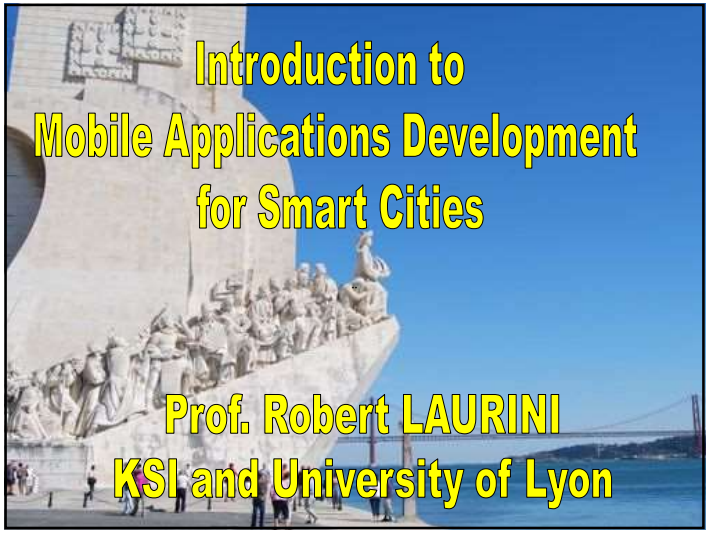

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Contents

1 – Introduction
2 – Reminder in GIS
3 – Outdoor and indoor positioning
4 – Mobile apps generalities
5 – Mobility as a Service
6 – Conclusions

2

Definition: Mobile Application (Mobile App)

- A mobile application, most commonly referred to as an app, is a type of application software designed to run on a mobile device, such as a smartphone or tablet computer.
- Mobile applications frequently serve to provide users with similar services to those accessed on PCs. Apps are generally small, individual software units with limited function.
- A mobile application also may be known as an app, web app, online app, iPhone app or smartphone app.

3

Definitions

- LBS
- Mobile app
- Continuous app
- Positioning
- Tracking
- Outdoor – Indoor

- https://www.slideshare.net/ProjectENhANCE/indoor-positioning-general-framework
- https://en.wikipedia.org/wiki/Indoor_positioning_system

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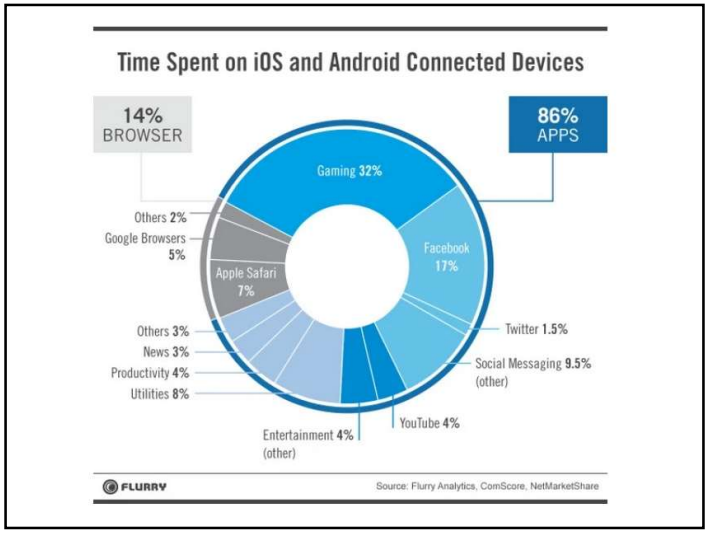

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Application development

- Native Applications
  - Native Application developed to be used on specific platform or operating system such as Android, iOS, etc .
- Hybrid Applications
  - Hybrid applications developed to be used across a number of platforms. They can be deployed on both of iOS and Android platforms.
- Progressive Web Applications (PWAs)
  - Progressive Web Applications developed to be used on web browser. User use these apps without download from Play Store/App Store.

