***EU CHIST-ERA 2012 call – C3N***

*Context- and Content-adaptive Communication Networks*

# macaco - Mobile context-Adaptive CAching for COntent-centric networking

**4th CHIST-ERA Project Seminar**

March 19, 2015. Madrid, Spain

# **MACACO -** Context and Motivation

# The smartphone phenomena

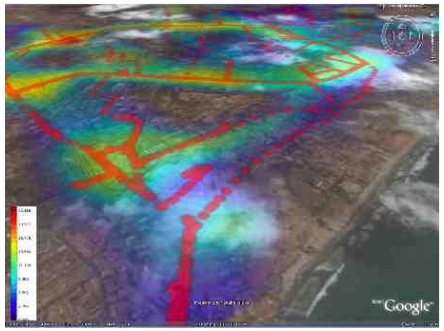
**Smartphones have the potential to be:**

visually-aware
sonically-aware
always-connected
directionally-aware
location-aware
motion-aware

+

In 2013, 4.1 billion users worldwide

=




- New potential for wireless and pervasive applications
- Increasing volume of mobile data between 2014-2018
  - "…worldwide mobile data traffic will increase nearly **11-fold** over the next four years and reach **an annual run rate of 190 exabytes** ($10^{18}$) by 2018…"
  - 54% of mobile connections will be 'smart' connections by 2018

[Cisco VNI Global Mobile Data Traffic Forecast (2013-2018)]

# macaco New demands: **Increased data usage**

The New York Times

Customers Angered as iPhones Overload AT&T

By JENNA WORTHAM
Published: September 2, 2009

Slim and sleek as it is, the iPhone is really the Hummer of cellphones.

Data offloading solutions are required to deal with such increasing volume of mobile data traffic.

IEEE SPECTRUM

The Great Radio Spectrum Famine

Mobile broadband is consuming spectrum. Serving up more won't be easy

By Mitchell Lazarus
Posted 30 Sep 2010 | 15:14 GMT

Data offloading :
use Wi-Fi/small cell access instead of 3G if possible

iPhone overload: Dutch T-Mobile issues refund after 3G issues

It's not just AT&T-Mobile in the Netherlands offers the iPhone and it's now …

by Iljitsch van Beijnum - June 7 2010, 4:15pm RST

Of the three mobile network operators in the Netherlands, only T-Mobile sells the iPhone. And only T-Mobile has a large part of its customer base irate from lack of 3G data access, dropped calls, and calls going directly to voicemail even with full 3G coverage.

ars technica

# Focus and intuition

- Current data offloading solution:
  - Use WiFi connectivity if available and if not, use 3G.
- Our focus : a more intelligent data offloading strategy
  - Build data offloading mechanisms that take advantage of **context** and **content information**

- Intuitions:
  - to **extract** and **forecast** the behaviour of mobile users in the three-dimensional space of **time, location** and **interest**
    - **'what', 'when' and 'where'** users are pulling data from the network
  - to **pre-fetch** the identified data and **cache** it at an earlier time
    - at the mobile terminals or at the edge nodes of the network

# Project contributions

1. To acquire real world data sets to model mobile node behaviour in the three-dimensional space : Originality

2. To derive appropriate models for the **correlation between user interests and their mobility** : Originality

3. To derive simple and efficient prediction algorithms to forecast the **node's mobility and interests** : Originality

4. To output data pre-fetching mechanisms
   1. To integrate content-centric caching approach with social context awareness and opportunistic resource availability : Originality

5. To design a federated testbed for (no commercial interest):
   1. Content and context data collection
   2. Assessment of off-loading solutions

# **MACACO** Project organization

# Project Consortium

- 6 international partners
  - INRIA coordination
  - 5 European partners and 1 Brazilian Institution
    - INRIA, N7, SUPSI, UOB, CNR, UFMG
  - 4 funded and 2 non-funded institutions
  - Funding organizations: ANR, SNSF, EPSRC

