



THE UNIVERSITY OF
BUCKINGHAM

Convergence in Wireless Transmission Technology Promises Best of Both Worlds

MSN 2009 Workshop
9th July 2009

Ali Al-Sherbaz

Torben Kuseler

University of Buckingham

Ali.al-sherbaz@buckingham.ac.uk

torben.kuseler@buckingham.ac.uk

Part One - Preamble

- What is the Mobile and Wireless Communications ?
- What is the 3G Vs. (WiFi & WiMAX) ?
- Are Both of them Going toward 4G ?

Part Two – Wireless Convergence

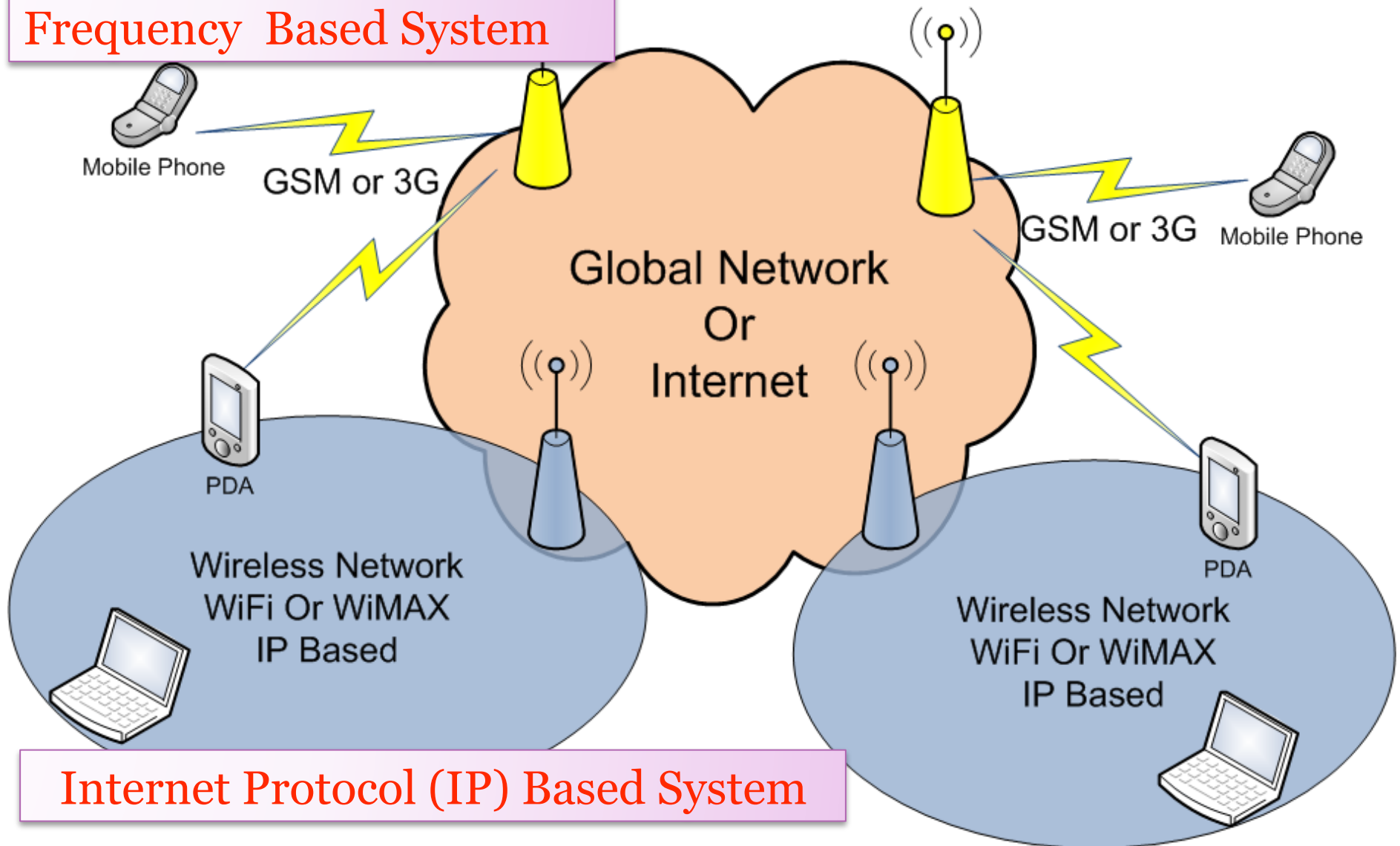
- What is the Wireless Convergence ?
- Single Carrier Wireless Convergence
 - Challenges
 - Technical Solution (Interpose a Thin Layer)
- Multi-Carrier (OFDM)Wireless Convergence

