



Cognitive Radio Experimentation World



Common Data Collection / Storage Methodology Design

Abstract: This public document gives an overview on the envisioned common data format used in the CREW project. The content is extracted out of a preliminary version of the public deliverable D3.1 “Basic operational platform” and is subject to approval by the commission and thus subject to changes. It is provided here to give applicants for open call proposals already an overview on the common data collection / storage methodology design envisioned within CREW.

DISCLAIMER: The content of this document is preliminary and subject to changes. Please refer to the public deliverable D3.1 for an official version which is approved by the European Commission.

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1 Common Data Collection/Storage Methodology Design

1.1 Introduction

Many usage scenarios that take place can be 'recorded'. In our federation data recorded in one testbed will be usable in other testbeds to support emulated usage scenarios (e.g. primary user data recorded in testbed A feeds into a sensing device in testbed B). To this end this task will define data of interest, common structures for storing data and create a federation database for storage of any collections made. The availability of this 'fluid' data will also be of key interest in the benchmarking processes in WP4 as it will enable us to compare and contrast how different approaches deal with given data sets. Making the data openly available in itself is also of huge importance as the data can be used to validate theoretical ideas or indeed as actual input to systems being tested, emulated, or simulated. Whenever possible, we will contribute collected data to open repositories. FARAMIR plans to build environmental maps of primary users and the CREW data can potential contribute to this. There is the potential to also contribute outside the EU to such repositories as CRAWDAD, a Community Resource for Archiving Wireless Data At Dartmouth, in the USA. To underpin this work, data logging facilities will need to be added to some testbeds. Task 4.4 in WP4 will also have an impact here.

1.2 Background on IEEE 1900.6

The IEEE 1900.6 standard "defines the information exchange between spectrum sensors and their clients in radio communication systems. The logical interface and supporting data structures used for information exchange are defined abstractly without constraining the sensing technology, client design, or data link between the sensor and client." [4] For the definition of common data formats in the CREW project, especially the definition of supporting data structures is of interest.

The scope of the 1900.6 standard is limited to the definition of spectrum sensing related parameters and data structures. However, since a significant part of the data relevant for the CREW common data format is also spectrum sensing related, we decided to use the 1900.6 definitions where applicable and extend the available data structures where necessary.

Clause 6 "Information description" of the IEEE 1900.6 standard [4] contains the information relevant to the CREW common data format. Here also a list and definitions of the defined data structures can be found. Within the CREW common data format task we extend the 1900.6 definitions with the additional data structures required. Such additional data structures are, e.g., related to meta information, experiment specification, and non-sensing related parameters such as throughput, bit/frame error rates, etc.

1.3 Definition of the data of interest

The results of an experiment should be stored in such a way that it is possible to utilize the outcome further for our CREW-specific goals (analysis & benchmarking, performance comparison of different CR equipment, "replaying" etc). To structure this process we group all relevant information into the following 3 categories 1. "experiment abstract", 2. "meta-information" and 3. "experiment-trace(s)".

Typically experimenters make several iterations of an experiment and obtain several traces. Some of these iterations may have involved slight changes in the experimental setup. These changes are often not enough to justify calling it a new experiment. Our specification allows to define a common set of meta-information (the devices involved, the location, etc.) which can be "refined" for each individual trace (iteration). Specifically, the experimenter defines a template (in category 2) which is valid, unless it is overwritten in the specification of an individual trace (in category 3).

The suggested file format for experiment specification and meta-information is JSON, which can be transcoded to XML but is easier human-readable. We plan to offer a web interface with forms that the user fills in and produce the JSON representation automatically (this would likely be implementation work for CREW Year 2).

Measurement traces may be in a proprietary format, as long as they easily are convertible to CSV (with open processing tools). We recommend Matlab mat-files as our preferred file format, as the “Experiment abstract and meta-information“ of an experiment can then also be added in each file for convenience. For this we plan to define Matlab structures (a template) to be used and provide a tool that parses the JSON representation into Matlab structures, so a user will only need to enter the information once. If the trace file is too big it can be split into parts, which has to be explained.

In the following we present a template for our envisioned data structure with additional “best practice” comments. Examples for data from different internal usage scenarios of the CREW project can be found in Section 1.4. Examples using the json format can be found in Section 1.5.

- 1 **Experiment Abstract:** This is the structured description of the entire experiment. It provides all basic information for understanding how the experiment was performed and who did it. This information is valid for the entire experiment set.
 - 1.1 Title: A few words with the core information.
 - 1.2 Unique CREW Tag: The tag for further references to other CREW experiments or publications.
 - 1.3 Author: List of all experiment authors.
 - 1.3.1 Name
 - 1.3.2 Email
 - 1.3.3 Address
 - 1.3.4 Phone
 - 1.4 Release Date: The release date of the experiment. It should be kept as specified in ISO 8601.
 - 1.5 Experiment summary: Detailed textual description of the experiment. What was done, why, what should be expected. How many experiment iterations were performed...
 - 1.6 Collection methodology: Textual description of how the data was collected.
 - 1.7 Further documentation:
 - 1.7.1 Description: Short description of the related documentation.
 - 1.7.2 Bibtex: The list of bibtex entires for the related publications.
 - 1.8 Related experiments: The list of the related experiments in the CREW database. For example if there are new or previous experiments based on this, experiments closely related to each other. Here also information on the relation should be added, e.g. “repetition of experiment on a larger scale”, or “repetition due to problems in previous experiments”
 - 1.9 Notes: Case specific experiment notes. For example problems with data that was discovered during evaluation or known limitations for further usage of the data
- 2 **Meta-information:** Meta-information is “the information required for describing, understanding, and evaluating information”. This is very well described in IEEE 1900.6 in Section 5.3.1 and in Table on page 18. To give IEEE 1900.6 support it is necessary to provide support for all parameters defined there. There is also an interface for retrieving data from sensor itself or Data Archive (DA from IEEE 1900.6)

The information in this category may be refined in category 3 with details per individual trace.

- 2.1 Device: Detailed description of the device types involved in the experiment.
 - 2.1.1 Name: Device name
 - 2.1.2 Description: Short textual description of the used device
 - 2.1.3 Datasheets: Links to the device datasheets. The specific datasheet information is also required for access in IEEE 1900.6.

