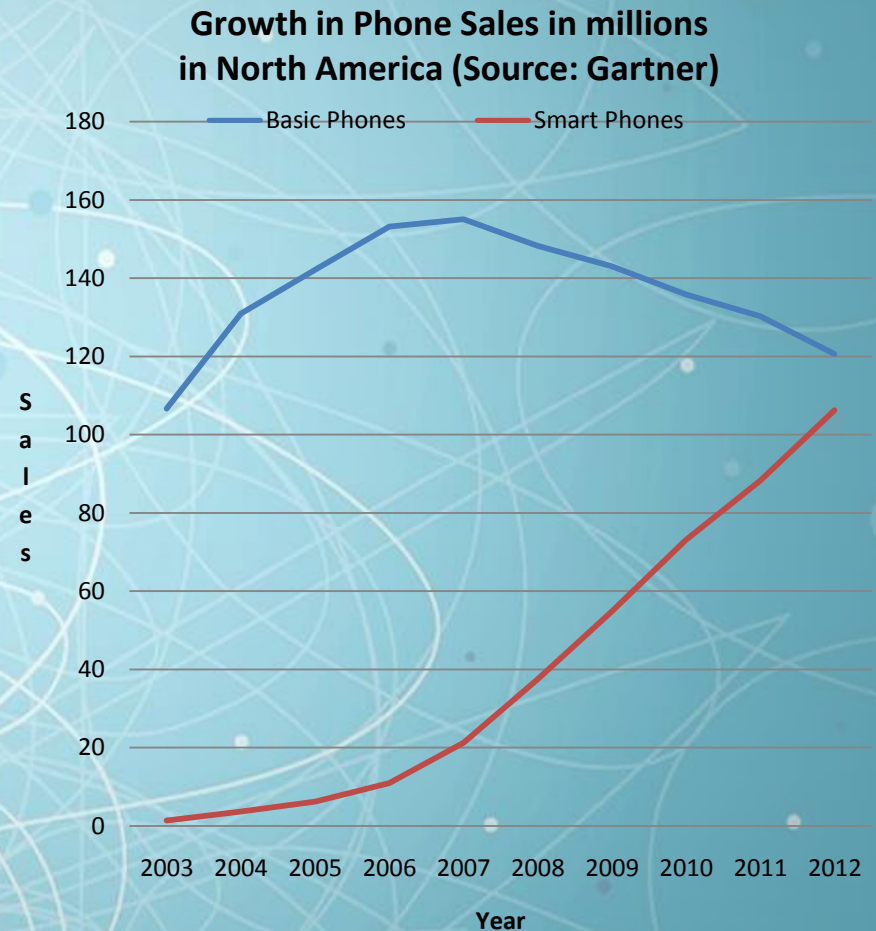


# Context-Aware Mobile Information Access

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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

