URUS project: Communication Systems

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URUS project

URUS project
Ubiquitous Networking Robotics in Urban Settings

http://urus.upc.es

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URUS Project Objectives

- **Objectives:**
  - The main objective is to develop an adaptable network robot architecture which integrates the basic functionalities required for a network robot system to do urban tasks

- ***1. Scientific and technological objectives***
  - Specifications in Urban areas
  - Cooperative localization and navigation
  - Cooperative environment perception
  - Cooperative map building and updating
  - Human robot interaction
  - Multi-task allocation
  - Wireless communication in Network Robots

- ***2. Experiment objectives***
  - Guiding and transportation of people
  - Surveillance: Steward service in public spaces

URUS Partners

Institut de Robótica i Informática Industria (IRI)
Universitat Politécnica de Catalunya (UPC)

Centre National de la Recherche Scientifique/ LAAS

Eidgenössische Technische Hochschule/ ETHZ

Asociación de Investigación y Cooperación Industrial de Andalucia/ AICIA

Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna/ SSSA

Universidad de Zaragoza/ UniZar

Instituto Superior Técnico/ IST

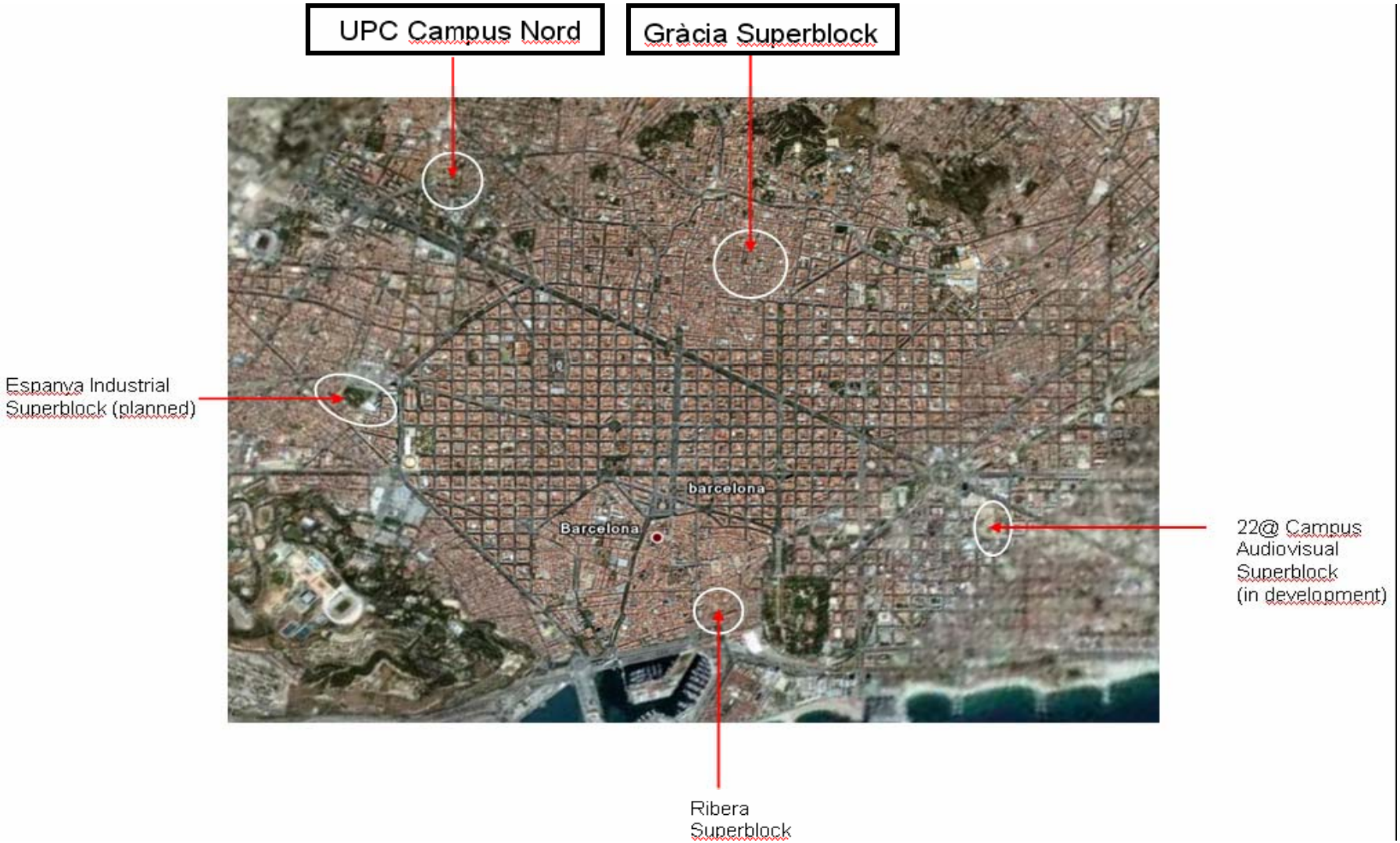
University of Surrey/ UniS

Urban Ecology Agency of Barcelona/ UbEc

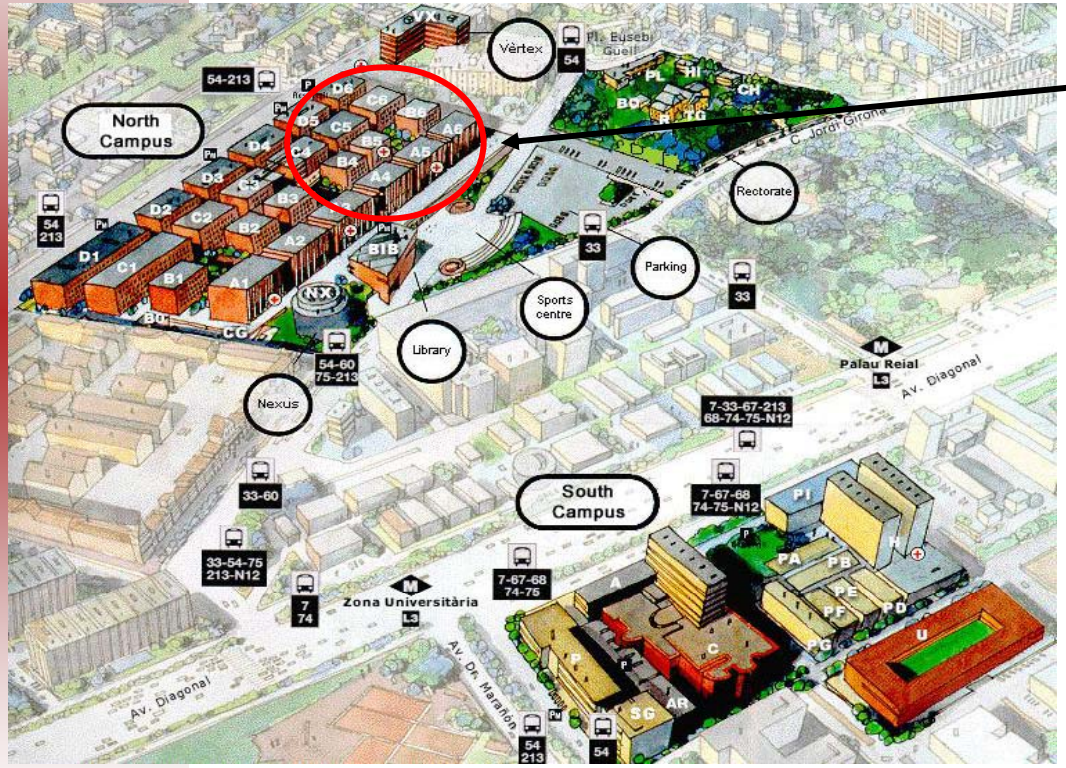
Telefónica I+D/ TID

RoboTech / RT

Experiment Locations



Experiment Locations: Scenario 1
UPC



Zone Campus Nord, UPC

Barcelona ROBOT Lab

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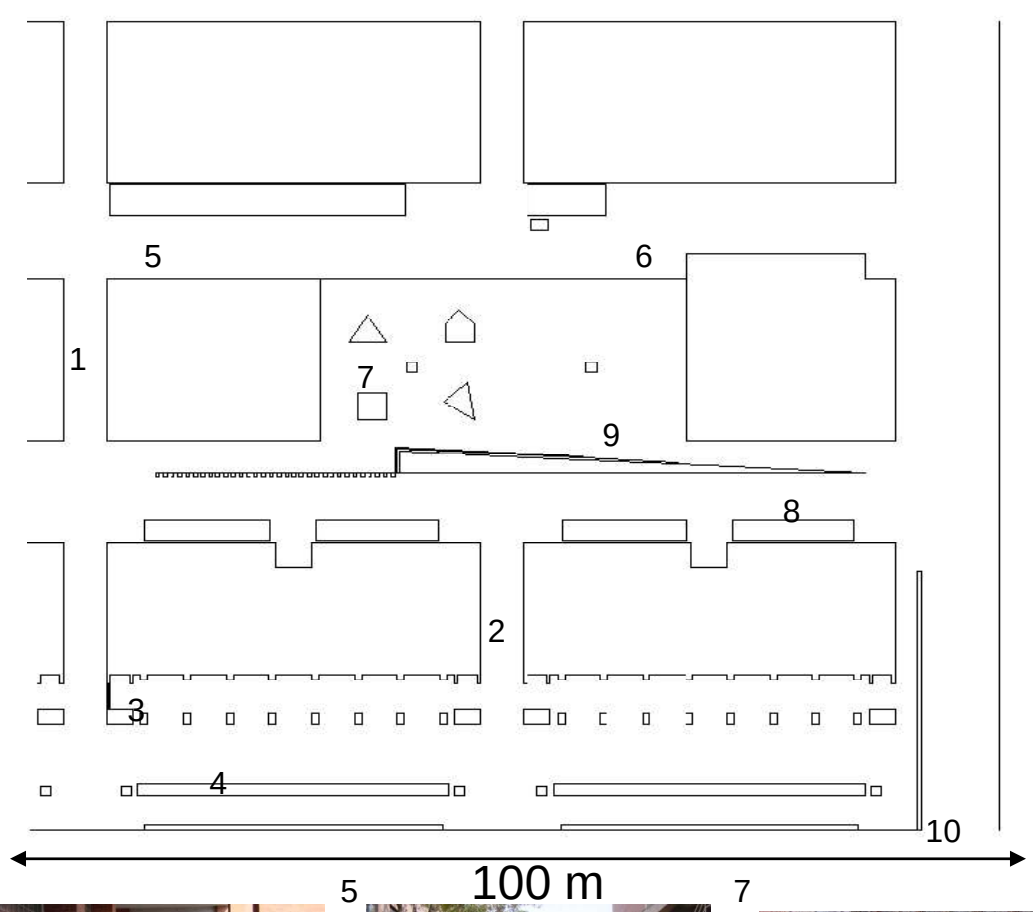
Barcelona ROBOT Lab
Campus Nord, UPC