- 2.1.4 Software: Specific software (hopefully with source code) used for measurements. For example custom USRP code.
 - 2.1.4.1 Description: What kind of software was used, what's the execution environment, etc.
 - 2.1.4.2 Operating system: The operating system used on the device. It is possible that hardware supports multiple operating systems, firmware version, in such case it is necessary to specify which one was used.
 - 2.1.4.3 Application Name: Names of the applications used.
 - 2.1.4.4 Code: References to the source code to download.
- 2.2 Location: A description of the area where the measurement was performed. Was it indoors/outdoors, location map, placement of the devices in the building, etc.
 - 2.2.1 Layout: Arrangement of devices and other objects in the environment.
 - 2.2.2 Mobility: Mobility information of devices or objects in the environment.
- 2.3 Time: general date / time range, will be refined in category 3 per trace.
- 2.4 Radio Frequency
 - 2.4.1 Operating range: The frequency range on which the devices are operating. For example 2.4 GHz ISM band.
 - 2.4.2 Interference sources: Possible sources of interference.
- 2.5 Parameters: Definition of parameters that can be changed between different iterations of the experiment.
 - 2.5.1 Description
 - 2.5.2 Name: Name of the parameters. For further usage in iteration description.
 - 2.5.3 Unit: Unit of measurement for the parameter.
- 2.6 Trace description
 - 2.6.1 Description: Detailed description of the generated trace files. It is left open in which format the actual measurement trace is stored as long as it is sufficiently well described and can be converted to CSV, which we consider the baseline. We also recommend other formats, such as matlab timeseries objects.
 - 2.6.2 Collected metrics: List of the types of collected data. For example signal power, time, location.
 - 2.6.2.1 Name
 - 2.6.2.2 Unit of Measurement: The unit used for data storage. For example Hz, dBm. The measurement units (frequency, power etc.) are described in IEEE 1900.6 in Section 6.2 on page 73 and should be referenced here)
 - 2.6.2.3 Accuracy: Information about device accuracy for this metric. Should be extracted from datasheet.
 - 2.6.3 Processing tools: Conversion, evaluation, etc.
- 2.7 Signal generation: If any how the signal was generated, trace, source files.
 - 2.7.1 Description: Description how signal was generated.
 - 2.7.2 Trace: Trace file of the generated file suitable for replaying the experiment.
- 3 **Experiment Iterations:** Each trace may include sensing data, but may also cover other parameters if they were dynamic and captured during the experiment (time or location data). A measurement trace must conform to the specification above in category 1. It may deviate from the specification in category 2, but then it must be explicitly stated below in which ways it differs,

i.e. the specification for an individual trace can overwrite/refine/augment any of the existing fields described in category 2)

- 3.1 Description: A brief description/relation to the other traces, e.g. this was the n-th iteration of the experiment.
- 3.2 Time: The actual start and end time of this experiment trace.
 - 3.2.1 Start time
 - 3.2.2 End time
- 3.3 Parameters: Values of the parameters defined in category 2.
 - 3.3.1 Name
 - 3.3.2 Value
- 3.4 Trace-file: List of trace files containing the traces in the format described in 2.5.3
- 3.5 If necessary the fields from category 2 can be redefined here. For example the location information if changed during the experiment. The change can be represented here without the need of creation of the new description.

1.4 Examples

1.4.1 BAN Example

1 Experiment Abstract

- 1.1 Title: Urban RF noise measurements with a IEEE 802.15.4 Body Area Network
- 1.2 Unique CREW Tag: 2011-1-Hauer
- 1.3 Author(s): Jan Hauer
 - 1.3.1 Contact information : hauer@tkn.tu-berlin.de, Einsteinufer 25, 10587 Berlin, Germany
- 1.4 Release Date: 2011.06.25 I would suggest using uniform date time encoding across the entire CREW data: here, in 2.3 and in measurements. My suggestion would be UTC: 1994-11-05T13:15:30Z (see here for more <http://www.w3.org/TR/NOTE-datetime>)
- 1.5 Experiment summary: *2.4 GHz RF noise measurements on 3 shimmer2r sensor nodes attached to a person, who was walking through a central shopping district in Berlin, Germany. The subject was walking for 30 minutes, we monitored RSSI on all 16 IEEE 802.15.4 channels (2400, 2405, ... MHz) in a round-robin fashion. Because we were monitoring the unlicensed 2.4 GHz band there are likely many signals from different devices. Our setup is completely passive, simply recording RF noise and location data.*
- 1.6 Collection methodology: *RF noise samples are collected by periodically reading the RSSI register of the shimmer2r radio (CC2420 radio). An RSSI reading represents the average signal power over 192 microseconds in dBm. Once an RSSI reading has been obtained, we switch to the next channel (2400->2405->...->2480->2400->2405 MHz, etc.) and collect the next sample. All RSSI values are stored on an SD card and extracted after the experiment. Location data is collected via a GPS-daughterboard, which allows to obtain GPS coordinates and time once per second. GPS location and time data is also stored on the SD card.*
- 1.7 Further documentation : *none*
- 1.8 Related experiments: *none*
- 1.9 Notes: *During the first 30 seconds of an experiment the GPS data is unavailable, because the GPS needs time for calibration.*

2 Meta-information

2.1 Devices

2.1.1 Datasheets:

- *Shimmer2r platform:* <http://www.shimmer-research.com/wp-content/uploads/2011/06/Shimmer-2R-Technical-Data-Sheet.pdf>
- *GPS board:* <http://www.shimmer-research.com/wp-content/uploads/2011/02/GPS-Spec-Sheet.pdf>
- *CC2420 Radio:* <http://www.ti.com/lit/gpn/cc2420>

2.1.2 Software

2.1.2.1 Description: maybe it would be nice to have the information here a little bit more structured

2.1.2.2 *Operating system:* TinyOS 2

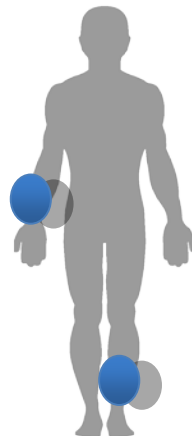
2.1.2.3 *Driver:* shimmer2r GPS vX.X

2.1.2.4 *Application:* ApplicationName

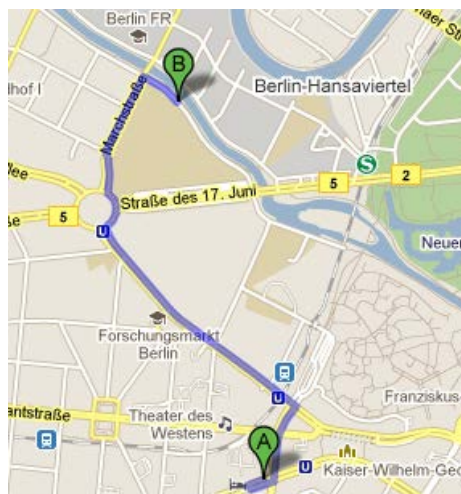
2.1.2.5 *Code: Language:* nesC *URI:* <http://github.com/XXXX>

2.2 Space

2.2.1 *Layout: Sensor nodes are attached to right hand and left foot of the subject as shown in the following schematic:*



The subject was walking on the pedestrian path from Kurfuerstendamm 192, 10879 Berlin, Germany, to Einsteinufer 25, 10551 Berlin, taking the route as shown in the following picture:



It was a typical urban main street environment with cars passing frequently and other pedestrians walking on the pedestrian path. There were houses next to the streets, a mix between apartment building and office buildings. The path can be seen in google-streetview: http://maps.google.de/maps?saddr=Kurf%C3%BCrstedamm,+Charlottenburg+10789+Berlin&daddr=Einsteinufer+26,+10587+Berlin&hl=de&ie=UTF8&ll=52.515646,13.326845&spn=0.019482,0.055661&sll=52.501646,13.311052&sspn=0.038716,0.111322&geocode=Fd0gIQMdUVPLACn3VCVx_1CoRzFZUEg_VssRdQ%3BFRIUIQMdHlnLACkxTgW3BFGorZG28WgySvDIFg&mra=iwd&z=15&layer=c&cbll=52.515978,13.326451&panoid=8GDeVURfbqbmeSuxIIaAQ&cbp=12,332.11,,0,13.95

2.2.2 Mobility: *could be Fixed, Mobile or Fixed and Mobile. Depending on the case, Speed could be 0 km/h (Stationary), 4 km/h (human walking speed), etc. This would again bring in a little more structure which could further be used to link to process vocabularies for describing experiments.* Execution:

Iteration 1: StartTime: 2011-05-22T17:15:00Z EndTime: XXX DurationTime: 785msec

Iteration 2: StartTime: 2011-05-22T18:15:00Z EndTime: YYY DurationTime: 900msec

2.3 RF Frequency

2.3.1 Operating range(s): *2.4 GHz ISM Band, 2400 – 2483 MHz*

2.3.2 Interference sources: *There was likely uncontrolled interference from various 2.4 GHz band devices. Measuring the power of their signal was a main goal of the experiments.*

2.4 Trace description

2.4.1 Collected metrics

2.4.1.1 RF Power

2.4.1.1.1 *on one of 16 IEEE 802.15.4 channels averaged over 192us*

2.4.1.1.2 *UoM: dBm*

2.4.1.1.3 *+/- 6 dB (RSSI accuracy) datasheet*

2.4.1.2 Time (GPS time)

2.4.1.2.1 *in unix time + microseconds*

2.4.1.2.2 *+/-40 ppm accuracy*

2.4.1.3 Location

2.4.1.3.1 *GPS coordinates*

2.4.1.3.2 *+/- 5m (GPS accuracy)*

2.4.2 Format: each experiment corresponds to two standard matlab timeseries objects with the following properties (timeseries struct members):

a)

- Name: 'RSSI on node in right hand'
- Time: [nx1 double]
- TimeInfo: [1x1 tsdata.timemetadata]
 - Units: seconds.microseconds
- Data: [nx1 double]
- DataInfo: [1x1 tsdata.datametadata]
 - Units: "dBm"

b)

- Name: 'RSSI on node on left foot'
- Time: [mx1 double]
- TimeInfo: [1x1 tsdata.timemetadata]
 - Units: seconds.microseconds
- Data: [mx1 double]
- DataInfo: [1x1 tsdata.datametadata]
 - Units: "dBm"

c)

- Name: 'GPS Location'
- Time: [nx1 double]
- TimeInfo: [1x1 tsdata.timemetadata]
 - Units: seconds.microseconds
- Data: [nx1 double]
- DataInfo: [1x1 tsdata.datametadata]
 - Units: "GPS coordinates"

2.4.3 Processing tools: none

2.4.4 Signal generation: none

3 Experiment Trace(s)

Trace 1:

Description: *first iteration of the experiment*

Time: *22.05.2011 at 17:15-18:15 CET*

Trace-specific meta-information : *none*

Trace-file: *LINK*

Trace 2:

Description: *second iteration of the experiment*

Time: *23.05.2011 at 16:05-17:05 CET*

Trace-specific meta-information:

Space.layout: in addition to the two nodes attached to right hand and left foot we used a third node attached to the chest

Format: we have an additional RSSI trace for the new node

Trace-file: *LINK*

1.4.2 BEE2 Example

The calibration process requires two steps. First the transmitter is calibrated and then the receiver. We consider this as two separate experiments because the two different devices are used for measurements and both give output in completely different formats. Both experiments are still tightly connected to each other. That is why both are mentioned in each other references, and most of the description is common.

1 Experiment Abstract

- 1.1 Title *Transmitter calibration of the radio Front Ends for BEE2*
- 1.2 Unique CREW Tag: *2011-1-Chwalisz*
- 1.3 Author(s): *Mikołaj Chwalisz*
- 1.3.1 Contact information: chwalisz@tkn.tu-berlin.de, *Einsteinufer 25, 10587 Berlin, Germany*
- 1.4 Release Date: *07.04.2011*
- 1.5 Experiment summary: *The calibration is a process aimed to give a meaningful comparison between measurements made by one device, with known magnitude and correctness, and a second device. This step is essential to be able to compare results with other experiments, especially with custom made devices. The other goal of the calibration is to determine the condition of the instrument to perform measurements. This also includes the ability to transfer defined measurement units.*
In order to calibrate the receiver, it is necessary to have a calibrated transmitter.
In this experiment we try to calibrate BEE2 Front End as the transmitter based on signal received by the R&S FSV Spectrum Analyzer
- 1.6 Collection methodology: *Devices where set to one frequency and the power level of the generic OFDM was measured. Whole experiments where done with cable connection. Transmitting device is set to one center frequency*
- 1.7 Further documentation: *The measurements where published in master thesis of Mikołaj Chwalisz.*
- 1.7.1 Bibtex: `@MastersThesis{ chwalisz2010mscthesis, title = "{Development of a testbed for spectrum diversity measurements in the ISM band}", author = "Mikołaj Chwalisz", school = {Warsaw University of Technology \& Technische Universit{a}t Berlin}, month = "March", year = "2011"}`
- 1.8 Related experiments: *This is part of calibration process of BEE2 Radio Front Ends. The other part has CREW Tag: 2011-2-Chwalisz*

1.9 Notes

2 Meta-information

2.1 Devices:

- *BEE2 Board: The Berkeley Emulation Engine 2 (BEE2) was developed to be a reusable, modular, and scalable framework for designing high-end reconfigurable computers at the Berkeley Wireless Research Center (BWRC). It is supposed to help solving computationally intensive problems such as: emulation and design of wireless communication systems, real-time scientific computation, high-performance real-time digital signal processing*
- *Radio Front End: The radio capabilities for BEE2 board in the CogRad testbed are provided by the radio Front End. It is made of the baseband board performing data processing, control and digital to analog conversion. The daughter card is used to perform up/down signal conversion to 2.4 GHz.*

http://bwrc.eecs.berkeley.edu/Research/Cognitive/prototyping_platform.htm

- *R&S FSV Spectrum Analyzer*

2.1.1 Datasheets:

- ♣ *BEE2: C. Chang, J. Wawrzynek, and R.W. Brodersen, BEE2: a high-end reconfigurable computing system, Design Test of Computers, IEEE 22 (2005), no. 2, 114–125.*

<http://bee2.eecs.berkeley.edu/wiki/BEE2wiki.html>

<http://bee2.eecs.berkeley.edu/>

▲ *Front End: Fred Burghardt, Cognitive Radio Testbed Users Manual, April 2009.*

http://bwrc.eecs.berkeley.edu/Research/Cognitive/prototyping_platform.htm

▲ *R&S FSV: http://www2.rohde-schwarz.com/file/FSV_dat-sw_en.pdf*

2.1.2 Device Software

2.1.2.1 Description: *MSSGE (Matlab / Simulink / System Generator / EDK) toolchain for FPGA designs. Used CASPER libraries and code from BWRC (Berkeley)*

2.1.2.2 Code Software like FPGA designs is available, please contact author.

2.2 Space

2.2.1 Layout: *Cable connection between devices.*

2.2.2 Mobility: *None*

2.3 Time Couple of seconds per measurement

2.4 RF Frequency

2.4.1 Operating range(s) *2.4 GHz ISM band, 2400 – 2483 MHz*

2.4.2 Interference sources: *None, cable, the no loss connection is assumed*

2.5 Trace description

2.5.1 Collected metrics: *Power measurements in dBm, detector and trace mode of spectrum analyzer defined in every trace file.*

2.5.2 Data accuracy: *Total measurement uncertainty: 0.28dB*

2.5.3 Format *text file with the following structure:*

▲ *Parameter listing:*

- *Name; Value; (Unit)*
- *Values;Number of values;*
- *Vector: Frequency;dBm*

▲ *Additional PNG file with spectrum analyzer screen shot*

2.5.4 Processing tools: *Basic analysis GUI and matlab scripts available, please contact author.*

2.5.5 Signal generation: *For signal generation the FE was used. One or two OFDM symbols stored in FE's FPGA fabric and send repeatedly. Resulting in constant OFDM stream. Matlab file with I/Q samples is available as well as the scripts to create it.*

