IP CREW

Cognitive Radio Experimentation World

USRP usage in w-iLab.t testbed

Wei Liu
lwei@intec.ugent.be 2013/02/20

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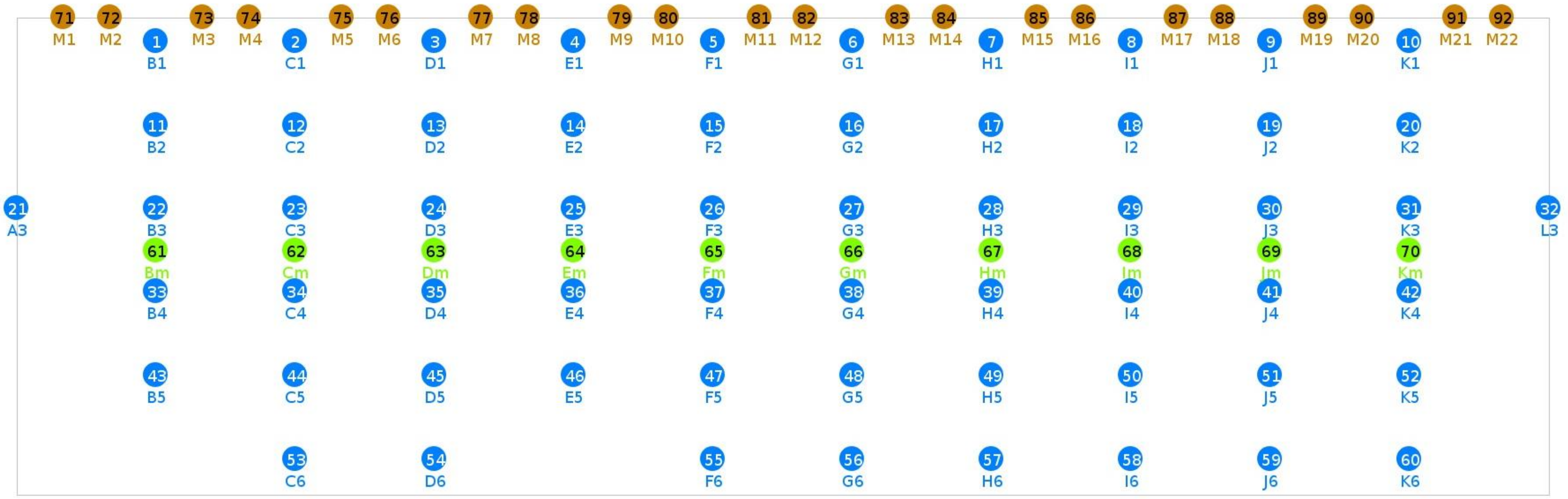
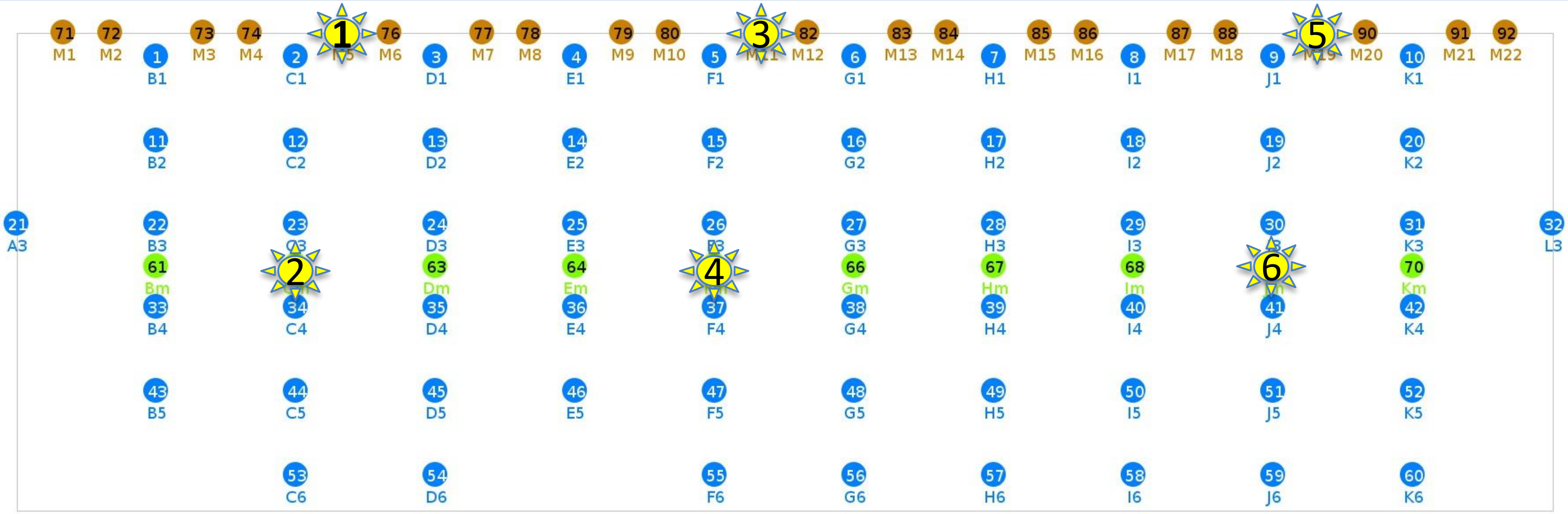
Outline

- **The cognitive components of w-iLab.t**
  - USRP N210
  - imec sensing engines
- **How to use USRP with GNURadio on w-iLab.t**
- **How to use USRP with OMF and Iris on w-iLab.t**

The cognitive components of w-iLab.t



The cognitive components of w-iLab.t



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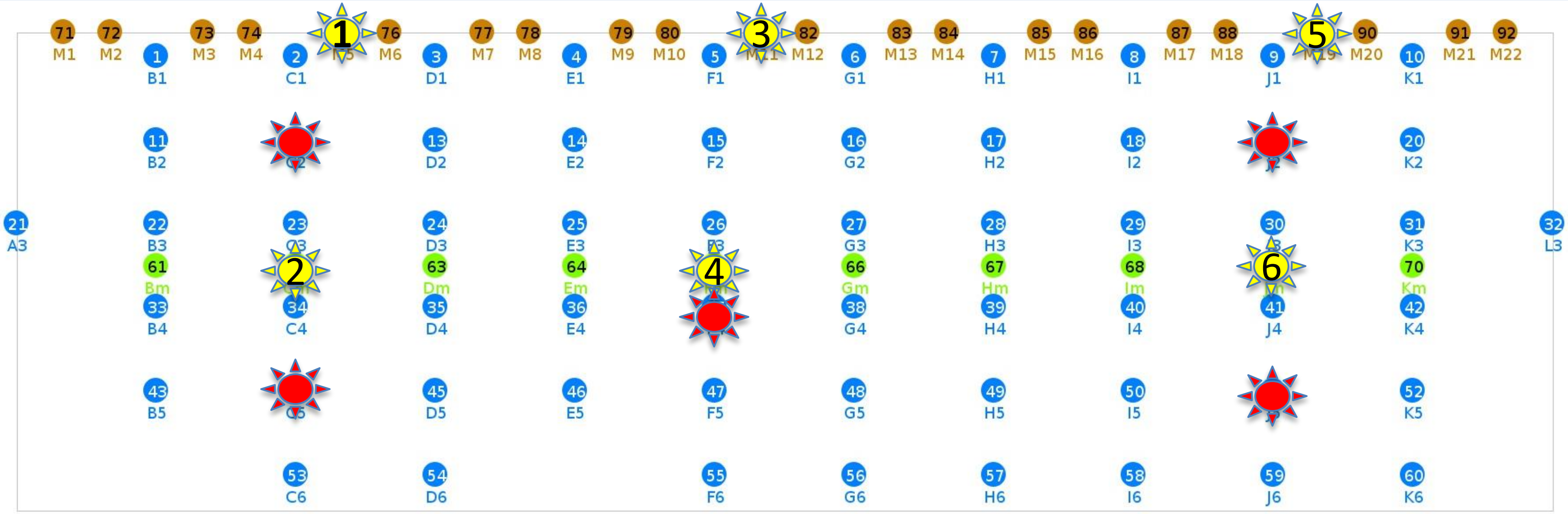
USRP N210