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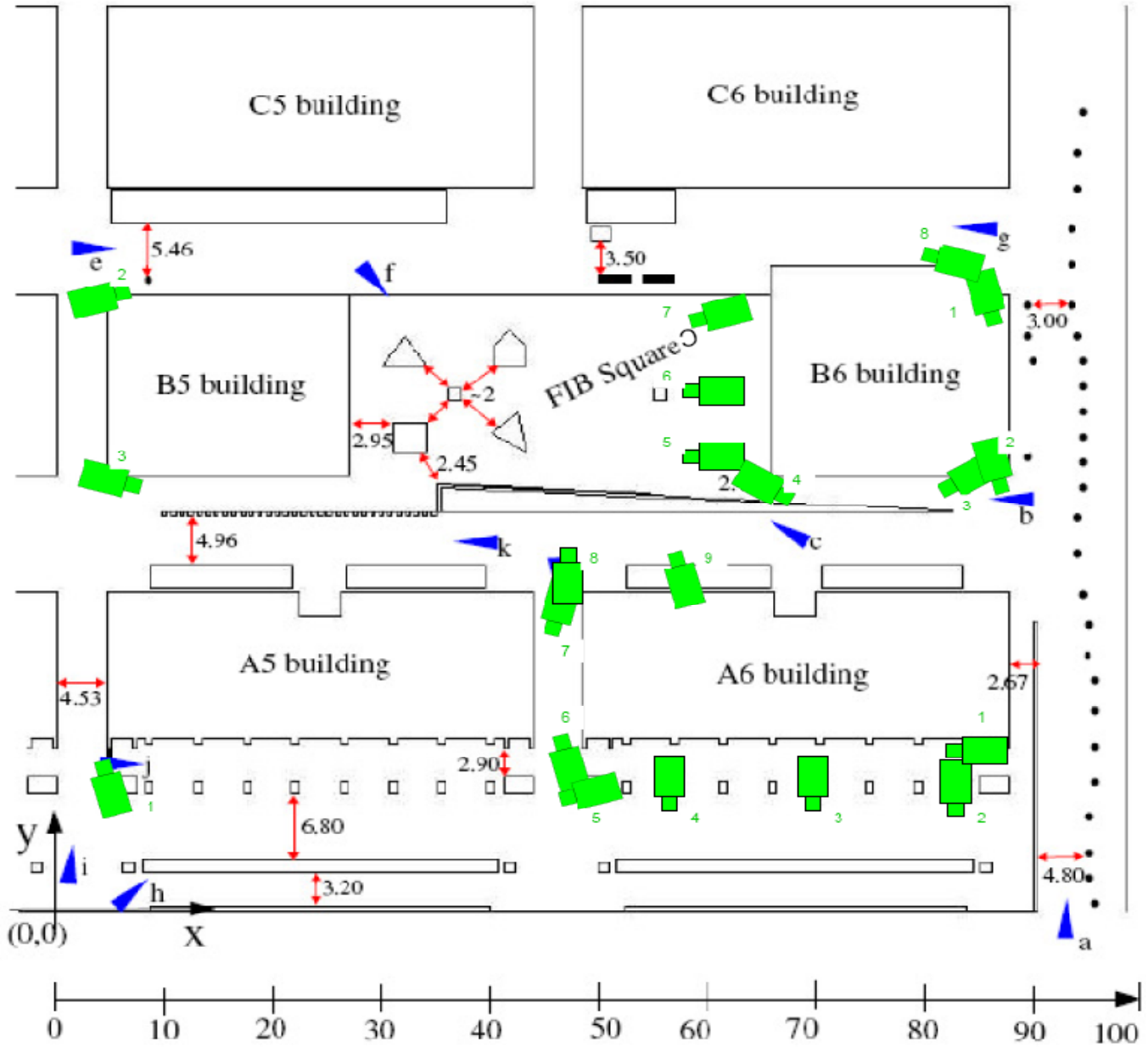
C5 building
C6 building
B5 building
B6 building
FIB Square
A5 building
A6 building
5.46
3.50
3.00
2.95
2.45
4.96
4.53
2.90
2.67
6.80
3.20
4.80
(0,0)
x
y
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10
20
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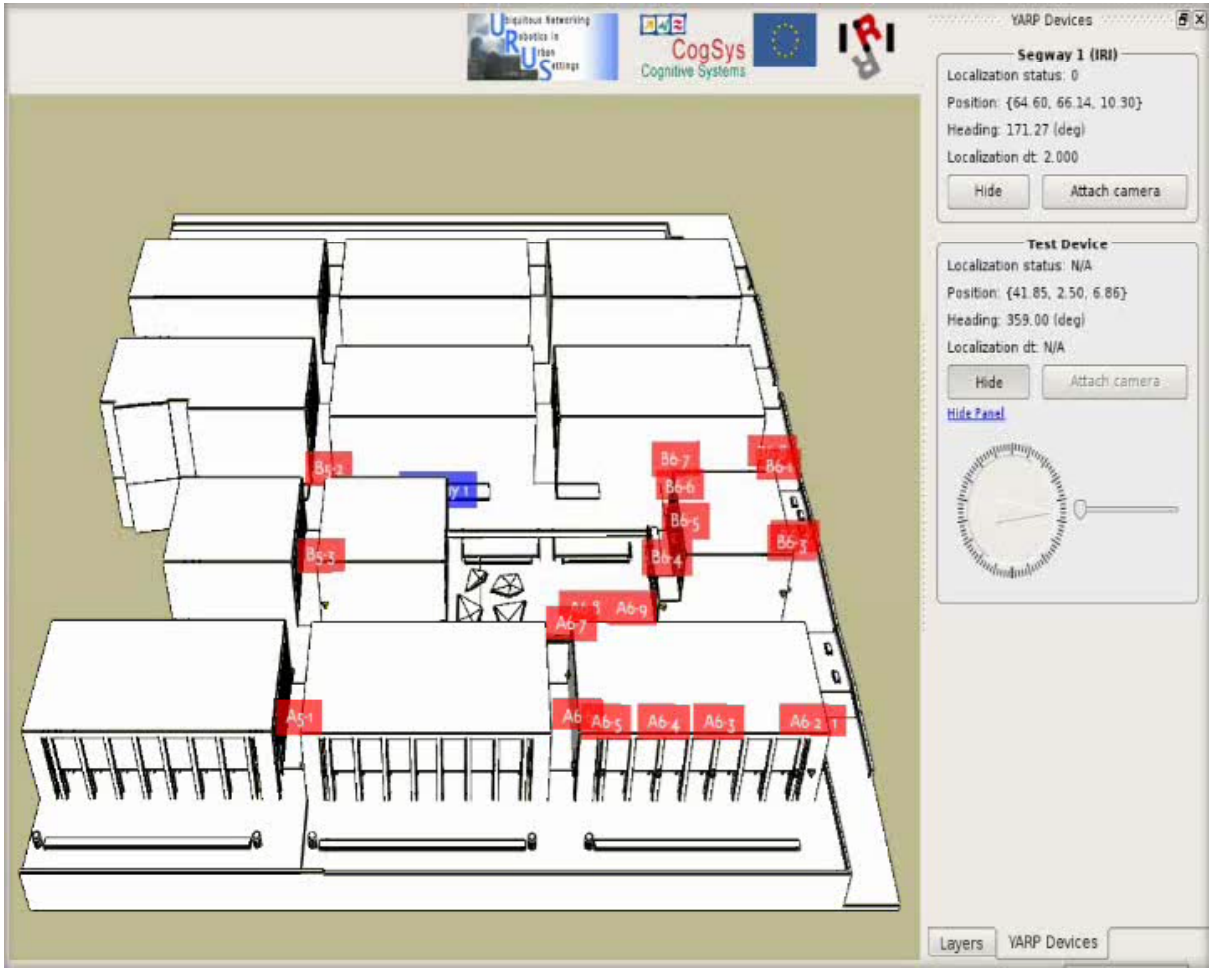
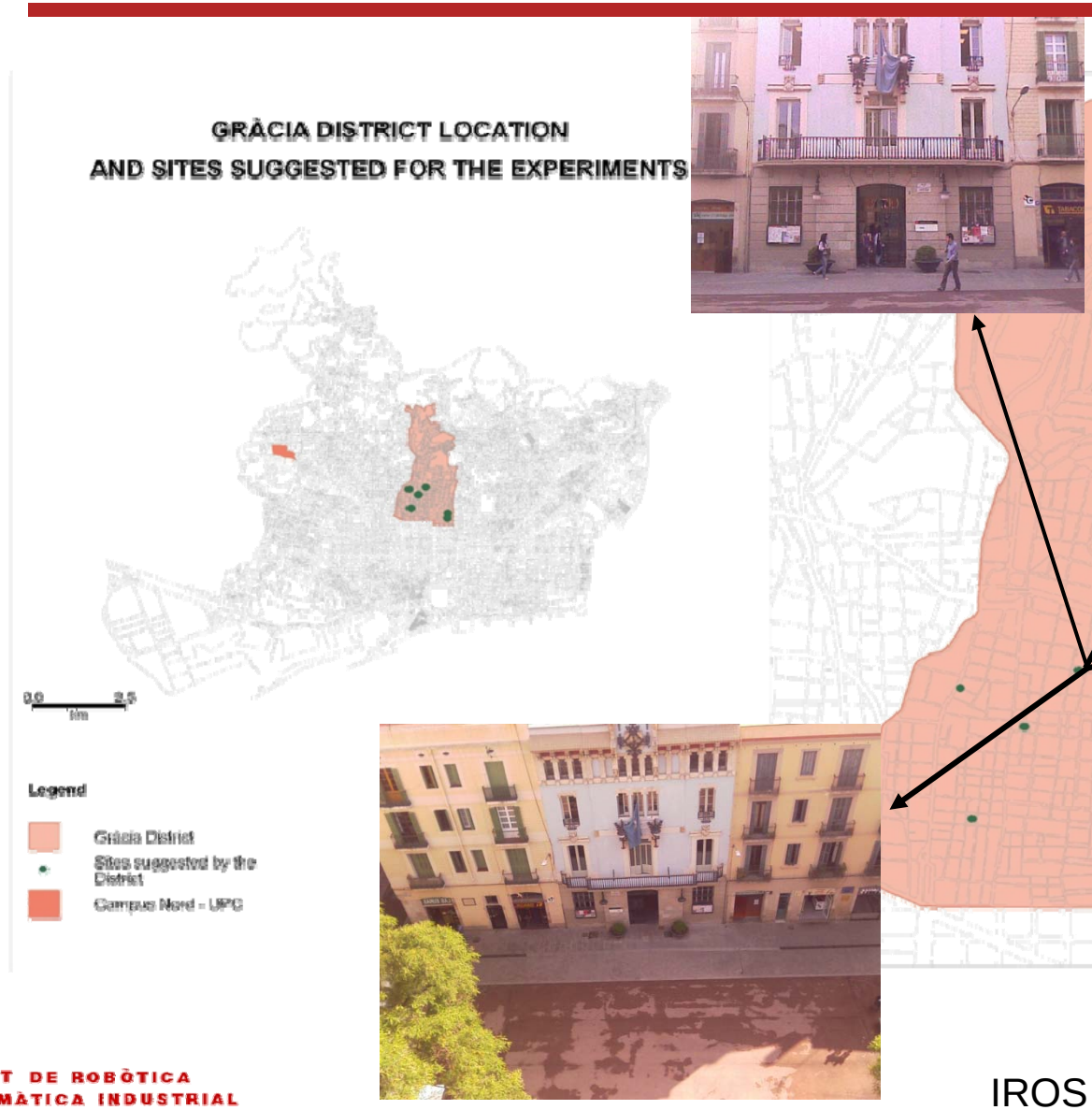
40
50
60
70
80
90
100

