Network of Excellence

NEWCOM#

Network of Excellence in Wireless Communications#

FP7 Contract Number: 318306

WP2.2 – Networking technologies for the Internet of Things (IoT) with mobile clouds

D22.1
Definition of EuWIn@CNIT/Bologna testbed interfaces and preliminary plan of activities

Contractual Delivery Date:	April 30, 2013
Actual Delivery Date:	April 30, 2013
Responsible Beneficiary:	CNIT/UniBo
Contributing Beneficiaries:	CNIT/UniBo, CTTC, CNRS/Eurecom
Estimated Person Months:	7
Dissemination Level:	Public
Nature:	Report
Version:	1.0

This page is left blank intentionally

Document Information

Document ID:	D22.1
Version Date:	May 13, 2013
Total Number of Pages:	47
Abstract:	This document presents the general scope of EuWin and provides a description of the technical facilities available at EuWin@CNIT/Bologna site. The functional description of the platforms set up and the corresponding user interfaces are provided. A preliminary plan of activities, preliminary JRAs, and laboratory policies are illustrated.
Keywords:	EuWin, Laboratory description, Experimental research, CNIT-BO site, Internet of Things, Smart City, Delay Tolerant Networks, Routing.

Authors

IMPORTANT: The information in the following two tables will be directly used for the MPA (Monitoring Partner Activity) procedure. Upon finalisation of the deliverable, please, ensure it is accurate. Use multiple pages if needed. Besides, please, adhere to the following rules:

- Beneficiary/Organisation: For multi-party beneficiaries (CNIT) and beneficiaries with Third Parties (CNRS and CTTC), please, indicate beneficiary *and* organisation (e.g., CNIT/Pisa, CNRS/Supelec).
- Role: Please, specify: Overall Editor / Section Editor / Contributor.

Full Name	Beneficiary / Organisation	e-mail	Role
Davide Dardari	CNIT/Bologna	davide.dardari@unibo.it	WP 2.2 Leader
Roberto Verdone	CNIT/Bologna	roberto.verdone@unibo.it	EuWin Director
Melchiorre Danilo Abrignani	CNIT/Bologna	danilo.abrignani@unibo.it	Task 2.2.1 Leader
Chiara Buratti	CNIT/Bologna	c.buratti@unibo.it	Task 2.2.2 Leader
Andrea Stajkic	CNIT/Bologna	andrea.stajkic@unibo.it	Software developer
Flavia Martelli	CNIT/Bologna	flavia.martelli@unibo.it	Software developer
Florian Kaltenberger	CNRS/Eurecom	Florian.kaltenberger @eurecom.fr	Contributor
Miquel Payaro	CTTC	miquel.payaro @cttc.es	Contributor
Sinan Gezici	BILKENT	gezici@ee.bilkent.edu.tr	Contributor
Anna Umbert	UPC	annau@tsc.upc.edu	Contributor

Reviewers

Full Name	Beneficiary / Organisation	e-mail	Date
Roberto Verdone	CNIT/Bologna	roberto.verdone	29.4.2013

		@unibo.it	

Version history

Issue	Date of Issue	Comments
0.1	1/2/2013	TOC definition – R. Verdone, D. Dardari
0.2	18/3/2013	Draft of sections 2 and 4 – R. Verdone
0.3	25/3/2013	Draft of sections 2.4, 3 and 4.3 – D. Dardari
0.4	10/4/2013	Contributions: Abrignani, Buratti, Stajkic, Martelli
0.5	12/4/2013	Integration - D. Dardari, R. Verdone
0.6	14/4/2013	Integration upgrade - R. Verdone
0.7	15/4/2013	Final version for internal review – D. Dardari
1.0	29/4/2013	Final version after internal revision – R. Verdone

Executive Summary

The purpose of this document is two-fold: on the one hand it explains the general scope of EuWin, common to the 3 EuWin laboratories at CTTC, CNIT/Bologna, and EURECOM – on the other hand it provides a detailed description of technical facilities available at EuWin@CNIT/Bologna site.

The EuWin@UNIBO site provides more than 200 wireless nodes implementing different types of radio interfaces, and deployed according to 3 platforms: Flexible Topology Testbed (FLEXTOP), Data Sensing and Processing Testbed (DATASENS) , and Localization Testbed (LOCTEST). The purpose, the functional description as well as the user interfaces of each platform are detailed in Sec. 3.

Some of the EuWIn facilities will support the joint research activities (JRAs) conducted within the Track #1 WPs, but also specific Track #2 JRAs are expected to be set up. In the last part of this document, Section 4, preliminary JRAs are described. Some of them are Inter-Track JRAs and some involve at least 2 EuWin sites in the spirit of establishing a structured integrated laboratory.

Finally, a preliminary plan of activities and laboratory policies are illustrated.

The most important outcome that stems from the contents in this deliverable is that EuWIn@UniBo is now ready to start the experimental activities of WP2.2.

Table of Contents

1. Introduction

EuWIn (the European Laboratory of Wireless Communications for the Future Internet) intends to become one of the durable and most successful outcomes of Newcom#. EuWIn fosters excellence in research in the field of wireless communications, and it aims at training a new generation of scientists prone to do research both from the theoretical and the experimental viewpoint.

The general theme of EuWIn is "**Fundamental Research Through Experimentation**". This motto emphasizes that the laboratory is not targeted to demonstration activities (though they might be considered sometimes); rather, the laboratory aims at making theoretical and fundamental research closer to the real world, in terms of adherence to the true problems that any new technology has to face at time of implementation, and of realism of model assumptions. As additional scope, EuWIn will represent a sort of gateway among the community of scientists doing fundamental research in the field of wireless communications, and industry.

Despite the intention to become a long-lasting initiative, EuWIn is described in this document only in terms of its plan of activities to be performed within the Newcom# course. EuWIn represents the experimental Track (Track #2) of Newcom#. EuWIn activities are devised as facilitators for the research performed within Track #1. Some of the EuWIn facilities will support the Joint Research Activities (JRAs) conducted within the Track #1 WPs. Inter-Track JRAs will be defined accordingly. On the other hand, EuWIn aims at creating a durable and self-sustainable environment that will survive after the end of Newcom#; therefore, all means to establish a structured integrated laboratory will be pursued and are described in this Deliverable.

EuWIn is composed of three sites, targeting at separate technologies and fields of experimentation: the laboratories of the research center CTTC of Barcelona (Spain), of CNIT/University of Bologna (Italy), and of the EURECOM institute of Sophia-Antipolis (France). The three institutions had developed experimental facilities in the context of other projects in the past years, and have committed to make them available to other Newcom# partners, through an integrated and open framework.

Additional Newcom# institutions, besides the three that committed towards the creation of an open laboratory context, have expressed the intention to contribute through some local experimental facilities to EuWIn: Bilkent, CNRS, PUT, UCL and UPC (third party of CTTC).

The three EuWIn sites cover aspects related to radio interfaces (mainly based on MIMO and PHY-layer algorithms) and localization techniques, at CTTC, flexible radio technologies over MIMO platforms, at CNRS/EURECOM and Internet of Things (IoT) and Smart City applications, at CNIT/UniBO. Overall, accounting for all institutions participating to Track #2, the experimental activities will deal with aspects of modulation, coding, signal processing, localization, radio channel characterization, routing, topology control.

The main scopes of EuWIn, the tools used to achieve integration within the sites, and the facilities available at each of the three sites, are discussed in Section 2 of this Deliverable. The Section also includes a short presentation of the EuWIn website, which is described in more detail in D36.1. In Section 3 the lab equipment made available at CNIT/University of Bologna, is presented, and the objectives of the testbeds are clearly identified; two additional parallel Deliverables report on the details related to the CTTC and EURECOM sites. The general parts of the three Deliverables are common, to emphasize the unique scope and the

integrated strategy, while Section 3 is different for each of the three Deliverables. Section 4 shows the plan of EuWIn activities. It is detailed for the next six months, while the plans for the following two years will be described in the Deliverables due at M12. The Section also presents the policy for access to the lab facilities. The conclusions shortly discuss on the potential role of EuWIn within the scientific community and for the European industry context.

1.1 Glossary

API - application programming interface
EIRP - effective isotropic radiated power
FCC - Federal Communication Commission
GNSS - global navigation satellite system
GPL - general public license
GUI – graphical user interface
HAL – hardware abstraction layer
IoT – Internet of things
ISM – industrial, scientific, medical
LEO - localization error outage
MAC – medium access control
MRM - monostatic radar module
NLOS - not line-of-sight
ON – opportunistic networks
OTA - over-the-air
PHY – physical layer
PRF - pulse repetition frequency
PRP – pulse repetition period
QoS – quality of service
RMSE - root mean square error
RSS – received signal strength
SDR – software defined radio
SPI – serial port interface
TOA – time-of-arrival
TW-TOA - two-way-TOA
USB – universal serial bus
USRP - universal software radio peripherals
UWB – ultra-wide bandwidth
VPN – virtual private network

2. EuWIn Scope and Activities

This Section describes the general goals of EuWIn, the types of activities planned and the policy for accessing its facilities. Short introduction to the EuWIn website structure is also given.

2.1 Introduction

As mentioned in Section 1, the three EuWIn sites deal with separate technical and scientific topics: Radio Interfaces (CTTC), IoT (UniBo) and Flexible Communication Terminals (EURECOM) However, the scope of EuWIn is to achieve an integrated laboratory able to address under a common environment the various topics of wireless communication technologies for the future Internet. To reach this goal, on the one hand the sites have been identified based on the complementarity of their competencies and facilities; on the other, some technical topics are common to two EuWIn sites, thus facilitating the integration of competencies and procedures: localization techniques are a common topic for CTTC and UniBO; MIMO based platforms for testing purposes are available at both EURECOM and CTTC; heterogeneous architectures and technologies for the IoT are considered both at UniBO and EURECOM sites.

All Newcom# institutions will be allowed to take advantage of this integrated (yet distributed) laboratory, through an open access policy described below. The procedures for the coordinated access to the lab facilities are also introduced in this Deliverable, and implemented through the EuWIn website. Newcom# associate partners will also be allowed to have access under agreed conditions, while institutions external to the Newcom# environment will undergo specific and selective agreements as described below.

The vision of EuWIn can be represented through the spheres shown in Figure 2-1.

The inner sphere includes the three EuWIn sites. The integration of facilities and coordination of activities is under the responsibility of the EuWIn Director, Roberto Verdone (CNIT/UniBO). The three institutions, as detailed later, have been working during the first semester of Newcom# to extend and integrate their pre-existing facilities, creating the tools for their use by the rest of the Network of Excellence.

The second "internal" sphere includes all Newcom# institutions (the figure emphasizes those who, at time of DoW preparation, expressed commitment towards EuWIn. During the three years of Newcom# the set of these institutions might change). All Newcom# institutions have access to the EuWIn facilities, according to the open access policy defined later, free of charge.

The third "internal" sphere includes the associate partners of Newcom#, both those defined at time of DoW preparation (mainly industries) and those accepted by the consortium after project kick off. These institutions have access free of charge to the EuWIn facilities based on a selective process/policy described later.

Finally, the "external" sphere includes all institutions interested in having access from outside Newcom# to the EuWIn facilities. This sphere is based on a case-by-case consideration of the access conditions, which will depend on the type of activity foreseen, the facility/site of interest, etc.