The cognitive components of w-iLab.t



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USRP N210

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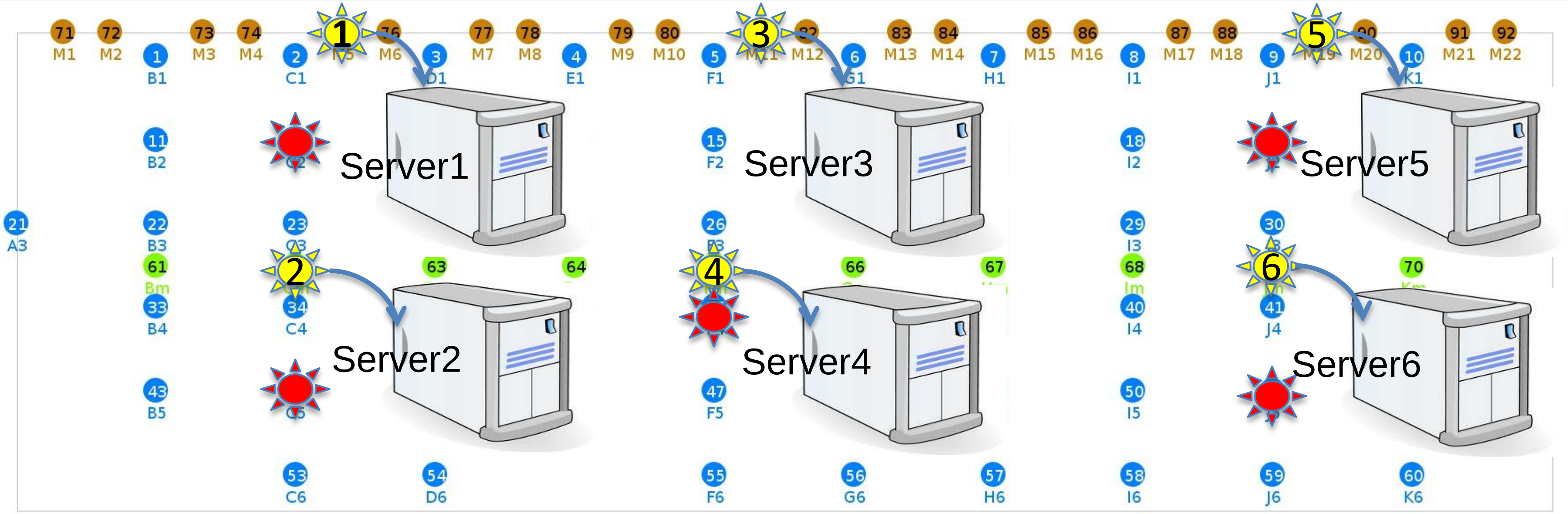
imec sensing engine

