CTVR Testbed
at
Trinity College Dublin

Paul Sutton

19th February 2013

CREW Training Days

Brussels

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Outline

- What is CTVR?
- Software Radio Experimentation @ CTVR
- The CTVR Testbed
- Using the Testbed
- Ireland's Spectrum Playground
- Future Plans for the Testbed
- How to Get Access

What is CTVR?

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What is CTVR?

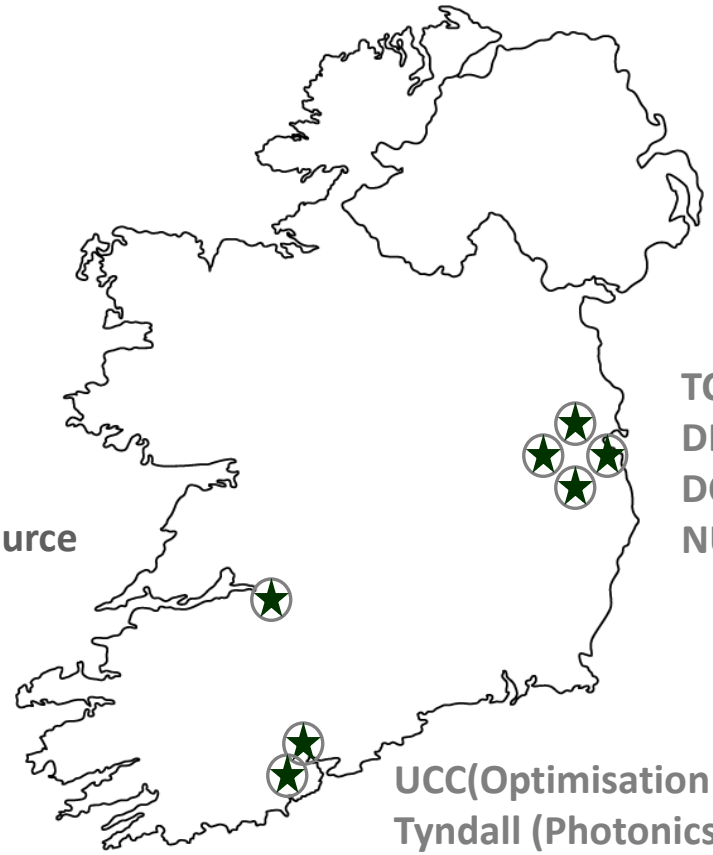
CTVR / the telecommunications research centre

- Founded in 2004
  - Funded by Science Foundation Ireland
  - Mission: To carry out industry-informed research in telecommunications of the highest quality.

- Bell Labs Ireland – founding industry partner

design for change

What is CTVR?



1 Director + 6 co-PIs
10 funded researchers
3 Centre Staff + 1.5 elsewhere
~110 active researchers in total

TCD(Wireless/Optical Networking)
DIT (Antennas)
DCU (Optical Systems)
NUIM (RF Design)

UL (Thermal/Resource Management)

UCC(Optimisation / Mobile Communications)
Tyndall (Photonics Integration/Photonic Systems)

+ 14 bilateral companies + 16 FP7 industry partners + 100 companies at CTVR events ++++

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What is CTVR?

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Software Radio Experimentation @ CTVR

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Experimentation @ CTVR

- Software radio experimentation since 2000
  - First version of Iris developed by Philip Mackenzie
  - Pentium III - single core, ~1GHz
    - (roughly equal to my 2 year-old phone)
  - TI TMS320C6201 full-length PCI board
  - + RedRiver WaveRunner Plus
  - Just to get samples to PC and demodulate FM

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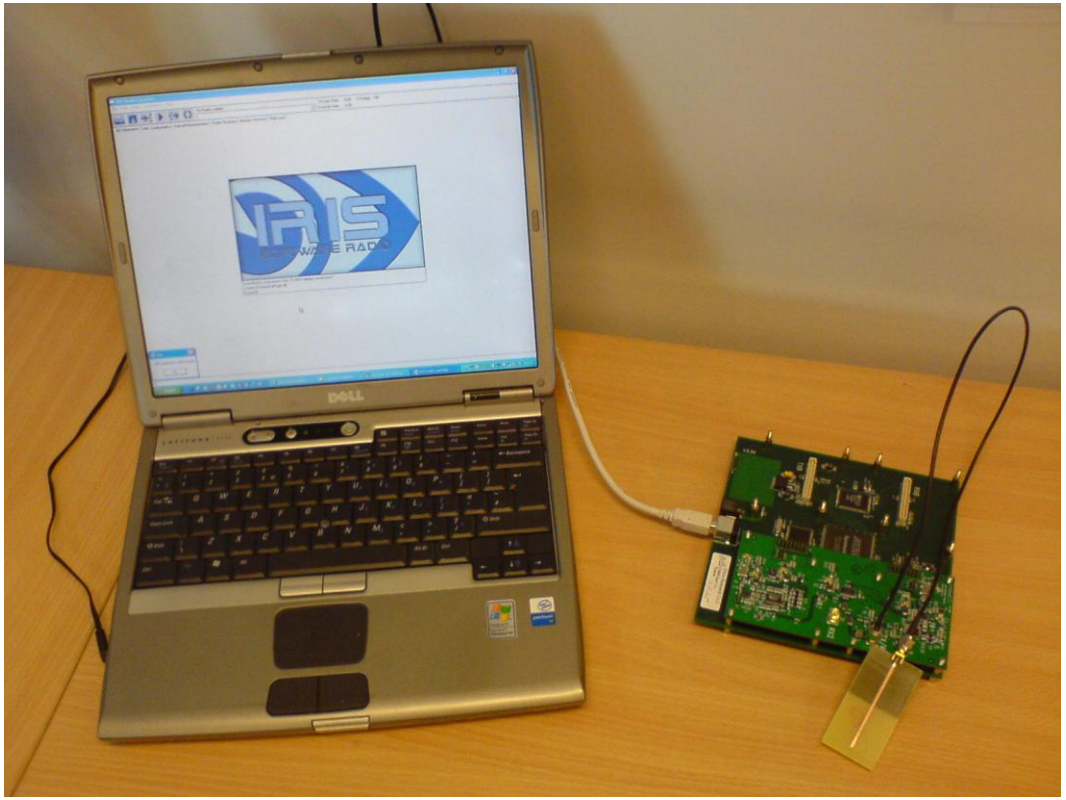
Experimentation @ CTVR

- Ettus Research LLC founded in 2004
  - USRP 1
    - USB 2.0 (8 MS/sec @ 16bit)
    - Altera cyclone FPGA
    - 64 MS/sec dual ADC
    - 128 MS/sec dual DAC
    - Baseband IQ
    - Motherboard
    - 2 Daughterboards



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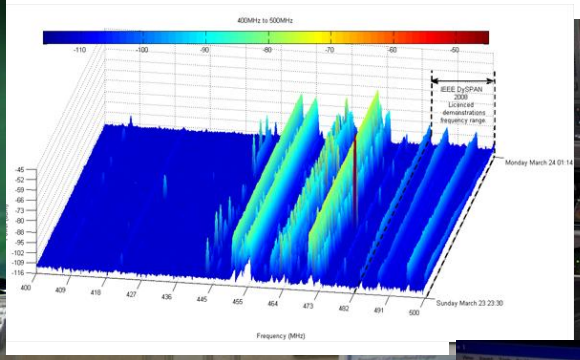
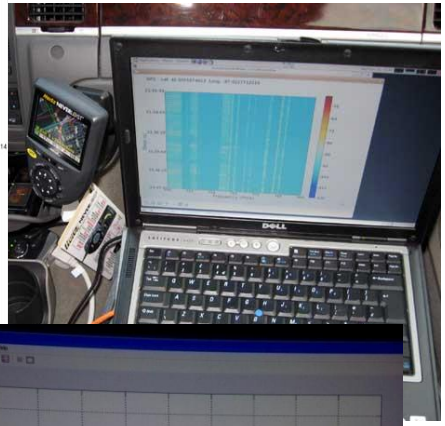
Experimentation @ CTVR

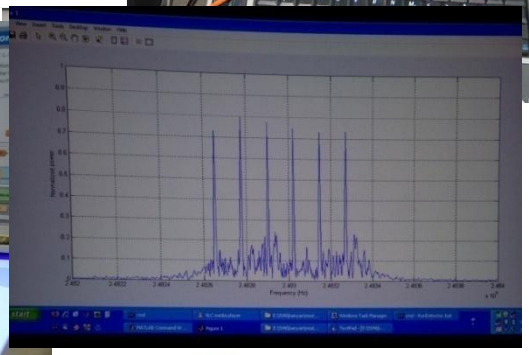
IEEE DySPAN 2007

SDR forum

DySPAN 2008
Dynamic Spectrum Access Networks







IEEE DySPAN 2012
Dynamic Spectrum Access Networks
OCTOBER 16-19, BELLEVUE, WASHINGTON, USA