At time of delivery of this document, the following Newcom# partners are involved in potential JRAs targeted at the exploitation of the EuWIn facilities: AAU, Bilkent, CNIT, CNRS, IASA, PUT, UCL, VUT Moreover, the following additional institutions from outside Newcom# have declared strong interest into the EuWIn WPs: ACTIX, Agilent, AVEA, U-Blox, NEC Labs, Orange Labs, Renesas Mobile, Samsung, Telecom Italia, Telefonica I+D, Thales Communications.
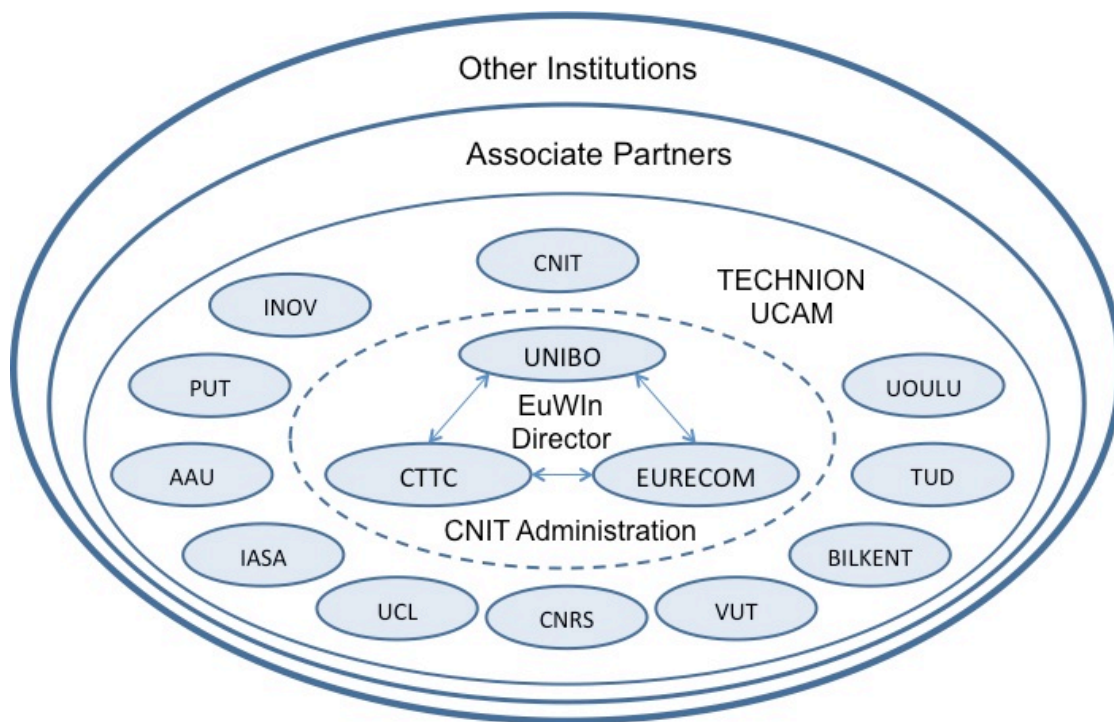

Figure 2-1: The Newcom# Spheres.

The EuWIn website will specify and publicize for each sphere the access policy and the procedures for a coordinated exploitation of the laboratory facilities.

2.2 EuWIn Goals and Lines of Action

The uttermost goal of EuWIn is the creation of a new generation of scientists willing to perform fundamental research through experimentation. Additionally, EuWIn, being one of the Tracks of Newcom#, aims at an active role within the Network of Excellence as an instrument for dissemination and link with industries.

These goals can be reached in the long term by developing instruments and activities which will allow the involvement, at different levels, of the largest possible number of researchers, from inside and outside Newcom#. EuWIn will therefore pursue its goals through the implementation of several types of actions:

1) **Real world measurements** helpful for fundamental research activities.
2) **Real world performance evaluation** of fundamental research results.
3) **Links with industries**, either associated to NEWCOM# or not.
4) **Dissemination** of NEWCOM# research outcomes.
5) **Durable integration** of resources and activities provided by NEWCOM#.
6) **World contests** open to all researchers, within and outside NEWCOM#.

These lines of action are discussed briefly in the following subsections.

2.2.1 Real World Measurements

Real world measurements will be useful in order to extract from them models and parameters to be used in theoretical research. Radio channel characterisation, for instance, is of outmost relevance to scientists studying the link-level performance of wireless systems; human mobility modelling, link-level assessment of the bit error rate against SNR (signal-to-noise-ratio) performance, are examples of research activities which can take advantage of measurement campaigns and are useful to the evaluation of the performance of wireless networks. All the EuWIn sites (and other Newcom# institutions) have facilities which will allow the development of measurement campaigns aimed at the definition of suitable models to be used for the performance of wireless systems, either at link or network level, as specified later. This line of activity indeed will provide *inputs* to the theoretical study of link and network level performance of wireless systems, performed within Track #1, making them more realistic in terms of models used.

2.2.2 Real World Performance Evaluation

Real world performance evaluation is a task performed in research either through mathematical modelling, simulation, emulation or experimentation; when the system under analysis is complex, the latter approach is the only one that is feasible. It requires flexible experimental facilities allowing the implementation of the link-level or network-level techniques/algorithms under evaluation. The EuWIn sites have developed facilities that are flexible enough in order to allow implementation of different techniques/algorithms designed by scientists performing theoretical research. This line of action therefore, will take the *outputs* of the research performed within Track #1, and provide assessment of the performance through experimentation.

2.2.3 Links with Industries

EuWIn will represent the main Newcom# instrument to create links with industries; the lab facilities will be used as proofs-of-concept of the techniques/algorithms designed, studied and evaluated within Track #1. Representatives from industry will be invited at all EuWIn events, and the researchers involved in the JRAs performed within EuWIn will organise visits at the premises of companies. The industry-academia link, which was missing in its predecessor Newcom++, will be established within Newcom# thanks to the availability of the EuWIn facilities and testbeds.

2.2.4 Dissemination

All EuWIn dissemination events, either intended for industry or academia, will have at least one of the EuWIn sites present, showing the facilities, making them available remotely, and reporting on the latest achievements. EuWIn leaflets, posters and video trailers will be generated and made available to all EuWIn researchers with the aim of creating a repository of promotional material to be used for dissemination purposes.

2.2.5 Durable Integration

EuWIn intends to create a framework which will go beyond the duration of the Newcom# project. To this aim, all coordination, promotional and dissemination activities will be geared towards a longer horizon than the three years of expected duration of Newcom#. However,

durable integration requires financial sources which should be found outside the Newcom# budget. EuWIn will seek for additional sources of funds through the participation of the EuWIn institutions to competitive EC calls, and from the private sector (industries willing to access the EuWIn facilities).

2.2.6 World Contests

Some of the EuWIn sites (among them, the one at UniBO) will launch international contests to test over the lab facilities techniques/algorithms designed by institutions willing to participate. This will create further visibility to the laboratory, while representing a potential source of incomes for future activities after the end of Newcom#.

2.3 EuWIn Activities

The lines of action described in the previous subsection take the form of activities performed within Track #2 as it follows:

1) **A Unique Portal:** facilities, activities and repository of measurements;
2) **Web Meetings,** to coordinate and plan visits of researchers;
3) **Workshops** on experimental research;
4) **Training Schools** on experimental research;
5) **Industry Liaisons**;
6) **Demonstration activities:** at conferences, fairs, etc;
7) **Experimental Tours**: PhD students visiting the three sites in sequence.

Short description of the activities is given in the following subsections.

2.3.1 A Unique Portal

Under the domain euwin.org, a website has been created (properly linked to the Newcom# website). The scope of the portal is to create a unique access to the laboratory, by providing shared documents, description of procedures for getting access to the facilities, and a repository of those measurement data that are shared and can be useful to the researchers involved in EuWIn activities. The website will also provide information on the events generated or participated by EuWIn, the contacts had with industries, etc.

2.3.2 Web Meetings

Besides the usual web meetings held periodically by the three WP Leaders of Track2, EuWIn will organise web meetings open to all EuWIn participants in order to disseminate within the project information regarding the latest development of the lab facilities, to coordinate and schedule the access and the activities of the EuWIn-related JRAs. These web meetings will be called by the EuWIn Director depending on needs and requests, and the dates will be fixed through polls, informing all researchers at least 30 days before the meeting will take place.

2.3.3 Workshops

To foster sensibility towards experimentation, EuWIn will organise workshops, with the contribution of both Newcom# researchers and scientists participating to other projects, which will aim at discussing the benefits of experimental research and compare the approaches toward open access platforms.

2.3.4 Training Schools

One of the most important activities performed within EuWIn, apart from the experimental trials, is the organisation/contribution to training schools. Through the participation of EuWIn key researchers as lecturers and the organisation of experimental sessions at the schools, the attendees will be trained towards experimental research.

2.3.5 Industry Liaisons

Each of the EuWIn sites will establish liaisons with specific industrial labs and companies, identified based on the topic of interest of the site. The EuWIn sites will be then responsible for the organisation of periodic meetings with the industry representatives in order to create stable contacts that might bring to forms of support to the EuWIn activities in the long term.

2.3.6 Demonstration Activities

The achievements got within Newcom# and the development of new facilities, will be demonstrated at fairs, exhibitions and other events participated by many industry representatives.

2.3.7 Experimental Tours

The most challenging objective of EuWIn is the creation of a generation of researchers prone to fundamental research trough experimentation, with competencies spanning over different layers of the protocol stack. This goal can be achieved by letting PhD students get involved into activities performed over the experimental facilities of different EuWIn sites, dealing with separate scientific topics. These activities will be denoted as "experimental tours", as the students will visit different sites, performing experiments that will be properly coordinated in order to achieve a unique scientific goal through the integration of measurements achieved over separate testbeds.

2.4 The Three EuWIn Sites

2.4.1 EuWIn@CTTC

The CTTC site (www.cttc.es) features the following three high performance testbeds, which are the core of the EuWIn@CTTC assets:

a) GEDOMIS® (GEneric hardware DemOnstrator for MIMO Systems): GEDOMIS® is an experimental platform that comprises a complete set of high performance baseband prototyping boards (FPGA and DSP-based), signal generation equipment, high-end RF front-ends, signal analysis instruments, specialized software tools and APIs. A key instrument of the testbed is the EB Propsim C8 channel emulator, which can be configured to provide realistic mobility scenarios of both certified and user-designed channel models. The Propsim C8 operates in real-time and facilitates the verification and testing of system designs prior to field-trials. Hence, GEDOMIS® offers a lab environment that enables the prototyping of next generation broadband wireless communication systems, which feature bit-intensive OFDM PHY-layer techniques possibly combined, if desired, with multi-antenna schemes. Moreover, the prototyping boards of GEDOMIS® feature various energy consumption measurement blocks, which can be used to assess the energy-efficiency for a given hardware implementation.

b) GNSS-SDR (Global Navigation Satellite System - Software Defined Radio): GNSS-SDR is an open source GNSS software defined receiver that adresses the design and

implementation of multi-constellation, multi-band GNSS receivers. According to its open nature, the source code is published under General Public License (GPL) v3, which secures practical usability, inspection, peer-review and continuous improvement by the research community, allowing the discussion based on tangible code and the analysis of results obtained with real signals. In addition to the source code, the project offers a development ecosystem (website, code repository, mailing list, bug tracker) that aims to build a community of researchers, developers and users around the project. The ultimate goal is to provide high-accuracy positioning for the masses, and for free. There are many ways for researchers to contribute to the project, e.g., programming new features (algorithms, receiver architectures, etc.), optimizing existing algorithms, reporting bugs or debugging existing features, among many others. This facility's equipment comprises an RF signal generator (Agilent's Vector Signal Generator E4438C equipped with GPS Personality), an assortment of GNSS antennas, RF measurement equipment (oscilloscope, network analyzer, spectrum analyzer), a set of Universal Software Radio Peripherals (V1 and V2) and USB data grabbers.

c) OpenInLocation (an open lab for research on indoor location): The main objectives of this lab is to drive R&D and innovation in indoor location by evaluating state-of-the-art and commercial technologies in challenging environments, improving them in terms of enabling High-Definition Situation-Aware (HDSA) applications and services, and, finally, fostering collaboration to contribute with new ideas for indoor positioning, to disseminate results and outreach to new audiences beyond Newcom#. This lab is composed of a set of extremely low-cost, programmable nodes that can act either as anchor node or as a mobile node, the wireless interfaces for such nodes (WiFi, Bluetooth, ZigBee, etc.), sensors (in IC form), and the corresponding software repository.

The common features to these three labs is that they promote collaborative research by offering an adequate framework and tools and they are all based on the principle of reproducible research, which enables practical discussions on tangible problems.