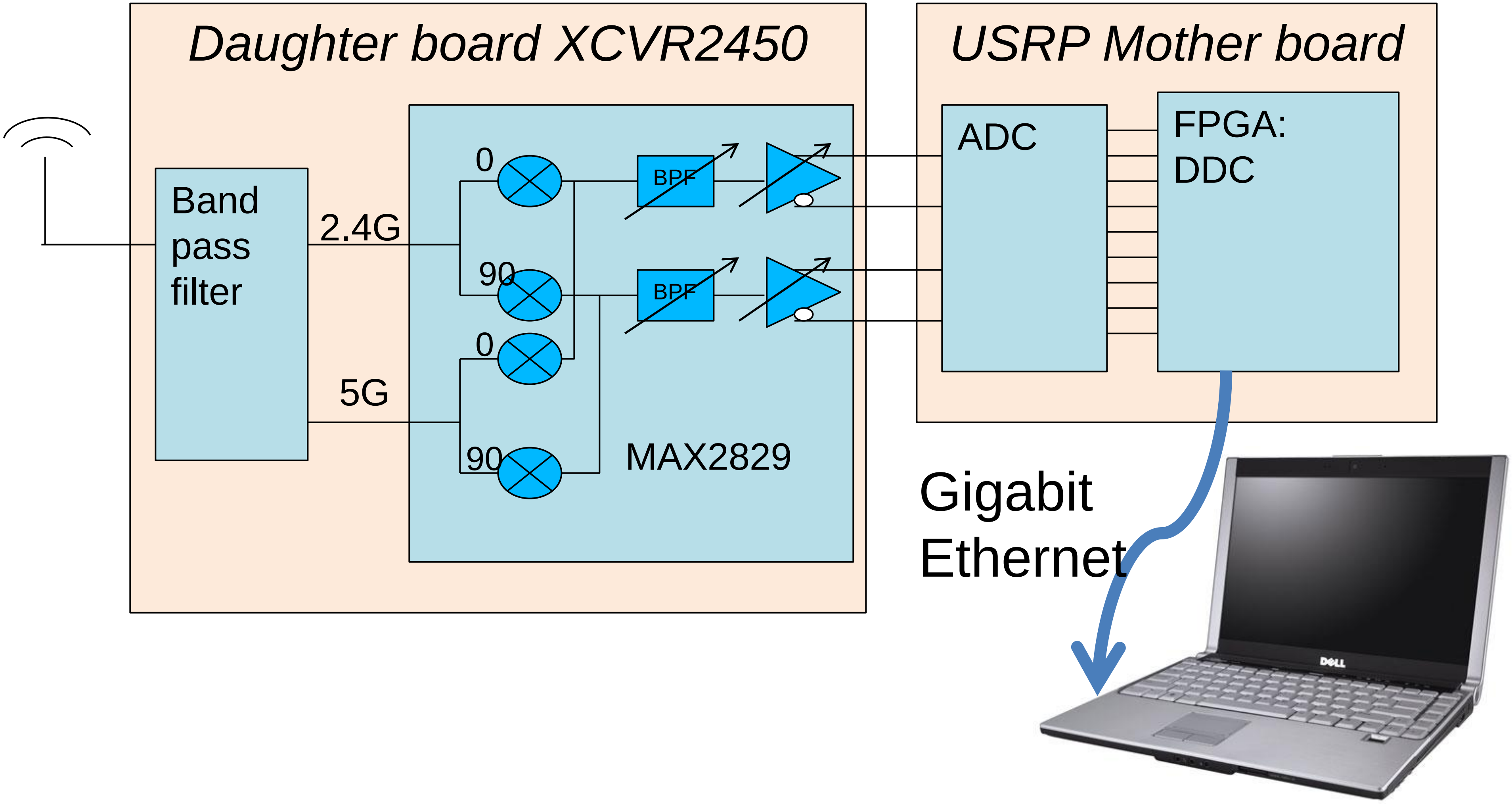
The cognitive components of w-iLab.t



USRP N210

imec sensing engine

USRP block diagram

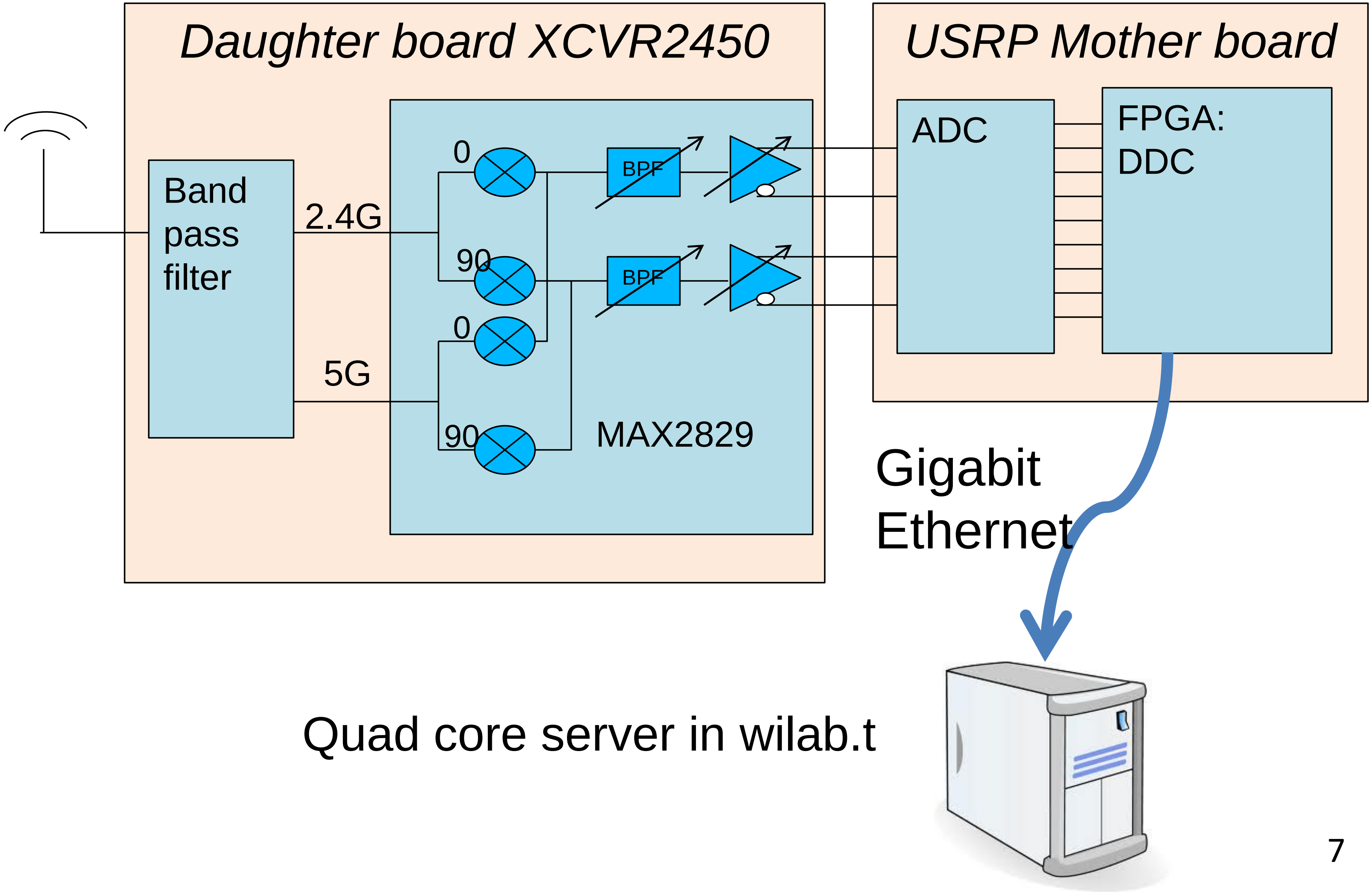


Daughter board XCVR2450

USRP Mother board

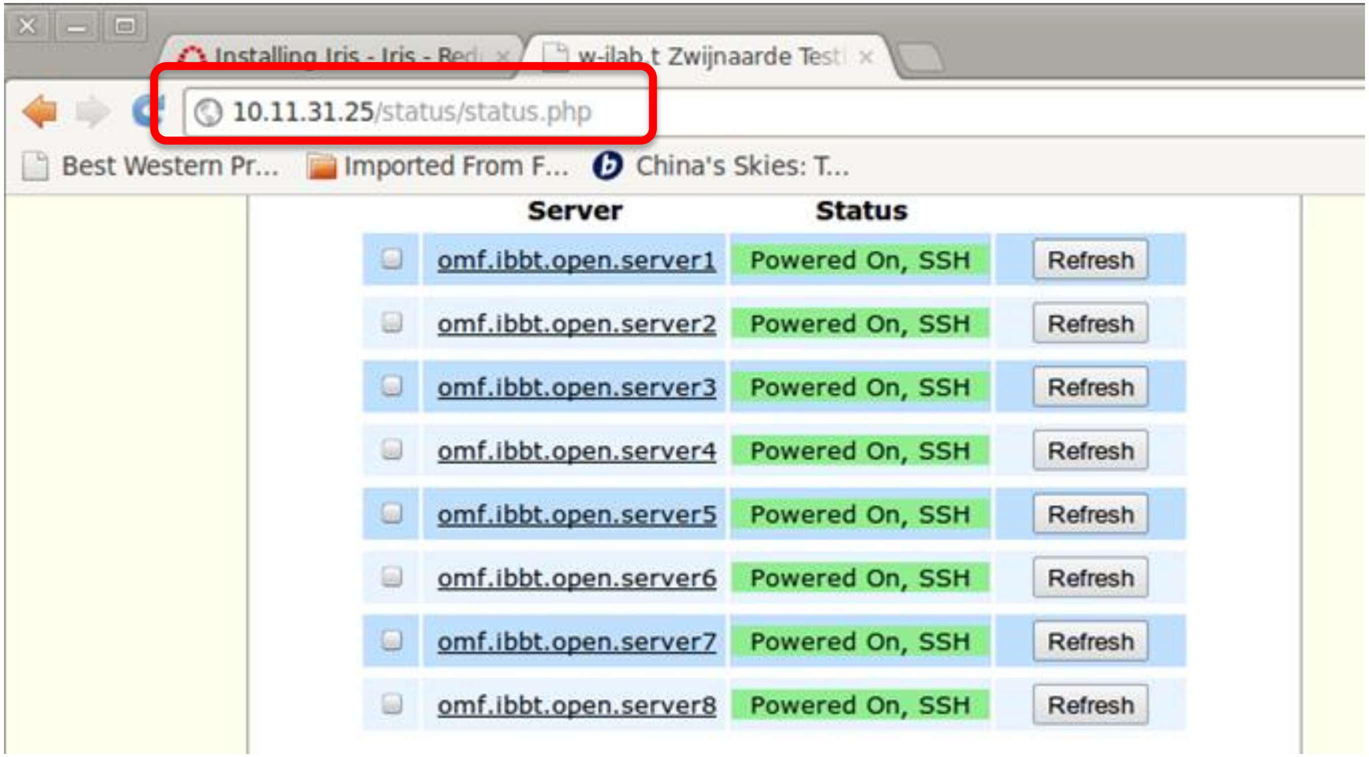
Gigabit Ethernet

USRP block diagram



Quad core server in wilab.t

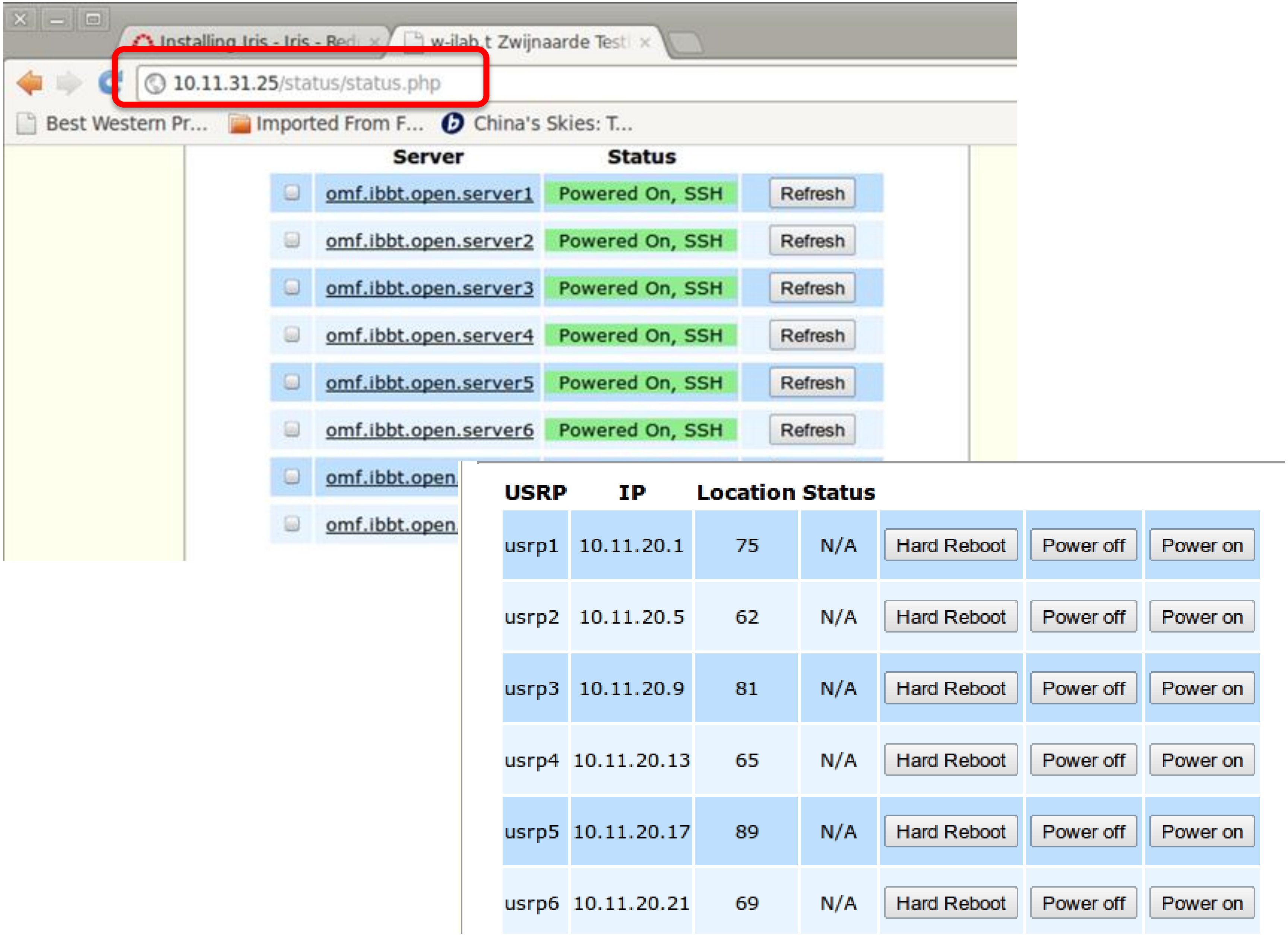
Access to USRP in w-iLab.t



10.11.31.25/status/status.php

	Server	Status	
□	omf.ibbt.open.server1	Powered On, SSH	Refresh
□	omf.ibbt.open.server2	Powered On, SSH	Refresh
□	omf.ibbt.open.server3	Powered On, SSH	Refresh
□	omf.ibbt.open.server4	Powered On, SSH	Refresh
□	omf.ibbt.open.server5	Powered On, SSH	Refresh
□	omf.ibbt.open.server6	Powered On, SSH	Refresh
□	omf.ibbt.open.server7	Powered On, SSH	Refresh
□	omf.ibbt.open.server8	Powered On, SSH	Refresh

Access to USRP in w-iLab.t



Installing Iris - Iris - Red
w-ilab.t Zwijnaarde Testb
10.11.31.25/status/status.php
Best Western Pr...
Imported From F...
China's Skies: T...

	Server	Status	
□	omf.ibbt.open.server1	Powered On, SSH	Refresh
□	omf.ibbt.open.server2	Powered On, SSH	Refresh
□	omf.ibbt.open.server3	Powered On, SSH	Refresh
□	omf.ibbt.open.server4	Powered On, SSH	Refresh
□	omf.ibbt.open.server5	Powered On, SSH	Refresh
□	omf.ibbt.open.server6	Powered On, SSH	Refresh
□	omf.ibbt.open		