3 Experiment Trace(s)

3.1 Trace 1:

3.1.1 Description *10dB Attenuator added into cable*

3.1.2 Time *20.01.2011 at 16:05 CET*

3.1.3 Trace-specific meta-information *none*

3.1.4 Trace-file *fec att10dB count500 swt1ms clrw.DAT*

3.2 Trace 2:

- 3.2.1 Description *signal was averaged over 500 sweeps*
- 3.2.2 Time *20.01.2011 at 16:15 CET*
- 3.2.3 Trace-specific meta-information *none*
- 3.2.4 Trace-file *fec att0dB count500 swt1.1ms rbw100khz avg.DAT*

1 Experiment Abstract

- 1.1 Title *Receiver calibration of the radio Front Ends for BEE2*
- 1.2 Unique CREW Tag: *2011-2-Chwalisz*
- 1.3 Author(s): *Mikołaj Chwalisz*
- 1.3.1 Contact information: chwalisz@tkn.tu-berlin.de, *Einsteinufer 25, 10587 Berlin, Germany*
- 1.4 Release Date: *07.04.2011*
- 1.5 Experiment summary: *The calibration is a process aimed to give a meaningful comparison between measurements made by one device, with known magnitude and correctness, and a second device. This step is essential to be able to compare results with other experiments, especially with custom made devices. The other goal of the calibration is to determine the condition of the instrument to perform measurements. This also includes the ability to transfer defined measurement units.*
In order to calibrate the receiver, we take the knowledge of the signal strength of the Front End from experiment 2011-1-Chwalisz and take it as the input for receiver calibration.
- 1.6 Collection methodology: *Devices were set to one frequency and the power level of the generic OFDM was measured. Whole experiments were done with cable connection. Transmitting device is set to one center frequency*
- 1.7 Further documentation: *The measurements were published in master thesis of Mikołaj Chwalisz.*
- 1.7.1 Bibtext: *@MastersThesis{ chwalisz2010mscthesi, title = "{Development of a testbed for spectrum diversity measurements in the ISM band}", author = "Mikołaj Chwalisz", school = {Warsaw University of Technology \& Technische Universit{a}t Berlin}, month = "March", year = "2011"}*
- 1.8 Related experiments *This is part of calibration process of BEE2 Radio Front Ends. The other part has CREW Tag: 2011-1-Chwalisz*
- 1.9 Notes

2 Meta-information

- 2.1 Devices:
 - *BEE2 Board: The Berkeley Emulation Engine 2 (BEE2) was developed to be a reusable, modular, and scalable framework for designing high-end reconfigurable computers at the Berkeley Wireless Research Center (BWRC). It is supposed to help solving computationally intensive problems such as: emulation and design of wireless communication systems, real-time scientific computation, high-performance real-time digital signal processing*
 - *Radio Front End: The radio capabilities for BEE2 board in the CogRad testbed are provided by the radio Front End. It is made of the baseband board performing data processing, control and digital to analog conversion. The daughter card is used to perform up/down signal conversion to 2.4 GHz.*

http://bwrc.eecs.berkeley.edu/Research/Cognitive/prototyping_platform.htm

2.1.1 Datasheets:

- ⤴ *BEE2: C. Chang, J. Wawrzynek, and R.W. Brodersen, BEE2: a high-end reconfigurable computing system, Design Test of Computers, IEEE 22 (2005), no. 2, 114–125.*

<http://bee2.eecs.berkeley.edu/wiki/BEE2wiki.html>

<http://bee2.eecs.berkeley.edu/>

- ⤴ *Front End: Fred Burghardt, Cognitive Radio Testbed Users Manual, April 2009.*

http://bwrc.eecs.berkeley.edu/Research/Cognitive/prototyping_platform.htm

2.1.2 Device Software

2.1.2.1 Description: *MSSGE (Matlab / Simulink / System Generator / EDK) toolchain for FPGA designs. Used CASPER libraries and code from BWRC (Berkeley).*

2.1.2.2 Code Software like FPGA designs is available, please contact author.

2.2 Space

2.2.1 Layout: *Cable connection between devices.*

2.2.2 Mobility: *None*

2.3 Time Couple of seconds per measurement

2.4 RF Frequency

2.4.1 Operating range(s) *2.4 GHz ISM band, 2400 – 2483 MHz*

2.4.2 Interference sources: *None, cable, the no loss connection is assumed*

2.5 Trace description

2.5.1 Collected metrics: *Calculated FFT data from I/Q measurements in dB. Exact relation to the dBm is to be defined by this experiment.*

2.5.2 Data accuracy:

2.5.3 Format *matlab file with the following structure:*

- ⤴ *frequency: Center frequency [double]*
 - *Unit: MHz*
- ⤴ *fe_id: [double]*
- ⤴ *name: file name [string]*
- ⤴ *fe: front end name [string]*
- ⤴ *fs: sampling frequency [double]*
 - *Unit: Hz*
- ⤴ *spectrum: FFT series [MxN double]*
 - *Unit: dB*
- ⤴ *frequency_series: [Mx1 double]*
 - *Unit: Hz*

- 2.5.4 Processing tools: *Basic analysis GUI and matlab scripts for loading the data is available*
- 2.5.5 Signal generation: *For signal generation the FE was used. One or two OFDM symbols stored in FE's FPGA fabric and send repeatedly. Resulting in constant OFDM stream. Matlab file with I/Q samples is available as well as the scripts to create it. Refer also to Experiment 2011-1-Chwalisz*

3 Experiment Trace(s)

3.1 Trace 1:

3.1.1 Description *10dB Attenuator added into cable, FE gains set to:*

▲ *agc = 130*

▲ *pga = 14*

3.1.2 Time *20.01.2011 at 16:55 CET*

3.1.3 Trace-specific meta-information *none*

3.1.4 Trace-file *memdump_0_FEA_agc_130_pga_14_att10db_b.fft*

3.2 Trace 2:

3.2.1 Description *10dB Attenuator added into cable, FE gains set to:*

▲ *agc = 130*

▲ *pga = 14*

3.2.2 Time *20.01.2011 at 17:10 CET*

3.2.3 Trace-specific meta-information *none*

3.2.4 Trace-file *memdump_0_FEA_agc_130_pga_14_att0db_b.fft*

1.4.3 Dublin Sensing Experiment

1 Experiment Abstract

- 1.1 Title: Sensing of DVB-T signals transmitted in the 2.4 GHz ISM band with a range of sensing devices
- 1.2 Unique CREW Tag: 2011-1-sensing_dublin
- 1.3 Author(s): Sofie Pollin, Peter Van Wesemael
- 1.3.1 Contact information : pollins@imec.be, Kapeldreef 75, 3001 Leuven, Belgium
- 1.4 Release Date: xxxx.xx.xx
- 1.5 Experiment summary: *An 8 MHz DVB-T signal is transmitted in the 2.4 GHz ISM band in a large meeting room at CTVR in Dublin. The goal is to familiarize with the results and output formats of various sensing solutions. Some of those are capable of sensing in the 2.4 GHz ISM band only. Some of them have special algorithms for detecting DVB-T signals. Hence, the decision to sense DVB-T signals in the 2.4 GHz ISM band. The DVB-T signals were transmitted at various transmit powers. Also, there were scenarios with users present, without users present, and with users walking in the meeting room. Ambient interference from other devices in the 2.4 GHz ISM band is present during the experiment.*
- 1.6 Collection methodology: *Sensing is done with a range of sensing solutions:*
 - 1.6.1 **imec Advanced Spectrum Sensing**
 - Low power/low cost SDR RFIC prototype*
 - Input range from 0.1 up to 6 GHz*
 - Programmable channel bandwidth from 1 up to 40 MHz*

On-chip 65MS/s 10b ADC

5 mm² – 40nm TSMC technology

1.6.2 USRP1 (Ettus Research)

Highly flexible low cost RF transceiver.

