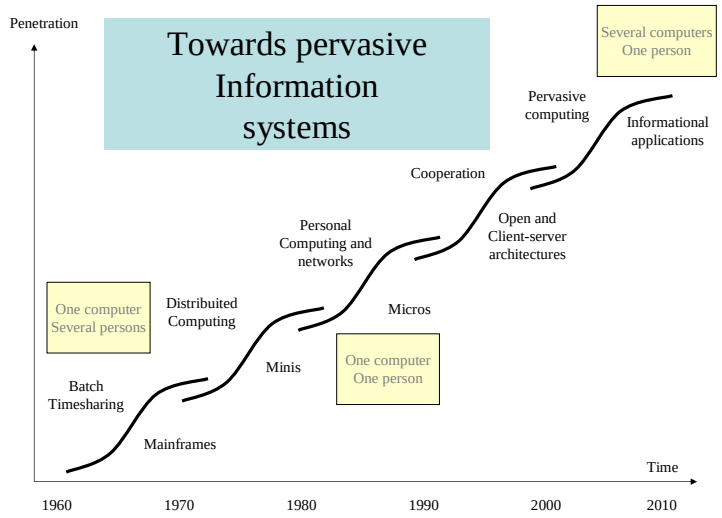
Pervasive and Mobile Information Systems: Infrastructures for Location-Based Services

- I – Generalities
- II – Technologies
- III – Location based services
- IV – Content aware services
- V – Mobile queries and transactions
- VI – Physical Hypermedia
- VII – Towards Pervasive Information Cities
- VIII – Conclusions

I – Generalities

- Definition
- Applications
- Infrastructures
- Pervasive computing
- Wireless networks

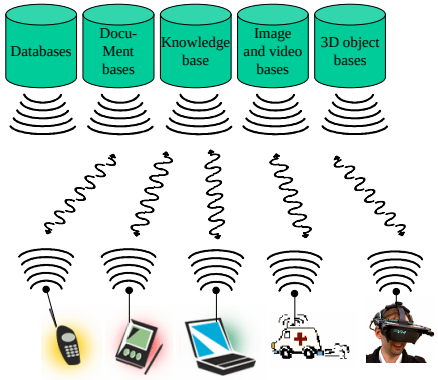
Towards pervasive Information systems



Pervasive Information Systems

- « *information everywhere at anytime* »
- Location-aware services
- Context-aware services
- « *ubiquitous / pervasive* »
- Four infrastructures
  - Telecommunications
  - Geolocation
  - Data
  - Services

Principles of pervasive information systems



Examples of applications

- Tourism (*e*-tourism, *m*-tourism)
- Fast delivery
- Police
- Monitoring (children, animals, etc.)
- *m*-commerce
- *m*-auctions
- Outdoor games
- …

Class of Applications

- **Resource tracking with dynamic distribution** Taxis, service people, rental equipment, doctors, fleet scheduling
- **Resource tracking** Objects without privacy controls, using passive sensors or RF tags, such as packages and train boxcars
- **Finding someone or something** Person by skill (doctor), business directory, navigation, weather, traffic, room schedules, stolen phone, emergency 911
- **Proximity-based notification (push or pull)** Targeted advertising, buddy list, common profile matching (dating), automatic airport check-in
- **Proximity-based actuation (push or pull)** Payment based upon proximity (EZ pass, toll watch)

Principles

- Mobility
- Decentralization
- Diversification (hardware)
- Connectivity
- Simplicity

Automatic adaptation

- For location
  - Category of location
  - Service discovery
- For user's profile
  - Language, interest, hobby
  - Pre-requisites
  - Profile variation according to location (ex. doctor)
- For context
- For hardware

Mobility

	Objects	Bases	Users
Fix			
Mobile			

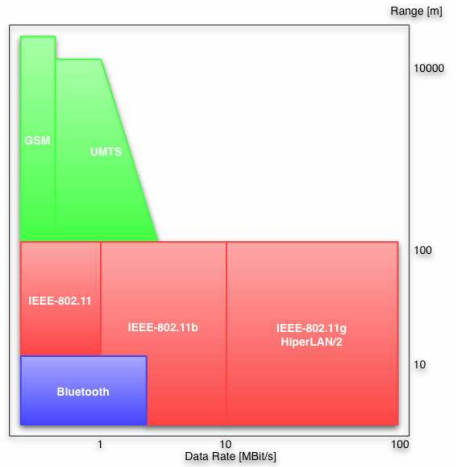
II – Technologies

- 2.1 – Communications
- 2.2 – Geolocation
- 2.3 – Devices
- 2.4 – Middeleware

2.1 – Communications

- Outdoor
  - WIFI
  - WIMAX
- Indoor
  - Bluetooth
  - RFID

Rate and Range



WIFI

- Wi-Fi, also unofficially known as Wireless Fidelity, is a wireless technology brand owned by the Wi-Fi Alliance intended to improve the interoperability of wireless local area network (LAN) products based on the IEEE 802.11 standards.
- Common applications for Wi-Fi include Internet and VoIP phone access, gaming, and network connectivity for consumer electronics such as televisions, DVD players, and digital cameras

Free WIFI hotspot

Public WiFi Service Limitations

- Data speeds
  - Limited by backhaul and multiple access scalability
  - 11 Mbps becomes irrelevant when connecting through a T1/E1 (~1.5 Mbps), DSL or cable modem (300 – 500 kbps)
- "Hotspot" coverage
  - Very limited
  - Predicated on "travel to compute" model
- Backhaul costs

Public WiFi Service Limitations

- Landlord fees/revenue sharing
  - Perceptions of ultra-low service fees are incorrect
  - Hotel room phone example
  - CTIA IT show / T-Mobile example
- Billing issues
  - WiFi roaming is in its infancy, need for multiple subscriptions
- Barriers to entry are few
  - "Java Joes" can provide free access next door to a Starbucks/T-Mobile

WIMAX

- WiMAX is an acronym that stands for Worldwide Interoperability for Microwave Access,
- and it also goes by the IEEE name 802.16.
- WiMAX is a technology that has the potential to do to the Internet access what cell phones did to landline phones.

WIFI and WIMAX

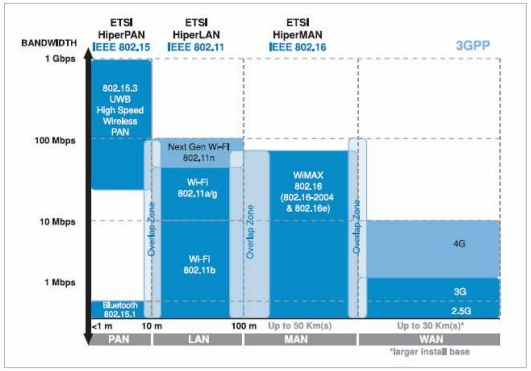
- WiFi's range is about 100 feet.
- WiMAX can cover up to 30 miles radius,
- this huge difference is due to the different frequencies used and the power of the transmitters
- This makes WiMAX a threat to DSL and Cable providers

WiMAX Definitions of terms

- The terms "fixed WiMAX", "mobile WiMAX", "802.16d" and "802.16e" are frequently used incorrectly. Correct definitions are:

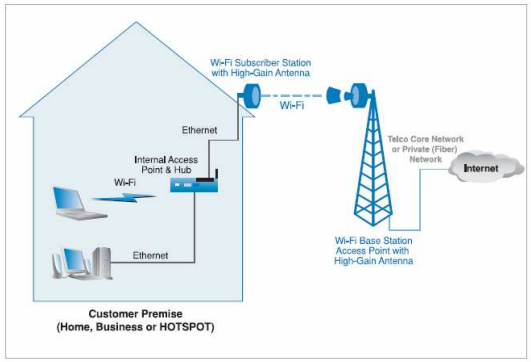
- **WiMAX 802.16d Fixed Wireless Standard**
  - Strictly speaking, 802.16d has never existed as a standard. The standard is correctly called 802.16-2004. However, this standard is frequently called 802.16d.
- **WiMAX 802.16e Mobile Wireless Standard**
  - Just as 802.16d has never existed, a standard called 802.16e hasn't either. It's an amendment to 802.16-2004, so is not a standard in its own right. It's properly referred to as 802.16e-2005.
- **Fixed WiMAX Wireless Standard**
  - This is a phrase frequently used to refer to systems built using 802.16-2004 as the air interface technology.
- **Mobile WiMAX**
  - A phrase frequently used to refer to systems built using 802.16e-2005 as the air interface technology. "Mobile WiMAX" implementations are therefore frequently used to deliver pure fixed services.

