Using Cellphone Call Data for Understanding Human Mobility Due to Large-Scale Events

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Research Team

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- Students
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  - Lucas Maia

Introduction

- Analyzing mobility patterns of mobile phone users can help us to understand some human dynamics, e.g.
  - for urban planning (as traffic, land occupation, network infrastructure, etc.)
  - for public health management (as disease spread control, etc.)
  - to better support ***large-scale events***
    - … huge number of people who move towards/from a specific place, in a determined time, to do something together.

Some Brazilian Large Scale Events

- Carnival
- Rock´n Rio
- New Year´s Eve Celebrations
- Religious events (Pope's Visit)
- Soccer Matches

Some Brazilian Large Scale *Sporting* Events

- 2014 Soccer World Cup
- 2016 Olympic Games

Our Goal

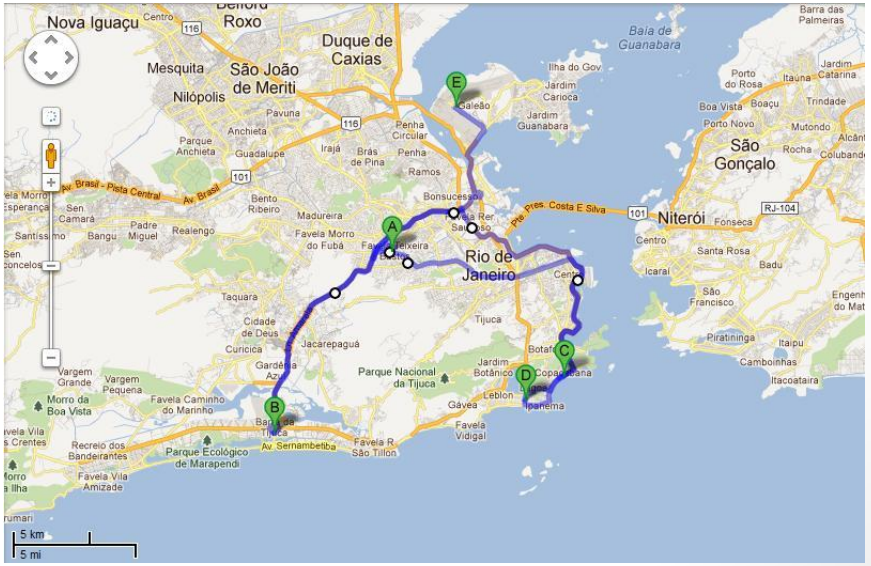
- *To characterize* and *to analyze* the human mobility and the workload dynamics of a mobile phone network in large scale events.

Characterization Methodology

Who moved towards the surroundings of the large-scale event when it took place?

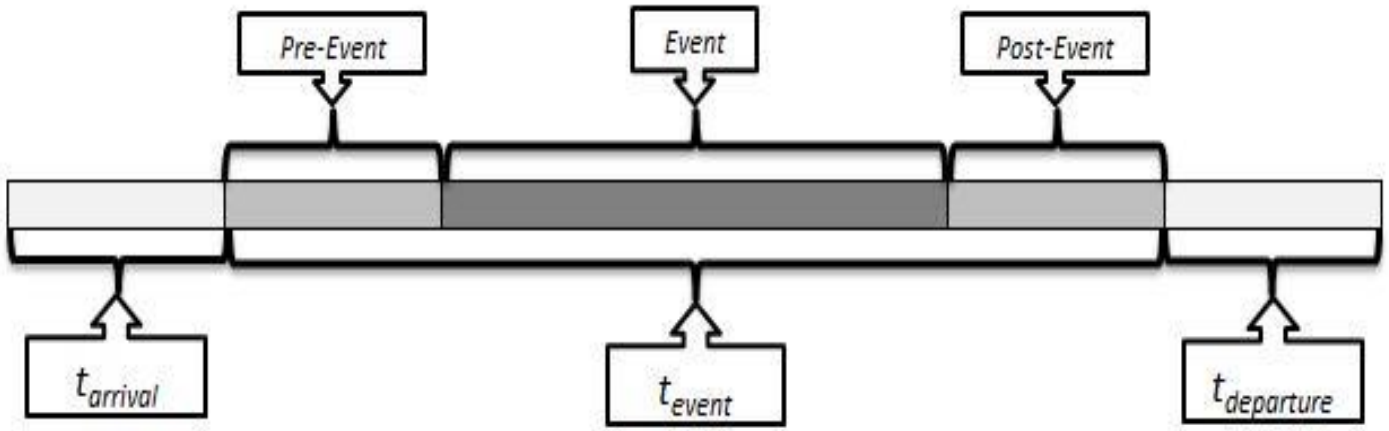
Where did they come from?

Where did they go after the event?



F. H. Z. Xavier, et al. "Analyzing the workload dynamics of a mobile phone network in large scale events," in *Proceedings of the UrbaNe Workshop – ACM CoNEXT 2012*, 2012.

