# MONOLOC, “Indoor positioning and Mobile Networks Management”

Javier Sainz

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# AGENDA

1. INTRODUCTION
2. CHALLENGES AND APPROACH
3. SYSTEM OVERVIEW
4. IMPLEMENTED SOLUTION
5. EXPLOITATION MODEL
6. CONCLUSIONS

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# INTRODUCTION
## PROJECT PARTNERS

- Advanced Management Platform for mobile and next-generation heterogeneous networks with user indoors location.








http://monoloc.creativit.com/

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# INTRODUCTION
## PROJECT OBJECTIVES

- **Development and validation of Technology Planning and Network Management to obtain a precise location** including inside buildings for mobile users in a networked environment and new generation mobile devices (Smartphone, LTE and Femtocells).
  - Development and validation of technologies for independent management of heterogeneous networks, which will optimize the performance of networks and resources
  - Development of prototype applications using these platforms

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# INTRODUCTION
## CHALLENGES (I)

- Movement towards a new paradigm of mobile network deployment. From large macro networks to client-side networks.
- Positioning
  - Application of mobile network positioning in indoor (beyond the cell ID)
  - Rather unstable positioning environment
  - Variety of techniques with non-straightforward applicability
  - Trade-off between cost and applicability
  - Terminal functionality and performance

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# INTRODUCTION
## CHALLENGES (II)

- New network schemes.
  - Self Organizing Networks
  - Interaction between customer side and core network. Self service.
  - Self-healing
  - Commissioning and decommissioning of mobile network infrastructure elements

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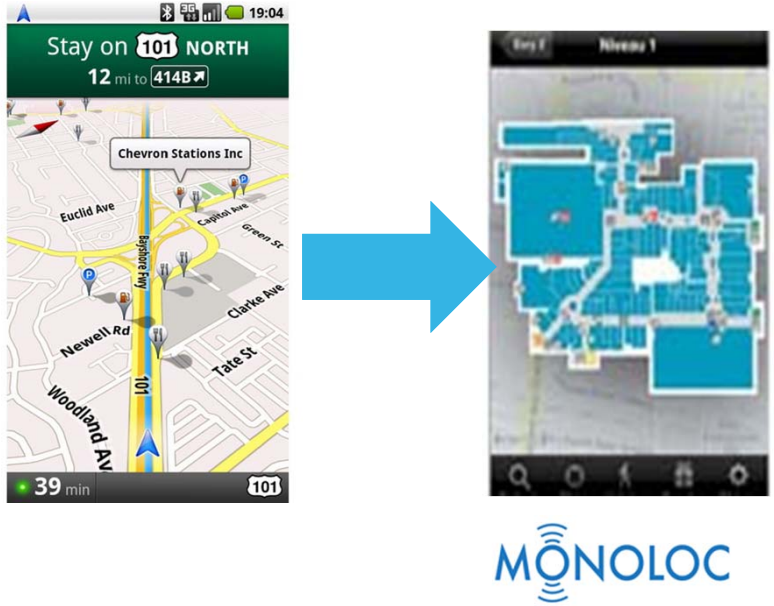
# INTRODUCTION

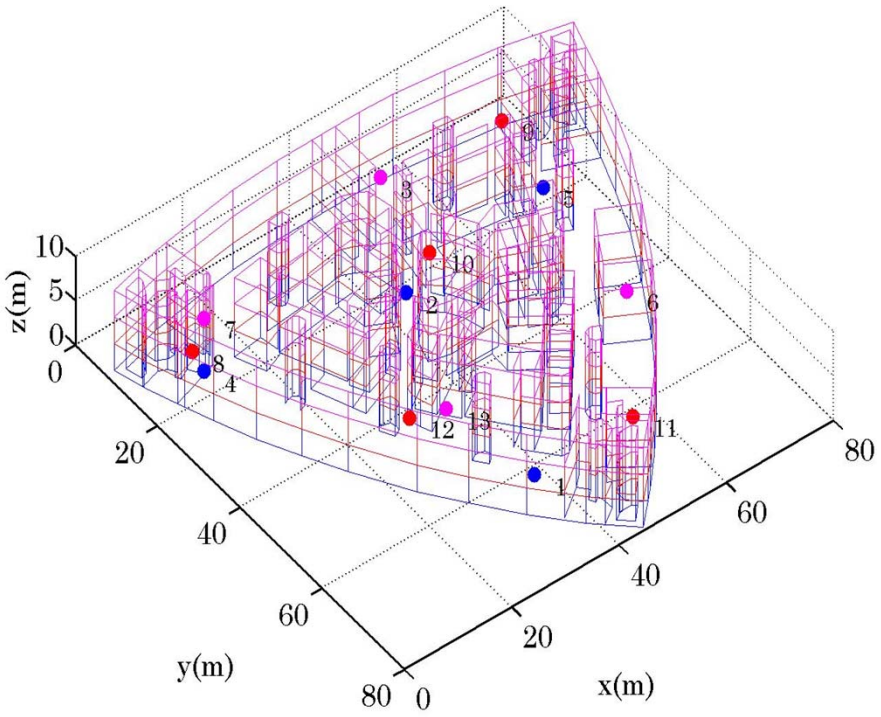
## GENERAL APPROACH. INDOOR LOCATION.

- No universal indoor solution like GPS for outdoor
- Proposal: Using Small-Cells Networks
  - Most people increasingly use smart phones
    - Universal solution.
  - No additional hardware
    - Non WiFi requeriments → Battery saving
  - Advantage of being network-aware
    - Small-cells power transmission
    - Small-cells outage



# CHALLENGES AND APPROACH
## INDOOR LOCATION ACCURACY

- Number of Small-cells deployed
- Type of small-cell deployment
- Radio-Map resolution
- Network Changes:
  - Cells Outage
  - Power transmission change
- Channel Variability due to:
  - Intrinsic Channel Variations
  - Environment Conditions



# CHALLENGES AND APPROACH
## INDOOR LOCATION ACCURACY

- **Number of Small Cells Deployed:**
  - **Finding the optimal number of small-cells** → guarantee a certain grade of indoor localization accuracy
  - **tradeoff between localization, data and voice services**

- **Type of Small Cell Deployment:**
  - **Optimizing the small-cells deployments** → taking into account the localization requirements

- **Radio Map Resolution:**
  - **Finding the optimal resolution** → provide certain grade of accuracy without making unnecessary computational efforts



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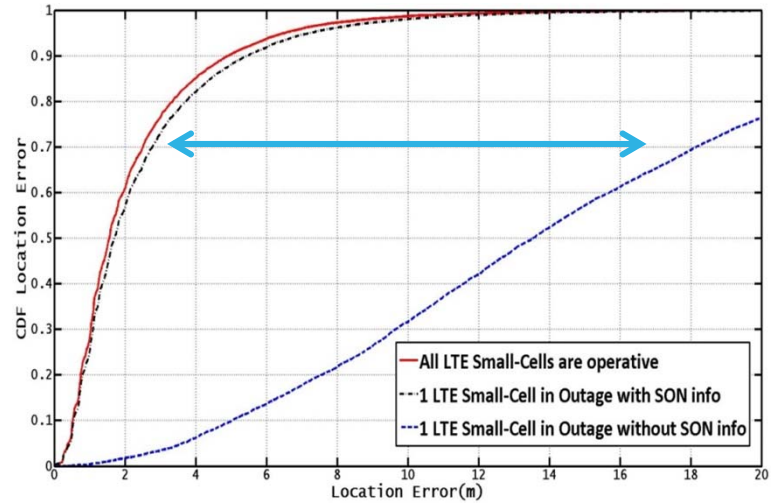
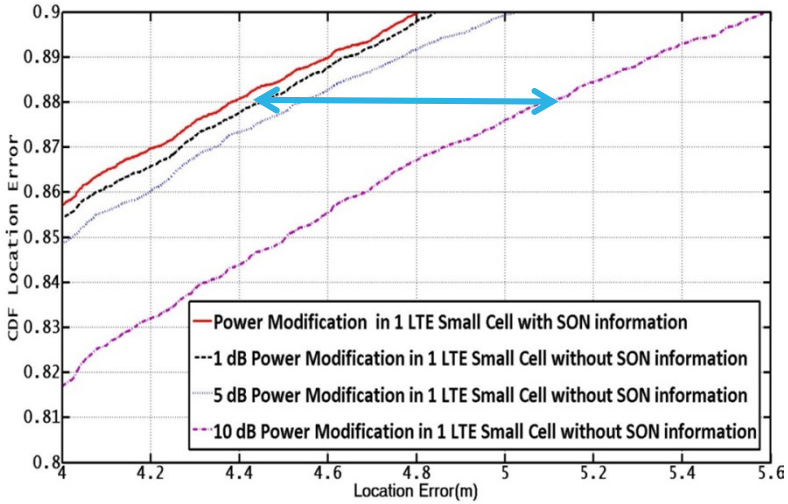
# CHALLENGES AND APPROACH
## INDOOR LOCATION ACCURACY

- **Outage Cell**
  - reduce the adverse effects caused by the outage of a cell using SON information.

