Mobile Networking

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History, Definitions, Applications, and Future,…

INTRODUCTION TO MOBILE NETWORKING II

Contents

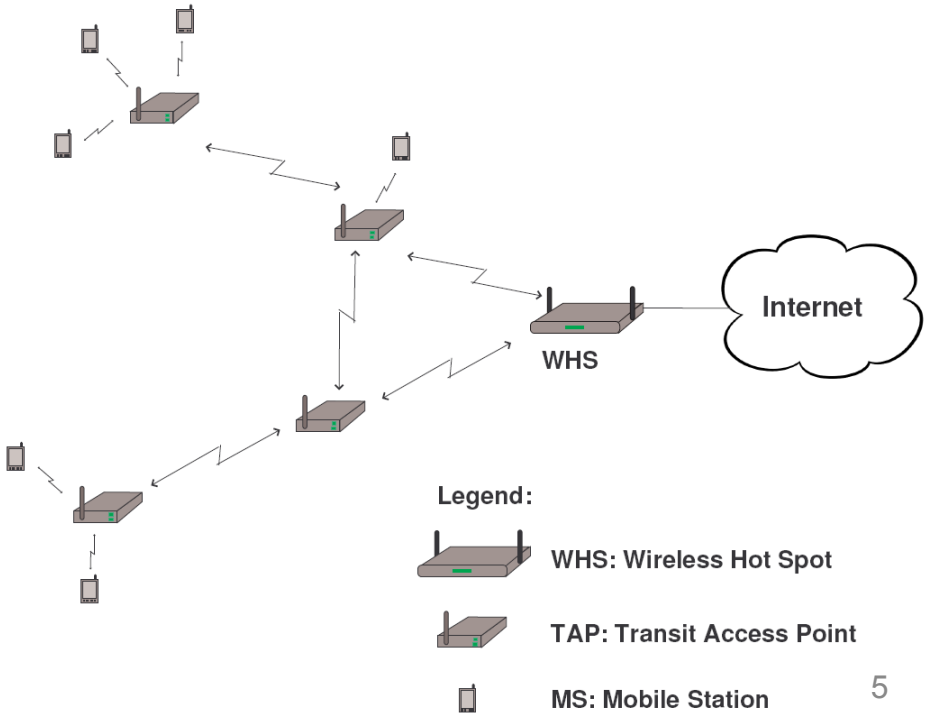
- New Mobile/Wireless Networks
- Mobile Services
- Wireless System Development
- Research in Mobile Networking

Mesh Networks, MANET, VANET, RFID, and Sensor Networks

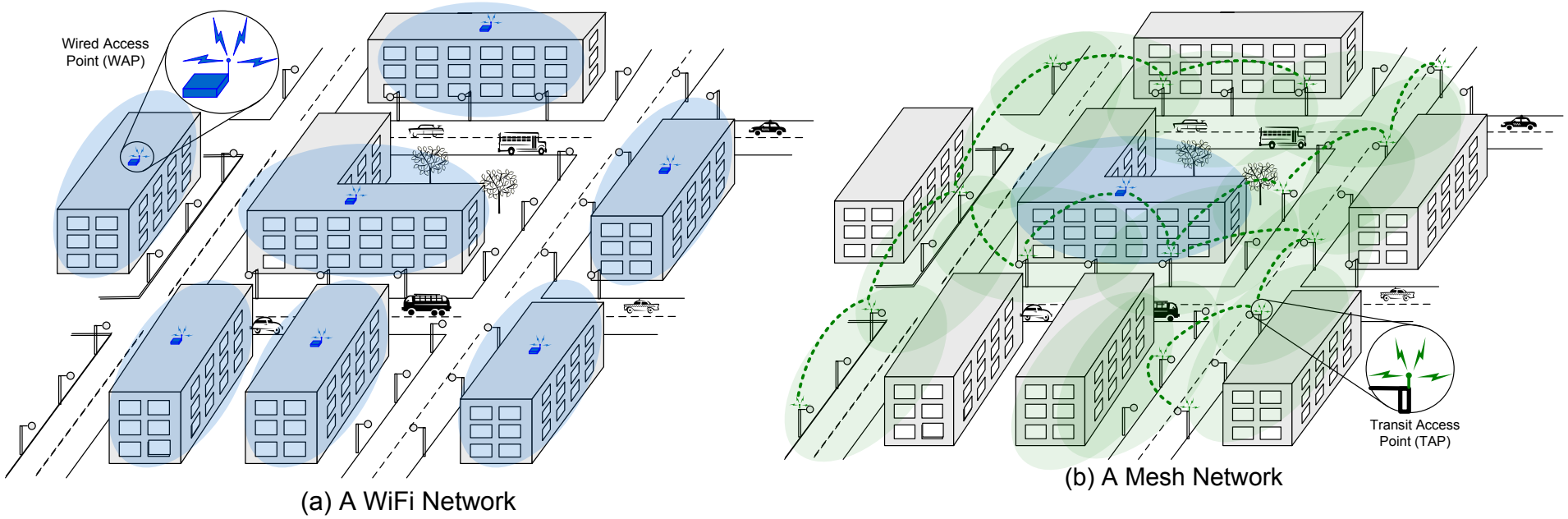
NEW MOBILE NETWORKS

Wireless Mesh Networks

- **Mesh network:**
  - One Wireless Hot Spot (WHS)
  - Several Transit Access Points (TAPs)
  - Mobile Stations



Wireless Mesh Networks



(a) A WiFi Network

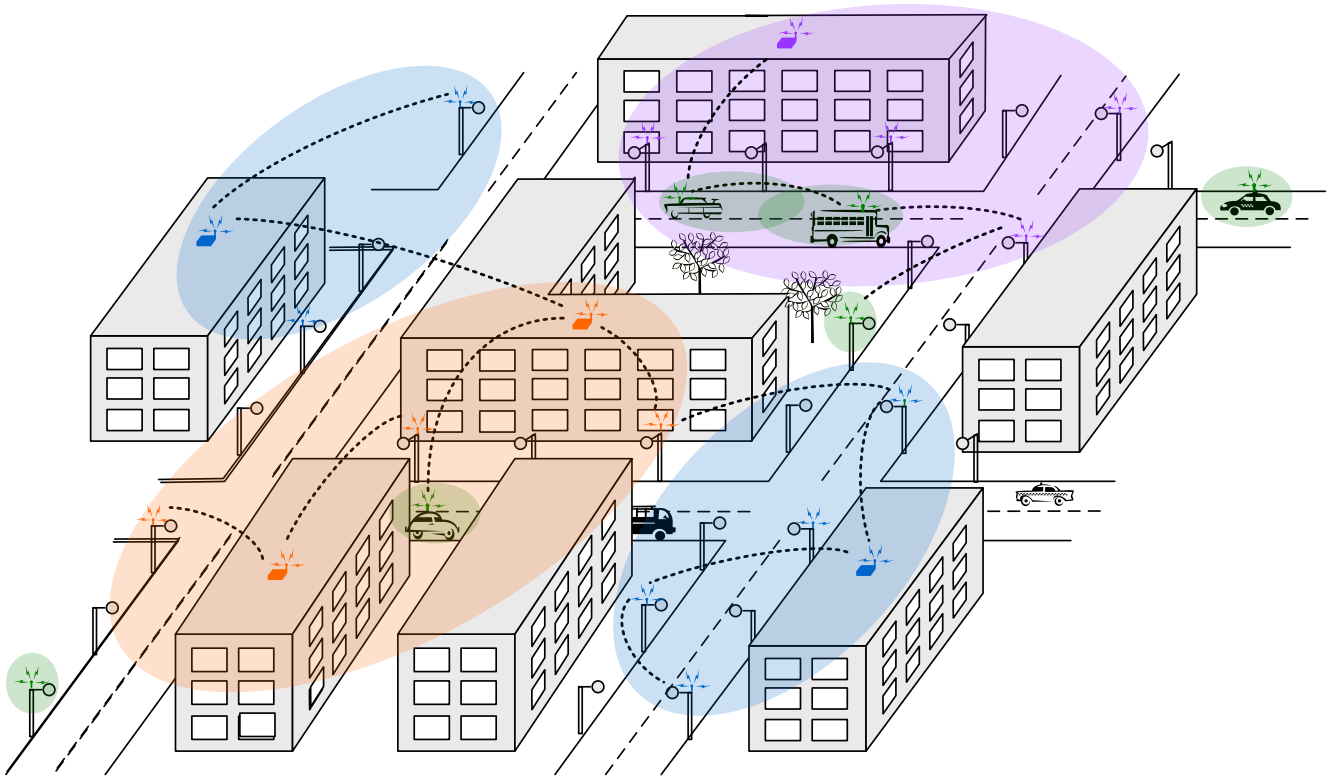
(b) A Mesh Network

- Wireless Mesh Network (WMN): Same coverage as with WiFi networks but with only one WAP (and several TAPs).
- WMNs allow a fast, easy and inexpensive network deployment.
- However, the lack of security guarantees slows down the deployment of WMNs