- Funding ~1M€ for a total effort of 277 MM

Agence Nationale de la Recherche ANR

EPSRC Engineering and Physical Sciences Research Council

FNSNF Swiss National Science Foundation

# Consortium

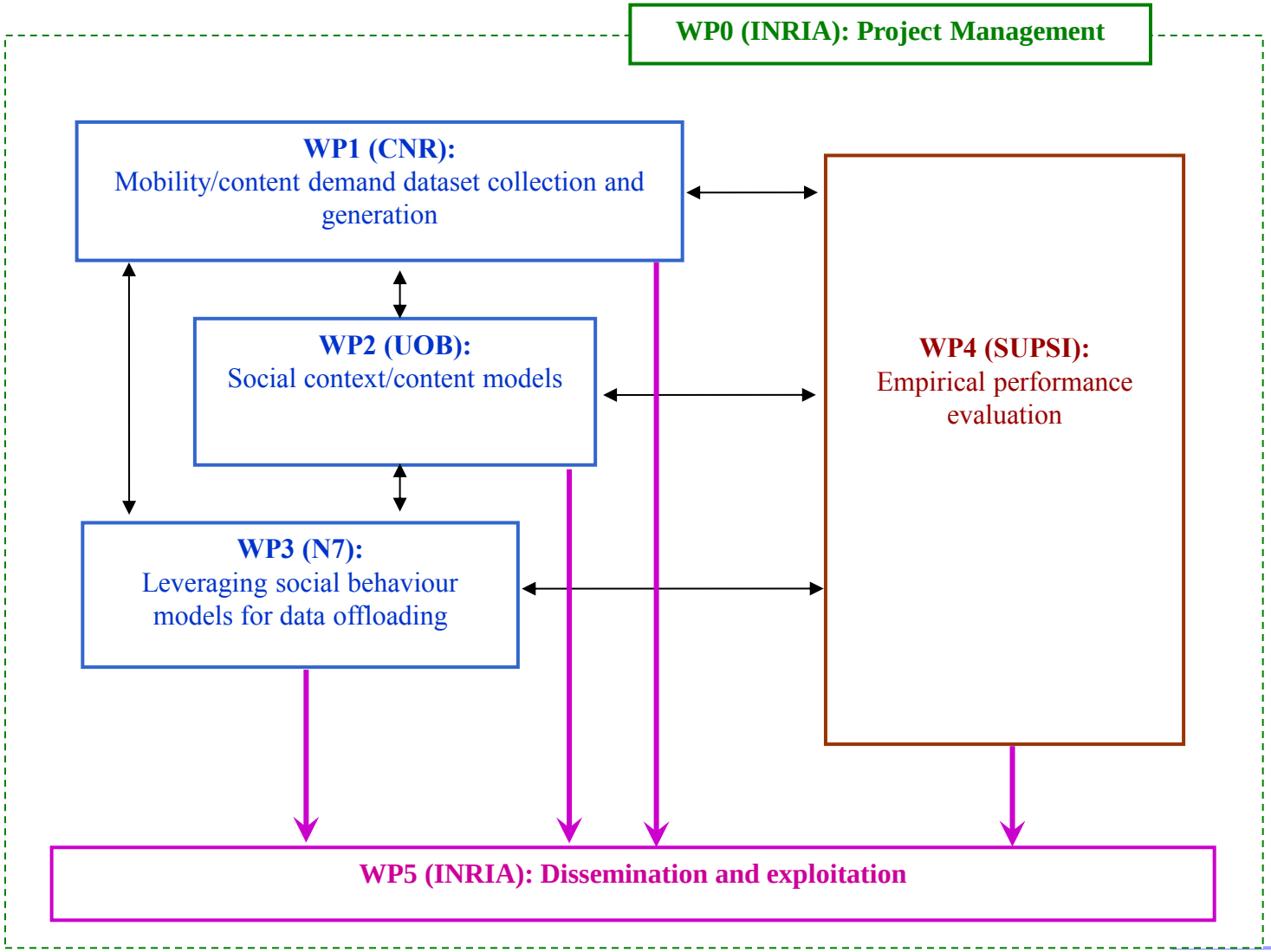
Brazil

UFMG

Pedro O. Vaz de Melo

# MACACO organization

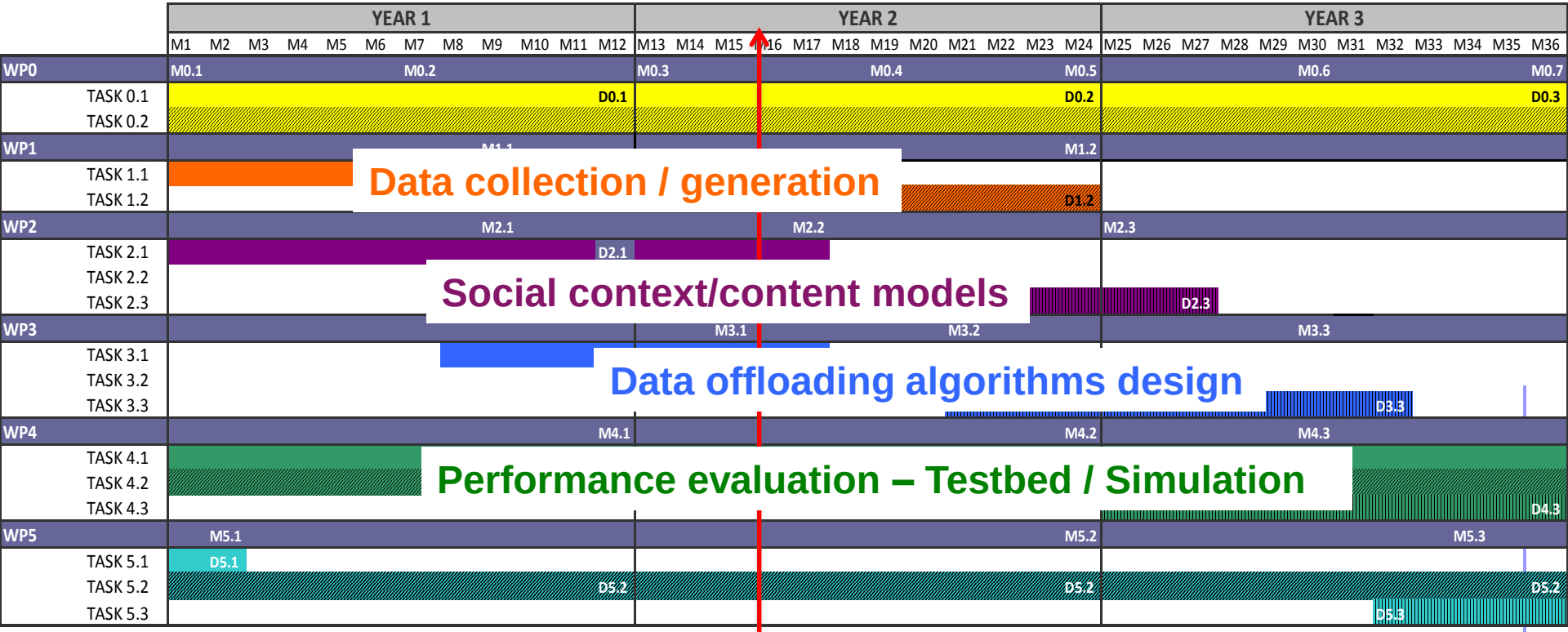
- Duration: 36 months, 6 Work Packages



# MACACO consortium : partner skills

| | INRIA | N7 | UOB | SUPSI | CNR | UFMG |
|---|---|---|---|---|---|---|
| Data collection | | | ■ | | | |
| Large scale data generation | | | | | ■ | |
| Context prediction models | | | ■ | | | ■ |
| Social network analysis | ■ | | | | ■ | ■ |
| Opportunistic protocol | ■ | ■ | | ■ | | |