□	omf.ibbt.open		

USRP	IP	Location	Status			
usrp1	10.11.20.1	75	N/A	Hard Reboot	Power off	Power on
usrp2	10.11.20.5	62	N/A	Hard Reboot	Power off	Power on
usrp3	10.11.20.9	81	N/A	Hard Reboot	Power off	Power on
usrp4	10.11.20.13	65	N/A	Hard Reboot	Power off	Power on
usrp5	10.11.20.17	89	N/A	Hard Reboot	Power off	Power on
usrp6	10.11.20.21	69	N/A	Hard Reboot	Power off	Power on

SDR platforms

- **GNU Radio is a free & open-source software development toolkit that provides signal processing blocks to implement software radios.**
  - GNU Radio Companion (GRC) is a graphical tool for creating signal flow graphs and generating flow-graph source code
- **Iris is a software radio architecture that has been developed by the CTVR , built in C++, it is used for constructing highly reconfigurable radio networks.**
- **UHD is the universal driver for USRP.**
- **GNURadio, Iris and UHD are installed on the *USRPServerBaseline1004.ndz* image by default**

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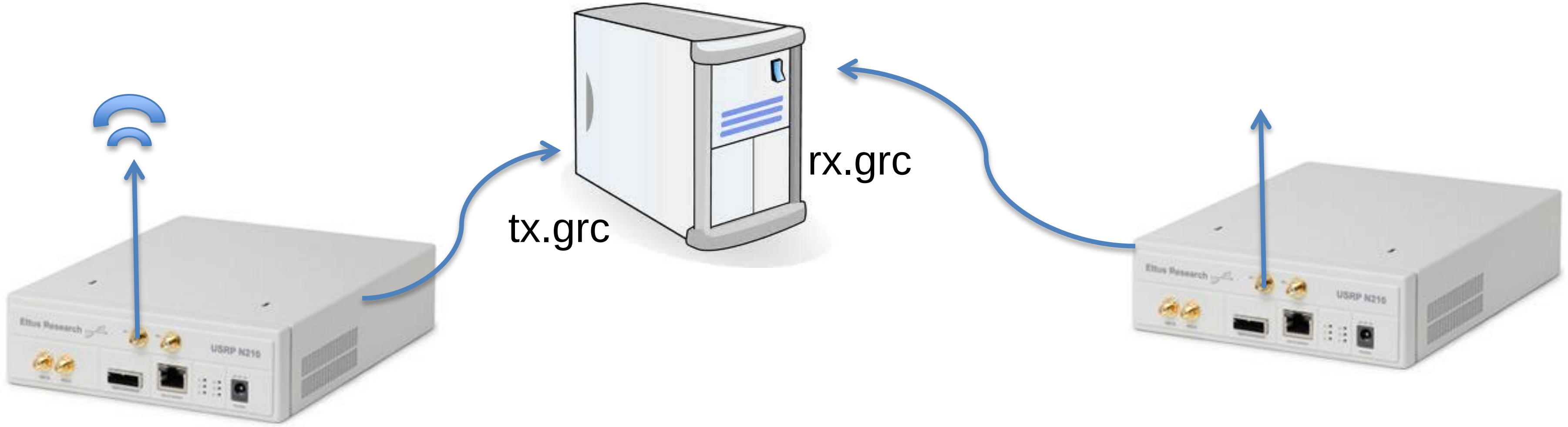
- **How to use USRP with GNURadio on w-iLab.t**
- **How to use USRP with OMF and Iris on w-iLab.t**

How to use USRP with GNURadio

Target :

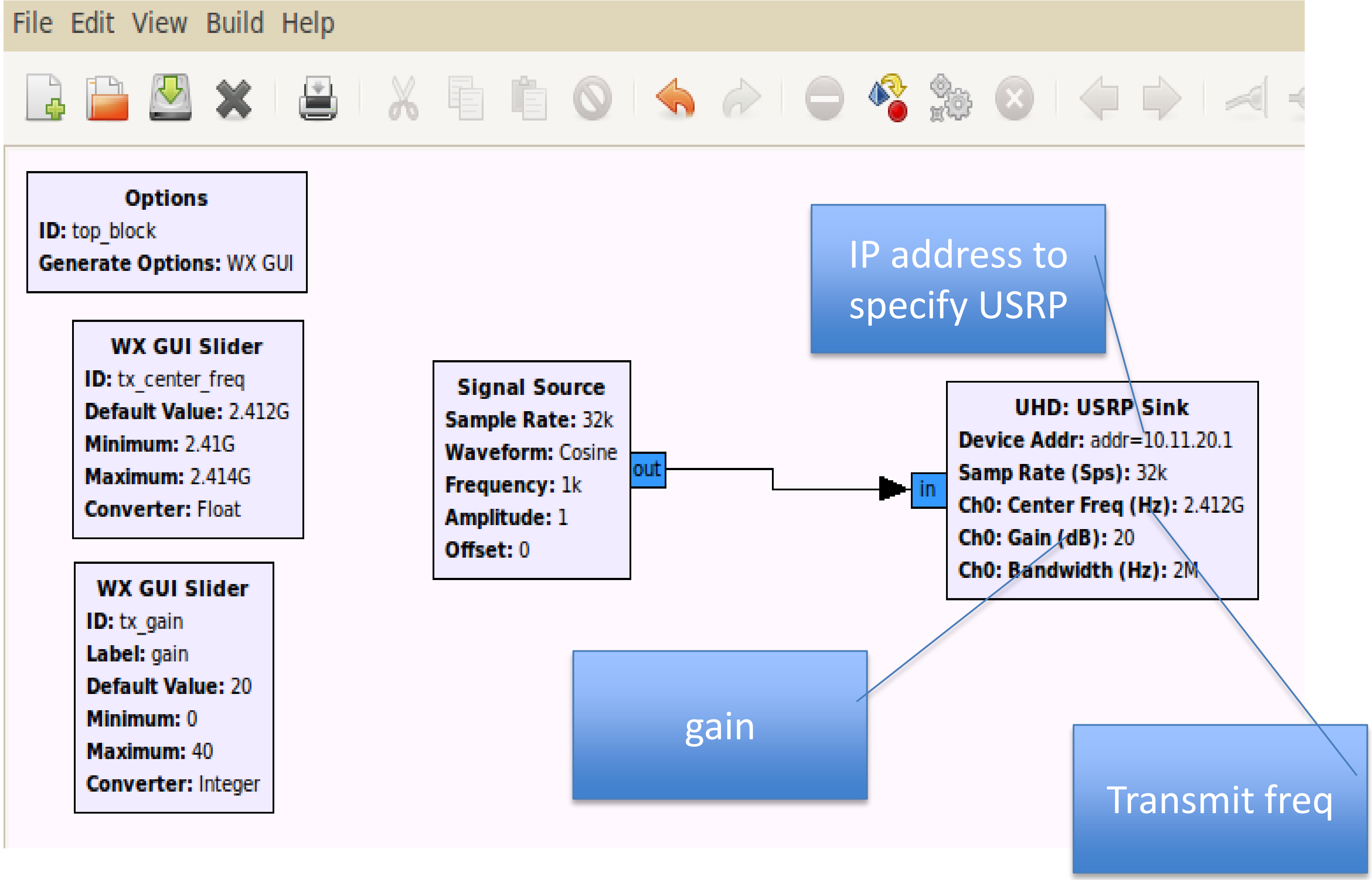
- Transmit a signal with one USRP and detect the transmit frequency with real-time FFT on another USRP.