Characteristics of WMNs

- **Multi-hop communications:**
  - ✧ Delayed detection and treatment of attacks
  - ✧ Routing becomes critical
  - ✧ Unfairness
- **The TAPs are not physically protected:**
  - ✧ Capture
  - ✧ Cloning
  - ✧ Tampering
- **Three fundamental security operations:**
  1. Detection of corrupt nodes
  2. Secure routing
  3. Fairness

Multi-operator WMNs

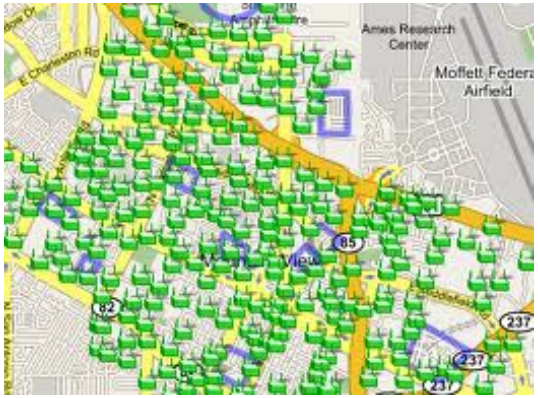


- **New challenges:**
  - Mutual authentication of nodes belonging to different “operating domains”
  - Competition for the channel (shared spectrum)

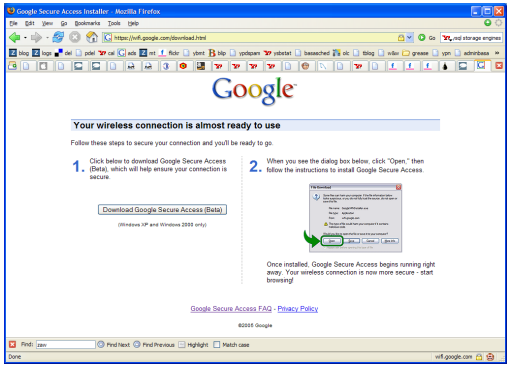
Wireless Mesh Networks

- **Easy to deploy:**
  - Single connection point to the Internet
- **Providing Internet connectivity in a sizable geographic area:**
  - Much lower cost than classic WiFi networks
- **Fairness and security are closely related**
- **Not yet ready for wide-scale deployment:**
  - Severe capacity and delay constraints
  - Lack of security guarantees

Example: Mountain View Google



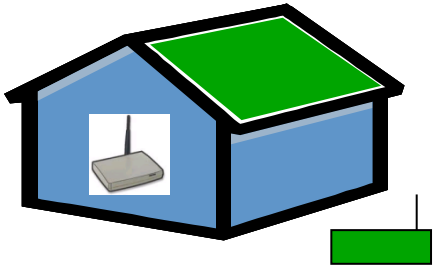
Google™ WiFi™ ZONE

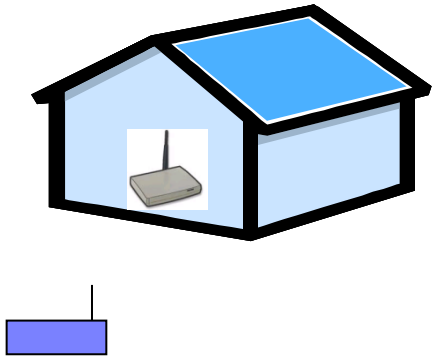


- 500 Tropos Networks MetroMesh routers (2009)
- 95% of the city's area of 12 square miles (31 km^2)
- Google WiFi only requires its end users have a Google Account
- Google offers a free virtual private network (VPN) software client called Google Secure Access (GSA)

Community networks

Example: service reciprocation in community networks





Example: FON

- A phenomenon of growing relevance, led by FON, http://en.fon.com/

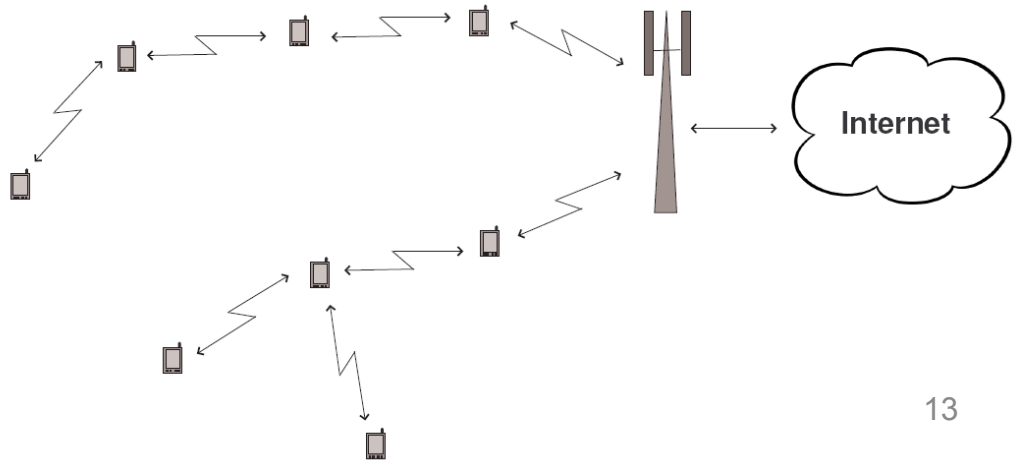
- FON claims
  - To have raised a total of more than 30M$, notably from Google, Skype, and BT

  - That the number of "Foneros" is around 7 millions

Hybrid Ad Hoc Networks

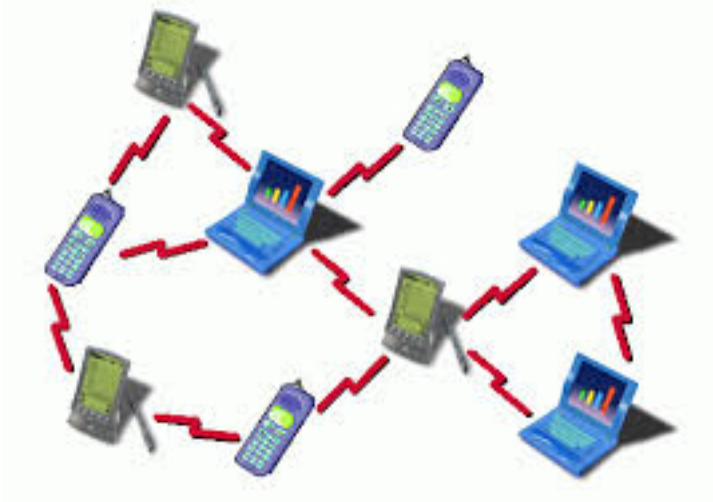
- **Hybrid ad hoc networks or multi-hop cellular networks:**
  - No relay stations
  - Other mobile stations relay the traffic

- **Problem of power management**



Mobile Ad Hoc Networks

- **Mobile ad hoc networks:**
  - Mobile ad hoc networks in hostile environments
  - In self-organized mobile ad hoc networks



Mobile Ad Hoc Networks

- **Mobile ad hoc networks in hostile environments:**
  - Presence of a strong attacker: military networks
  - Security challenges:
    - Secure routing
    - Prevention of traffic analysis
    - Resistance of a captured device to reverse engineering and key retrieval.

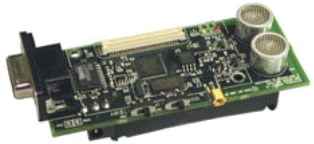
- **In self-organized mobile ad hoc networks:**
  - No authority in the initialization phase
  - Nodes have to figure out how to secure the communications
  - Selfishness can be a serious issue:
    - Nodes selfishly refuse to forward packets
    - Greedily overuse the common channel

Wireless sensors

TelosB Sensor Mote

Imote2

Cricket Mote



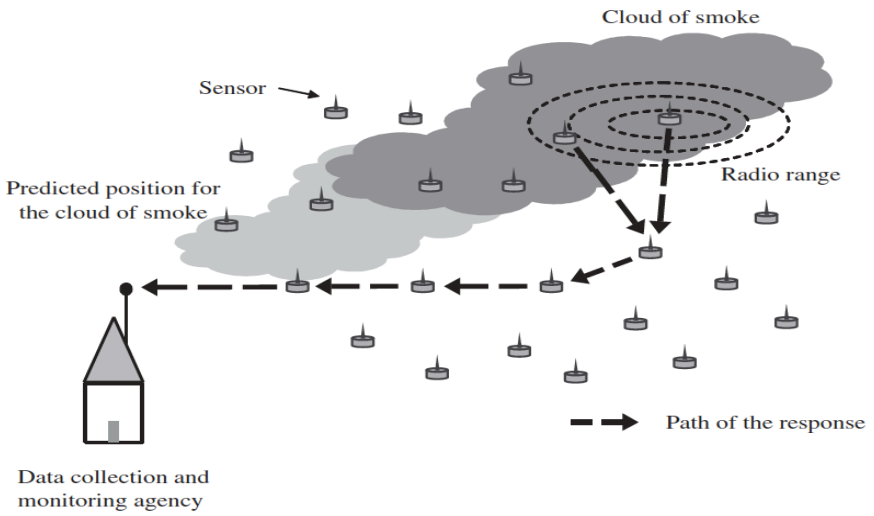
Iris Mote

MicaZ

IEEE 802.15.4 Chipcon Wireless Transceiver
Frequency band: 2.4 to 2.4835 GHz
Data rate: 250 kbps
RF power: -24 dBm to 0 dBm
Receive Sensitivity: -90 dBm (min), -94 dBm (typ)
Range (onboard antenna): 50m indoors / 125m ourdoors

