

Business Analytics and Data Driven Decision Making

Session#06: Lecture#11: Visual Analytics: Geospatial Analysis

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Mobile Devices and Services

- Large diffusion of mobile devices, mobile services, and location based services



Which Location Data?

- Location data from mobile phones (e.g., iPhone, GPhone, etc.)
 - ▶ Cell positions in the GSM/UMTS network
- Location data from GPS-equipped devices
 - ▶ Humans (pedestrians, drivers) with GPS-equipped smart-phones
 - ▶ Vessels with AIS transmitters (due to maritime regulations)
- Location data from intelligent transportation environments
 - ▶ Vehicular ad-hoc networks (VANET)
- Location data from indoor positioning systems
 - ▶ RFIDs (radio-frequency ids)
 - ▶ Wi-Fi access points



Examples of Location Data

- Vehicles (private cars) moving in Milan
 - ▶ ~2M GPS recordings from 17241 distinct objects
 - ▶ (7 days period, 214,780 trajectories)
- Vehicles (couriers) moving in London
 - ▶ ~92.5M GPS recordings from 126 distinct objects
 - ▶ (18 months period, 72,389 trajectories)
- Vessels sailing in Mediterranean sea
 - ▶ ~4.5M GPS recordings from 1753 distinct objects
 - ▶ (3 days period, 1503 trajectories)



What Can We Learn From Location Data?

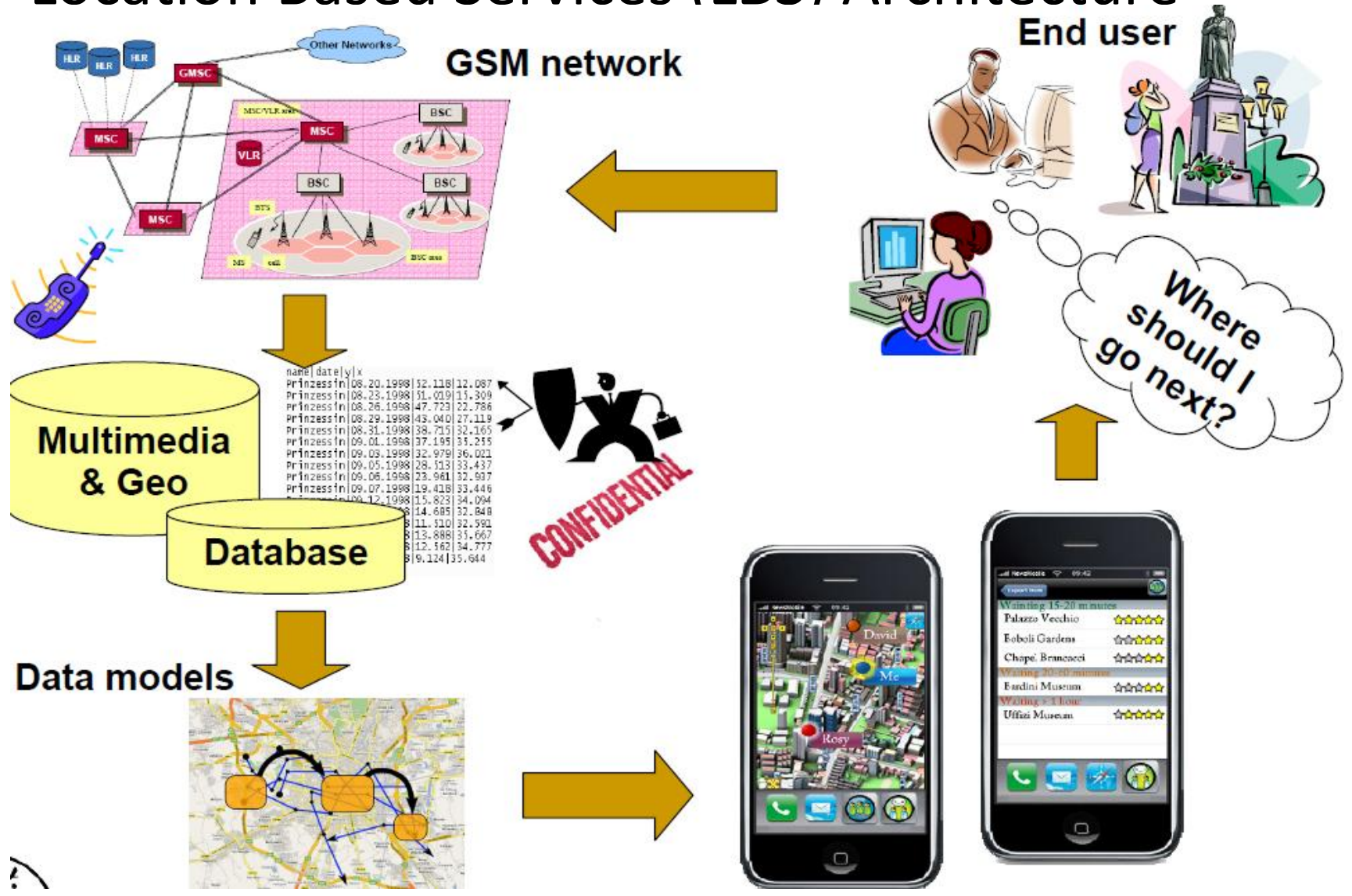
- **Traffic monitoring**

- ▶ How many cars are in the downtown area?
- ▶ Send an alert if a non-friendly vehicle enters a restricted region
- ▶ Once an accident is discovered, immediately send alarm to the nearest police and ambulance cars