- Log in to the USRPX server:
  - *ssh –X usrpuser@10.11.17.X*
- Start GNURadio Companion:
  - *gnuradio-companion*
- Run the flow graph as if it is running on your own PC

GNURadio Companion

Transmission flow-graph



Options
ID: top_block
Generate Options: WX GUI

WX GUI Slider
ID: tx_center_freq
Default Value: 2.412G
Minimum: 2.41G
Maximum: 2.414G
Converter: Float

WX GUI Slider
ID: tx_gain
Label: gain
Default Value: 20
Minimum: 0
Maximum: 40
Converter: Integer

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0

UHD: USRP Sink
Device Addr: addr=10.11.20.1
Samp Rate (Sps): 32k
Ch0: Center Freq (Hz): 2.412G
Ch0: Gain (dB): 20
Ch0: Bandwidth (Hz): 2M

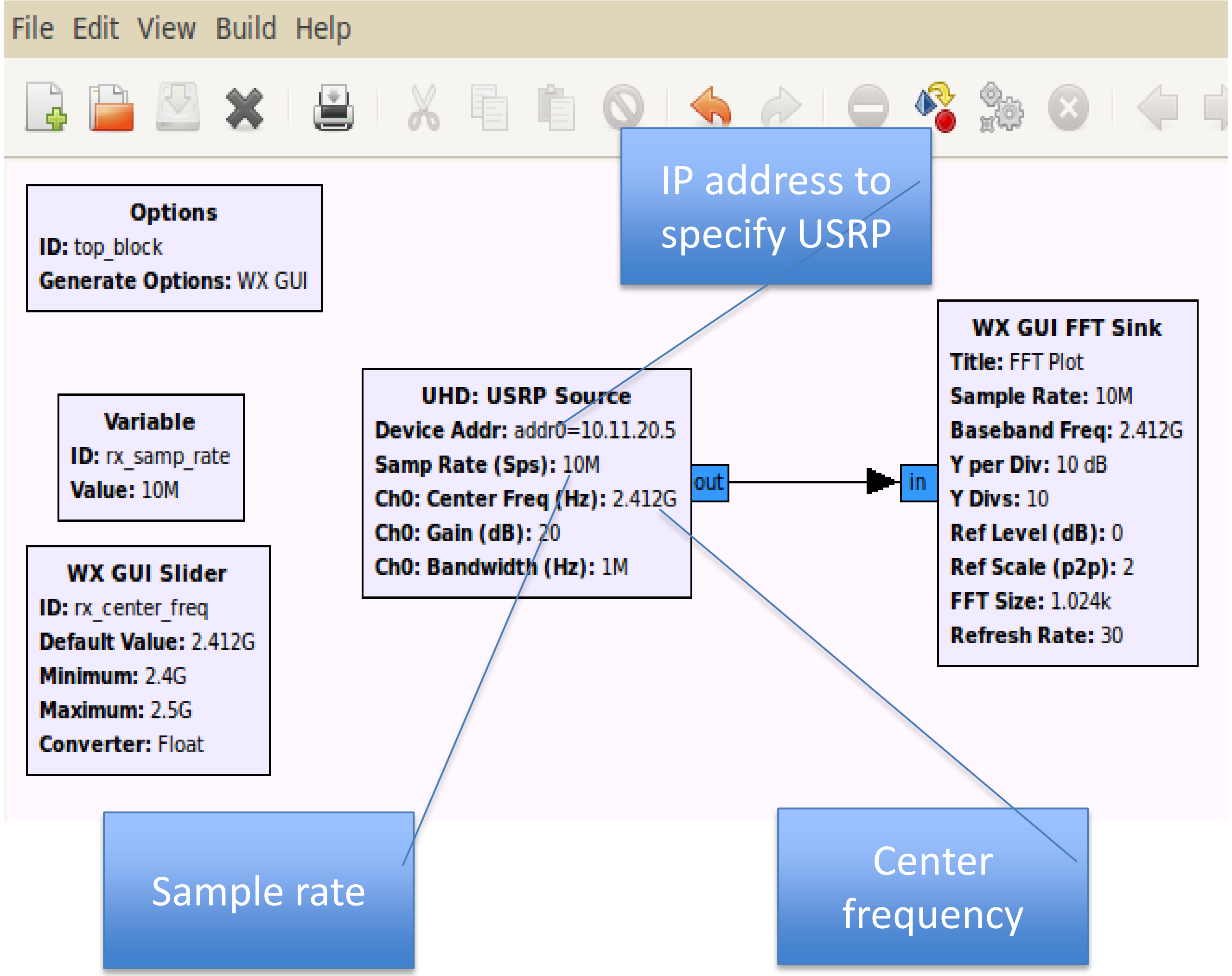
IP address to specify USRP

gain

Transmit freq

GNURadio Companion

Receiving flow-graph



Options
ID: top_block
Generate Options: WX GUI

Variable
ID: rx_samp_rate
Value: 10M

WX GUI Slider
ID: rx_center_freq
Default Value: 2.412G
Minimum: 2.4G
Maximum: 2.5G
Converter: Float

UHD: USRP Source
Device Addr: addr0=10.11.20.5
Samp Rate (Sps): 10M
Ch0: Center Freq (Hz): 2.412G
Ch0: Gain (dB): 20
Ch0: Bandwidth (Hz): 1M

WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 10M
Baseband Freq: 2.412G
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 0
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30

IP address to specify USRP

Sample rate

Center frequency

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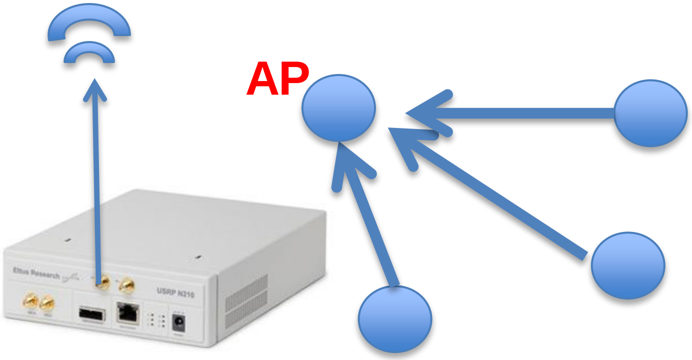
- **How to use USRP via OMF and Iris on w-iLab.t**

