

Mobile Telephone Data and Traffic Management: Exploratory Research



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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

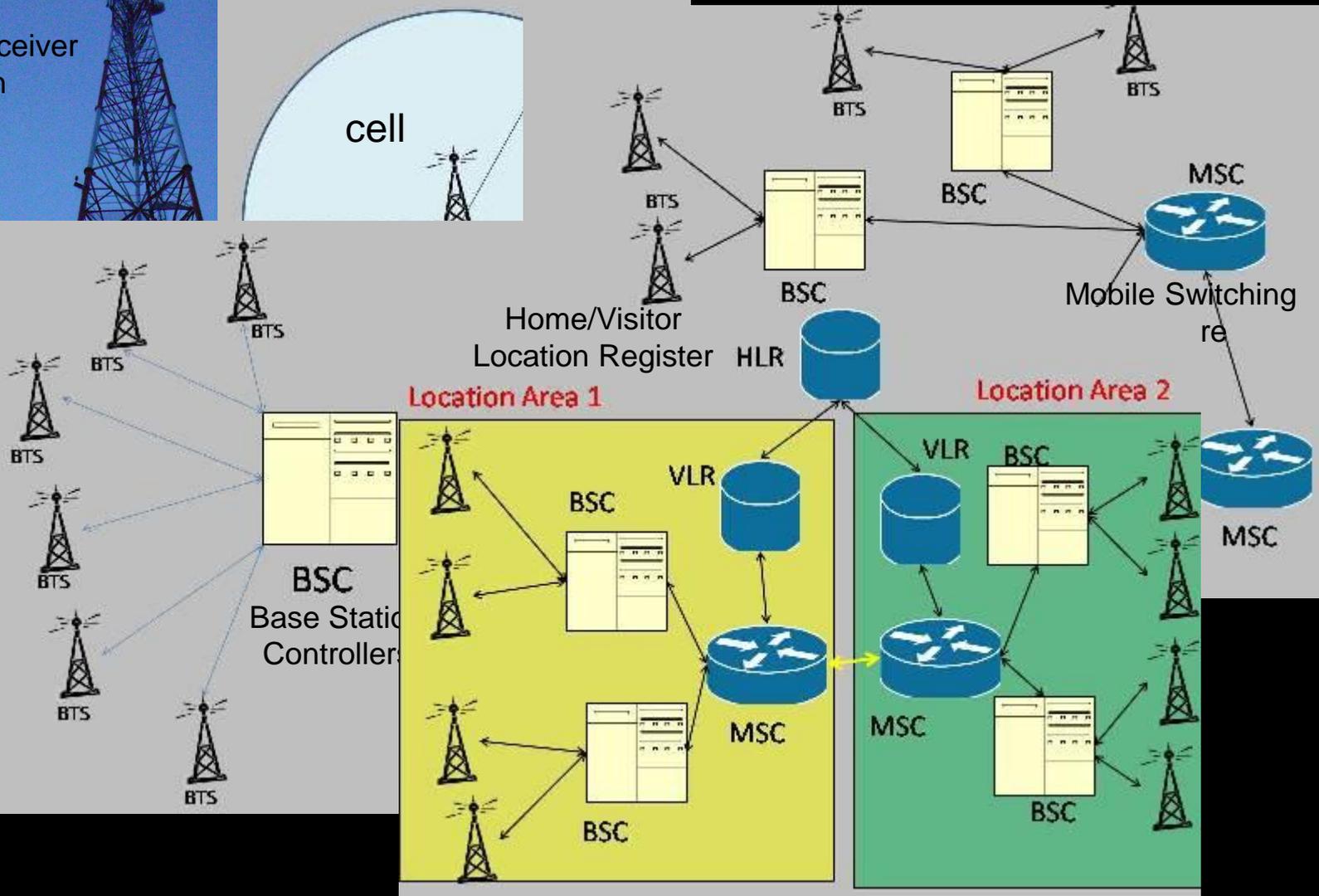
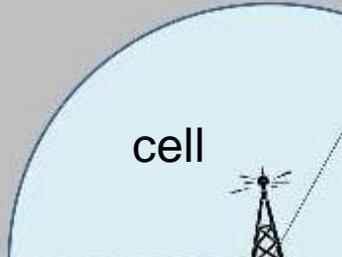
- Location update and positioning technology
 - Databases (HLR and VLR)
 - Location areas and Cell id's
 - Triangulation and Received Signal Strength (RSS)
 - AoA, ToA, TDoA, E-OTD
- Handovers
- Cell dwell time
- Communication counts
 - Erlang
 - SMS
 - New calls, Duration of calls, Originating calls,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