IEEE DySPAN 2010
Dynamic Spectrum Access Networks

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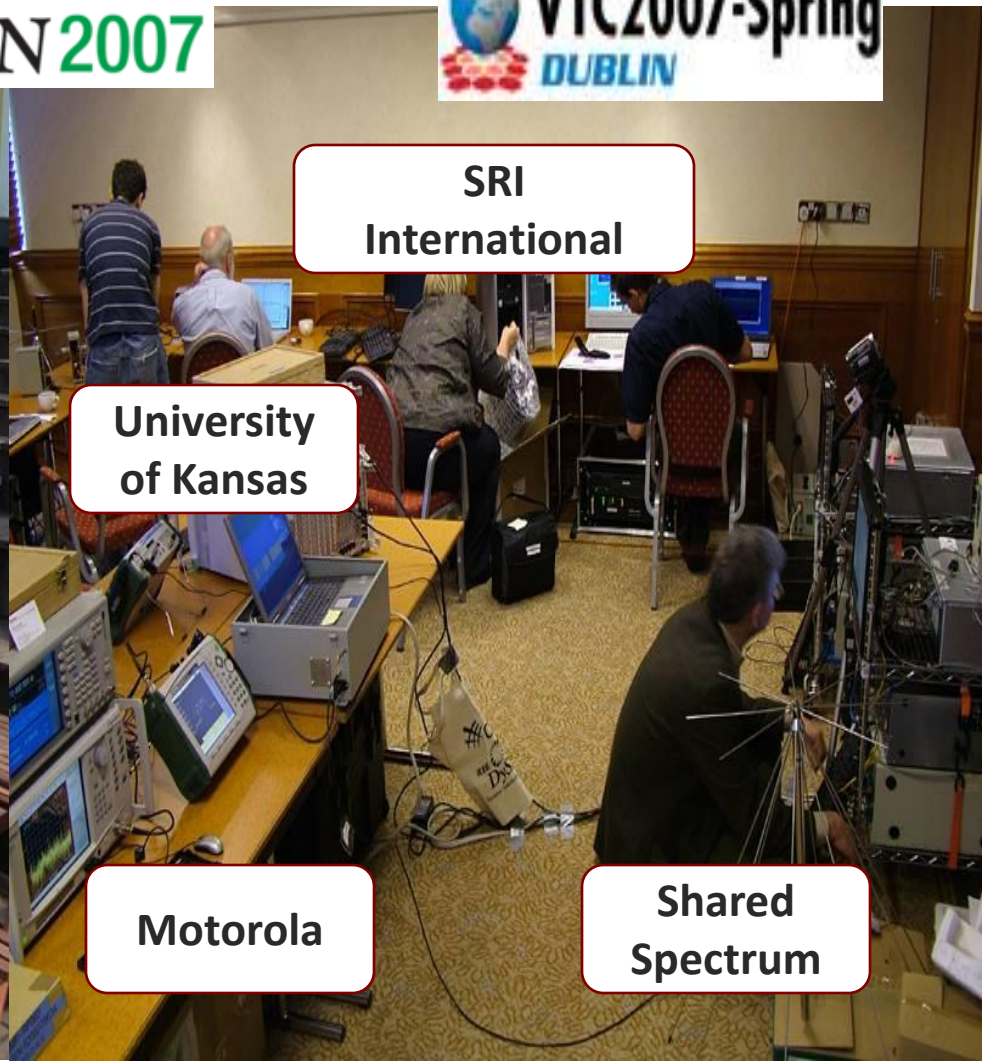
SDR forum

IEEE DySPAN 2007

VTC2007-Spring DUBLIN

DARPA XG node coexisting with Qinetiq

Qinetiq Radios from Cockpit



SRI International

University of Kansas

Motorola

Shared Spectrum

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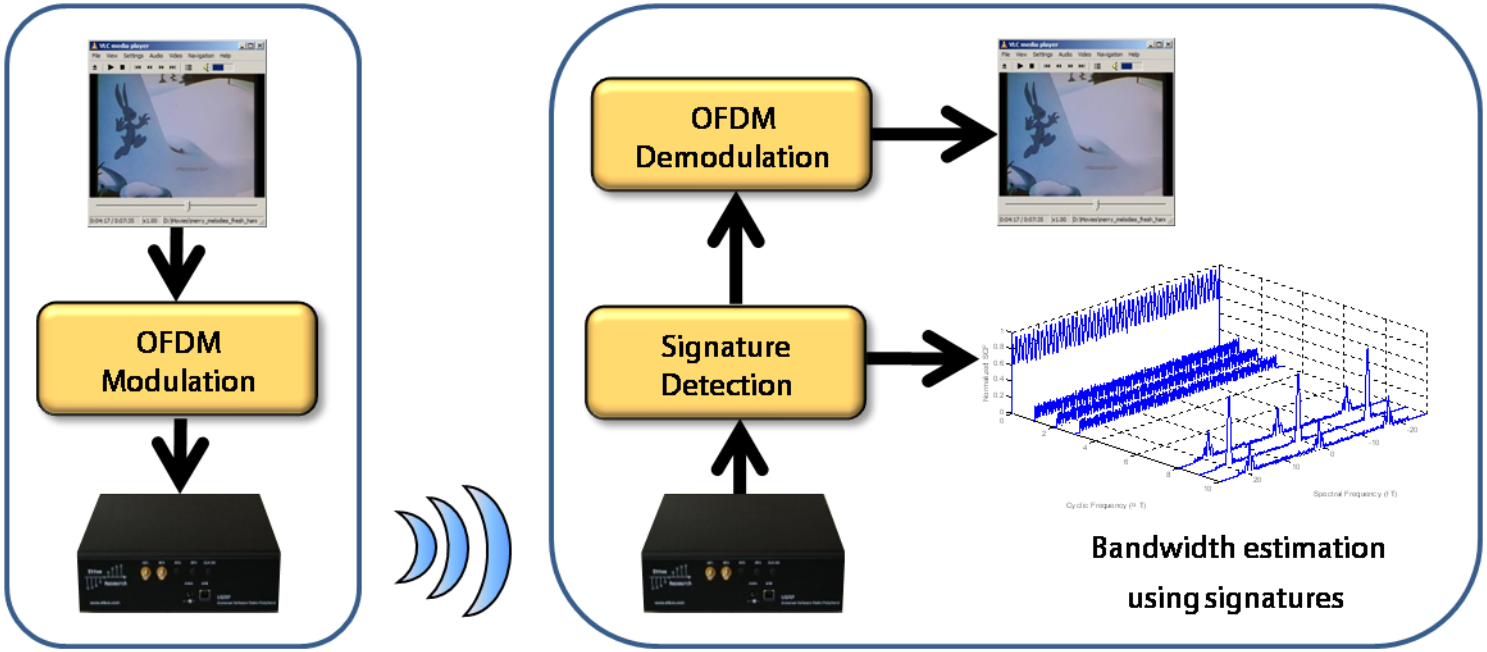
Experimentation @ CTVR

- Some of our demonstration systems:

Experimentation @ CTVR

- Some of our demonstration systems:
- **Bandwidth-Adaptive OFDM waveform**
  - Bandwidth adaptive waveform with embedded cyclostationary signatures
  - Receiver chain includes a low-complexity cyclostationary analyzer
  - Run-time reconfigurable OFDM modulation and demodulation



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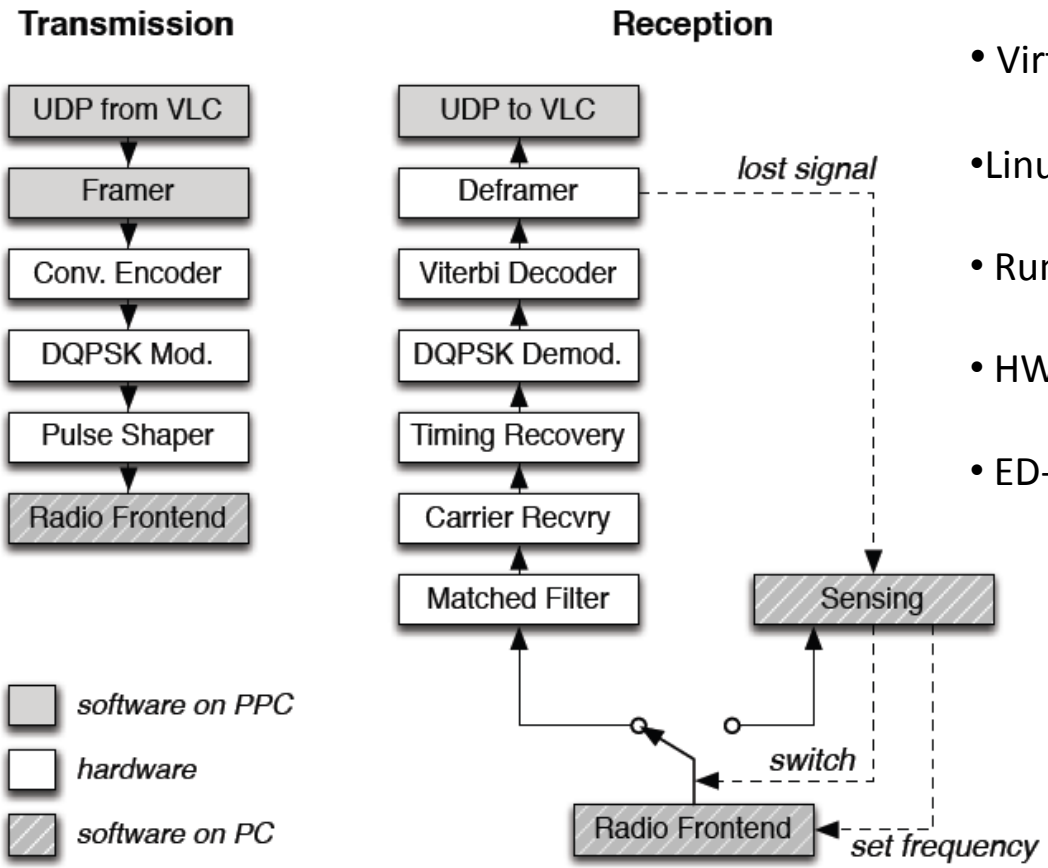
- **Frequency Rendezvous on FPGA**