- **Cell Power Awareness**
  - Take advantage of the small-cells **network awareness to improve** the indoor localization **accuracy**

<u>In WLANs this is more difficult to perform</u>

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# CHALLENGES AND APPROACH
## UNPREDICTABLE ENVIRONMENT

- Challenge →
  - Reducing the adverse effects caused by the unpredictable indoor environment changes like opening or closing doors, people clusters, furniture changes, etc.

- Approach →
  - Designing a recalibration system capable to detect the environment changes and to minimize their adverse effects



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# SYSTEM OVERVIEW

1. System Architecture
2. Localization Subsystem
3. SON Interface Server
4. Application Server
5. Positioning.



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# SYSTEM OVERVIEW
## SYSTEM ARCHITECTURE

- Three main blocks:
  - Localization Subsystem
    - Centralized Architecture
  - Self-Optimizing Network (SON) Subsystem
    - Three possible types of architecture:
      - Centralized
      - Distributed
      - Hybrid
  - Application Server



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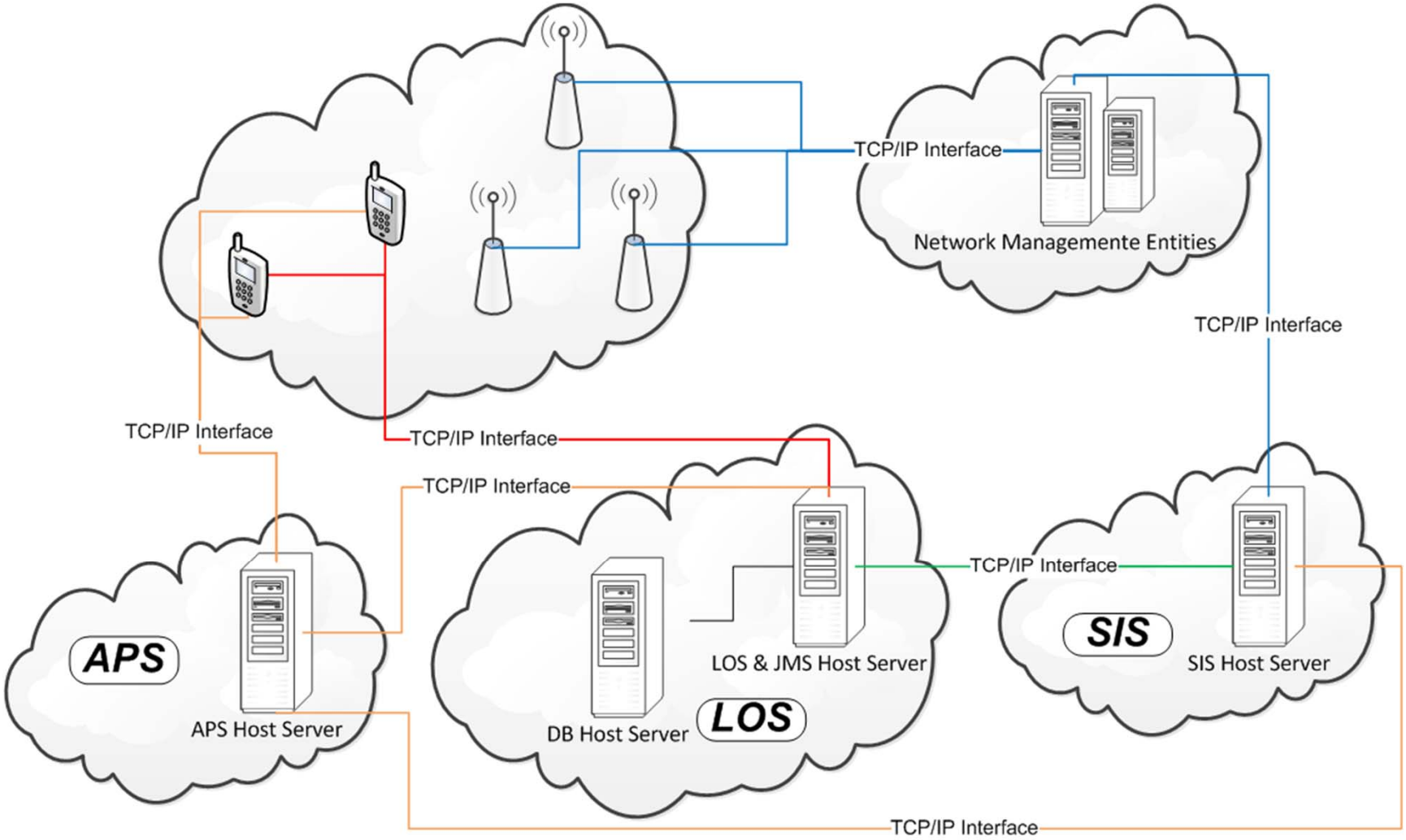
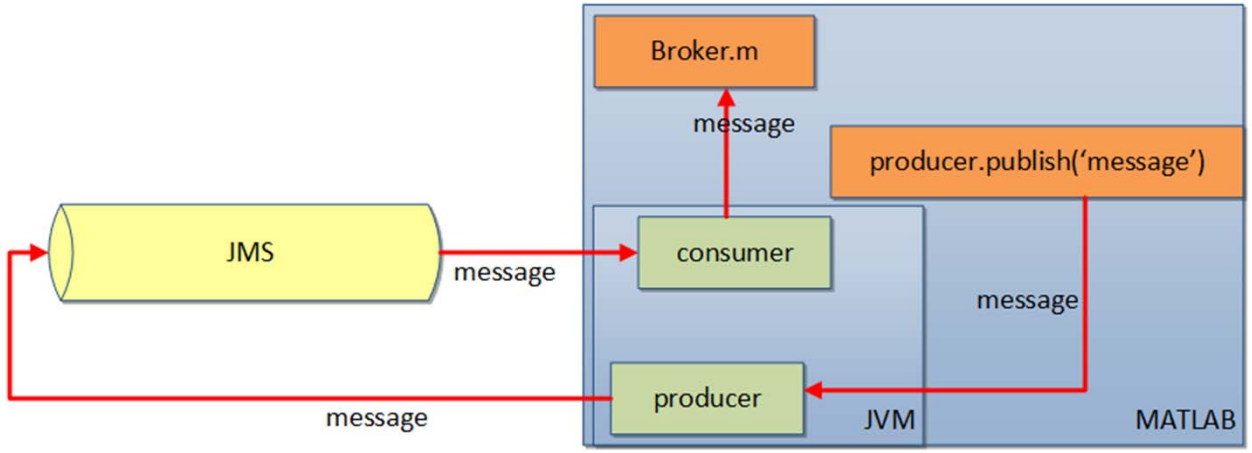
# SYSTEM OVERVIEW
## SYSTEM ARCHITECTURE