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2 – Reminder in GIS

- Geographic Information Systems
- Important concepts
  - Coordinates, spherical geometry
  - Computational geometry
  - Data acquisition
  - Spatial Indexing
  - Mapping

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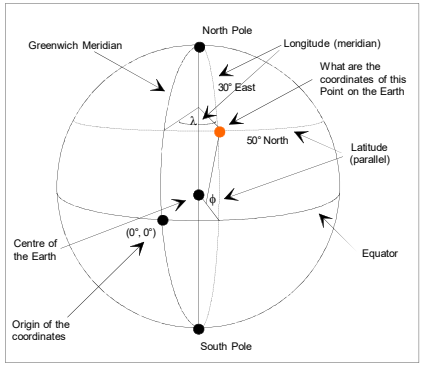
Coordinates



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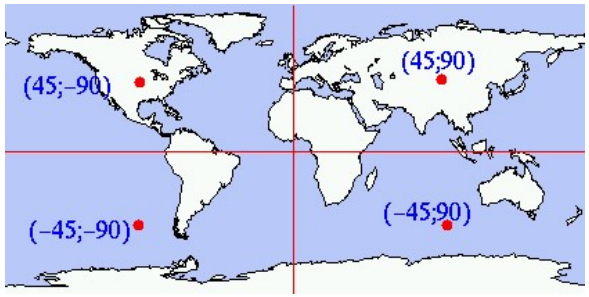
Coordinate center



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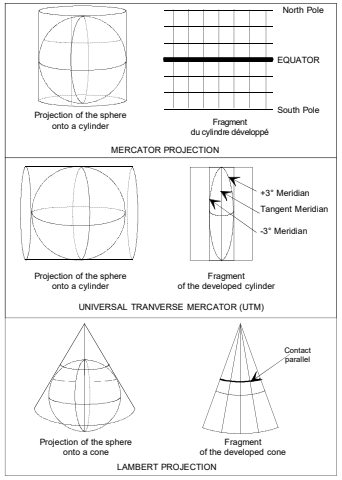
Projections of a sphere



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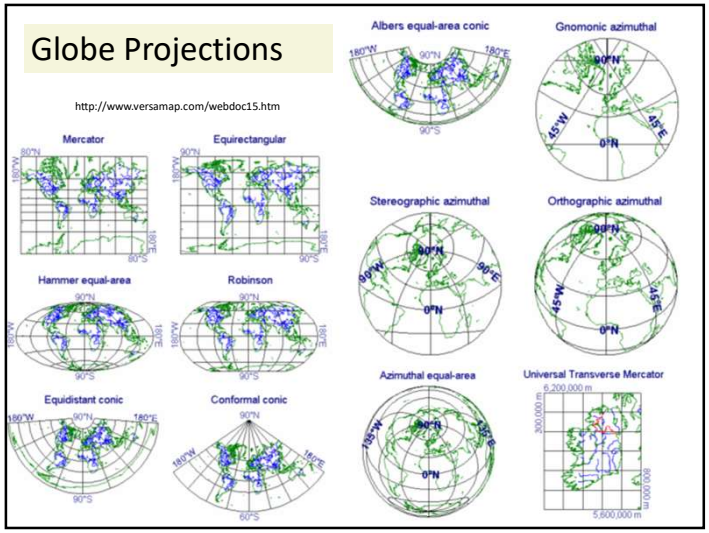
Globe Projections



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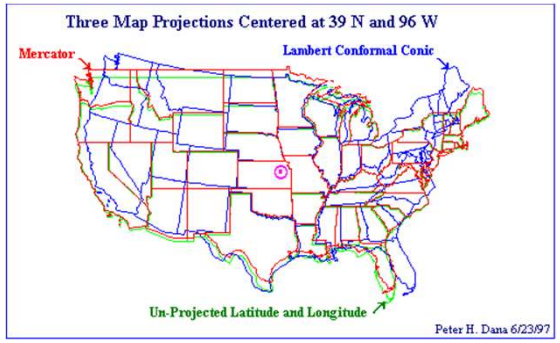
Different projections