2.4.2 EuWIn@UNIBO

The EuWin@UNIBO site provides more than 200 wireless nodes implementing different types of radio interfaces, and deployed according to the following platforms:

Flexible Topology Testbed (FLEXTOP) – 100 nodes equipped with IEEE 802.15.4 radios distributed inside the lab creating an open and flexible platform for emulating several types of network topologies, achieved through proper software setting of the inter-node losses. This platform is based on over-the-air (OTA) implementation of software, meaning that NEWCOM# partners will be given remote access to implement the software;

Data Sensing and Processing Testbed (DATASENS) – An infrastructure of approximately 100 nodes using IEEE 802.15.4 radios deployed inside one of the University buildings, in rooms and corridors, implementing sensors able to monitor/emulate physical instances like light intensity, temperature, current drain, equipped with small LCD screens that will ease the management and control of application tasks. In addition to the nodes composing the fixed infrastructure, approximately 50 battery-supplied mobile nodes (with 802.15.4 devices) carried by people moving around, are part of the testbeds (Roaming Nodes);

Localization Testbed (LOCTEST) - Approximately 50 additional nodes with high-accuracy localization capabilities, using IEEE 802.15.4a or IEEE 802.15.4f Ultra-Wide Bandwidth (UWB) radios, will be deployed in the same building depending on the future commercial availability of low-cost UWB-based devices;

The infrastructure also includes some network coordination nodes equipped with mini-PC boards and different types of gateways (WLAN, LAN) for proper interconnection to the Internet.

2.4.3 EuWIn@EURECOM

EURECOM (www.eurecom.fr) is a research and teaching institute located in the Sophia Antipolis Technopole in the South of France. EURECOM's research activity traditionally focuses on 3 domains which have led to the creation of three research departments: Networking & Security, Multimedia Communications, and Mobile Communications. The Mobile Communications Department has its focus on digital signal processing for mobile communications, information theory, 4th generation and clean-slate cellular radio systems, wireless protocols, mobile ad hoc networks, software radios, and SW and HW prototyping. In addition to fundamental research, the department has strong expertise in open-architecture multi-way real-time radio platforms (www.openairinterface.org) for use in publicly-funded research projects aiming at demonstrating innovations at all protocols layers (RF to applications). The latter is provided to EuWIN for use within the network and afterwards. The OpenAirInterface.org (OAI) development and facilities primarily target cellular technologies (LTE/LTE-Advanced and beyond) and rapidly-deployable mesh/ad-hoc networks. The platform comprises both hardware and software components and can be used for simulation/emulation as well as real-time experimentation. It comprises the entire protocol stack from the physical to the networking layer. The objective of this platform is to provide methods for protocol validation, performance evaluation and pre-deployment system test.

2.5 Liaisons with Industries

2.5.1 EuWIn@CTTC

Currently, the CTTC team involved in WP2.1 ("Radio interfaces for next-generation wireless systems") has links with many industry players, among which the most relevant follow:

AT4 Wireless (recently acquired by Agilent Technologies): This collaboration started in 2009, when the CTTC team started to develop, together with the AT4 Wireless team, the test platform E2010, which is designed to perform compatibility tests to LTE terminals. The experience gained through this collaboration has contributed to a knowledge transfer, which is foreseen to be very useful in Task 2.1.4 ("High spectrally-efficient radio interfaces").

AVIAT Networks: This collaboration started in 2012. CTTC is carrying out a series of projects for the Silicon Valley-based company AVIAT Networks. Among these projects, the most relevant for Newcom# is the project where CTTC is providing a baseband processing solution for the improvement of energy efficiency in new generation transmitters for wireless backhauling equipments. This collaboration can have a positive impact on CTTC's participation in Task 2.1.2 ("Low-energy-consumption and low-emission radio interfaces"). Moreover, within this same topic, CTTC has submitted a proposal in the Seventh Framework Programme together with the Slovenian branch of AVIAT Networks.

Nutaq (before Lyrtech RD): This collaboration started in 2012. Nutaq is currently commercializing a software IP that contains the physical layer of the WiMAX standard developed by CTTC, which is named BeMImoMAX (http://nutaq.com/public/files/products/bemimomax/bemimomax.pdf). The CTTC team is now adapting this IP to make it compatible with the LTE standard. If other IPs are obtained as a result of the experimental research performed within Newcom#, CTTC can study together with Nutaq and the other partners involved in the research the possibility of commercializing them.

2.5.2 EuWIn@UniBO

The EuWIn site in Bologna has links with many industries, owing to the participation to many EC projects and industrial contracts. The main industry links, related to the scopes of EuWIn, are mentioned here:

The FLEXTOP testbed developed within EuWIn is of interest to the research labs of Telecom Italia, with particular reference to IoT applications;

EuWIn@UniBo has a peculiar link with Embit srl, a small Italian company which is design centre for Texas Instruments and Freescale and the provider of all wireless devices implemented within the laboratory;

The EuWIn site in Bologna has a preferred link with Intel labs of Ireland, which also investigate smart city applications of wireless communications.

2.5.3 EuWIn@EURECOM

OAI has explicit links with industrial partners who contribute to its development both within the context of publicly-funded projects and out of mutual interest on specific research subjects. Currently, the main industrial collaborators, which are, incidentally, affiliate members of the NoE, include:

Alcatel Lucent Bell-Labs (Villarceaux, France) contribute to optimized real-time signal processing for SDR, innovative protocol extensions to LTE, emulation tools based on OAI, interfacing of OAI to industrial-grade RF platforms (remote radio-heads - RRH).

Orange Labs (Beijing, China, subdivision of Orange France) contribute to optimized real-time signal processing for SDR, interfacing of OAI to other hardware platforms (custom and USRP).

Agilent (Beijing, China) contribute to optimized real-time signal processing for SDR.

Thales Communications (Gennevilliers, France) contribute to development of multi-hop protocols and resource allocation strategies for rapidly-deployable mesh networks and innovative signal processing for improving RF amplifier efficiency in terminals.

2.6 The EuWIn Website

The EuWIn website has been designed using the same platform chosen for the Newcom# portal, i.e., Joomla. This makes their maintenance easier. It has been devised both as an instrument for facilitating cooperation among the institutions involved (through a private part used as repository of shared documents and measurement databases), and as a dissemination tool providing all the information needed to join the laboratory activities.

However, it is important to emphasise that the EuWIn website does not represent a duplication of the information reported in the Newcom# portal, and all official documents related to the project will be found only on the Newcom# portal. Therefore, deliverables and meeting minutes will be posted on the latter, whereas promotional material (leaflets, video trailers, etc.) and documents describing in detail the lab facilities, will be found on the EuWIn website.

Moreover, the EuWIn website is integrated in the Newcom# portal, as all user credentials made available to Newcom# researchers to access the project portal will be imported on the EuWIn site, so that all Newcom# researchers will be given access to the private area of the EuWIn website under the same credentials.

The structure devised for the EuWIn website is as follows.

HOME   *it contains a short welcome message and describes the goals of EuWIn*

STRUCTURE   *description of the lab structure is given, using contents of this Deliverable*
   → *Sites*   *map, link to three institution websites*
   → *Director*   *short descript of role, personal welcome message*
   → *WP Leaders*   *short descript of roles, personal welcome messages*
   → *Partners*   *mention of Newcom# partners active within EuWIn*
   → *Liaisons*   *mention of the industries/labs/projects linked to EuWIn activities*

FACILITIES   *general description of the various platforms*
   → *Platform#1 (eg GEDOMIS) description*
   → *Platform#2 (eg FLEXTOP)*
   → *Platform#3 (eg DATASENS)*
   → *Platform#4 (eg LOCTEST)*
   → *…*

ACCESS   *the general access policy is described*
   → *Documents*   *link to public documents*
   → *Join*   *forms to be filled for requesting access*
   → *Visit*   *forms to be filled for proposing a visit to the laboratory sites*

DEMOS   *inaugural video and images*
   → *one per demo realised, with some info (where, who, picture, what facility)*

WORKSHOPS   *description of the philosophy behind the organisation of workshops*
   → *one per workshop organised, contributed (where, programme, what facility)*

SCHOOLS   *description of the philosophy behind the organisation of schools*
   → *one page per school organised, contributed (where, programme, what facility)*

REPOSITORY   *a username/password form to be filled for restricted access*

CONTACTS

Concerning the repository, whose access will be restricted to Newcom# partners and affiliate institutions, it was agreed by the WP Leaders that it will contain the outcome of the measurement campaigns performed within the Newcom# JRAs, and the documents needed to coordinate/facilitate access to the lab facilities.

The first version of the website, released at M6, will replace the three pages DEMOS, WORKSHOPS, SCHOOLS, with one single page EVENTS. More details regarding the first version of the EuWIn website are found in D3.6.1.

3. EuWIn Technical Facilities at CNIT/UniBO

The technical facilities made available at the University of Bologna research unit of CNIT, are described below. Three testbeds will be available: FLEXTOP, DATASENS and LOCTEST. However, the third platform will be developed at a later stage, as the SW/HW platforms needed for its deployment are still not available from the manufacturer side. Financial resources for its purchase are already available.
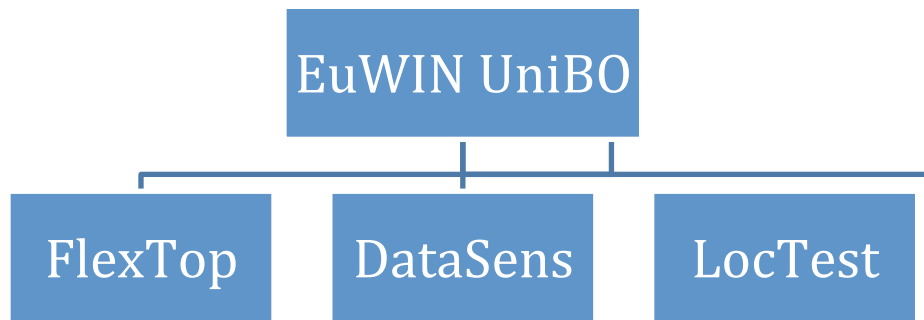

Figure 3-1: The EuWIn@UniBO site platforms

3.1 The Flexible Topology Testbed (FLEXTOP)

The FLEXTOP platform is described in the following, and its objectives discussed. Fig. 3-2 shows its general architecture.
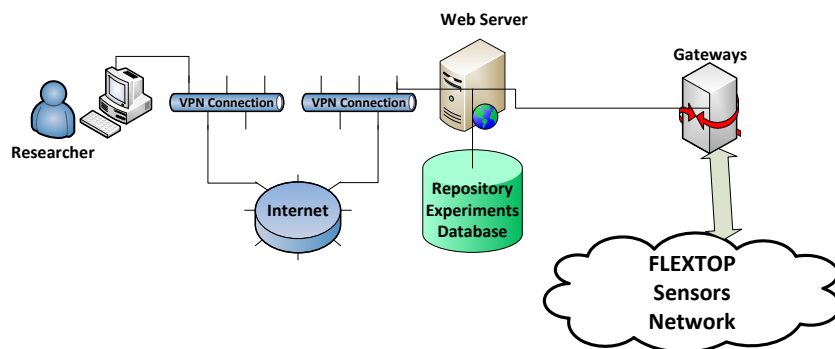
3.1.1 Description

Figure 3-2: FLEXTOP testbed architecture

FLEXTOP is a platform composed of one hundred programmable wireless nodes and a dedicated software environment developed in previous projects. The radio transceivers are manufactured by Texas Instruments and are IEEE 802.15.4 compliant (PHY and MAC). IEEE 802.15.4 is the de facto standard technology for wireless sensor networks and the current best option for the development of test beds for testing IoT solutions. The hardware architecture of the wireless nodes have been designed by CNIT/UniBO in collaboration with Embit srl, an Italian SME that acts as design center for Texas Instruments. The nodes have been jointly conceived by CNIT/UniBO and Embit in order to permit OTA programming of the firmware that implements the protocol stack. Through this platform any protocol stack compatible with 802.15.4 can be tested (e.g. Zigbee, or 6lowPAN/ROLL as proposed by many IoT developers, etc.).

FLEXTOP is a remotely accessible testbed. While it will be deployed at the premises of the University of Bologna, researchers will be able to upload their firmware implementing the protocol stack (above MAC) on the wireless nodes, run the experiments and download the log files including all experiments' results.

The wireless nodes are deployed according to a fixed grid of positions in a corridor. However, the researcher using the testbed can set different values of transmit powers achieving very different network topologies (linear, star, double linear, etc.). In particular, nodes can be turned on and off independently during the experiments, and the creation of sub-sets of networks is possible. At start of each experiment, the network will automatically measure and generate the 100x100 matrix of channel gains, which will be useful to certify the propagation environment. Experiments will be run at night, when nobody is allowed to walk in the corridor: therefore the experimental environment will be stable for the full duration, making experiment results certified.