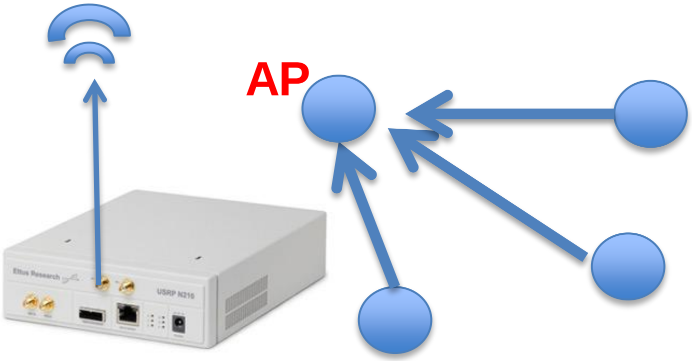
How to use USRP via the OMF framework

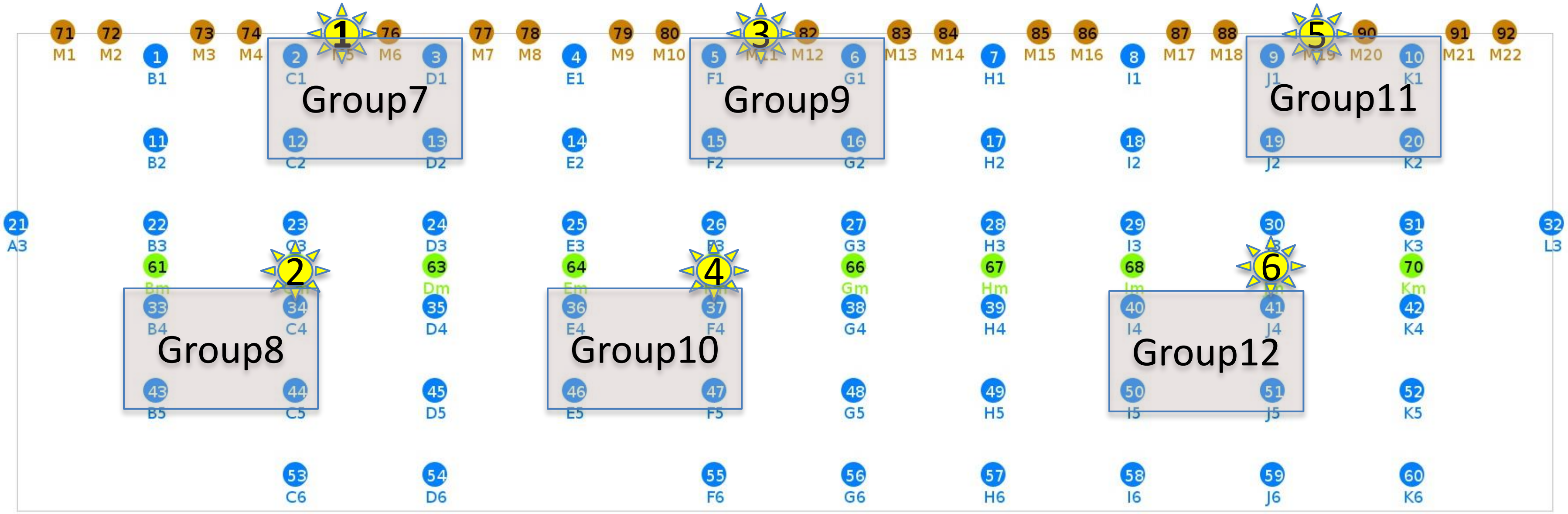
- **Target:**
  - Run an OMF experiment:
    - Generate Wi-Fi traffic by 4 nodes
    - Detect the Wi-Fi activity with USRP



How to use USRP via the OMF framework

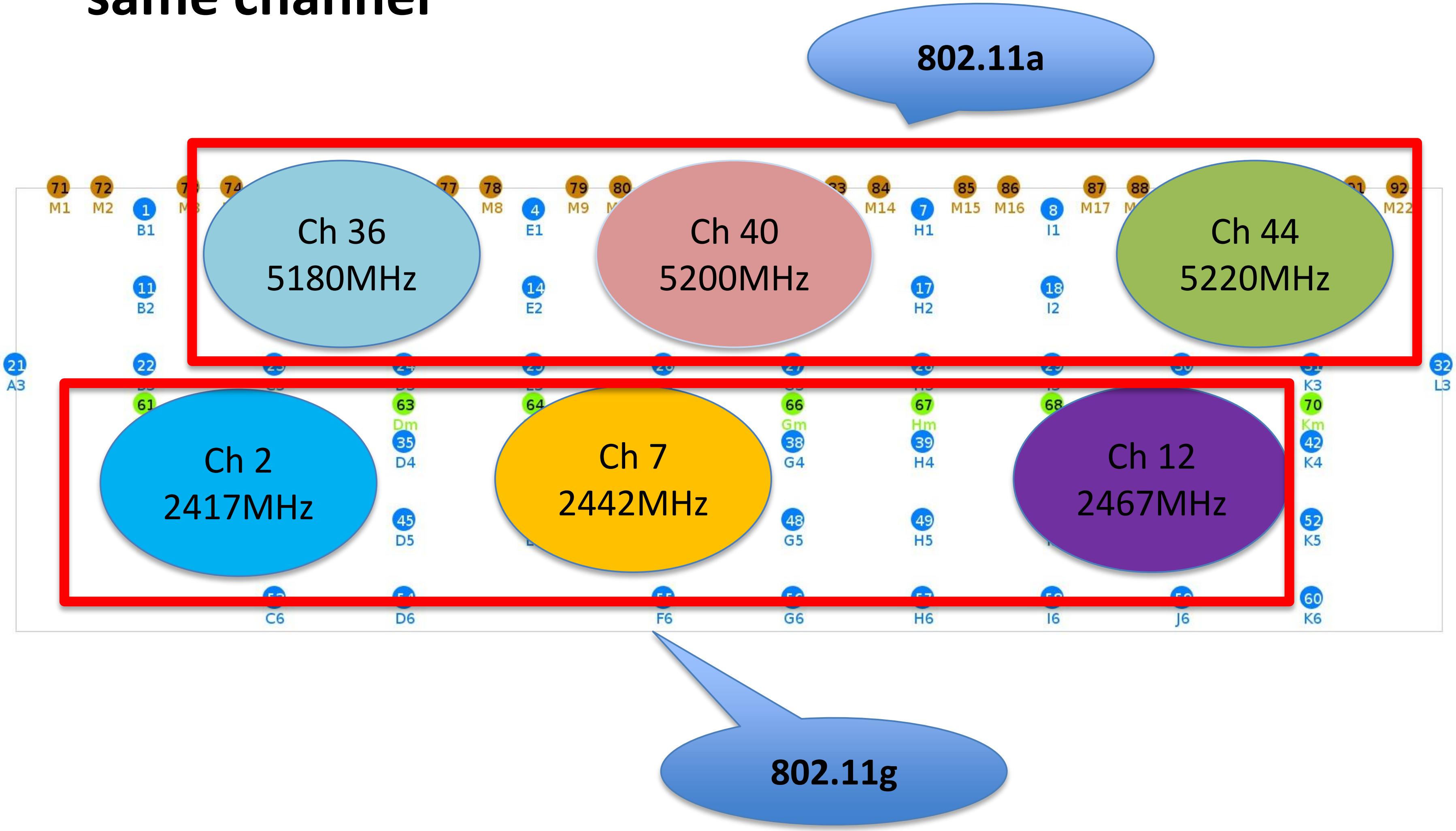
- **Target:**
  - Run an OMF experiment:
    - Generate Wi-Fi traffic by 4 nodes
    - Detect the Wi-Fi activity with USRP
  - Practical Configurations
    - Group 1 to Group 6 operate with USRP to detect Wi-Fi activity
    - Group 7 to Group 12 control Wi-Fi nodes to generate interference





Practical Configuration

- By default, USRPX and Group(X+6) are tuned on the same channel


802.11a

Ch 36 5180MHz

Ch 40 5200MHz

Ch 44 5220MHz

Ch 2 2417MHz

Ch 7 2442MHz

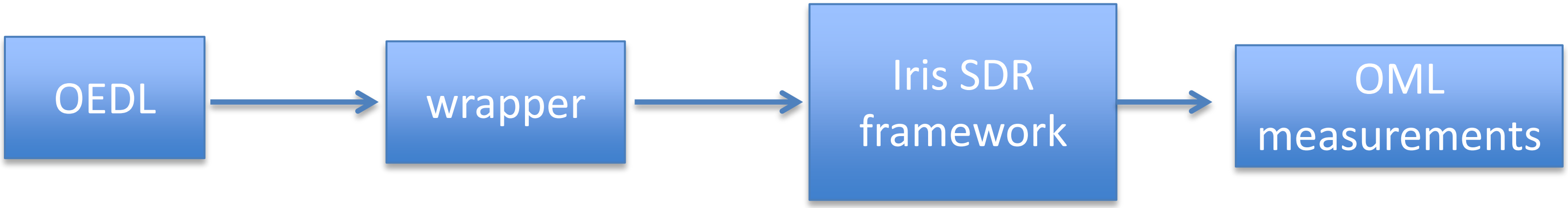
Ch 12 2467MHz

802.11g

Behind the scenes

USRP configuration

- Main OEDL script: oedl_usrpX.rb
  - Specify which USRP to use
  - Distribute Iris SDR configuration files to the corresponding USRP server
- Wrapper file: Call the iris SDR binary
- Iris configuration file: Calculate PSD over specified frequency
- OML collects measurements into the database



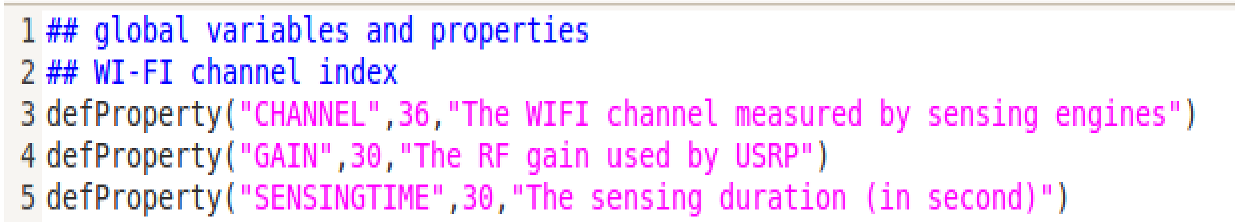
Wi-Fi configuration

- Main OEDL script: oedl_interference.rb
  - Specify which Wi-Fi nodes to use
  - Specify channel and transmit power
  - Establish Wi-Fi traffic between 1 AP and 3 clients

How to get there

How to get there?