- **Location-aware queries**

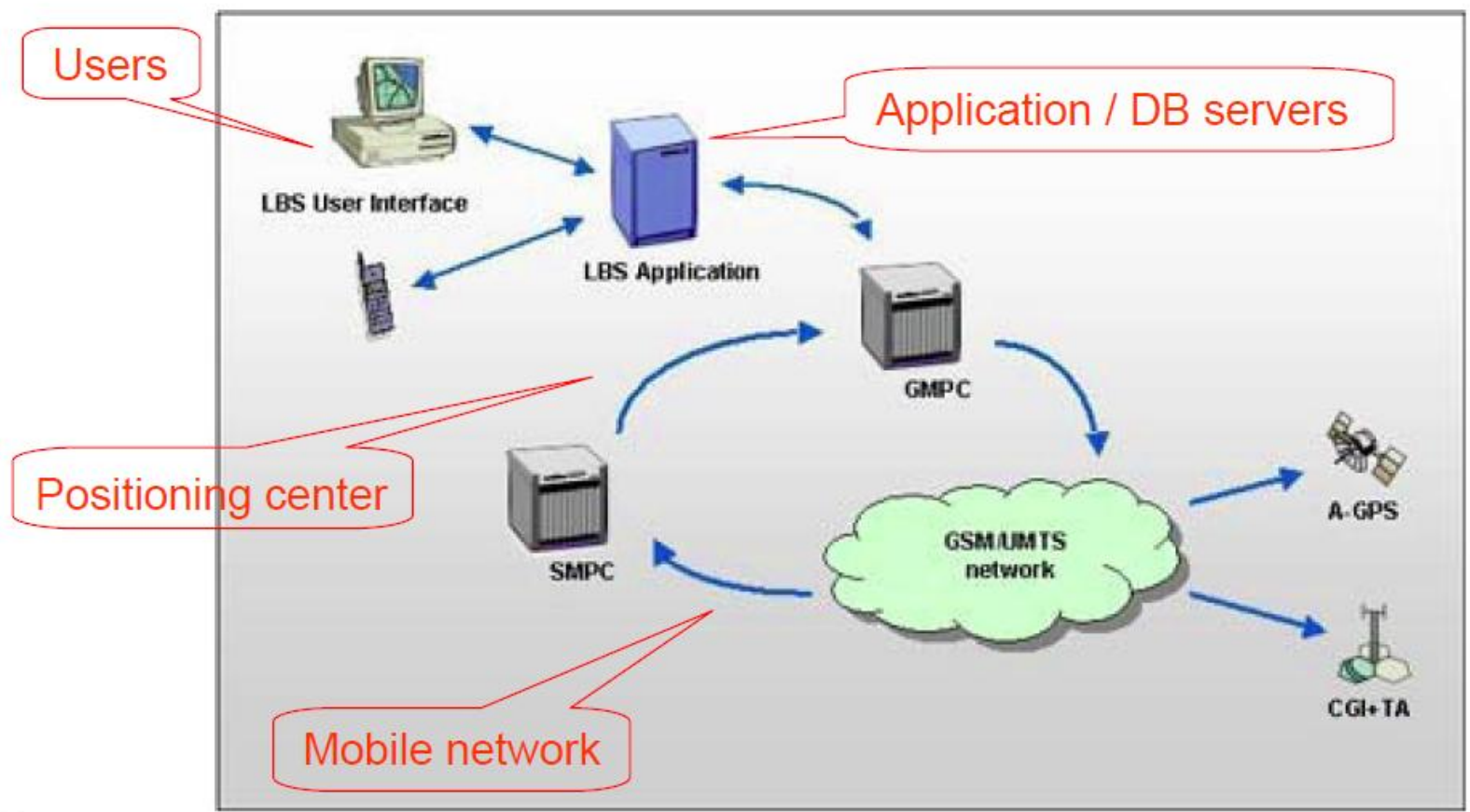
- ▶ Where is my nearest Gas station?
- ▶ What are the fast food restaurants within 3 miles from my location?
- ▶ Let me know if I am near to a restaurant while any of my friends are there
- ▶ Send E-coupons to all customers within 3 miles of my stores
- ▶ Get me the list of all customers that I am considered their nearest restaurant

Location Based Services (LBS) Architecture



LBS Infrastructure

- Mobile Location Systems (MLS): four main components



LBS Infrastructure (Cont.)