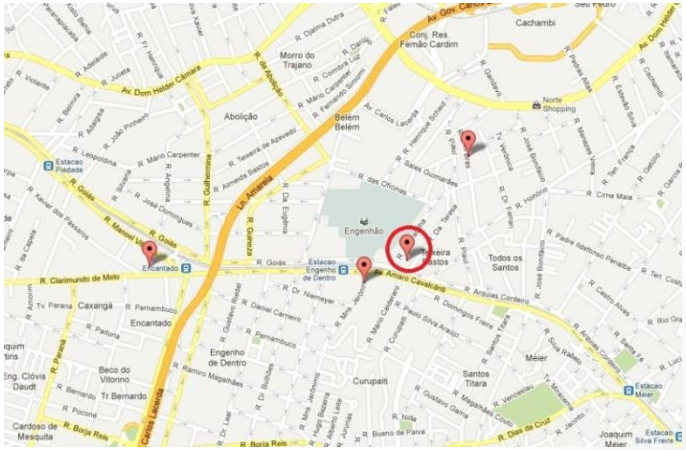
Timeline



Methodology Steps

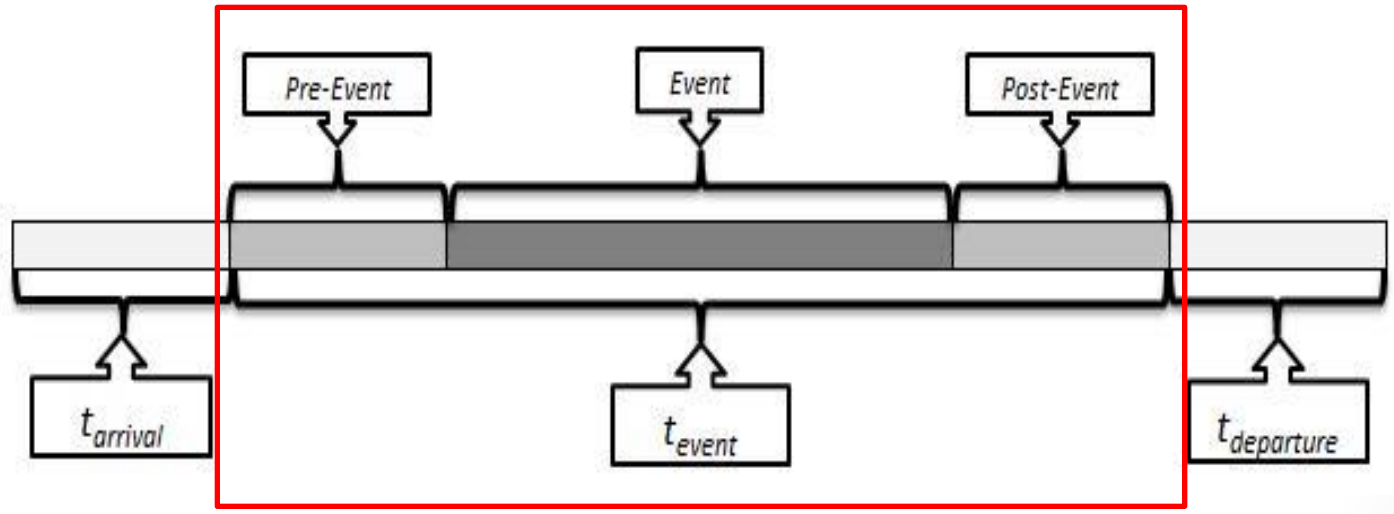
- ***First Step***
  - Identifying the antennas that cover the region where the event was held:
    - Indoor antennas of a stadium
    - Sectors of antennas which cover a square or celebration area

Antennas/sectors within a determined distance of the center of the event place



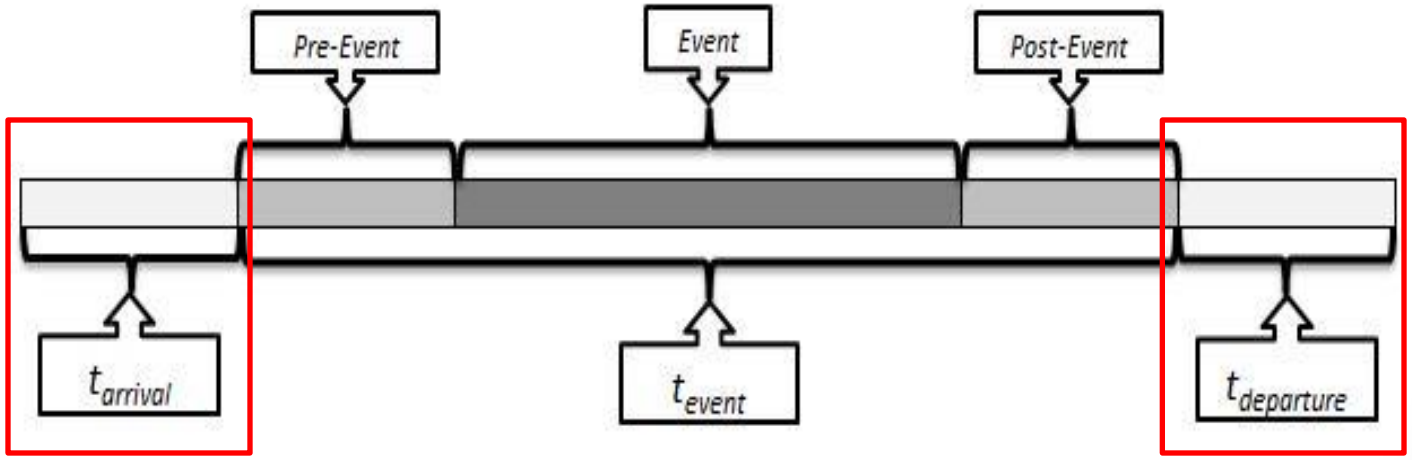
Methodology Steps

- ***Second Step***
  - Identifying users who made at least one call in the previously selected antennas/sectors during the t_{event}
  - We named these users as ***attendees***



Methodology Steps

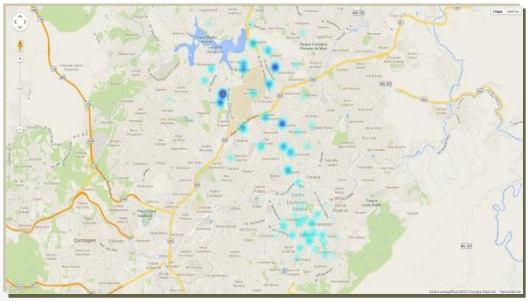
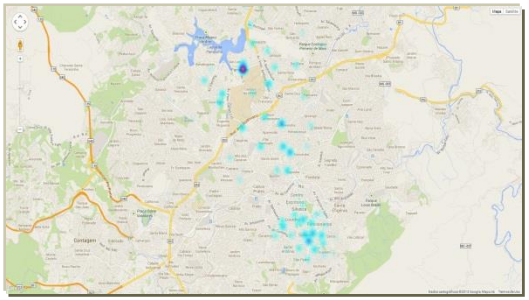
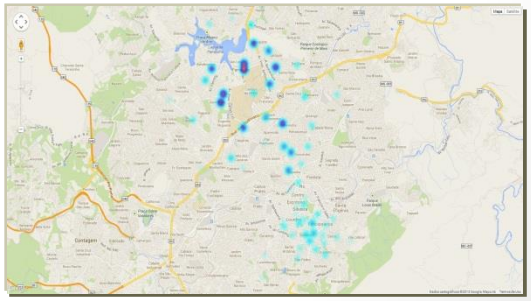
- ***Third Step (1/2)***
  - Identifying the *attendees* who made at least one call *before* the start or *after* the end of the event



Methodology Steps

- ***Third Step (2/2)***
  - Creating *heat maps* to represent the intensity of the activity in the mobile phone network
  - In this study, we used:
    - the geographical location of the antennas and
    - the number of calls that each antenna received

    for mapping the *movement* of the attendees incoming and outgoing the analyzed events

Datasets (1/2)

- Calls made *before*, *during*, and *after* some matches of both rounds of the 2011 Brazilian Soccer Championship at *Engenhão Stadium* in Rio de Janeiro



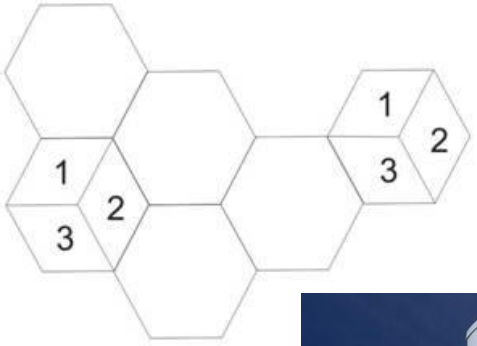
Datasets (2/2)

- Calls made *before*, *during*, and *after* some New Year´s Eve Celebrations in three large Brazilian cities: *Belo Horizonte* (BH), *Recife* and *Salvador*

- We have also analyzed an anonymized dataset with calls made on *a day without soccer matches or without any kind of celebrations*.