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Minimum path

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Global curvilinear distance between two points

$P_1(L0_1, LA_1)$

$P_2(L0_2, LA_2)$

$$d(P_1, P_2) = R \times \arccos(\sin(LA_1) \times \sin(LA_2) + \cos(LA_1) \times \cos(LA_2) \times \cos(LO_2 - LO_1))$$

$R = Mean\ Earth\ Radius$

$R = 6{,}378.135\ Km\ \ (Equatorial\ \ Radius)$

$R = 6{,}356.766\ Km\ \ (Polar\ Radius)$

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3 – Outdoor and indoor positionings

- How to know the positioning of an object?
- Outdoor
  - GPS (Global Positioning System)
  - GLONASS
  - GALILEO
- Indoor (3D buildings)
  - WIFI
  - Phone cells

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Global Positioning System

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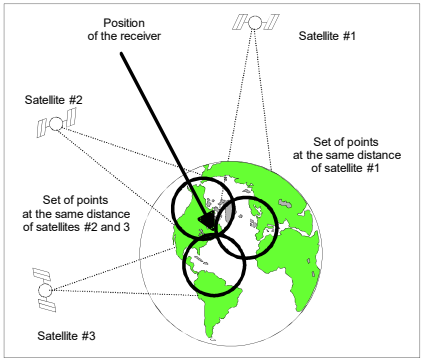
Principles of GPS



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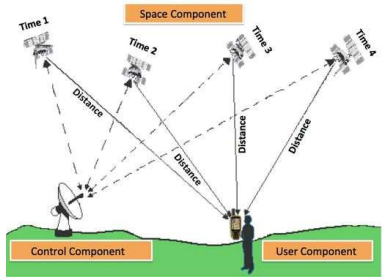
Taking signal velocity into account



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GPS Constellation

- Accuracy: 5 m (2000) ➔ 30 cm (2018)
- Total satellites 33
- Satellites in orbit 31
- First launch February 1978; 41 years ago
- Total launches 72

- Orbital characteristics
  - Orbital height 20,180 km (12,540 mi)

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GLONASS Constellation

- Accuracy 2.8–7.38 meters
- Total satellites 26
- Satellites in orbit 24
- First launch 12 October 1982
- Last launch 17 June 2018
- Orbital characteristics
  - Orbital height 19,130 km

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GALILEO Constellation

- Accuracy 1 metre (public); 1 cm (encrypted)
- Total satellites 30
- Satellites in orbit 22 operational
- First launch 2011
- Total launches 24
- Orbital characteristics
  - Orbital height 23,222 km (14,429 mi)

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Indoor positioning

- Terminal-based
  - Easily implemented, no permission required
- Infrastructure-based
  - WIFI-based
- Hybrid-based
  - Combining

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Positioning approaches

- Pattern recognition/Fingerprint
- Triangulation
- Trilaterisation
- Proximity sensing/Connection positioning

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Connection based positioning

- In simple methods called as "Cell of Origin or "Cell Identity" terminal simply uses the location of the serving wireless node.
- To run this positioning system just a database of station IDs and locations is needed.
- The position is determined by measuring the signal strengths from different stations
  - It is assumed that the closest station is the station from which the strongest incoming signal on the device is received
  - Terminal just send the ID of the serving station to the IPS database which send the location of the station to the terminal.
- This method is accurate only for short range technologies like Wi Fi and Bluetooth. Used in some GSM networks.