Wireless technologies target segments

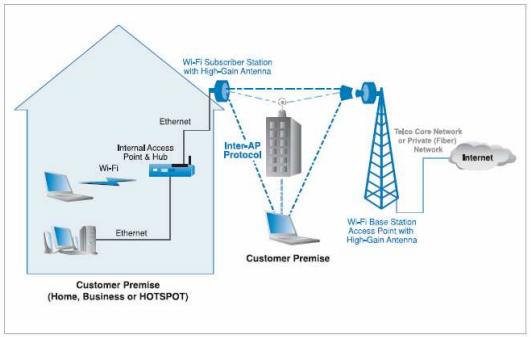


http://www.intel.com/netcomms/technologies/wimax/304471.pdf

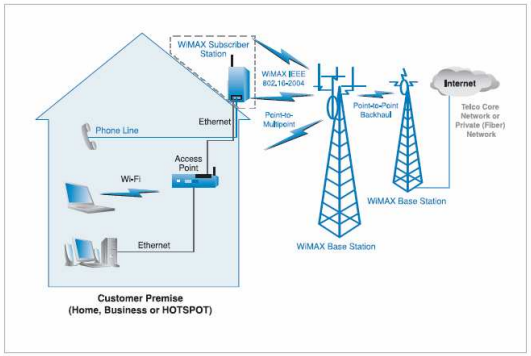
802.11 last-mile networks



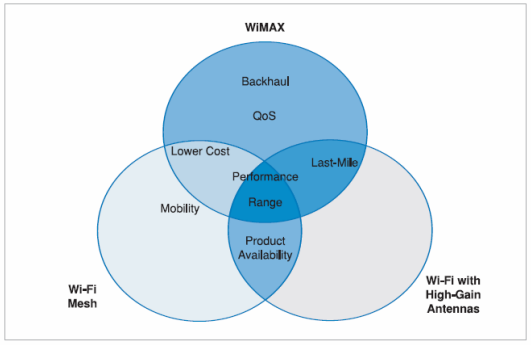
802.11 mesh networking



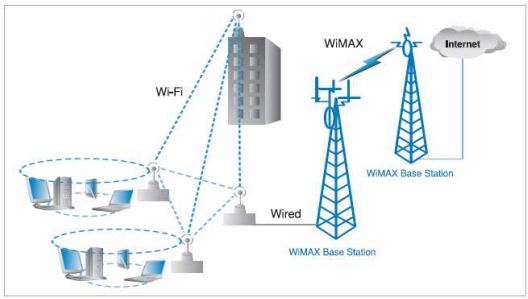
WiMAX network topology



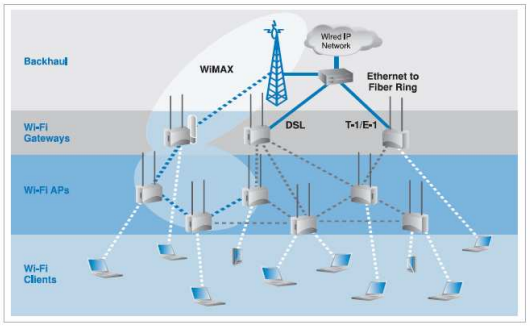
2004-2005 WiMAX and Wi-Fi metro-access solution features



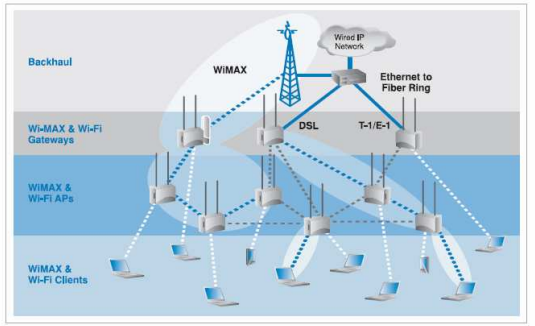
Phase 1 – WiMAX backhaul for a Wi-Fi mesh topology



Phase 2 – WiMAX as an intra-mesh backhaul option



Phase 3 – WiMAX as a client connection option



WiNetworks - WiNetworks is an innovative provider of unique WiMAX systems built according to the 802.16e mobile WiMAX standard. WiNetwork's Win-Max systems offer a full range of products including the Compact Base Station, Customer Premise Equipment (CPEs), and Relay Stations.

Mobile Metrics - Mobile Metrics was founded in 2003 specifically to address the wireless data test market, and to the best of our knowledge was the first company to specialize exclusively in this field.

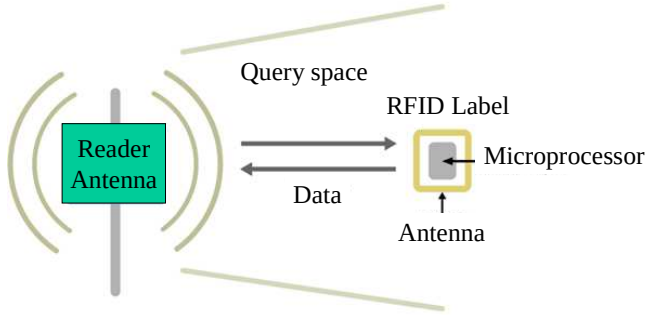
Telsima - Telsima Corporation is a leading provider of WiMAX Forum Certified™ solutions, enabling mobile, multimedia 4G wireless networks.

Nextwave - NextWave Wireless is a family of industry leading companies bound by a common vision - to make Wireless 2.0 a global reality by delivering the technologies and innovations needed to make wireless broadband faster, more reliable, and more affordable.

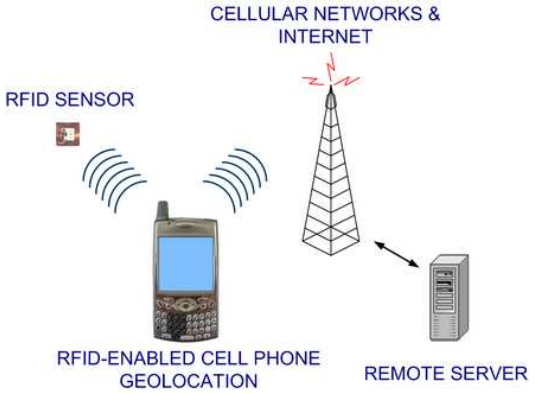
Nortel - Nortel has shaped the evolution of communications for more than a century. With customers in more than 150 countries, Nortel solutions power the globe's top 25 service provider networks, serve as the foundations of world economies and financial enters, and drive communications that enrich rural and underdeveloped regions across the globe.

Asentria - Asentria is the leading provider of remote site monitoring solutions that simplify and enhance the operation of distributed remote equipment sites that are vital to voice and data networks.

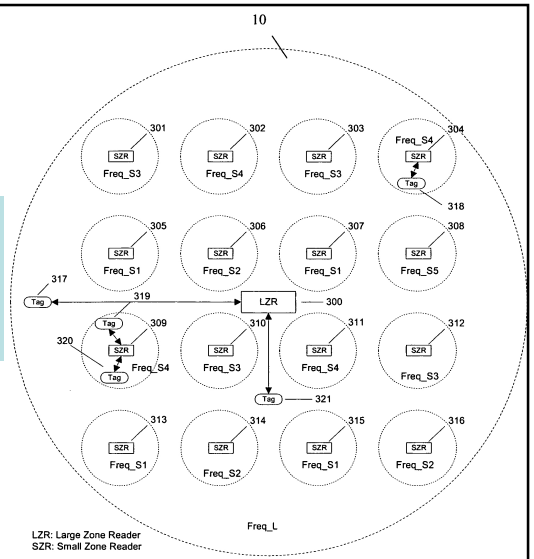
Radio Fequency Identification



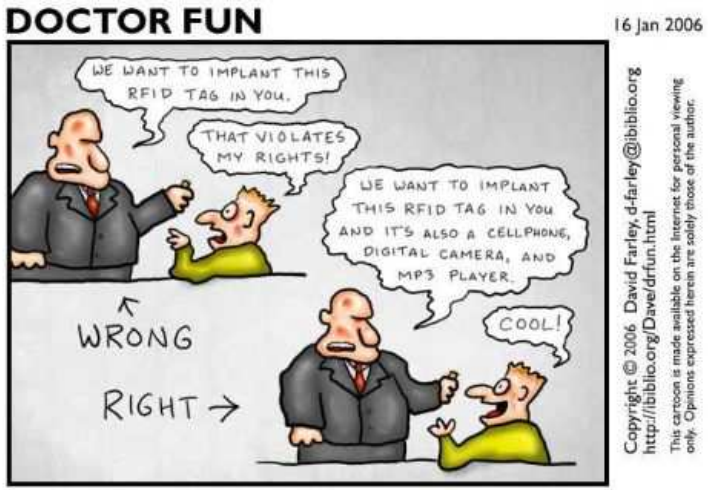
RFID principles



RFID cell organization



Example of RFID



Bluetooth

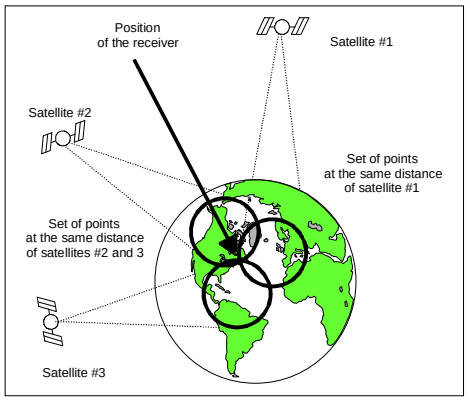
- Bluetooth is an industrial specification for wireless personal area networks (PANs). Bluetooth provides a way to connect and exchange information between devices such as mobile phones, laptops, PCs, printers, digital cameras, and video game consoles over a secure, globally unlicensed short-range radio frequency. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group.