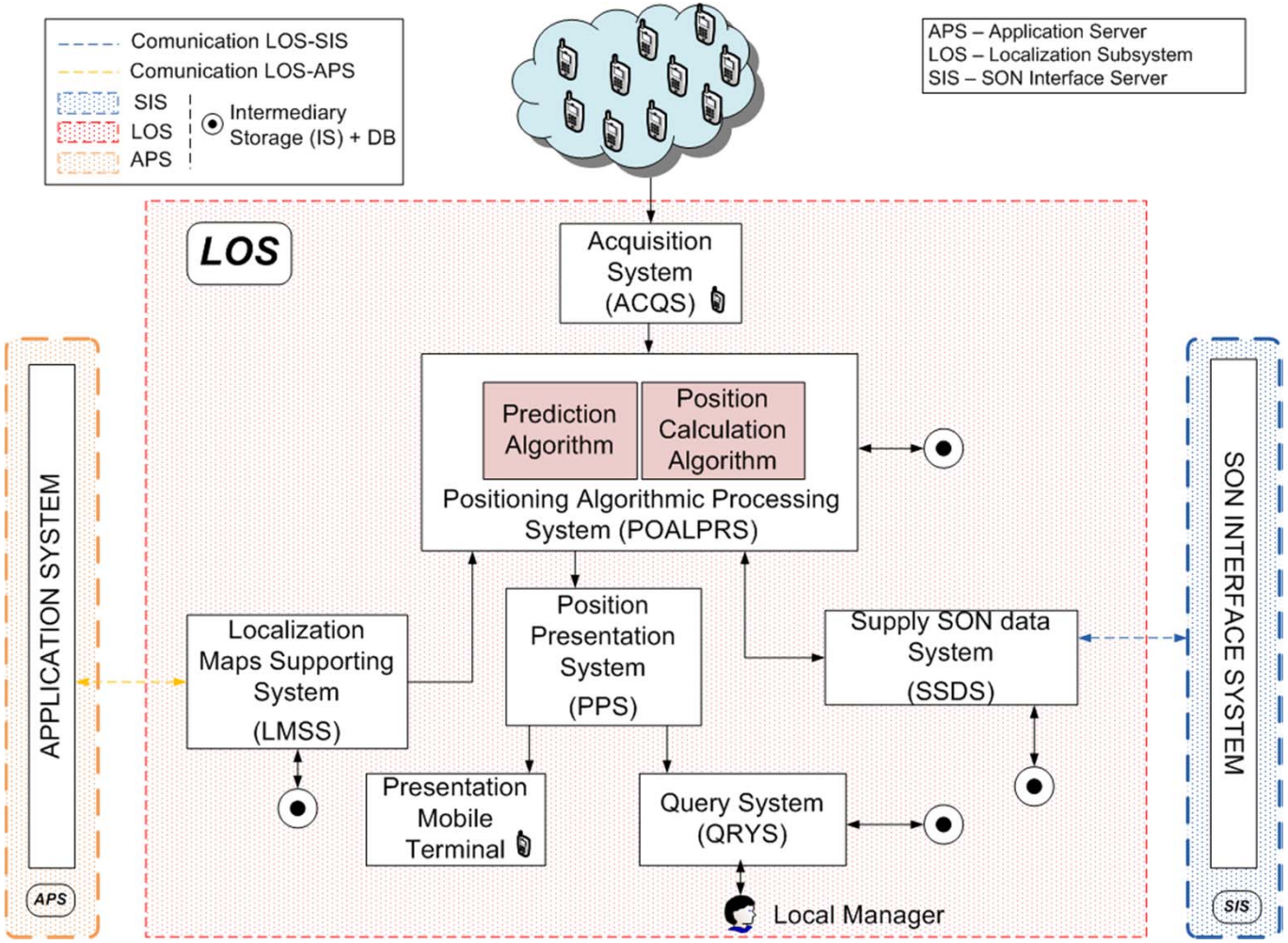
# SYSTEM OVERVIEW

## JMS <-> MatLab

- JMS as distributed integrator of MATLAB and JAVA
- The messages that are interchanged through the JMS queues implemented are **JSON messages**
- There are **different JMS queues** implemented at each connection between the different developed systems:
  - Smartphone – LOS
  - LOS – SIS
  - APS – SIS
  - APS – LOS



# SYSTEM OVERVIEW
## LOCALIZATION SUBSYSTEM ARCHITECTURE

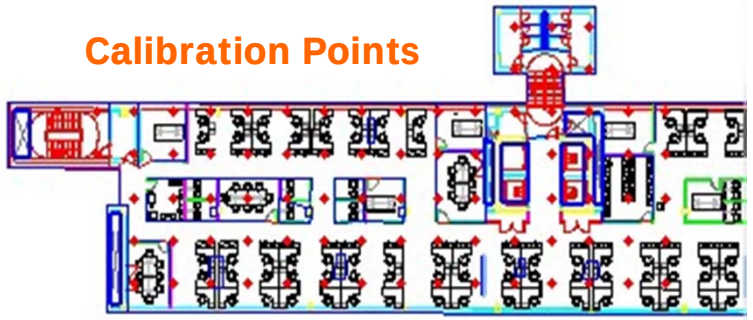


# SYSTEM OVERVIEW
## POSITIONING. HOW DOES IT WORK?

- LOS Positioning Engine for Self Organized Networks

Offline Phases

1. Offline Calibration Stage: Location Fingerprint RF Database Generation




2. Offline Preprocessing of Location Fingerprint Database

Real Time Phases

3. Real Time Cluster Matching with Online Indoor Base Station Receiver Power Measurements

4. Real Time Estimation of Indoor User Location

5. Real Time Refinement of Location Estimation Accuracy & Prediction

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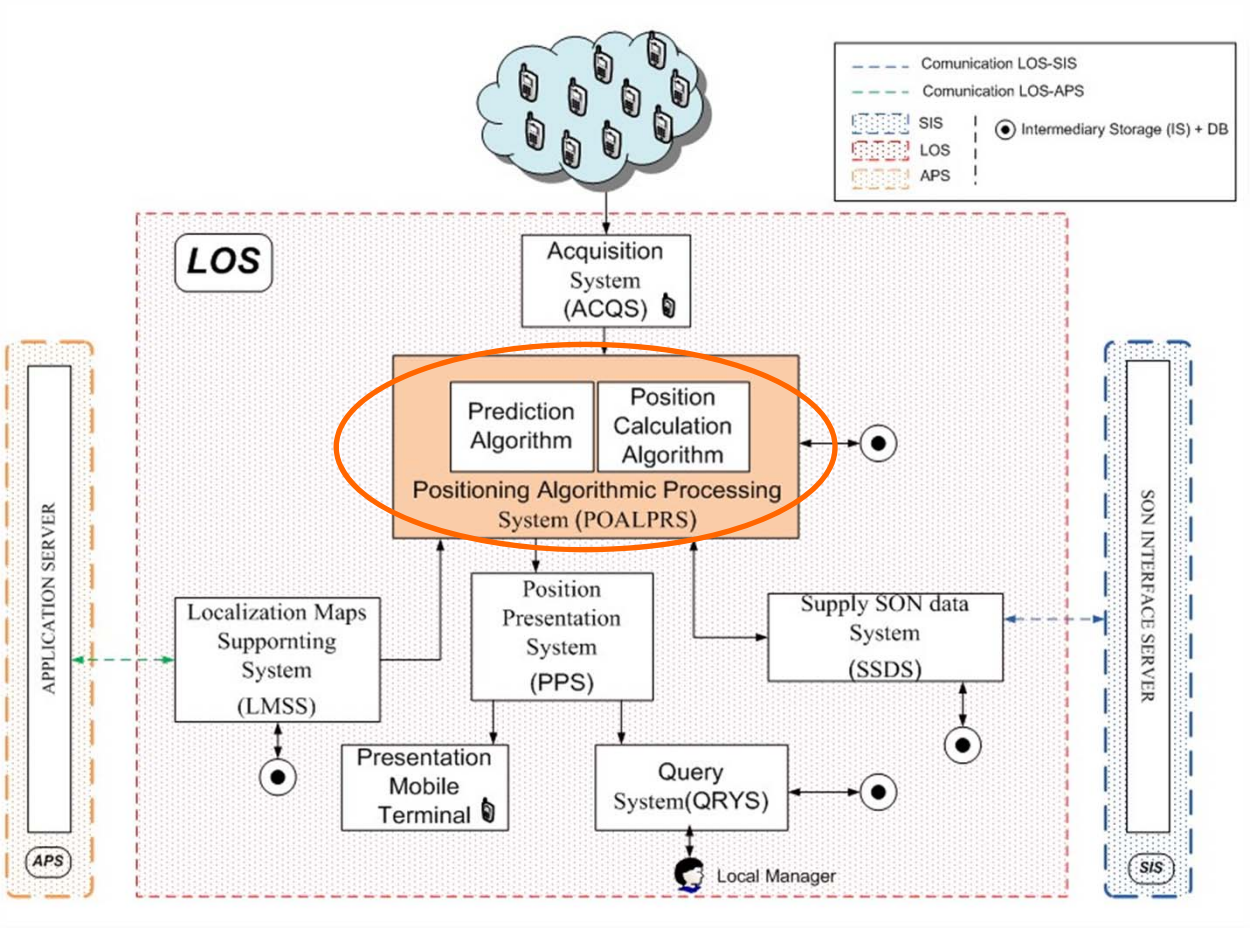
# SYSTEM OVERVIEW