Datasets structure

- *Call Id*
- *User Id (anonymized)*
- *Start time of a call*
- *End time of the same call*
- *Start Antenna* (with its sectors)
- *End Antenna* (with its sectors)



Analyzed Days

- *Aug 28th, 2011 and Dec 04th, 2011*
  - These matches were between Vasco and Flamengo
  - There were about *33,500 fans* in each match (*~10,000 fans* of carrier who has 30% of the market share)

- *Dec 31th, 2011*
  - New Year's Celebrations in Belo Horizonte (*~100,000 attendees*), Recife (*~10,000 attendees*), and Salvador (*~1,000,000 attendees*)

- *Oct 30th, 2011 and Jan 03rd, 2012*
  - Days with no large-scale event

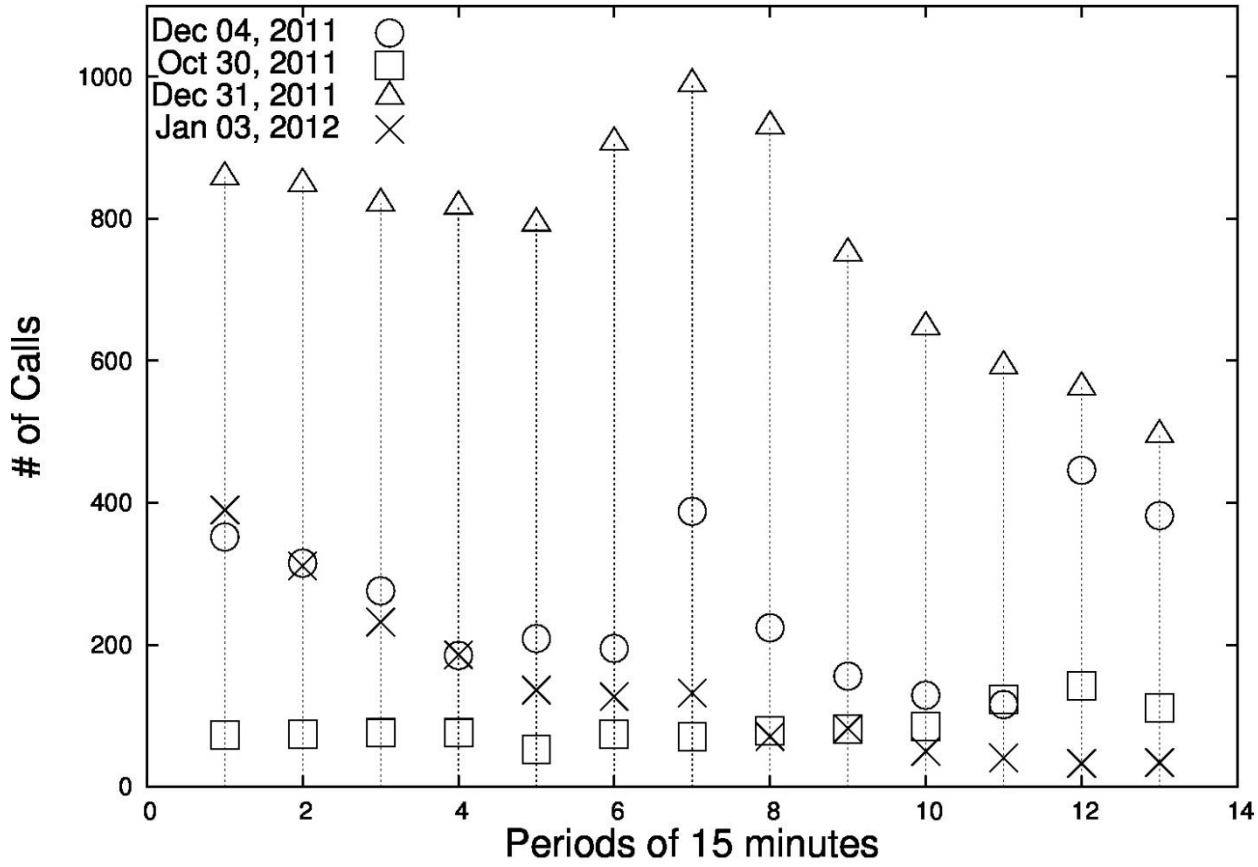
Workload Overview

- Calls made during all *timeline*

City	*Day*	*# of Calls done by Attendees*	*#Attendees*	*Average Calls per Attendees*
BH	**Dec 31, 2011**	***5,187 (45.7%)***	***1,938 (33,8%)***	***2.7 (+28.6%)***
	Jan 03, 2012	779 (15,8%)	365 (12,5%)	2.1
Recife	**Dec 31, 2011**	***9,951 (65.5%)***	***3,566 (50,1%)***	***2.8 (+33.3%)***
	Jan 03, 2012	924 (26,4%)	444 (21,0%)	2.1
Salvador	**Dec 31, 2011**	***12,826 (34.8%)***	***7,458 (38,8%)***	***1.7 (+13.3%)***
	Jan 03, 2012	1,019 (15.7%)	689 (17,0%)	1.5
Soccer 1 (Rio)	Aug 28, 2011	***3.362 (6.7%)***	***1.366 (4,7%)***	***2.5 (+38.9%)***
Soccer 2 (Rio)	**Dec 04, 2011**	***4,284 (9.0%)***	***1,754 (6,4%)***	***2.4 (+33.3%)***
	Oct 30, 2011	1,270 (3.1%)	691 (2,7%)	1.8