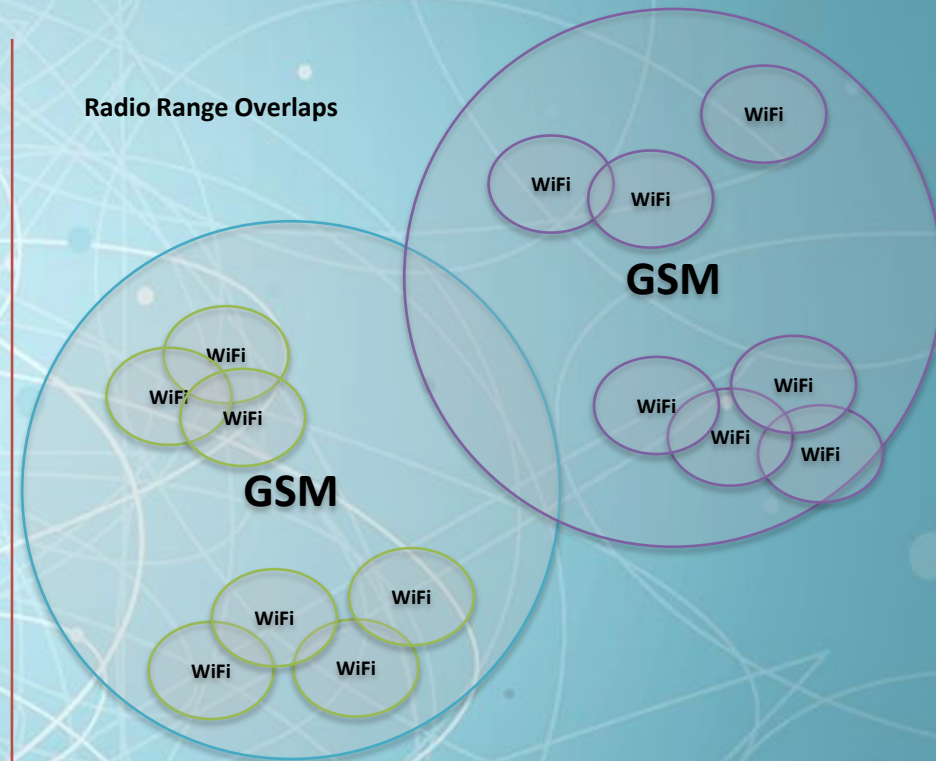


# Why Relative Location?

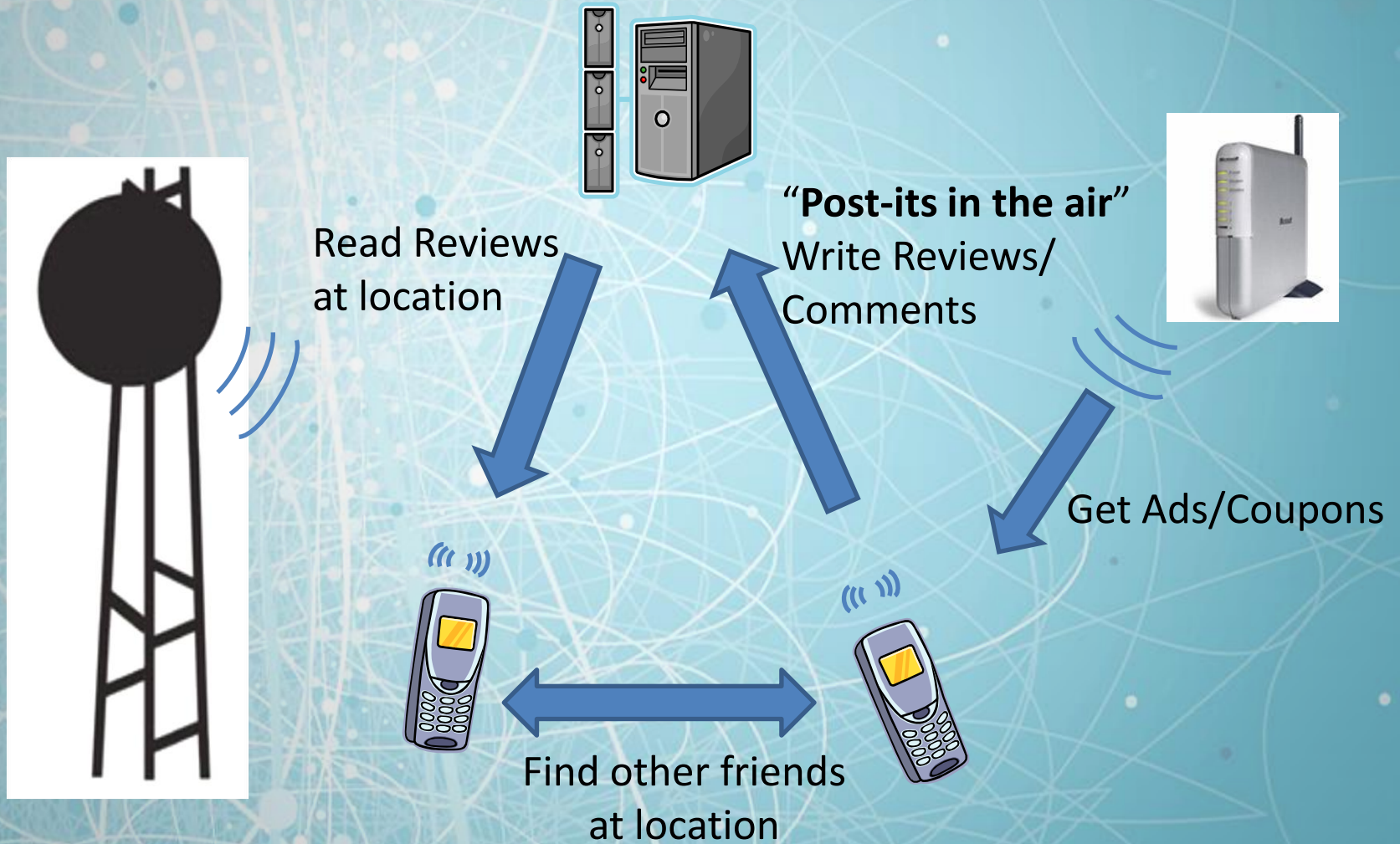
- Why not just GPS?
  - not all phones have it
  - coverage (indoors, urban canyons, inside a bus)
  - time to lock (~26 secs even with warm start)
  - energy (~600 mW on iPAQ 6965)
- No need for periodic “wardriving” (as in WiFi, GSM)