Part Three – Vision and Future Work

- Cognitive Radio
- IEEE 802.21 and IEEE 802.22

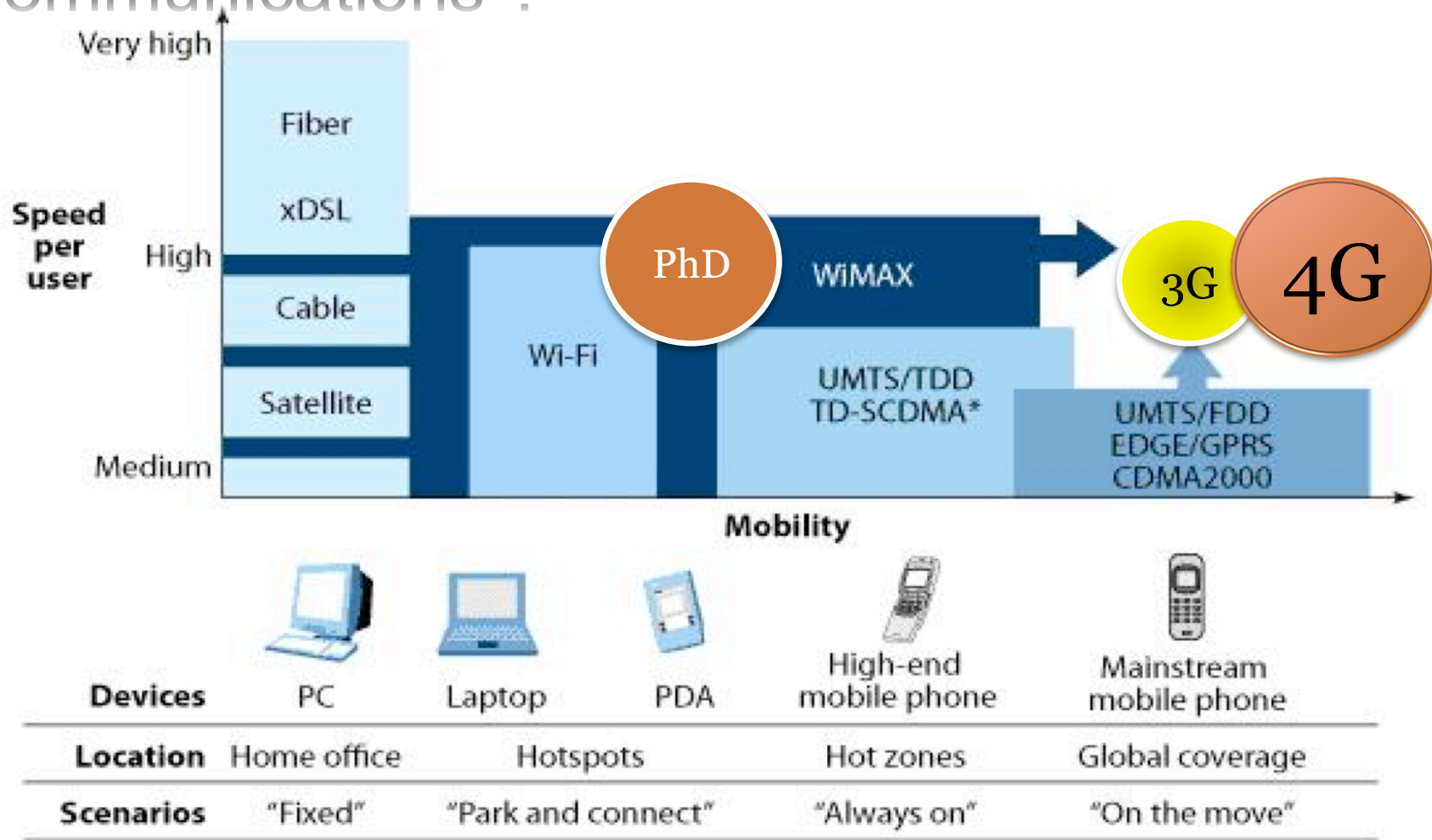
What is the Mobile and Wireless Communications?