## POSITIONING. HOW DOES IT WORK?

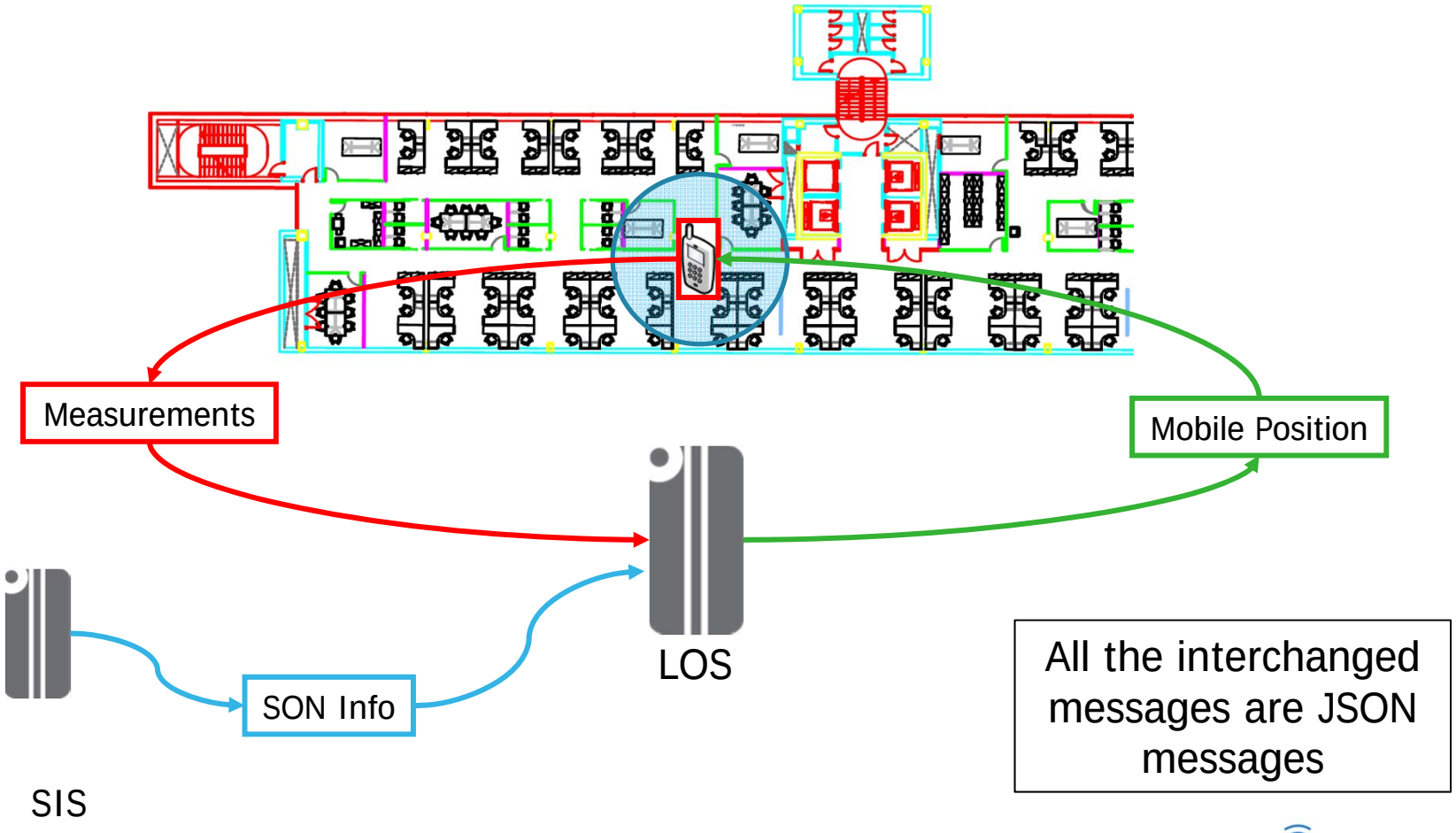
- Real Time Position Estimation



# SYSTEM OVERVIEW

## POSITIONING. HOW DOES IT WORK?

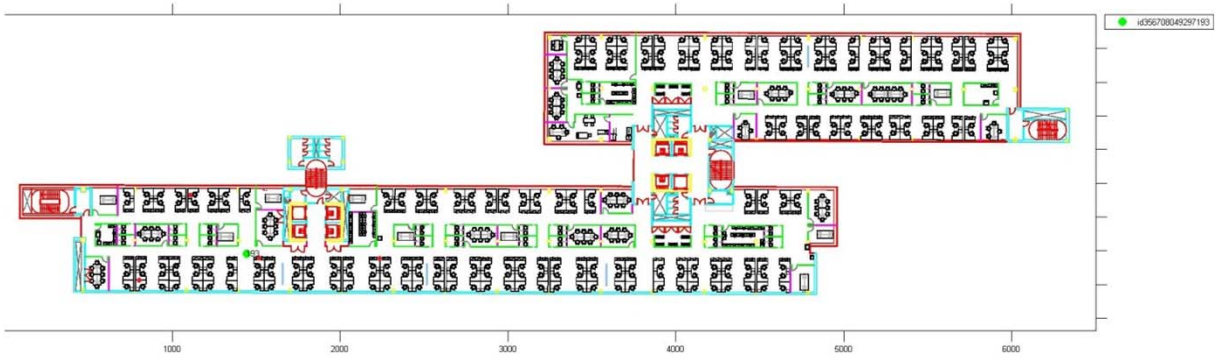
- Real Time Position Estimation

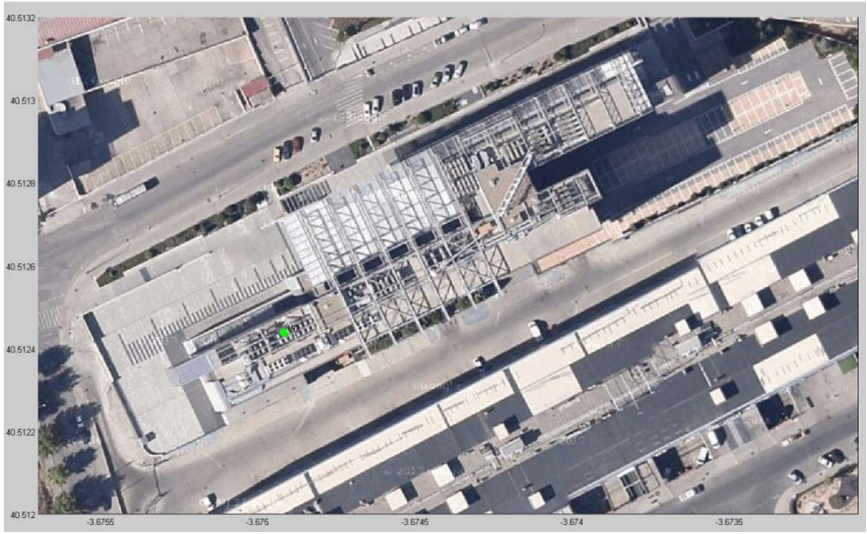