2.2 – Geolocation

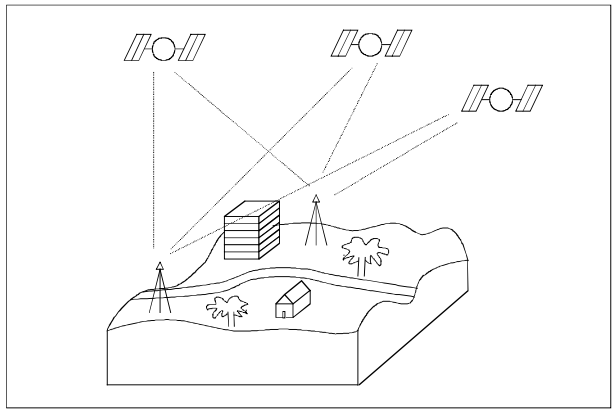
- GPS
- Galileo

Global Positioning System

Principles of GPS



Differential GPS



Other methods

- Network triangulation based on signal intensity
- Nearby RFID beacons
- Etc.

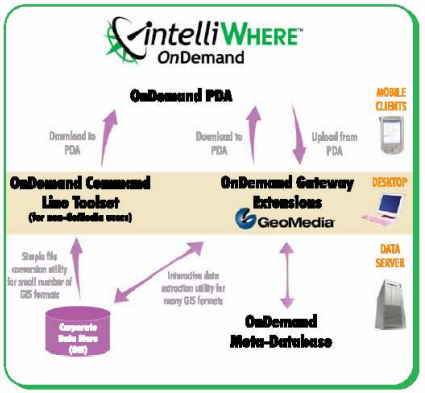
2.3 – Devices

- Handheld devices
- Smartphones
- Others

IntelliWhere

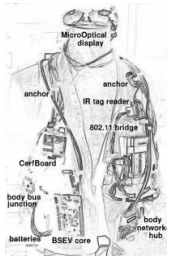
http://www.intelliwhere.com

IntelliWhere on Demand



On-board computer

Wearable hardware



http://www.media.mit.edu/wearables/mithril/

Smartphones



Portable location device

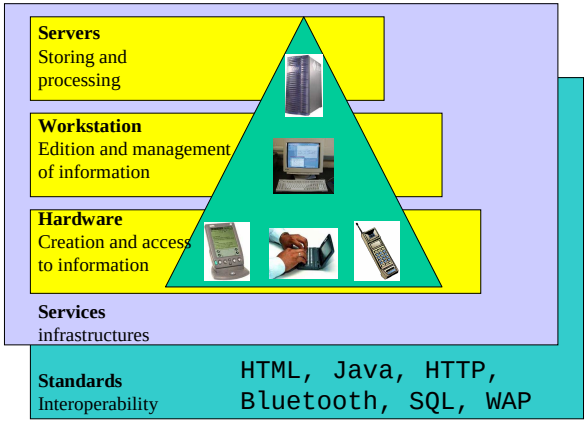
KLIC KP-100 - Is the World's First Terrestrial-Based Personal Portable Location Detection Device

KLIC(Korea Location Information & Communications) unveiled the world's first terrestrial-based personal portable location detection device the 'KP-100'. The portable device will utilize a location based service called 'mypol' which keeps track of children, the disabled, patients etc.

The KP-100 measures 45.9 x 63.9 x 17.2mm and weighs 49 grams. One also comes across a SOS Button which can be used in case of an emergency. Suggested price is 160,000(KRW) and one needs to shell out 9,000(KRW) as subscription service.

Gil Soo Lee, executive director of the company says "since it is a terrestrial-based device instead of GPS, it can keep track of the object even when people are outside of building as well as when they are inside. The device enables to check the location of the users within 1m. It can be charged via a handset charger and it runs for about four days per charge."

2.4 – Middleware



Services

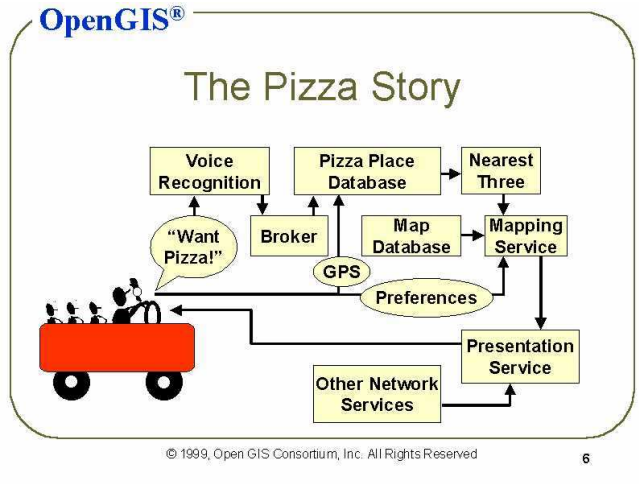
- File transfers
- Images - drawings - multimedia
- Text processing
- Mail
- Access to remote databases
- Office automation
- Monitoring - Robotics
- Integrated services

Hardware

- Wireless computers and devices
- Mass memories
- Printers, Xerox copiers, etc.
- Video Monitors
- Routers, Hubs
- Etc.,

III – Location based services

- 3.1 – Definitions
- 3.2 – Architectures
- 3.3 – Service discovery
- 3.4 – Some LBS solution providers



3.1 – Definitions

- Location:
  - ***"Location"*** means locating a wireless device.

)

- Location based Service:
  - Location-based services and advertising allow consumers to receive services and advertising based on their geographic location.

Service Category

- Information based on location
- Payment based on location
- Emergencies
- Monitoring
- SPAM services (advertisement…)

Table 1: Wireless Location-Based Services: Feature and Performance Requirements

Feature Requirements	Performance Requirements
Address verification and matching	Scalable architecture
Map rendering	Gigabytes to terabytes of data
Yellow page directory query	Multiple CPU processing
Driving directions	DBMS table partitioning
Personalization by location	Distributed processing
Proximity analysis	Native spatial data management
Standards-based location service APIs	Online services interoperability
Personal/in-car navigation capability	Millisecond location query
Voice (VoiceXML) capability	Million + daily queries
XML integration with e-business apps	25,000+ user sessions per hour
Web Services Directories	Portal caching

http://www.gisdevelopment.net/technology/lbs/techlbs007.htm

Table 3: Partner Tools, Location Services, and Content

Partner Tools	Partner Online Services	Partner Content
Mobile mapping	Mobile positioning	Navigation datasets
Internet mapping	Dynamic traffic	Yellow and white page data
Geocoding	Yellow pages directories	Business information
	Geocoding	Demographic information

Introduction to LBS

- The convergence of multiple technologies
  - Internet
  - Wireless communication
  - Geographic information system
  - Location technologies
  - Mobile devices

Introduction

- Emerging mobile computing application
  - Often need to know where things are physically located.
- Relating location to other pertinent information gives meaning and value
  - We need directions from one place to another.
  - We want to interact naturally with I/O devices available in our environment.
  - "where am I?", "how long I get to…?", "what is the current traffic situation on route…?"

Mobile Wireless System Components

- Wireless communication system consist of three main components:
  - The Mobile switching Centers (MSC)
  - The base stations
  - The user handsets

Mobile Wireless System Components

- Mobile Switching Centers
  - Is responsible for:
    - Interacting with the base stations
    - Controlling call processing and billing
  - They use two databases
    - Home Location Register (HLR)
    - Visiting Location Register (VLR)

Mobile Wireless System Components

- The base stations
  - The links between the MSC and handsets
  - It manages a cell within a wireless telephony network
  - It comprises:
    - Control unit
    - Base radio station
    - An antenna

Mobile Wireless System Components

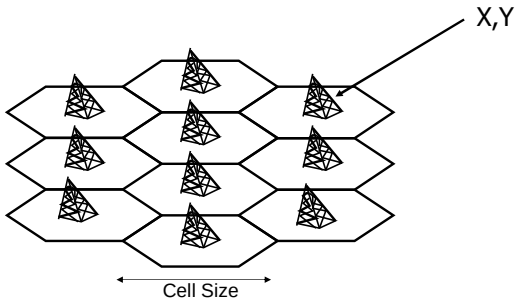
- The mobile handsets
  - Cell phones, handheld computing devices
  - It consists of:
    - Control/interface unit
    - A transceiver
    - An antenna system

Location Technologies

- Network-based
  - Technologies that exploit the cellular infrastructure to obtain geo-location information.
- Handset-based
  - Location intelligence is stored within terminal
- Each of these groups may be divided into:
  - The MU uses signal transmitted by the base stations to calculate its own position
  - The base stations measure the signals transmitted by the MU and relay them to a central site for processing.