Frequency Based System



Internet Protocol (IP) Based System

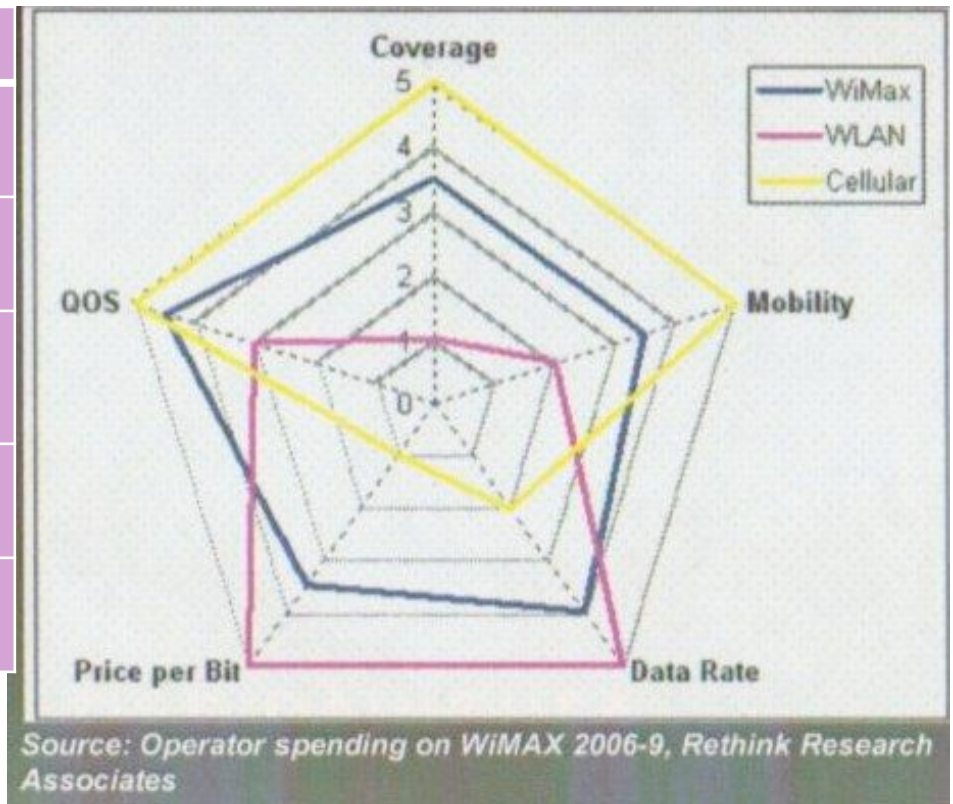
What is the Mobile and Wireless Communications ?