For these experiments RFX2400 daughterboard used. It operates between 2.3 and 2.9 GHz.

Can sample up to 8Msamples/sec.

Experiment parameters

1.6.3 Iris

Component based architecture for software defined radio

Designed and developed in CTVR, Trinity College Dublin

Highly reconfigurable

Parameters and components of radio can be changed in real time.

USRP1 front-end used in experiments

1.6.4 Wi-Spy 2.4x (MetaGeek, LLC.)

Low-cost spectrum sensor for 2.4 GHz ISM band

We used Kismet Spec-tools for Linux OS to acquire power spectral density estimates in a non-proprietary format

Spectrum dumps are performed as fixed bandwidth sweeps of the entire ISM 2.4 GHz band

1.6.5 AirMagnet Spectrum XT

USB product designed for troubleshooting and deploying WLAN networks

ISM 2.4 GHz/ 5 GHz

internal or external antenna

- **TelosB**

Sensor network hardware platform developed at UC Berkeley

Uses the IEEE 802.15.4-compliant CC2420 transceiver, which can measure RF energy in 2.4 GHz ISM band

IEEE 802.15.4 channel (resolution) bandwidth is 2 MHz,

Traces were collected for a range of scenarios:

- *Slow On/Off Pattern (60 s On / 60 s Off)*
- *Fast On/Off Pattern (10 ms On / 100 ms Off)*
- *Change of TX Power (-4 dBm / -15 dBm / -30 dBm)*
- *Change of Distance between TX and Sensing Nodes*
- *Change of Center Freq. (2.404 GHz : 8 MHz : 2.496 GHz)*

1.7 Further documentation : *Our setup and data is also described in paper ‘Christoph Heller, Stefan Bouckaert, Ingrid Moerman, Pollin Sofie; Van Wesemael Peter, Danny Finn, Daniel Willkomm, Jan-Hinrich Hauer, “A Performance Comparison of Different Spectrum Sensing Techniques, “ WinnComm 2011.’*

1.8 Related experiments: *Follow-up experiments in Dresden and Dublin with CREW Tag: 2011-4-sensing_dresden and 2011-6-sensing_berlin*

1.9 Notes:

2 Meta-information

2.1 Devices

2.1.1 Datasheets:

- **imec Advanced Spectrum Sensing**

The imec spectrum sensing solution is a prototype, hence no datasheet is available. More information can be found in these leaflets and publications:

http://www2.imec.be/content/user/File/Brochures/GR2011_Leaflet_Spectral%20Sensing.pdf

http://www2.imec.be/content/user/File/Brochures/GR2010_Leaflet%20Scaldio.pdf

http://www2.imec.be/content/user/File/Brochures/GR2011_Leaflet_COBRA.pdf

M. Ingels et al. A 5mm² 40nm LP CMOS Transceiver for a Software-Defined Radio Platform. IEEE Journal of Solid-State Circuits, 45(12):2794{2806, 2010.

1.9.1 USRP1 (Ettus Research)

http://www.ettus.com/downloads/ettus_ds_usrp_v7.pdf

http://www.ettus.com/downloads/ettus_daughterboards.pdf

1.9.2 Iris

L. E. Doyle, P. Sutton, K. Nolan, B. Ozgul, J. Lotze, T. Rondeau, S. Fahmy, H. Lahlou, and L. A. DaSilva, "Experiences from the Iris testbed in dynamic spectrum access and cognitive radio experimentation," IEEE Symposia on New Frontiers in Dynamic Spectrum Access Networks (DySPAN), Singapore, 6-9 April, 2010.

Paul Sutton, Jorg Lotze, Hicham Lahlou, Baris Ozgul, Keith Nolan, Linda Doyle, Suhaib Fahmy, Juanjo Noguera, "Multi-Platform Demonstrations using the Iris Architecture for Cognitive Radio Network Testbeds", Crowncom 2010, Cannes, France

1.9.3 Wi-Spy 2.4x (MetaGeek, LLC.)

http://files.metageek.net/marketing/Wi-Spy_2.4x/Wi-spy_24x_medium.pdf

1.9.4 AirMagnet Spectrum XT

http://airmagnet.flukenetworks.com/assets/datasheets/AirMagnet_SpectrumXT_Datasheet.pdf

- **TelosB**

http://www.willow.co.uk/TelosB_Datasheet.pdf

2.1.2 Software:

2.1.2.1 Description:

For the overall processing, comparison and evaluation of the results Matlab is used. The signal generator used for the test signal generation is also controlled from Matlab. The different devices use different software:

Imec advanced spectrum sensing: c-code controlled from a Matlab environment

USRP1: ???

Iris: ???

WiSpy 2.4x: ???

AirMagnet Spectrum XT: ???

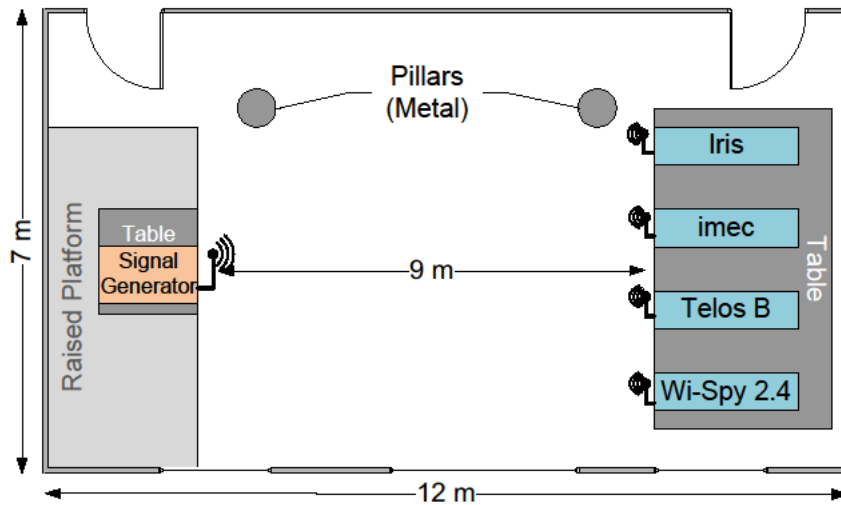
TelosB:???

2.1.2.2 Code: crew.intec.ugent.be or <https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/>

2.2 Space

2.2.1 Layout:

The transmitter and sensing agents are set up in a large meeting room.