- A **spatial database** manages spatial objects:
 - ▶ Points: e.g., locations of hotels/restaurants
 - ▶ Line segments: e.g., road segments
 - ▶ Polygons: e.g., landmarks, regions, areas



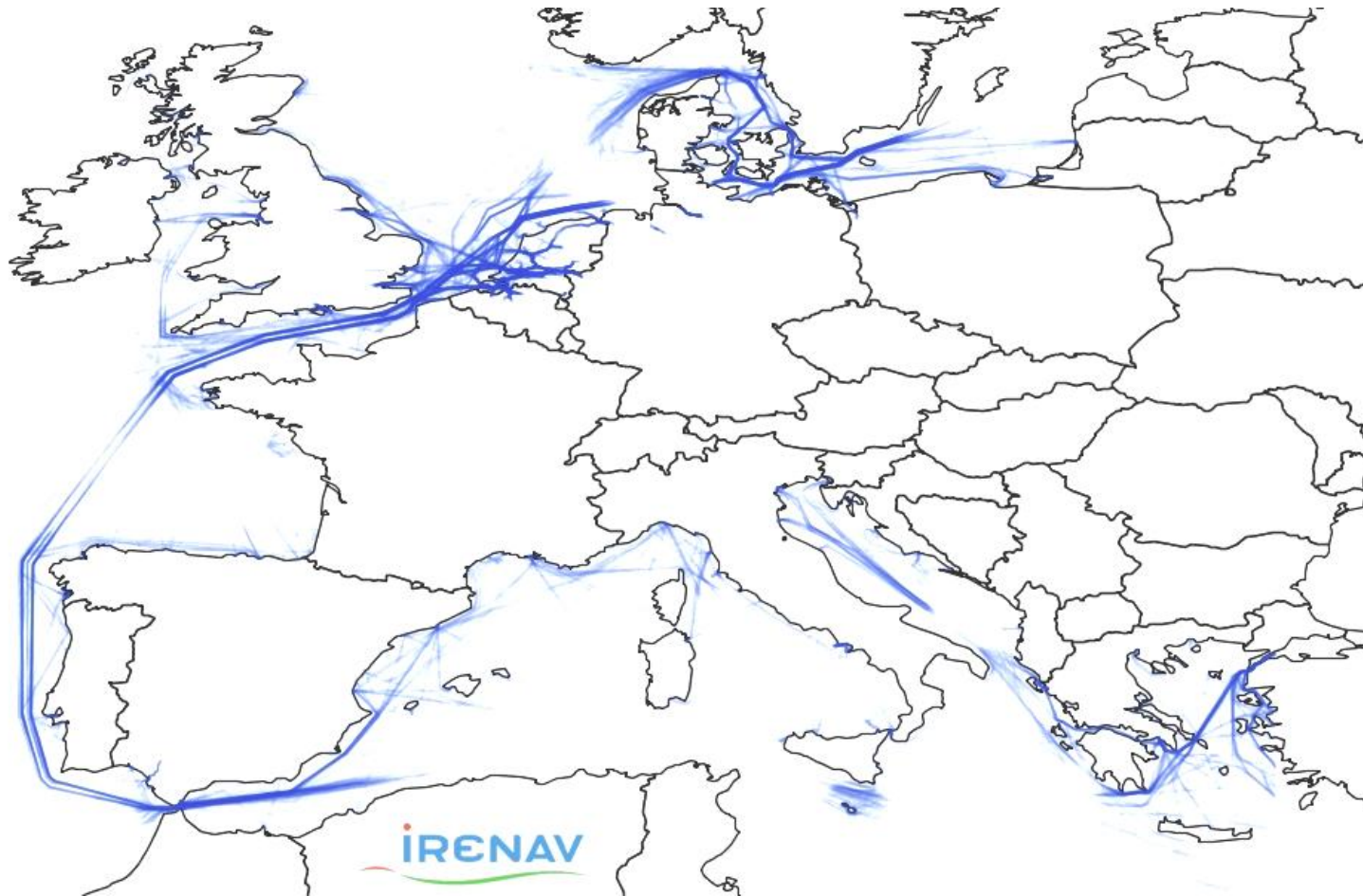
Road Network



Satellite Image

LBS Infrastructure (Cont.)

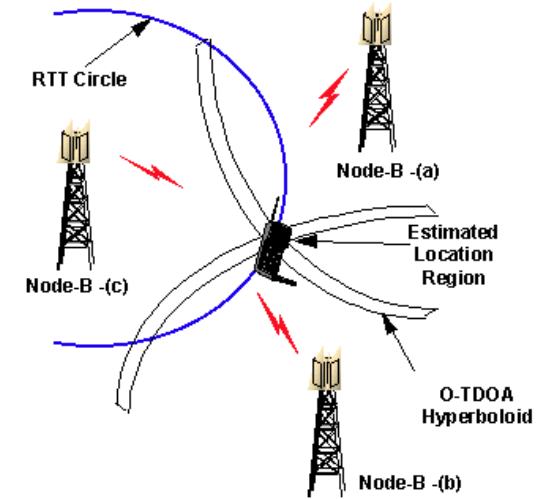
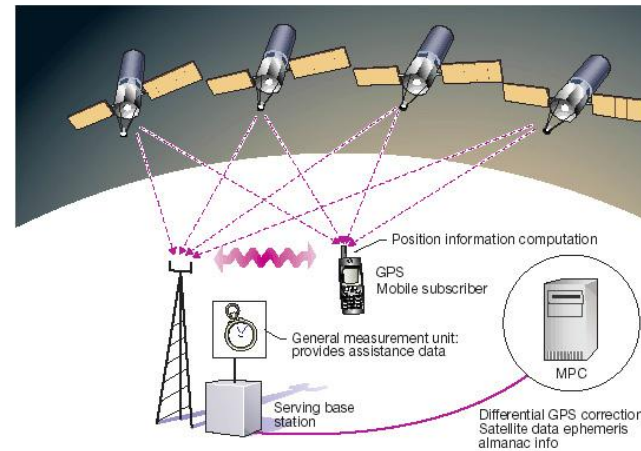
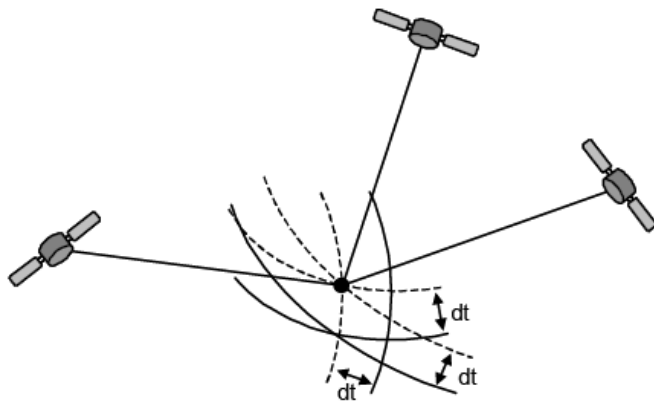
- Spatio-temporal database = Spatial database + time