* Time-division synchronous code-division multiple access

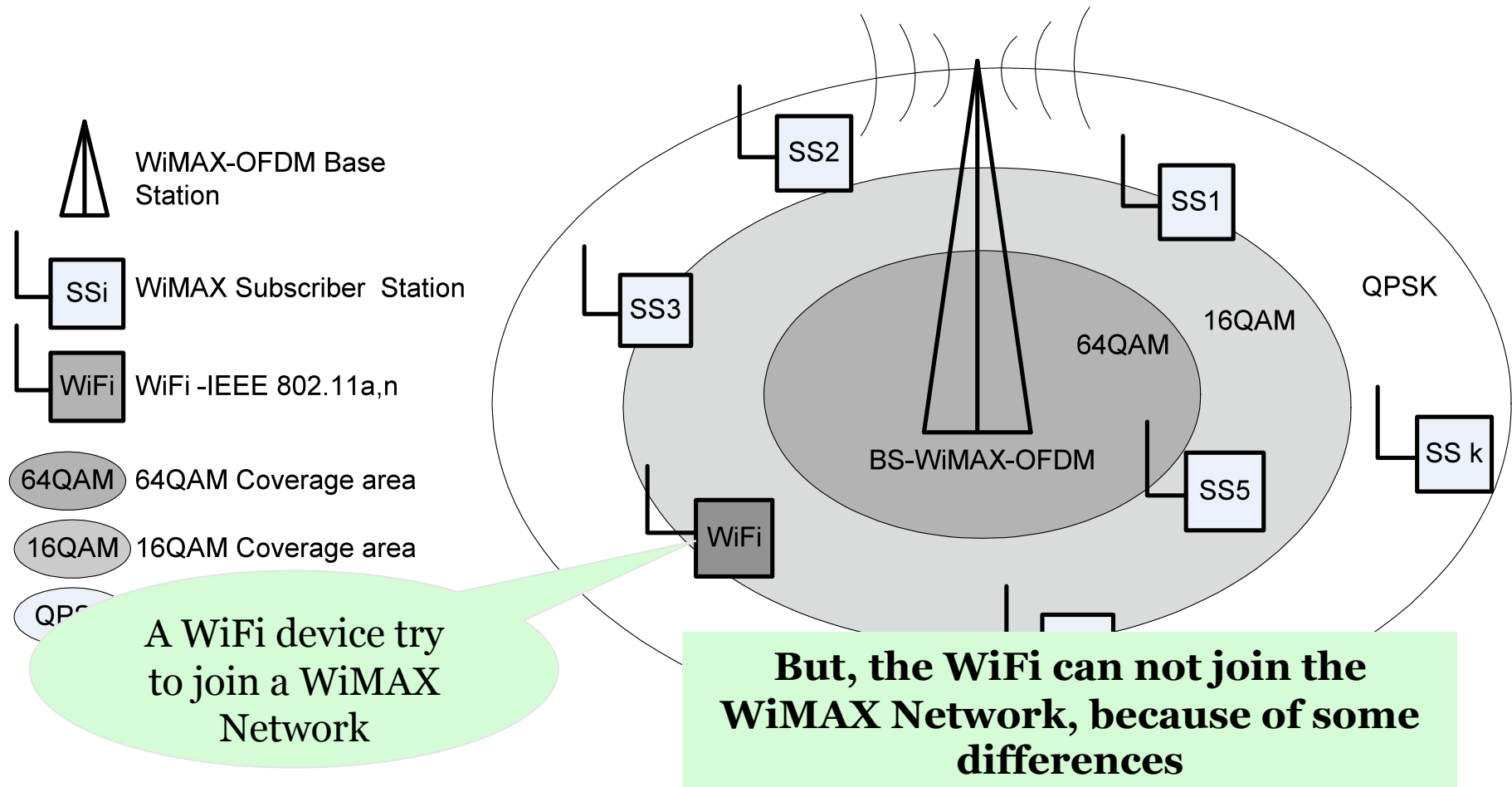
What is the 3G Vs. (WiMAX & WiFi) ?

	3G	WiMAX	WiFi
Coverage	High	Medium	Low
Mobility	High	Medium	Low
Data Rate	Low	Medium	High
Cost	High	Medium	Low
QoS	High	High	Low



Are Both of them Going toward 4G ?

What is the Wireless Convergence ?