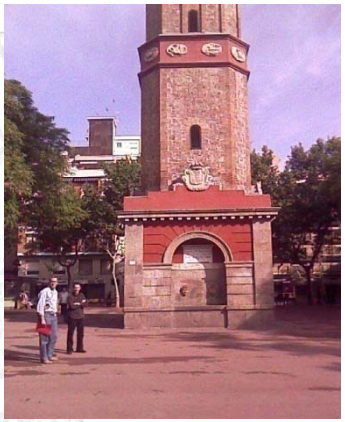
Experiment Location: Scenario 1
UPC



Experiment Location: Inauguration

Experiment Location: Scenario 2
Gracia District





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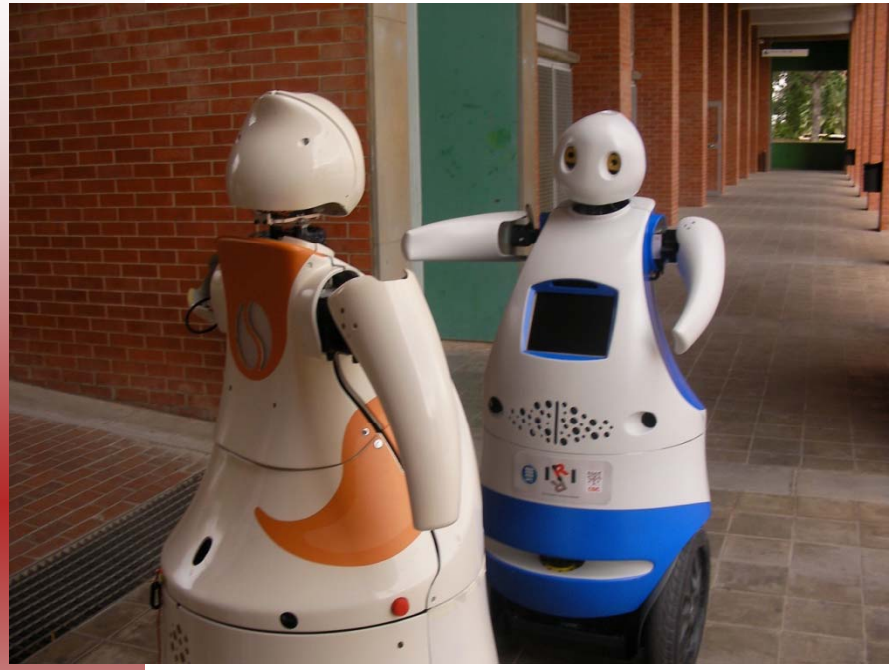
Robots in Experiment Site 1

Robots in Experiment Site 1



Video of Tibi and Dabo

Robots in Experiment Site 1

Smarttek robot

Video of Romeo robot

Experiments

- **Urban experiments:**
  - 1.- Transportation of people and goods
    - Transporting people and goods
      - Taxi service requested via the phone
      - User request the service directly
  - 2.- Guiding people
    - Guiding a person with one robot
  - 3.- Surveillance
    - Steward service in public spaces.
  - 4.- Map building

System Architectures

URUS Global Architecture

URUS_rot3D.exe

Robot 1 **Robot 2** **Robot N**

Functional Layer	Functional Layer	Functional Layer
Supervisor Task Allocation	Supervisor Task Allocation	Supervisor Task Allocation

WLAN GSM/3G *WLAN GSM/3G* *WLAN GSM/3G* *Blue Tooth*

Ethernet

Central Station

Task Allocation
Environment Perception
GSM/3G Interface
Global Supervision

GSM/3G Network

Ethernet (Gb)

Mica2/Ethernet network

IROS_NRS_Workshop_USA_2009

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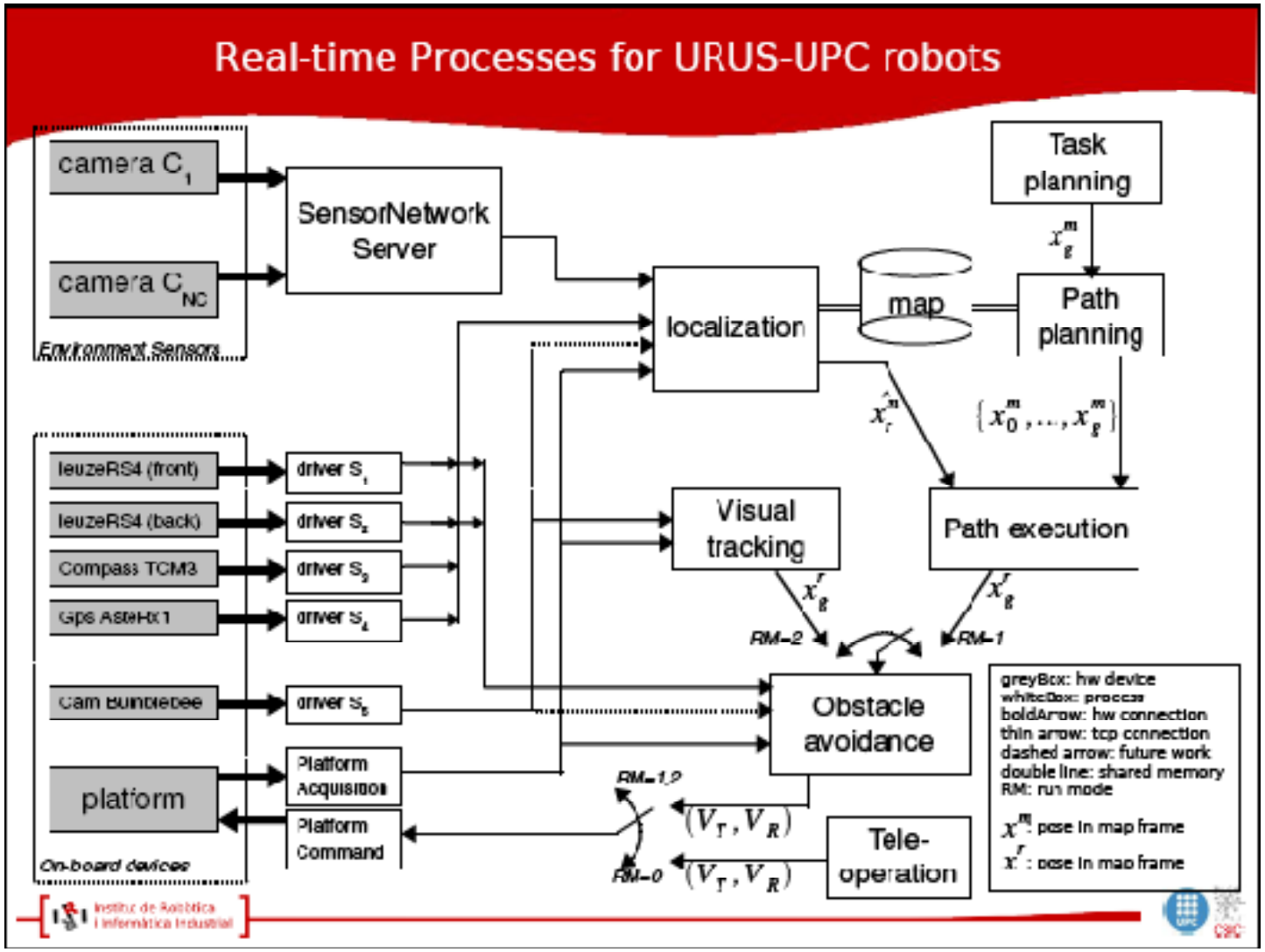
Tibi & Dabo Architectures