- Log on to experiment controller : 10.11.31.22
  - User name : demoX
  - Password : demoX
- Go to /home/demoX/CREW_training/USRP
- For group1 to group6 :
  - Go to 25MHz folder, open oedl_usrpX.rb (X is the group number)
  - Open the oedl_usrpX.rb script to adjust spectrum sensing parameters

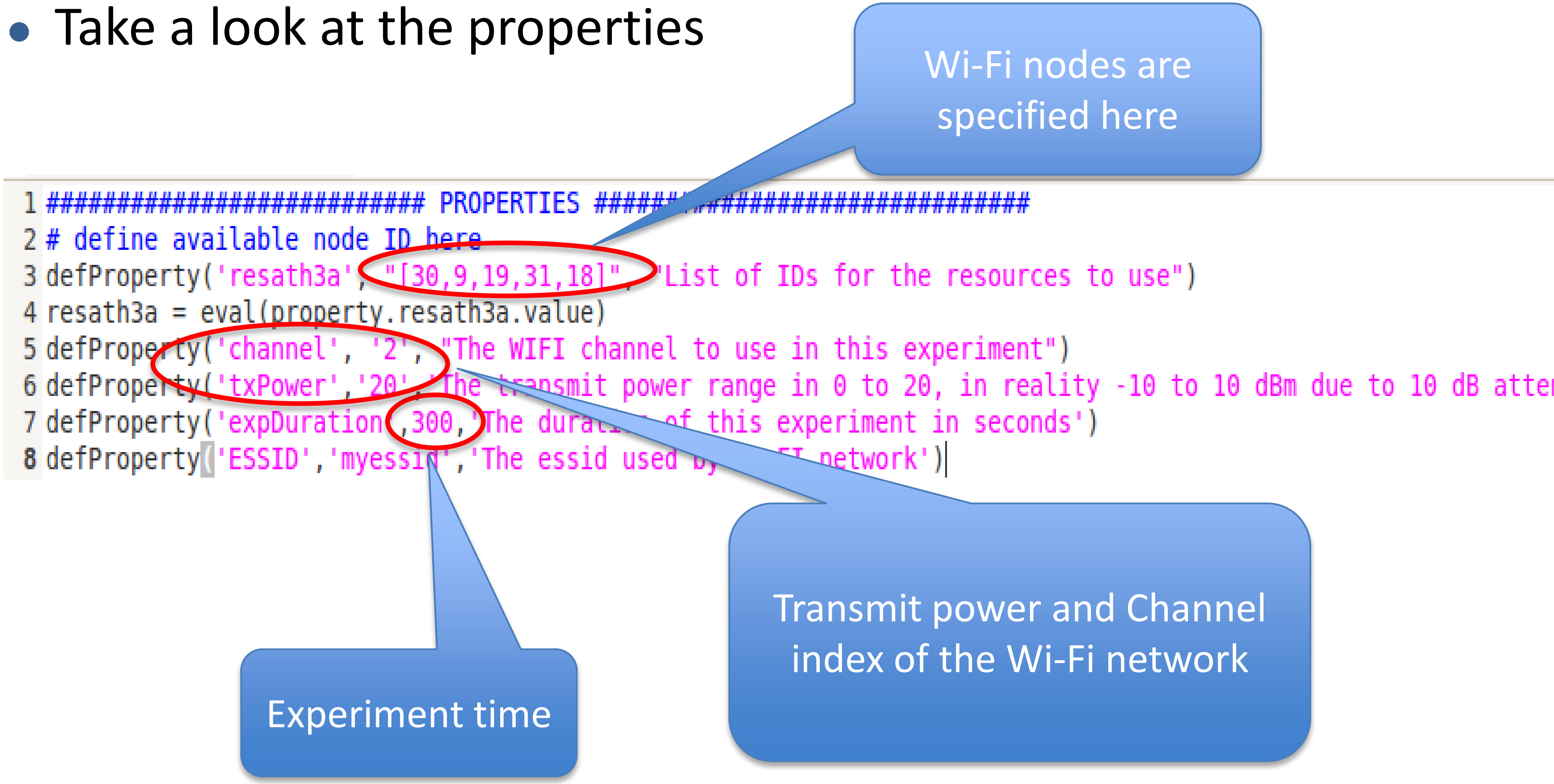


```
## global variables and properties
## WI-FI channel index
defProperty("CHANNEL",36,"The WIFI channel measured by sensing engines")
defProperty("GAIN",30,"The RF gain used by USRP")
defProperty("SENSINGTIME",30,"The sensing duration (in second)")
```

Using USRP via OMF framework

Set up Wi-Fi interference

- For demo7 to 12 : go to CREW_training/interference
- Open oedl_interference.rb
- Take a look at the properties



```
############################ PROPERTIES ##############################
# define available node ID here
defProperty('resath3a', "[30,9,19,31,18]", "List of IDs for the resources to use")
resath3a = eval(property.resath3a.value)
defProperty('channel', '2', "The WIFI channel to use in this experiment")
defProperty('txPower','20','The transmit power range in 0 to 20, in reality -10 to 10 dBm due to 10 dB atte
defProperty('expDuration',300,'The duration of this experiment in seconds')
defProperty('ESSID','myessid','The essid used by the WIFI network')
```

Wi-Fi nodes are specified here

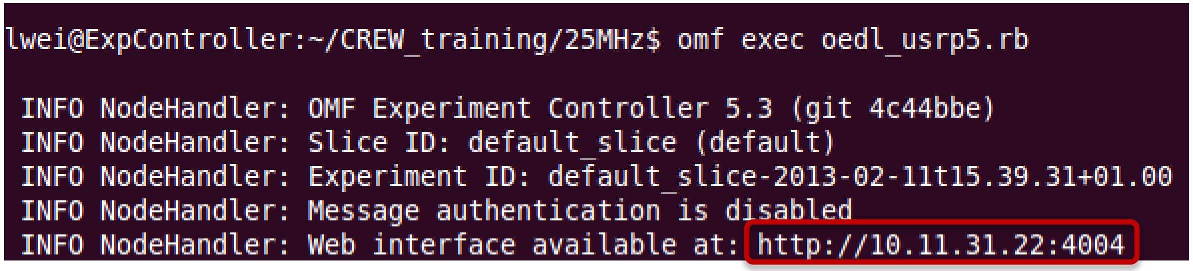
Transmit power and Channel index of the Wi-Fi network

Experiment time

Using USRP via OMF framework

Run the script :

- Group 7 to 12 run: omf exec oedl_interference.rb
- Group 1 to 6 run: omf exec oedl_usrpX.rb