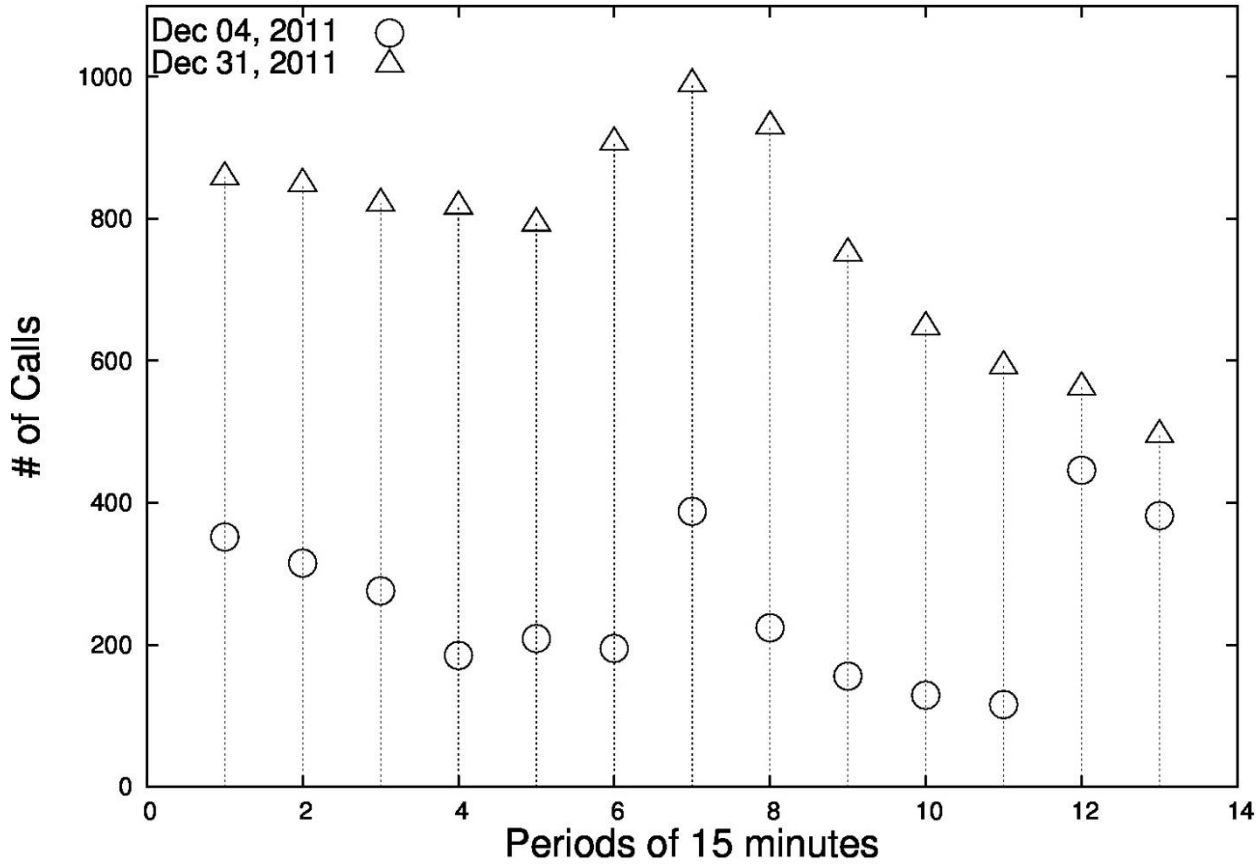
✓ The difference of the increased number of calls among New Year´s Eve Celebrations and Soccer Matches

Number of calls made by *attendees*



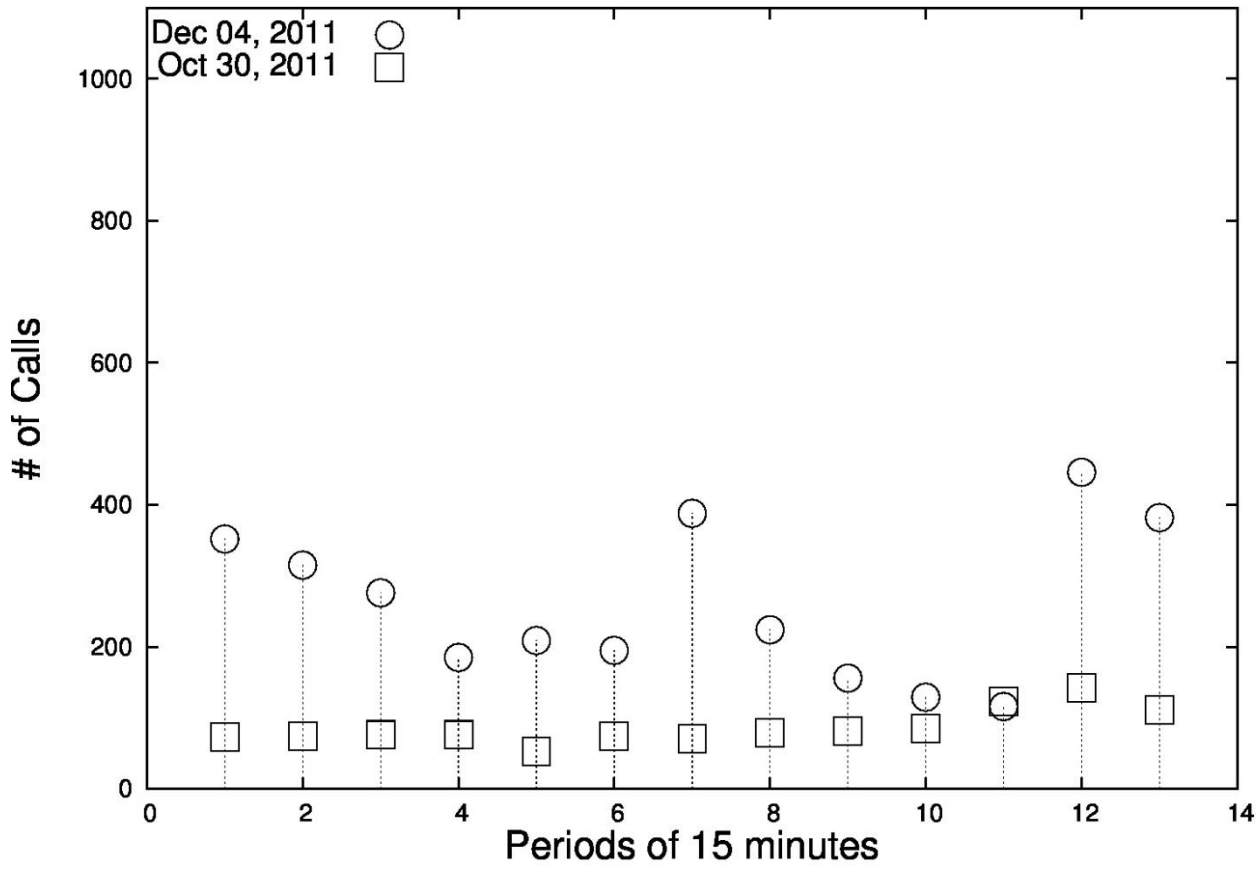
Recife´s New Year´s Eve Celebration, one of analyzed Soccer Matches, and days with no event