LBS Infrastructure (Cont.)

- **Geo-positioning technologies:**
 - ▶ Using the mobile telephone network
 - Time of Arrival (TOA), UpLink TOA (UL-TOA)

- **Using information from satellites**
 - ▶ Global Positioning System (GPS)
 - ▶ Assisted (A-GPS), Differential GPS (D-GPS)



LBS Applications

- **Navigation** (for vehicle or pedestrian)
 - ▶ Routing, finding the nearest point-of-interest (POI), ...
- **Information services**
 - ▶ Find-the-Nearest, What-is-around, ...
- **Tracing services**
 - ▶ Tracing of a stolen phone/car, locating persons in an emergency situation, ...
- **Resource management**
 - ▶ Fleet management (taxi, truck, etc.), administration of container goods, ...

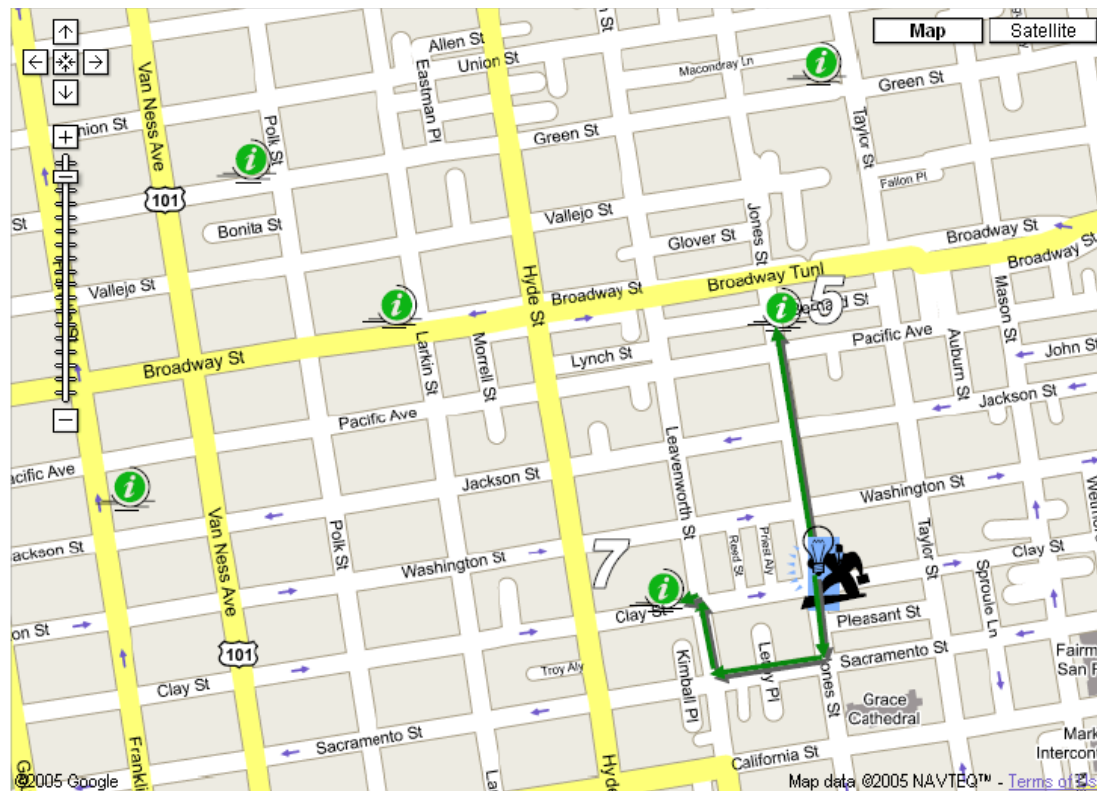
LBS Applications (Cont.)