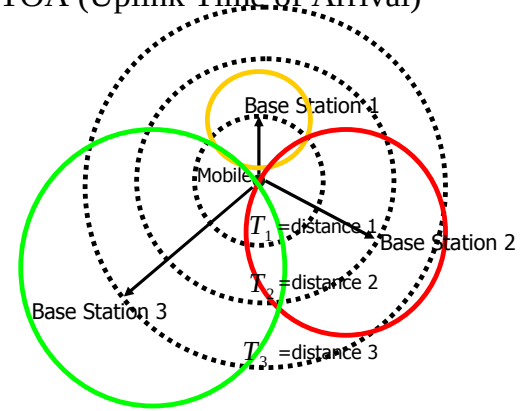
Location Technologies network-based

- CGI+TA (Cell Global Identity + Timing Advance)



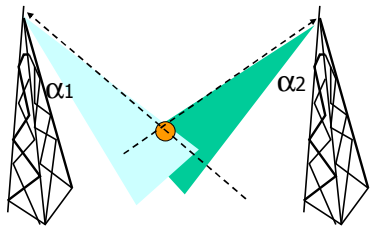
Location Technologies network-based

- UL-TOA (Uplink Time of Arrival)



Location Technologies network-based

- AOA (Angle of Arrival)

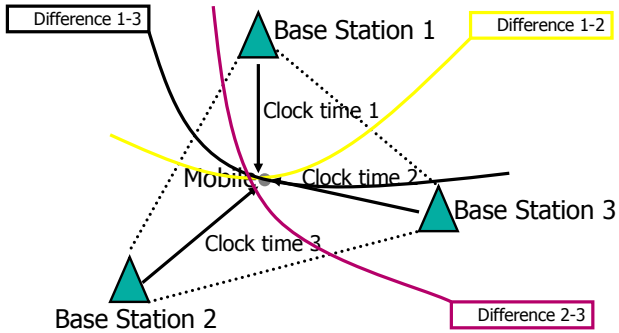


Location Technologies handset-based

- GPS (Global Positioning System)
- AGPS (Network Assisted GPS)

Location Technologies handset-based

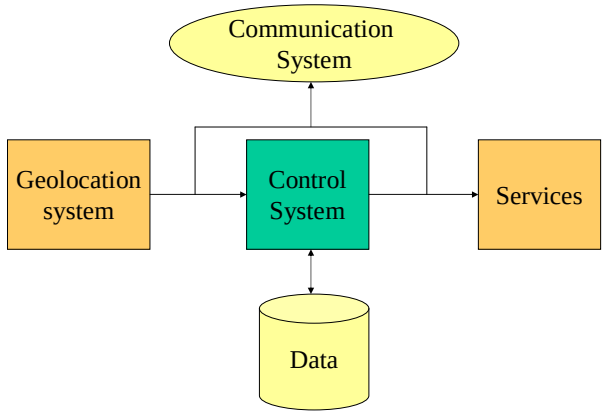
- EOTD (Enhanced Observed Time Difference)



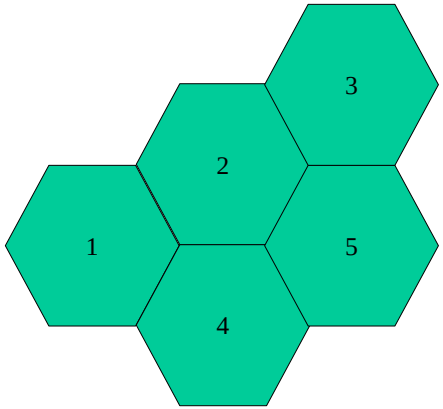
Spatial Data

- Essential component of LBS architecture
  - Storing and analysing spatial data
- Geographical Information System (GIS)
  - Refers to the computer-based capability to manipulate geographic data
- Maps or images can be stored in vector or raster format.
- A spatial object must have:
  - Location: a known point
  - Form: a geometric representation
  - Attribute: the nature of the object
  - Spatial relationship: the boundary of an area