- Virtex Pro II Dev Board
- Linux OS on embedded PPC
- Running Iris architecture
- HW components in the logic fabric
- ED-based sensing algorithm

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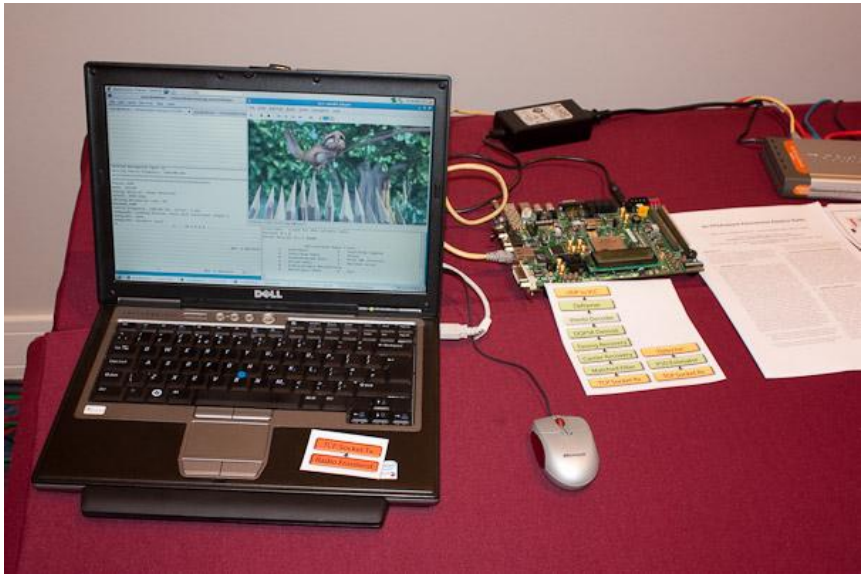

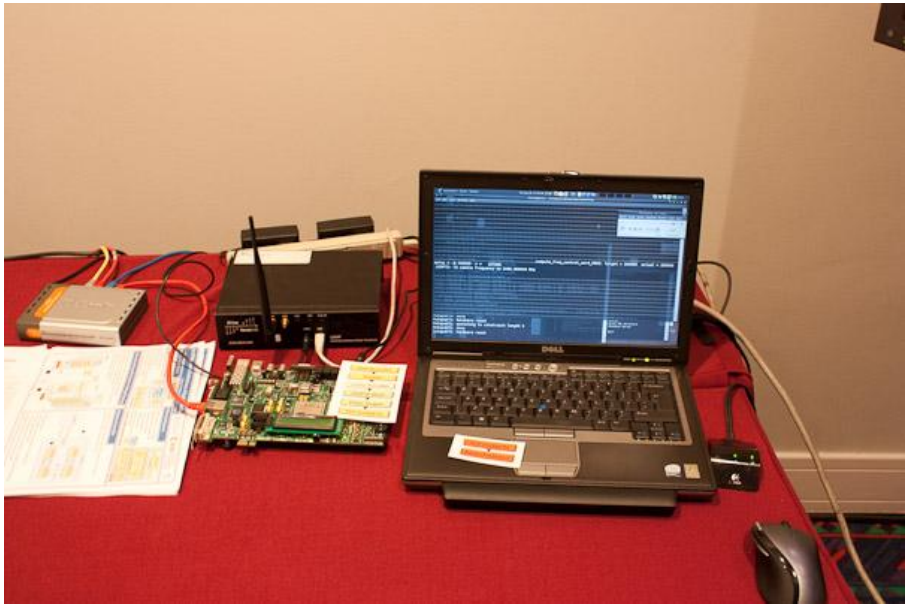

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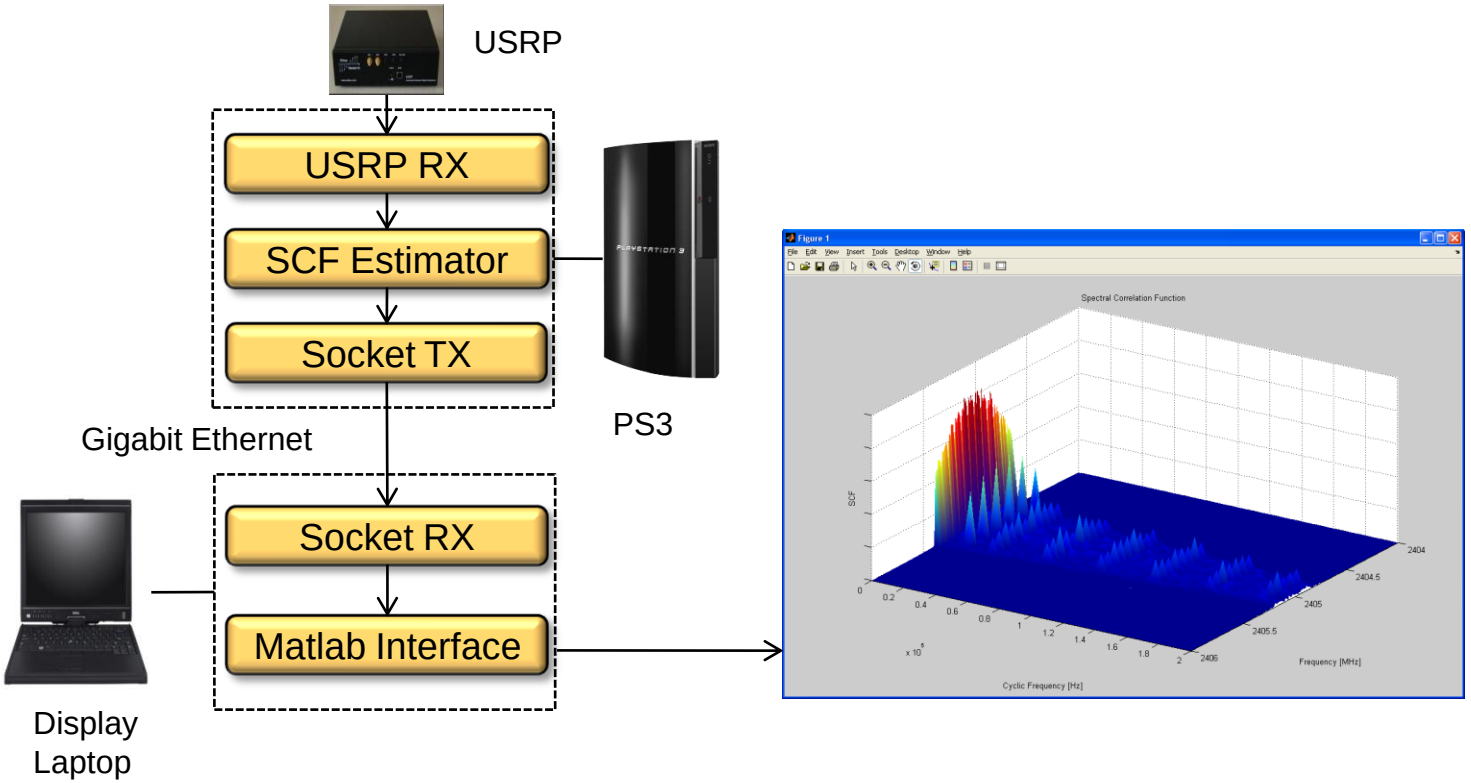
- **Cyclostationary Signal Analysis on Cell BE (Playstation 3)**



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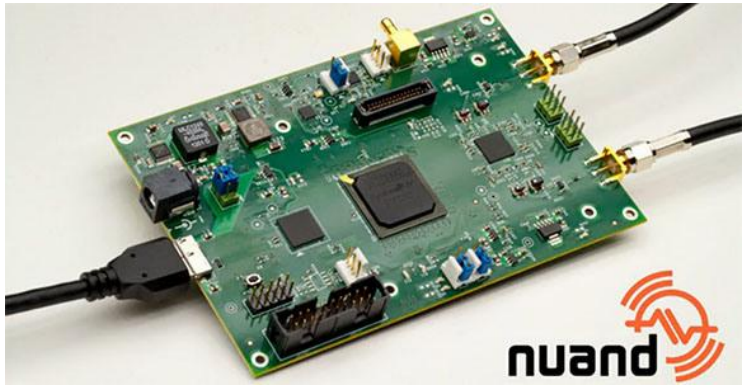