| Protocol performance evaluation | ■ | ■ | | ■ | ■ | ■ |
| Testbed experimenting | | ■ | ■ | ■ | | |
| Protocol standardization | ■ | | | ■ | | |

# Project timeline




Nov 2013
Kickoff, Paris

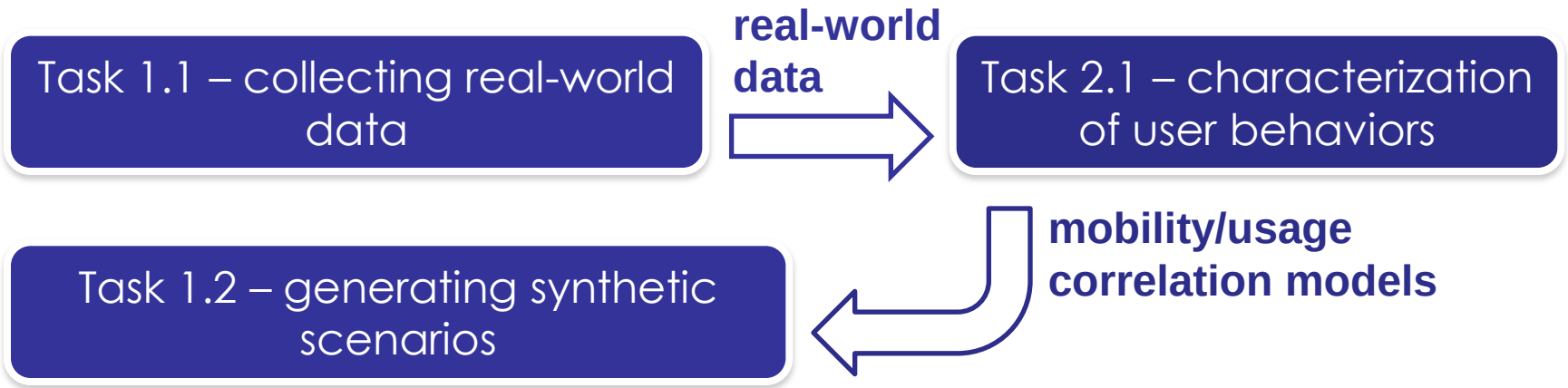
Nov 2014

Nov 2015

Project Seminar, Madrid-> Focus on WP1 and WP2 in this presentation

# WP1 – CNR-IEITT, Marco Fiore

- **Goal**: providing datasets coupling mobile users' movement patterns & service demand *(unavailable to date!)*
  - Collection of a significant **real-world** data sample
    - Small-scale (~100 smartphones with dedicated monitoring software)
  - Generation of **synthetic** mobility/usage datasets
    - Large-scale (order-of-thousand simulated users in urban scenarios)