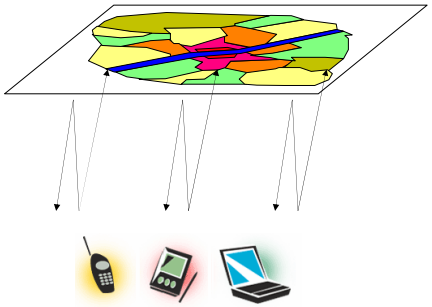
3.2 – Architectures



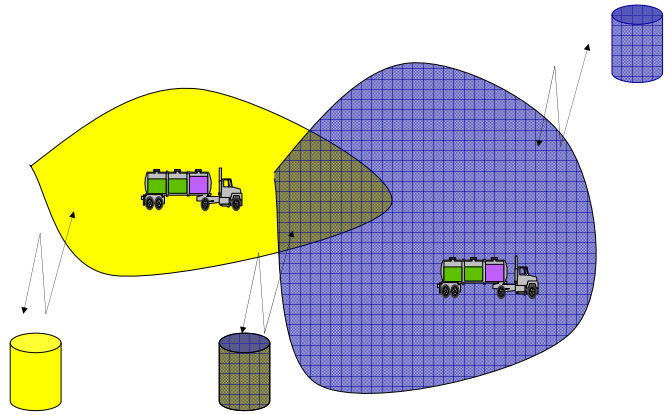
Theoretical organization of cells



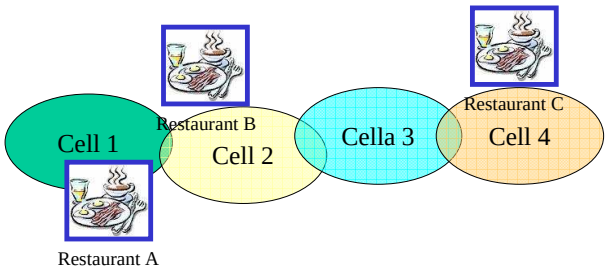
Automatic adaptation to location



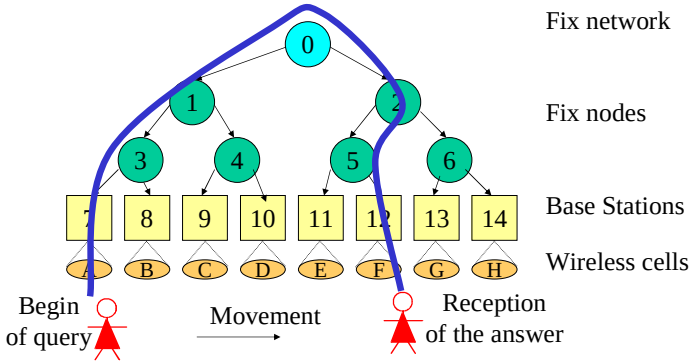
Zone overlaps



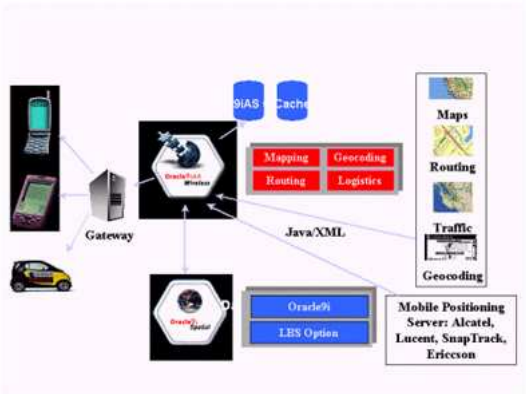
Cells and services

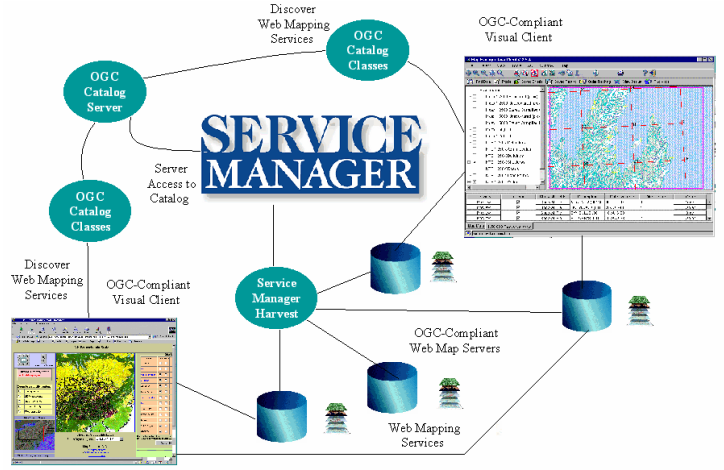


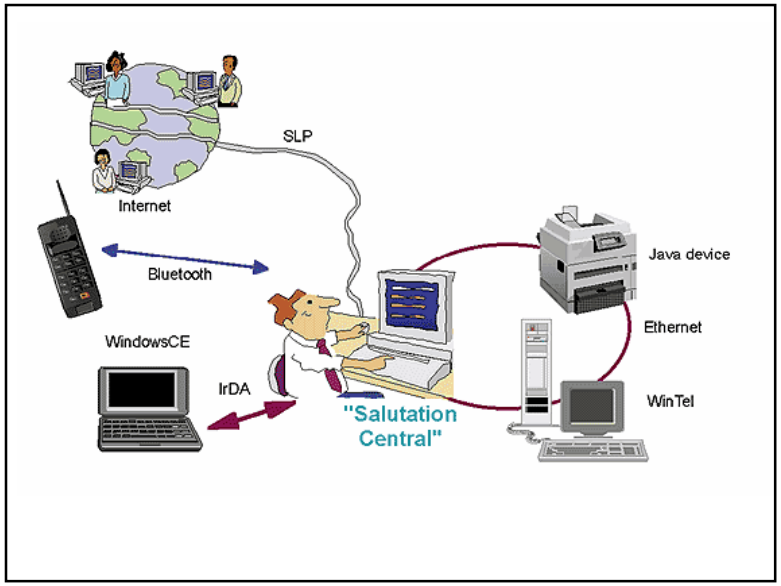
Cell architectures

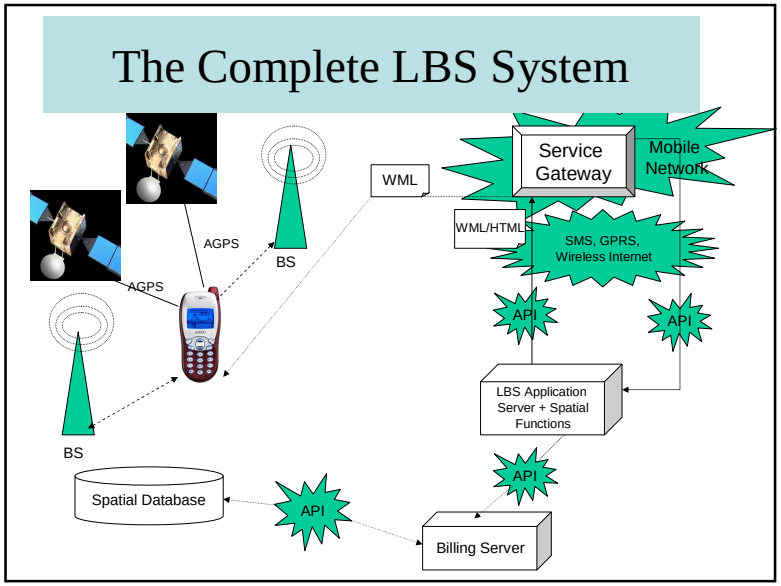


ORACLE Solution









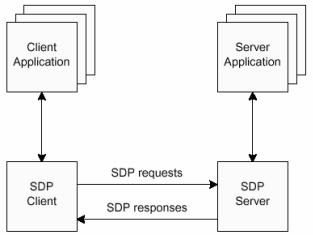
3.3 – Service discovery

- Find the hosts in charge of the service discovery protocols
- Find addresses of service providers

SDP

- Service Discovery Protocol of Bluetooth
- http://www.palowireless.com/infotooth/tutorial/sdp.asp

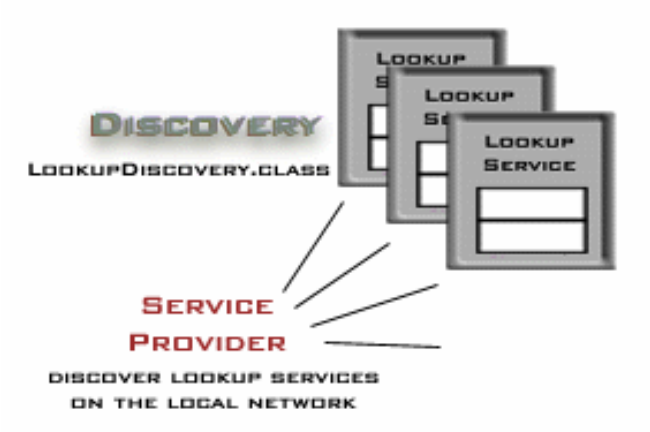
Principles of SDP



PDU : Protocol Data Unit

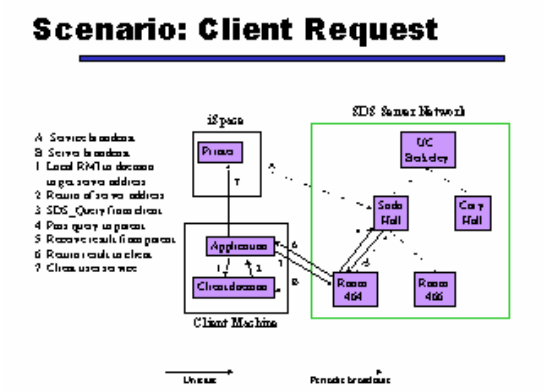
Proposed Services

- Classes of services
- Attributes of service
  - **`ServiceClassIDList`**
  - **`ProviderName`**
- Identifier of service (16 bits)

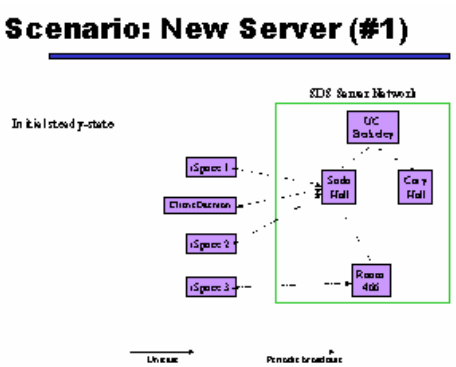


Services Directory

- Directory of services
  - Hierarchical and distributed organization
  - push / pull
- For example, linked to hosts dedicated to antennas management



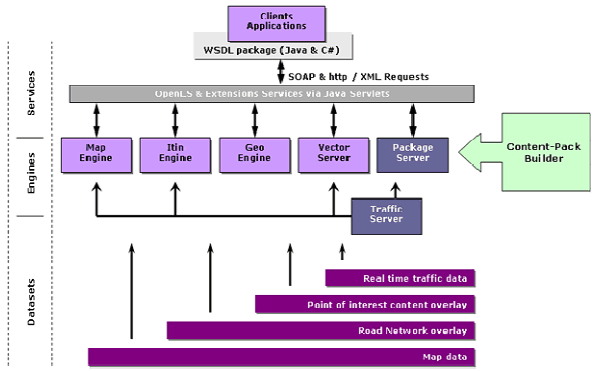
http://www.cs.berkeley.edu/~ravenben/research/SDS-898/sld011.htm



3.4 – Some LBS solution providers

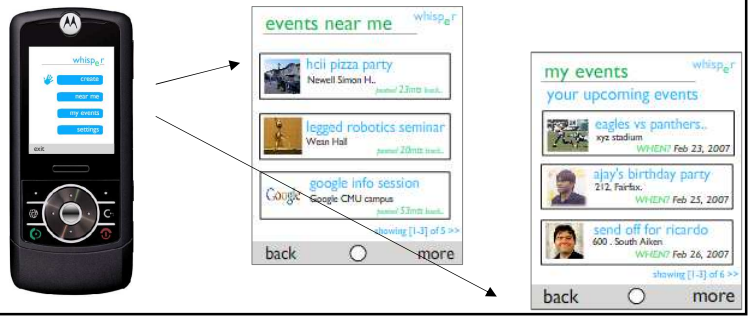
- LOCATIONET
- PTV
- TeleCommunication Systems (TCS)
- DoCoMo Machine
- Gaeasoft
- MSP Technology Inc.
- CORE
- Cambridge Positioning Systems, Ltd.(CPS)
- Webraska
- Microsoft
- SnapTrack
- Twenty First Century Aerospace Technology Co., Ltd

Webraska architecture



Whisper Mobile

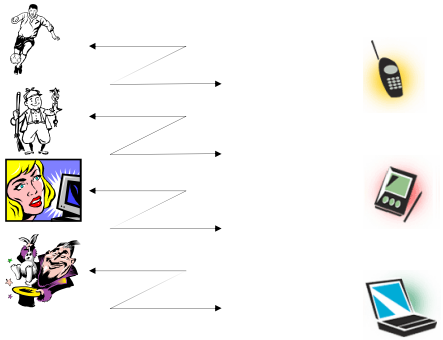
- Goal: Make it easy to find, share, and coordinate friends going to social events



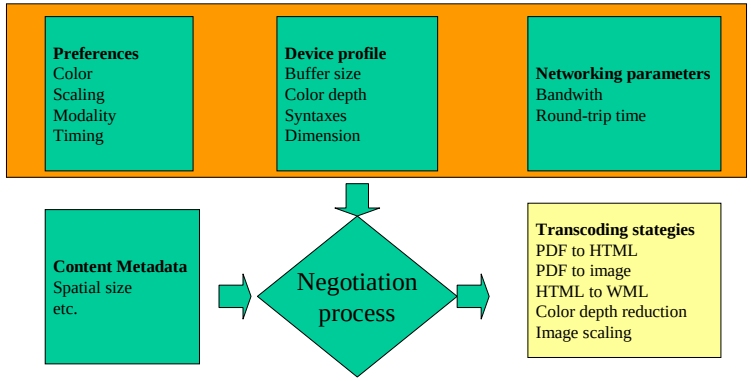
IV – Content aware services

- Profiles
- Roles
- Devices (format, etc.)