Sensor Networks

- Large number of sensor nodes, a few base stations
- Sensors are usually battery powered:
  - Main design criteria: reduce the energy consumption
- Multi-hop communication reduces energy consumption

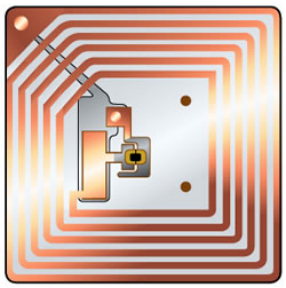


Radio-frequency Identification (RFID)

SDI 010 RFID Reader

ISO14443-A and B (13.56 MHz)
Operating distance: 1cm
Communication speed: up to 848 Kbit/s

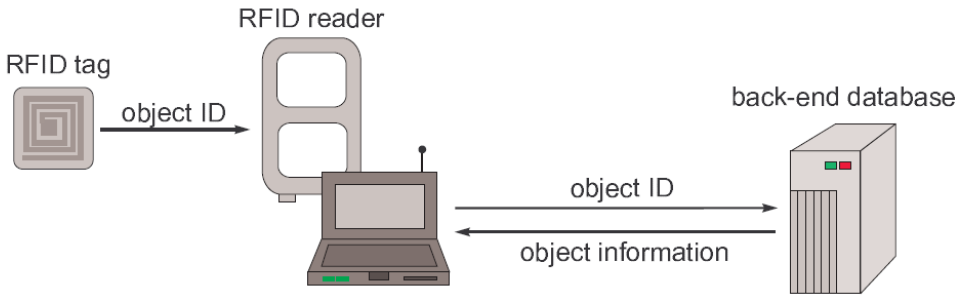
RFID tag



RFID

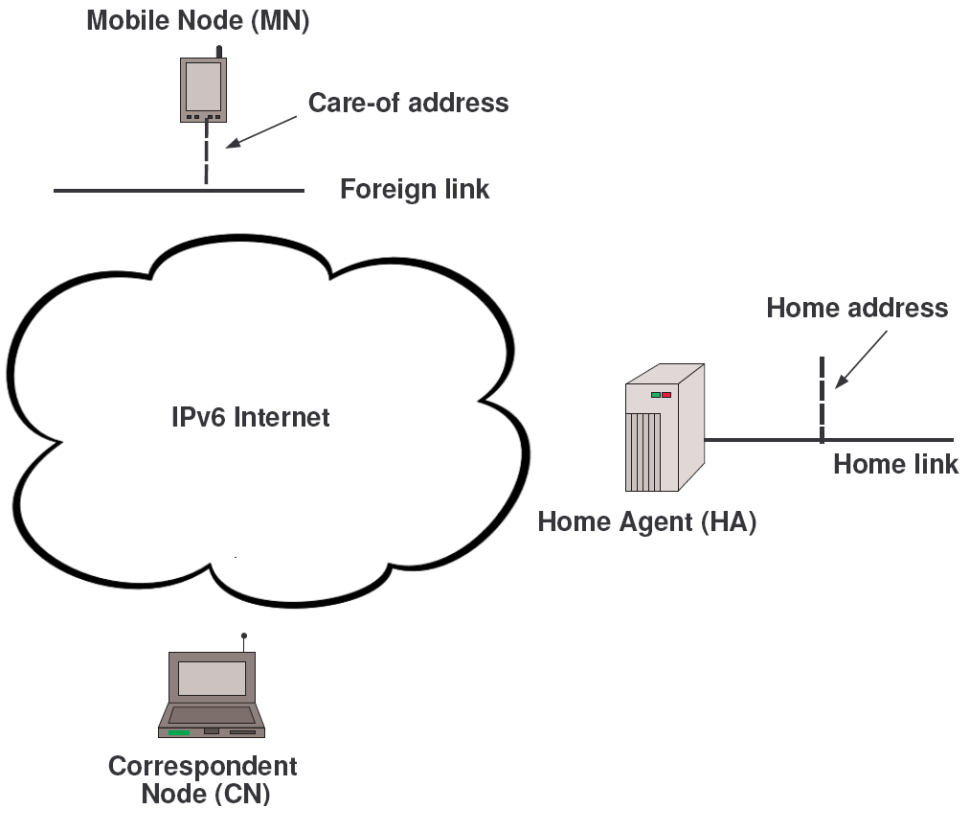
- **RFID systems:**
  - RFID tags
  - RFID readers
  - Back-end databases

- **RFID tag: microchip and antenna**
  - Active: have battery
  - Passive: harvest energy from the reader's signal



Mobility in the Internet

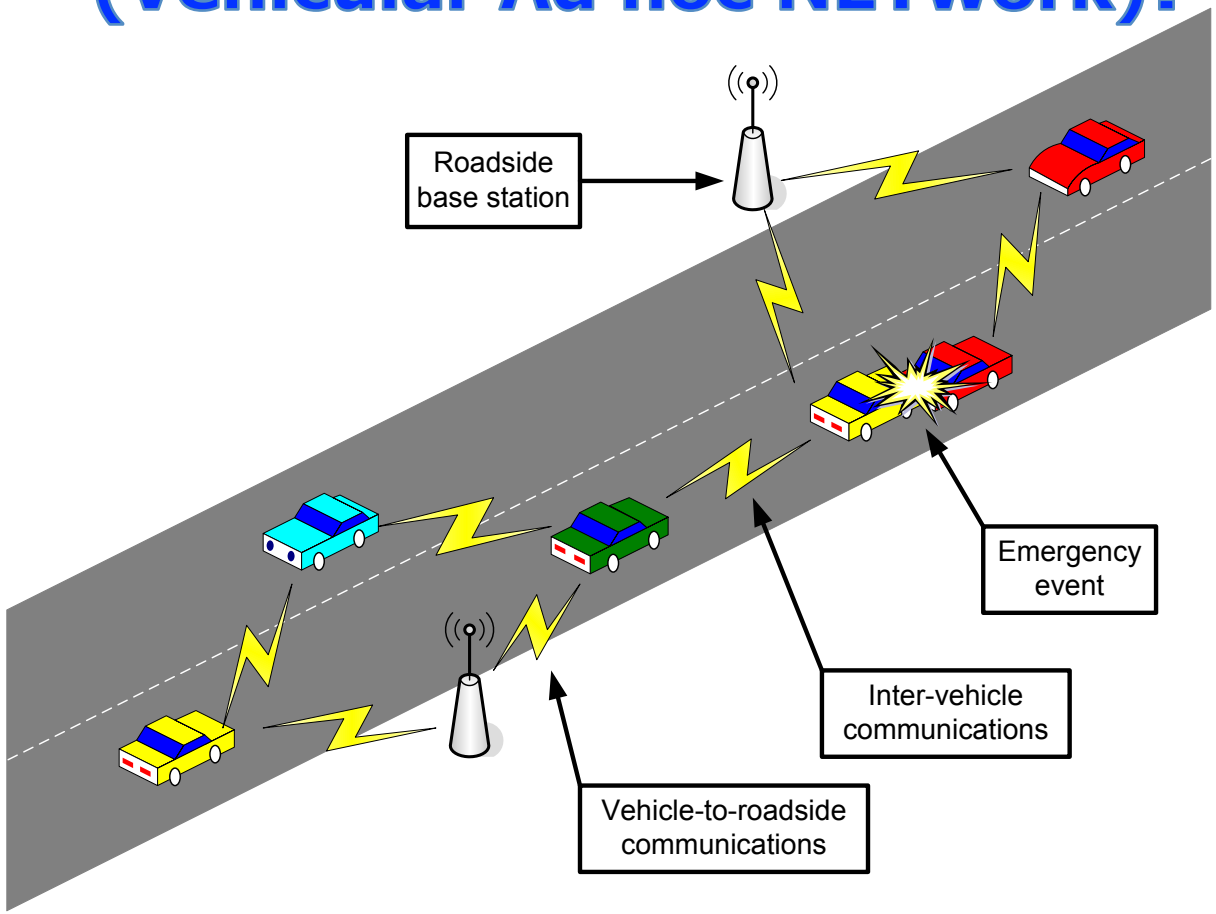
- When a node changes location ➔ Its address will be changed
- Mobile IP: solves this problem at the IP layer



Vehicular Communications (VC): why?

