Mobile Telephone Data and Traffic Management: Exploratory Research

Peter Nijkamp
Topics

• History of wireless location technology
• Which data types can be retrieved
• How these data types can be used to create useful (transportation) applications
• Review research projects and field test
• Current city Amsterdam: an example
• Issues regarding telecom data
• Future work
History telecom network

- 1982: CEPT create the Groupe Special Mobile to develop 2G standard (GSM)
- 1987: memorandum of understanding 13 countries to develop cellular system
- 1991: first commercial launch
- 1993: over million subscribers in 48 countries operated by 70 carriers
- 2009: 80% mobile market uses GSM in more than 212 countries used over 3 billion people!
- Recent market surveys show cellular phone penetration reaches 100% in many countries
Cell phone activity parameters

- Location update and positioning technology
  - Databases (HLR and VLR)
  - Location areas and Cell id’s
  - Triangulation and Received Signal Strength (RSS)
  - AoA, ToA, TDoA, E-OTD
- Handovers
- Cell dwell time
- Communication counts
  - Erlang
  - SMS
  - New calls, Duration of calls, Originating calls, Sum of call length, Average call length
GSM network Architecture
Positioning technology

Position obtained at the cell ID level

Position obtained with triangulation

Position obtained with RSS
Handovers

- Handover (or handoff) is the switching of an on-going call to a different channel or cell. It is the mechanism of managing a permanent connection when the phone moves through two cells of the network.
- Together with the Mobile Switching Centers (MSC) they provide the call routing and roaming capabilities of GSM.
Cell dwell time

- Cell Dwell Time is the duration that a cellular phone remains associated to a base station between handover events.
- In the literature this count is used on an individual cell basis and from multiple adjacent cells to estimate traffic congestion.
Call volume parameters

- Erlang
  - Erlang is one person hour of phone use. Erlang data is aggregated and anonymous data in terms of usage time and depends on the number of communications and their duration
- SMS
- New calls, Duration of calls, Originating calls, Sum of call length, Average call length
Traffic parameters

- OD matrices (handover, location update)
  - Caceres et al., 2007; White and Wells, 2002; Sohn and Kim, 2008
- Travel speed (handover)
  - Caceres et al., 2008; Ygnance et al., 2001; Thiesenhusen et al., 2003; Fontaine and Smith, 2004; Birle and Wermuth, 2006; Bar-Gera, 2007
- Travel time (handover)
  - Caceres et al., 2008; Linauer and Leish, 2003; Yim, 2003; Buisson, 2006; Bar-Gera, 2007; Liu et al., 2008
- Traffic flow (handover, call duration)
  - Thiesenhusen et al., 2003; Caceres et al., 2007
- Traffic congestion (call volume)
  - Ygnance et al., 2001; Astarita, 2005;
- Traffic density (Erlang)
  - Ratti et al., 2006; Hansapalangkul et al., 2007; Pattara-Atikom et al., 2007
- People presence / activity (network counters)
  - Dal Fiore and Beinat, 2009; Vaccari et al, 2009
Historical review (I)

Table: year, project name, promoters, location, cell phone data, traffic estimation, results

• 15 years of research and field tests
• First start CAPITAL project in 1994
• Speed and time are most studied estimations
• Projects are often initiated by Technology providers, Telco’s and Transport agencies
• Validation studies mostly carried out by Universities
Historical review (II)

- Adoption is still limited, field is largely dominated by R&D
- Technology is promising but not yet developed for large scale utilization
- Accuracy early generated systems was not sufficient to produce useful traffic information
- Recent studies show better results however.
- Transport agencies historically failed to define suitable performance requirements
- This causes problems for validation to draw clear conclusions
Current City Amsterdam
Growing interest in urban dynamics

> How many people are in that area?
> Where are traffic jams?
> Where are incidents or major events?
> What percentage of people have left the area?
> What is the current demand and supply of public transportation?
> How much CO2 was emitted today?
> Is there a relation between energy consumption and the presence of people
> What’s the hottest spot in town now?
> People create the dynamics of the city

> A telecom network is a *natural* candidate to sense this dynamics

> It addresses the collective behavior of the city, rather than the physical parameters of the city

> It provides a new layer of information for essential services, in the public and private sector

> … and also opens technical and ethical challenges
Visualization
Current City Rome (2006)
Visualization – New Years Eve
Current City Amsterdam (2008)
Data Collection, Processing and Analyzing

- anonymous
- aggregated

- interpretation
- processing
- modeling

- time patterns
- spatial patterns
- flows, crowds

- real-time, operations
- data mining, strategy
~ 40 x 30 km
Jordaan

Central Station

Rembrandtplein

Museumplein

WTC
World Trade Center

Aggregated call intensity

Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Central Station

Aggregated call intensity
Rembrandtplein

Aggregated call intensity

Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Queens day (2008)
Visualization – Queens day
Heartbeat of the city

Creating normality maps to detect anomalies
Visualization
Demand & Supply Transportation
Issues regarding telecom data

• Legal aspects and privacy
  – Directive 2002/22/EC (driver E112)
  – Aggregated anonymous data
  – Directive 2002/58/EC (location privacy)
  – Opt-in / Opt-out policy (perceived privacy concerns)

• Role transport agencies (need to balance between)
  – Regulation on privacy, data ownership, road safety, interoperability, market structure, performance requirements, service of general economic interest…
Future work

• Develop new applications (Proof of Concepts)
  – crowd management
  – evacuation support for disaster management
  – traffic management inner city of Amsterdam
  – Incident management based on network activity
• Analyze of third generation telecom networks
• Analyze of main solution providers WLT
  – Cellint, Inrix, ITIS Holding, Intellione, AIRSAGE, TomTOM, NAVTEQ, Globis Data..