GSM network Architecture

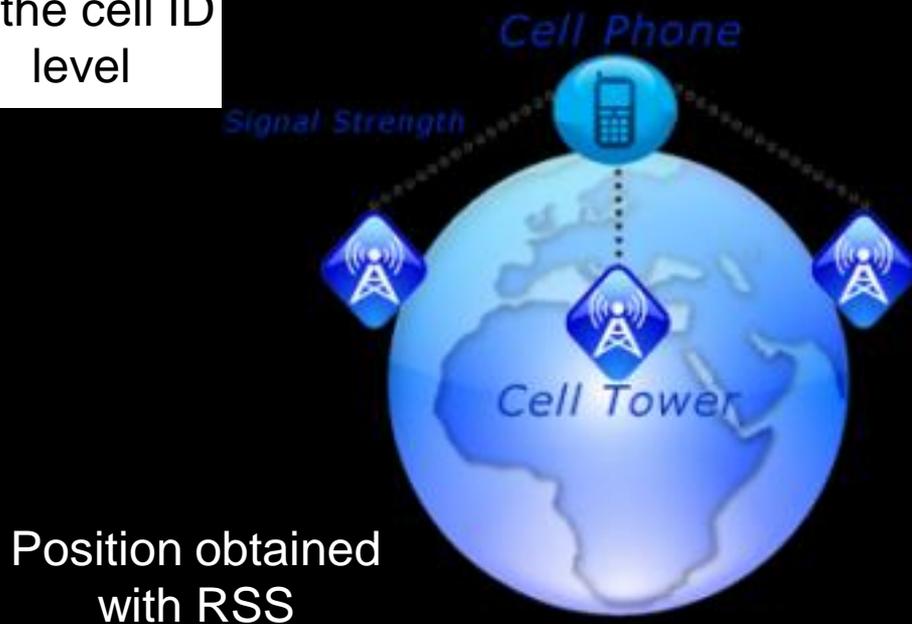
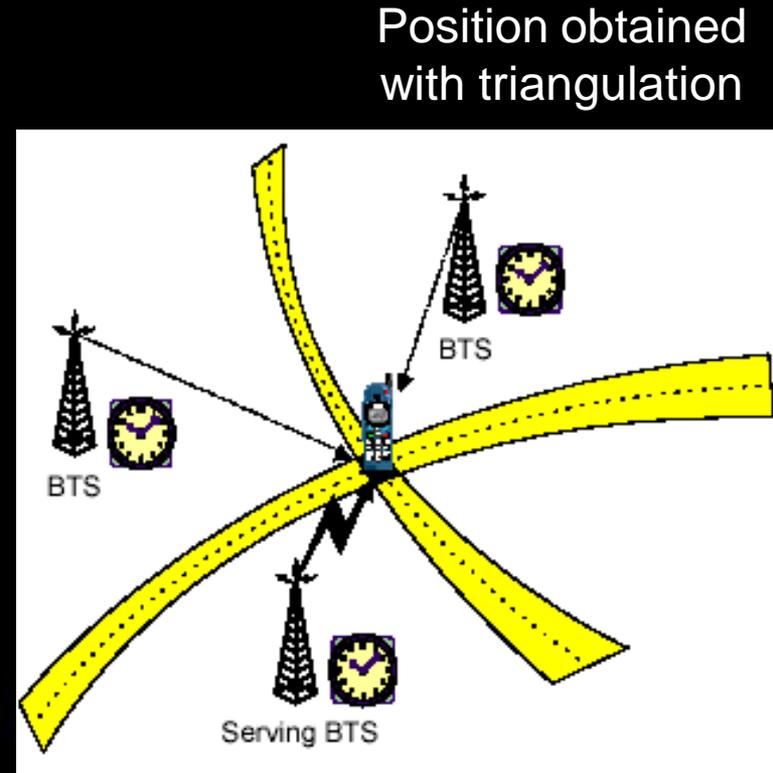
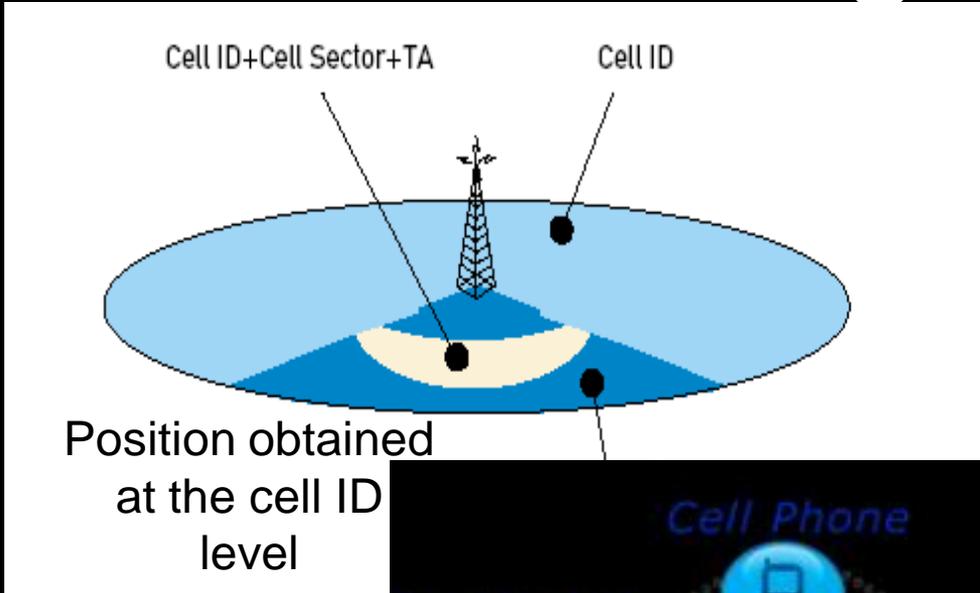
BTS
Base Transceiver
Station



cell

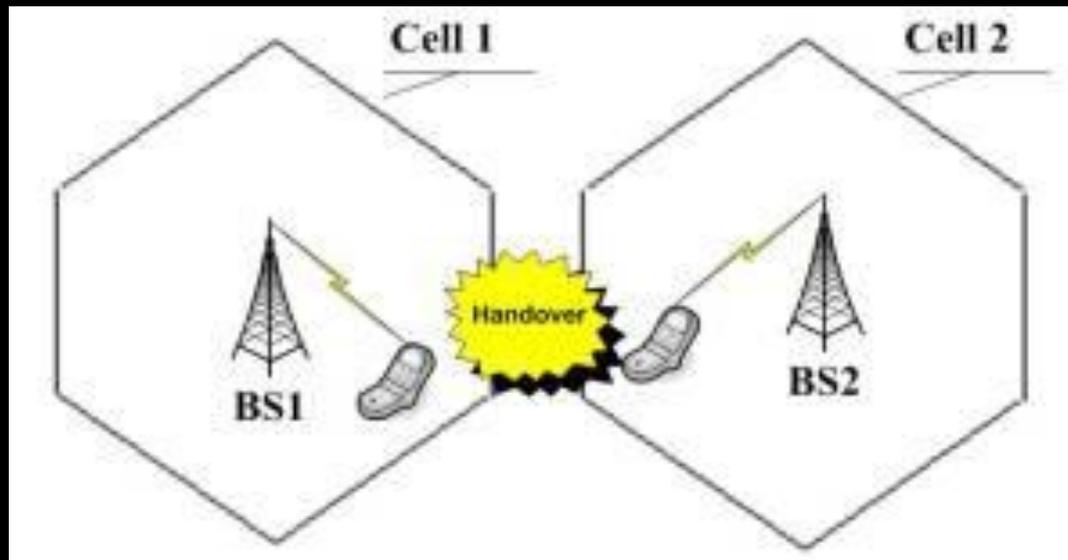


Positioning technology



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 Beinart, 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