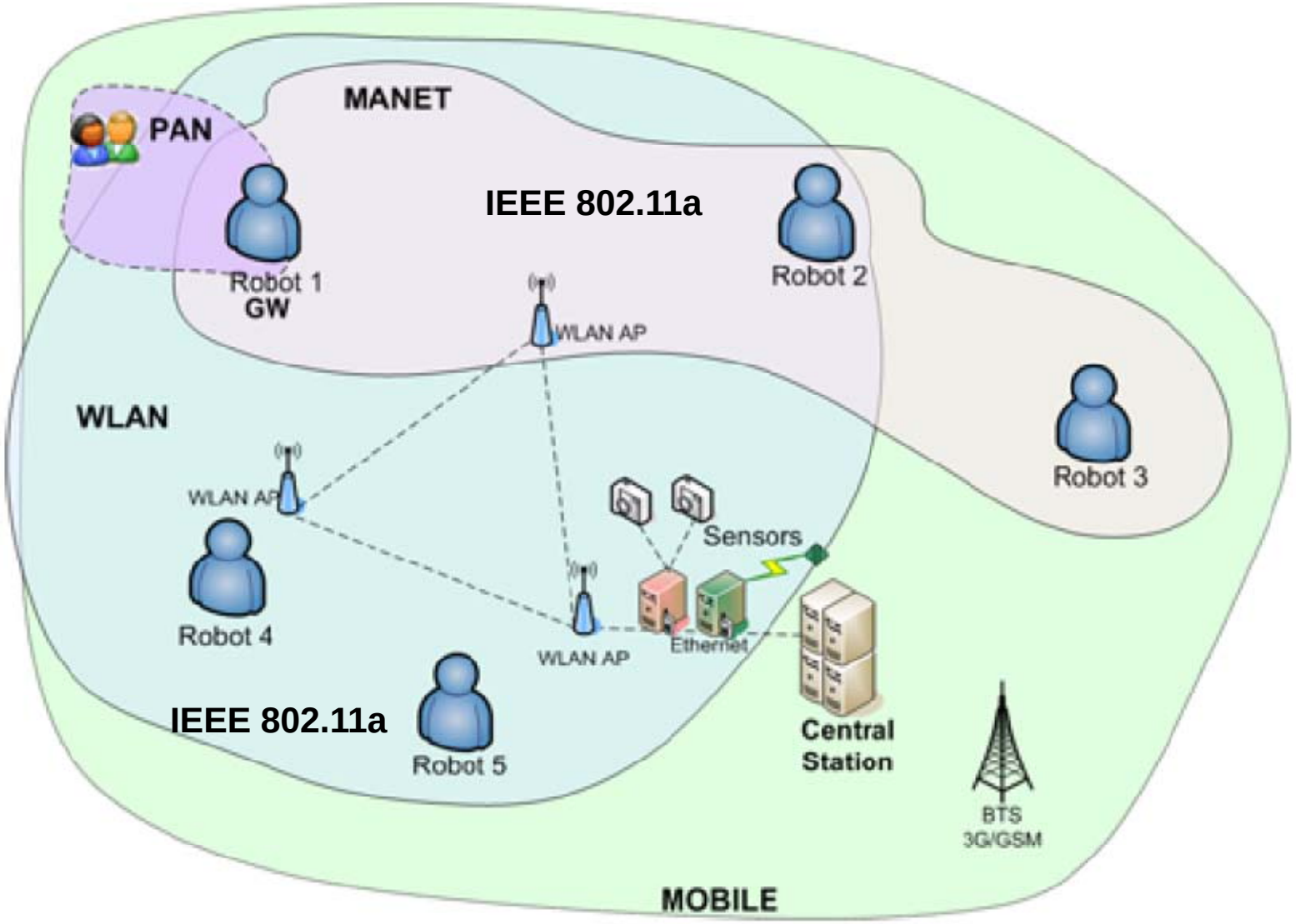


Communication Systems

URUS Communication Objectives

- *Transparent communication* between services running in different entities regardless of WirelessLocal Area Network (WLAN) connectivity availability and changing propagation issues
- *Traffic management and to allow Real time* in communications between robots while performing cooperative tasks,
- *Location and identification of nodes* of the Wireless Sensor Network (WSN), for instance a node carried by a person or a robot, to ease service provision.

URUS Communication Systems

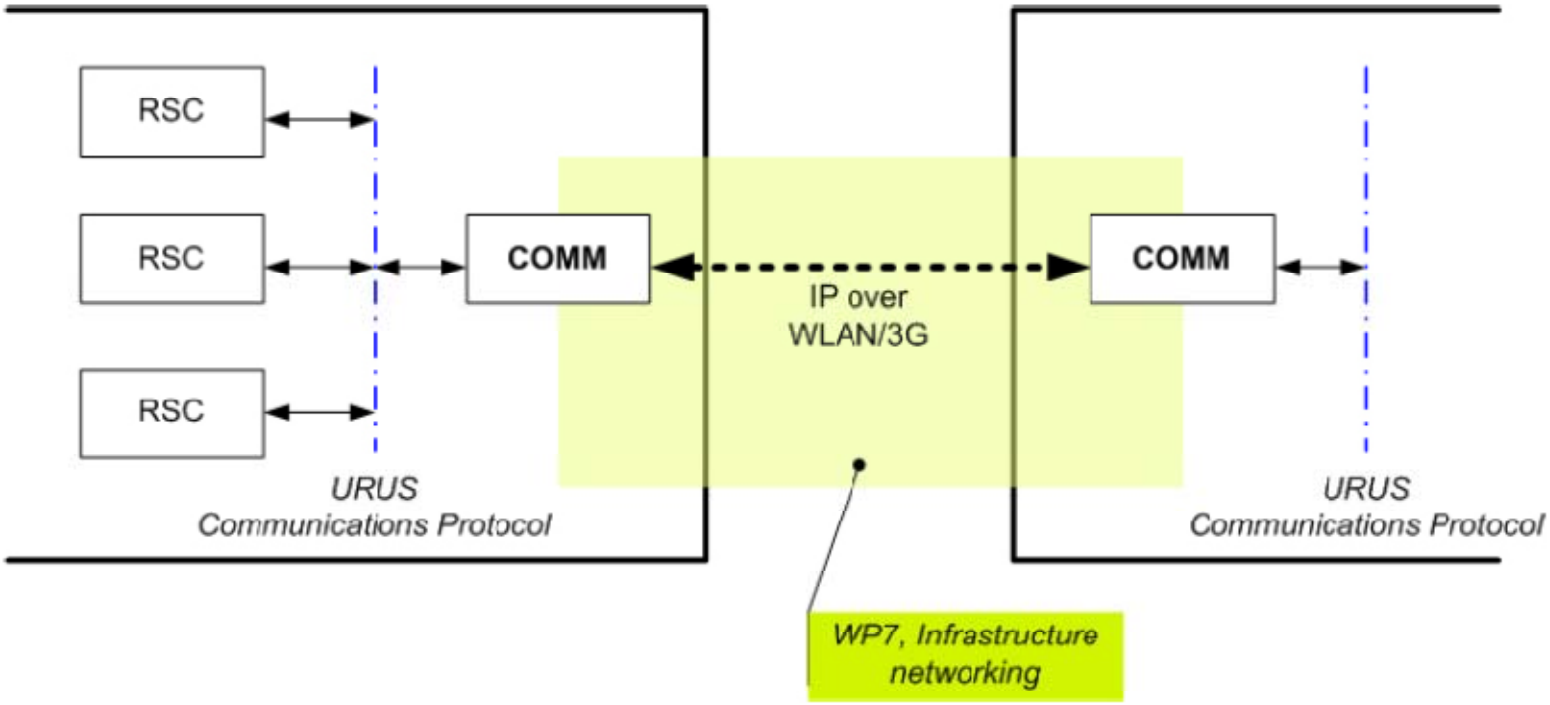


URUS Communication Systems

- **Internal Communication:** Between components of the same entity
  - We have developed an ***URUS communication protocol*** based on YARP (Yet Another Robot Platform)
- **External Communication:** Between components running in different entities
  - We are using 4 different network technologies:
    - Infrastructure (WLAN), Mobile Ad-hoc Network (MANET) (WLAN), Personal Area Network (PAN) (Bluetooth) and MOBILE
    - (GSM/3G.
  - We have developed the following components
    - The COMM component
    - The MANET component