The Convergence is a smart modification in the WiFi PHY or MAC layer to enable the WiFi devices to join the WiMAX wireless network

Single Carrier Wireless Convergence Challenges

Step1:IEEE Standards Investigation

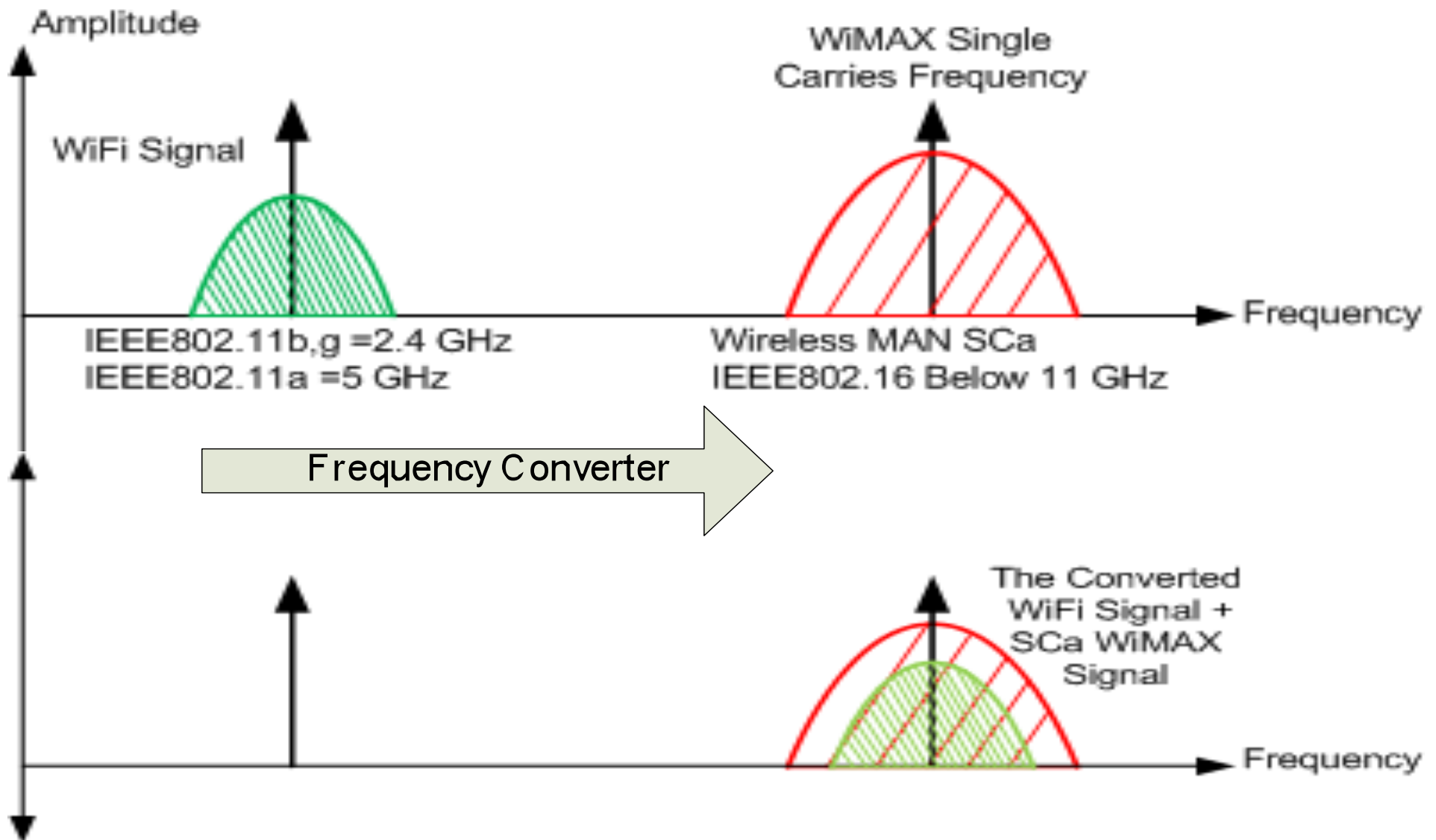
- WiFi = IEEE 802.11
- WiMAX = IEEE 802.16