# 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 reminders
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)	<b>1 – 54 Mbps</b>	hotspots
WWAN (3G, GPRS)	50 – 500Kbps	<b>Wide-area</b>

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



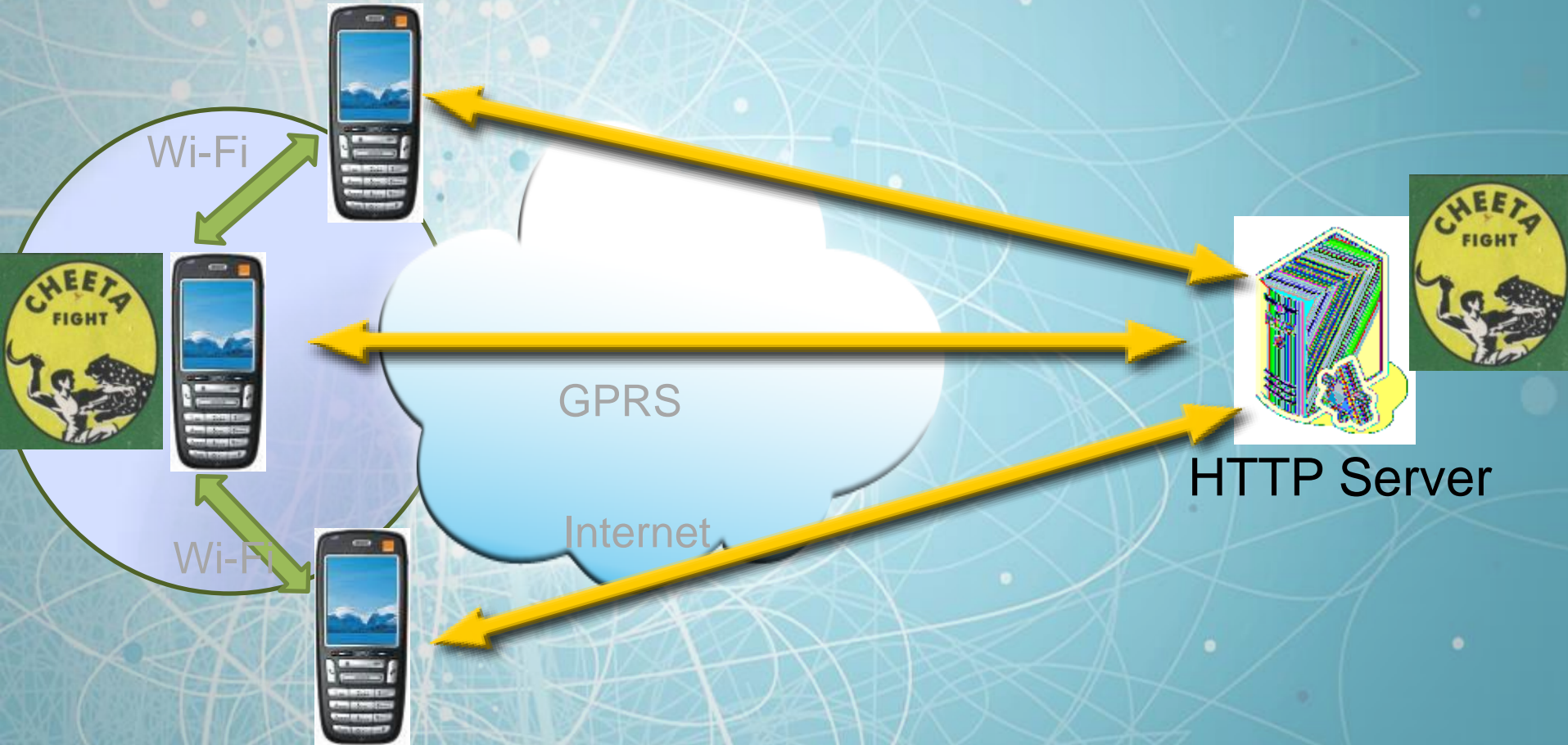
# COMBINE Approach

## 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



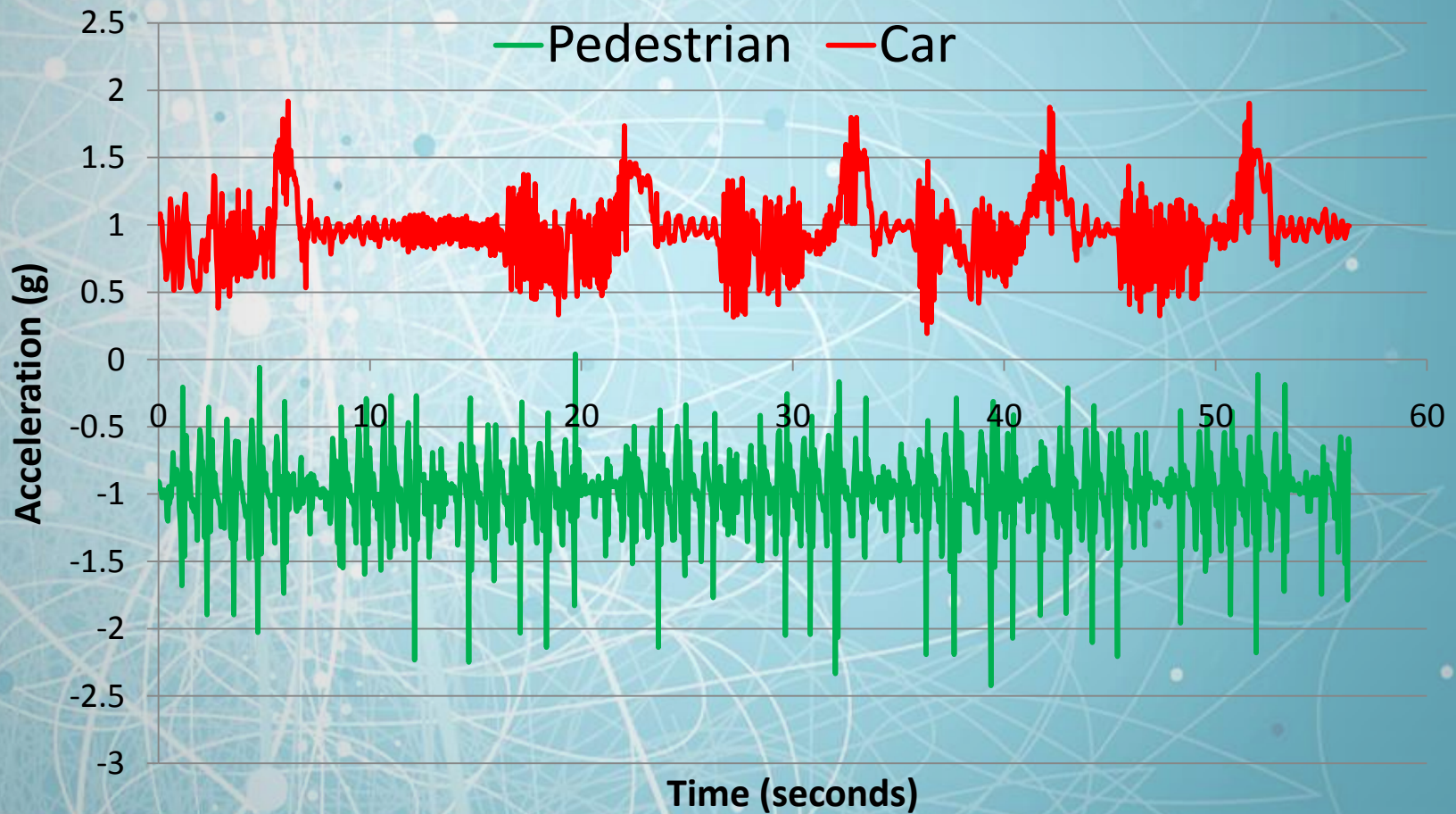
- Widespread distribution of mobile phones
- Road and Traffic information without deployed infrastructure