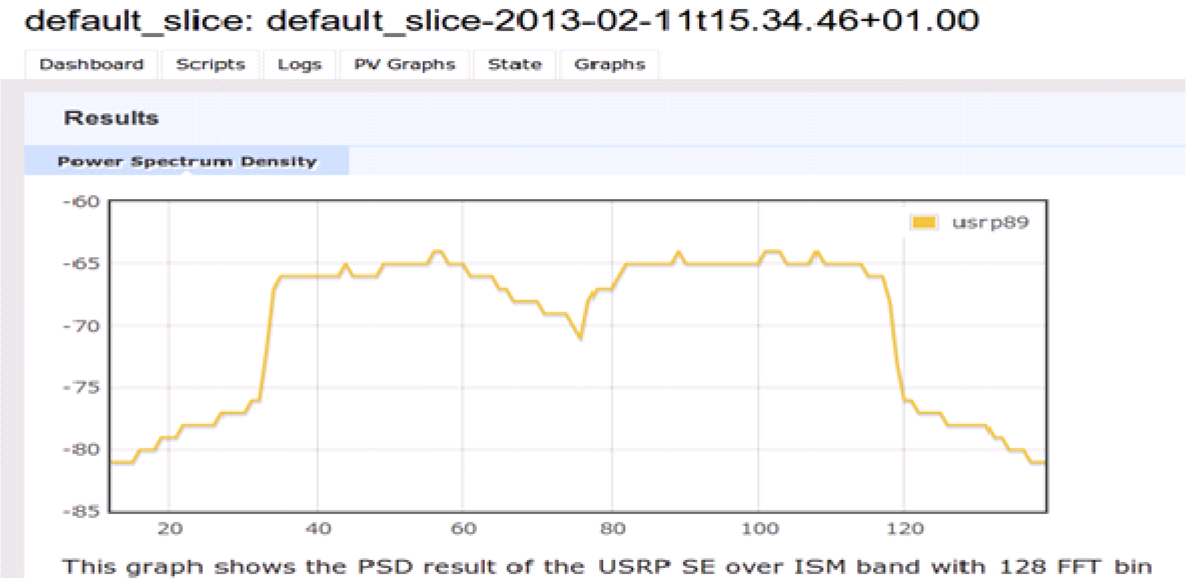


```
lwei@ExpController:~/CREW_training/25MHz$ omf exec oedl_usrp5.rb

 INFO NodeHandler: OMF Experiment Controller 5.3 (git 4c44bbe)
 INFO NodeHandler: Slice ID: default_slice (default)
 INFO NodeHandler: Experiment ID: default_slice-2013-02-11t15.39.31+01.00
 INFO NodeHandler: Message authentication is disabled
 INFO NodeHandler: Web interface available at: http://10.11.31.22:4004
```

The result on the OMF portal at run time

- **Spectrum of USRP**



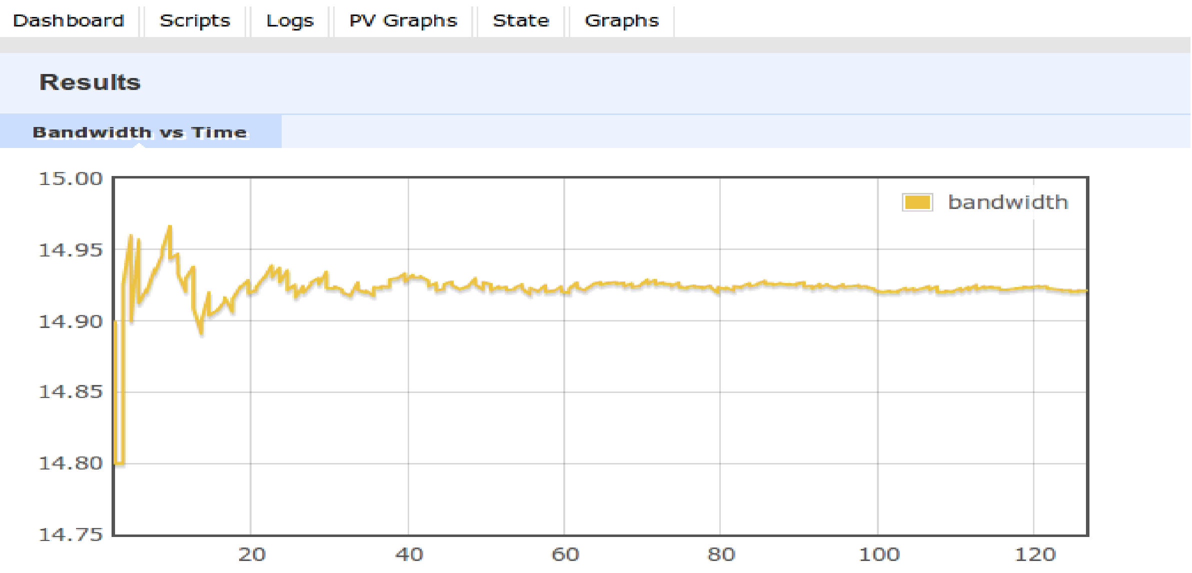
default_slice: default_slice-2013-02-11t15.34.46+01.00

Results

Power Spectrum Density

This graph shows the PSD result of the USRP SE over ISM band with 128 FFT bin

- **Bandwidth vs Time**

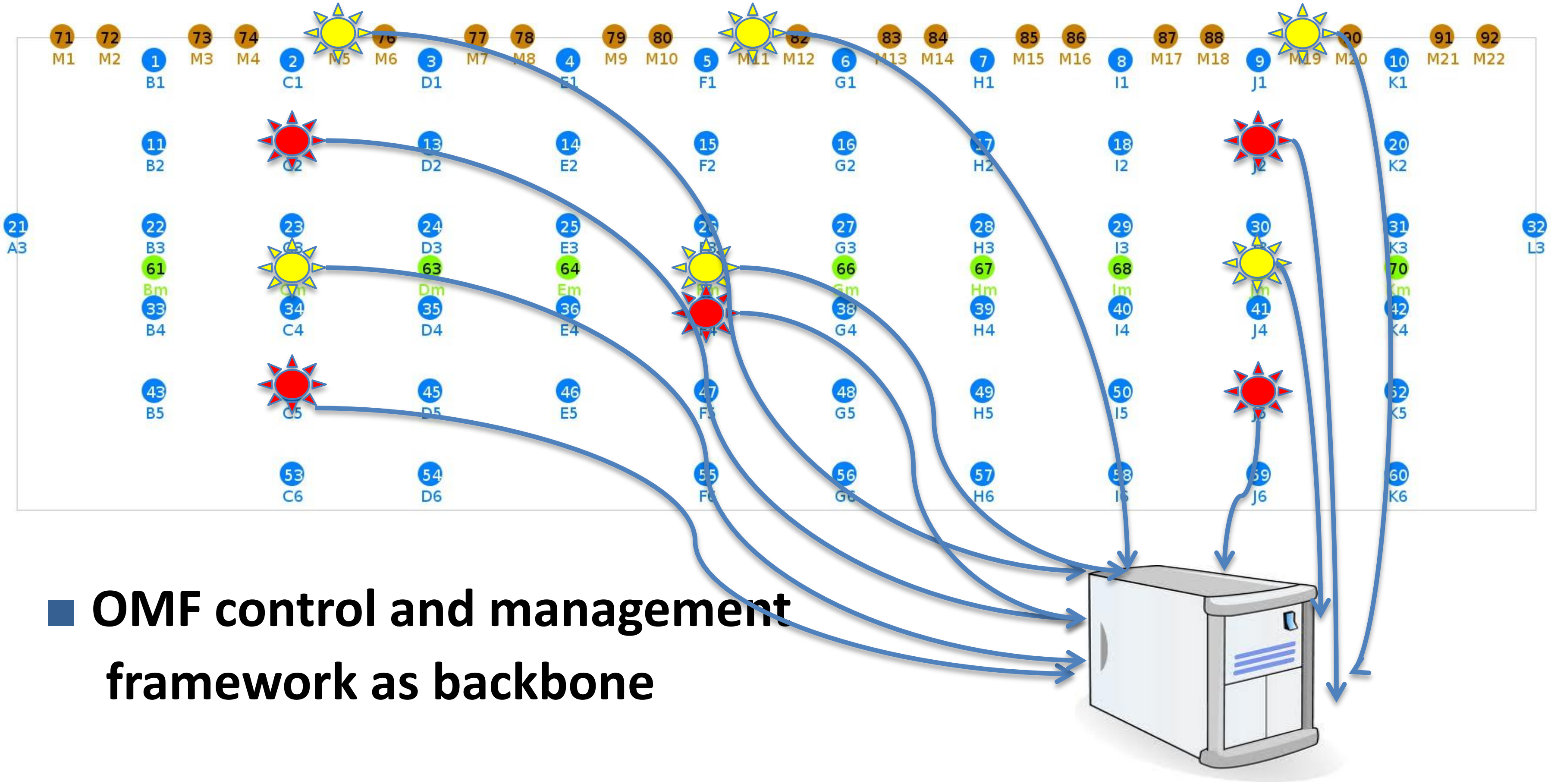


Results

Bandwidth vs Time

Distributed sensing demo

- Distributed and heterogeneous spectral sensing



- OMF control and management framework as backbone