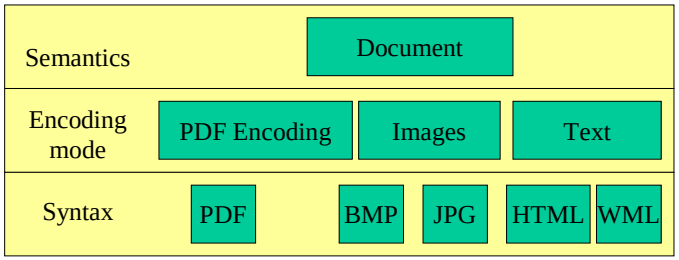
Automatic adaptation to profile

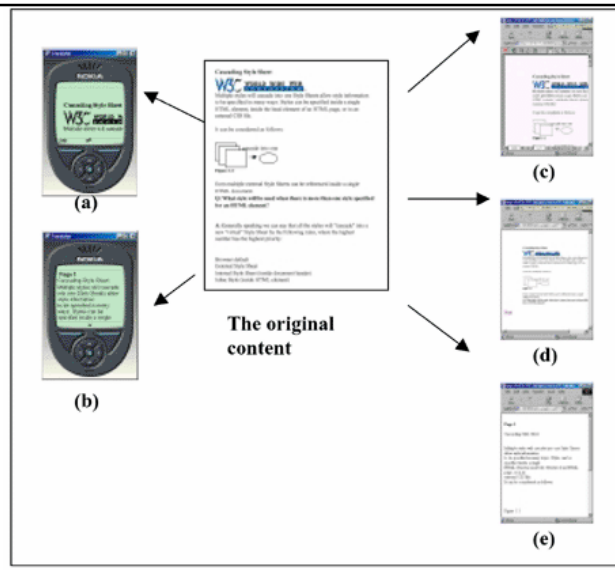


Strategy of conversion



Modalities





Profile and locations

- Example « a doctor »
  - In his hospital
  - In other places
  - In other hospitals
- The profile can evolve
  - According location,
  - According the days of the week
  - According some periods (vacations)
  - etc.

V – Mobile queries and transactions

- Pedestrian (moving):
  - Find the nearest restaurant (fix)
  - Find the nearest taxi (mobile)
- Vehicle :
  - Find always the 5 nearest open gas stations
  - Find the list of nearest vehicles of a fleet

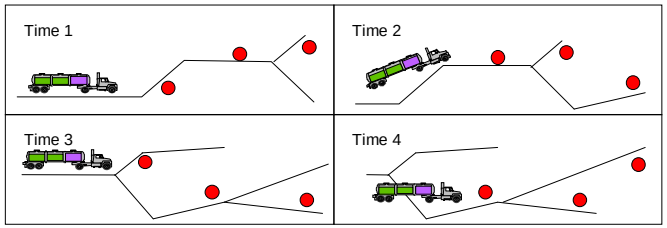
Mobile GIS

- User's mobility (the answer varies in function of the querier's location)
- Mobile queries
- Continuous queries
- Mobile and continuous queries

Mobile and continuous queries

- Mobile queries: the contents varies according to the position
- Continuous queries: compiled one, but executed continuously (or regularly, for instance each minute)

Mobile and continuous queries

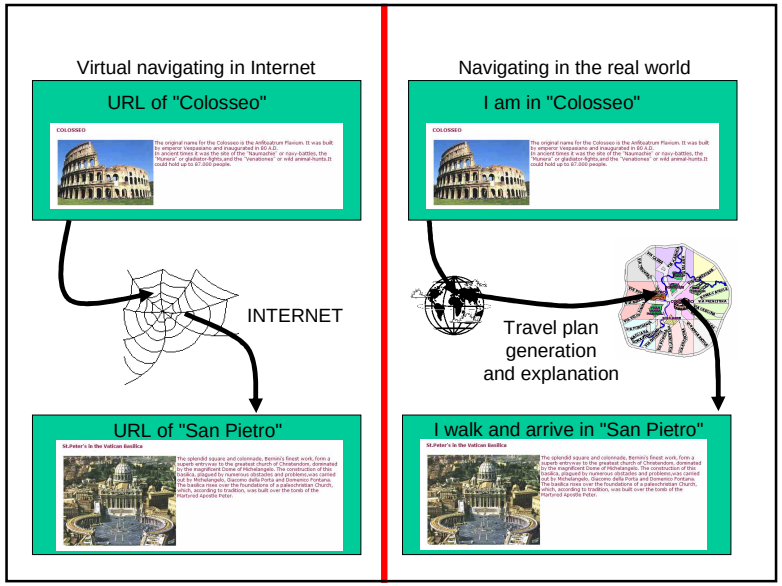


Information management

- Automatic roaming between cells
- Indexing services according time and space
- Localization and utilization of caches
  - Queries and results
  - Anticipation for mobile and continuous queries
  - Moving data from caches to caches for optimizing

VI – Physical Hypermedia

- Definition: Application of web navigation metaphor to pervasive systems
- Itinerary in the web: URL (protocol)
- Itinerary in the real world: list of nodes and arcs generated through Internet
- Example: walk from Coloseo to Vaticano



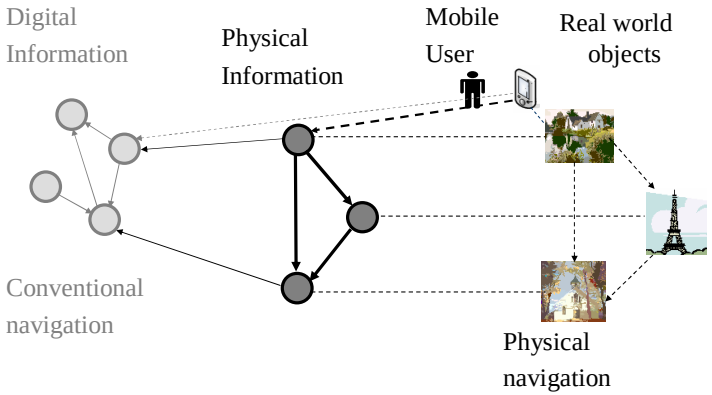
From URL to W-links

- URL links
  - In Internet world
- Walking links (W-links)
  - Roadmap issued from Internet

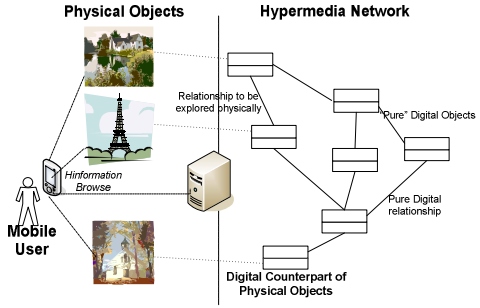
Software for Physical Hypermedia

- A PH application is a specific class of pervasive software whose basic objective aims at enhancing objects of the real world with digital information and links

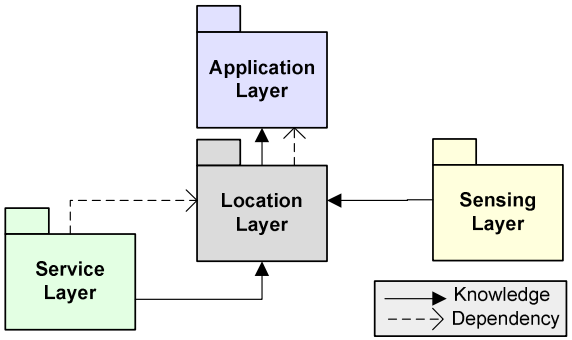
Physical Hypermedia Application



Enriching real world objects with hypermedia



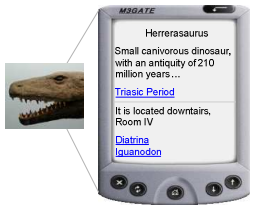
An architecture for pervasive hypermedia services



Example

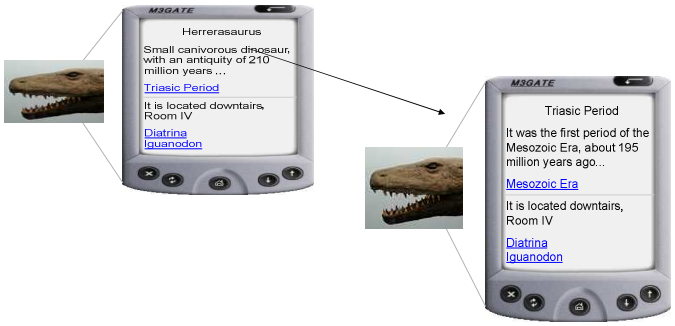
- Natural Science Museum of La Plata.
- Prototypical application
- The physical objects are skeletons of pre-historical animals, which have been enriched with simple digital information and hypermedia links. The prototype uses a HP iPaq 2210 with infrared as sensing hardware.

Let's suppose that the user is facing an Herrerasaurus

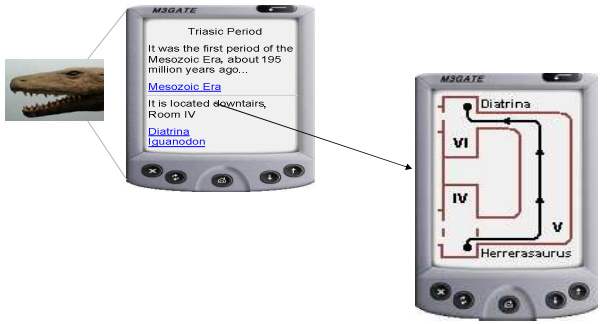


Example of service offered by the browser

Let's suppose that the user is facing an Herrerasaurus



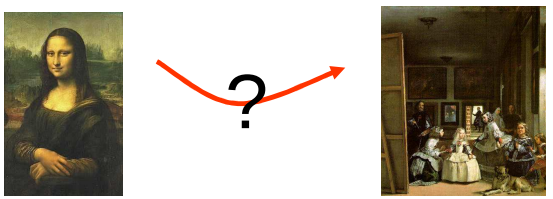
Roadmap to another animal



Consequence

- The user A is moving from Velociraptor to Tyranosaurus; when he faces Herrarosaurus, the object plays the role of Navigation Point, indicates that the user is the correct way and offers some additional services, one of which is to view the Herrarosaurus's information.
- Meanwhile, user B is not traversing any physical link and therefore when he faces Herrarosaurus, the some default service is triggered showing the hypermedia information.