- On-board navigation
 - ▶ Internet-connected automotive navigation system
 - ▶ Up-to-minute information about traffic
 - ▶ Yahoo! or Google local search for finding POIs



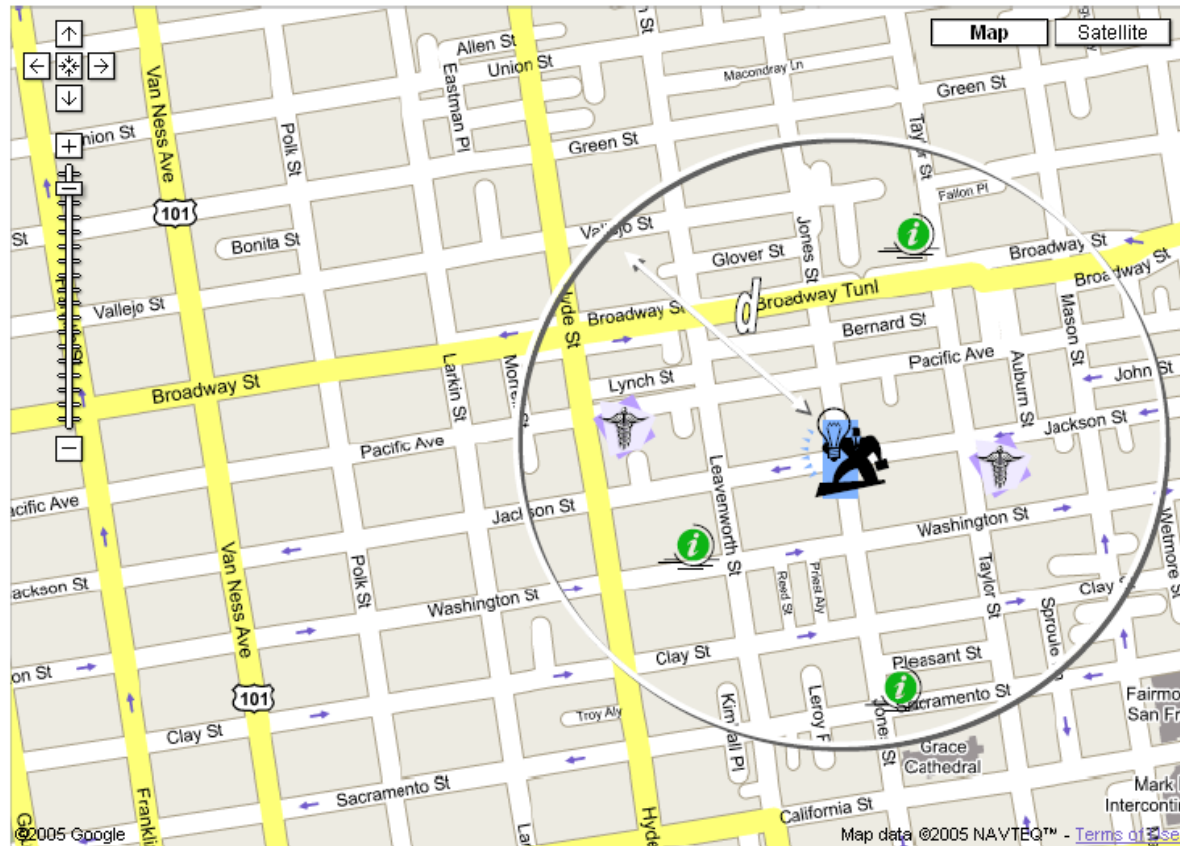
LBS Applications (Cont.)

- **Find-the-Nearest:** Retrieve and display the nearest POI (restaurants, museums, gas stations, hospitals, etc.) with respect to a specified reference location
 - ▶ E.g., find the two restaurants that are closest to my current location



LBS Applications (Cont.)

- **What-is-around:** Retrieve and display all POI located in the surrounding area (according to user's location or an arbitrary point)
 - ▶ E.g., get me all the gas-stations and ATMs within 1km