COMM Component

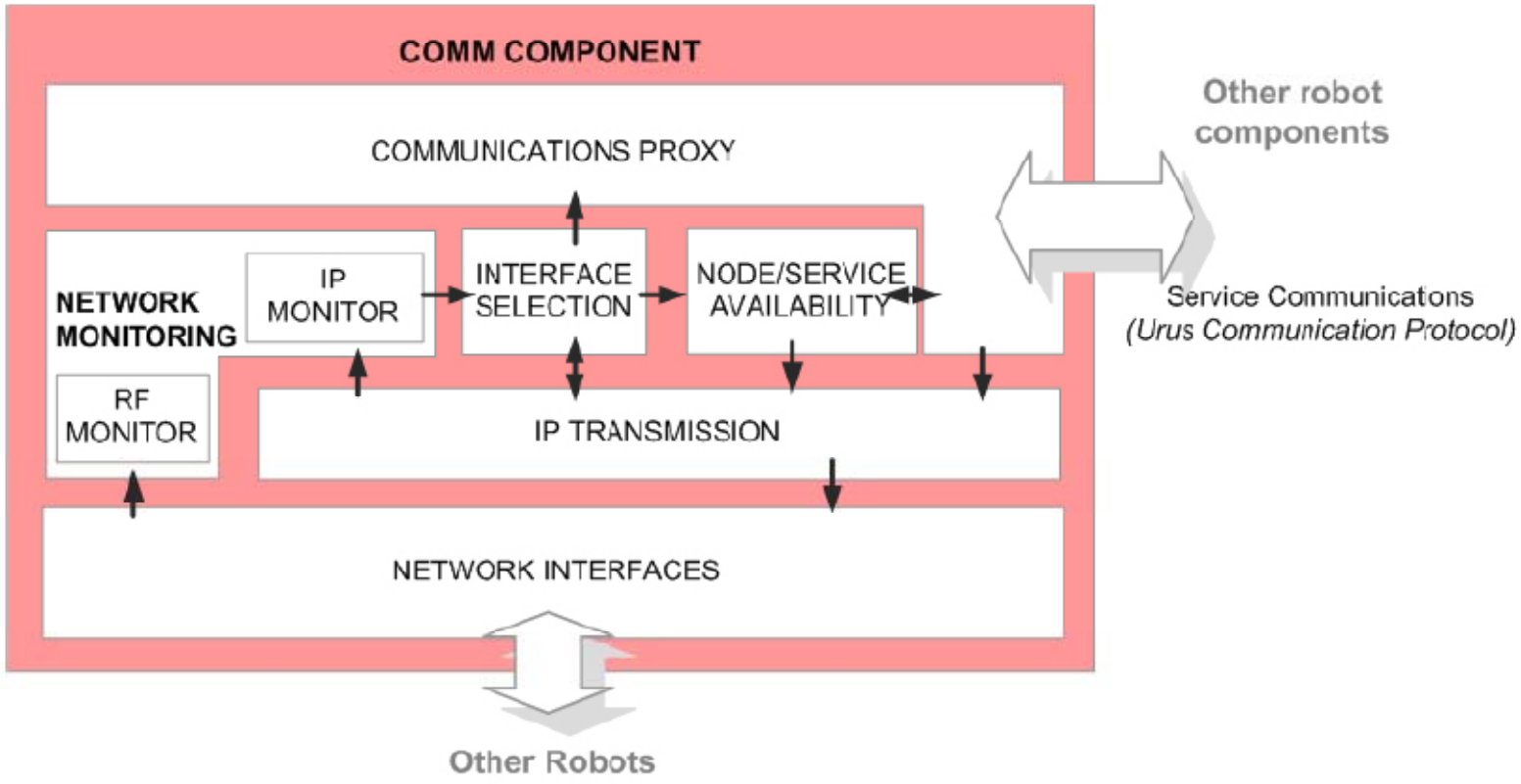
COMM Component



COMM Requirements

- Hide the complexity associated to the use of WLAN for communications and cellular networks as backup.
  - Offer URUS Communications Protocol interfaces for local components to request communications services (including the MANET Component when the robot plays the role of Gateway when involved in a MANET).
- Provide the means for best effort connectivity between Robots and with the Central Station (CS).
  - Detect connectivity loses in WLAN and re-direct traffic to GSM/3G as a backup.
  - Maintain updated information on how to reach any entity in the robotic system (Robots may be using their WLAN fixed IP address or their 3G dynamic IP address in different moments).
  - Optimize remote communications.

Architecture of the COMM Component



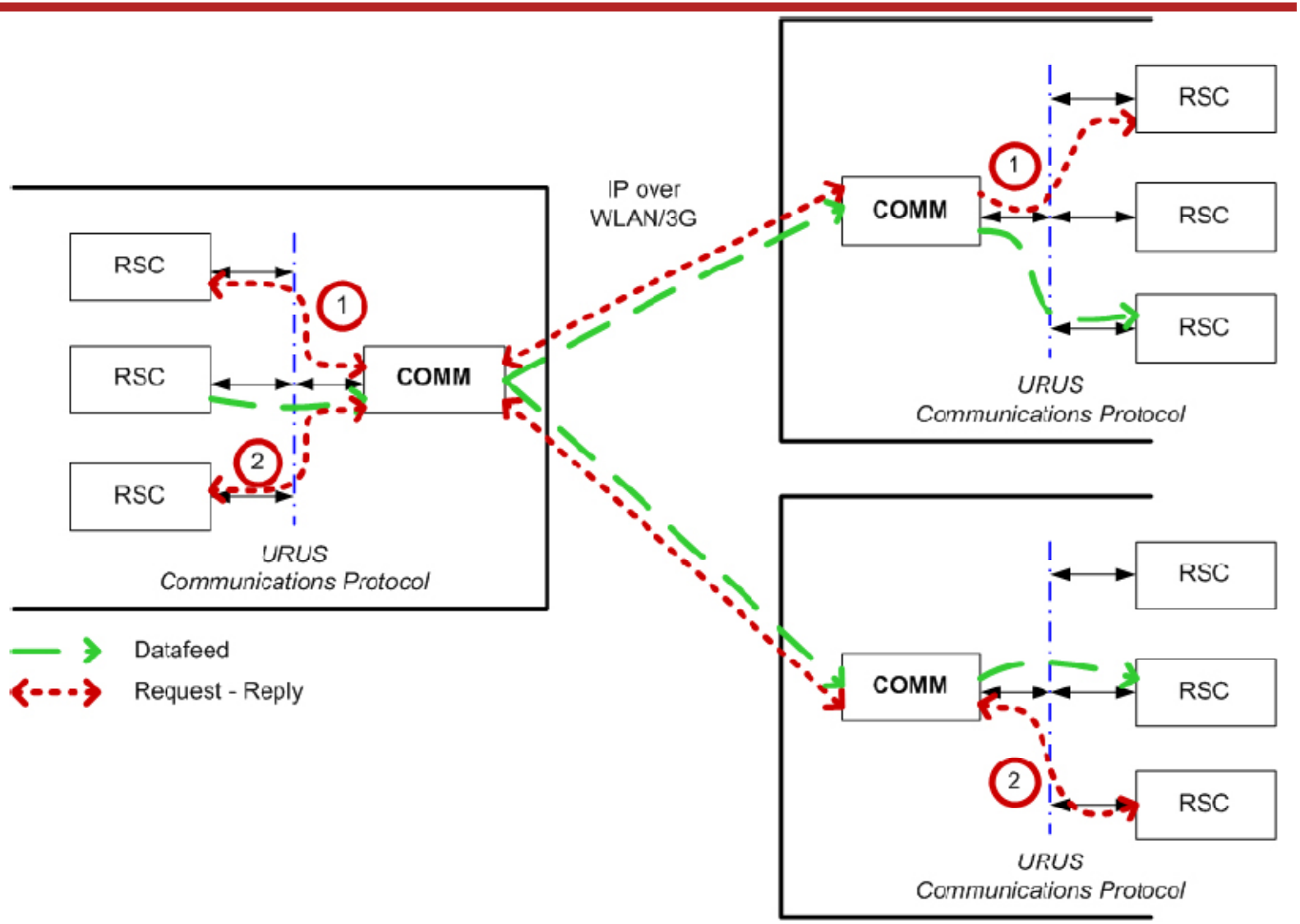
COMM Functions

- ***Network interfaces***: This module wraps the drivers for the WLAN and 3G/GSM cards that will be used. Provides access to basic functions associated to data exchange and monitoring.
- ***IP transmission***: It implements the transport mechanisms over IP to meet the communications needs of the the local robot components with components in different robots.
- ***Network Monitoring***: This module deals with monitoring at RF and IP level.
  - RF Monitoring: It monitor RF activity and triggers interface selection based on connection availability and WLAN signal strength.
  - IP Monitoring: It monitors IP activity and triggers interface selection based on IP transport related events (timeouts, lost packages, delivery errors, etc).
- ***Interface selection***: Manages physical interface selection depending on RF and IP status.

COMM Functions

- ***Node / Service Availability***: Maintains updated information on how to reach any entity in the robotic system in coordination with other robots and the CS.
- ***Communications proxy***: Wraps the component to comply with the URUS Communications Protocol.
- ***Request-Reply and Datafeed connections***:
  - Request-Reply provides a way for point to point two way communications and works on a demand basis.
  - Datafeed provides a way for point to multi-point one way communications and works on a subscription basis.