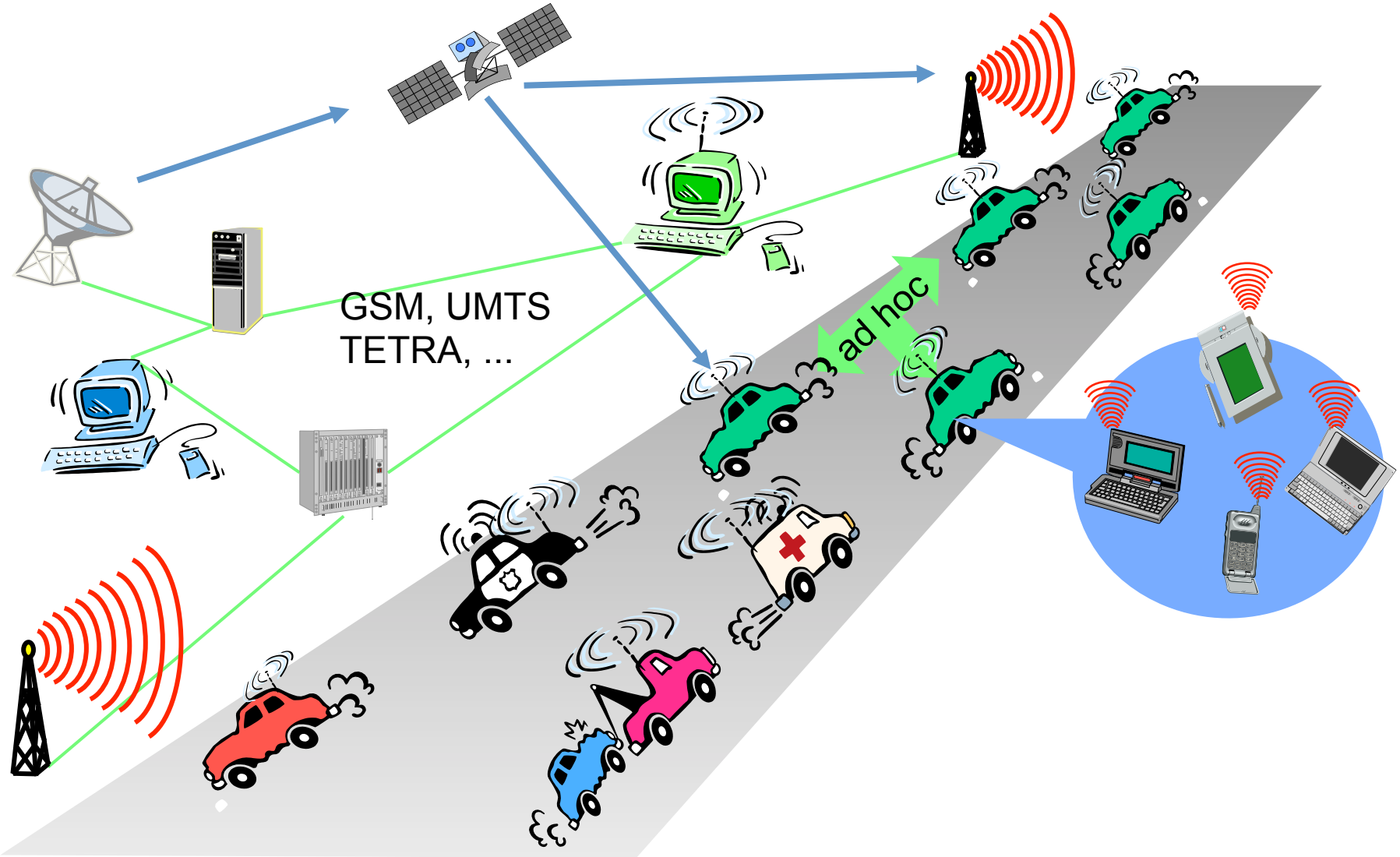
- Combat the awful side-effects of road traffic
  - In the EU, around 40,000 people die yearly on the roads; more than 1.5 millions are injured
  - Traffic jams generate a tremendous waste of time and of fuel
- Most of these problems can be solved by providing appropriate ***information*** to the driver or to the vehicle

What is a VANET (Vehicular Ad hoc NETwork)?

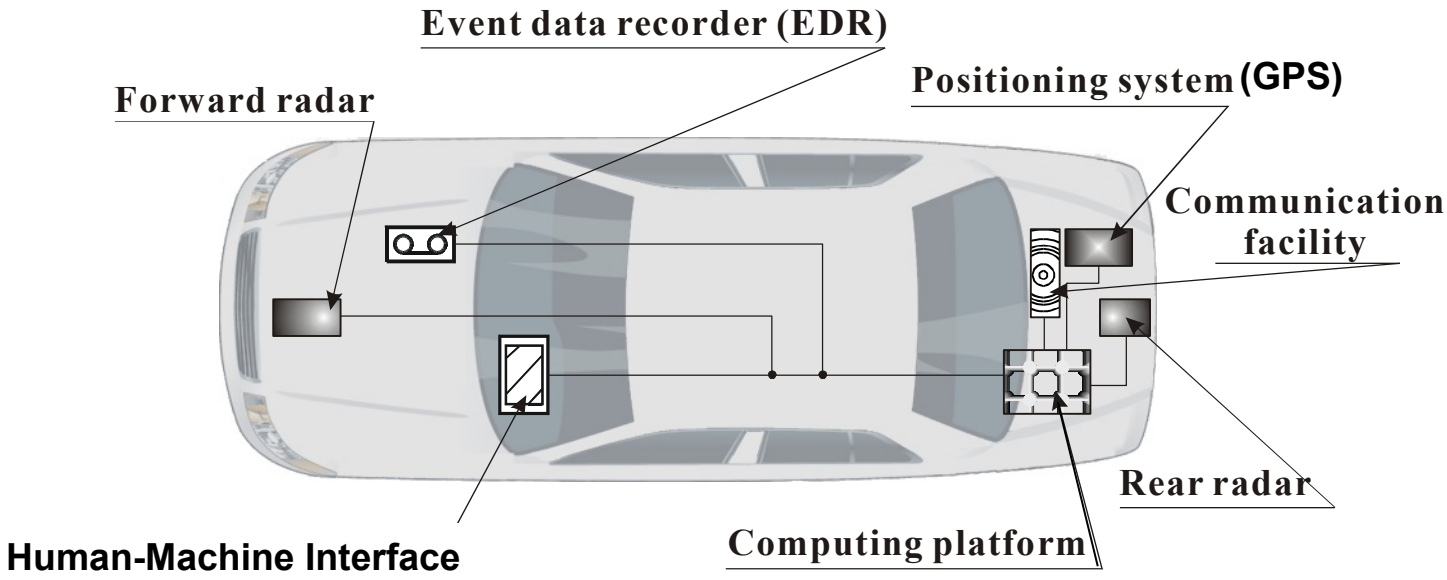


- Communication: Dedicated Short Range Communications (DSRC) (5.9 GHz)
- Example of protocol: IEEE 802.11p
- Penetration will be progressive (over 2 decades or so)