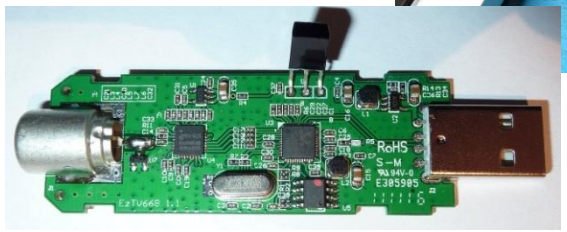

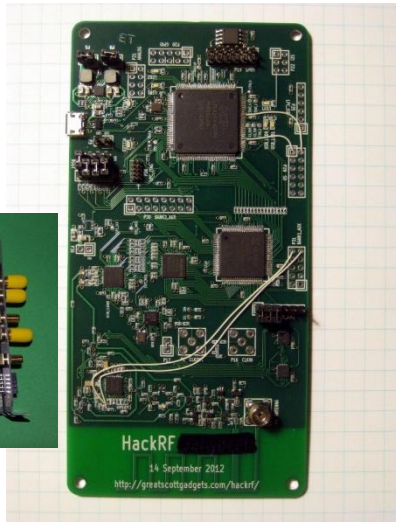

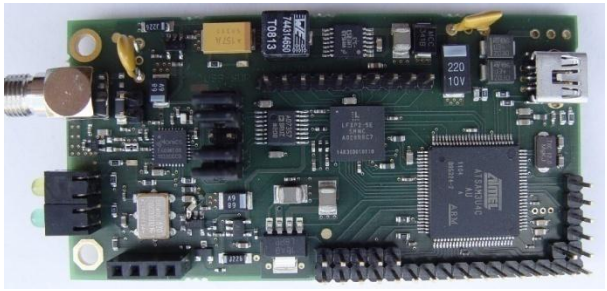

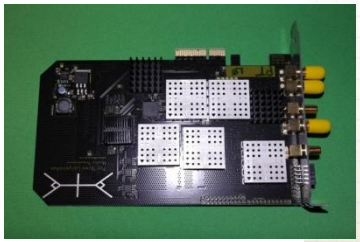

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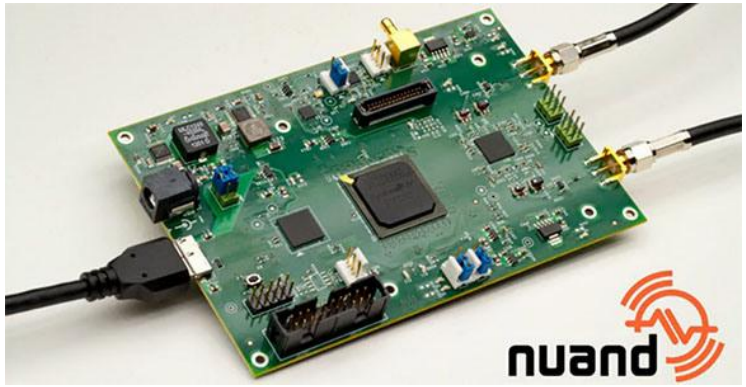

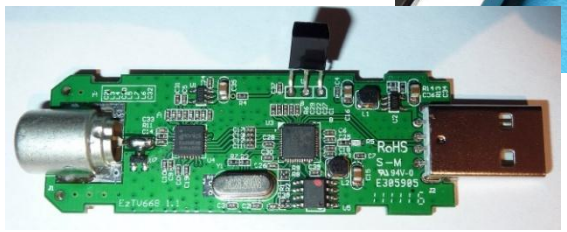

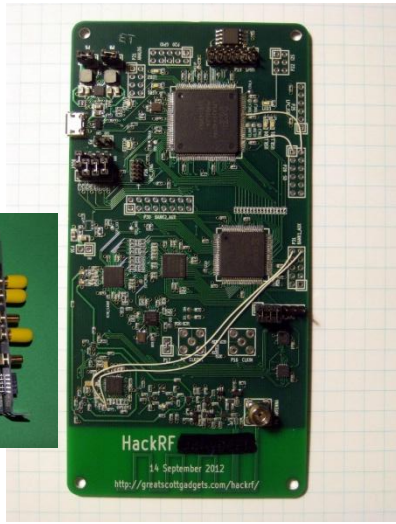

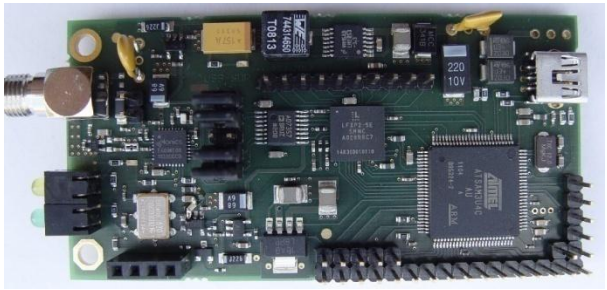

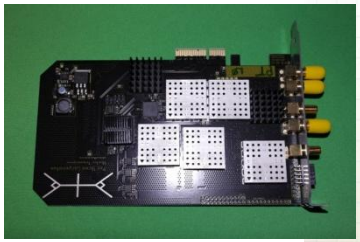

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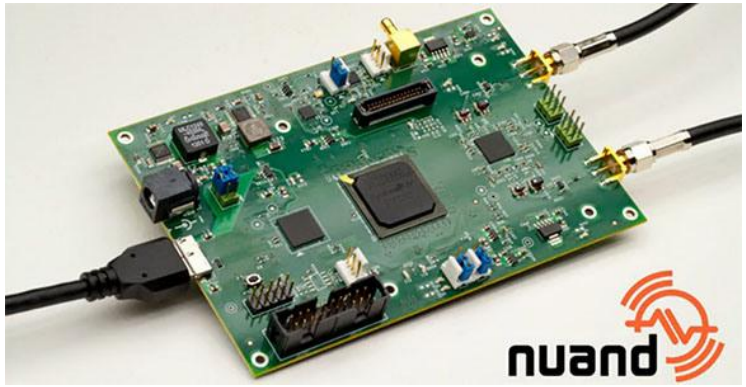

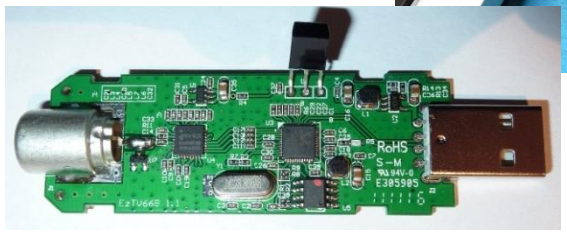

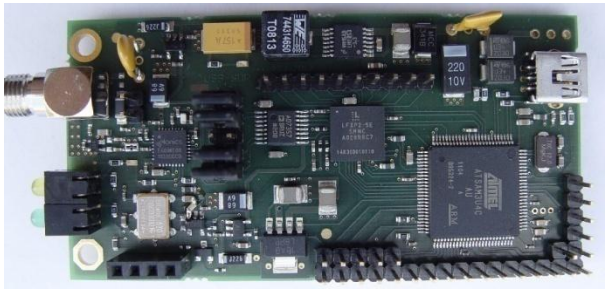

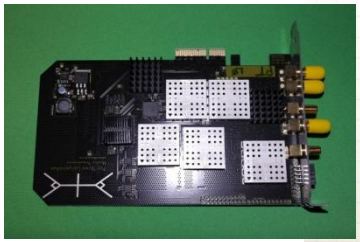

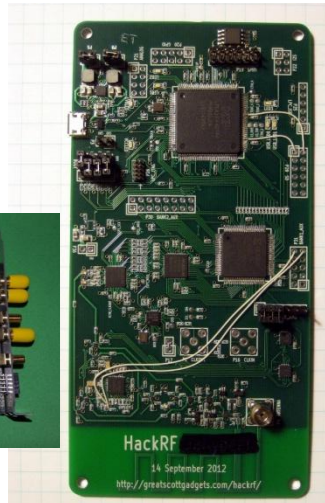

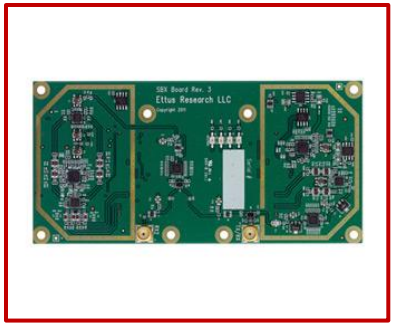

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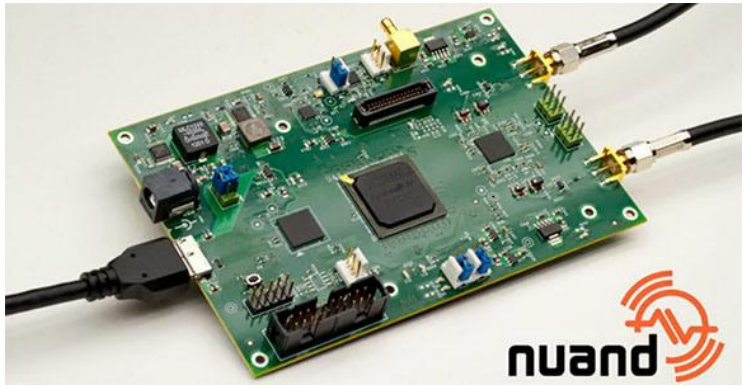