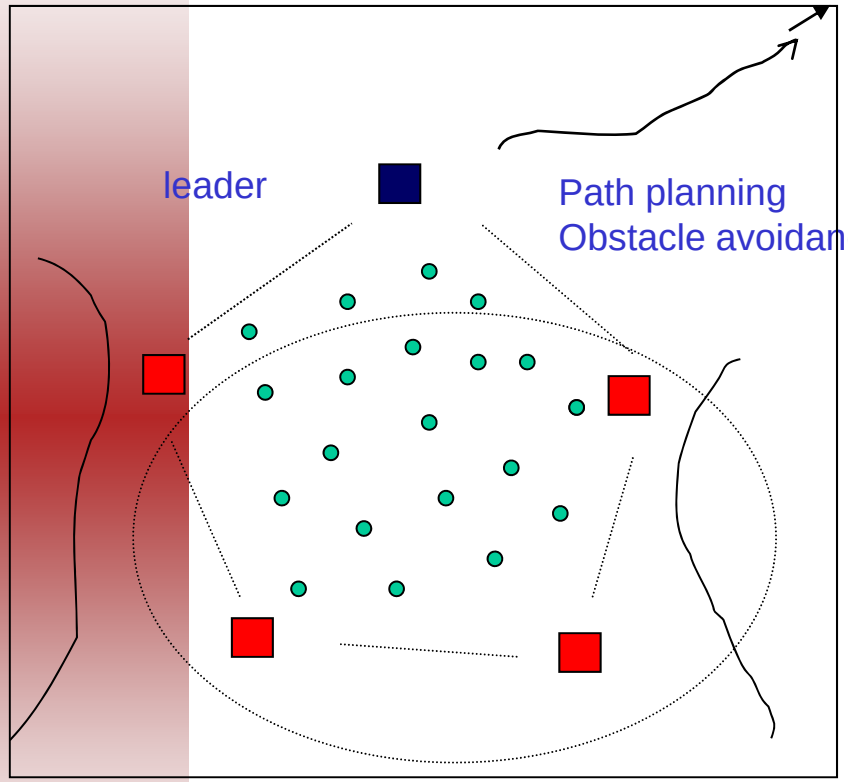
High Level Operations for Reply-Request and Data Feed Communications