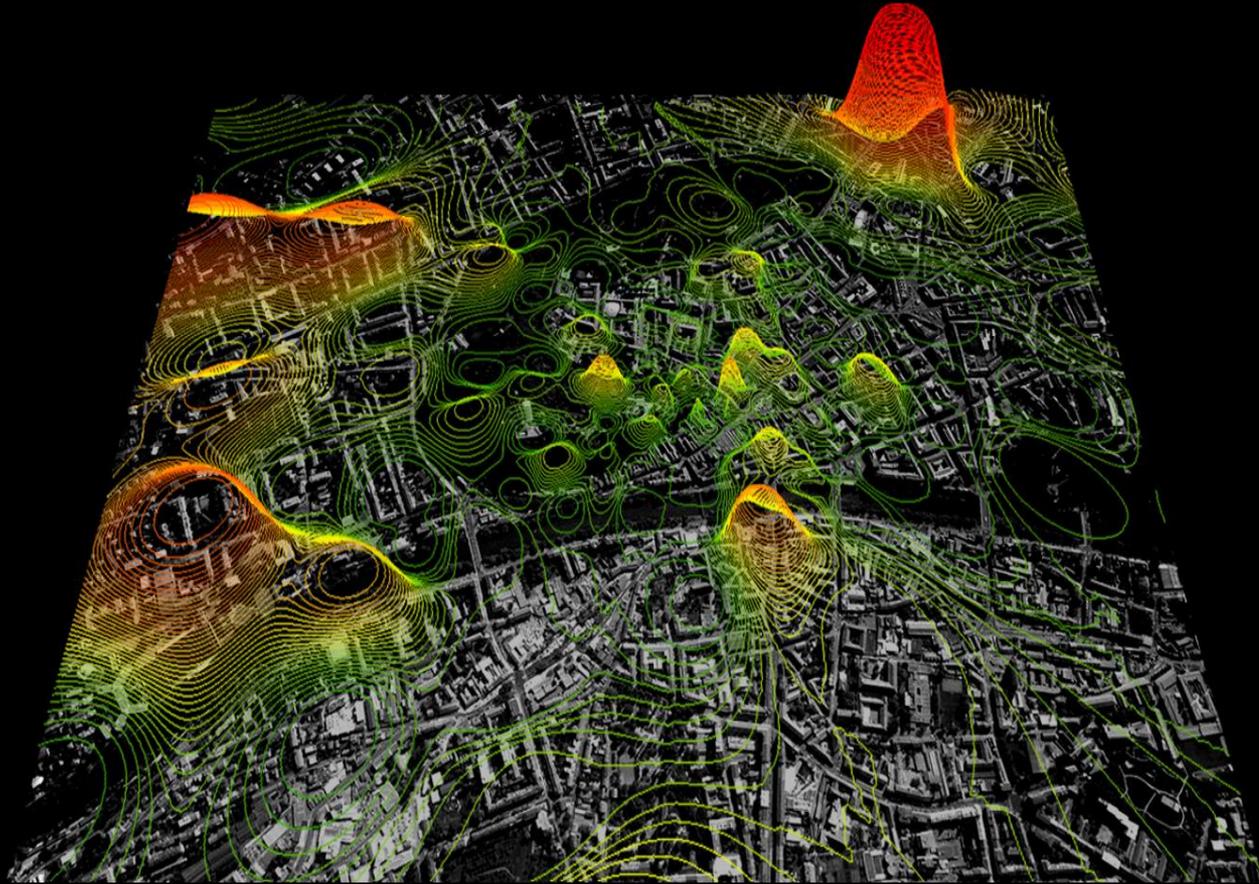
Current City Amsterdam

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?