Roadmap generation between two Physical Hypermedia



- How to go from *la Gioconda* of Leonardo of the Louvres Museum in Paris to *las Meninas* in the Prado Museum in Madrid?
- Generation of a W-link in the PH domain.

Example of pervasive cooperation

- From Louvres database ➔ exit from *Gioconda* to the next metro station
- From Paris public transportation company database ➔ go from this station to Paris airport
- From airline database ➔ go from Paris airport to Madrid airport
- From Madrid public transportation company database ➔ go from Madrid airport to Prado museum nearest station
- From Prado database➔ go from the previous station to the Prado gate, and then to *Meninas*.

Various types of roadmaps

- Text
- Voice
- Map
- Pictures

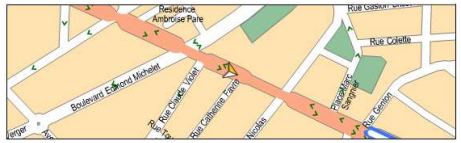
Example with text and map

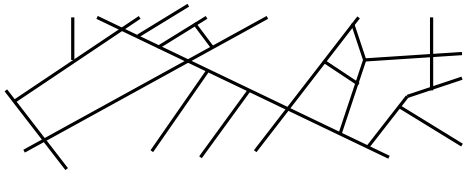
Lost in China!

Itinerary based on pictures

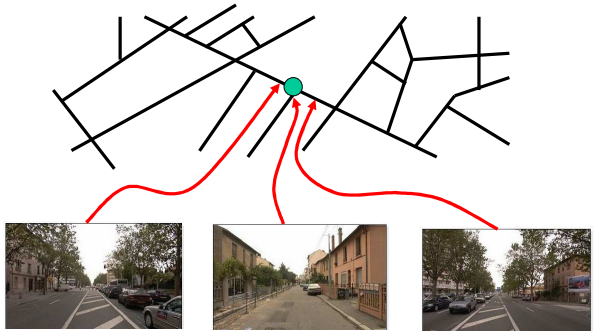
- Objective
  - Generate a sequence of pictures to explain an itinerary
- Pre-requisites
  - Outdoor and indoor network
  - Taking pictures and storing them
  - Locating pictures

Road network





Assigning pictures to nodes



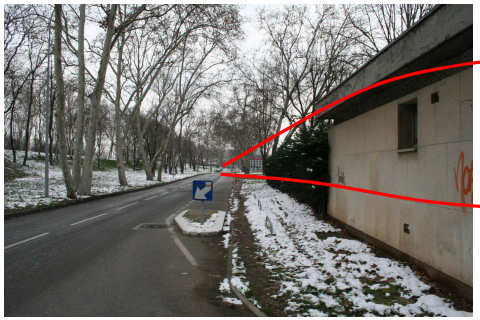
Explanations for itineraries

- Not only a sequence of pictures
- How to inform to turn right or left?
- Solution
  - Decorating the picture with a located arrow
- Consequences
  - Locate node (= crossroads) in pictures
  - Pixels (x, y) ➔ nodes

Arrow indicating where to go

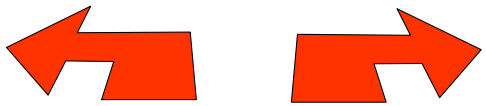
Turning arrow

Assigning nodes

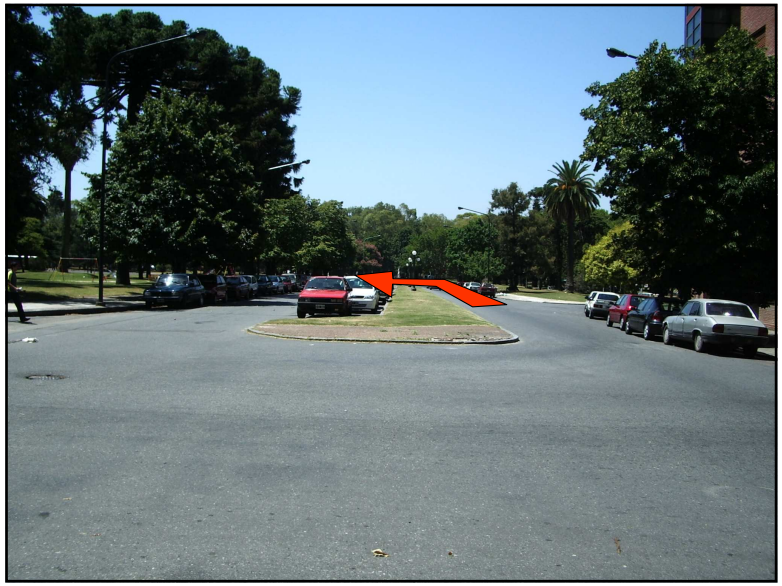


Directions

- Decorate pictures with arrows showing the direction, and located at the node



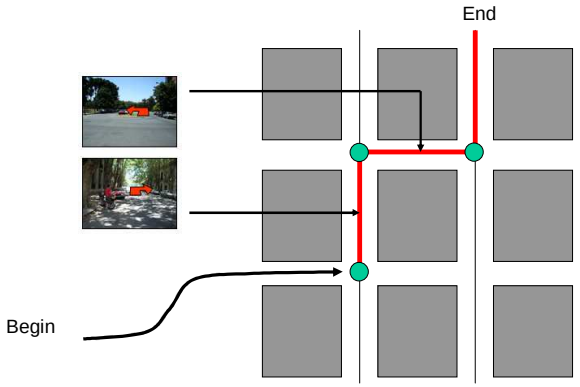
- No decorated pictures
- Arrow-decorated pictures



Generation of itineraries

- Running a shortest path algorithm
- Results
  - A sequence of nodes and arcs
  - A sequence of decorated pictures

Itinerary with arrow-decorated pictures



Conclusion on W-links

- Using Internet to generate roadmaps from one object to another one
- Picture-based roadmaps look a good candidate for pedestrian in tourist cities

VII – Towards Pervasive Information Cities

- 7.1 – Infrastructures
- 7.2 – Portals and access
- 7.3 – Examples
- 7.4 – LBS Privacy

7.1 – Infrastructures

- Telecommunication Infrastructure
- Geolocation Infrastructure
- Services Infrastructure
- Data Infrastructure

Telecommunication Infrastructure

- Organize wireless networks
  - WIFI/WIMAX covering the whole city
- Locate antennas
- Locate data servers
- Geolocation systems
- Can be seen as a future public service

Geolocation Infrastucture

- GPS, Galileo
- RFID and indoor beacons
- Cell phone cell

- Indoor/outdoor
- Roaming

Services Infrastructure

- Promote web sites of all urban actors (ex. Tourism)
- Necessity of updating data in real time
- Organization of service providers
- Automatic generation of portals adapted to user's profile and the location
- Protocols service discovery
- Standards?

Data Infrastructure

- Basic geographic information of road networks
  - Location of main buildings, landmarks, shops, etc.
  - Aerial Photos, 3D
- Data linked to services (for instance)
  - Museum opening hours
  - Menus of restaurants
  - Located news
  - Etc.

7.2 – Portals and access

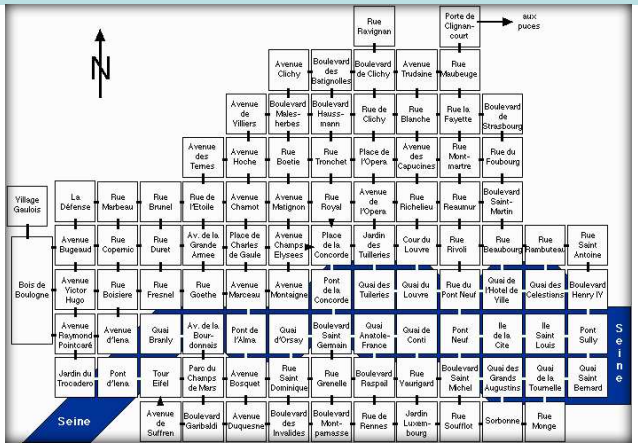
- Examples of city websites
  - Dedicated for desktop computers
  - Any kind of users not necessary in the city
  - Promotion product
- Necessity of new types of portals for LBS
  - Automatic adaptation of contents
  - According to profile, language, hobbies, etc.
  - Assisting people locally

http://puebla.turista.com.mx/

Access based on aerial photos, Venice, Italy

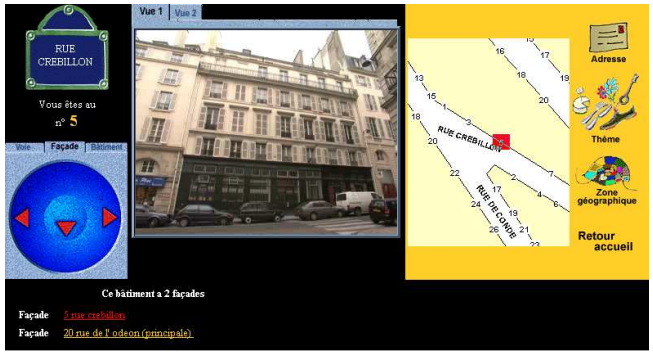
http://www.comune.venezia.it.