Example: road traffic

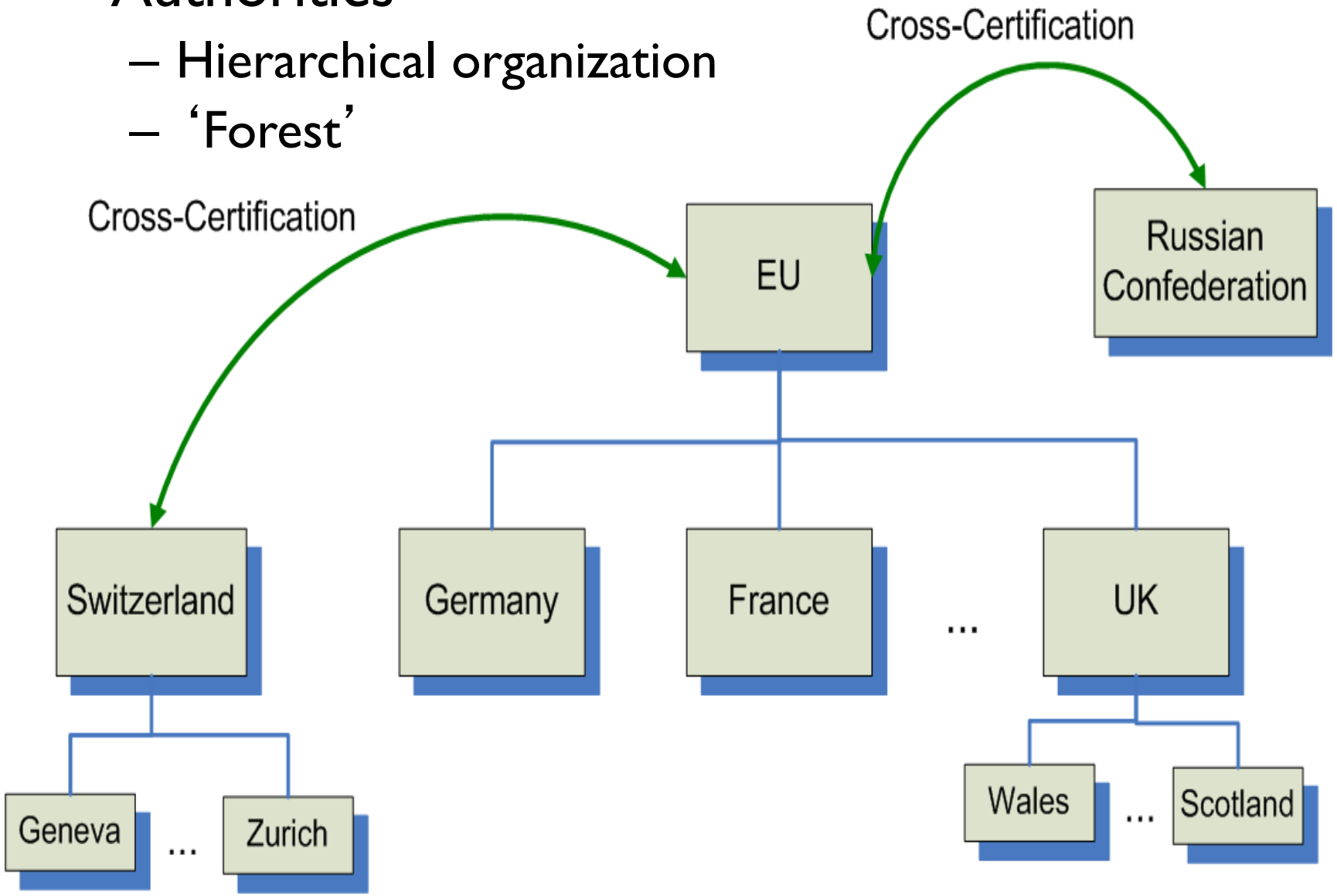


A Smart Vehicle



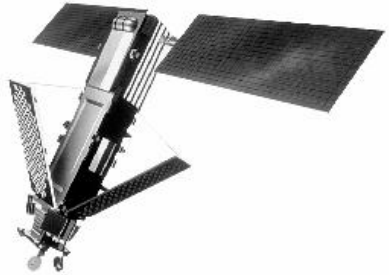
Secure VC Building Blocks

- Authorities
  - Hierarchical organization
  - 'Forest'



Satellite Communications

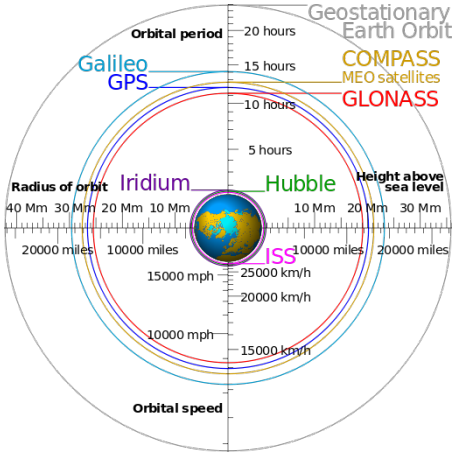
Iridium Satellite



Supports 1100 concurrent phone calls
Orbit altitude: approx. 780 km
Frequency band: 1616-1626.5 MHz
Rate: 25 kBd
FDMA/TDMA

Global Positioning System (GPS)
30 satellites currently
Orbit altitude: approx. 20200 km
Frequency: 1575.42 MHz (L1)
Bit-rate: 50 bps
CDMA

Iridium 9505A Satellite Phone

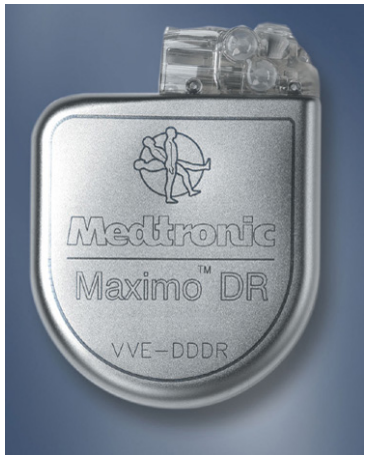


BTCC-45 Bluetooth GPS Receiver

European attempt: Galileo

Medical Implants

Implantable Cardioverter Defibrillator (ICD)



Operating frequency: 175kHz
Range: few centimeters

Medical Implant Communication Service (MICS)
Frequency band: 402-405 MHz
Maximum transmit power (EIRP): 25 microwatt
Range: few meters

Software Defined Radio

Tuning Frequency:
30KHz - 30MHz (continuous)
Tuning Steps:
1/5/10/50/100/500Hz & 1/5/9/10KHz
Antenna Jacket / Impedance:
BNC-socket / 50Ohms
Max. Allowed Antenna Level :
+10dBm typ. / saturation at -15dBm typ.
Noise Floor (0.15-30MHz BW 2.3KHz):
Standard: < -131dBm (0.06 μ V) typ.
HighIP: < -119dBm (0.25 μ V) typ.
Frequency Stability (15min. warm-up period):
+/- 1ppm typ.

Application: Cognitive Radios → Dynamic Spectrum Access

Contents

- New Mobile/Wireless Networks
- Mobile Services
- Wireless System Development
- Research in Mobile Networking

Mobile Applications

- **Person to person communication** (e.g., voice, SMS)
- **Person to server** (e.g., location-based services, timetable consultation, telebanking)
- **Vehicles**
  - position via GPS
  - local ad-hoc network with vehicles close-by to prevent accidents, guidance system, adaptive cruise control
  - transmission of news, road condition, weather, music via Digital Audio Broadcasting
  - vehicle data (e.g., from buses, trains, aircrafts) transmitted for maintenance
- **Disaster situations**
  - replacement of a fixed infrastructure in case of earthquakes, hurricanes, fire etc.
- **Military networks**

Mobile Applications

- **Replacement of fixed networks**
  - Sensors
  - Trade shows networks
  - LANs in historic buildings
- **Entertainment, education, ...**
  - Outdoor Internet access
  - Travel guide with up-to-date location dependent information
  - Ad-hoc networks for multi user games
  - Location-dependent advertising

Novel Mobile Services*

LOCATION-BASED SERVICES

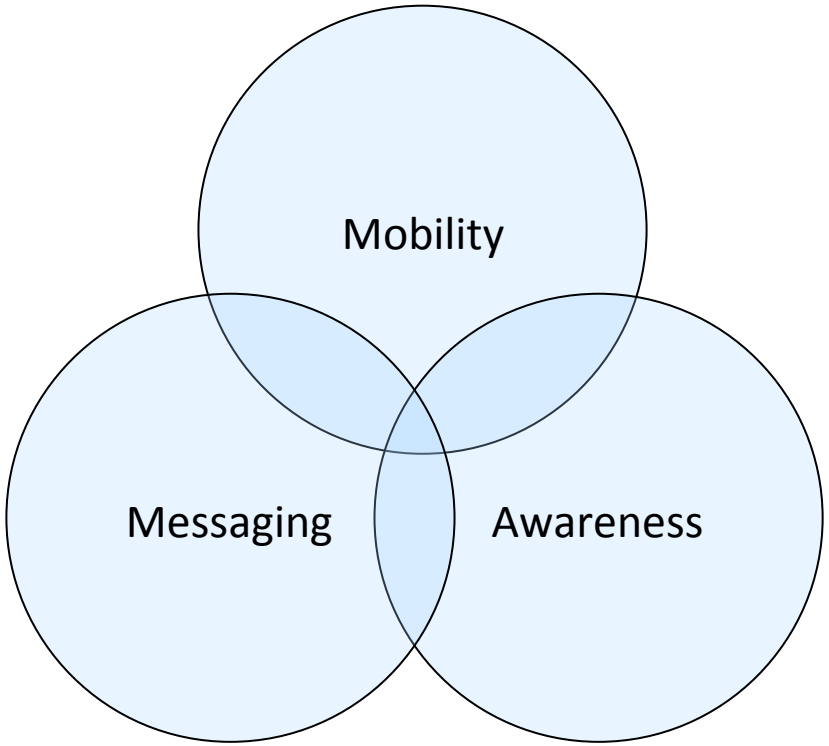
*** Some slides in this section are derived from Ubiquitous Computing course, presented by Prof. Jason I. Hong at CMU (http://www.cs.cmu.edu/~jasonh/)**

Location-based Services

- **Location aware services**
  - What services, e.g., printer, fax, phone, server etc. exist in the local environment
- **Follow-on services**
  - Transmission of the actual workspace to the current location
- **Information services**
  - "push": e.g., current special offers in the shop nearby
  - "pull": e.g., where is the closest "Gas Station"?
- **Support services**
  - Caches, intermediate results, state information etc. "follow" the mobile device through the fixed network
- **Location-Based Services (LBSs)**
  - Foursquare, Facebook Mobile,…

inTouch: Coordination for Families

- Make it easier to coordinate with others while mobile
  - Better awareness and messaging