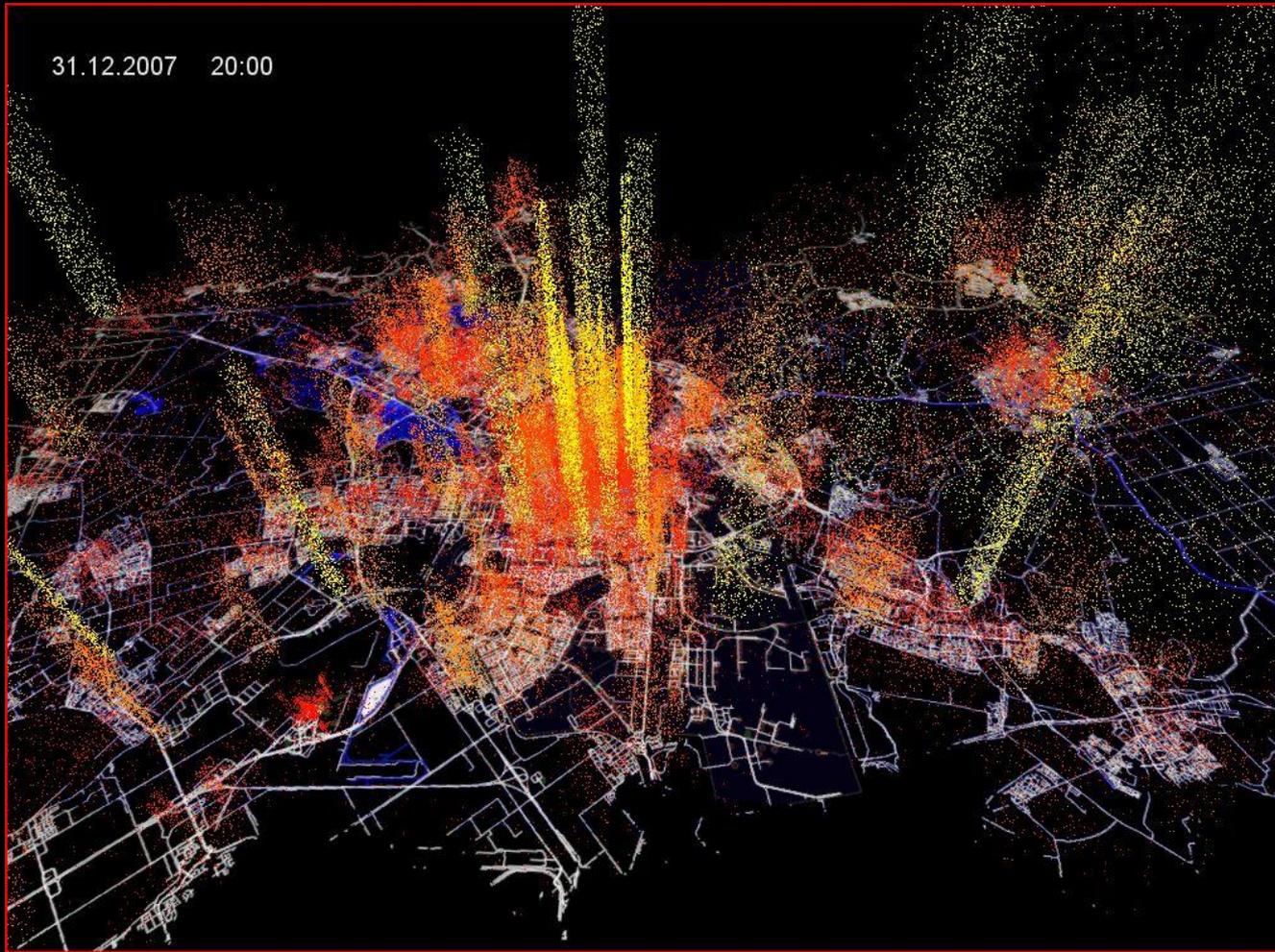
- > People create the dynamics of the city
- > A telecom network is a *natural* candidate to sense this dynamics
- > It addresses the collective behavior of the city, rather than the physical parameters of the city
- > It provides a new layer of information for essential services, in the public and private sector
- > ... and also opens technical and ethical challenges

Visualization Current City Rome (2006)

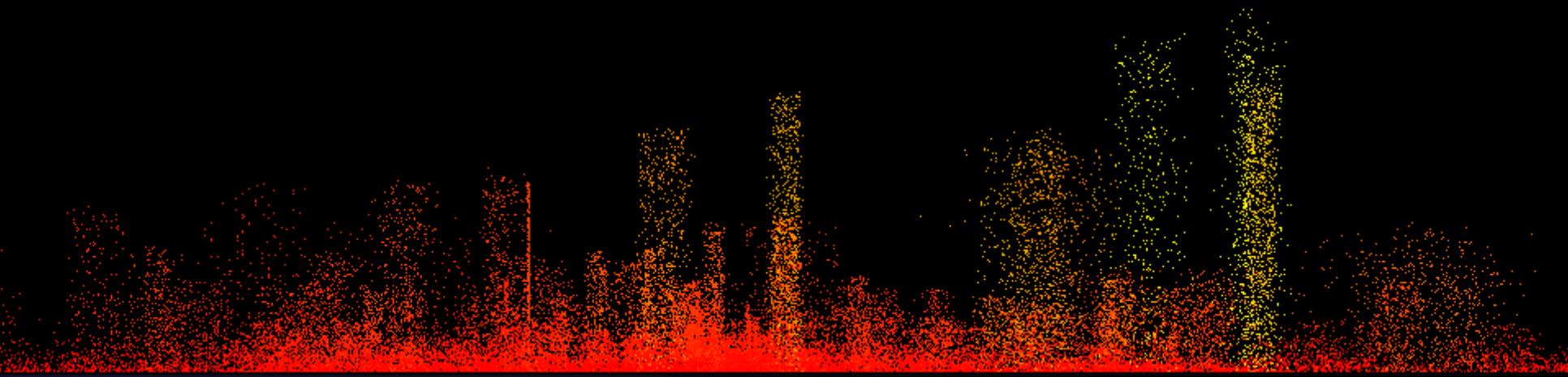




Visualization – New Years Eve Current City Amsterdam (2008)



01.01.2008 09:00

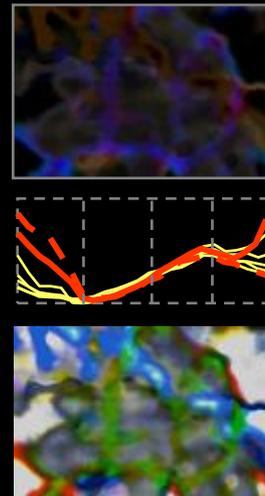
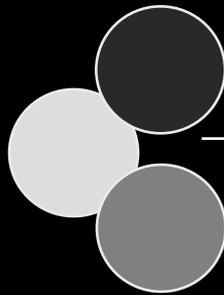
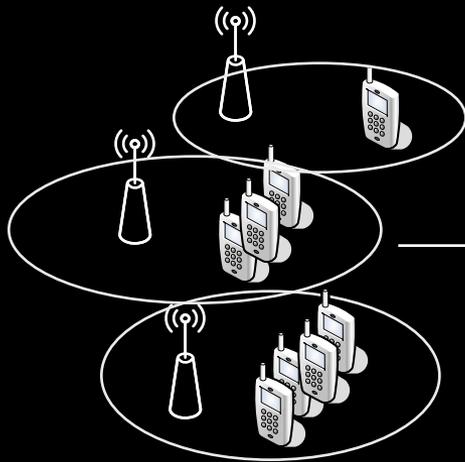