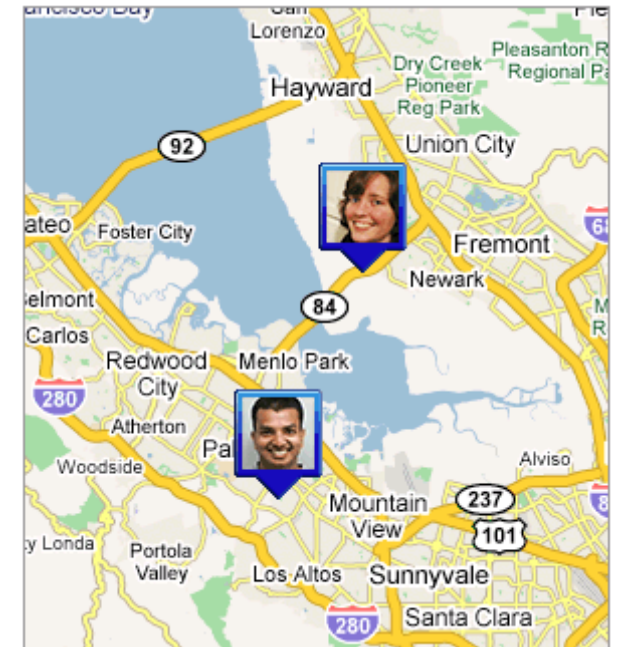
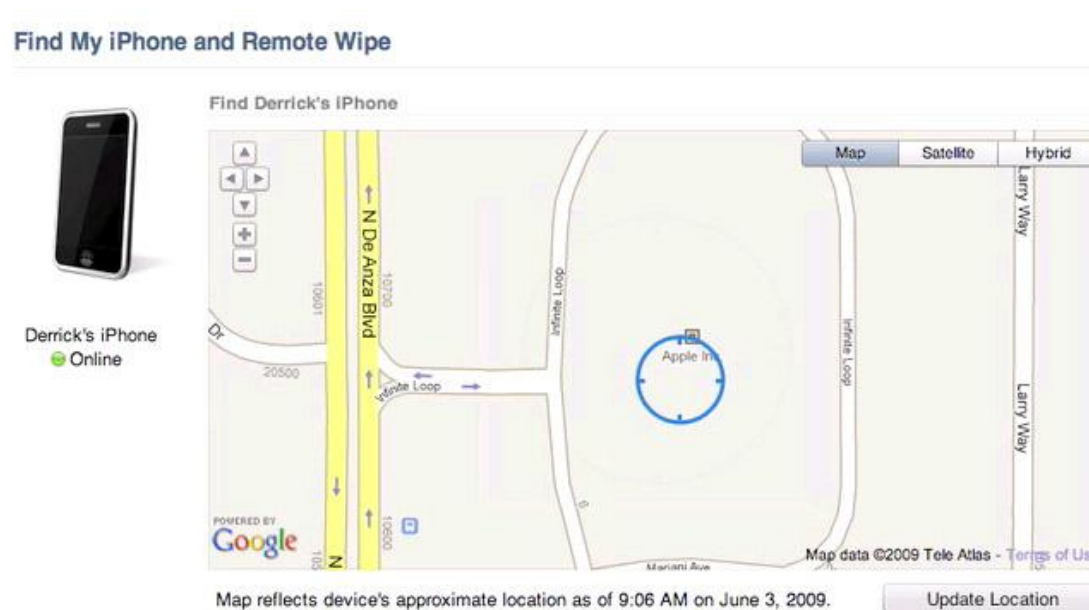
LBS Applications (Cont.)

■ Google

- ▶ See in real time where your friends are! (launched by Google)

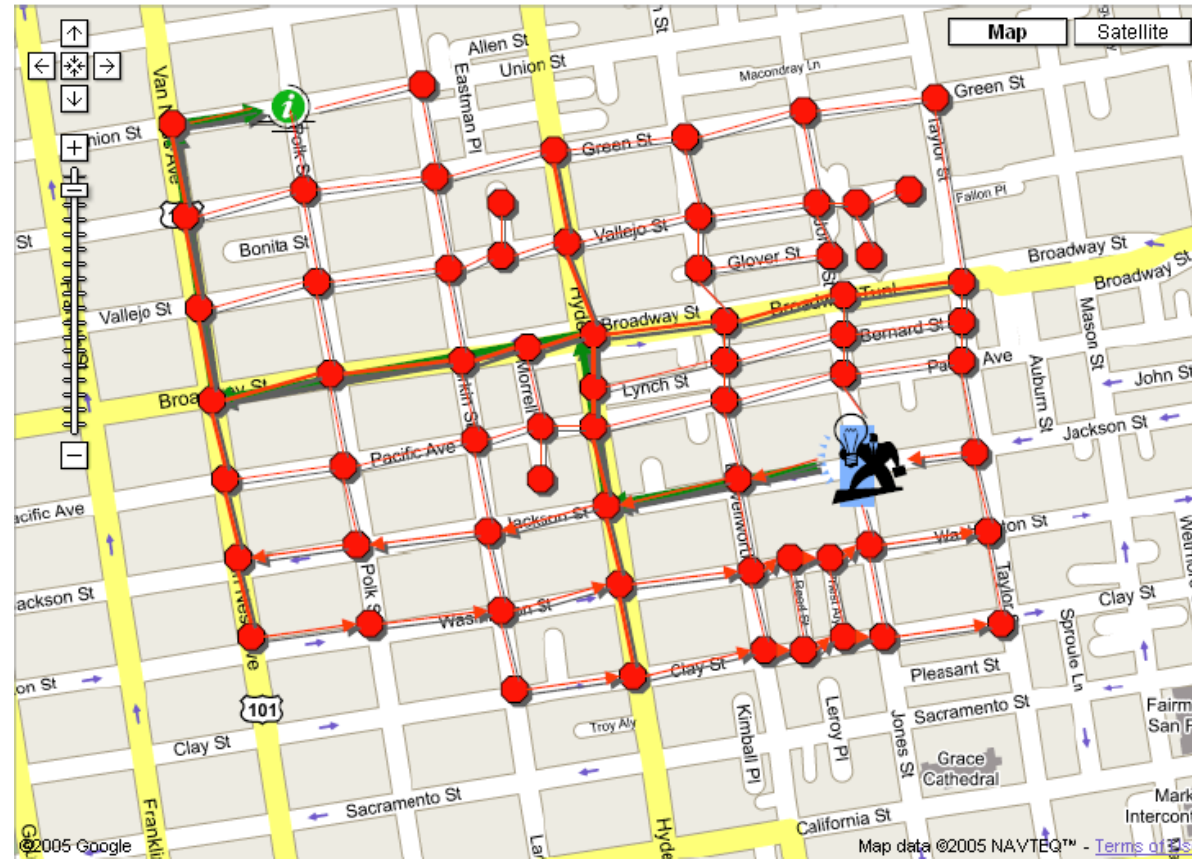
■ Apple

- ▶ Find my iPhone, i.e., track your lost iPhone (launched by Apple)