# Data collection

- To configure smartphones to continuously collect user's context and content information
  - Context = location, networking environment (3G, WiFi, BT), motion (accelerometer, proximity)
  - Content = apps that have created traffic in up and downlink, native browser URLs

- The testbed may be composed of users:
  - Using the acquired MACACO smartphones
  - Using their own smartphones with the deployed application installed
    - Incentivizing Android users (work colleagues, students, family, etc) to participate of the testbed
  - The same application for the two cases
  - In the 5 countries of MACACO

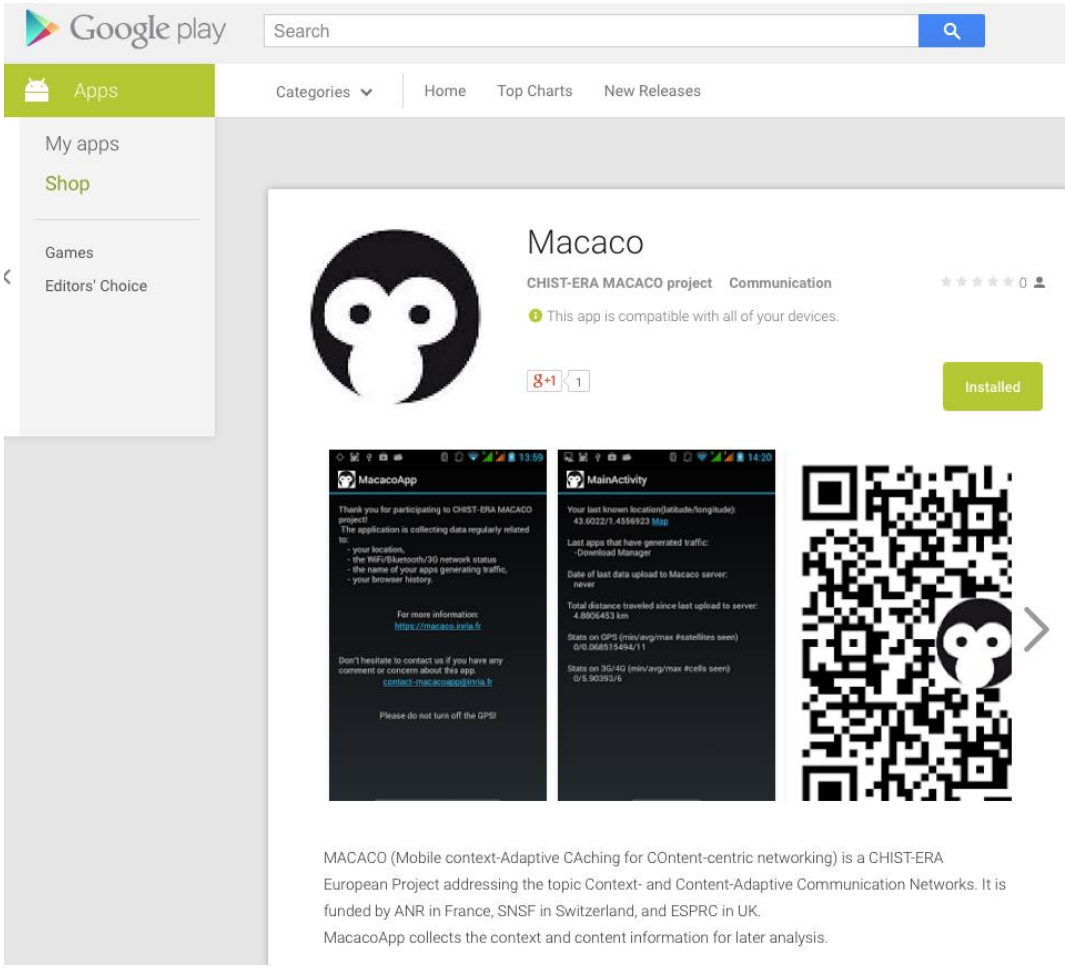
# Progress on WP1 – data collection

Macaco testbed and infrastructure for WP1:

- Software developments for data collection:
  - **Final version** of **data collection application** for Android smartphones is available
  - Energy consumption optimization
  - Data storage optimization
  - Included survey on **Personality traits** (Big Five questionnaire)
  - Client – server application for **uploading** gathered data
- Complete backup architecture (Servers in Toulouse and Paris)
- **Anonymity and privacy issues** handled according to best practices in EU with CNIL (French privacy body)
  - Data encryption on the phone,
  - User privacy with Hash SHA256,
  - Secured communication of app with Macaco servers.