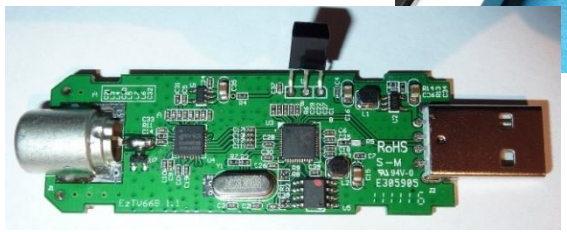

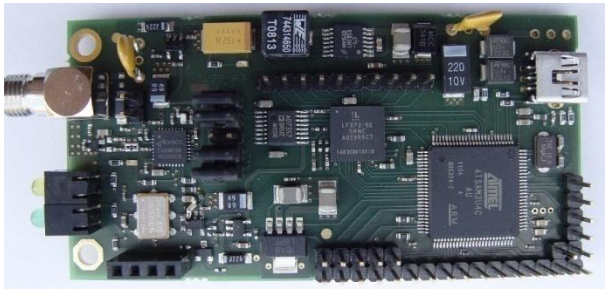

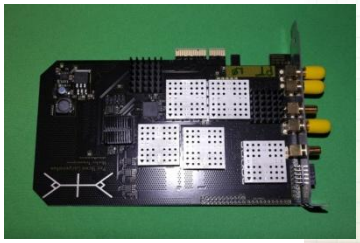

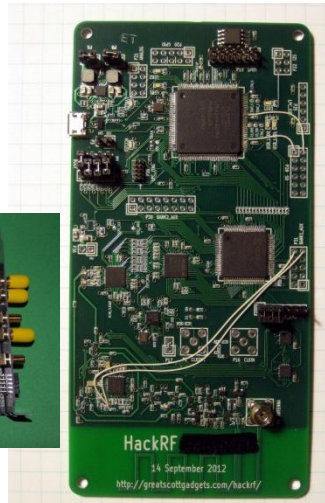

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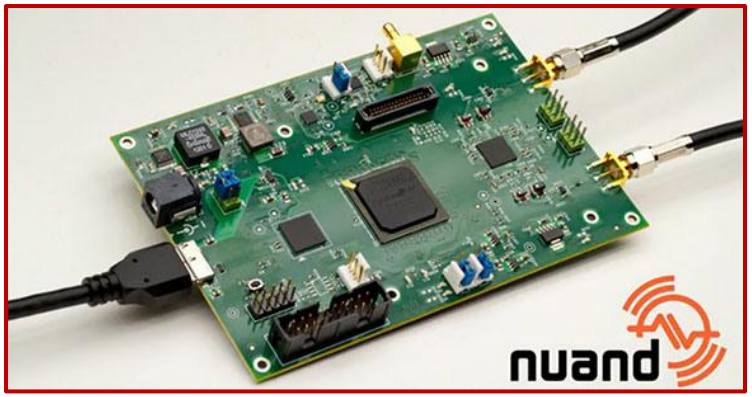

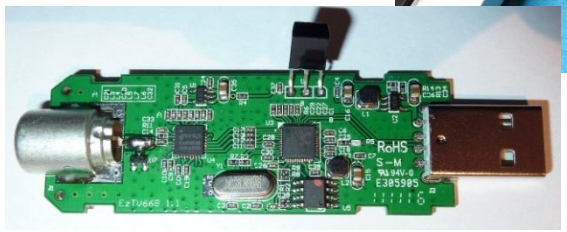

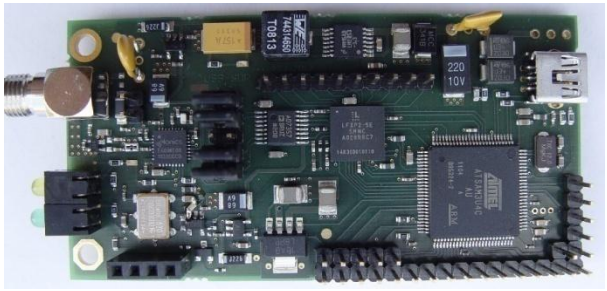

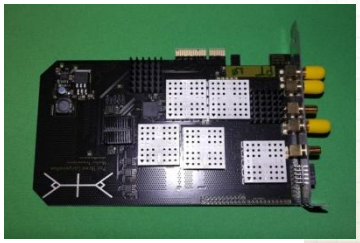

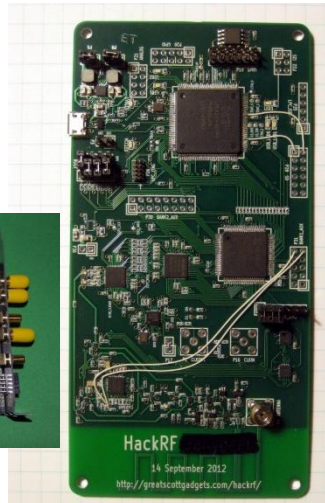

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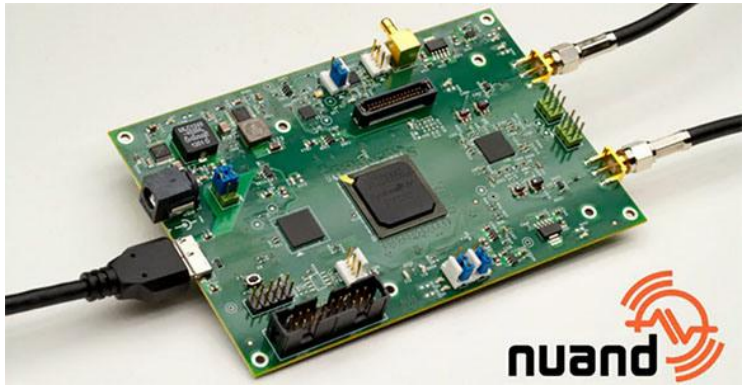

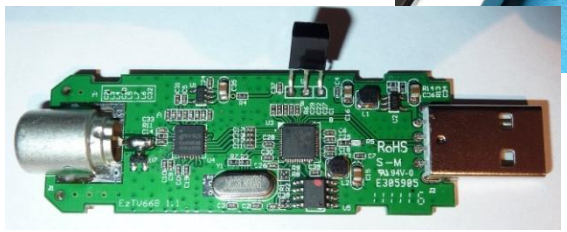

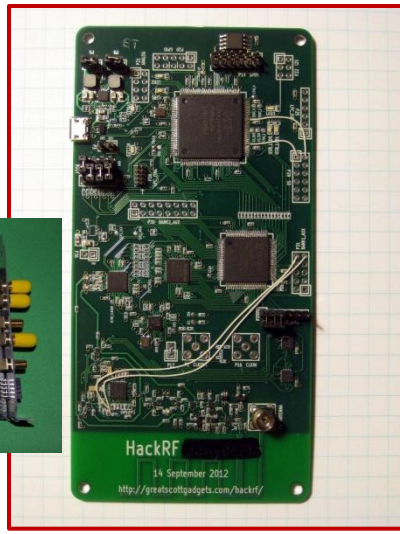

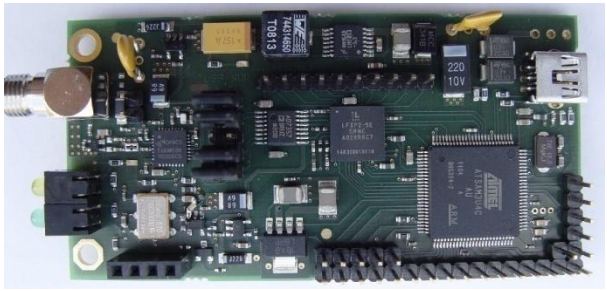

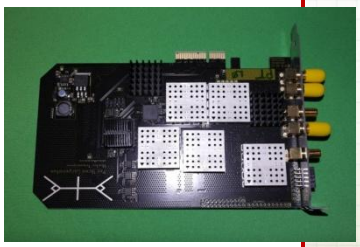

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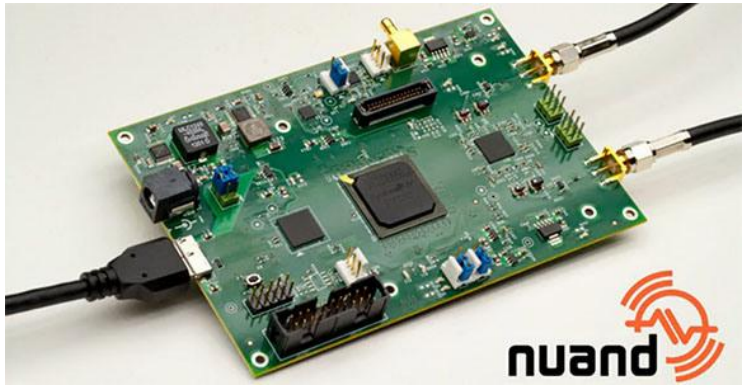

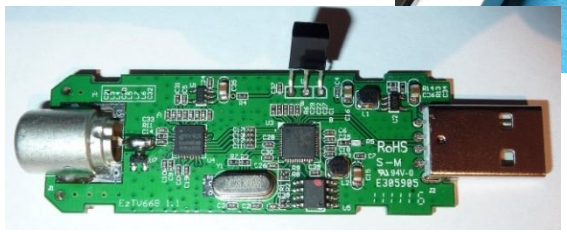

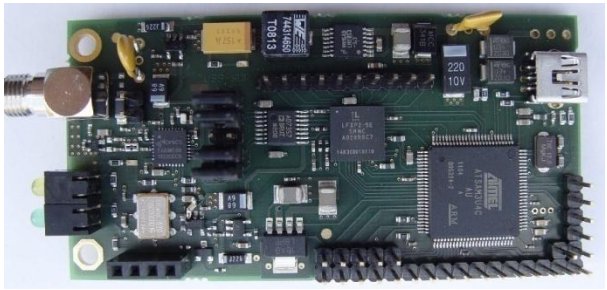

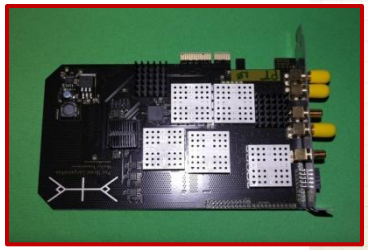

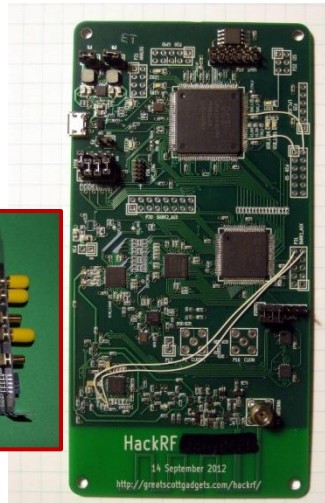

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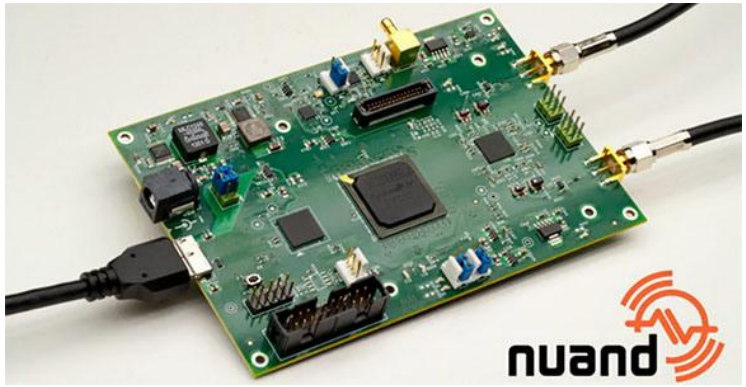