Data Collection, Processing and Analyzing

- > anonymous
- > aggregated

- > interpretation
- > processing
- > modeling

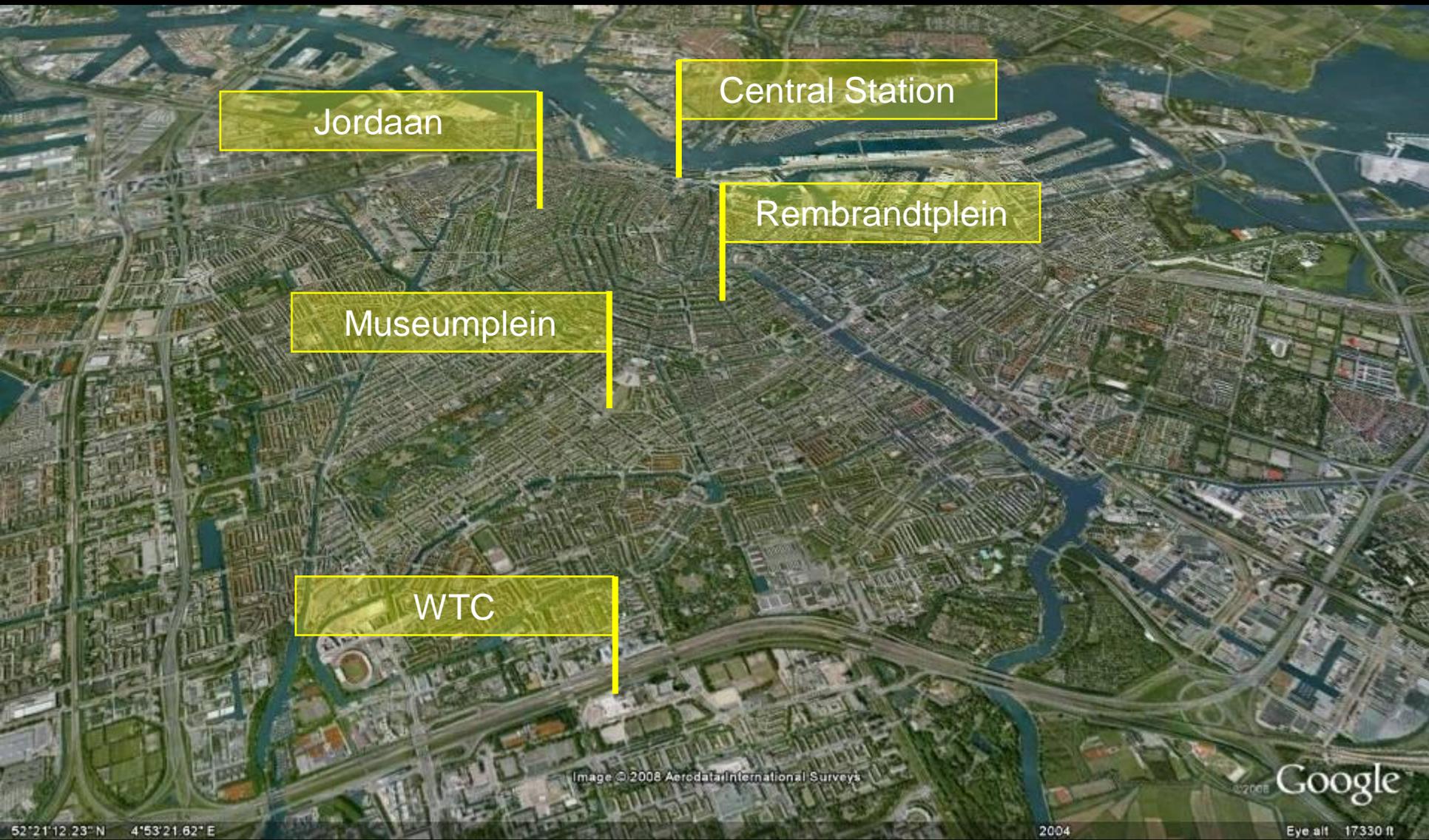
- > time patterns
- > spatial patterns
- > flows, crowds



- > real-time, operations
- > data mining, strategy



~ 40 x 30 km



Jordaan

Central Station

Rembrandtplein

Museumplein

WTC

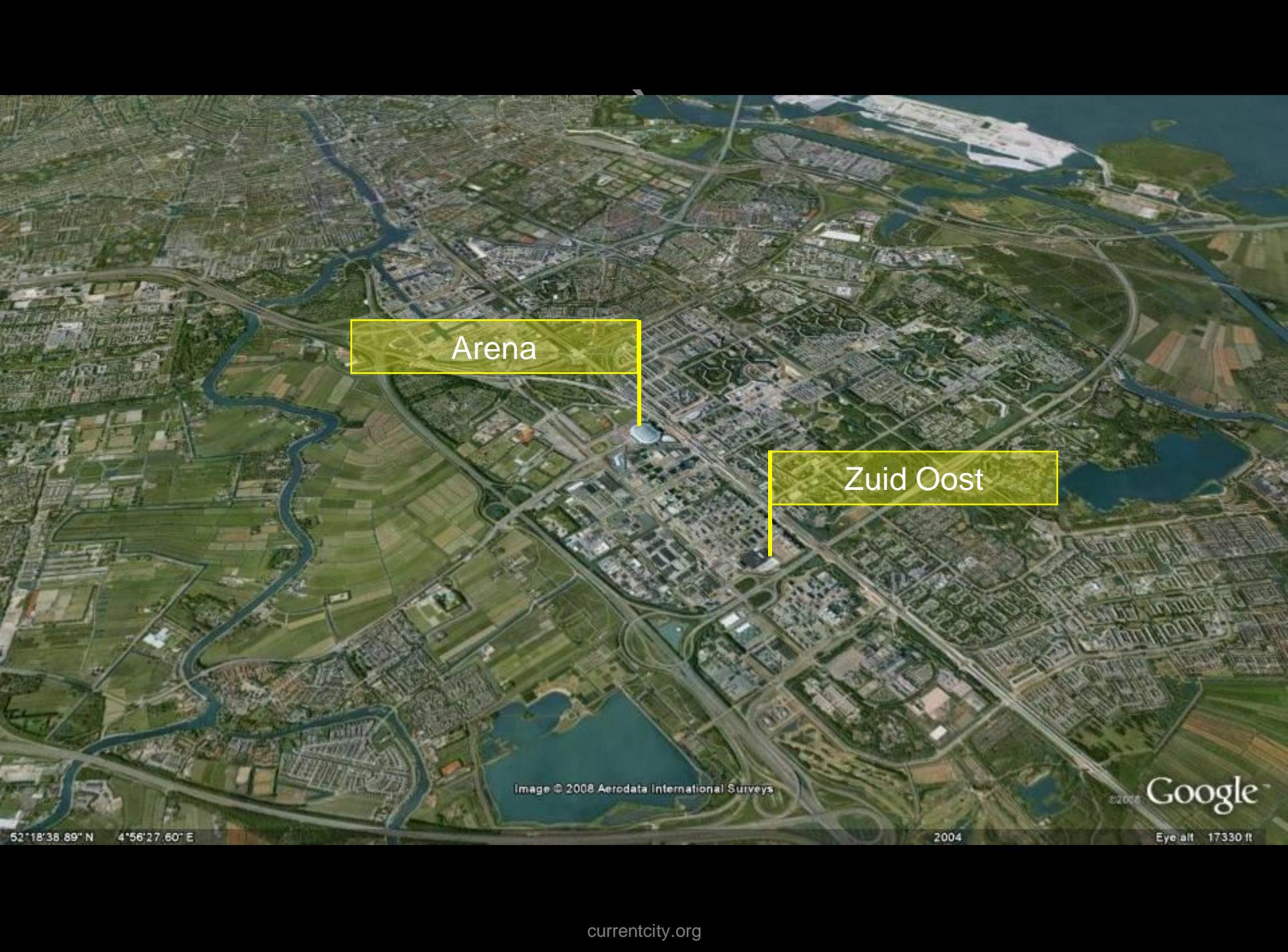
Image © 2008 Aerodata/International Surveys