# 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**



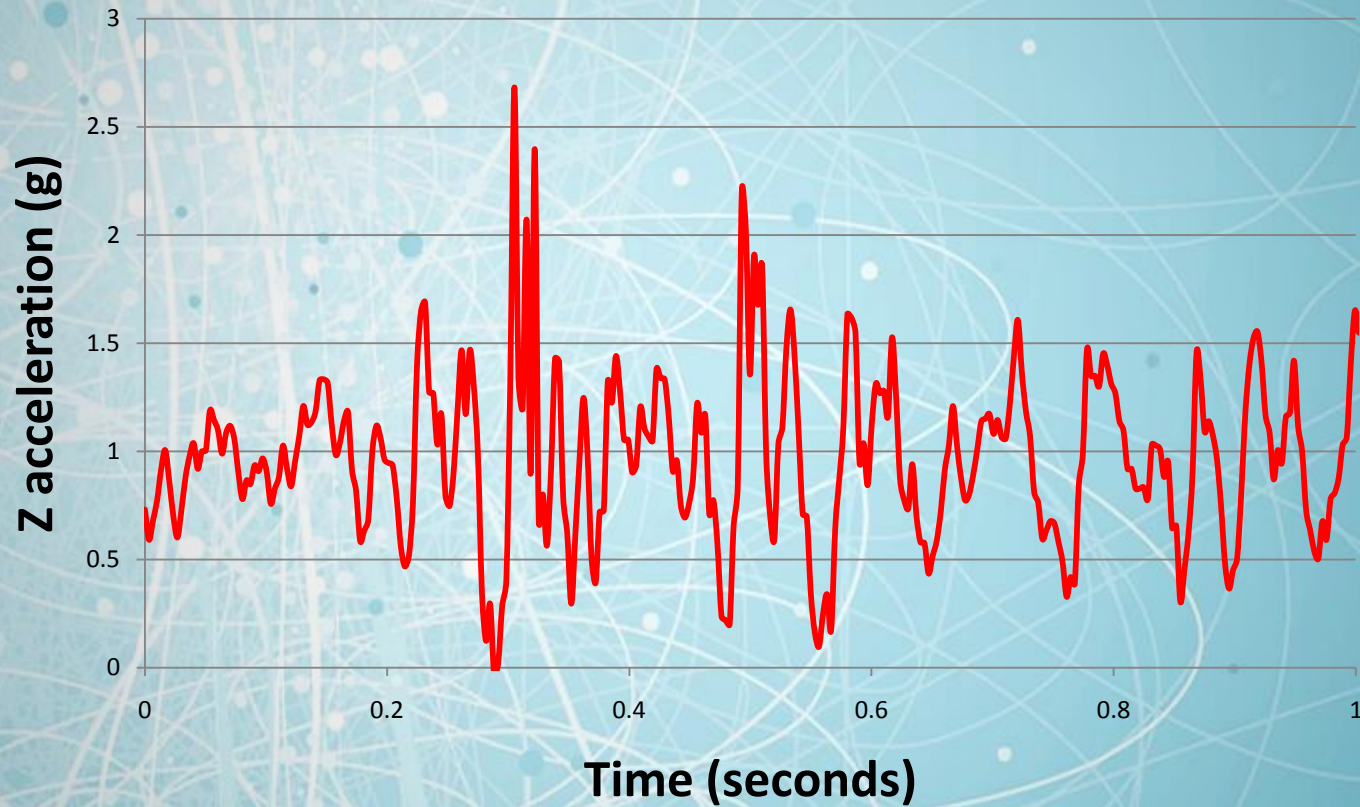
# Differentiating pedestrians from stop-and-go traffic