2.2.2 Mobility: *none*

2.3 Time: 2011-01-11 – 2011-01-13

2.4 RF Frequency

2.4.1 Operating range(s): *2.4 GHz ISM Band, 2400 – 2483 MHz*

2.5 Interference sources: *There was likely uncontrolled interference from various 2.4 GHz band devices.*

2.6 Trace description

2.6.1 Collected metrics (*what type of data did we collect, signal power, time, location, ...*)

1.9.5 imec Advanced Spectrum Sensing

Raw IQ time domain samples sampled at 40 MSamples/s. with a 20 MHz analog signal bandwidth.

1.9.6 USRP1 (Ettus Research)

Output type: IQ samples

Bandwidth: 8MHz

1.9.7 Iris

I/Q data samples and PSD measurements

1.9.8 Wi-Spy 2.4x (MetaGeek, LLC.)

Spectrum dumps are performed as fixed bandwidth sweeps of the entire ISM 2.4 GHz band

The resolution bandwidth is 327 KHz, sweep time is 507 ms

1.9.9 AirMagnet Spectrum XT

CSV log files: 1 report/second

- **TelosB**

Take one RSSI sample per channel (signal power averaged over 192 us)

Output data -> total: 2 ms per sample (sampling frequency 500 Hz)

2.6.2 Data accuracy:

1.9.10 imec Advanced Spectrum Sensing

RBW / Sweep time 260 Hz / 1s

1.9.11 USRP1 (Ettus Research)

Resolution BW: 7.81 kHz

Sensing time: 5.12ms

1.9.12 Iris

???

1.9.13 Wi-Spy 2.4x (MetaGeek, LLC.)

???

1.9.14 AirMagnet Spectrum XT

amplitude accuracy: +/- 2 dB

Resolution bandwidth 156.3 kHz

sweep time: 64 ms per 20 MHz

- **TelosB**

Sweep over spectrum in steps of 2 MHz (e.g. 2400->2402->2404 MHz)

Take one RSSI sample per channel (signal power averaged over 192 us)

3.5.1 *Format: Format (detailed description of the trace format: It is left open in which format the actual measurement trace is stored as long as it is sufficiently well described and can be converted to CSV, which we consider the baseline. We also recommend other formats, such as matlab timeseries objects. The measurement units (frequency, power etc.) are described in IEEE 1900.6 in Section 6.2 on page 73 and should be referenced here)*

2.6.3 Processing tools: none

2.6.4 Signal generation:

- Source: Anritsu MG3700A RF Signal Generator
- Characteristic: DVB-T Signal
- Center Frequency: 2.477 GHz
- Bandwidth: 8 MHz
- CP Ratio: 1/4
- Power: -4 dBm

3 Experiment Trace(s)

3.1 Trace 1: https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/imec_scaldio2b/

3.1.1 Description: imec sensing agent traces

3.1.2 Time 2011-01-12 11h10m09s – 18h27m07s

3.1.3 Trace-specific meta-information *none*

3.1.4 Trace-file: IMEC_1.1_onoff.tgz, IMEC_1.1_signal.tgz, IMEC_1.1_silent.tgz, IMEC_1.2_onoff.tgz, IMEC_1.2_signal.tgz, IMEC_1.3_onoff.tgz, IMEC_1.3_signal.tgz, IMEC_1.4_signal.tgz, IMEC_1.5_signal.tgz, IMEC_2.1_signal-15dBm.tgz, IMEC_2.2_signal-15dBm.tgz, IMEC_2.3_signal-15dBm.tgz, IMEC_3.1_signal-30dBm.tgz, IMEC_3.2_signal-30dBm.tgz, IMEC_3.3_signal-30dBm.tgz, IMEC_4.1_signal.tgz, IMEC_4.2_signal.tgz, IMEC_4.3_signal.tgz, IMEC_5.1_signal.tgz, IMEC_5.2_signal.tgz, IMEC_6.1_signal.tgz, IMEC_7.1_signal.tgz

3.2 Trace 2: <https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin->

Jan2011/Airmagnet%20Spectrum%20XT/Description: imec sensing agent traces

- 3.2.1 Time 2011-01-12 11h10m09s – 18h27m07s
- 3.2.2 Trace-specific meta-information *none*
- 3.2.3 Trace-file: CREW_1_1_onoff_2011-01-12_14-49-12.csv, CREW_1_1_signal_2011-01-12_12-02-05.csv, CREW_1_1_silent_2011-01-12_11-15-36.csv, CREW_1_2_onoff_2011-01-12_15-08-13.csv, CREW_1_2_signal_2011-01-12_12-24-18.csv, CREW_1_2_silent_2011-01-12_15-24-37.csv, CREW_1_3_onoff_2011-01-12_15-17-20.csv, CREW_1_3_signal_2011-01-12_12-36-20.csv, CREW_1_4_signal_2011-01-12_15-59-40.csv, CREW_1_5_signal_2011-01-12_16-05-45.csv, CREW_2_1_signal_2011-01-12_16-22-55.csv, CREW_2_2_signal_2011-01-12_16-30-26.csv, CREW_2_3_signal_2011-01-12_16-38-03.csv, CREW_3_1_signal_2011-01-12_16-43-29.csv, CREW_3_2_signal_2011-01-12_16-51-01.csv, CREW_3_3_signal_2011-01-12_16-58-16.csv, CREW_4_1_signal_2011-01-12_17-11-50.csv, CREW_4_2_signal_2011-01-12_17-15-05.csv, CREW_4_3_signal_2011-01-12_17-19-28.csv, CREW_5_1_signal_2011-01-12_17-23-05.csv, CREW_5_2_signal_2011-01-12_17-28-49.csv, CREW_5_3_signal_2011-01-12_17-31-53.csv, CREW_6_1_signal_2011-01-12_17-42-05.csv, CREW_7_1_signal_2011-01-12_18-20-12.csv
- 3.3 Trace 3: https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/IrisReadings/I_and_Q_data/
 - 3.3.1 Time 2011-01-12 11h10m09s – 18h27m07s
 - 3.3.2 Trace-specific meta-information *none*
 - 3.3.3 Trace-file: measurement1.2onoff, measurement1.2silent, measurement2.1onoff, measurement2.3signal, measurement3.3signal, measurement4.2signal, measurement4.3signal, measurement5.2signal, measurement5.3signal, measurement6.1signal
- 3.4 Trace 4: https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/IrisReadings/PSD_estimates/
 - 3.4.1 Time 2011-01-12 11h10m09s – 18h27m07s
 - 3.4.2 Trace-specific meta-information *none*
 - 3.4.3 Trace-file: measurement1.2onoff, measurement1.2silent, measurement2.1onoff, measurement2.1signal, measurement2.2signal, measurement2.3signal, measurement3.3signal, measurement4.2signal, measurement4.3signal, measurement5.2signal, measurement5.3signal, measurement6.1signal
- 3.5 Trace 5: <https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/telos/>
 - 3.5.1 Time 2011-01-12 11h10m09s – 18h27m07s
 - 3.5.2 Trace-specific meta-information *none*
 - 3.5.3 Trace-file: CREW_Measurement_1.1_signa.txt, CREW_Measurement_1.1_silent.txt, CREW_Measurement_1.2_OnOff_1channe.txt, CREW_Measurement_1.2_OnOff_5channels.txt, CREW_Measurement_1.2_Silent_1channe.txt, CREW_Measurement_1.2_Silent_5channels.txt, CREW_Measurement_1.2_signa.txt, CREW_Measurement_1.3_OnOff_1channe.txt, CREW_Measurement_1.3_OnOff_5channels.txt, CREW_Measurement_1.3_signa.txt, CREW_Measurement_1.4_Signal_1channe.txt, CREW_Measurement_1.4_Signal_5channels.txt, CREW_Measurement_1.4_signa.txt, CREW_Measurement_1.5_Signal_1channe.txt, CREW_Measurement_1.5_Signal_5channels.txt, CREW_Measurement_2.1_Signal_1channe.txt, CREW_Measurement_2.1_Signal_5channels.txt, CREW_Measurement_2.2_Signal_1channe.txt,