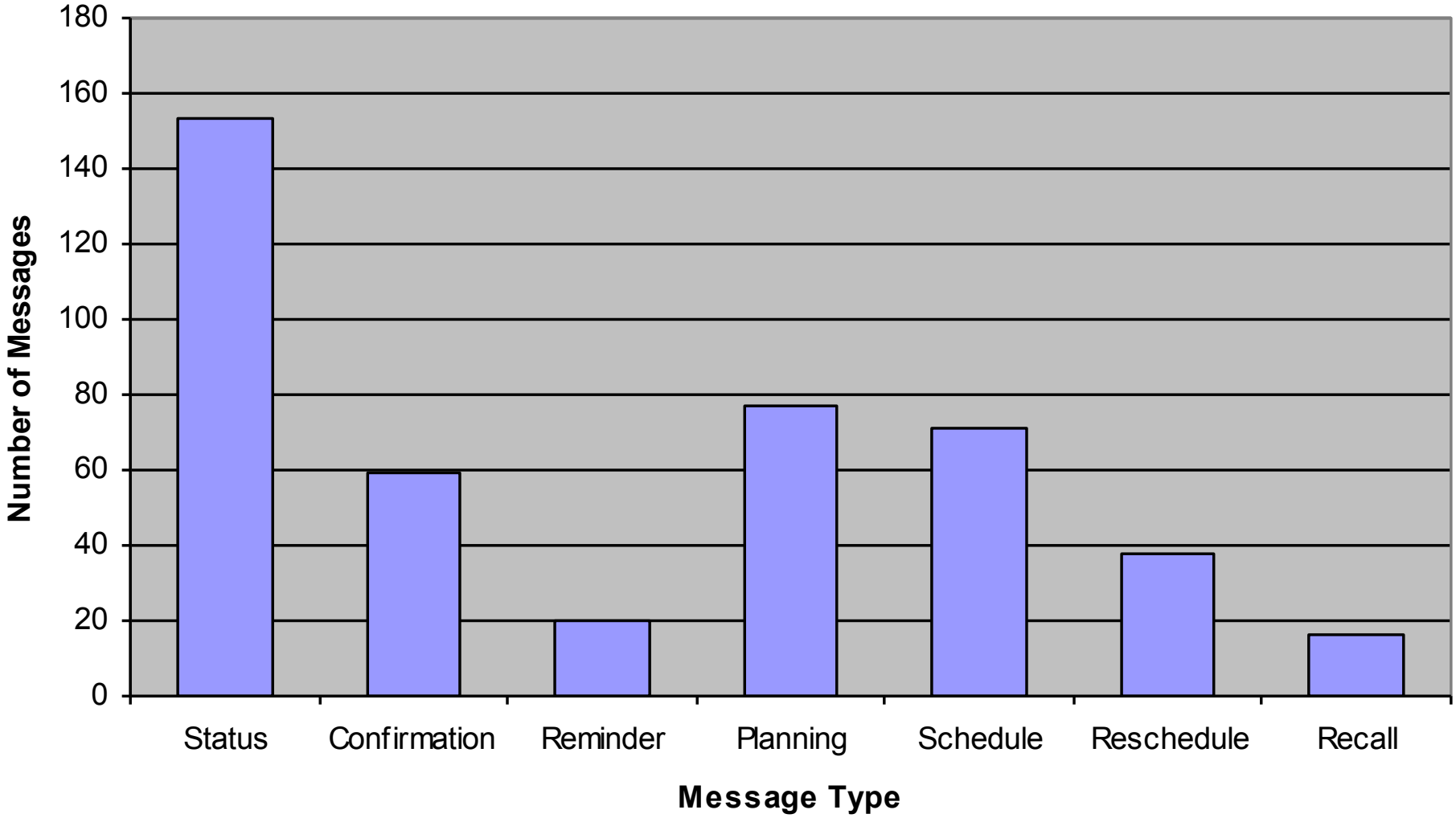
Examples:

- Dual-career families
- Work groups
- Ad hoc (ex. conferences)
- Carpools

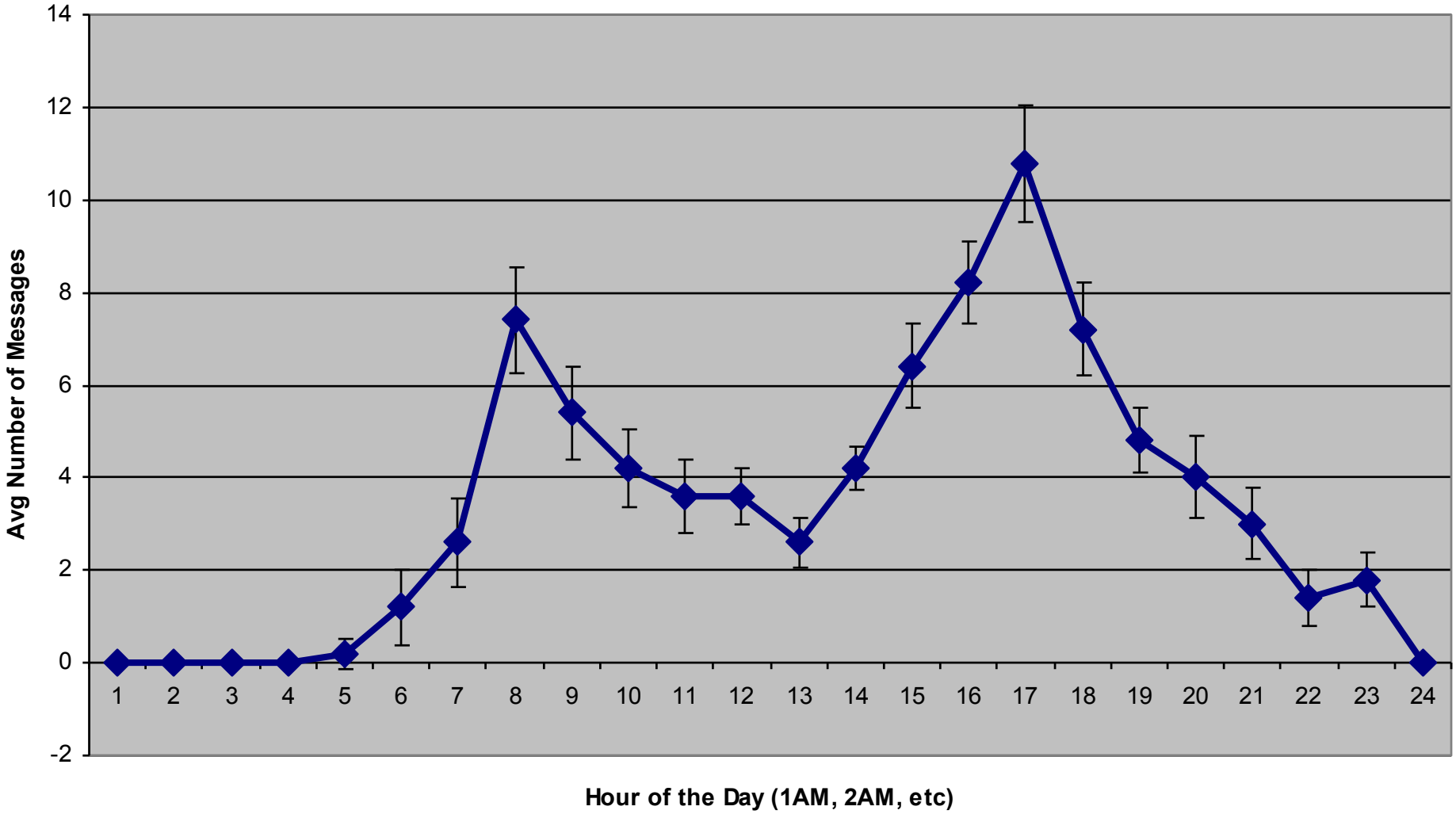
inTouch: Coordination for Families

- Two-week field study with six dual-career families

Check, Double Check, Triple Check

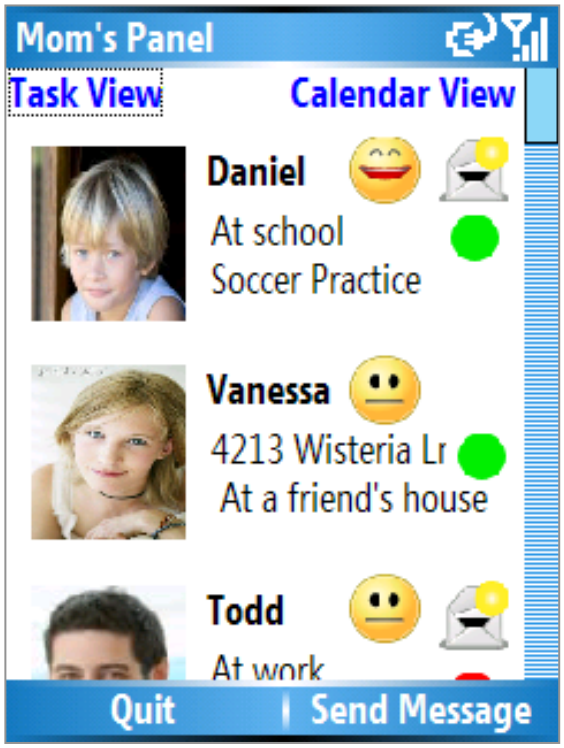


Key Transition Times



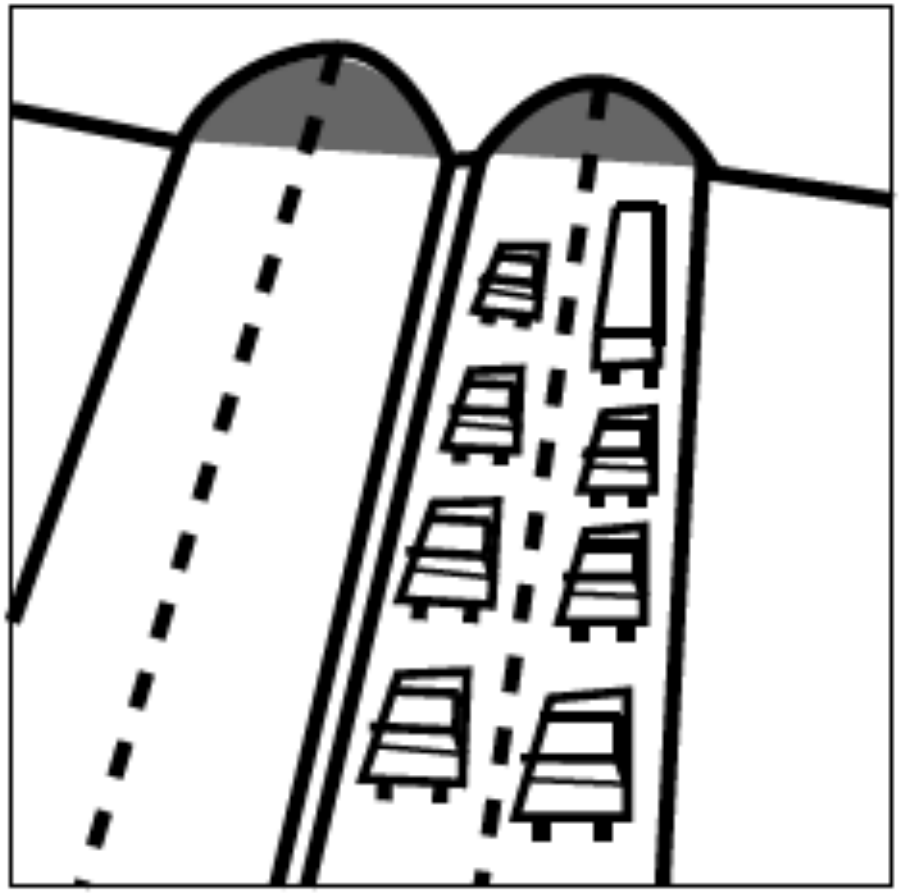
inTouch: Coordination for Families

- Make it easier to coordinate with others while mobile
  - Better awareness
  - Contextual messaging



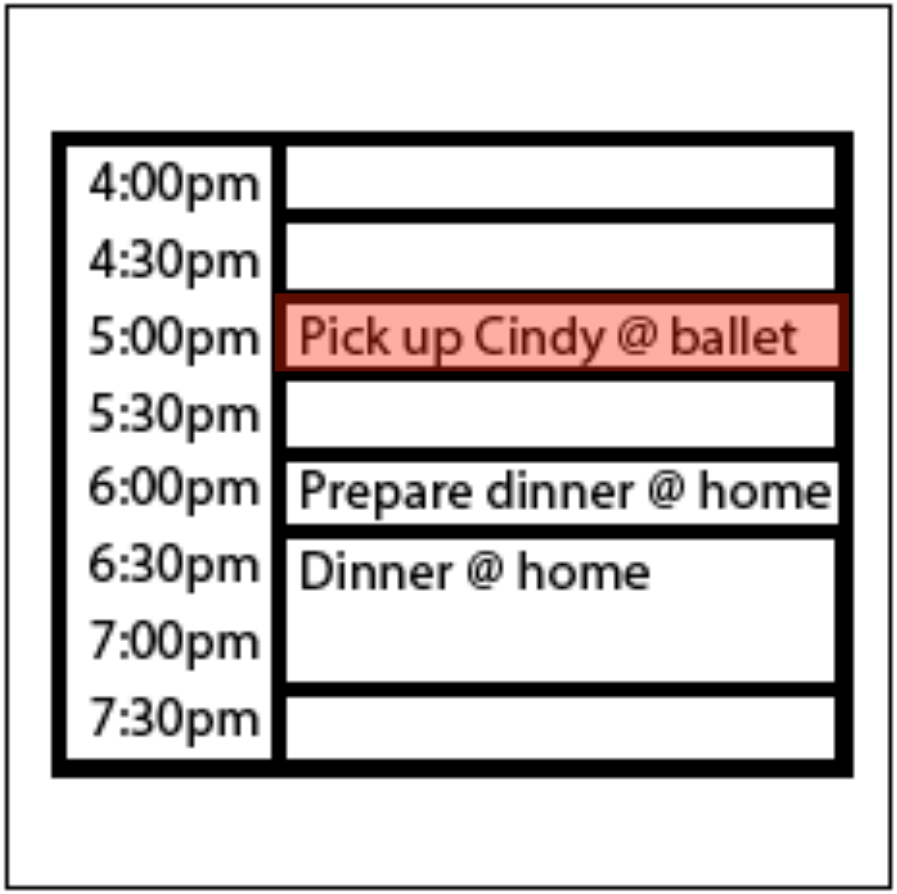
Combines:
- Shared calendar
- Shared todo lists
- Reminders
- Real-time location
- Proximity

1



It's 4:30pm and Mom is stuck in traffic

2



inTouch checks her calendar and sees she's supposed to pick up Cindy from ballet

3

Mom's phone senses that she is in a traffic jam, and automatically prepares a status message

4

Mom hits "send", and Cindy sees that Mom is running late. Cindy decides to wait inside.

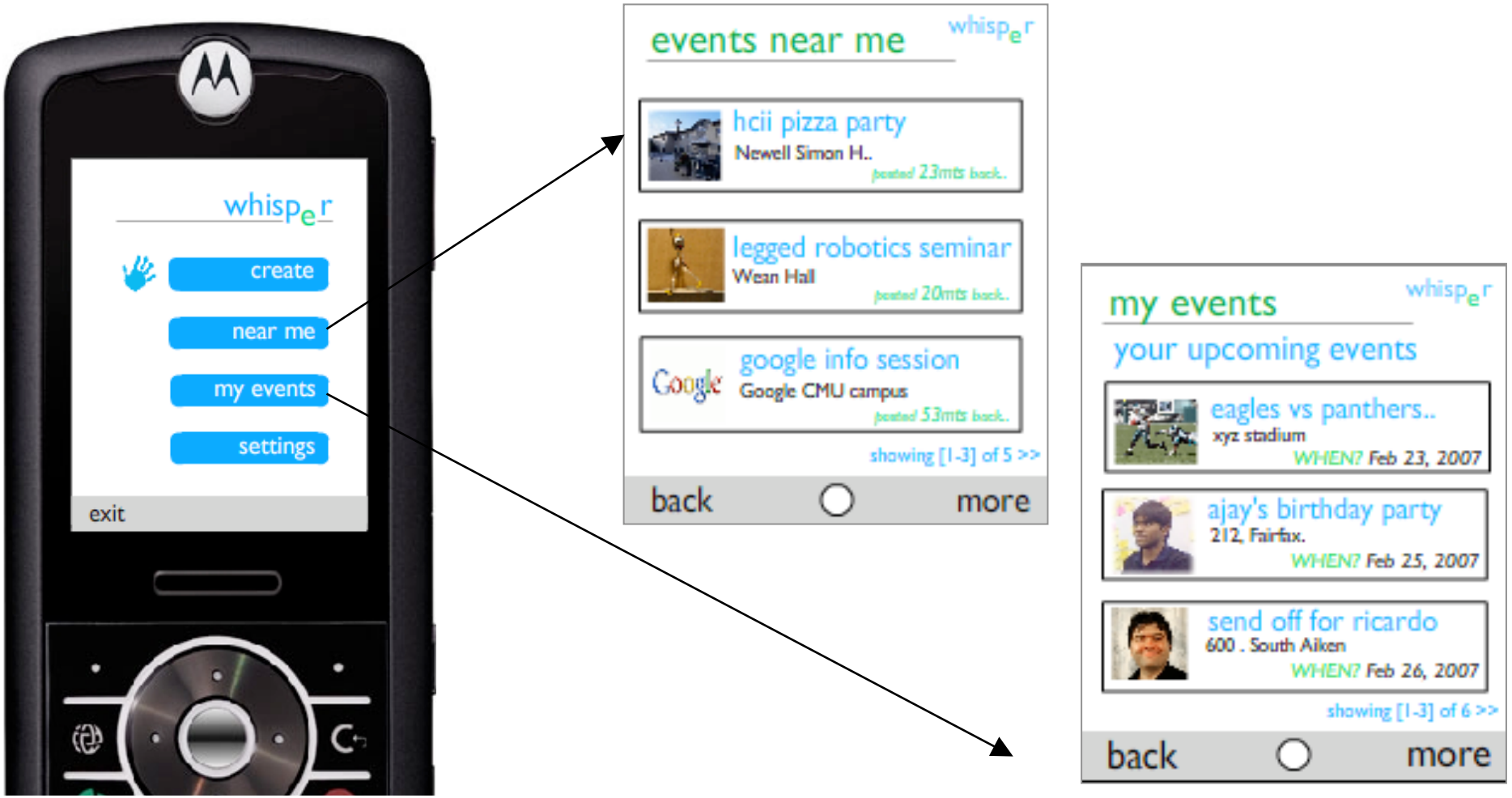
Contextual Messaging

- Using current context to:
  - Select a message template
  - Fill in the blanks (like a MadLib)
  - In most cases, can just hit "send"