The nodes do not carry sensors. However, several types of sensor data can be simulated by programming the application layer of the nodes so as to let them generate data according to specific and realistic environmental conditions. Therefore, the one hundred nodes will emulate a true and flexible sensor network.

Packet Error Rates, Delays and Throughput are the performance figures that can be captured from the wireless network during the experiments.

Figure 3-2 above represents the architecture of FLEXTOP. Through a VPN connection a Researcher from the Internet can access the lab facilities. Through a web browser it is possible to download the GUI application that has been developed and will be used to send the firmware and send the desired parameters of the experiment. In order to use FLEXTOP a researcher needs a PC with a VPN Client, a browser and a Java Virtual Machine installed.

The server allows the access to the user and it is used as a Repository for experiments' results; furthermore, on the server there is a Database that stores all information related to the experiments (parameters, raw data, firmware, etc.).

The "core" of the platform is the set of one hundred wireless nodes, which are deployed on the corridor walls of the main building of the School of Engineering. Figure 3-3 shows a map of the building floor and an example of network topology layout that can be created by selecting specific nodes (32 nodes are active in this case).

Two gateways (only one is shown in Figure 3-2 for the sake of simplicity) allow the interfacing between the server and the wireless nodes. They are single board computers based on ARM architecture running on embedded Linux. The aim of these devices is to communicate with the coordinators of the wireless sensor network; the coordinators are connected to the gateways through a wired interface. The gateways also include sniffers which will store in log files all information captured from the network (packets sent, source and destination addresses, etc.). The gateways (shown in Fig. 3-4) are also responsible for storing the experiments results in a raw file, as well as storing the data coming from the sniffers.
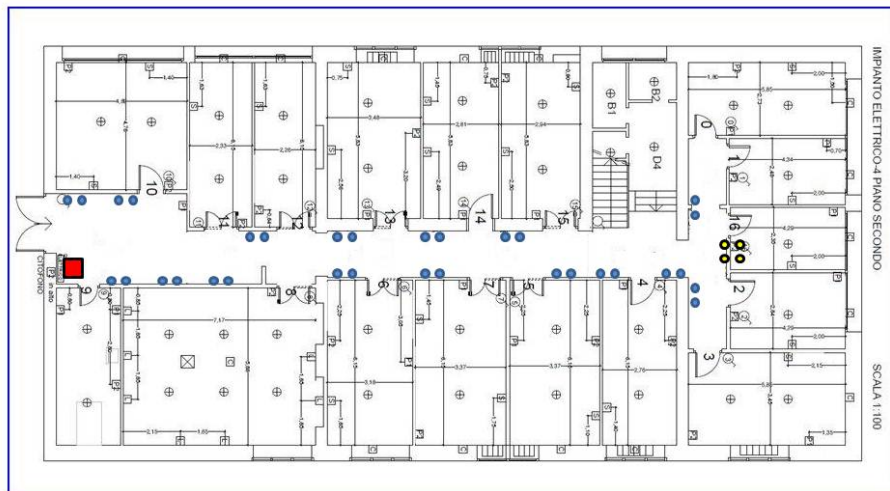
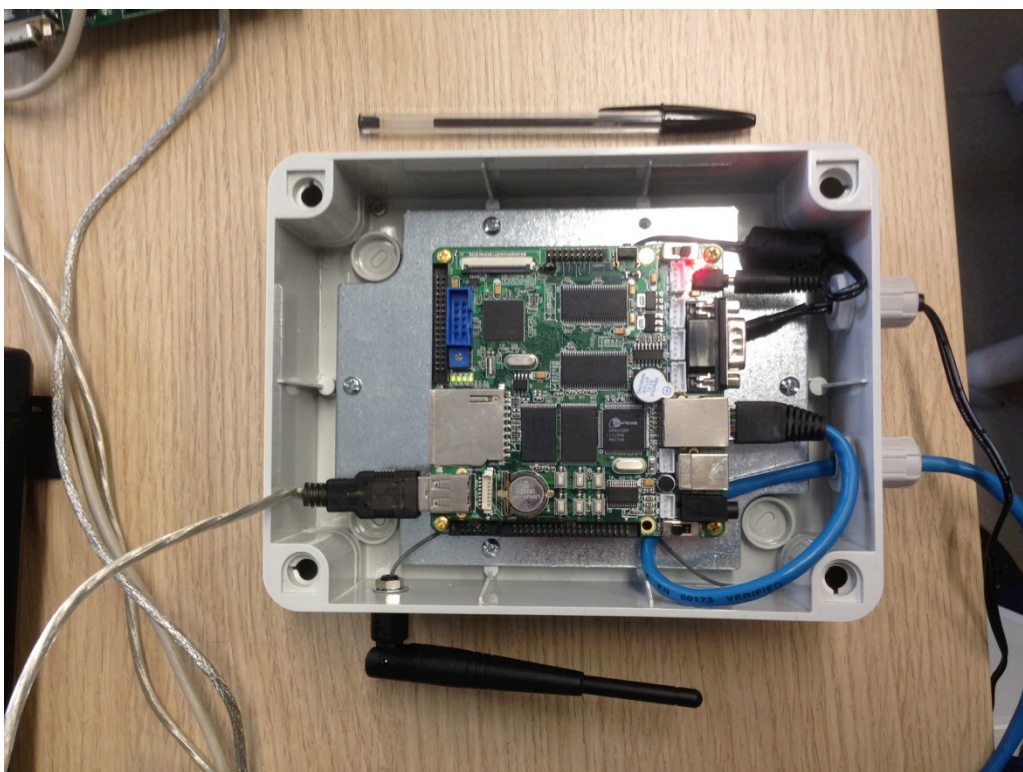**Figure 3-3: Example of network topology layout**

Figure 3-4: FLEXTOP Gateway

Sniffers are TI CC2531 based devices. Through a custom firmware the researchers can directly communicate with the sniffers as well as send commands to them. Coordinators are TI CC2530 based devices. Through the gateways the researcher can send the new firmware to the coordinators. Coordinators manage the firmware performing the OTA download to all devices in the network.

The wireless nodes are also based on TI CC2530. The main specifications of these devices are as follows:
- 256 KB Internal flash + 256 K external EEPROM
- 8KB of RAM
- Tx power 0 through +20 dBm
- Receive sensitivity -102 dBm
- Unique IEEE (extended) address
- Over-the-air programmable

They are plugged to the energy grid through USB hubs (see Figure 3-5). The USB cables are 1.5 m long. This allows on the one hand sufficient spacing among nodes, to avoid radio saturation phenomena; on the other, a further degree of flexibility is achieved, as the nodes can be moved in different positions. A FLEXTOP wireless node is shown in Figure 3-6.
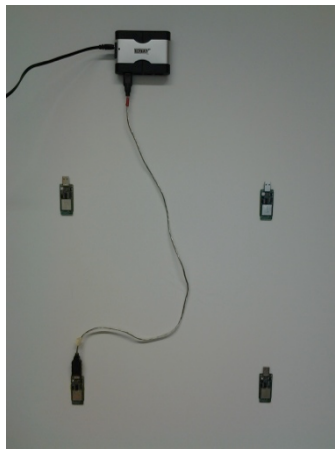

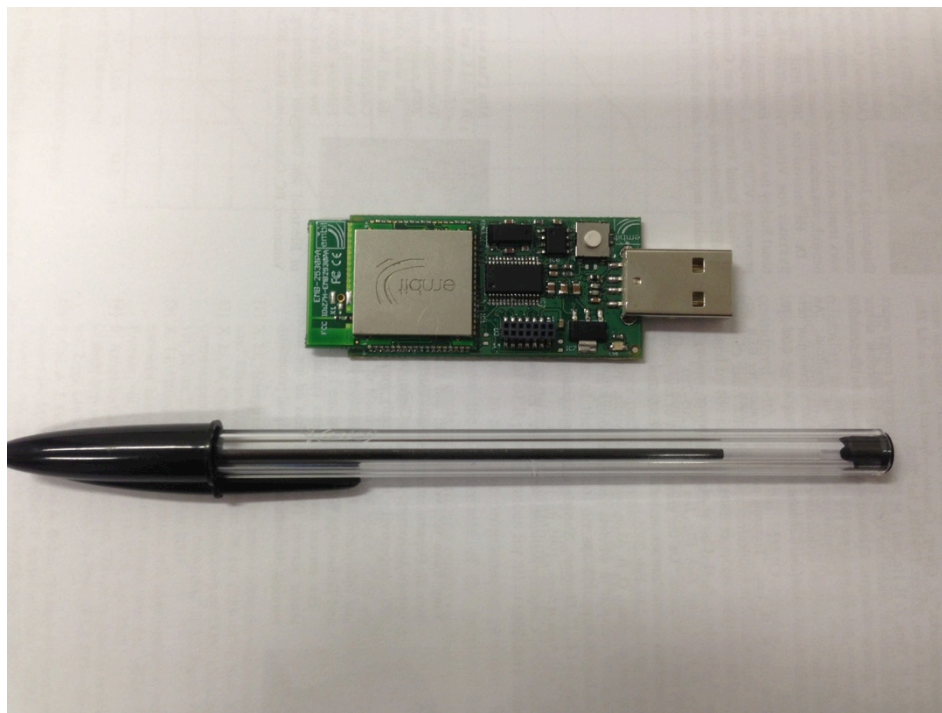
Figure 3-5: The wireless Nodes

Figure 3-6: FLEXTOP node

3.1.2 User Interfaces

The researcher willing to perform experiments on the FLEXTOP test bed needs to install on his/her own computer a Java Virtual Machine and a Web Browser; at least 20 MB of free space on the Hard Disk is needed.

Links for the software to be downloaded will be provided on the EuWin website, as well as the guide to install the VPN client software.

A Java Application is used to set the information and parameters of the experiment, as well as to send the firmware image that will be uploaded on the devices using the OTA scheme.
In order to obtain the grant to access the FLEXTOP testbed, a researcher has to follow the registration procedure, as described in the following section. Once the user is registered, he/she will receive the private web server URL, which for security reason is accessible from the VPN. The Java application with the installation and user guide will be available on this private web server. This private Web server is also used for sharing some information on the experiments among researchers. The Java Application (GUI) is shown in Figure 3-7.
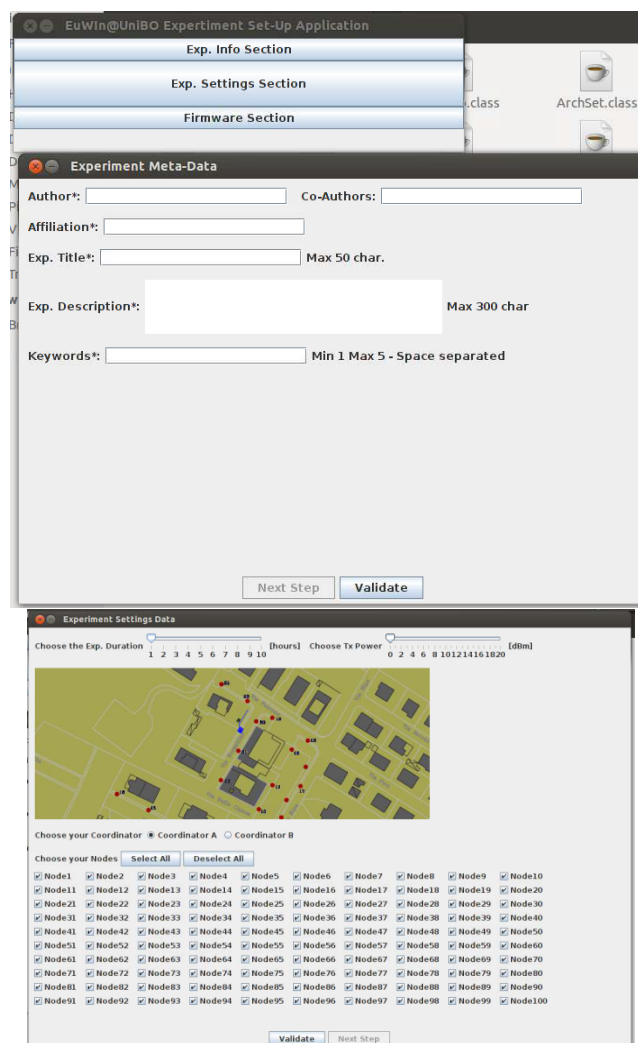

Figure 3-7: GUI provided to the user

Figure 3-7 shows some details regarding the Java Application. The researcher has to fill 3 different forms:
- Experiment Meta-data: details about the experiment, title, description, authors and keywords;
- Experiment Setting Data: duration of the experiment in hours, transmission power (in dBm), nodes and coordinator selected to be used in the experiment;
- Firmware upload: this screen will enable the researcher to send the firmware image to the remote server. This image will be OTA uploaded on the FLEXTOP devices.