Number of calls made by *attendees*



Recife´s New Year´s Eve Celebration and one of analyzed Soccer Matches

Number of calls made by *attendees*



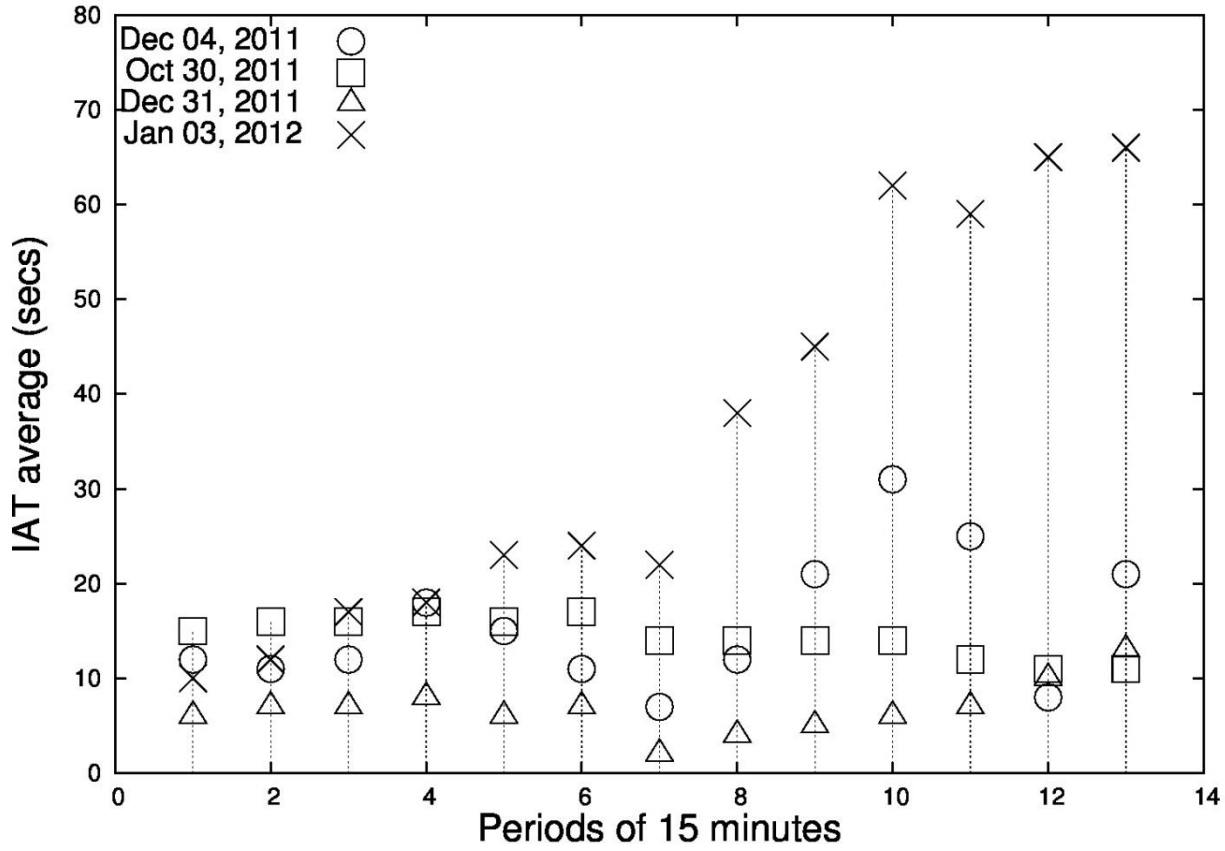
One of analyzed Soccer Matches and a day with no large scale event

Calls' Inter-Arrival Time (IAT)

City	*IAT Average (secs)*	S_{inter}	S_{intra}
BH	7,19	2,64	2,96
Recife	5,65	4,05	1,30
Salvador	12,45	8,02	11,63
Rio (04/12)	16,13	15,58	8,22
Rio (28/08)	33,84	46,71	29,82

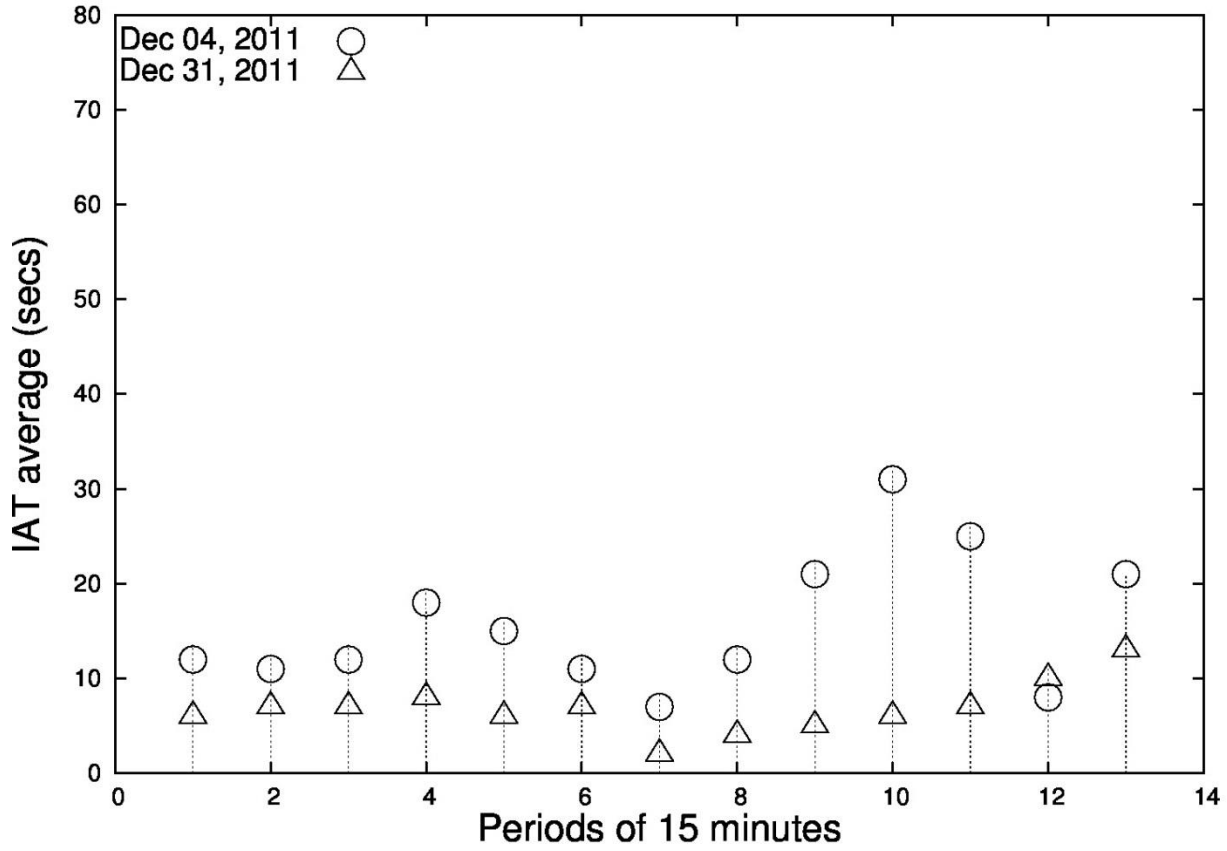
- S_{inter}: *average time of standard deviations of different antennas*
- S_{intra}: *average of standard deviations during the* t_{event}