CREW_Measurement_2.2_Signal_5channels.txt,
 CREW_Measurement_2.3_Signal_1channe.txt,
 CREW_Measurement_2.3_Signal_5channels.txt,
 CREW_Measurement_3.1_Signal_1channe.txt,
 CREW_Measurement_3.1_Signal_5channels.txt,
 CREW_Measurement_3.2_Signal_1channe.txt,
 CREW_Measurement_3.2_Signal_5channels.txt,
 CREW_Measurement_3.3_Signal_1channe.txt,
 CREW_Measurement_3.3_Signal_5channels.txt,
 CREW_Measurement_4.1_Signal_1channe.txt,
 CREW_Measurement_4.1_Signal_5channels.txt,
 CREW_Measurement_4.2_Signal_1channe.txt,
 CREW_Measurement_4.2_Signal_5channels.txt,
 CREW_Measurement_4.3_Signal_1channe.txt,
 CREW_Measurement_4.3_Signal_5channels.txt,
 CREW_Measurement_5.1_Signal_1channe.txt,
 CREW_Measurement_5.1_Signal_5channels.txt,
 CREW_Measurement_5.2_Signal_1channe.txt,
 CREW_Measurement_5.2_Signal_5channels.txt,
 CREW_Measurement_5.3_Signal_1channe.txt,
 CREW_Measurement_5.3_Signal_5channels.txt,
 CREW_Measurement_6.1_Signal_1channe.txt,
 CREW_Measurement_6.1_Signal_5channels.txt,
 CREW_Measurement_7.1_Signal_16channels.txt,
 CREW_Measurement_7.1_Signal_1channe.txt,

3.6 Trace 6: <https://svn.atlantis.ugent.be/svn/CREW/Data/Dublin-Jan2011/wispy/>

3.6.1 Time 2011-01-12 11h10m09s – 18h27m07s

3.6.2 Trace-specific meta-information *none*

3.6.3 Trace-file: measurement1.1signal.txt, measurement1.1silent.txt, measurement1.2onoff.txt, measurement1.2signal.txt, measurement1.2silent.txt, measurement1.3onoff.txt, measurement1.3signal.txt, measurement1.4signal.txt, measurement1.5signal.txt, measurement2.1signal.txt, measurement2.2signal.txt, measurement2.3signal.txt, measurement3.1signal.txt, measurement3.2signal.txt, measurement3.3signal.txt, measurement4.1signal.txt, measurement4.2signal.txt, measurement4.3signal.txt, measurement5.1signal.txt, measurement5.2signal.txt, measurement5.3signal.txt, measurement6.1signal.txt, measurement7.1signal.txt,

1.5 JSON Examples

1.5.1 BEE2 example

```

{
  "Experiment Abstract" : {
    "Title" : "Transmitter calibration of the radio Front Ends for BEE2",
    "Tag" : "2011-1-Chwalisz",
    "Authors" : [
      {
        "Name" : "Mikolaj Chwalisz",
        "Email" : "chwalisz@tkn.tu-berlin.de",
        "Address" : "Einsteinufer 25, 10587 Berlin, Germany",
        "Phone" : "+49 30314 23824"
      },
      {
        "Name" : "Daniel Willkomm",
        "Email" : "willkomm@tkn.tu-berlin.de",

```

```

    "Address" : "Einsteinufer 25, 10587 Berlin, Germany",
    "Phone" : "+49 3031421980"
  }
],
"Release Date" : "2011-04-07",
"Experiment summary" : "The calibration is a process aimed to give a meaningful comparison between
measurements made by one device, with known magnitude and correctness, and a second device. This step is
essential to be able to compare results with other experiments, specially with custom made devices. The other
goal of he calibration is to determine the condition of the instrument to perform measurements. This also
includes the ability to transfer defined measurement units.\nIn order to calibrate the receiver, it is necessary to
have a calibrated transmitter.\nIn this experiment we try to calibrate BEE2 Front End as the transmitter based on
signal received by the R&S FSV Spectrum Analyzer",
"Collection methodology" : "Devices where set to one frequency and the power level of the generic OFDM
was measured. Whole experiments where done with cable connection. Transmitting device is set to one center
frequency",
  "Further documentation" : {
    "Description" : "The measurements where published in master thesis of Mikołaj Chwalisz.",
    "Bibtex" : [
      "bibtexentry"
    ]
  },
  "Notes" : "none"
},
"Meta information" : {
  "Devices" : [
    {
      "Name" : "BEE2 Board",
      "Description" : "The Berkeley Emulation Engine 2 (BEE2) was developed to be a reusable, modular,
and scalable framework for designing high-end reconfigurable computers at the Berkeley Wireless Research
Center (BWRC). It is supposed to help solving computationally intensive problems such as: emulation and
design of wireless communication systems, real-time scientific computation, high-performance real-time digital
signal processing.",
      "Datasheets" : [
        "C. Chang, J. Wawrzynek, and R.W. Brodersen, BEE2: a high-end reconfigurable computing
system, Design Test of Computers, IEEE 22 (2005), no. 2, 114–125.",
        "http://bee2.eecs.berkeley.edu/wiki/BEE2wiki.html",
        "http://bee2.eecs.berkeley.edu/"
      ],
      "Software" : {
        "Description" : "MSSGE (Matlab / Simulink / System Generator / EDK) toolchain for FPGA
designs. Used CASPER libraries and code from BWRC (Berkeley).",
        "OperatingSystem" : "Linux BORPH",
        "Driver" : "none",
        "Application Name" : [
          "fpga1fe2011, ",
          "cntrlfpga2009"
        ],
        "Code" : "Ask authors."
      }
    }
  ],
  {
    "Name" : "Radio Front End",
    "Description" : "The Berkeley Emulation Engine 2 (BEE2) was developed to be a reusable, modular,
and scalable framework for desigThe radio capabilities for BEE2 board in the CogRad testbed are provided by
the radio Front End. It is made of the baseband board performing data processing, control and digital to analog
conversion. The daughter card is used to perform up/down signal conversion to 2.4 GHz.",
    "Datasheets" : [
      "http://bwrc.eecs.berkeley.edu/Research/Cognitive/prototyping_platform.htm"
    ],
    "Software" : {