# Data collection: the app

- MACACO App available for Android



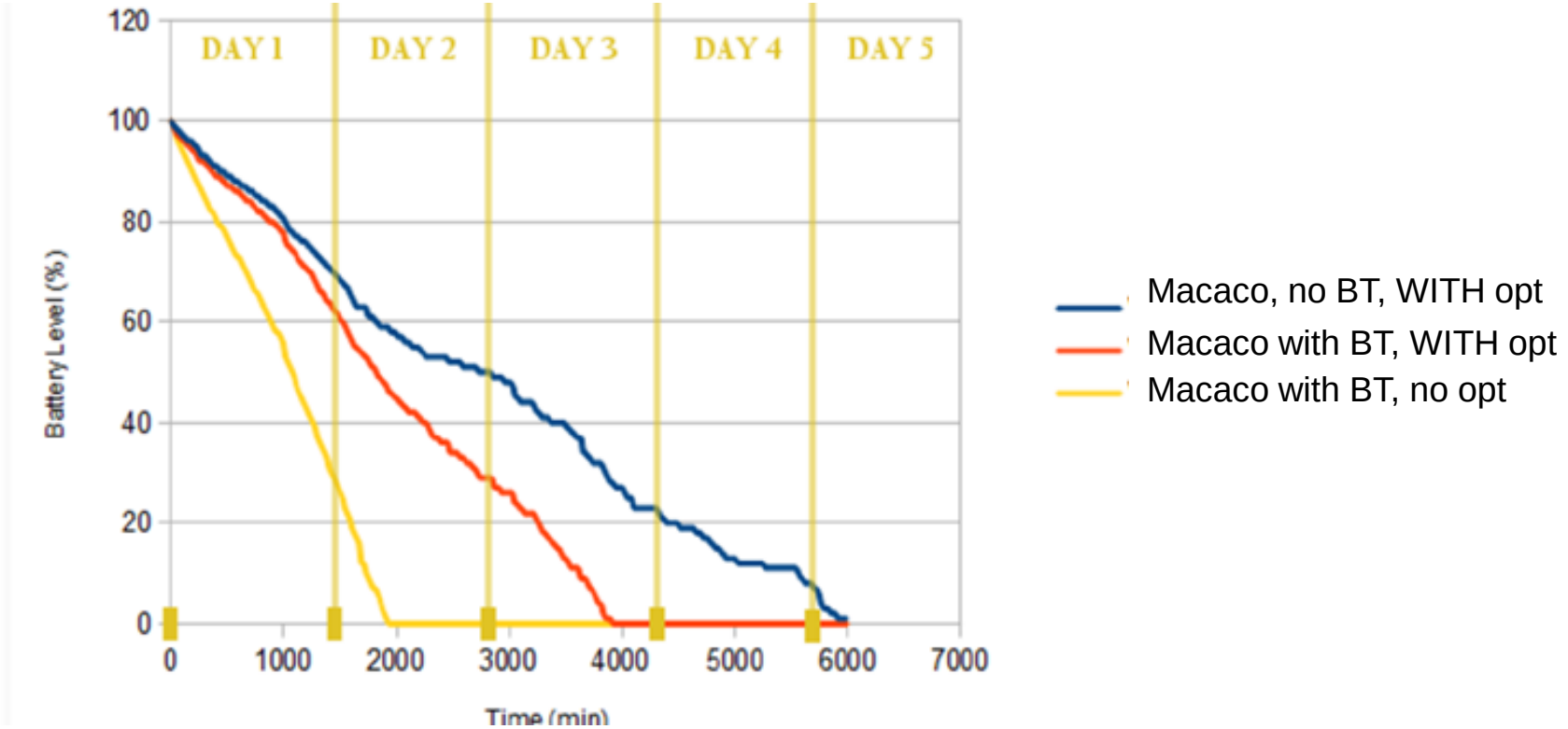
# Data collection: the app

Macaco App: Design of an energy optimization heuristic

- If no mobility then no GPS measurement

Results

- Impact of Bluetooth is really important
- Real energy savings.