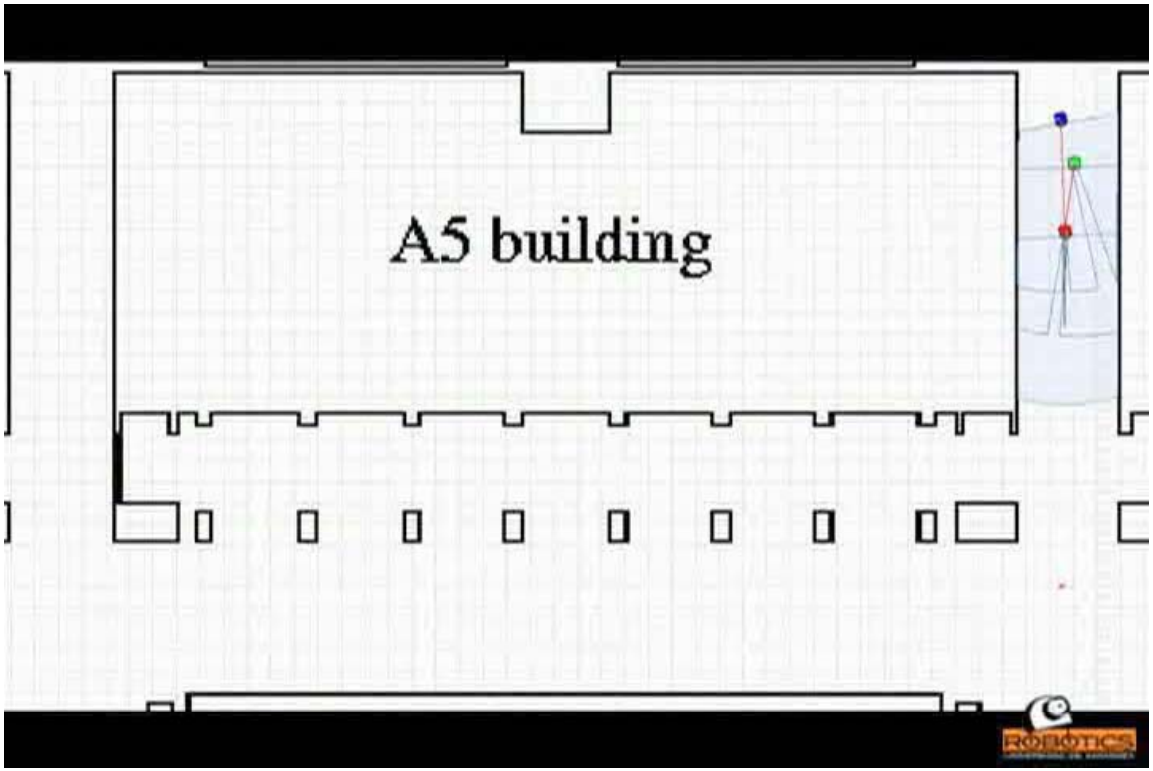


Ad-hoc Networking:
The MANET Component

Motivation

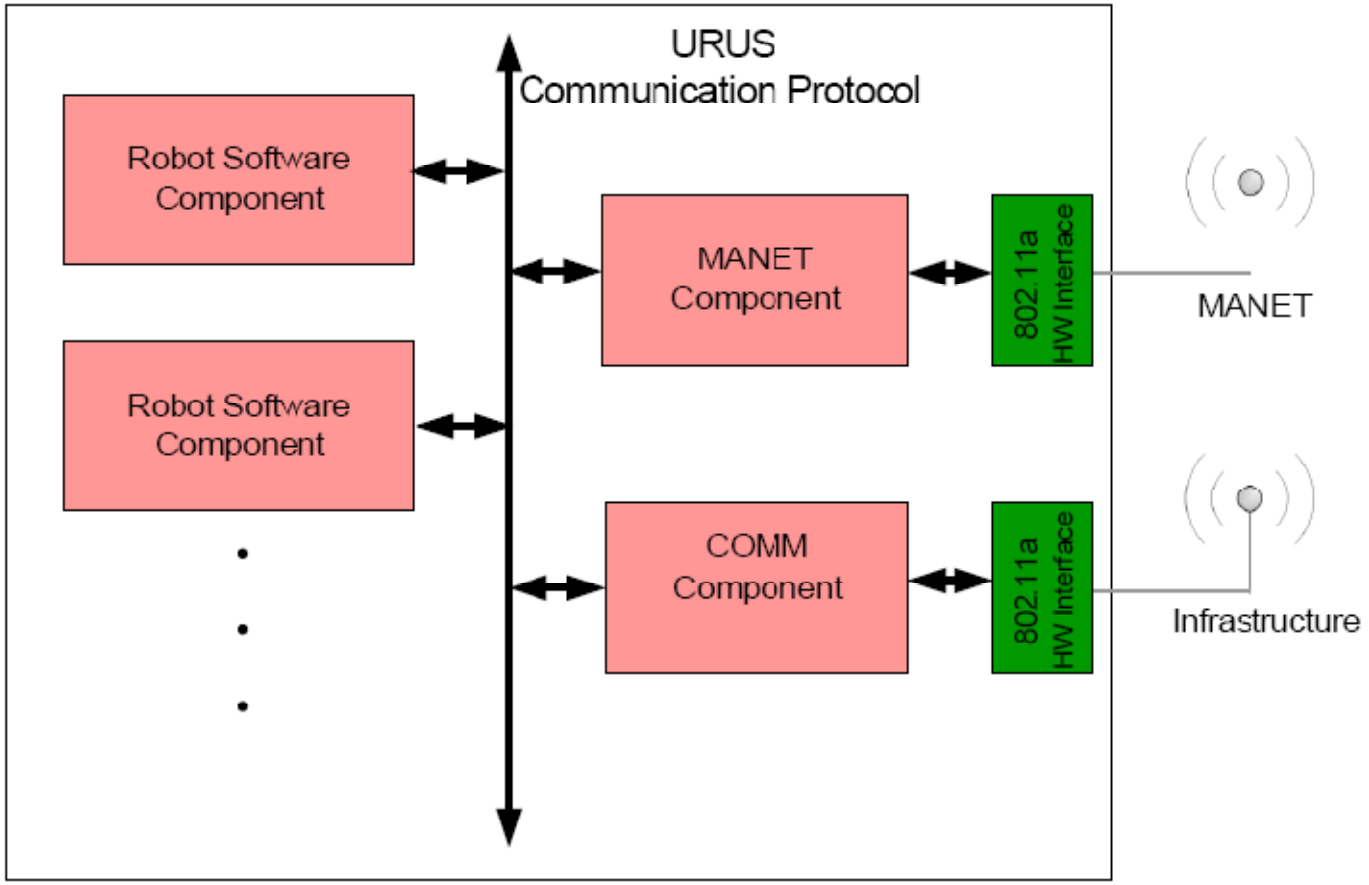
Robot formation



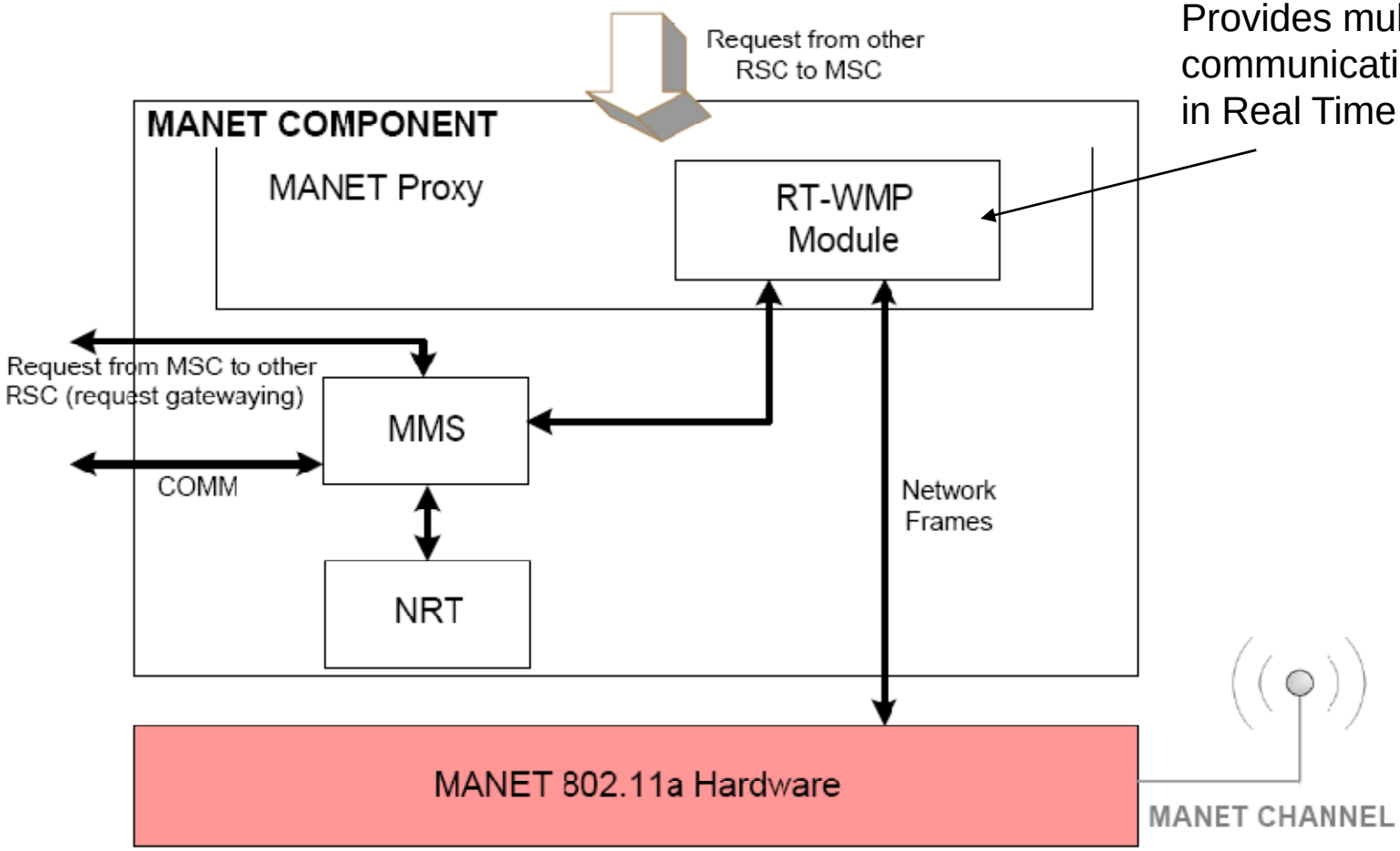


[Mosteo et al. ICRA08]

MANET Software Component Interaction



Architecture of the MANET Component



Provides multi-hop communication support in Real Time

[Tardoli and Villarroel. ICMASS07]

Example of Complex Communications

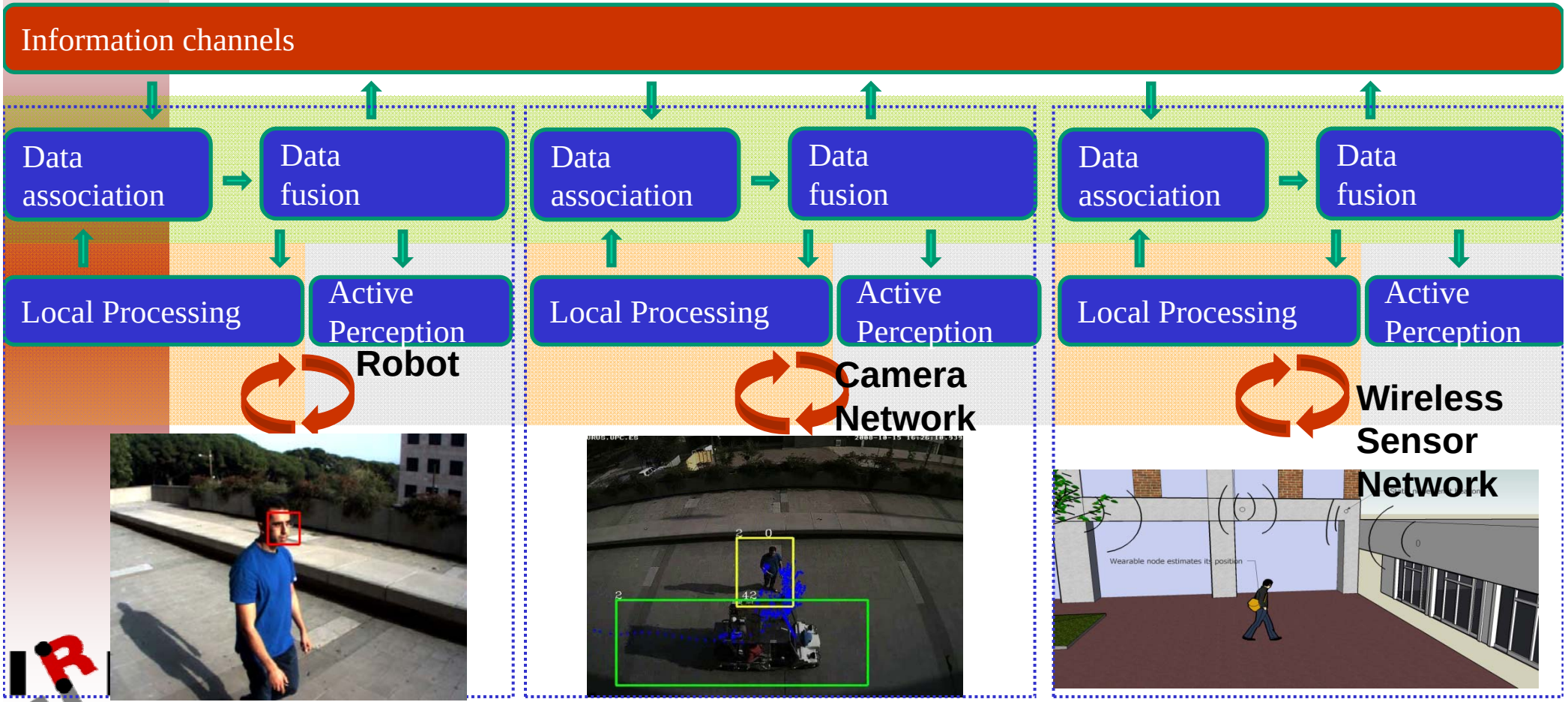
Communication in Cooperative Environment Perception

Cooperative perception using:

- embedded and own sensors
- fusion techniques and technologies

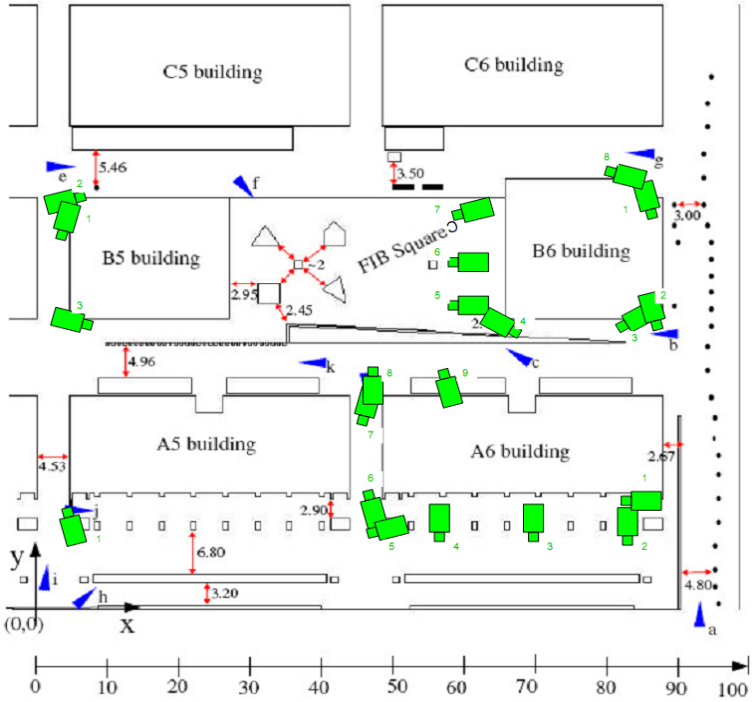
Communications Between Different Processes

- Communications for cooperative person tracking in URUS and decentralized estimation between robots, camera network and WSN