Since the facilities are inside the University network, proper level of security has to be implemented. The researcher who asks for the access grant is responsible for the correct use of this grant. All the accesses will be logged and stored in a secure area.

In order to prepare software to be used in the experiments properly, it is suggested to use:

A Virtual machine having on disposal at least 512 MB of RAM as well as at least 10 GB of hard drive size reserved for it, running on Windows XP, e.g. VmWare VMPlayer, Oracle VirtualBox;

IAR Embedded Workbench for 8051- integrated development environment and optimizing C/C++ compiler for 8051 MCUs (30 days evaluation version can be downloaded);

TI-MAC and/or Z-Stack – In order to obtain the software which is compliant with Flextop devices, two paths can be followed. The first one implies that the user has been working with the default software provided by Texas Instruments. In this case porting of the software must be performed, which implies performing changes at the HAL and MAC level as well as including the linker (xcl) file provided to be used for the OTA programming. Files to be used and steps to be taken in order to obtain the compliant software can be found on the website. The other option is to download the ported version of the software from the website and use it to perform necessary modifications. The migration guide will be provided on the EuWin website as well.

Once the software to be used in the experiment is ready, the user has to produce the binary image that will be sent by the Coordinator to the devices using the OTA scheme. Instructions on how to produce the binary image using the IAR can be found in the section below (and the guide provided on the EuWin website).

The results will be provided on the Private web site, they will be sent via email to the author and then on a restricted Area on the Euwin website. The result will be given as text files as described in the following:

- Coordinator output: the coordinator is directly connected to the gateway via a serial interface. A program running on the gateway is able to store all the data coming from the coordinator. The structure of this file is chosen by the researcher when he/she downloads the firmware.
- Three files are generated by the sniffer
- A file describing the channel and environmental condition; before each experiment, an application will be run that will provide an output file containing the path loss matrix. This matrix will contain the RSSI values obtained from the communication among each pair of devices.

3.1.3 Objectives

FLEXTOP is a platform devised in order to achieve separate types of objectives.

Objective # 1

The platform will permit testing of separate protocol stacks in realistic settings, and their performance comparison under a certified environment, with known propagation conditions. For instance, different routing protocols can be tested, and their suitability to different network topologies measured. The platform will therefore constitute a sort of reference context for comparison of protocols. In the second year of activity of Newcom#, EuWIn@UniBO intends to launch some international contexts based on FLEXTOP. Plans will be done and presented at the end of first year of Newcom# activities.

Objective # 2

Besides scientific goals, the platform can be used for performing pre-deployment tests. Industries developing IoT or smart city applications based on 802.15.4 will be allowed to first test their solutions on the FLEXTOP platform, to check their performance under a controlled environment. This will allow establishment of proper liaisons with industry.

Objective # 3

The platform can be used as a benchmark for those research groups, inside or outside Newcom#, developing 802.15.4 network simulators, to test their implemented software and certify its adherence to real network environments. EuWIn will therefore release a sort of "certification" that intends to become in the long term a reference "brand".

Objective # 4

A similar objective can be pursued with respect to mathematical models developed by scientists that provide performance of 802.15.4 networks under specific algorithm implementations.

3.2 Data Sensing and Processing Testbed (DATASENS)

The DATASENS platform is described below, and its objectives discussed.

3.2.1 Description

DATASENS is composed of:

- 50 nodes in fixed positions: they are IEEE802.15.4-Compliant Devices, Custom TI cc2530 based solution, equipped with Temperature and Light Sensors;

- 50 mobile nodes: they are IEEE802.15.4-Compliant Devices, Custom TI cc2530 based solution, with external EEPROM of 256KB, battery equipped (USB Rechargeable).

All devices transmit periodically (with frequency that can be set in the range 15 ms – 10 sec) a beacon packet containing their address, and record in the external memory all addresses of the neighboring nodes, extracted from the beacons received. At the end of each experiment, a contact list will be available at each node, and through the USB interface it will be downloaded on a PC for processing purposes.

The fixed nodes will be plugged to the energy grid in rooms of the University of Bologna, while the mobile nodes are equipped with a battery and a case that will allow carrying them in pockets. Therefore the network will be composed of both fixed and personal devices which will be connected through a dynamic topology.

DATASENS is an in situ programmable network.

As previously described, the DATASENS testbed will consist of 50 mobile as well as 50 fixed devices. The picture showing the device can be seen below. Mobile devices will be equipped with the external memory while the set of fixed devices will have temperature and luminosity sensors. In order to use the external memory the SPI interface must be established while for the light sensor I2C interface must be used.
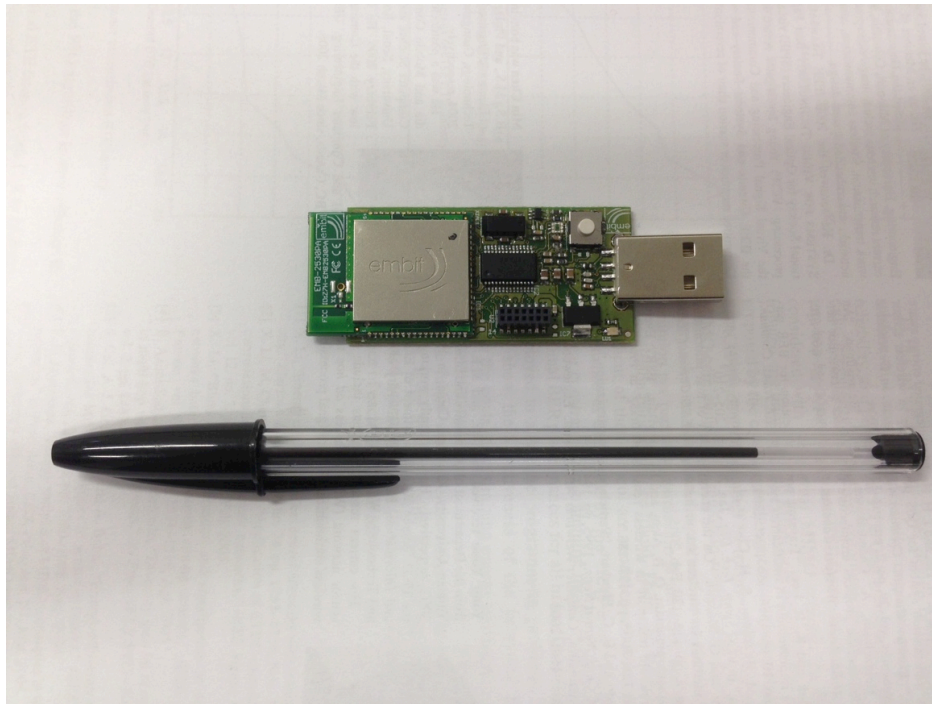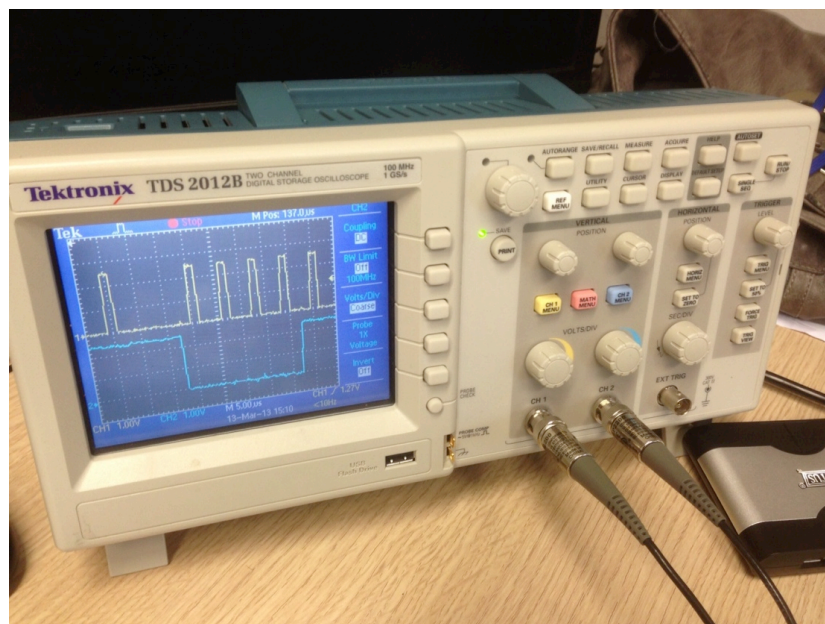

Figure 3-8: DATASENS Fixed Device

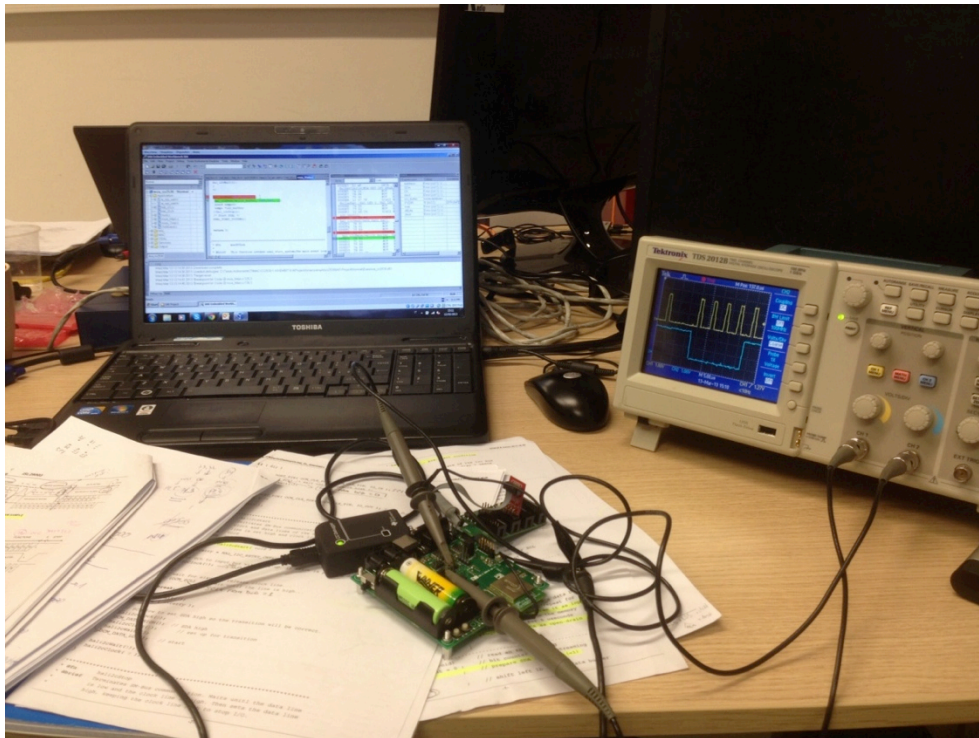**Figure 3-9: DATASENS Device testing phase**

Figure 3-10: DATASENS Device testing phase

Since in order to use the DATASENS testbed the user will have to be present on site, all support (therefore necessary drivers and software as well) will be provided locally.

DATASENS can be integrated with FLEXTOP to achieve a unique network with 200 wireless nodes.

Moreover, DATASENS is portable and will be used to characterize the human mobility in different locations and contexts.

3.2.2 User Interfaces

The recommended software tools to be used in this testbed are the same as in the case of FLEXTOP. Apart from being available on the EuWin website, taking into account that the user will be present at the lab site while using this testbed, he/she will be provided with support regarding this part, including drivers for the sensors and external memory.

3.2.3 Objectives

The main scope of DATASENS is to characterise mobility of humans in different environments, with the specific purpose of mobile cloud modelling. As a secondary goal, DATASENS will permit the implementation and testing of delay tolerant networking approaches to routing.

3.3 Localization Testbed (LOCTEST)

The purpose of the LOCTEST platform is two-fold: to implement and assess the performance of indoor localization algorithms, and to use the raw positioning information provided by the network as input of routing and context-aware applications.