Google

2004

Eye alt 17330 ft

52°21'12.23"N 4°53'21.62"E



Arena

Zuid Oost

Image © 2008 Aerodata International Surveys

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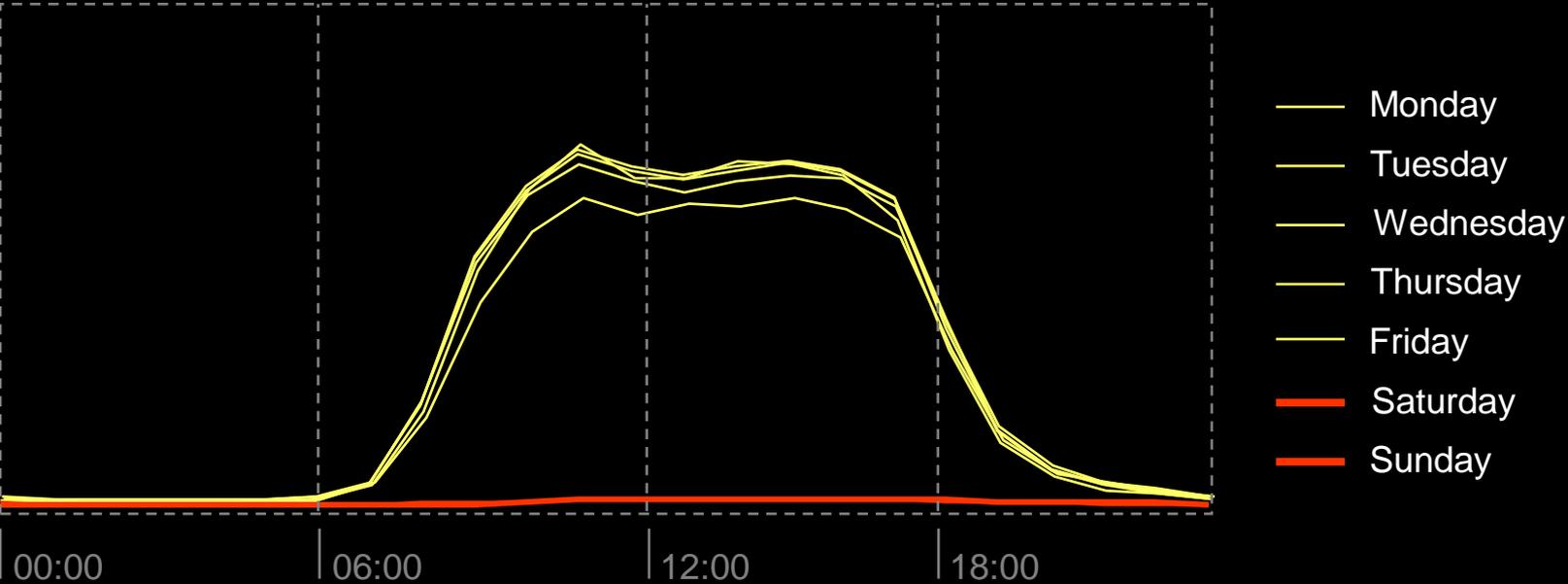
52°18'38.89" N 4°56'27.60" E