IAT of calls made by *attendees*



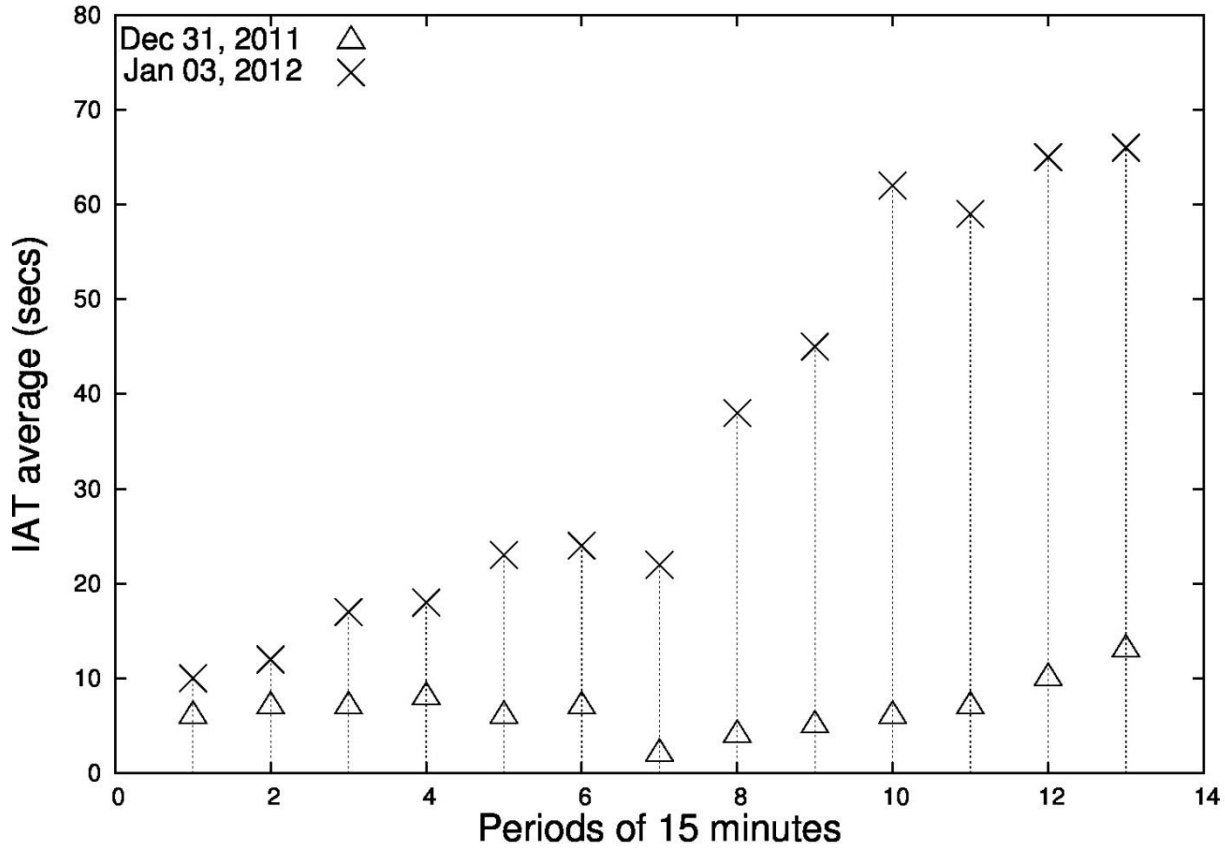
BH´s New Year´s Eve Celebration, one of analyzed Soccer Matches, and days with no event

IAT of calls made by *attendees*



BH´s New Year´s Eve Celebration, one of analyzed Soccer Matches, and days with no event

IAT of calls made by *attendees*



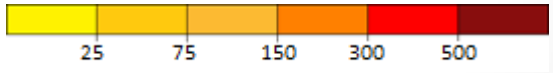
BH´s New Year´s Eve Celebration and a day without large scale event