Step2:Differences

- Frequency Bands
- Synchronization
- Protocol Matching

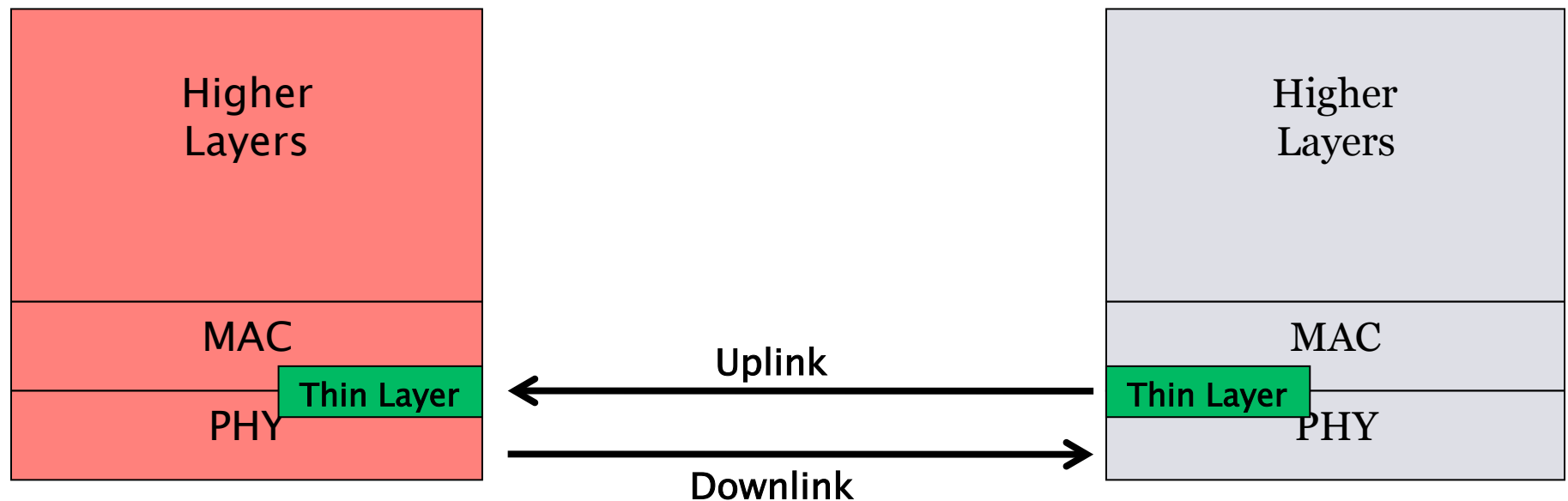
Solution

First different: Frequency Bands
Solution : Frequency Conversion



Second and Third Different: Synchronization and Protocol Matching
Solution :