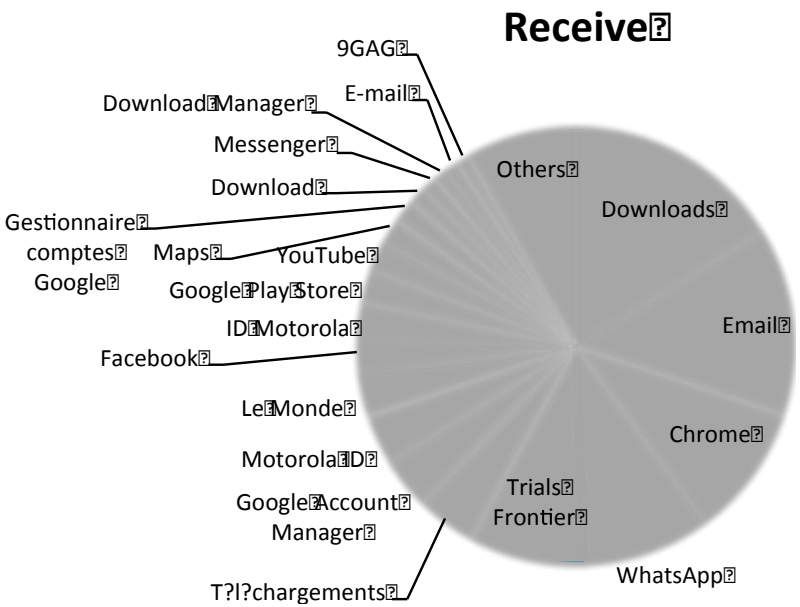


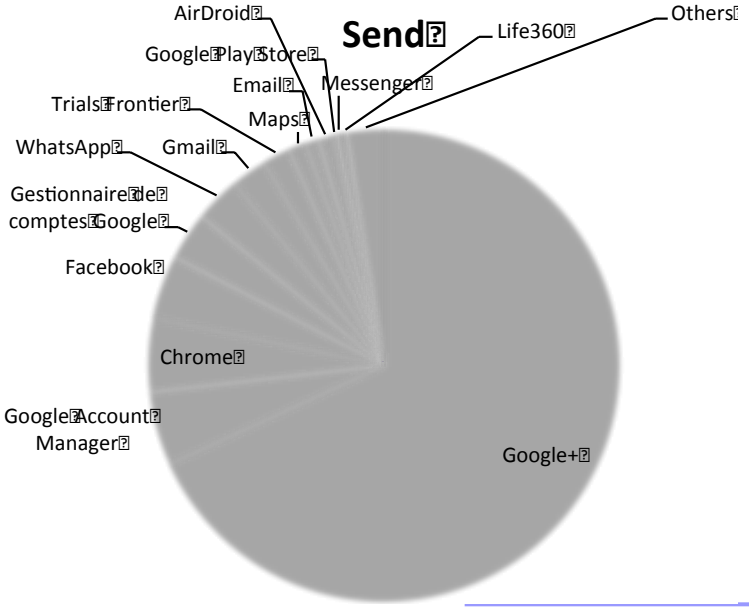
# Data collection phase

- Deployment and data collection
  - Delayed because of longer than expected App development.
  - Main data available by summer 2015.
- First data available
  - Measurements with 9 phones for 3 days at ACM/IFIP/USENIX Middelware conference in December 2014
  - Colleagues / project member testings
- Upcoming deployment
  - Will be launched by all partners of the project
  - Several incentivizing methods will be tested
    - Lend a Macaco smartphone to students for 6 months to 1 year, pay data plan.
    - Reimburse personal data plan if Macaco is being used
    - Lottery to have users participate for a minimum amount of time to the experiments

# Some stats on collected data

- 1st version, 24/4/2014 - 15/6/2014, 11 devices, 938 measurements
- 2nd version, 11/7/2014 – 12/3/2015, 31 devices, 411321 measurements
  - 2669 IP v4 addresses, 9131 Bluetooth addresses,
  - 59384 Wi-Fi addresses (29160 names)
  - 4717 Browser History
  - Apps generate traffic: 122, receive/send 10551/3798 MBytes



# WP2 : Social context/content models

- Requires the data of WP1
- Studies have already started using other data traces
  - that however lack the complete content description of Macaco
- First modelling results have been published:
  - A framework for profiling access network state from measurements of the mobile traffic generated by subscribers [Infocom 14].
  - A measurement-driven modelling of mobile data traffic usage of smartphone subscribers from a large-scale dataset collected from a major metropolitan 3G network [Percom 2015]
  - RECAST algorithm to classify dynamic user interactions by separating random ties from social ones [MSwim 2014]
  - Code offloading on opportunistic computing. [Percom Demo 2014]
  - Investigation of human mobility in terms of relevance, time and distance. It analyses the variables that characterize the way humans move among PoIs. [IEEE PerMoby workshop 2014]

# Organizational setup

- Timeline related to WP1.1
  - March 2014 : Version 1.0 of data collection application
  - April 2014 – May 2014: Alpha version app tests at N7, UOB and SUPSI