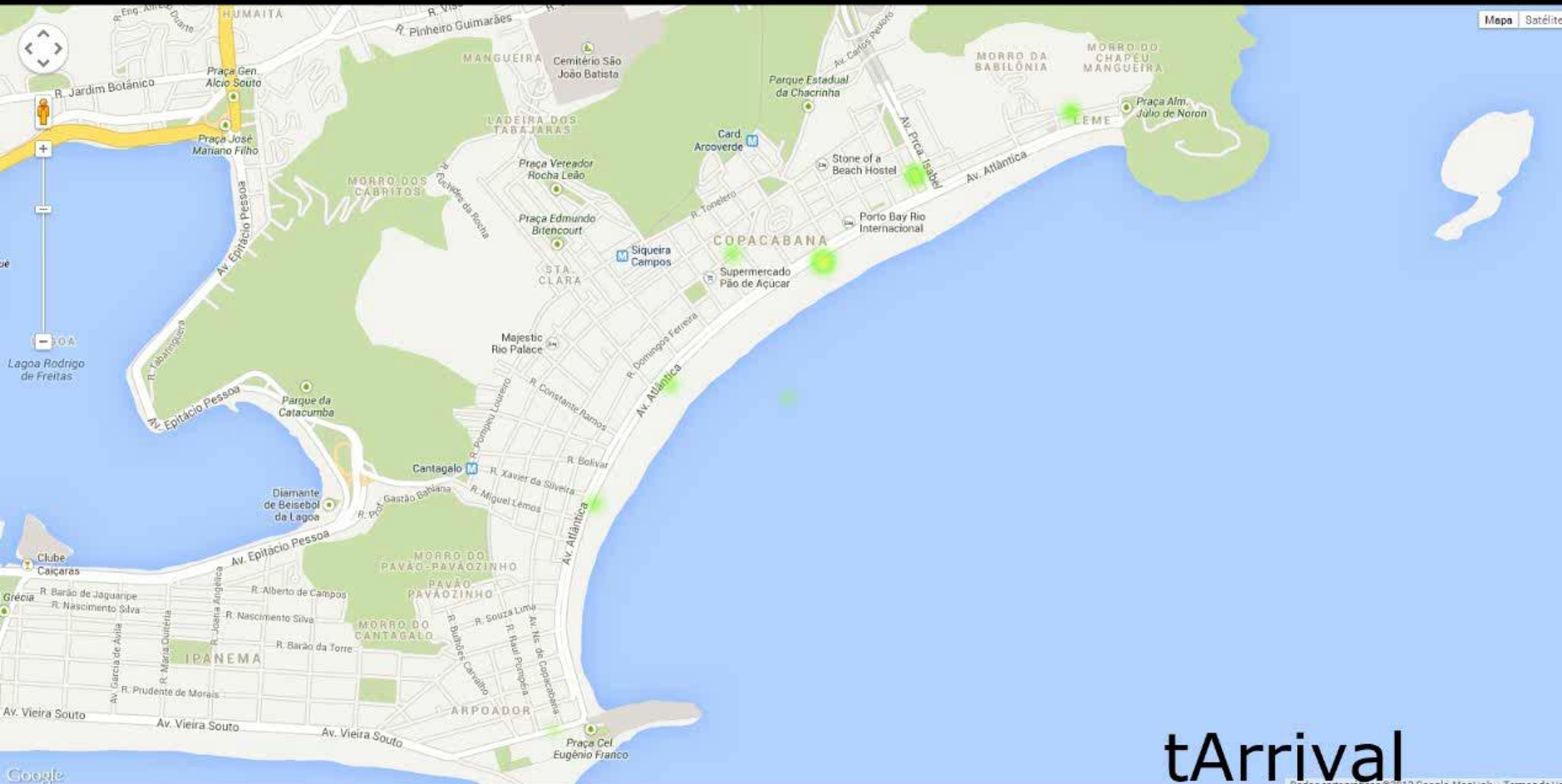
Heat Maps

(a) $t_{arrival}$

(b) t_{event}

(c) $t_{departure}$




Mapa
Satélite
HUMAITÁ
R. Pinheiro Guimarães
MANGUEIRA
Cemitério São João Batista
Praça Gen. Alcio Souto
R. Jardim Botânico
Praça José Mariano Filho
LADEIRA DOS TABAJARAS
Parque Estadual da Chacrinha
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Stone of a Beach Hostel
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R. Tabatinguera
Parque da Catacumba
R. Constante Ramos
R. Pompeu Loureiro
R. Bolivar
Cantagalo
R. Xavier da Silveira
Diamante de Beisebol da Lagoa
R. Prof. Gastão Bahiana
R. Miguel Lemos
Clube Caiçaras
MORRO DO PAVÃO-PAVÃOZINHO
PAVÃO-PAVÃOZINHO
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Termos de Uso

tArrival

Identifying Users' Movements

a) People who made calls using a specific antenna/sector
b) People who made calls in different antennas/sectors
c) People who started a call in an antenna/sector and finished it in another one

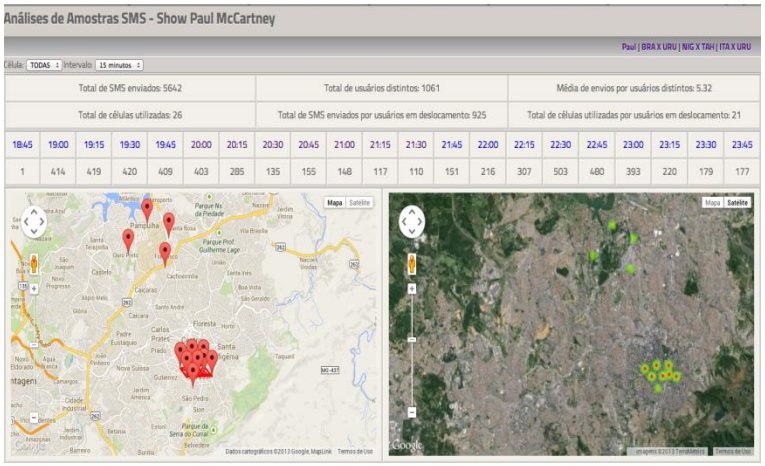
(a) $t_{arrival}$ (b) t_{event} (c) $t_{departure}$

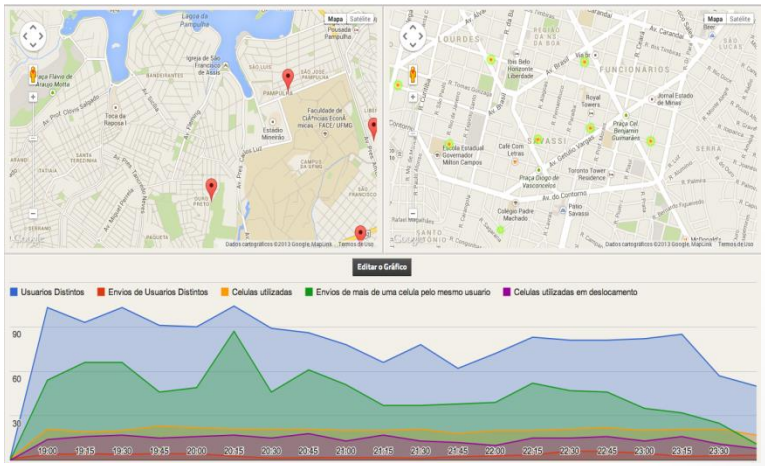
Next Steps (working in progress)

- We are analyzing other datasets
  - Rock Concerts
  - Formula 1 Grand Prix
  - Soccer matches

Next Steps (working in progress)