3.3.1 Description

Due to the today unavailability of commercial low-cost UWB radios based on the IEEE802.15.4a/f standards, the LOCTEST platform will be developed in 2 steps. In the first step DATASENS nodes will be used as part of the LOCTEST platform providing received signal strength (RSS) measurements as input for the localization algorithms. The final accuracy expected will not be high but sufficient for several applications.

As soon as UWB devices will be available, approximately 50 additional nodes with high-accuracy localization capabilities, using IEEE 802.15.4a or IEEE 802.15.4f UWB radios will be added and deployed in the same building. LOCTEST is an in situ programmable network. UWB activity will be complemented by UWB dedicated platforms and instruments available at EuWIN@UNIBO, EUWIN@CTTC and Bilkent premises as described in Sec. 3.5.

3.3.2 User Interfaces

During the first step, the recommended software tools to be used in this testbed are the same as in the case of FLEXTOP. Apart from being available on the EuWin website, taking into account that the user will be present at the lab site while using this testbed, he/she will be provided with all support regarding this part, including drivers for the sensors and external memory.

3.3.3 Objectives

The main objectives of the LOCTEST platform as here summarized.

Objective # 1
The main objective of the LOCTEST platform is to test and assess the performance of active and passive localization algorithms. The adoption of a large number of low-cost devices will enable the exploitation of cooperative schemes in which mobile users cooperate to improve the localization accuracy, especially in the presence of poor measurements or not line-of-sight (NLOS) channel conditions. The performance assessment will require controlled scenarios where the position of mobile users is a priori know with high precision through the use of markers. The key indicators are the localization error outage (LEO), the position root mean square error (RMSE).

Part of the activity will be carried out in synergy with EuWIN@CTTC site and with the UWB platform available at Bilkent laboratories described in Sec. 3.5.

There is the intention to create a EuWIn database containing indoor RSS/ranging measurements that can be used as input in Track 1 research activities to test and compare off-line localization algorithms using real data.

Objective # 2
The position information provided by the LOCTEST platform can be used as input for geo-routing algorithms under testing in the DATASENS platforms. This will give the opportunity to understand the impact of context information (such as mobile user position) on the effectiveness of the algorithm designed. Furthermore, position information can be associated to log of contacts thus enriching the EuWin database of indoor mobility traces for the detection of sociality behaviour of human environments.

3.4 Other Facilities at CNIT-UniBO

CNIT-UniBO makes available other facilities related to ultra-wide bandwidth (UWB) devices at Cesena Campus premises. These devices can be used to set up experiments in the field of active and passive (radar) localization.

3.4.1 UWB devices

Two UWB-based devices, model PulsOn220 made by Time Domain, are available to perform time-of-arrival (TOA) ranging measurements in both static and dynamic scenarios. The UWB node works with a center frequency of 4.7 GHz and a 10 dB bandwidth of 3.2 GHz. The effective isotropic radiated power (EIRP) is −12.8dBm with is complaint with the Federal Communication Commission (FCC) emission masks.
The two UWB devices are programmed to perform distance estimation and acquire the UWB received waveform samples by adopting the following approach. First, device 1 sends a UWB pulse and waits for a reply signal from device 2. Device 2, which is in scanning mode, receives the signal and responds immediately. After receiving the reply signal from device 2, device 1 makes an estimation of two-way-TOA (TW-TOA). Based on TW-TOA, ranging estimation can be obtained by getting ensemble mean of several TW-TOA measurements [5].

Figure 3-11: The UWB platform at EuWIN@UNIBO, Cesena Campus

3.4.2 UWB radar devices

The Novelda NVA R640 UWB radar development kit is available. It is based on the NVA6100 chip, operating in the 2 − 6 GHz band. It is equipped with a low power RF pulse generator with first order Gaussian pulse shaping and pulse width < 1 ns. The power spectral emission mask is compliant with the FCC Part 15 limit. A Matlab application programming interface (API) to control the key radar parameters and to acquire the samples of the received signal for successive post-processing has been developed. The main system parameters are the pulse repetition frequency (PRF), the observation window length, and the time offset starting from which the received signal is acquired.

Specifically, the radar sends periodically UWB pulses at frequency PRF and collects the samples of the signal backscattered by the surrounding environment in a limited observation window of starting from a selectable time offset. This platform can be used as a first step in testing passive localization algorithms [4].

Figure 3-12: The UWB radar platform at EuWin@Unibo, Cesena campus.

3.5 External facilities

Partners participating to intra- and inter-WP JRAs make available the following instrumentations and platforms. These platforms will be useful to complement the JRA within EuWin at UniBo as well as to enforce the synergies among EuWin laboratories. They are described here as they will contribute to WP2.2 activities.

3.5.1 UPC real-time platform for spectrum selection in opportunistic networks

This platform is a flexible testbed where the spectrum selected for the communication between some nodes can be dynamically assigned and modified depending on actual measurements. In this way, the platform can be used to show the behaviour of the spectrum opportunity identification and spectrum selection procedures in different scenarios where two or more devices need to communicate forming an opportunistic network (ON) (e.g. digital home environments, etc.). Moreover, different interference conditions can also be generated in different experiments to see the reactivity of the considered algorithms.

The platform available at UPC is implemented by means of Universal Software Radio Peripherals version 1 (USRPs v1) with *XCVR2450 Transceivers* motherboards and computers where the software GNU Radio was installed. The frequency ranges they work in are 2.400 - 2.500 GHz and 4.9 - 5.9 GHz [1]. The first range consists specifically of the 13 sub-bands around the 2.4 GHz Industrial, Scientific and Medical (ISM) band (2.412 GHz to

2.472 GHz in 5 MHz steps); such a band is used by WiFi applications (i.e. IEEE 802.11b, 802.11g and 802.11n standards). The facilities of that platform do not allow remote access.

Figure 3-13 presents a possible scenario considered in the testbed. It consists in two nodes that have to communicate forming an opportunistic network and a node (denoted in the figure as infrastructure node) that controls the creation, maintenance and termination of the opportunistic network. These nodes are implemented through USRPs. Moreover, the testbed implements the control signalling needed for the creation of the ON link and its modification whenever the conditions in the currently allocated spectrum degrade. As seen in the figure, USRP#1 implements the infrastructure and the associated spectrum opportunity identification and spectrum selection functionalities. The result of executing these functions, with the specific frequency block assigned for the ON link between the two terminals is notified using a Cognitive Control Channel. USRP#2 and USRP#3 are the terminals exchanging data. During the communication between USRP#2 and USRP#3 the testbed monitors the quality of the data transmission in terms of the efficiency, defined as the ratio between successfully transmitted data packets and total number of transmitted data packets including retransmissions. This is computed based on the received acknowledgements for each packet.
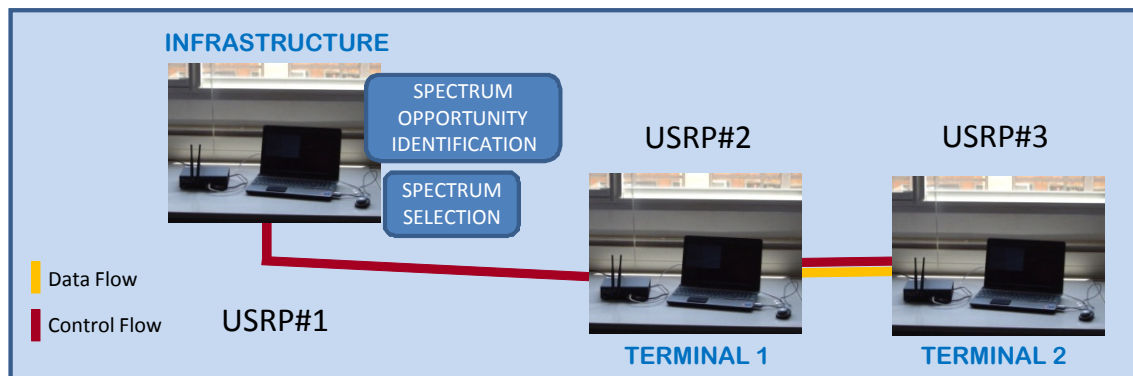

Figure 3-13. Basic Architecture of the Testbed

In addition, different external interference sources can exist in the system, as seen in Figure 3-14, whose operating frequency at each time can be defined as part of the testbed configuration set-up. Taking into account that our hardware operates in the WiFi band, one possibility is to use an access point whose channel is manually modified to interfere the spectrum block used by the terminals. Moreover a second possibility is to have controlled interference sources implemented with other USRPs. In that case the periods in which the interference source is active or inactive are also controlled following specific random patterns whose statistics can also be configured. These interference sources allow illustrating how the cognitive management system is able to detect and react to time-varying QoS conditions over the different spectrum blocks.

The platform provides a powerful tool for testing different spectrum selection algorithms in real operational radio environments under various interference conditions, thus enabling to gain deeper insight into the performance of algorithmic solutions, beyond the purely theoretical analyses based on models and/or simulations.

More details on the capabilities of UPC platform can be found in [2] and [3].
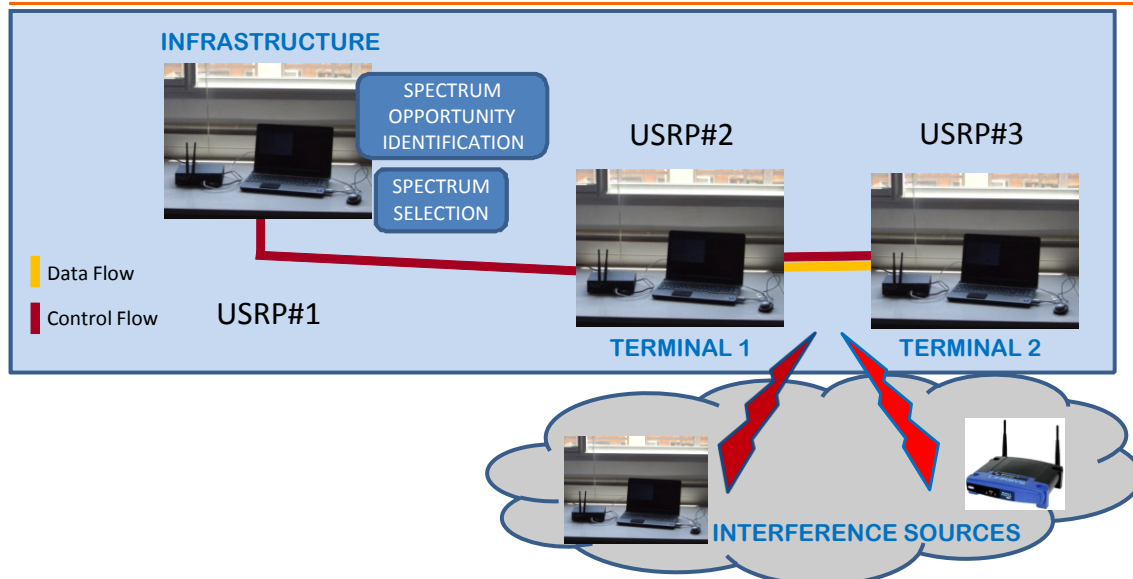
Figure 3-14. External Interference Sources

3.5.2 UWB Monostatic Radar Platform

Bilkent University has TimeDomain PulsOn 410 Monostatic Radar Module (MRM), which is a coherent UWB radar module with 1.4 GHz of RF bandwidth. There are 4 transceiver (radar) units, which can be used to transmit UWB pulses and receive reflections from the objects in the environment. The units operate at a center frequency of 4.3 GHz.

Figure 3-15: The UWB Monostatic radar platform

In passive localization applications, moving targets can be detected by eliminating the clutter via moving target indicator (MTI) filters. Then, positions of targets can be estimated based on estimates from multiple MRM devices.

Figure 3-15: MRM device

3.5.3 CTTC wide-band instrumentation

CTTC offers a set of equipment and facilities for the proposed JRAs, in the framework of EuWIn@CTTC and its OpenInLocation laboratory:

RF measurement equipment

Spectrum analyzer	Agilent E4403B.
Network analyzer	Rohde & Schwarz's ZVA24-M2 24GHz, 4 Ports Vector Network Analyzer
Oscilloscope	Infiinum DCA-J Oscilloscope Agilent 86100C
Precision Time Base Module	Agilent 86107A
RF ancillary (connectors, cables, power sources, etc.)	General equipment of a RF Lab is available.