- When is contextual messaging useful?
  - Calendar alarms "running late, will be there in ***<ETA>***"
  - Current activity "in a meeting now, done at ***<time>***"
  - Daily rhythms "picked up kid ok" at 3PM
  - Messages received "where r u?" -> "I am at ***<place>***"

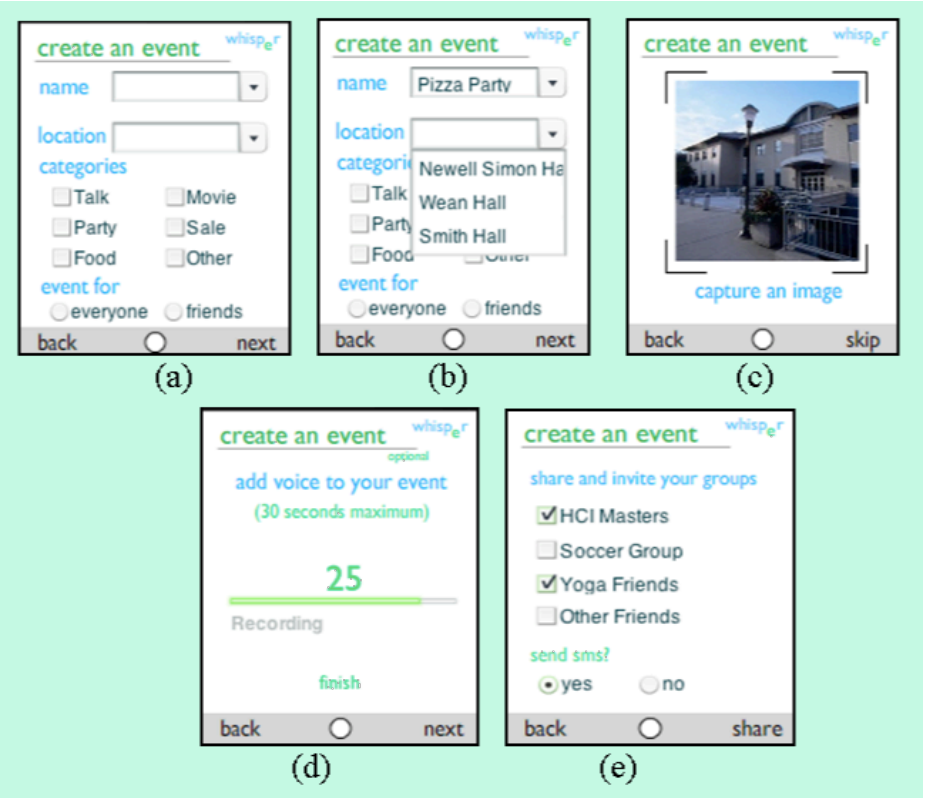
Whisper Mobile

- Goal: Make it easy to find, share, and coordinate friends going to social events



Whisper Mobile: Creating an Event

- Minimal text input
  - Use location
  - Use audio
  - Use camera



whisper beta

Your Events. Your People.

- Developing working prototype of web site and mobile
  - Web crawler for finding social events
  - Web site to coordinate on scale of weeks and days

- Link with inTouch
  - Coordinate friends
  - See who's late, where we're going next
  - Mobile to coordinate on scale of hours and minutes

New Context-Based Applications

- Search for local services
- Connect with friends and strangers
  - Bluedating, bluelocator, bluetella
  - **Aka-Aki**
  - Friend finder
- Improve urban mobility
  - Vehicular Networks

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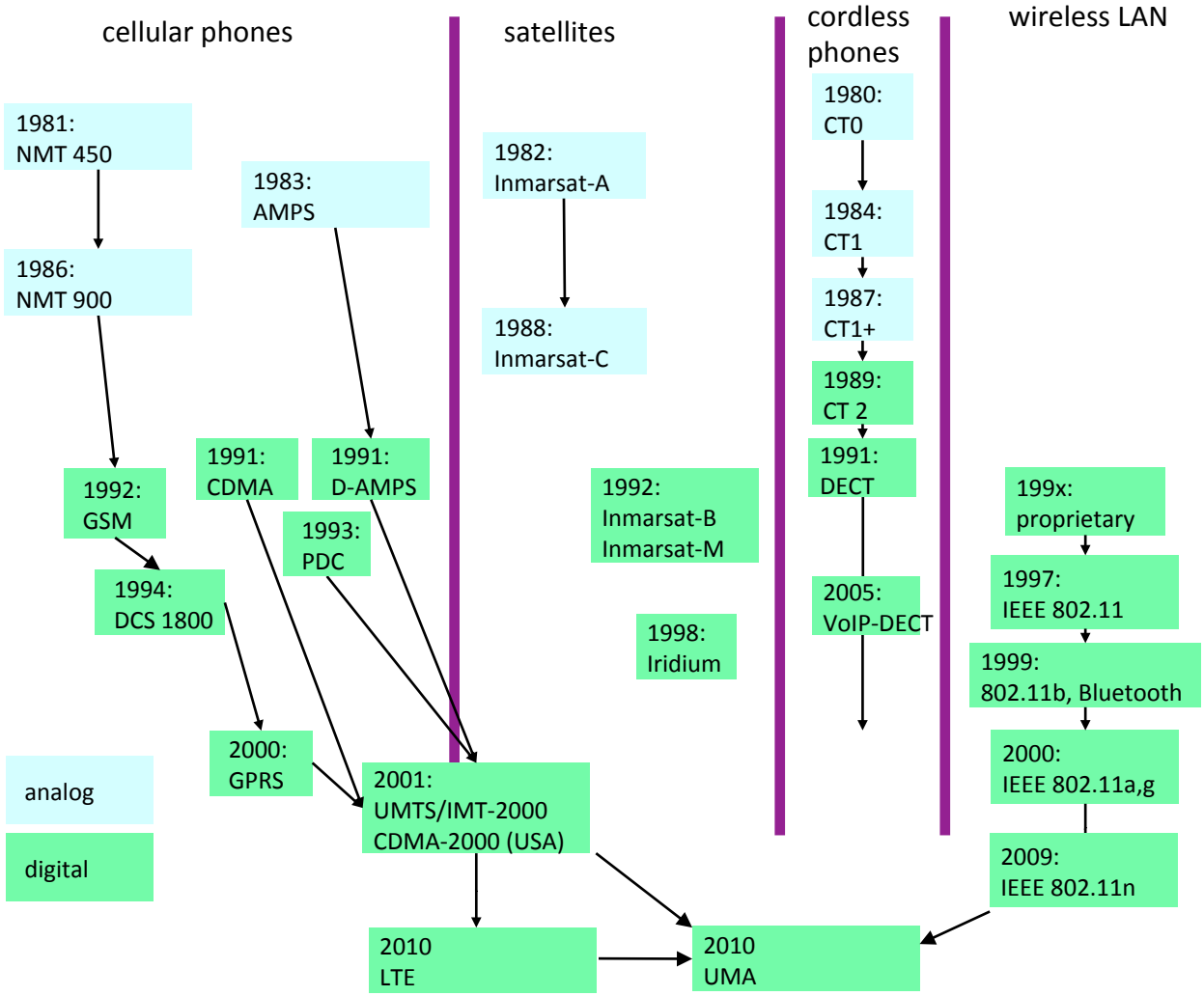
History…

WIRELESS SYSTEMS DEVELOPMENT

Development over the Last 25 Years



NMT: Nordic Mobile Telephone
AMPS: Advanced Mobile Phone System (USA)
CT: Cordless Telephone
UMTS: Universal Mobile Telecom. System
LTE: Long Term Evolution
DECT: Digital Enhanced Cordless Telecom.
DCS: Digital Cellular System
PDC: Pacific Digital Cellular
PAN: Personal Area Network
UMA: Universal Mobile Access

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RESEARCH AREAS IN MOBILE NETWORKING

Research in Mobile Networks

- **Wireless Communication**
  - transmission quality (bandwidth, error rate, delay)
  - modulation, coding, interference
  - media access
  - ...
- **Mobility**
  - location dependent services, also called location based services
  - location transparency
  - quality of service support (delay, jitter)
  - security
  - …

Research in Mobile Networks

- **Portability**
  - integration ("system on a chip")
  - power consumption
  - limited computing power, sizes of display, ...
  - usability
  - ...
- **Security/privacy**

Influence of Mobile Networking on the layer model

■ Application layer	–location-dependent services
■ Transport layer	–new applications, multimedia –adaptive applications
■ Network layer	–congestion and flow control –quality of service –addressing, routing, mobility management
■ Data link layer	–hand-over –media access –multiplexing
■ Physical layer	–modulation –power management, interference –attenuation –frequency allocation