2004

Eye alt 17330 ft



World Trade Center

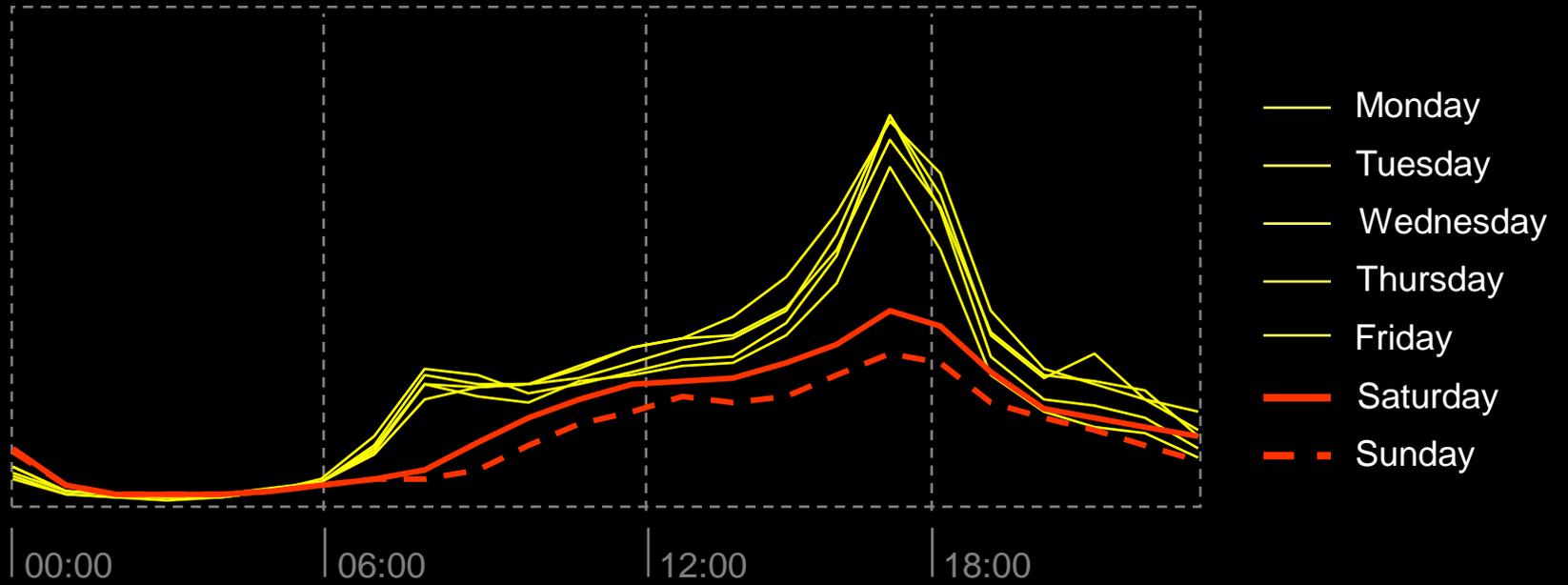


Aggregated call intensity



Source: bMA Amsterdam

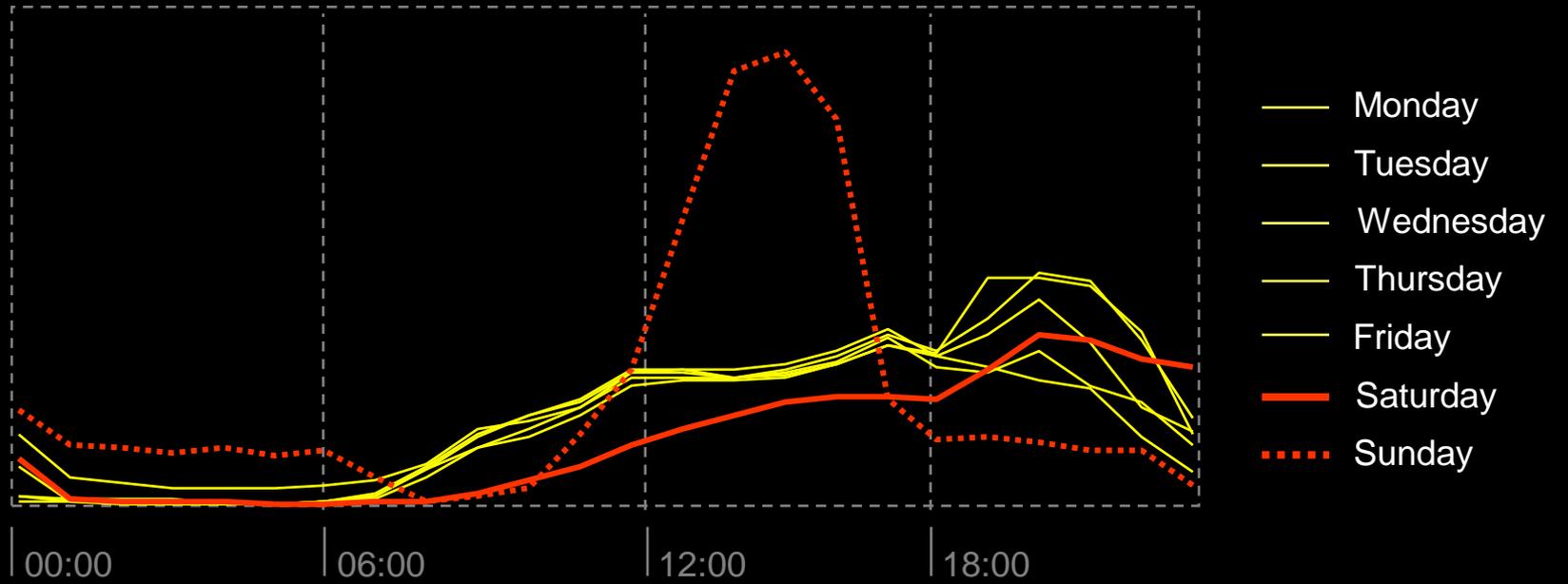
Central Station



Aggregated call intensity



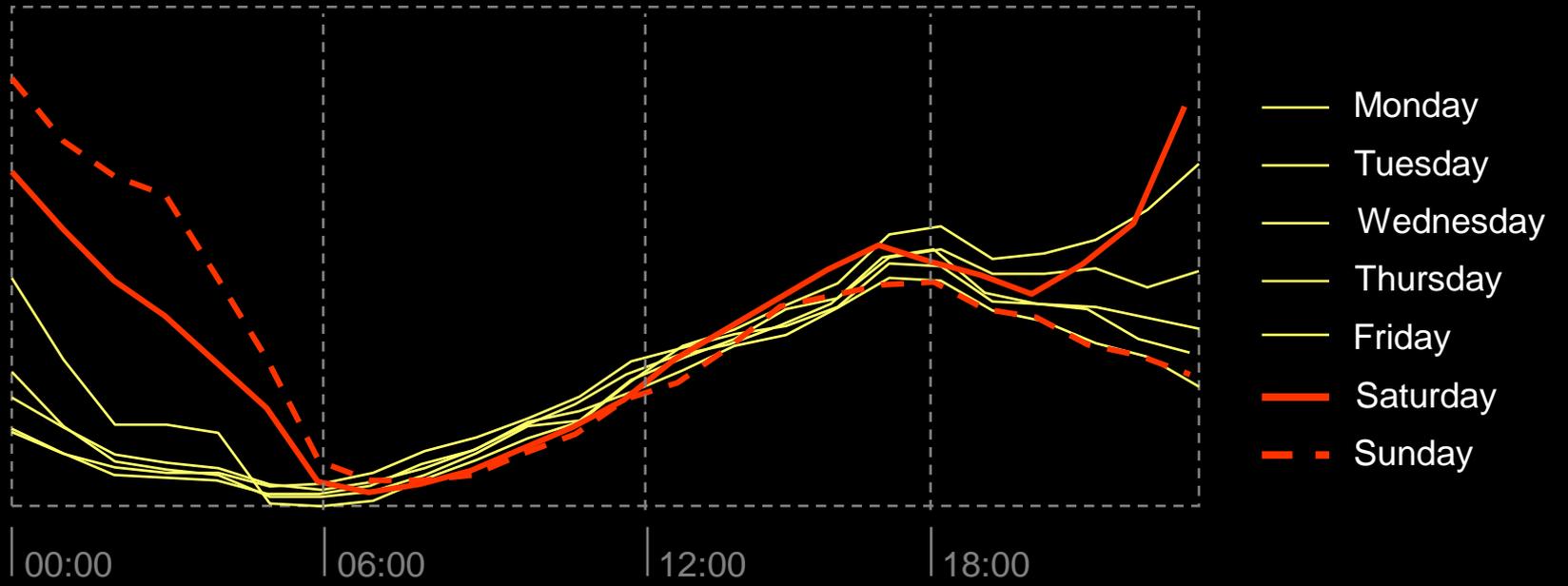
Amsterdam Arena



Aggregated call intensity



Rembrandtplein



Aggregated call intensity

Queens day (2008)



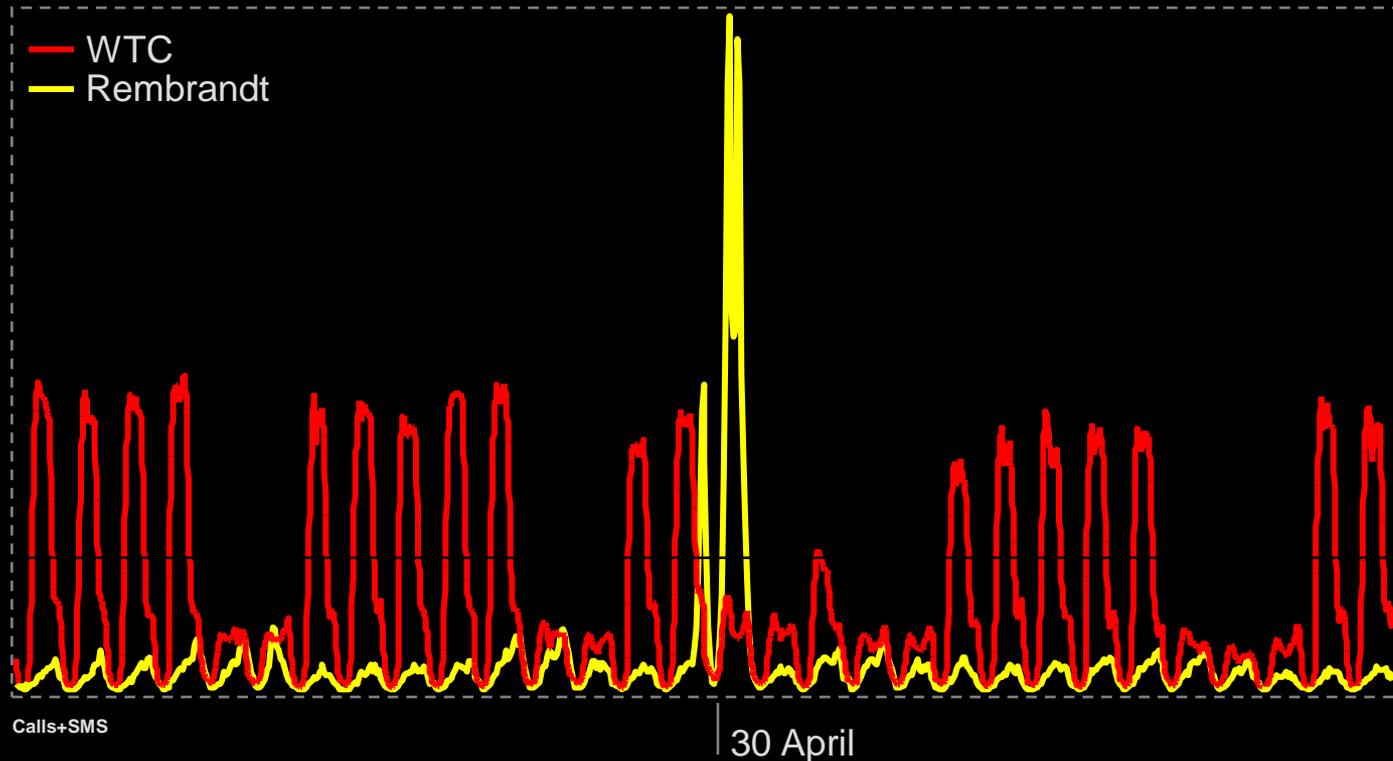


30 April 2008 14:30

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Visualization – Queens day

Heartbeat of the city



Creating normality maps to detect anomalies

Visualization Demand & Supply Transportation



REAL TIME 12:56

low high

Issues regarding telecom data

- Legal aspects and privacy
 - Directive 2002/22/EC (driver E112)
 - Aggregated anonymous data
 - Directive 1995/46/EC (protection personal 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, Intrix, ITIS Holding, Intellione, AIRSAGE, TomTOM, NAVTEQ, Globis Data..

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