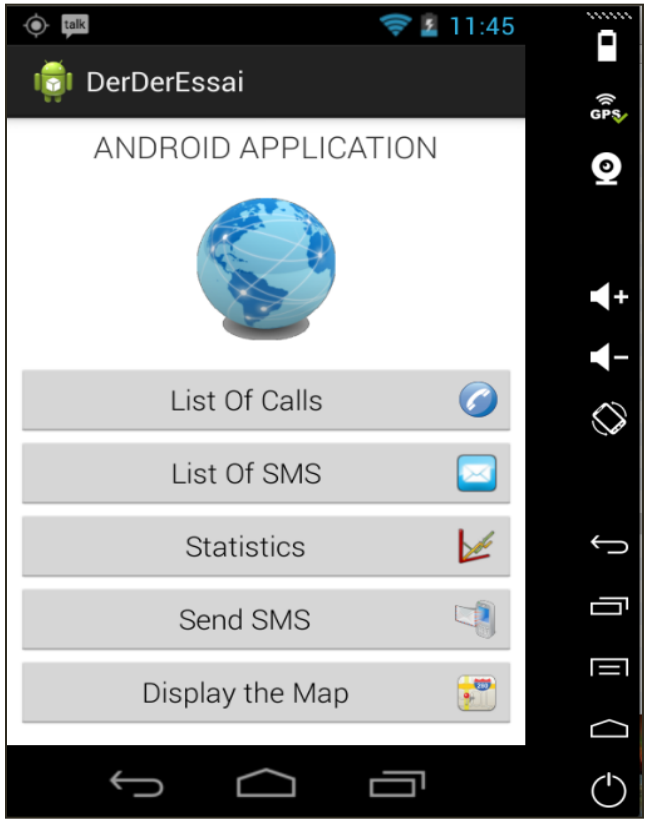
- We are also collecting and analyzing data about SMS (text messaging) and tweets sent due to large scale events

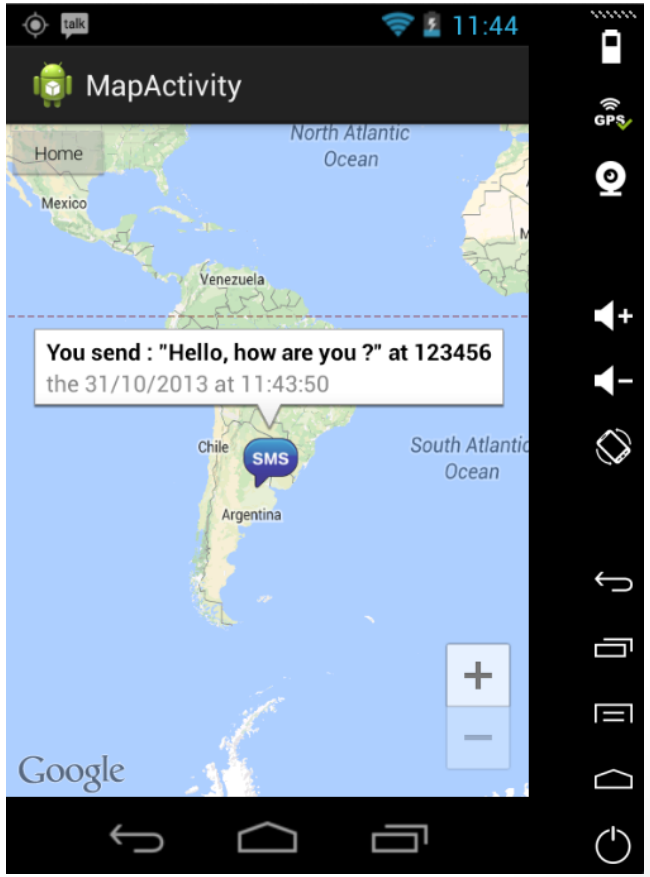




Next Steps (working in progress)

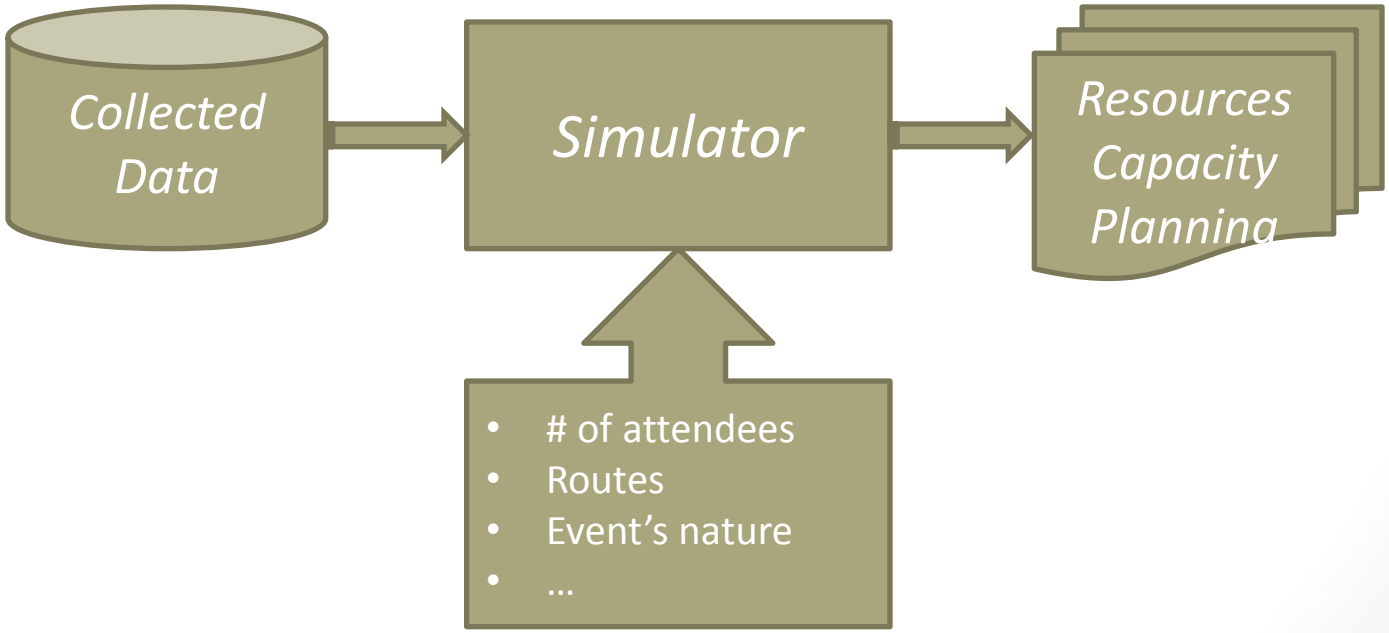
- We are building an app for collecting geo-located text messages





Next Steps (working in progress)

- We are building a simulating system to help carriers in planning the usage of their resources during large scale events



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Acknowledgements

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