```

```

    "Description" : "MSSGE (Matlab / Simulink / System Generator / EDK) toolchain for FPGA
designs. Used CASPER libraries and code from BWRC (Berkeley).",
    "OperatingSystem" : "none",
    "Driver" : "none",
    "Application Name" : "fe2011....",
    "Code" : "Ask authors."
  }
},
{
  "Name" : "RS FSV Spectrum Analyzer",
  "Description" : "OTS Spectrum Analyzer",
  "Datasheets" : [
    "http://www2.rohde-schwarz.com/file/FSV_dat-sw_en.pdf"
  ],
  "Software" : {
    "Description" : "NA",
    "OperatingSystem" : "NA",
    "Driver" : "NA",
    "Application Name" : "NA",
    "Code" : "NA"
  }
}
],
"Space" : {
  "Mobility" : "none",
  "Layout" : "Cable connection between devices."
},
"Time" : "Couple of seconds per measurement",
"Signal generation" : {
  "Description" : "For signal generation the FE was used. One or two OFDM symbols stored in FE's FPGA
fabric and send repeatedly. Resulting in constant OFDM stream. Matlab file with I/Q samples is available as well
as the scripts to create it.",

  "Trace" : "OFDM generation Matlab code is available, contact author."
},
"Radio Frequency" : {
  "Interference Sources" : "None, cable connection",
  "Operating Range" : "2.4 GHz ISM band, 2400 – 2483 MHz"
},
"Parameters" : [
  {
    "Description" : "Cable attenuation",
    "Name" : "Att",
    "Unit" : "dB"
  }
]
],
"Trace Description" : {
  "Format" : "Text file with the following structure: \nParameter listing:\nName; Value;
(Unit)\nValues;Number of values; \nVector: Frequency;dBm \nAdditional PNG file with spectrum analyzer
screen shot",
  "Collected Metrics" : [
    {
      "Name" : "RFPower",
      "Unit of Measurements" : "dBm",
      "Accuracy" : "+-0.28dB"
    }
  ]
}
},
"Experiment Iterations" : [

```

```

{
  "Description" : "10dB Attenuator added into cable",
  "Time" : "2011-01-20T16:05+02:00",
  "Parameters" : [
    {
      "Name" : "Att",
      "Value" : 10
    }
  ],
  "Trace files" : [
    "fec_att10dB_count500_swt_ms_clrw.DAT",
    "fec_att10dB_count500_swt_ms_clrw.png"
  ]
},
{
  "Description" : "signal was averaged over 500 sweeps",
  "Time" : "2011-01-20T16:05+02:00",
  "Parameters" : [
    {
      "Name" : "Att",
      "Value" : 0
    }
  ],
  "Trace files" : [
    "fec_att0dB_count500_swt1.1ms_rbw100khz_avg.DAT",
    "fec_att0dB_count500_swt1.1ms_rbw100khz_avg.png"
  ]
}
]
}

```

1.5.2 Outdoor spectrum sensing with VSN Example

```

{
  "Experiment Abstract": {
    "Title": "Outdoor spectrum sensing with VSN",
    "UID": "2011-01-20T11:05+02:00::cfortuna::VSNMirenVarSweep",
    "Authors": [
      {
        "Name": "Carolina Fortuna",
        "Email": "carolina.fortuna@ijs.si",
        "Address": "Jamova 39, Ljubljana, Slovenia",
        "Phone": "+386 1 477 3114"
      },
      {
        "Name": "Zoltan Padrah",
        "Email": "zoltan.padrah@ijs.si",
        "Address": "Jamova 39, Ljubljana, Slovenia",
        "Phone": "+386 1 477 3114"
      },
      {
        "Name": "Marko Mihelin",
        "Email": "marko.mihelin@gmail.com",
        "Address": "Jamova 39, Ljubljana, Slovenia",
        "Phone": "+386 1 477 3114"
      }
    ],
    "Release Date": "2011-01-20T11:05+02:00",
    "Experiment summary": "Measurement of spectrum occupancy in a rural area (Miren, Slovenia) using static low cost sensors called Versatile Sensor Nodes. The measured spectrum will then be compared to the same measurements performed using calibrated USRP. ",

```

```

"Collection methodology": "Several sensors have been placed in outdoor environment on a fixed frequency,
no controlled transmitters were used - we just measure normal everyday power spectrum.",
"Further documentation": {
  "Description": "Similar experiments were reported in ISABEL 2010 paper.",
  "Bibtex": [
    "bibtexentry"
  ]
},
"Notes": "http://sensorlab.ijs.si/publication/9/ism-bands-spectrum-sensing-based-on-versatile-sensor-node-
platform"
},
"Meta information": {
  "Devices": [
    {
      "Name": "VSN",
      "Description": "The JSI Versatile Sensor Node platform",
      "Datasheets": [
        "http://sensorlab.ijs.si/publication/9/ism-bands-spectrum-sensing-based-on-versatile-sensor-node-
platform",
        "http://xpack.ijs.si/svn/hardware/"
      ],
      "Data collection": "wireless",
      "Software": {
        "Description": "Codesourcery toolchain, STM and Sensorlab libraries with Contiki.",
        "OperatingSystem": "Contiki",
        "Driver": "custom",
        "Application Name": [
          "ssappv1.2"
        ],
        "Code": {
          "URL": "http://xpack.ijs.si/svn/vsndrivers/trunk/VSNDrivers/",
          "RevisionNo": "435"
        }
      }
    }
  ],
  {
    "Name": "USRP N210",
    "Description": "USRP N210 connected to a PC used for data processing and connectivity. The PC runs
GNU radio which then runs the application. For the RF front end we use a WBX daughterboard.",
    "Datasheets": [
      "http://www.ettus.com/downloads/ettus_daughterboards.pdf"
    ],
    "Data collection": "local storage",
    "Software": {
      "Description": "NA",
      "OperatingSystem": "Linux on PC",
      "Driver": "UHD",
      "Application Name": [
        "usrpsa1.4",
        "GNU radio"
      ],
      "Code": "NA"
    }
  }
},
"Location": {
  "Mobility": "none",
  "Layout": "http://xpack.ijs.si/Miren.kml",
  "GeoLoc": "http://api.geonames.org/hierarchy?geonameId=3167024&username=sensors_ijs"
},

```



```

"Time": {
  "StartTime": "2011-01-20T06:05+02:00",
  "EndTime": "2011-01-20T11:05+02:00"
},
"Signal generation": {
  "Description": "No signal has been generated.",
  "Trace": "NA"
},
"Radio Frequency": {
  "Interference Sources": "None",
  "Operating Range": {
    "StartFrequency": "815",
    "StopFrequency": "950",
    "Unit of Measurement": "MHz"
  },
  "Parameters": [
    {
      "Description": "Bandwidth",
      "Name": "Bandwidth",
      "Unit": "Hz"
    }
  ],
  "Trace Description": {
    "Description": "csv file for frequency values and csv file for measured power.",
    "FileFormat": {
      "Header": "NA",
      "Collected Metrics": [
        {
          "Name": "Frequency",
          "Unit of Measurements": "Hz",
          "Accuracy": "+1Hz"
        },
        {
          "Name": "Power",
          "Unit of Measurement": "dB",
          "Accuracy": "+-0.28dB"
        }
      ]
    }
  }
},
"Experiment Iterations": [
  {
    "Description": "sweep step 10MHz",
    "Time": {
      "StartTime": "2011-01-20T06:05+02:00",
      "EndTime": "2011-01-20T08:05+02:00"
    },
    "Parameters": [
      {
        "Name": "Frequency",
        "Value": 0.1
      }
    ],
    "Trace files": [
      "frequency2011-01-20T06:05iteration1.csv",
      "power2011-01-20T06:05iteration1.csv"
    ]
  }
],

```

```
{
  "Description": "sweep step 20MHz",
  "Time": "2011-01-20T06:35+02:00",
  "Parameters": [
    {
      "Name": "Frequency",
      "Value": 0.2
    }
  ],
  "Trace files": [
    "frequency2011-01-20T06:35iter2.csv",
    "power2011-01-20T06:35iter2.csv"
  ]
}
]
```

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