# Pothole Detection



# Pothole Detection



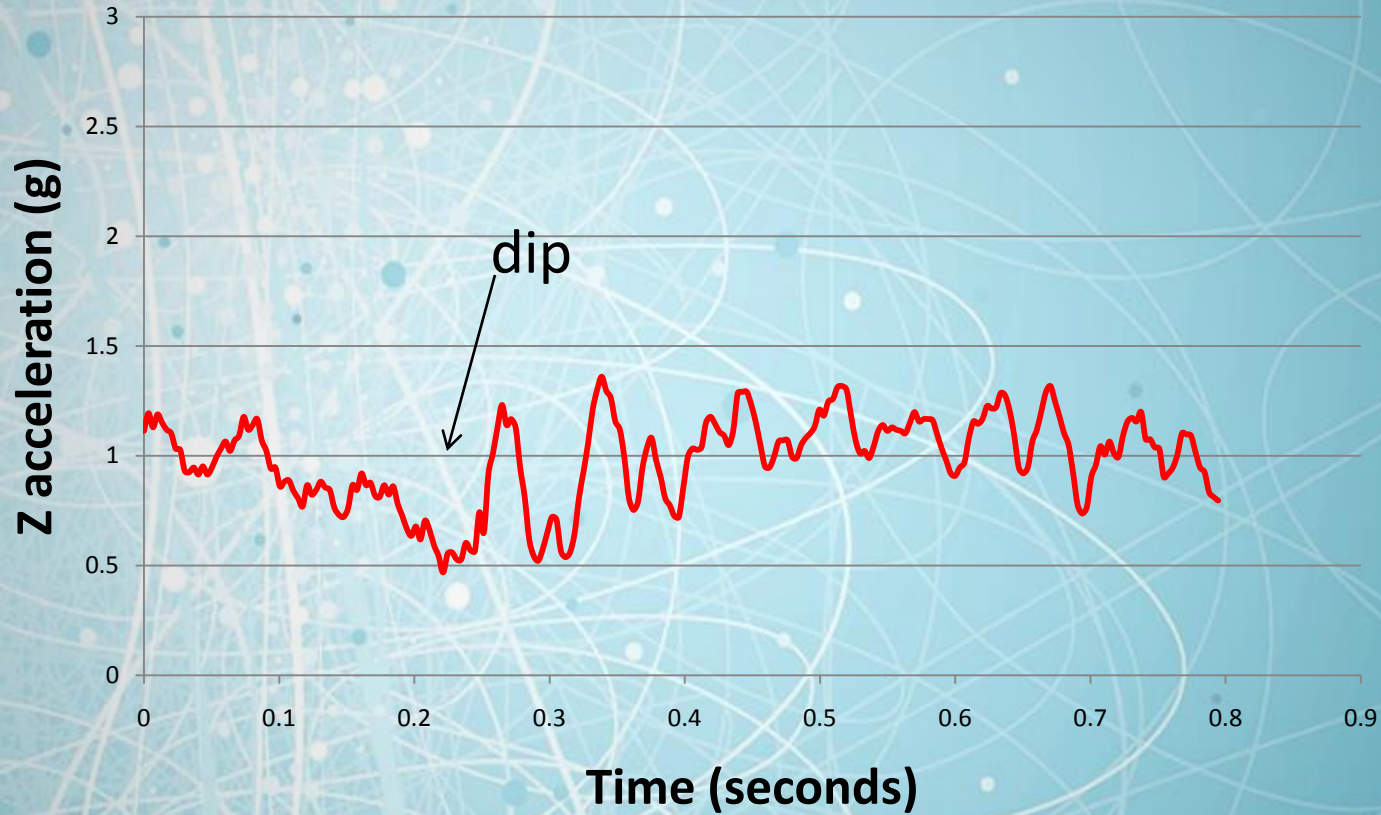
High speed ( $\geq 25$  kmph)