Interpose an extra thin layer in both WiFi & WiMAX-Single Carrier sides



**WiMAX -SC
Base Station Side**

**WiMAX side thin layer
is in charge of
Protocol Matching**

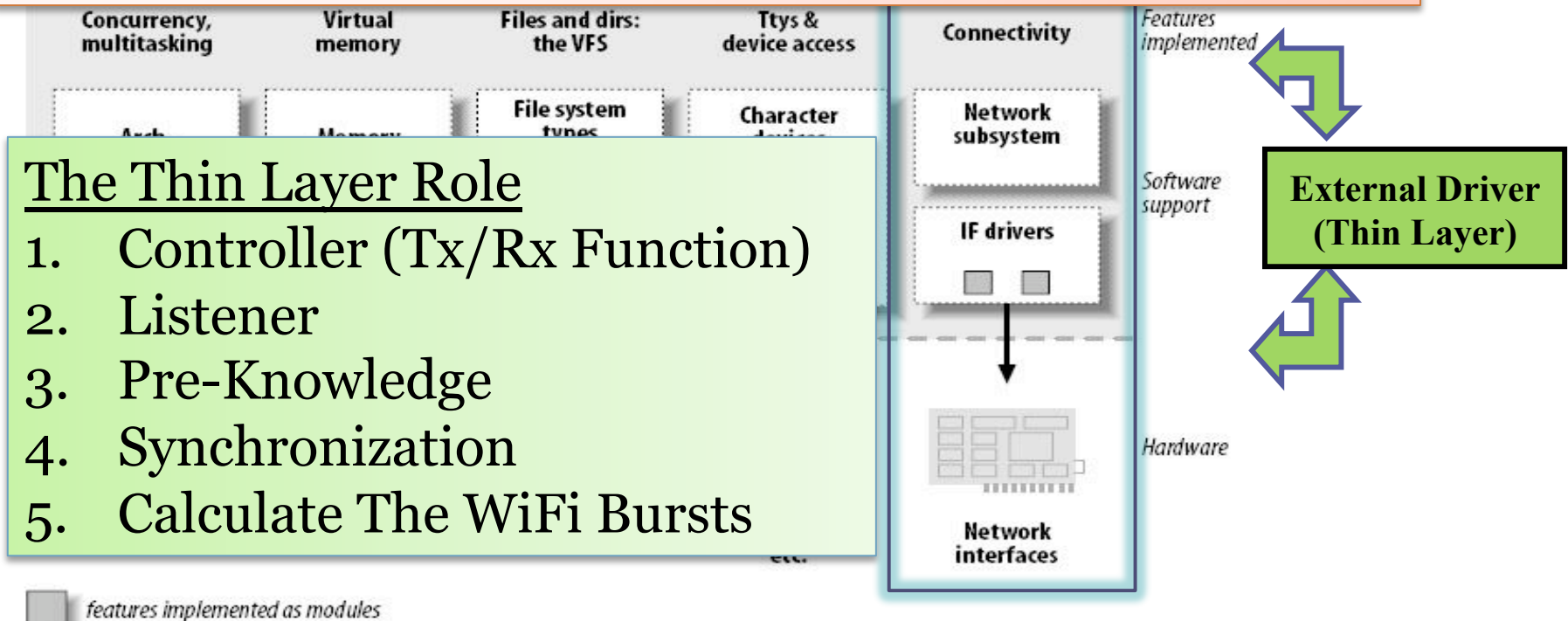
WiFi Side

**WiFi side thin layer
is in charge of
Synchronization**

Solution

Technical Solution – Linux

1. Under Linux – Kernel 2.6 (Open Source)
2. CISCO Wireless Network Device Driver (C-Code , 26000 lines)
3. Programming Language is C (There is no OOP)
4. I have joint a two days Microsoft workshop in Birmingham. They helped us to work under Windows XP, using WDK.