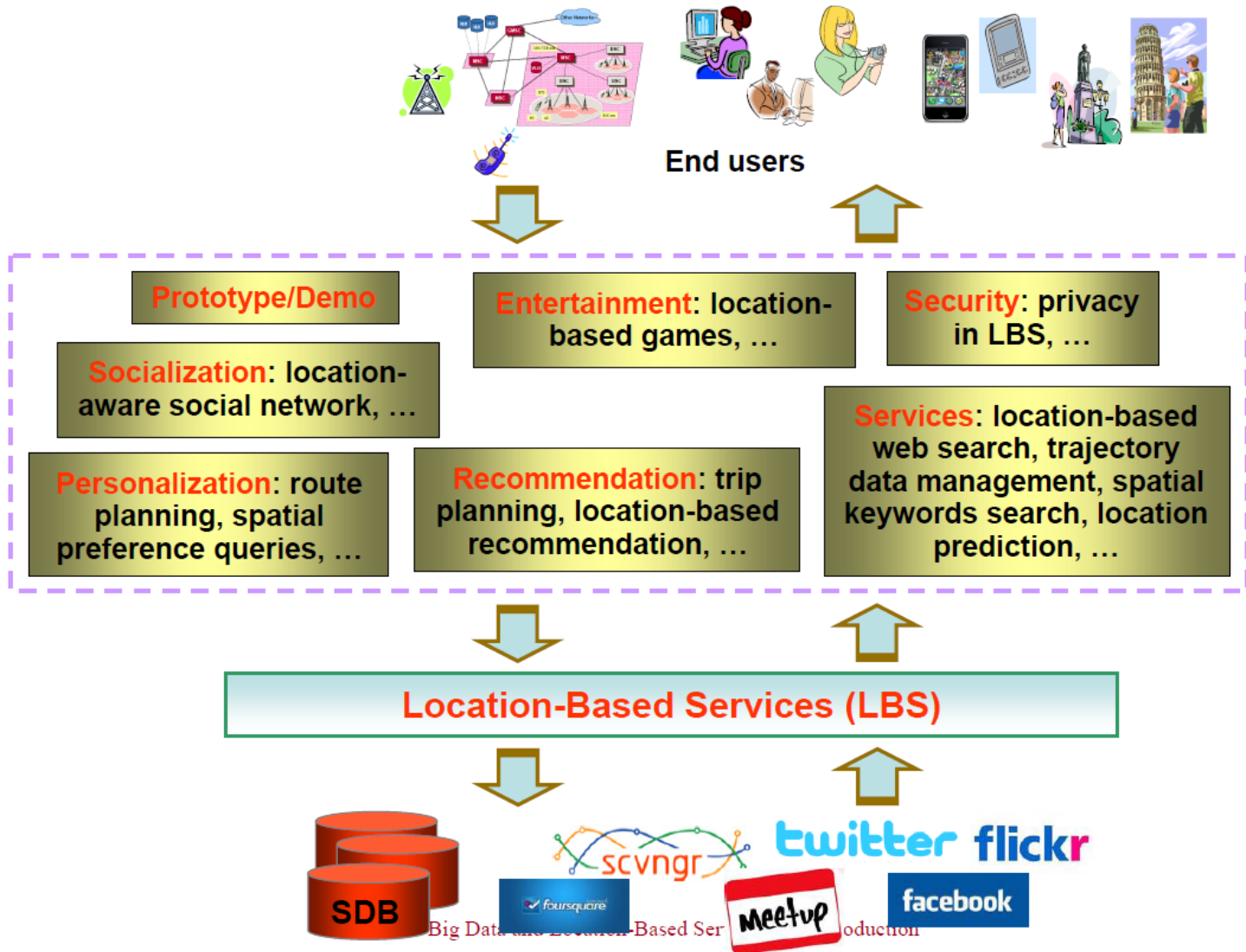


LBS Applications (Cont.)