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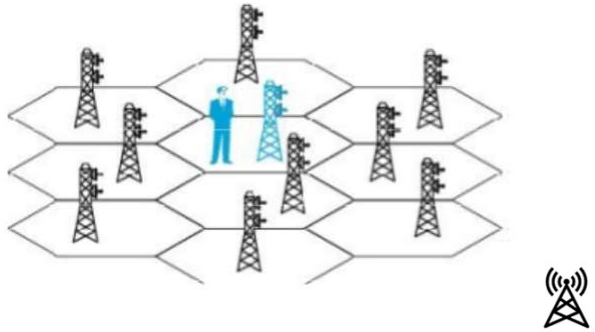
Connection-based positioning



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Trilateration/multilateration

- These methods assume that signal strength and/or time delay is directly proportional to the distance between the user terminal and the base station.
  - When this assumption holds, it is a simple geometrical exercise to compute the location of the user terminal provided that signals from at least **three** separate base stations can be reliably received.
- The challenge for a trilateration method is in the determination of the distance between the base station and the user terminal
  - Methods that are based on time measurements assume accurate synchronization between the base stations and the user terminal
  - Methods that are based on the signal strength have problems with interference and multipath propagation effects

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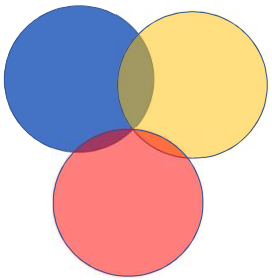
Trilateration



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Triangulation

- Base stations measure the angle of arrival (AoA) for the received signal from user terminal
- Location of the terminal is computed using the known locations of the base stations and AoA measurements.
- Needs directive antennas and thus, challenging to implement

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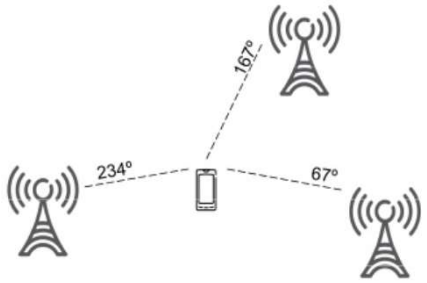
Triangulation



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Fingerprint based approach

- Based on spatial differences in the radio environment.
- Fingerprint based methods include two phases:
  - 1) Offline Phase
    - A fingerprint database is built by collecting signal strengths from all identified base stations at pre-defined locations.
    - Several measurements are collected at each location and e.g. the median signal strength values are calculated.
    - The values are inserted into a radio environment map
  - 2) Online Phase
    - User terminal that desire to define location measure the signal strengths from surrounding base stations and compared result with the radio environment radio map.
    - Usually many measurements are needed to define the location from the radio environment map.

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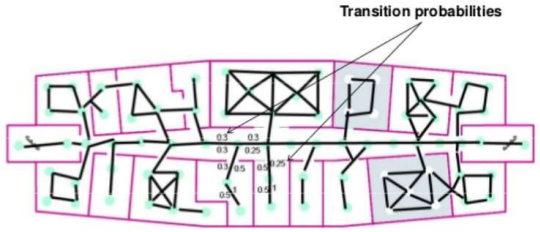
Example of fingerprinting



Light blue dots represent locations where signal strength has been measured and black lines show possible routes

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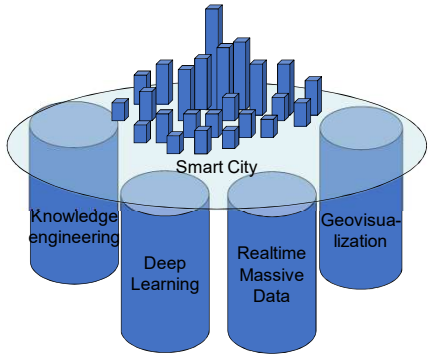
Smart City ICT pillars



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Data Acquisition Sensors

- Digital Sensors
- Citizens as Sensors - Crowdsourcing

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Sensors with physical connections

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Wireless sensors

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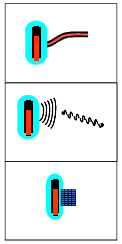
Various architectures for sensors



Sensors con cable

Wireless sensors

Sensors with storage capacity

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Usage of sensors

- Acoustic, sound, vibration
- Automotive, transportation
- Chemical
- Electric current, electric potential, magnetic, radio
- Flow, fluid velocity
- Ionizing radiation, subatomic particles
- Navigation instruments
- Position, angle, displacement, distance, speed, acceleration
- Optical, light, imaging, photon
- Pressure
- Force, density, level
- Thermal, heat, temperature
- Proximity, presence

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3 – Mobile application generalities

- Various meanings.
- 1 – the user is not mobile, but his/her environment is mobile
- 2 – the user is mobile, but environment not
- *3 – both user and environment are mobile.*
- If either user and environment are fixed, conventional applications (Facebook, games, messaging, website browsing, news reading, etc.)