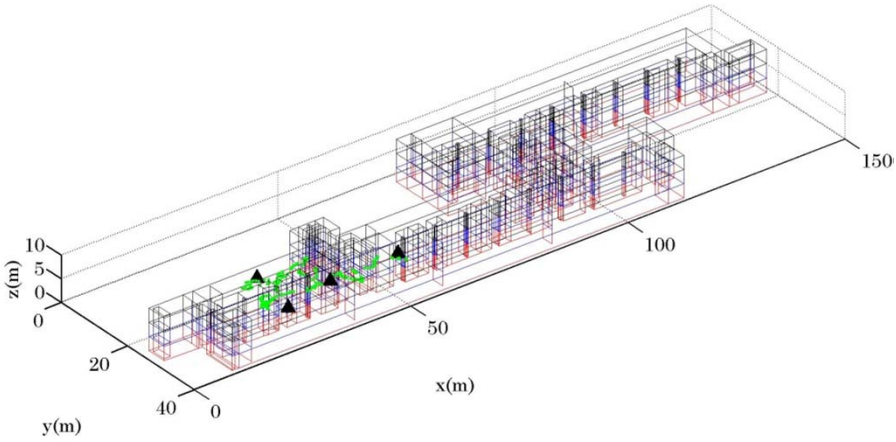
# SYSTEM OVERVIEW

## POSITIONING. HOW DOES IT WORK?

- Indoor RT Positioning: Local Maps/Google Maps

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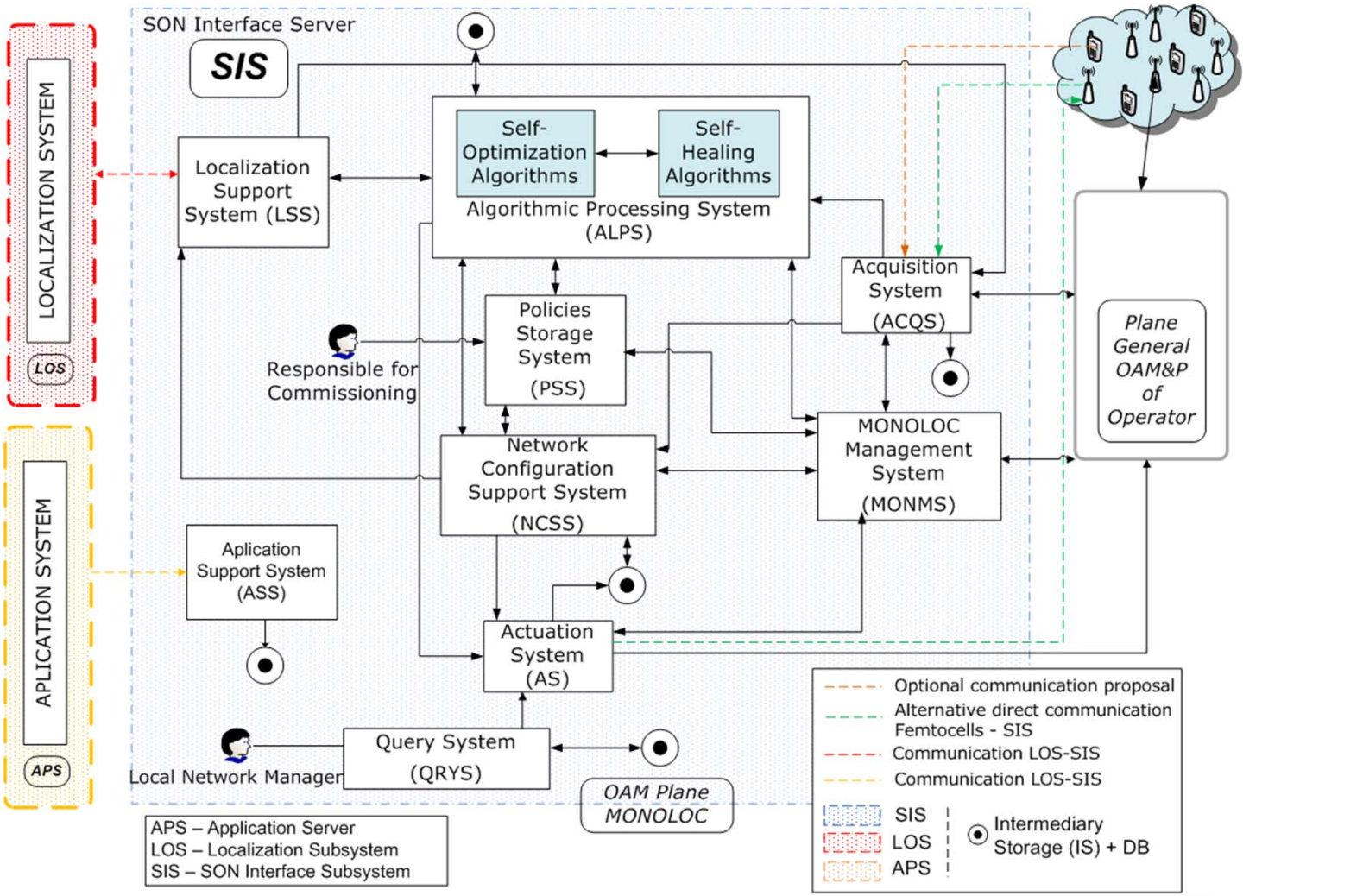
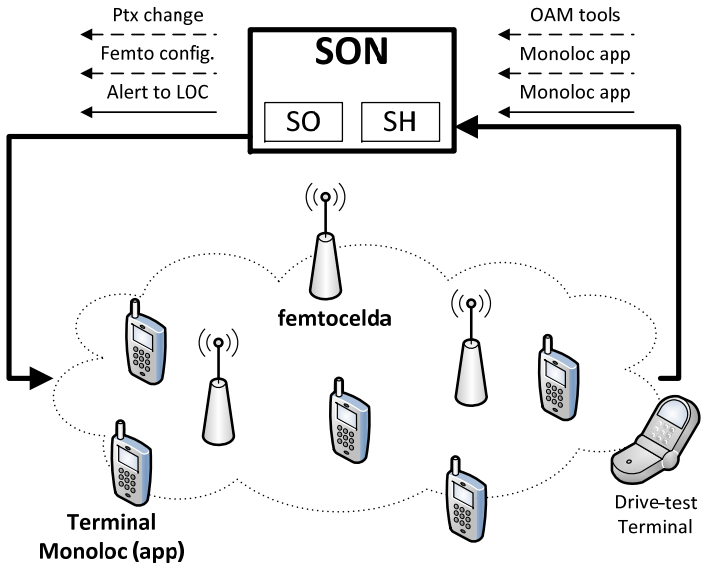
# SYSTEM OVERVIEW