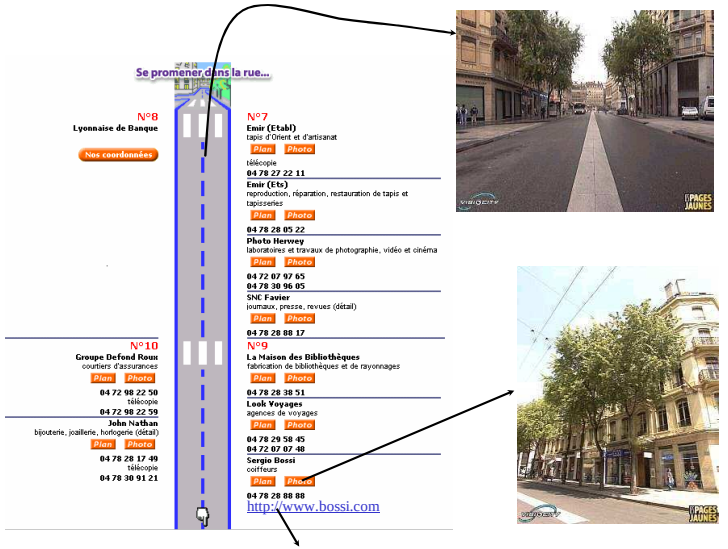
Streetmap access - Paris



Façades

http://www.cnrs.fr



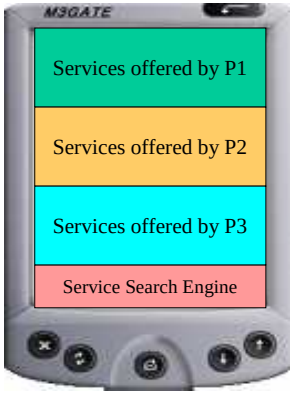


Other example

Portals for LBS

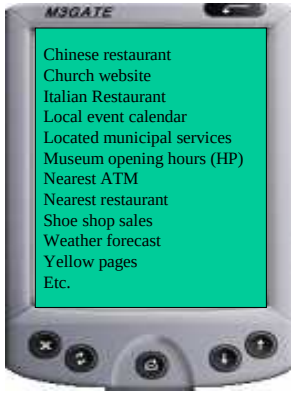
- Provider 1 (generalist)
  - Yellow pages, Nearest restaurant, Nearest ATM
- Provider 2 (local information)
  - Museum opening hours (HP), Shoe shop sales, Chinese restaurant, Italian Restaurant, Church website
- Provider 3 (municipal information)
  - Local event calendar (Sports, Culture, etc.)
  - Located municipal services
  - Weather forecast

Provider-oriented portal



- The simplest to generate automatically
- Few providers
- Small list of services offered by each provider

Service-oriented portal



- Services sorted by alphabetic order
- Mixing city-wide and street-wide information
- What if a long list of services?

Profile-oriented portal

- Services ranked according to user's profile

Map-oriented portal

- Services are sorted by places
- Clickable zones or with arrows
- ➔Algorithm for arrow positioning when moving

Street-view-oriented portal

- Dedicated to pedestrians
- Services are sorted by street
- ➔Algorithm for arrow positioning when moving

7.3 – Examples

- Not a lot of existing systems
- A lot are planning such systems
- Some places with fully-deployed systems
- Main problems:
  - Targeted user number
  - Data flows
  - Hotspots location
  - Maintenance

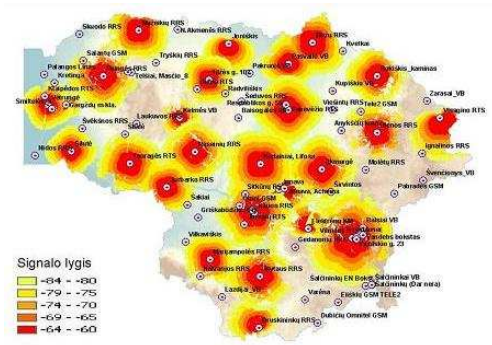
Example of hotspot location City of Lincoln, Nebraska

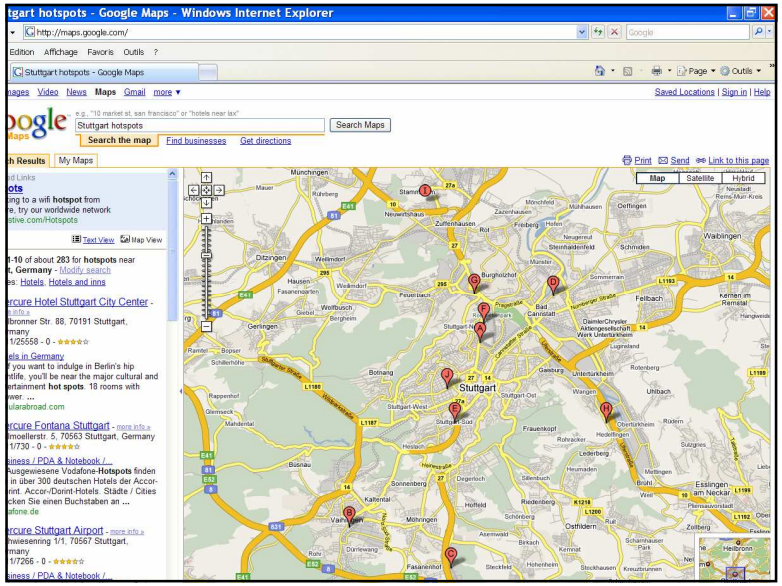
Examples in the US

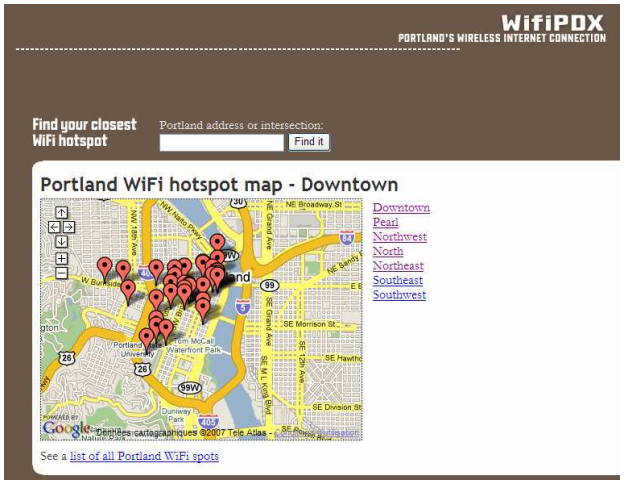
EC-Economic Development, PS-Public Safety, ED-Education, TT-Tour and Travel

City	Method	Goal	Status	Funding/Cost
Mesa, AZ	Wi-Fi Mesh	EC,PS,ED	In Planning	Needed
Philadelphia, PA	Wi-Fi Mesh	EC,ED,TT	Partial Deployment	Other
Washtenaw County, Michigan	Hy-Brid	EC,PS,TT	In Planning	Other
Overland PK, KS	Wi-Fi Mesh	EC,PS,TT	In Planning	Needed
San Carlos, CA	Wi-Fi Mesh / Wi-Fi Zones	EC,PS,ED,TT	Partial Deployment	Public/Private
Corpus Christi, TX	Wi-Fi Mesh/ Wi-Max	EC,PS,ED,TT	Fully Deployment	Bonds

Lithuania WIMAX Hotspot coverage







Metropolitan WIMAX coverage

Roma Wireless map

7.4 – LBS Privacy

- Location data of individuals must be considered as a constituent of privacy data
- Real time privacy intrusion
- Misuse of Collected location data stored in server.
- Communication may be intercepted

Intrusion

- Possible intrusion or misuse of privacy data relating to the location based service should be rejected or prevented.
  - Technical elements
  - Human elements
  - Social elements
- A sign of intrusion or misuse may be discovered in
  - SPAM emails or other advertisements
  - Additional service providing that the users don't know of or agree to
  - Unreasonable exchange or data traffics during any interaction on the location based service
- Some types of intrusion or misuse would be illegal.
  - Civil damage compensation
  - Criminal penalties
  - Administrative sanctions

How to resolve these problems

- Privacy issues or disputes would be unavoidable in this area.
- Their resolution
  - **Legal method** – adequate and effective legislation and its enforcement with reasonable dispute resolution measures
  - **Technological method** – better technology for privacy protection or removal of unnecessary privacy collection functions
  - **Self regulation method** – better guidelines or relevant parties agreeing on a common privacy goal on the basis of the international privacy protection standards
  - **Education**

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- City benefits
  - Enable Public Safety
  - Bring Needed Services
  - Bridge the Digital Divide
  - Enable Better City Government Collaboration

VIII – Conclusions (1/2)

- Information « everywhere, everytime »
- Importance of pervasive information
- Indoor/Outdoor
- Four basic infrastructures
  - Telecommunications
  - Geolocation
  - Data
  - Services

Conclusions (2/2)

- New applications to be defined
- Problems
  - Efficiency
  - Quality of service
  - Security
  - Confidentiality
- Physical hypermedia
- LBS are coming!