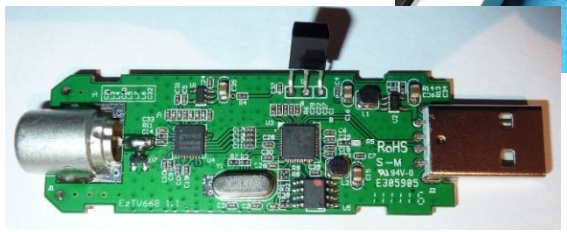

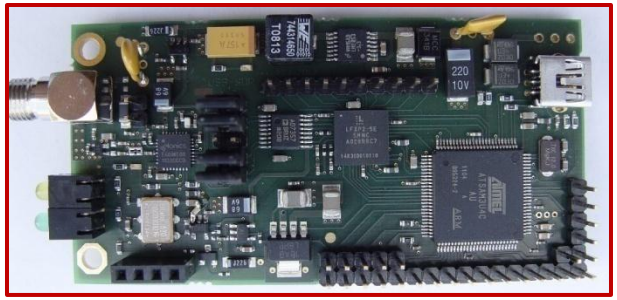

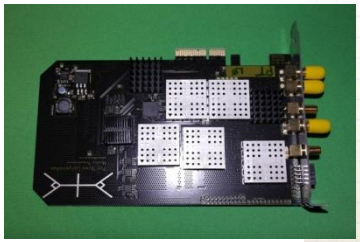

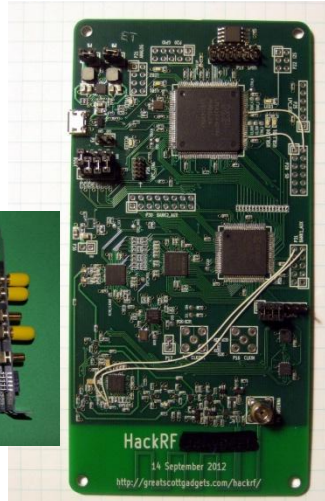

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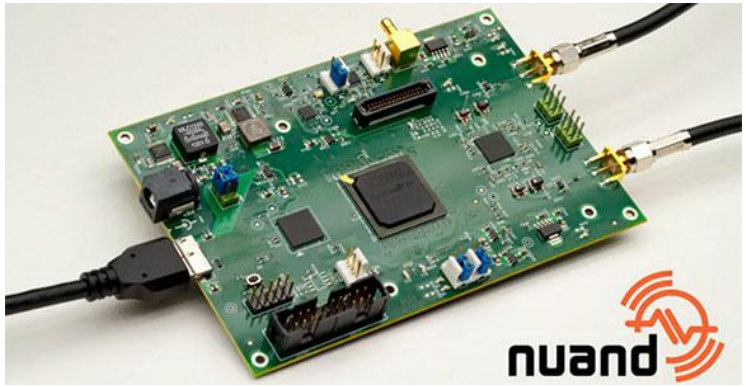

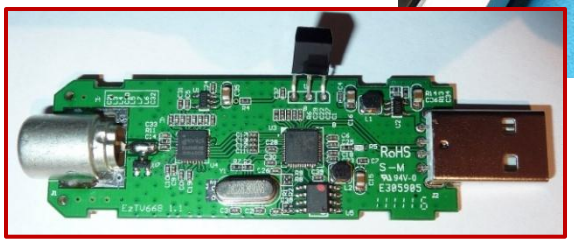

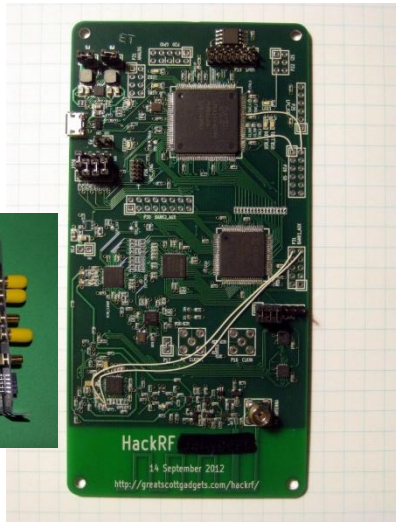

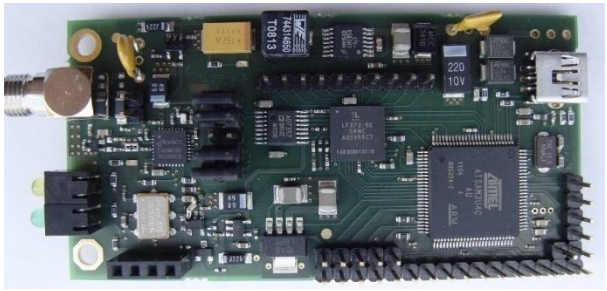

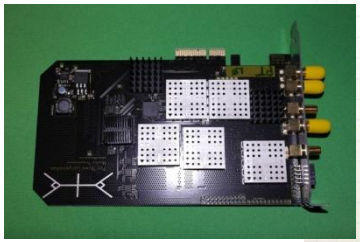

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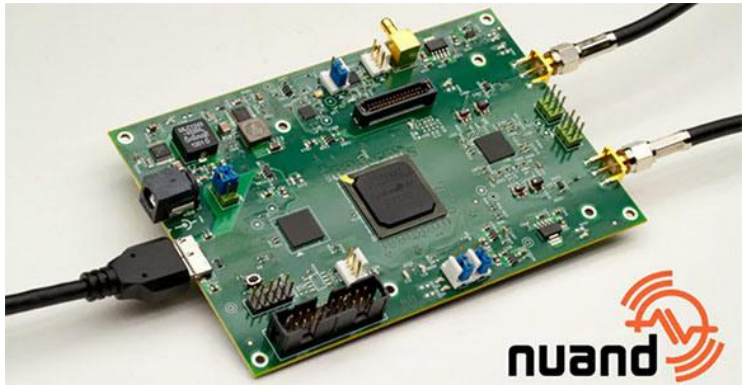
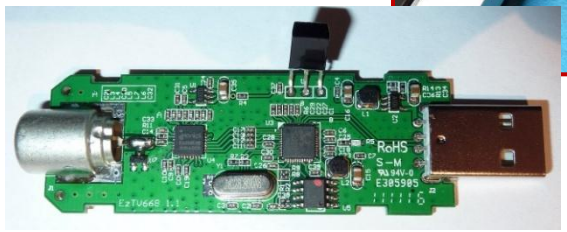
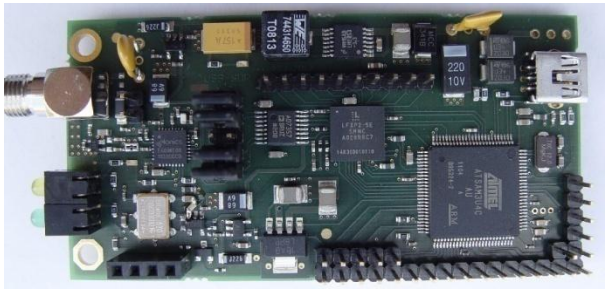
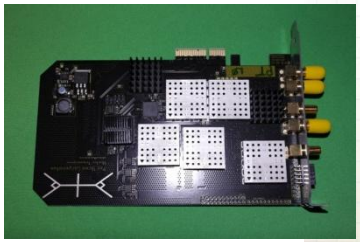
Experimentation @ CTVR

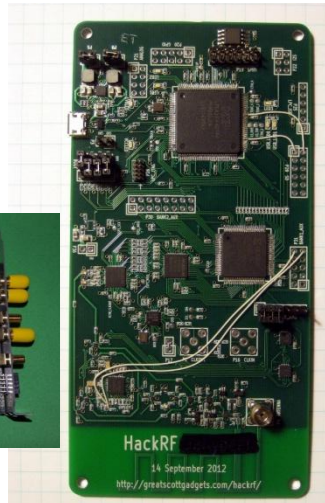
- Wide range of RF front-ends now available:











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Experimentation @ CTVR

- Highly-developed software radio applications

Experimentation @ CTVR

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Experimentation @ CTVR

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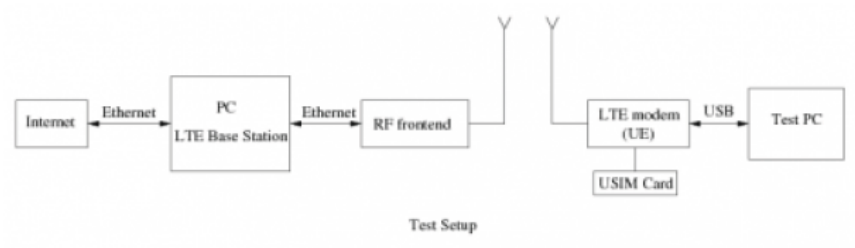
GNU Radio

French programmer builds his own LTE base station

September 3, 2012 By Jose Alvarez Leave a Comment



Test Setup

Many carriers around the world are rolling out Long Term Evolution (LTE) services, but French computer programmer Fabrice Bellard has decided to make his own, with details on how he made it. "It simulates an LTE infrastructure, so it can work without a real LTE network behind it. In short, it is possible to use it like a Wifi access point," Bellard said.