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User fixed, environment mobile

- Examples
  - Surveillance of kids, pets, etc.
  - Uber taxis
  - Crowd estimating (march, etc.)
  - Anti-groping (in Japan)
- Positions of objects must be known, f.i. via GPS

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User mobile, environment fixed

- Prototypical queries
- « Where is the nearest restaurant? »
- « Pizza ordering »
- Based on maps (f.i. Google maps)
- User position is known
- Usually Euclidean distance,
  - sometimes road distance
  - Sometimes taking traffic conditions into account
- LOCATION-BASED SERVICES (LBS)

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Location Based Services (LBS)

- Location based services (LBS) are services offered through a mobile phone and take into account the device's geographic location. LBS typically provide information or entertainment. Because LBS are largely dependent on the mobile user's location, the primary objective of the service provider's system is to determine where the user is.
- Some of the most common LBS applications include local news, directions, points of interest, directory assistance, fleet management, emergency, asset tracking, location-sensitive building, and local advertisement.
- Location Based Services Market Expected to Reach $62 Billion, Globally, by 2022

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Everything mobile

- Dynamic positionning
- Crowdsourcing

- Example: traffic jams

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4 – Mobility as a Service (MaaS)

- https://en.wikipedia.org/wiki/Mobility_as_a_service
- WHIM
- https://www.slideshare.net/welkaim/mobility-as-a-service-maas

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Mobility as a Service (MaaS): What is It?

- A Concept
  - Integrated view of all relevant service options for a specific user trip
  - On-demand access to service(s) of choice with no-hassle provider payments
  - Necessity of ownership of personal mobility options potentially eliminated
- An Application
  - Google Maps-like views of trip plans, service options, O-D times and costs
  - Booking, scheduling, payments, notifications all included in functionality
- An App
  - Accessible from your smartphone for immediate use, tailored to your situation
  - As easy to use as single function travel apps (e.g., Uber, UAL, Hotels.com)

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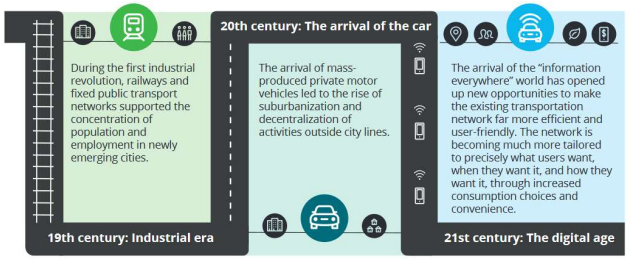
Mobility through ages



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Mobility As A Service (MaaS)

- Definition
  - "MaaS is provision of transport via a real-time personalized service model that integrates all types of mobility choices and presents them to the customer in a completely integrated manner to get them from *A* to *B* as easily as possible."
- MaaS is a new concept in the transport sector: it provides a new way of thinking in terms of how the delivery and consumption of transport (or mobility) is managed:
  - Integrated and seamless mobility services offered to a client by a public or a private mobility aggregators.
  - MaaS is based on disruptive digital business services and models.
  - MaaS is generally based on subscription business model. but could accept micro-transaction
- • MaaS could be seen as an Over The Top service.