- **Route:** Find the optimal route from a departure to a destination point

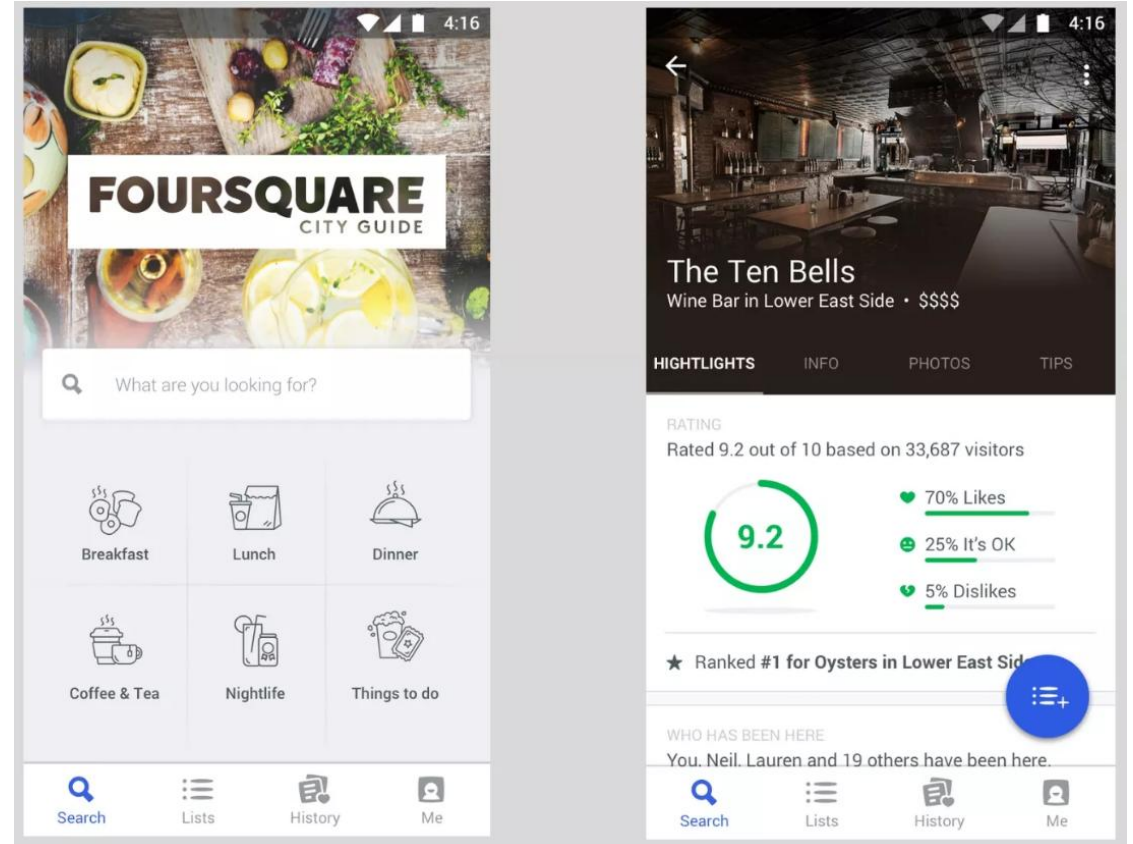


Framework



Research Issues

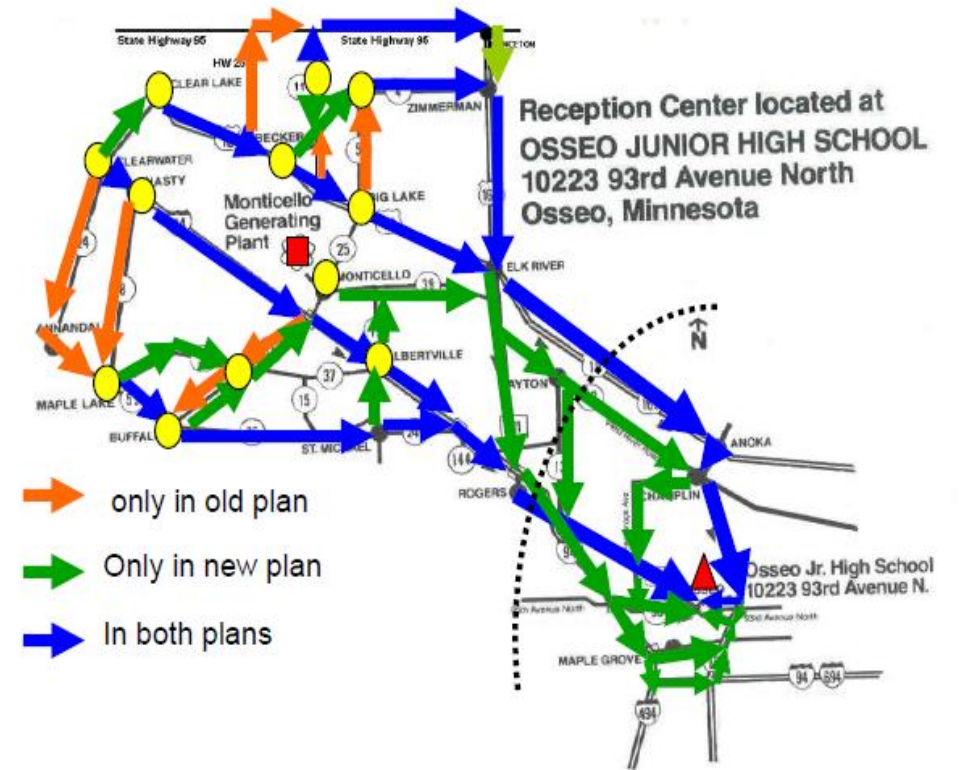
- Socialization
- Location-aware social networks (a.k.a. Geo-social networks), e.g., foursquare
 - ▶ <https://foursquare.com/>



Research Issues (Cont.)

Personalization

- ▶ Route planning, which is to retrieve paths or routes, preferably optimal ones and in real-time, from sources to destinations
 - Spatial preference queries



Research Issues (Cont.)

■ Recommendation

- ▶ Trip planning: Given a starting location, a destination, and arbitrary points of interest, the trip planning query finds the best possible trip
 - Location-based recommendation



Research Issues (Cont.)

■ Entertainment

- ▶ Location-based games, e.g., INGRESS, PokeMon Go, etc.



- ▶ How LBS changes lives?!

– https://www.youtube.com/watch?v=0yAHjqV_Y1A

Research Issues (Cont.)

Security

Privacy in location-based services



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