- Timeline related to WP2.1 and WP1.2
  - Manpower WP1.1/WP1.2
    - **3-month internship** at N7 for data application development finalization (March-May 2014)
    - **3-month PhD** at N7 support for supervision and roll out of data collection testbed, first analysis (May-July 2014)
  - Manpower WP2.2
    - **Post-doc recruitment** at UOB to start in April 2015
    - **3-years PhD** at INRIA to work on datasets modeling (not funded by Macaco)
    - **6-month internship** at INRIA for data modeling (May-Nov. 2015)
  - Manpower WP3
    - **12-month post-doc** at N7, started in January 2015

# Ressources and funding

| Partner | Person.months | Total costs | % of requested budget |
|---|---|---|---|
| INRIA | 12.07 | 62,146.85 € | 39.5% |
| N7 (INP Toulouse) | 18 | 32,664 € | 22% |
| University of Birmingham | 2 | 16,771.93 £ | 5% |
| SUPSI | 16 | 97,698.76 CHF | 25% |

The UK partner, Mirco Musolesi, is joining University College London in June 2015

# Collaborative set-up

- GranData company collaboration
  - bringing cellular datasets access to MACACO

- PRIVA'MOV project (IMU LABEX), **Marco Fiore (CNR) implication**
  - *Goal:* to develop and deploy a privacy-aware crowdsensing platform to collect mobility traces from real users
  - Collaboration already started
  - MACACO will share data collection and analysis experiences with PRIVA'MOV participants

- GOMOBILE project (N7 and LPT lab (Theoretical Physics Lab, Toulouse))
  - Accepted project : Google Matrix analysis of dynamic networks
  - 3-year PhD related to WP2 of Macaco.
  - Funding : Toulouse University and Region Midi-Pyrénées

# Meetings

| Date | Location | Purpose |
|---|---|---|
| Nov 25, 2013 | Paris | Kickoff |
| Feb 3, 2014 | Skype | Data collection application |
| Apr 25, 2014 | Skype | Data collection application |
| May 21, 2014 | SUPSI, Lugano | First semester meeting |
| Jun 18, 2014 | Skype | MACACOApp development and legal issues |
| Jul 1, 2014 | Skype | MACACOApp development and legal issues |
| Oct 21, 2014 | CNR, Torino | Second semester meeting |

# Issues encountered

- Delayed WP1 (**6 months** delay)
  - Difficulty to hire full-time developers for app development
  - Long management of legal / privacy issues related to data collection
  - Shift in funding start for a partner (UOB)
  - Main risk already highlighted in the proposal

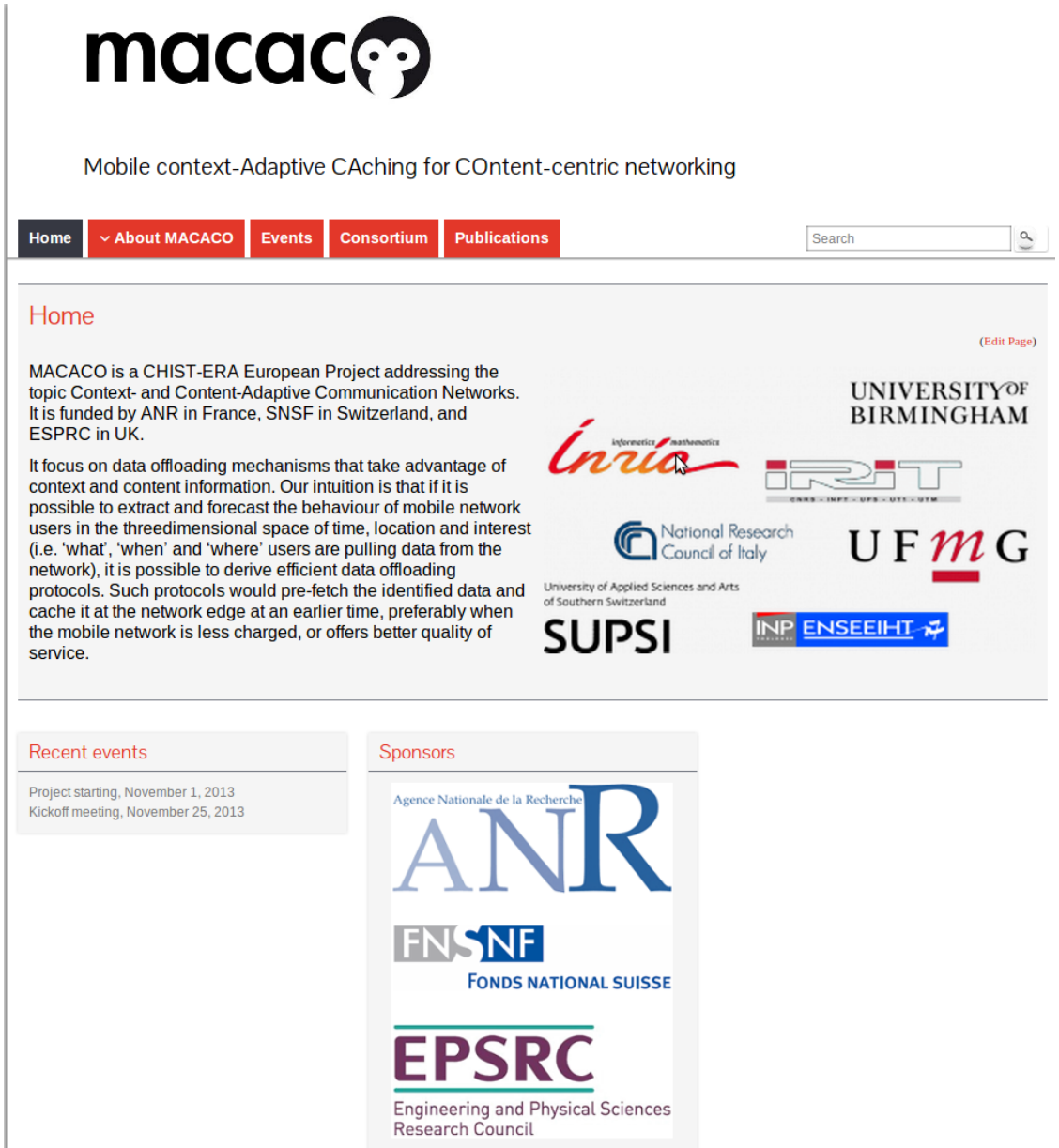
- WP2 has still started on time with **other real-world datasets**
  - That miss a good description of the content of exchanges
  - But that can be easily improved with Macaco data