The CTVR Testbed

- What is CTVR?
- Software Radio Experimentation @ CTVR
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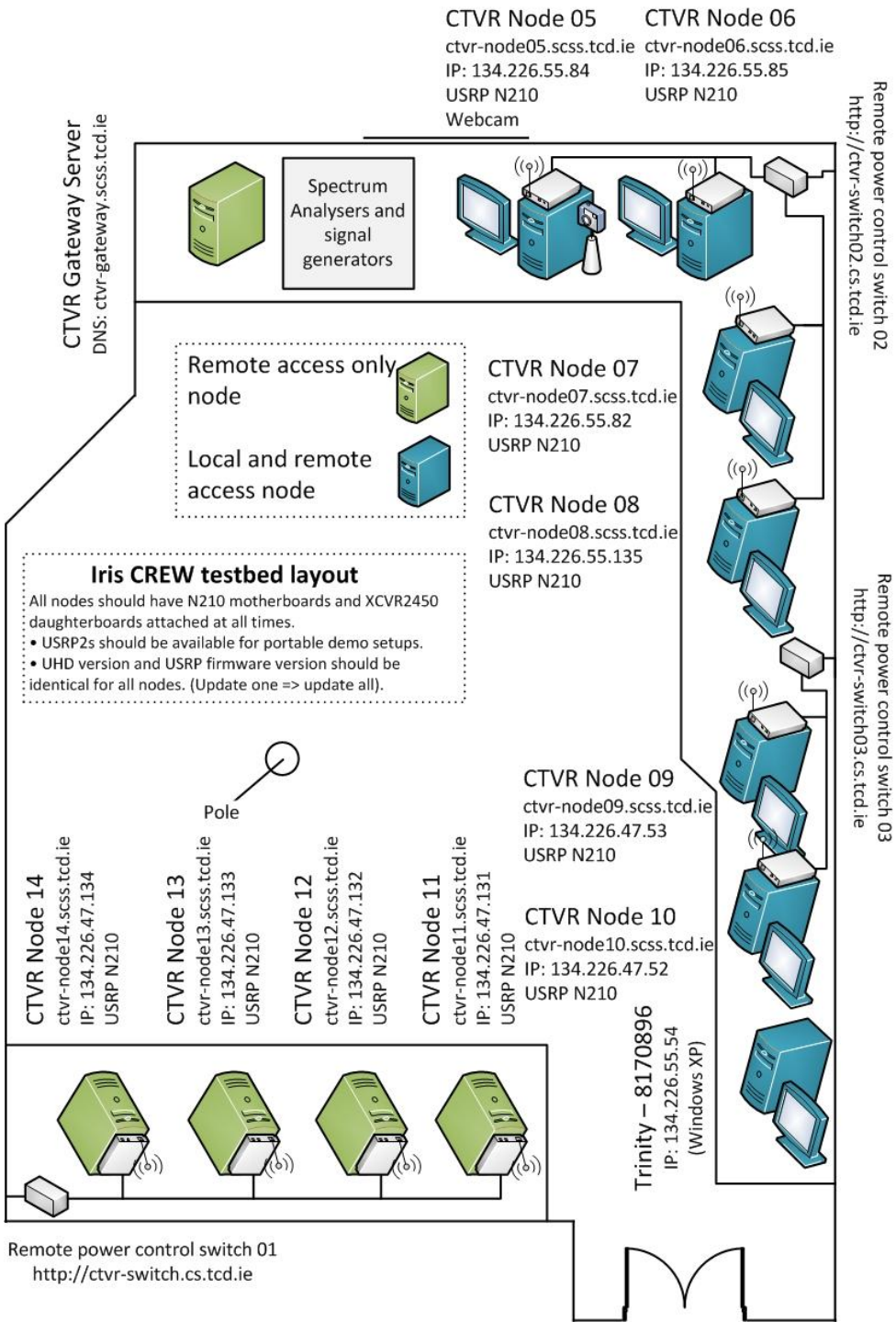
- Using the Testbed
- Ireland's Spectrum Playground
- Future Plans for the Testbed
- How to Get Access



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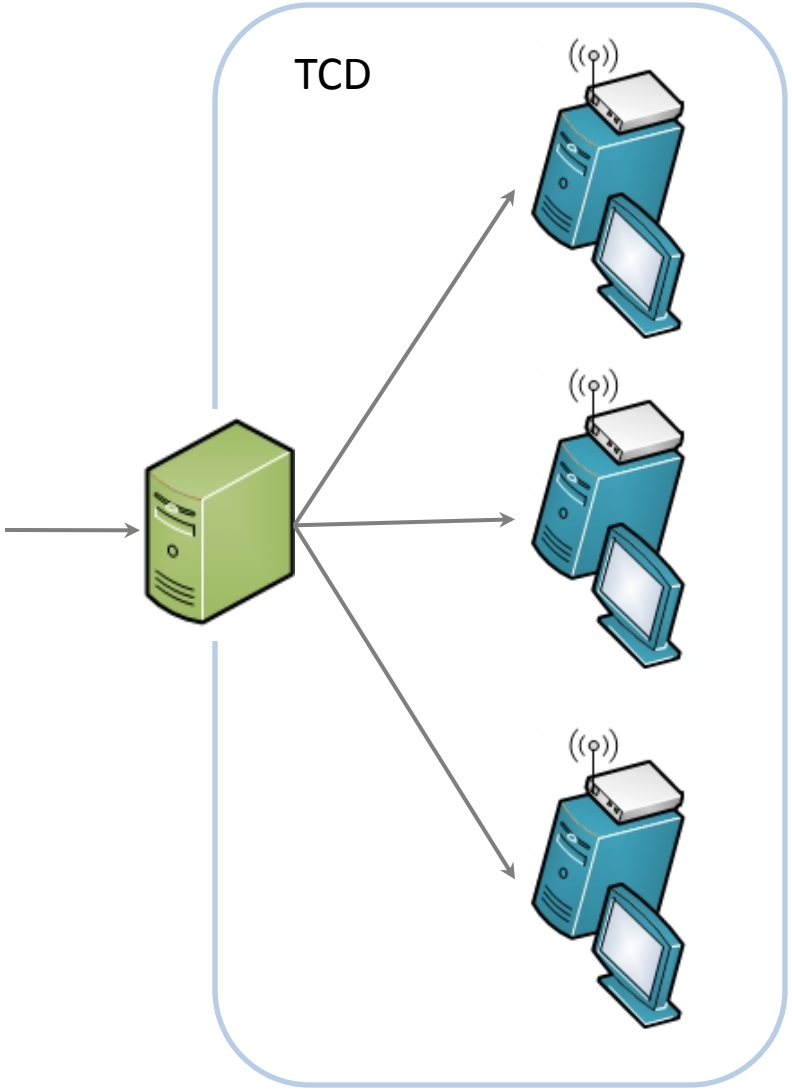
The CTVR Testbed

- Node Servers:
  - Dell tower servers (e.g. Poweredge T110 II)
  - Quad-core processors (e.g. Intel Xeon)
  - 3 x GigE interfaces
  - Ubuntu 12.04 LTS
  - Main partition = 30GB
    - Regularly re-imaged (automated boot option)
  - Large data partition (/data)
  - Common admin user
  - Not directly accessible outside TCD

The CTVR Testbed

- Gateway server
  - ctvr-gateway.scss.tcd.ie
  - Individual user accounts
  - External ssh access



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The CTVR Testbed

- RF Front Ends
  - USRP N210
    - GigE interface to PC
    - Dual 100 MS/s, 14-bit ADC
    - Dual 400 MS/s, 16-bit DAC
    - DDC/DUC with 25 mHz Resolution
    - Up to 50 MS/s Gigabit Ethernet Streaming (8bit resolution)
    - Spartan 3A-DSP 3400 FPGA
    - 2.5 ppm TCXO Frequency Reference

  - XCVR2450
    - 2.4-2.5 GHz, 4.9-5.9 GHz Tx/Rx
    - Half-duplex
    - Typical power output 100mW

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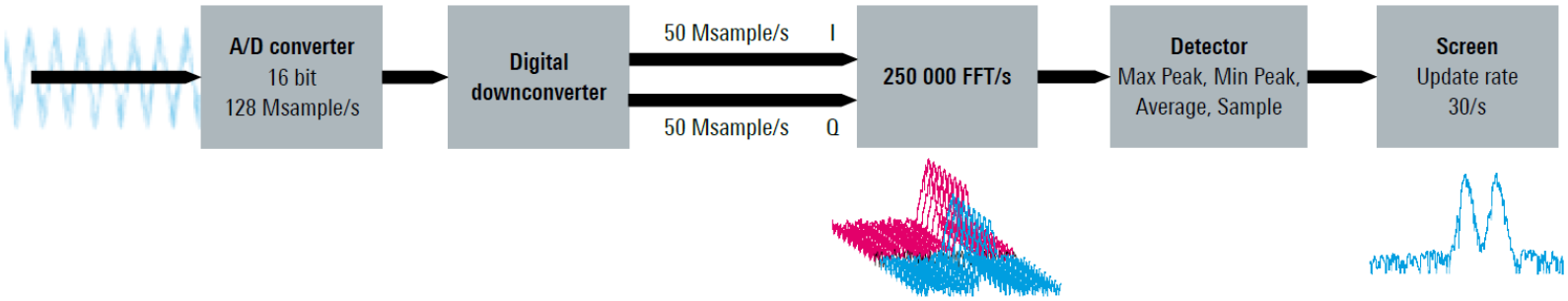
The CTVR Testbed