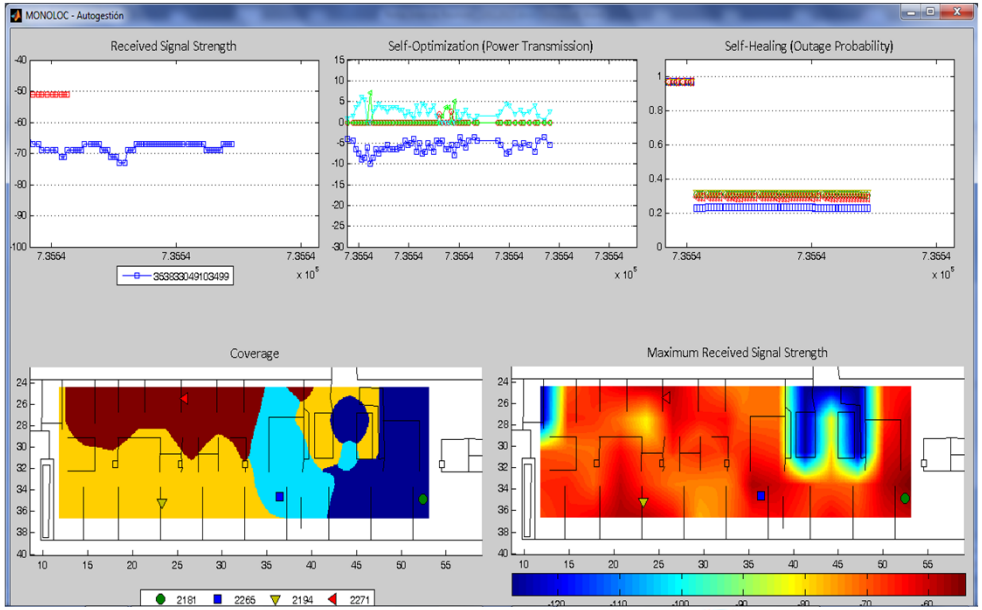
## SELF-OPTIMIZING NETWORK SUBSYSTEM ARCHITECTURE



# SYSTEM OVERVIEW
## SON INTERFACE SERVER

- SON Mechanisms
  - Based on direct terminal feedback + classic OAM SON applications
  - **Self-Optimization + Self-Healing**
  - Integration with the rest of the system
  - Real Time Interface

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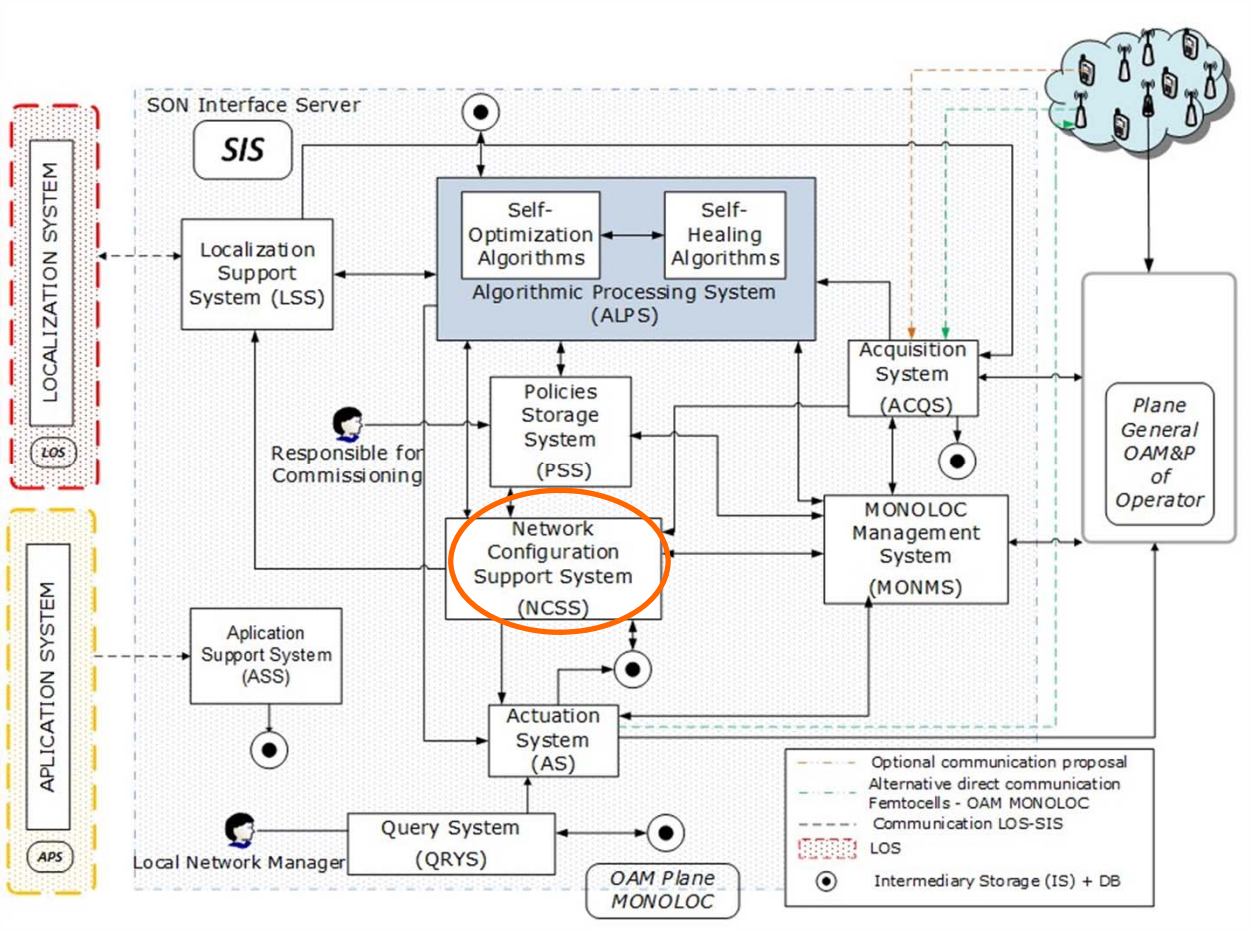
# SYSTEM OVERVIEW

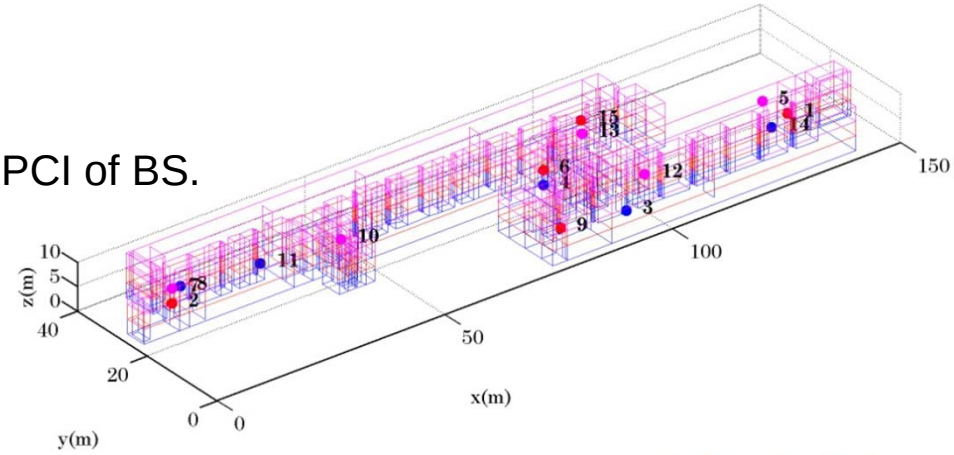
## DESIGN OF FEMTOCELL NETWORK TO PROVIDE LOCALIZATION



# SYSTEM OVERVIEW

## DESIGN OF FEMTOCELL NETWORK TO PROVIDE LOCALIZATION

- Evolutionary algorithm with multistep multi-objective fitness assessment
  - Objectives:
    - Simultaneous HeNB coverage to offer location services (Home e-Node B)
    - Design of the HeNB network oriented to provide fingerprint based positioning systems
    - Avoid PCI collision/confusion Physical Cell ID
  - Inputs:
    - Objective functions; In-building maps; Propagation model; type of BS; allowed PSC/PCI; Costs, allowed channels.
  - Outputs:
    - Number of BS required; Position of BS; PCI of BS.