The equipment can be used to characterize the TimeDomain PulsOn 410 Monostatic Radar Module.

Measurement facilities

CTTC's anechoic chamber was designed by the group ETS-Lindgren as a turnkey solution for making antenna measurements of wireless telecommunication devices. The system can be used to perform antenna measurements in far-field test distances of the 3D radiation pattern. The measurement setup including multi-axis positioner, positioning controller, commercial software for antenna measurements, and fully anechoic chamber is completely automatic.
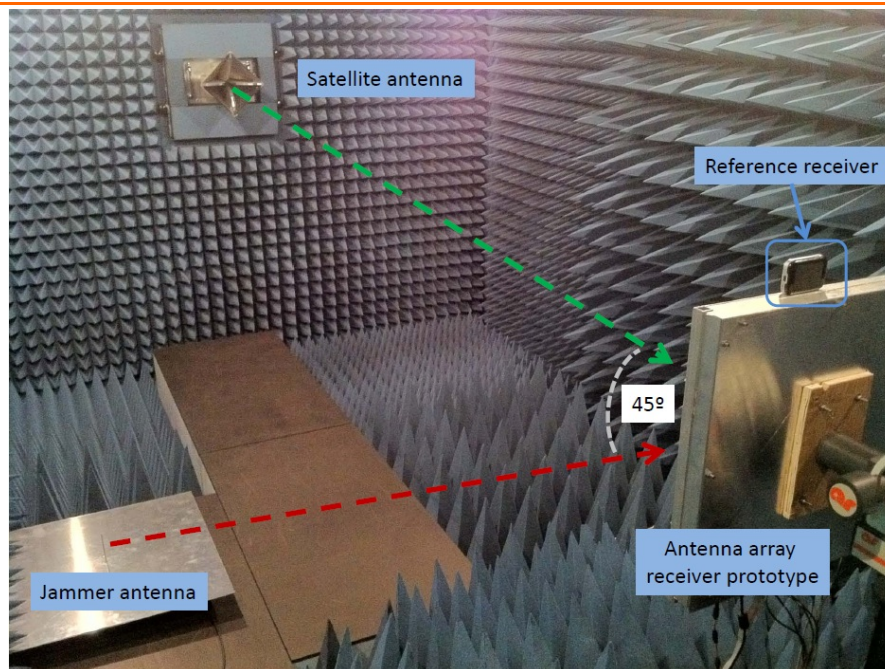
Figure 3-16: Experimental setup at the CTTC anechoic chamber.

The anechoic chamber can be used for measuring the radiation pattern of UWB antennas, as well as for performance assessment in the absence of multipath.

The OpenInLocation laboratory is developing methodologies for the systematic assessment of technologies for indoor location. The proposed JRAs are seen as a good opportunity to add UWB to the pool of technologies under test. Using Raspberry Pi, Arduino or similar platforms, this laboratory allows the implementation, experimental validation and/or performance assessment of sensors and radio interfaces in both controlled and real-world environments, providing the user with practical, easy-to-reproduce-at-home hardware setups and software tools that allow focusing in location-related issues instead of spending time and money in building and programming a dedicated platform. In case of UWB, to the best of our knowledge there is still no commercial device available with such degree of openness, and hence the interest of incorporating the assessment of a technology with good potential for indoor positioning.

4. Preliminary Plans of Activities and Policies

This Section gives details regarding the plans of activities for the next six months (M7 to M12), leaving to the annual Deliverables (to be delivered at M12) the definition of the activities planned for the next years. The Section also provides description of the policy agreed to give access to the lab facilities.

4.1 Introduction

Track #2 intends to create a framework that will survive to the end of Newcom#. Therefore, on the one hand the plan of activities has been devised as a component of the NoE; on the other, all dissemination and promotional actions are conducted under a more general perspective. For the same reason, the access policy has been discussed under a long-term vision.

4.2 Steps Followed

The achievements of Track #2, after the first six months of Newcom# fully dedicated to the lab set-up and the definition of the activity plan, have been reached through the following sequence of steps and actions:

- Set-up of the facilities and creation of the documentation needed for the open access at the individual site premises, since kick-off till M6; it is envisaged that the sites will undergo continuous update during the course of Newcom#;

- Face-to-face meetings among the EuWIn Director and the three WPLeaders to discuss about EuWIn goals and plans, at the Newcom# kick-off meeting (November 2012, Pisa) and the Track #1 meeting (March 2013, Paris);

- Monthly skype meetings among the EuWIn Director and the three WP Leaders to discuss the status of lab set-up and coordinate activity plans;

- First presentation of the EuWIn scopes and facilities in Pisa, during the Newcom# kick-off meeting;

- A Track #2 session dedicated to the discussion of JRAs and presentation of EuWIn facilities in Paris, on March 7, during the Track #1 meeting;

- A Track #2 web meeting held on April 9, discussing among all researchers involved, the access policy and the plan of activities.

4.3 Plans of Activities

At time of preparation of this Deliverable, the following plans have been made. They are presented through the same itemised list reported in subsection 2.3.

1) **A Unique Portal**

    The first release of the website is made public at the end of M6, time of delivery of this Deliverable. The website will be updated every six months, based on the achievements at the end of each period.

2) **Web Meetings**

Web meetings will be organized based on the request of Newcom# researchers. So, no periodic meetings are planned.

3) **Workshops**

The first Newcom# Emerging Topic Workshop (ETW) will be dedicated to the theme that represents the motto of EuWIn: "Fundamental Research Through Experimentation". It will be held in Bologna, at the premises of the EUWIn site, on July 8-9. The TPC of the workshop includes the three Track #2 WP Leaders, the EuWIn Director and Dr. Florian Kaltenberger of EURECOM. It will include three sequential sessions: one will be dedicated to industry speeches, one to presentations given by representatives of other EC funded projects, and the last one to talks given by Newcom# researchers involved in some experimental activities. At time of writing, a list of potential industry speakers and projects has been defined, and the invitations are sent. The final programme will be ready after delivery of this Deliverable, and will be posted on the EuWIn website under "EVENTS". The workshop intends to group together separate experiences carried out in Europe, showing how experimental testbeds can be useful to fundamental research and the development of new techniques/protocols.

4) **Training Schools**

The first Newcom# Training School will be dedicated to the topic of interference management. It will be held in May 28-31, 2013 in Sophia-Antipolis at the premises of the EuWIn site of EURECOM. One of the four days of the school will be fully dedicated to experimental activities, involving the facilities of EURECOM and CTTC. The programme is available in the EURACON website www.euracon.org (EURACON is the association in charge of administration, logistics and publicity of the School).

The third Newcom# Training School will be dedicated to the topic of experimental research. It will be organized, jointly with the COST Action IC1004, in November 2013 in Barcelona at the premises of the EuWIn site. The school will comprise oral, poster and lab sessions. The programme will be defined before end of summer 2013. The TPC includes the three Track #2 WP Leaders, the EuWIn Director, Dr. Florian Kaltenberger of EURECOM, Prof. Claude Oestges of UCL. The programme will be available in the EURACON website www.euracon.org.

5) **Industry Liaisons**

During the third week of June 2013 (most probably on June 17) Newcom# will visit the Orange Labs at Issy-Les-Moulinaux, in France. The three EuWIn sites will present their facilities in that context.

6) **Demonstration activities**

The inaugural event of EuWIn will take place in Bologna, at the premises of the EuWIN site, on July 8, 2013. During this event, all EuWIn facilities will be presented to the public, both through talks and demos/posters. The event will be professionally video recorded in order to prepare two video trailers (one and five minutes, respectively) to be used for promotional purposes later. Industry representatives and researchers from other EC projects will be invited. EC officers will also be invited. The event will be followed (till the morning of the 9th) by the Emerging Topic Workshop

and (from the afternoon of the 9th till the 10th) by the Track #2 meeting, which will include parallel networking sessions and plenary talks to present to all Newcom# researchers the scopes of Track #2 JRAs. The entire event will be a major occasion to show EuWIn facilities to many researchers and industry representatives.

7) **Experimental Tours**
This line of activity deals with PhD students visiting the three sites in sequence to perform measurements that are closely related and that are made toward a unified scope. This kind of activity is planned for the second year of Newcom#.

4.4 Access Policy

The policy for access to the EuWIn facilities has been thoroughly discussed by the WP Leaders under the coordination of the EuWIn Director, and the following decisions have been made. The discussion is reported based on the definition of the EuWIn spheres presented in this Deliverable.

The Newcom# partners.

They are given free of charge and prioritised access to the facilities (this was a commitment taken at time of DoW approval).

The Newcom# associate institutions.

Their number is not defined at time of writing of this Deliverable, since Newcom# can decide to accept new associate partners during its life. Therefore, the EuWIn sites can not commit to provide access to all of them. The general policy however is that EuWIn intends to be as much open as possible, given the resource constraints (in terms of space, and availability of researchers for support). Therefore, it is decided that all Newcom# associate partners will have free of charge and open access to all information and data made available through the repository of the EuWIn website. On the other hand, physical access to the lab facilities will be given based on requests raised by the associate institutions (with specification of the goals and the mutual benefits), and on the availability of resources. These requests will have lower priority with respect to those coming from Newcom# partners, and will be processed according to an order which will defined by the WP Leader for each EuWIn site, depending on the mutual benefits expected.

A welcome letter will be sent to new associate institutions upon previous agreement with one of the EuWIn WP Leaders, informing about the general policy of collaboration. These institutions will be listed on the EuWIn website for better visibility.

External Institutions.

In this case the policy depends on the specific platform and EuWIn site. The WP Leaders will decide whether to provide access to the databases and/or the facilities, and whether free of charge or based on the payment of a fee, on a case-by-case basis, in agreement with the guidelines and the approval of the Executive Board.

4.5 Preliminary JRAs

Although the first 6 months of EuWin activity have been mainly devoted in laboratory setup and interfaces definition, some preliminary JRAs have been already defined. In the following a brief description of them is given. Their development is scope of the next activity within WP2.2.

JRA Title	**Design and experimental validation of algorithms for active and passive indoor positioning**
Related Task	Tasks 2.1.3 and 2.2.2
Related topic/scenario	Localization techniques of wireless communication terminals in indoor environments.
Description	Indoor localization remains as a challenging problem, the solution of which could trigger a myriad of new services and applications. UWB has been recognized as a feasible technology for solving that problem. However, there are still issues that need to be addressed.
Objectives	Implementation of estimation and tracking algorithms for indoor UWB/RSS positioning and radar applications. Investigation of cooperation techniques in cloud moving users
Value proposition	The framework under consideration is expected to be general and of wide application in different contexts regarding indoor positioning, navigation and guidance, and short-range (i.e. automotive) radar applications.
Challenges	Channel and nodes' position randomness. Achieving real-time solutions. Anomalous propagation conditions Robustness.
Candidate platform for experimentation	BILKENT equipment: TimeDomain's PulsOn devices EuWIn@CTTC : measurement equipment for UWB. • Network Analyzer 67GHz Agilent E8361A • Pulse generator Picosecond 10050A • TDR/TDT Pulse generator Picosecond 4022-TDRT • Oscilloscope Infiniium Agilent DSO81004A • General lab. equipment (oscilloscopes, etc.) EuWin@BO: Zigbee-based wireless sensor networks (>50) TimeDomain's PulsOn devices, Novelda Radar devices
Collaborations	BILKENT, CTTC, CNIT, CNRS