- Spectrum Analyzer

  - Rohde & Schwarz FSVR
  - Real-time spectrum analyzer
  - 10Hz – 7GHz
  - 40 MHz real-time analysis bandwidth
  - Real-time streaming of IQ capture data
  - Spectrogram, Frequency mask trigger, Persistence mode



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The CTVR Testbed

- Vector Signal Generator

  - Rohde & Schwarz SMU200A
  - 100KHz – 6GHz
  - Up to 200MHz RF bandwidth
  - Very short frequency setting times (< 3ms)
  - Arbitrary waveform generator (e.g. from Matlab – up to 64MSamples)
  - Fading simulator
  - Wide range of supported standards
    - Unlocked on as-needed basis

The CTVR Testbed

- Local Access

- Anritsu MS2721B Handheld spectrum analyzer
- Anristu MG3700A Vector signal generator
- 5 x Ettus Usrp 1
- 4 x Ettus Usrp 2
- 4 x Ettus Usrp E100
- 7 x RFX400
- 2 x TVRX
- 2 x RFX900
- 8 x RFX1800
- 8 x RFX2400
- 6 x WBX
- 5 x XCVR2450
- 5 x SBX

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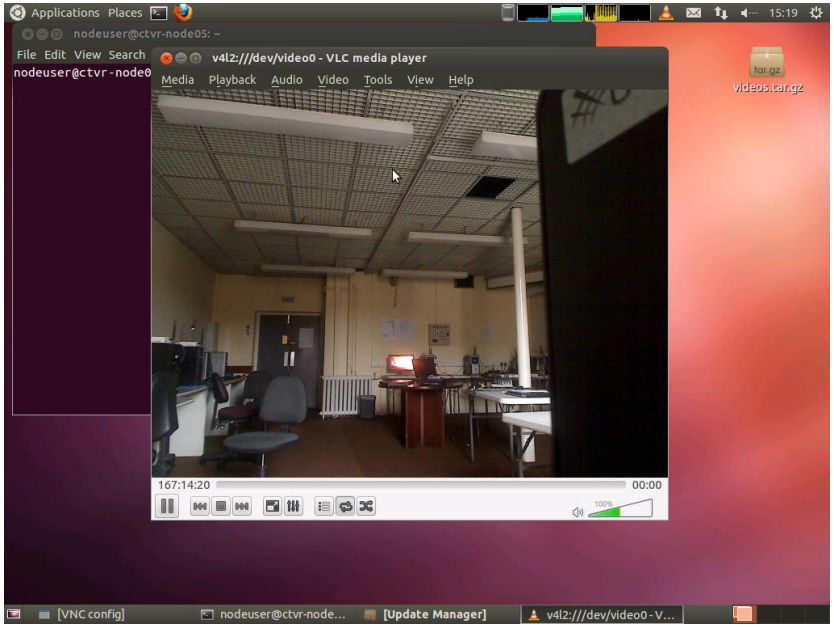
The CTVR Testbed

- Power Switches
  - Remote power on/off of RF front ends

- Webcam
  - Attached to ctvr-node05
  - /dev/video0



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Using the Testbed

- Booking the testbed
  - Google calendar (ctvr.testbed)
  - Booking includes name, resources, frequency bands etc.

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Using the Testbed

- Usage Guidelines
  - **Book testbed nodes before using them.**
    - Use the google calendar en.wireless.testbed and include your name, the nodes you will be using and the frequency ranges you will operate on. If you have trouble accessing the calendar, contact pdifranc@tcd.ie, suttonpd@tcd.ie or timforde@mee.tcd.ie.
  - **Use the nodeuser account.**
    - Don't create new user accounts on any of the testbed nodes.
  - **Leave nodes as you found them.**
    - They will be periodically reimaged but remove temporary files/directories used for experiments. If you need files to be preserved between experiments, you can create a folder on the /data partition but be sure to back them up elsewhere as this partition may also be reimaged from time to time.
  - **Report faulty/missing equipment.**
    - If any equipment is found to be faulty or missing, notify pdifranc@tcd.ie. Check the inventory (https://ntrg020.cs.tcd.ie/irisv2/wiki/TestbedInventory) to see if it has already been reported.
  - If there is any problem with the testbed or you have any trouble using it, use the testbedusers mailing list (iris-testbed-users@scss.tcd.ie) or contact pdifranc@tcd.ie. Subscribe to the testbed-users mailing list at https://lists.scss.tcd.ie/mailman/listinfo/iris-testbed-users.

Using the Testbed

- Universal Hardware Driver (UHD)
  - Driver used to interact with USRP hardware.
    - Driver version must match USRP firmware version
  - Need to setup GigE interface
    - Bring up interface
      - `ifconfig eth1 up`
    - Set static IP
      - `ifconfig $1 192.168.10.1 netmask 255.255.255.0`
    - Set route
      - `route add -net 192.168.10.0 netmask 255.255.255.0 gw 192.168.10.2 dev eth1`
  - Use the wiki pages, manual etc
    - http://ettus-apps.sourcerepo.com/redmine/ettus/projects/uhd/wiki

Using the Testbed

- Demo1 - Accessing a testbed node
  - Check calendar
  - Set up SSH tunnel for VNC
  - Start VNC server
  - VNC to Node05
  - Webcam
  - Turn on USRP
  - Setup networking
  - uhd_find
  - uhd_usrp_probe
  - Run a transmitter

Using the Testbed

- Demo 2 - Accessing the spectrum analyser
  - VNC to the analyser from Node05
  - Show the transmitting waveform
  - Show persistence mode, spectrogram, etc
  - Change frequency, span etc.

Using the Testbed

- Demo 3 - Using the spectrum analyser to capture IQ data
  - RDP to XP machine
  - Run IQWizard to capture data
  - Look at data in Matlab

Using the Testbed

- Demo 4 - Running a receiver
  - Set up tunnel to Node06
  - VNC to Node06
  - Turn on USRP
  - Set up networking
  - Check USRP connectivity
  - Run receiver

Using the Testbed

- Demo 5 - Finishing up cleanly
  - Turning off usrps
  - Delete temporary files
  - Logging out
  - Closing tunnels

Ireland's Spectrum Playground

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Ireland's Spectrum Playground

www.testandtrial.ie

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Future Plans for the Testbed

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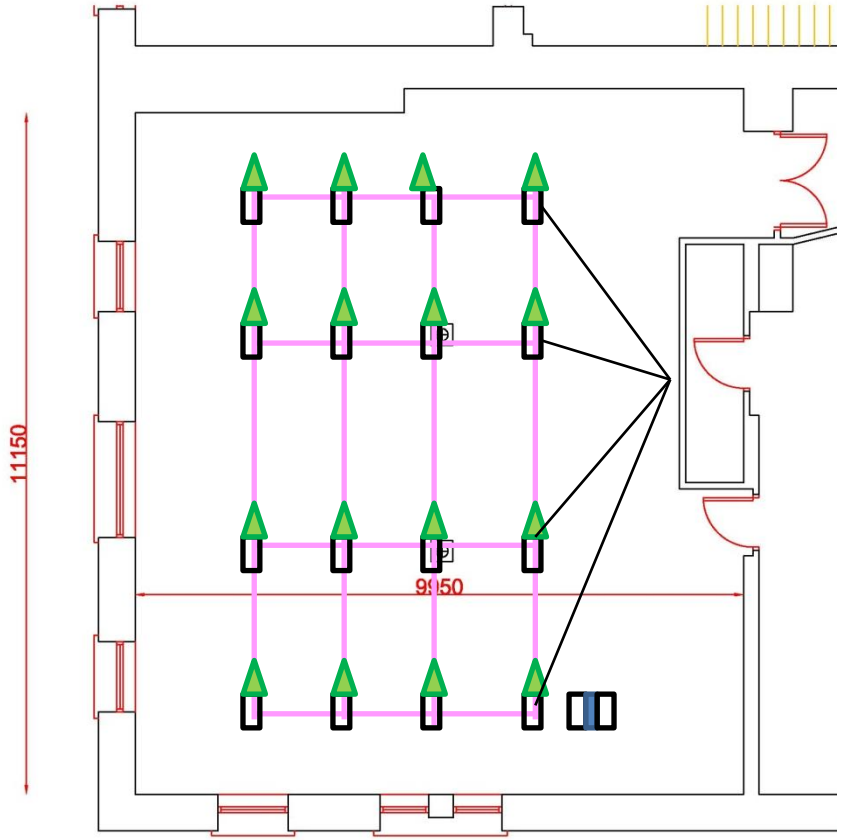
Future Plans for the Testbed

- Testbed Redevelopment
  - Up to 32 nodes
  - 10m x 10m room
  - 16 fixed ceiling-mounted Usrps
  - 16 bench-mounted Usrps
  - Centralized server room
  - Rack-mount servers
    - Direct ethernet link to usrp



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How to Get Access

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How to Get Access

Justin Tallon tallonj@tcd.ie

Danny Finn finnda@tcd.ie

https://ntrg020.cs.tcd.ie/testbed