- WP2 and WP3 have started with two post-docs in 2015 and 1 PhD
  - Jan 2015 – Feb 2015 : post-doc at N7
  - Apr. 2015 – April 2016 : post-doc at UOB
  - Oct 2014 – Oct 2017 : PhD at Inria

# MACACO publications


1. P. Olmo V. de Melo, A. C. Viana, M. Fiore, K. Jaffres-Runser, F. Le Mouel, A. A. F. Loureiro, Lavanya Addepallib, and Chen Guangshuo. RECAST: Telling Apart Social and Random Relationships in Dynamic Networks**.** To appear at **Performance and Evaluation Elsevier Journal. 2015**.
2. E. Mucceli A. C. Viana, K. P. Naveen, and C. Sarraute. *Measurement-driven mobile data traffic modeling in a large metropolitan area*. **IEEE Percom.** Missouri. March, 2015
3. Alan Ferrari, Dario Gallucci, Daniele Puccinelli and Silvia Giordano. Detecting Energy Leaks in Android App with POEM. **(PerMoby'15) of IEEE Percom**. St. Louis USA, Mar 2015.
4. Alan Ferrari, Daniele Puccinelli and Silvia Giordano. Managing your privacy in Mobile Applications with Mockingbird. *2015 IEEE International Conference on Pervasive Computing and Communications Work in Progress (WiP'15)*. St. Louis USA, Mar 2015.
5. Eduardo Mucelli Rezende Oliveira, Aline Carneiro Viana, *From Routine To Better Network Services,* **IEEE/IFIP WMNC**, May 2014
6. Eduardo Mucelli Rezende Oliveira, Aline Carneiro Viana, *From Routine to Network Deployment for Data Offloading in Metropolitan Areas***, IEEE SECON**, June 2014
7. D. Naboulsi, R. Stanica, M. Fiore, *Classifying Call Profiles in Large-scale Mobile Traffic Datasets***, IEEE INFOCOM**, April 2014
8. Eduardo Mucelli Rezende Oliveira, Aline Carneiro Viana, *Routine-based network deployment for data offloading in metropolitan areas***. IEEE WCNC,** April 2014
9. Eduardo Mucelli Rezende Oliveira, Aline Carneiro Viana, Routine-based Network Deployment, **IEEE INFOCOM Student workshop**, April 2014
10. Kamini Garg and Silvia Giordano, Poster Abstract: Towards Developing a Generalized Modeling Framework for Data Dissemination, In Proceedings of the **12th European Conference on Wireless Sensor Networks** (EWSN), Porto, Portugal, February 2015.
11. Matteo Zignani, Michela Papandrea, Sabrina Gaito, Silvia Giordano and Gian Paolo Rossi; "On the key features in human mobility: relevance, time and distance"; **IEEE PERCOM,** March 2014
12. Steven Mudda, Silvia Giordano; "Mobile P2P Queries over Temporal Data"; **IEEE PerMoby,** March 2014.
13. Alan Ferrari, Daniele Puccinelli, Silvia Giordano; "Code Ofloading on Opportunistic Computing"; **Demonstrations track, IEEE PERCOM,** March 2014

# MACACO web site: *macaco.inria.fr*



# Any questions?