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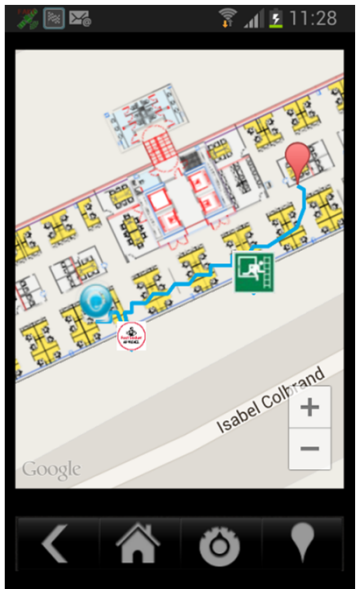
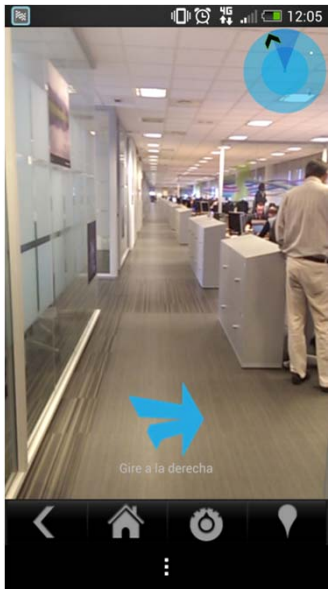
# SYSTEM OVERVIEW
## MOBILE APPLICATION

- Destination selection.
- Positioning the user and indication of optimal routes to the chosen destinations
- Augmented Reality interface with route guidance

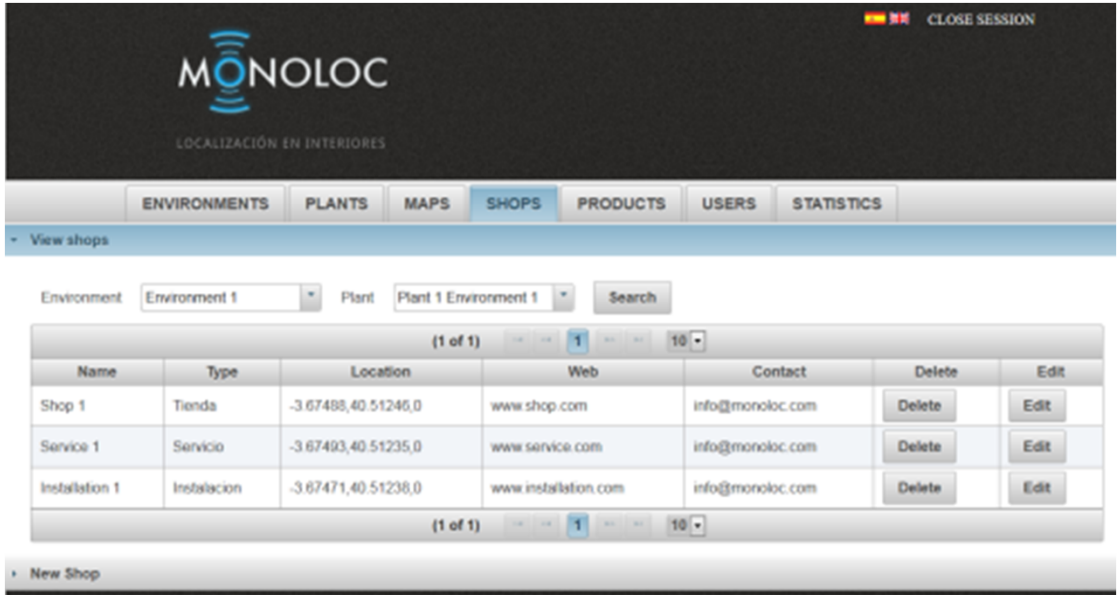



# SYSTEM OVERVIEW

## WEB SERVER APPLICATION

- Web Server application → manage the indoor information (shops, products, services, areas of interest like the emergency exists,…)
- Managed by the administrators→ in charge of exploiting the indoor environment (Supermarkets, Malls, Transport Stations or Airports, Public areas)
- These administrators provide → area maps, layout, location of services, shops, products,…



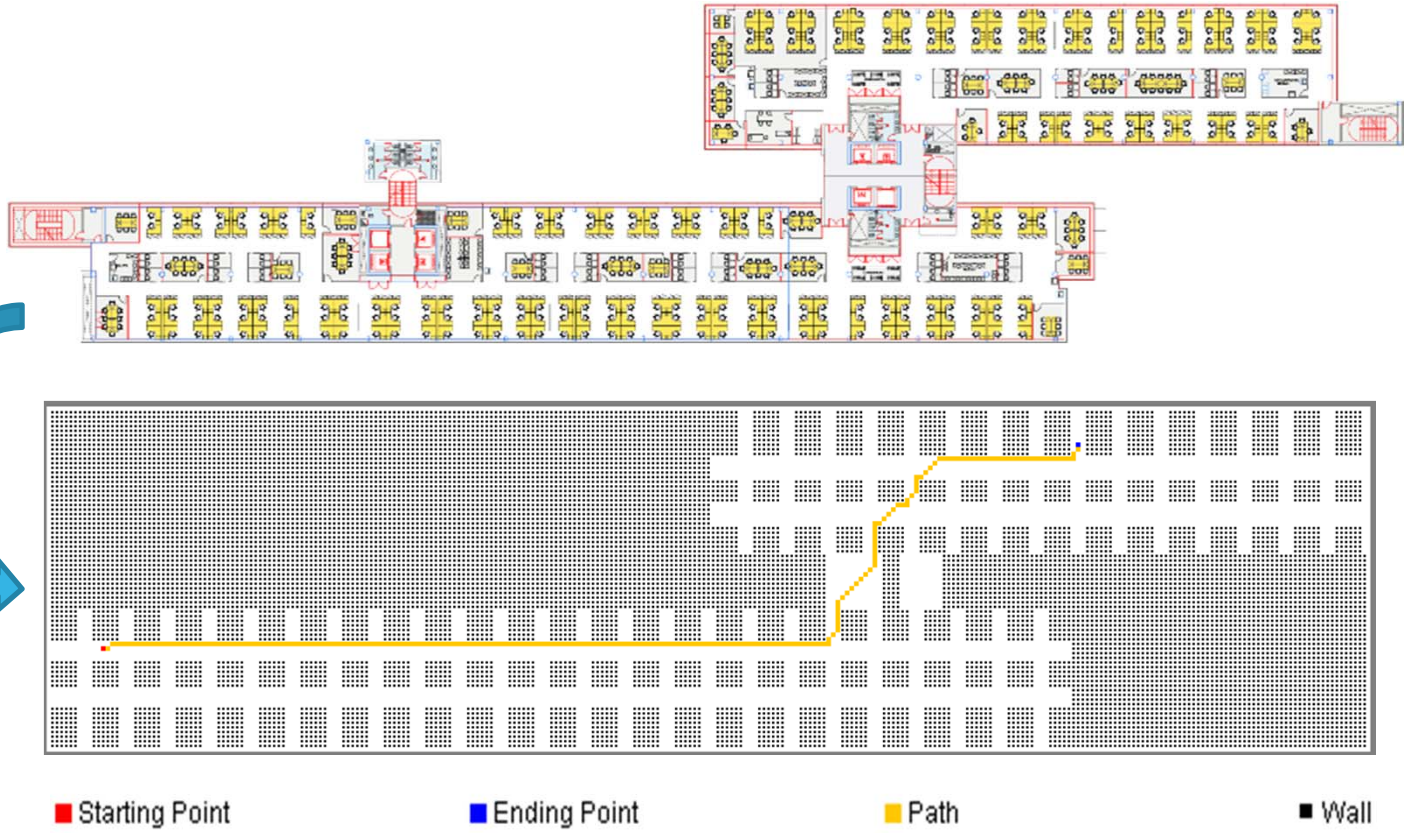

Example of the Web Server Application Interface

# SYSTEM OVERVIEW

## PATHFINDING

- The Monoloc System includes a routing module to find in the mobile application the optimal path in an environment between selected locations.