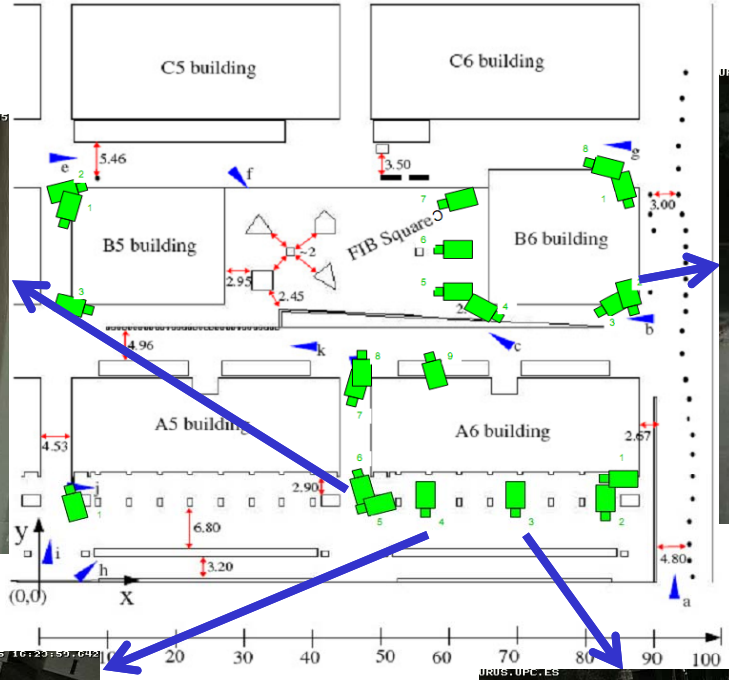


Example of Communication in Camera Network

- 21 cameras with little camera overlap
- Shadows challenging
- Delineates foreground objects from non-stationary background e.g trees

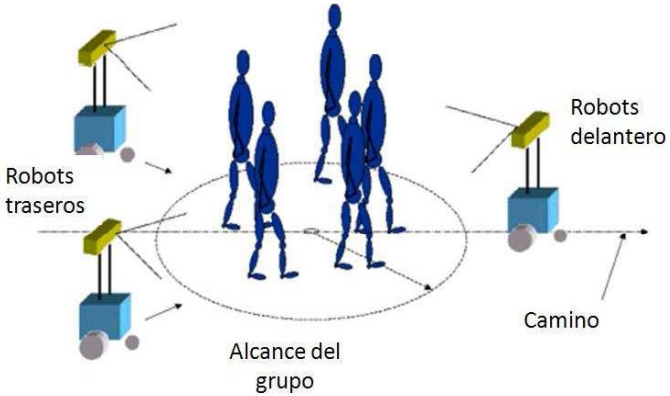


Example of Communication in Camera Network: Tracking



Communication for Guiding People (I)

Robot formation



Dog shepherding

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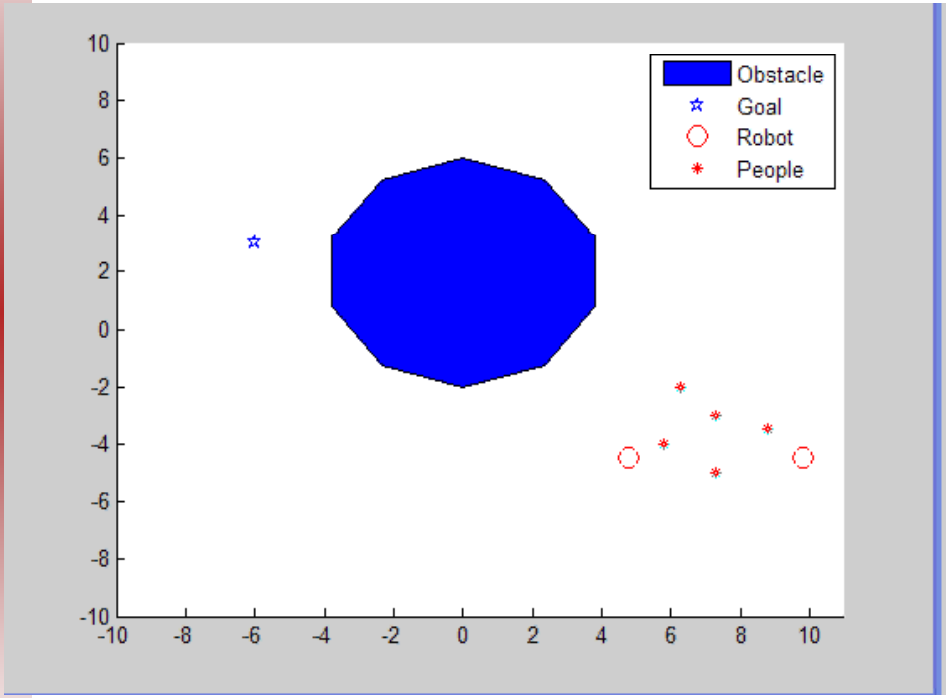
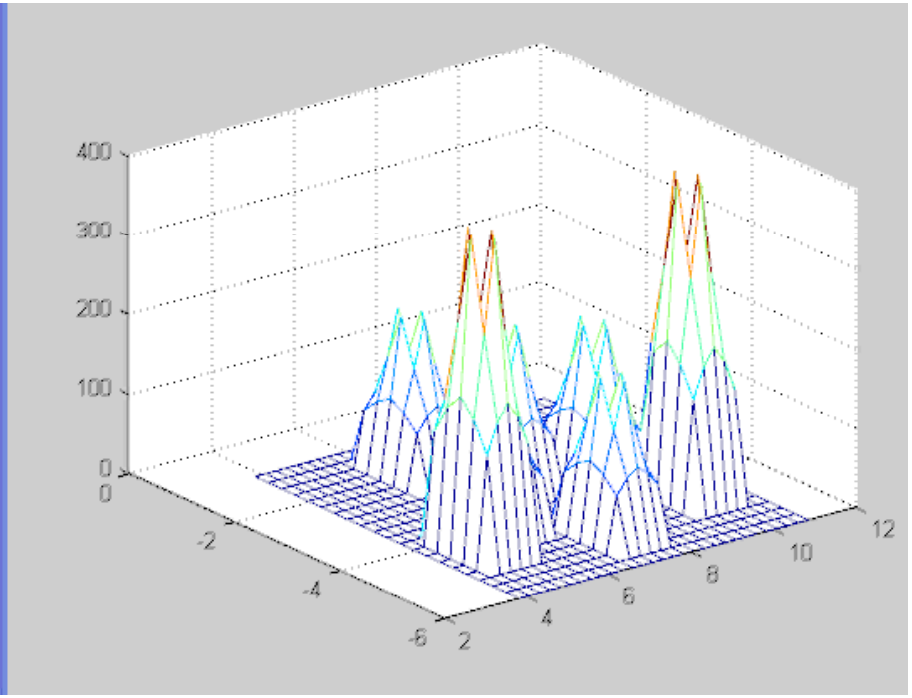
Communication for Guiding People (II)

Simulation results

[Guia_personas_Anais_1.avi]

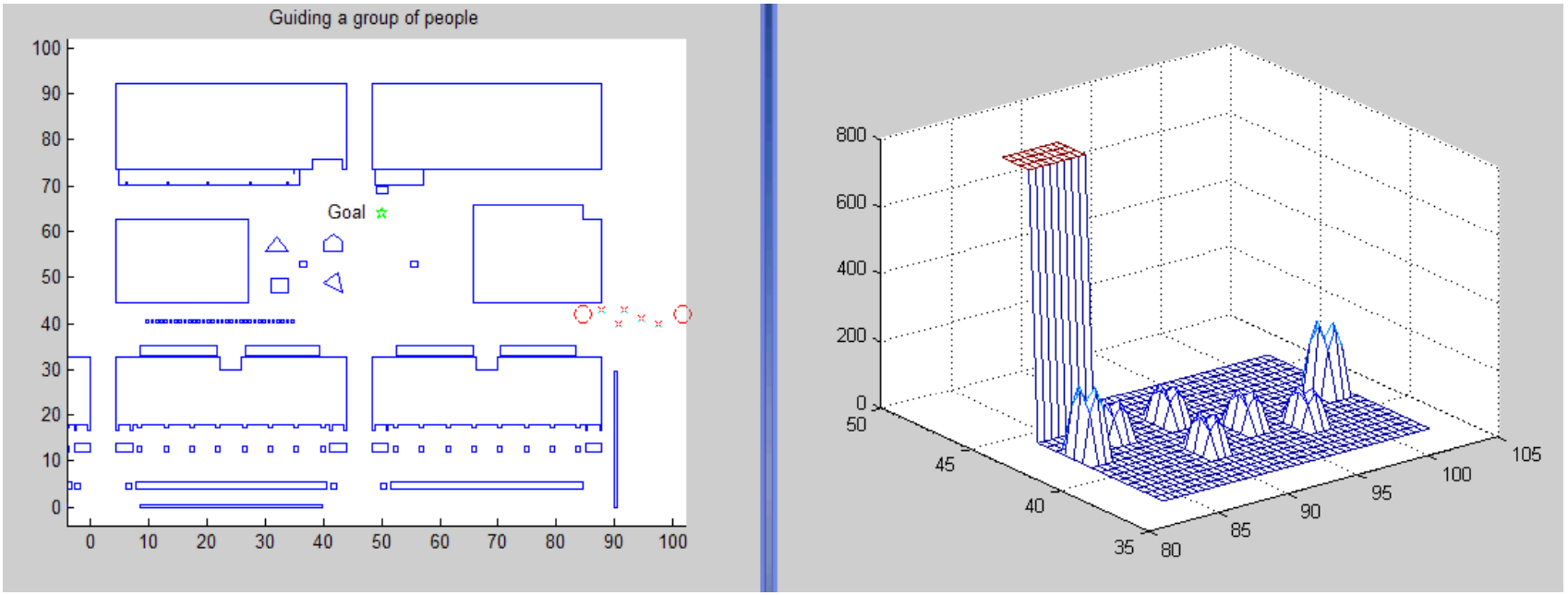




Communication for Guiding People (III)

Simulation results

Guia_personas_Anais_3.avi



Conclusions

- The communication system allows to share information in the urban site between different entities.
- The COMM component is a valuable software tool that allows to maintain the connectivity.
- The MANET component allows to maintain robot formation without the need of the urban network.