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MaaS from a user's perspective

- **Journey Planning:** real-time journey planning allows a user to plan their journey. choosing from multiple modes that are 'intelligently' suggested based on their personal preferences (like for example. cost. comfort, time).
- **Ease of Transaction:** The user can access mobility using a range of payment channels for example a phone. watch. smartcard or bank card regardless of which modes of transport they use.
- **Flexible Payment terms:** The user can pay for their mobility choice via pre-pay. post-pay or pay-as-you-go.
- **User Experience:** Data analytics will enhance the overall user experience. This feature may be seen as a virtual 'concierge service" that provides the user with the best possible whole journey experience by managing the choices they make.
- **Personalized Service:** A fully personalized service that builds a relationship between the user and the MaaS provider by allowing two-way communication. The MaaS 'service' will be highly customer relevant and focused and will react to user feedback.

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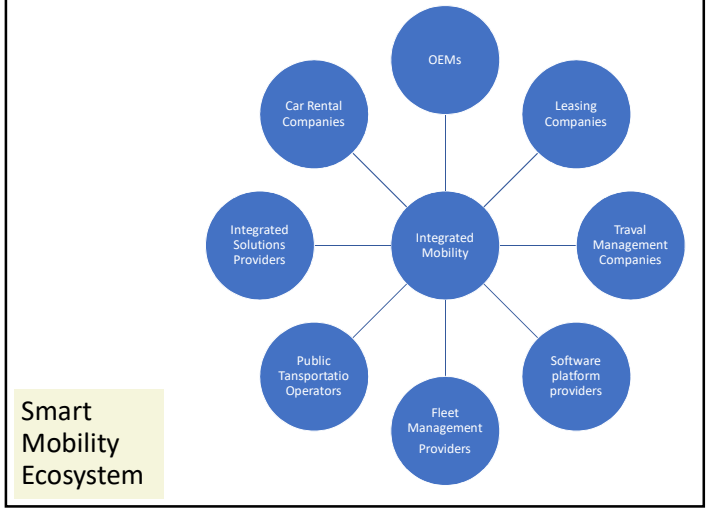

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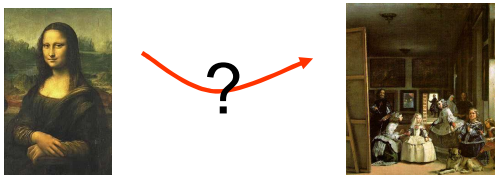
Cooperation between providers



- How to go from Leonardo's Mona Lisa in the Louvres Museum in Paris to the Velásquez Meninas in the Prado Museum in Madrid?
- How to create the route from one painting to another painting?
- Path generation based on several systems

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Example of cooperation

- With the database of the Louvres ➔ Going from the Gioconda to the nearest subway station
- With the database of the public transportation company of Paris ➔ going from the nearest metro station to the airport of Paris
- With the airline database ➔ going from Paris Airport to Madrid Airport
- With the database of the transportation company of Madrid ➔ going from Madrid Airport to the nearest metro station to the Prado
- With the database of the Prado ➔ going from the nearest metro station to the painting of Meninas

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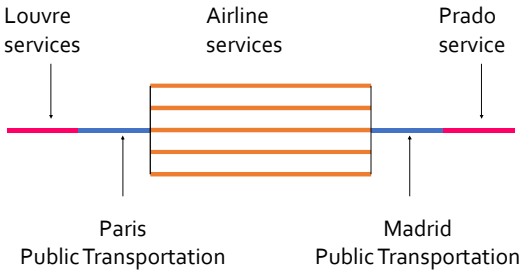
Interoperability schema of services



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6 – Conclusions

- User mobility is an important aspect.
- Question: What and who are mobile?
- Outdoor and indoor positioning
- Location-Based Services
- Mobility as a Service

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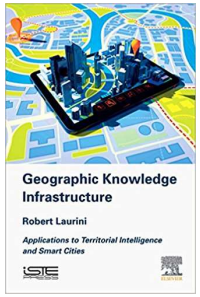
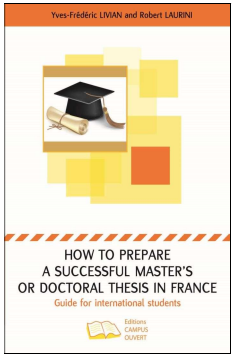
Thanks for your attention!





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- http://www.laurini.net/robert/

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