The map of the environment is mapped at a logical level and the most optimal routes between the different points are calculated.

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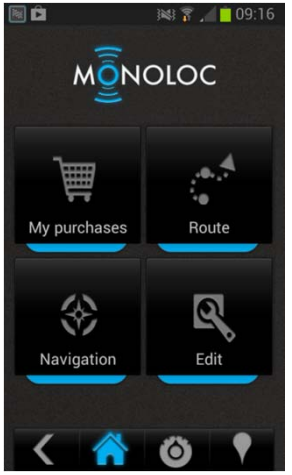
# SYSTEM OVERVIEW
## MOBILE APPLICATION

- The mobile app was developed for Android OS. It works in connection with the Web Server Application and the Location Server.
- Functionalities:
  - User positioning
  - Route generation, and route guidance
  - Wish list generation, and user guidance through the wished products
  - Augmented reality interface with route guidance

Main Interface

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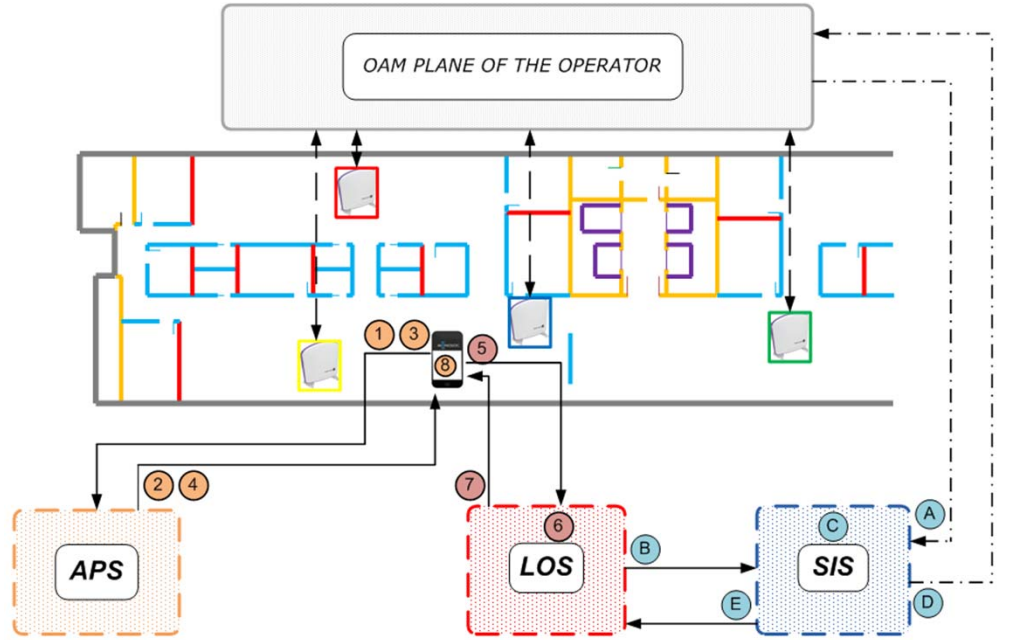
# SYSTEM OVERVIEW
## DEMOSTRATION PLATFORM




**MONOLOC - Online Processes**

- 1 2 Authentication Process
- 3 4 Download Maps of the Site
- 5 Send Radio Measurement
- 6 Calculate the mobile's position
- 7 Send the mobile's position and the prediction
- 8 Use the mobile's position & show it on the mobile's screen

**MONOLOC - No Online Processes**

- A Obtain info from the OAM
- B Obtain info from LOS (Measurements, position, prediction)
- C Perform SON algorithms
- D Send Information of Network Modifications to the OAM
- E Send Network Info to the LOS

**Elements & Interfaces**

Femtocell

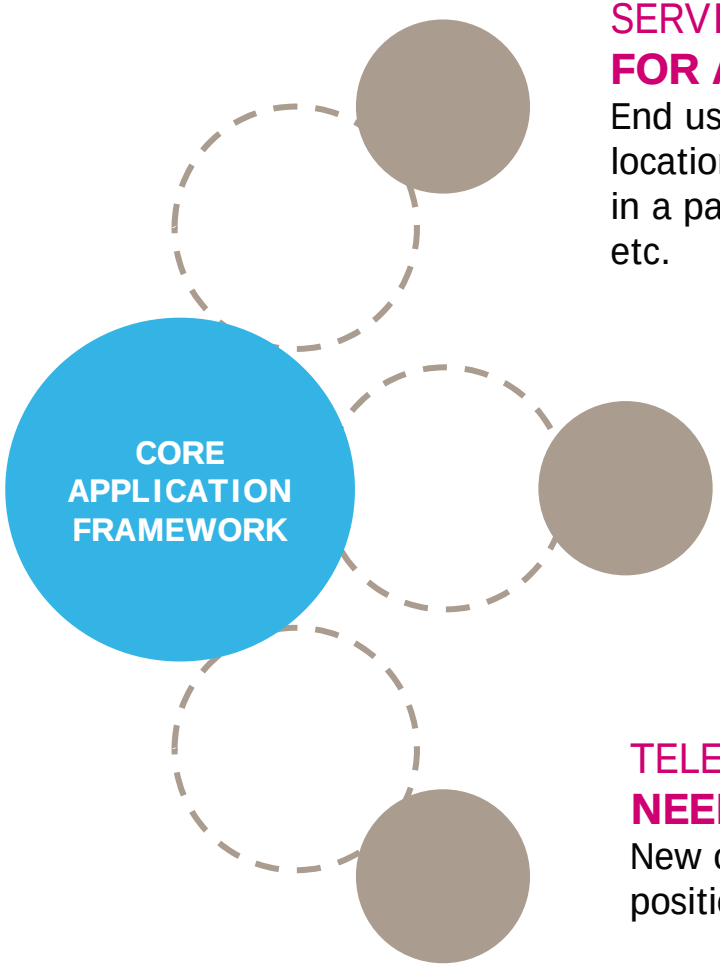
Mobile User

MONOLOC Interfaces (Online)

MONOLOC Interface (Not Online)

Standardized Interface

# EXPLOITATION MODEL
## EXPLOITATION PRINCIPLES




SERVICE EXPLOITATION

**FOR AN END-USE BUSINESS REASON**

End user benefits from value added services adding private location to customers or potential customers. E.g. find a the car in a parking, get advertising of information on specific places, etc.

CUSTOMIZATION

**FOR SPECIFIC USE CASES**

Different customers and uses may require very specific use of the positioning, architecture, etc.

TELECOM INFRASTRUCTURE

**NEEDED FOR THE SERVICE**

New or additional infrastructure needed to comply with the positioning requirements

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# CONCLUSIONS

## PROJECT ACHIEVEMENTS

**INDOOR LOCALIZATION SYSTEM**

**KEY OBJETIVES ACHIEVED**

- Define the complete architecture of an Indoor Localization System
- Implement the needed interfaces to communicate the different blocks of the system.
- Implement a mobile app to perform the calibration phase of the positioning algorithms and generate the radio map of the objective environment
- Develop indoor positioning methods (published at BLTJ September 2013)
- Develop a radio planning tool taking into account indoor mobile localization
- Implement a pilot demonstration platform

**LOCALIZATION & SON SYNERGIES**

**KEY OBJETIVES ARCHIEVED**

- Define SON algorithms into a femtocell network and implement some of them into the pilot demonstration platform.
- Use SON info to improve indoor localization performance; & vice versa.
- Implement the synergies between localization & SONS into the pilot demonstration platform.

**MOBILE & COMMERCIAL APPLICATIONS**

**KEY OBJETIVES ACHIEVED**

- Implement a Android app to offer indoor positioning over femtocells network
- Implement a web based application to manage the indoor environment information. This app is orientated to commercial areas.
- Performance survey of the commercial smartphones.
- System load survey in terms of users number over the system

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# Thank You

Contact:

**Javier Sainz Guerra**

jsg@grupoinnovati.com

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