JRA Title	**Spectrum Selection in Opportunistic Networks**
Related Task	Task 2.2.3.- Experimental Activities on Opportunistic Networks with Mobile clouds
Related topic/scenario	
Description	It is envisaged that this task will carry out experimental activities to test the behaviour of spectrum selection for opportunistic networks (ON) in which a number of links between terminals and/or infrastructure nodes needs to be established. UPC has currently a platform implemented by means of Universal Software Radio Peripheral (USRP) boards where the spectrum selected for the communication between some nodes can be dynamically modified depending on actual measurements. Moreover, different interference conditions can also be generated in different experiments to see the reactivity of the considered algorithms. Thanks to the flexibility provided by the USRPs and the capability to reconfigure them by means of GNU radio, other aspects of the links to be established can also be dynamically modified apart from the operating frequency (e.g. modulation, transmit power, etc.), so that the testbed can be potentially extended to evaluate also other adaptive strategies (e.g. link adaptation, etc.) for ONs.
Objectives	The aim of this activity is to validate performance of spectrum opportunity identification and spectrum selection functionalities in Opportunistic Networks in real environments
Value proposition	The objective of this activity is to show the behaviour of the spectrum opportunity identification and spectrum selection procedures in an ON. For that purpose, different scenarios can be considered where two or more devices need to communicate through ON links (e.g. digital home environments, etc.). In addition to spectrum, the platform is flexible and it can be extended to allow also testing other adaptive mechanisms such as link adaptation, etc.
Challenges	To evaluate dynamic spectrum selection functionalities in the considered platform and to illustrate how the cognitive management system is able to detect and react to time-varying QoS conditions over the different spectrum blocks.
Candidate platform for experimentation	Current platform existing at UPC consists of several USRP1 with daughter boards XCVR2450, configured through GNU radio. The possibility to use other existing platforms such as the DATASENS or FLEXTOP from EuWIn@CNIT/Bologna can be explored. This would allow performing similar analysis in scenarios with a larger number of nodes.
Collaborations	Anna Umbert (annau@tsc.upc.edu), Jordi Pérez-Romero (jorperez@tsc.upc.edu)

JRA Title	**Experimental activity on data sensing and fusion**
Related Task	Task 2.2.2
Related topic/scenario	Environmental monitoring (wireless sensor networks), source localization, compressed sensing, cognitive radio (spectrum sensing).
Description	The idea is to implement and test on hardware practical algorithms for the estimation of a spatial field using randomly distributed wireless nodes equipped with sensors.
Objectives	Asses the performance of Energy-efficient data collection and estimation algorithms developed in Tasks 1.3.2 and 1.2.3.
Value proposition	The framework under consideration is expected to be general and of wide application in different contexts regarding cognitive radio (spectrum sensing), environmental monitoring, and source localization.
Challenges	Propose low-complexity algorithms, that are easily and efficiently implemented on devices with limited resources
Candidate platform for experimentation	• Data Sensing and Processing testbed (DATASENS) • Localization Testbed (LOCTEST)
Collaborations	Tasks 1.3.2 and 1.2.3

5. Conclusions

The first 6 months of activities have been mainly devoted to the set up of the EuWin@UNIBO site facilities. Three different platforms have been designed and deployed providing more than 200 wireless nodes with the purpose to do theoretical research through experimentation in the field of Internet of Things with mobile clouds and smart cities. Particular effort has been dedicated to software/firmware development and to implement over–the-air remote access. The platforms architecture and user interfaces are described in this document.

The EuWIn website has been designed using the same platform chosen for the Newcom# portal and the first release has been made public at M6. The website will be updated every six months, based on the achievements at the end of each period. This will be under the responsibility of EuWIn@UniBo researchers.

The plan of activities for the next six months (M7 to M12) has been defined, leaving to the annual deliverable (M12) the definition of the activities planned for the next years. Instead, the access policy to the lab facilities has been discussed under a long-term vision.

The next steps include the consolidation of the preliminary JRAs as well as the creation of new ones based on feedback from partners, with particular emphasis on inter-WP and inter-Track collaborations.

A particular effort will be devoted to industry liaisons, demonstration activities and experimental tours. To this purpose the inaugural event of EuWIn is currently under organization and will take place in Bologna, at the premises of the EuWIn site, on July 8, 2013. During this event, all EuWIn facilities will be presented to the public, both through talks and demos/posters.

References

[1] www.ettus.com

[2] A. Raschellà, A. Umbert, J. Pérez-Romero, O. Sallent, "On Demonstrating Spectrum Selection Functionality for Opportunistic Networks", Proceedings of the Second International Conference on Mobile Services, Resources, and Users (MOBILITY 2012), October 2012.

[3] A. Raschellà, A. Umbert, J. Pérez-Romero, O. Sallent, "A Testbed Platform to Demonstrate Spectrum Selection in Opportunistic Networks", Proceedings of Wireless and Mobile Networking Conference (WMNC 2013), April 2013.

[4] V. Casadei, N. Nanna, and D. Dardari, "Experimental study in breath detection and human target ranging in the presence of obstacles using ultra-wideband signals," International Journal of Ultra Wideband Communications and Systems - Special Issue on Applications of Ultra Wideband Technology in Healthcare, vol. 2, no. 2, pp. 116–123, 2011.

[5] A. Conti, M. Guerra, D. Dardari, N. Decarli, and M. Z. Win, "Network experimentation for cooperative localization," IEEE J. Select. Areas Commun., vol. 30, no. 2, pp. 467–475, Feb. 2012.
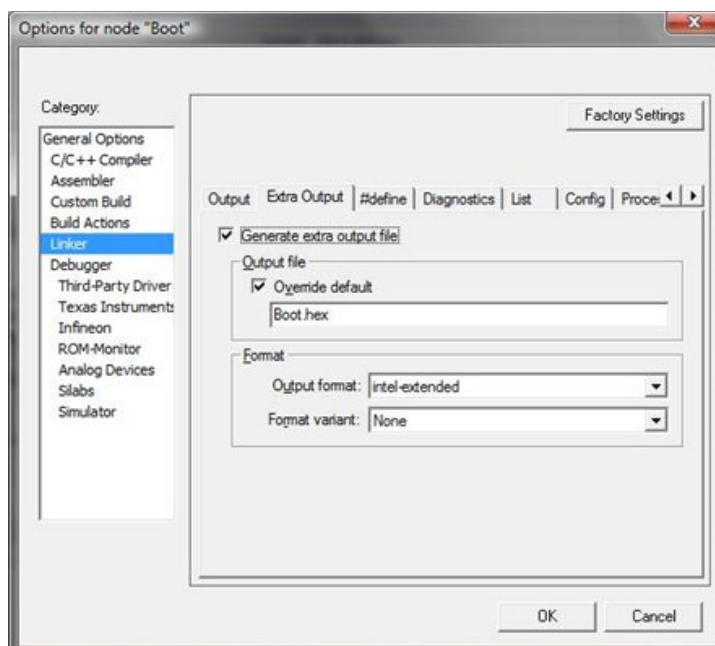
ANNEX A

Producing the binary image:
In order to obtain the desired format of the image the user must perform following steps: go to (Project->Options->Linker->Output) and configure it like on the picture. Then build the project.
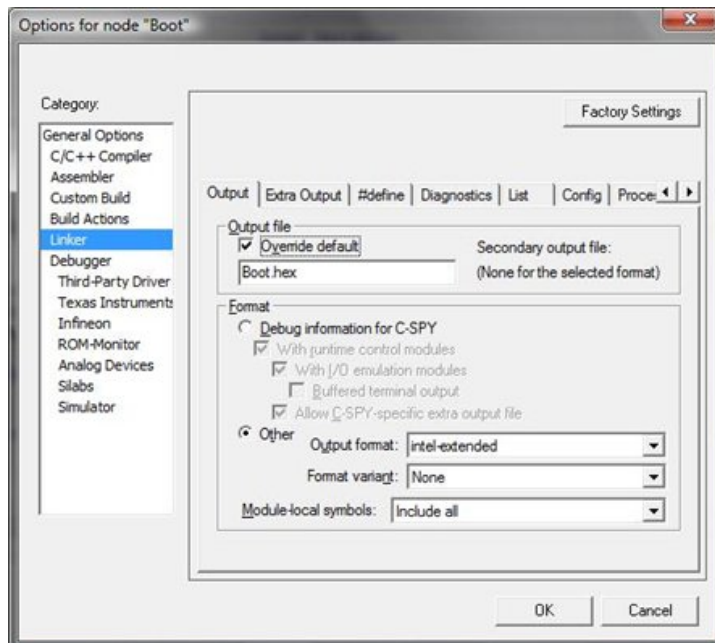
or in (Project->Options->Linker->ExtraOutput) and configure like this:

The important point is to change to intel-extended. If the user wants to debug and generate the hex file, he/she should use the second example (Extra Output) and keep the original configuration for the Output. For generating the binary (.bin) file, the user needs to change the Output Format to simple code.

ANNEX B

Sniffers are realized using TI CC2531-based devices, which will be attached to the gateways.

A custom firmware has been developed in order to manage their operation.

The basic sniffer behavior is to continuously listen to a radio channel and to record all IEEE 802.15.4 frames that are being transmitted on this channel. The sniffer operates at the MAC layer, meaning that the recorded information is related to the MAC command frame as defined in IEEE 802.15.4 standard.

Four basic commands have been defined:

- START → this command starts the sniffing operation. If no channel has been previously set (with a CH0xx command), the default channel is channel 11;
- STOPP → this command stops the sniffing operation;
- CH0xx → this command changes the operating channel (to channel number *xx*, 11<=*xx*<=27, if a wrong number is given, the operation continues on the previous channel);
- RESET → this command resets the device.

As for the sniffer output, three text files will be provided for each performed experiment, as detailed below. The first file is generated during the experiment, while the other two files are created at the end of the experiment and contain information obtained parsing the first file.

1. sniffer_raw_data.txt

   This file is the one containing all the raw data recorded by the sniffer for the whole experiment duration. Each line corresponds to a received frame, according to the following format:

N	t	Frame control	Sequence number	Destination PAN Id	Destination Address	Source PAN Id	Source Address	Auxiliary security hdr	Frame payload

   Fields are Tab ('\t') separated.

   N is the received frame number (by the sniffer). This counter is reset by START and RESET commands.

   T represents the timestamp at which the sniffer receives the frame.

   The other fields correspond to the frame fields as defined by IEEE 802.15.4-2006 standard [see Section 7.2.1, page 138 of the standard]. Values are given in hexadecimal format. Some fields are optional so they are not present for all received frames.

   If an address field contains an extended address, its value is given as big endian and its last 4 bytes are separated by a space from the first 4 (e.g.: if the address is A0:B0:C0:D0:E0:F0:72:57, then the address field is reported as 5772F0E0 D0C0B0A0).

   Bytes in the frame payload field are separated by spaces.

   Besides frames received by the sniffer, in this file lines regarding commands are reported (of the type "--- COMMAND RX!\tSTART\t---");

2. sniffer_parsed_data.txt

   This file contains all the data but in a parsed, human-readable format, detailed as follows.

   Each line corresponds to a received frame. 17 columns are reported for each frame. Values are Tab separated.

Pkt	Time [us]	FCF	Type	Security	Frame_pend	Ack_req	ID_compr	dest_addr _mode
Frame _versio n	source_addr _mode	SN	Dest_PAN_I D	Dest_addr	Source_PAN_I D	Source_add r	Payload

Pkt column contains the number of the received frame.

The time column reports the time in us at which the frame is received, with respect to the first received frame (i.e., for the first frame time = 0 us).

FCF reports the frame control field in hexadecimal format.

Type is the type of the received frame. Possible types are command, beacon, data, ack.

Security, Frame_pend, Ack_req, ID_compr columns correspond to the 'Security enabled', 'Frame pending', 'Ack request', 'PAN ID compression' bits of the frame control field as specified in the standard.

dest_addr_mode column can contain one of the following information: dest_no_addr, dest_short_addr, dest_ext_addr, according to the 'Destination addressing mode' bits of the frame (see standard for details). The same applies for the source_addr_mode column.

For the meaning of the Frame_version field, see Section 7.2.1.1.7 of the standard.

SN is the frame sequence number.

Dest_PAN_ID, Dest_addr, Source_PAN_ID, Source_addr columns report the frame addressing fields. Values are hexadecimal.

The Payload is the MAC frame payload, which contains all data from the upper layers. It is reported in hexadecimal. Each byte is separated by a space.

When a field is not present in the received frame, a minus (-) sign is reported in the corresponding column. (Ack frames, for example, never contain addressing fields and payload, therefore lines corresponding to acks have a '-' in the last 5 columns)

3. sniffer_parsed_data_simple.txt

   This file is a simplified version of the previous one, where only the following 8 columns are reported for each received frame; columns are Tab separated.

Pkt	Time [us]	Type	SN	Dest_PAN_ID	Dest_addr	Source_PAN_ID	Source_addr

For each column, the same explanations reported for sniffer_parsed_data.txt file apply.

Comments and suggestions for the improvement of this document are most welcome and should be sent to:

project_office@newcom-project.eu

http://www.newcom-project.eu