*z-peak*: look for significant spike

# Pothole Detection



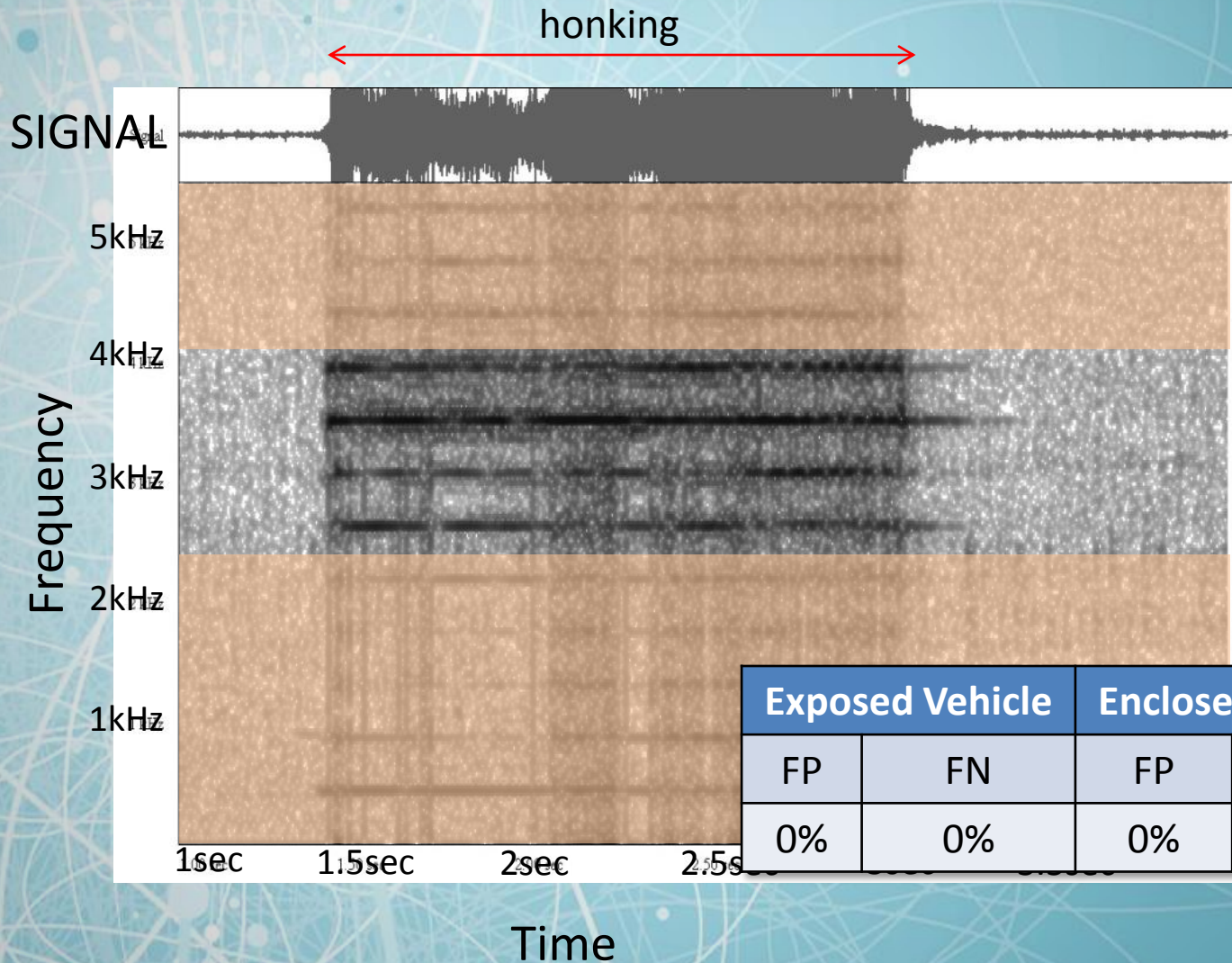
# Pothole Detection



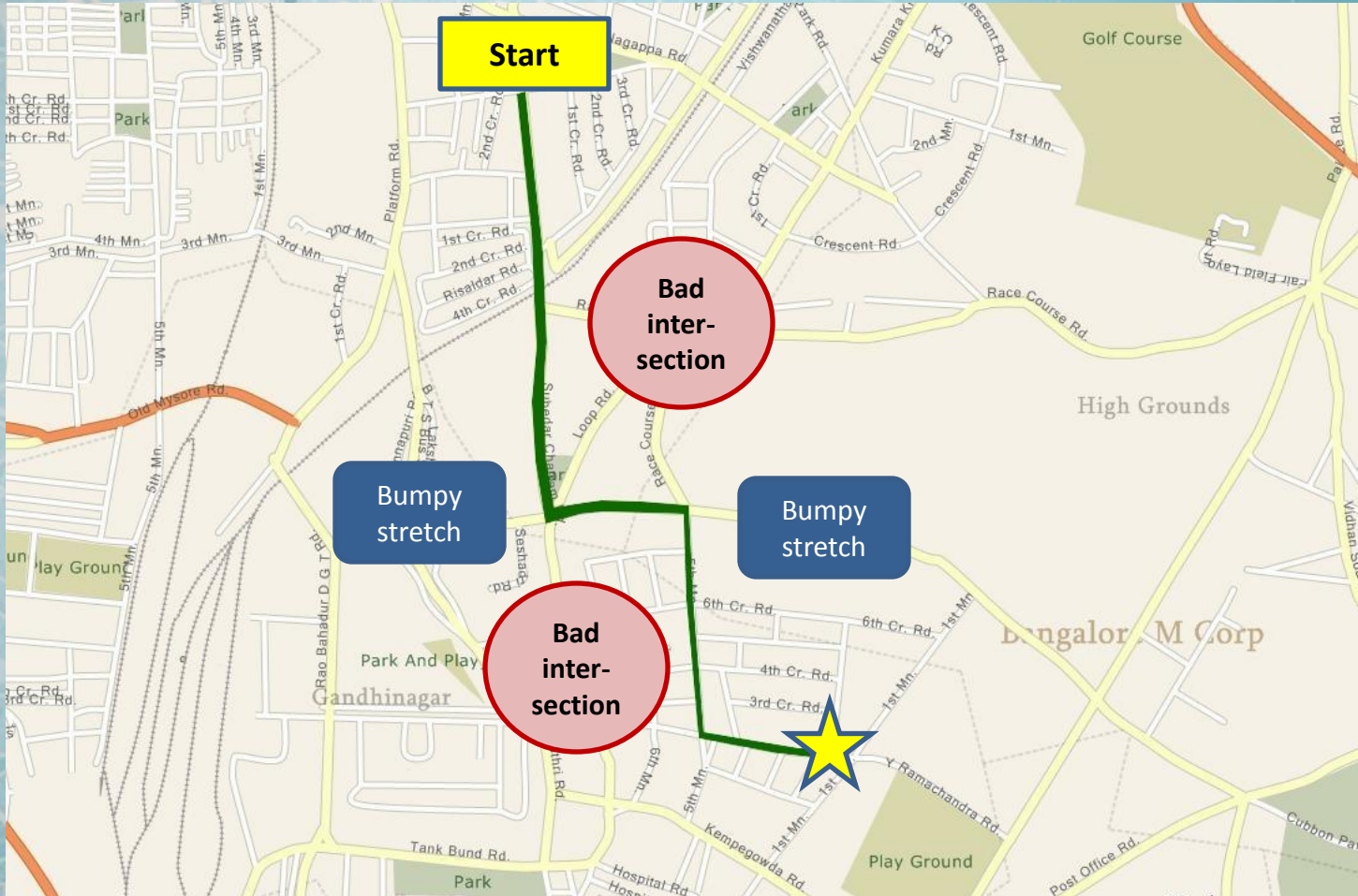
Low speed (< 25 kmph)

*z-sus*: look for sustained dip

# Honk Detection



# 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>

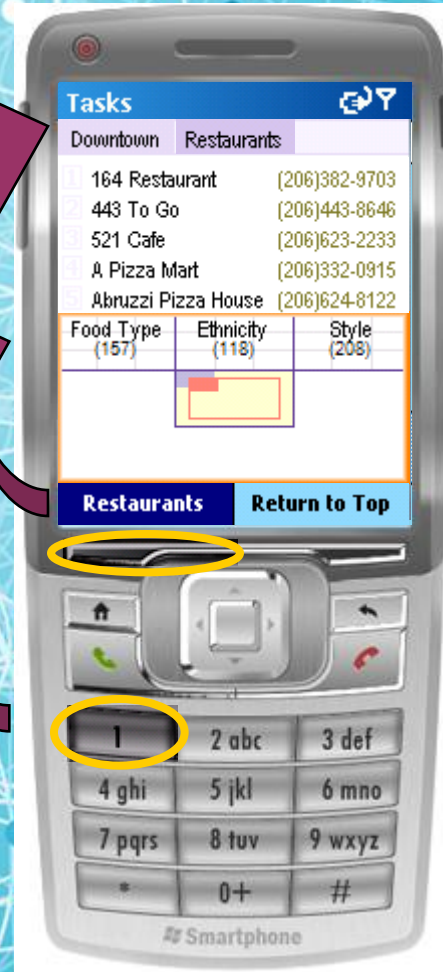


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# Mobile Data Access: Today

A Facet-Based Interface for Mobile Search



- Continuous Feedback Immediately Updates Results
- Dynamic Queries

Data Type:  
Save  
**Off Device**  
Search Terms

Problem:  
Navigates  
★ **Suggests Data Entry** ★

Keypad Mapping

# 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  $\Rightarrow$  Location
  - Accelerometer  $\Rightarrow$  Walking, Running, Potholes, ...
  - Microphone  $\Rightarrow$  Voice, Music, Honks, ...
  - Camera  $\Rightarrow$  Books, DVDs, Ads,...
- Context-awareness using mobile phone sensors key to richer information access

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