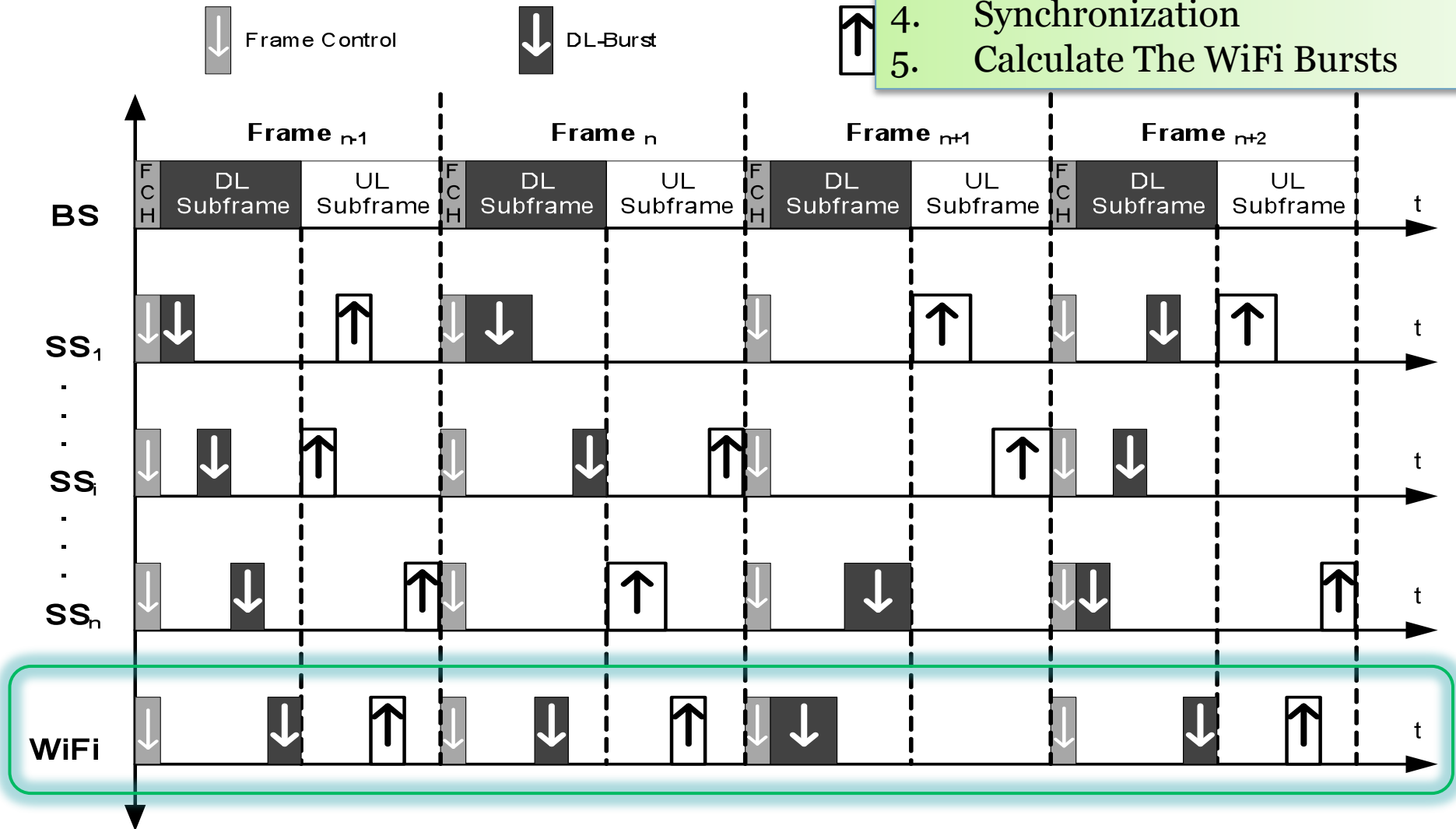


Solution

WiMAX-WiFi Timing Diagram

The Thin Layer Role

1. Controller (Tx/Rx Functions)
2. Listener
3. Pre-Knowledge
4. Synchronization
5. Calculate The WiFi Bursts



Challenges

✓ **Multi Carrier (OFDM):** WiMAX-Fixed (OFDM-256) and WiFi-OFDM-64 have been selected to achieve the multi-carrier convergence.

✓ The mismatch between the fixed WiMAX-OFDM ($N_{fft}=256$) and the WiFi-OFDM

Wireless Convergence Multi-Carrier (OFDM – Orthogonal Frequency Division Multiplexing) Challenges

✓ The proposal does not suggest changing the standard itself but modifying some functions to be configurable

$$S(t) = Re \left\{ e^{j2\pi f_c t} \cdot \sum_{\substack{k=-N_{used}/2 \\ k \neq 0}}^{N_{used}/2} C_k \cdot e^{j2\pi k \Delta f (t-T_g)} \right\}$$

This equation underpins the design of the proposed convergence bridge.

Challenges

The WiMAX and WiFi OFDM Equations:

A General OFDM Signal

$$S(t) = Re \left\{ e^{j2\pi f_c t} \cdot \sum_{\substack{k=-N_{used}/2 \\ k \neq 0}}^{N_{used}/2} C_k \cdot e^{j2\pi k \Delta f (t-T_g)} \right\}$$

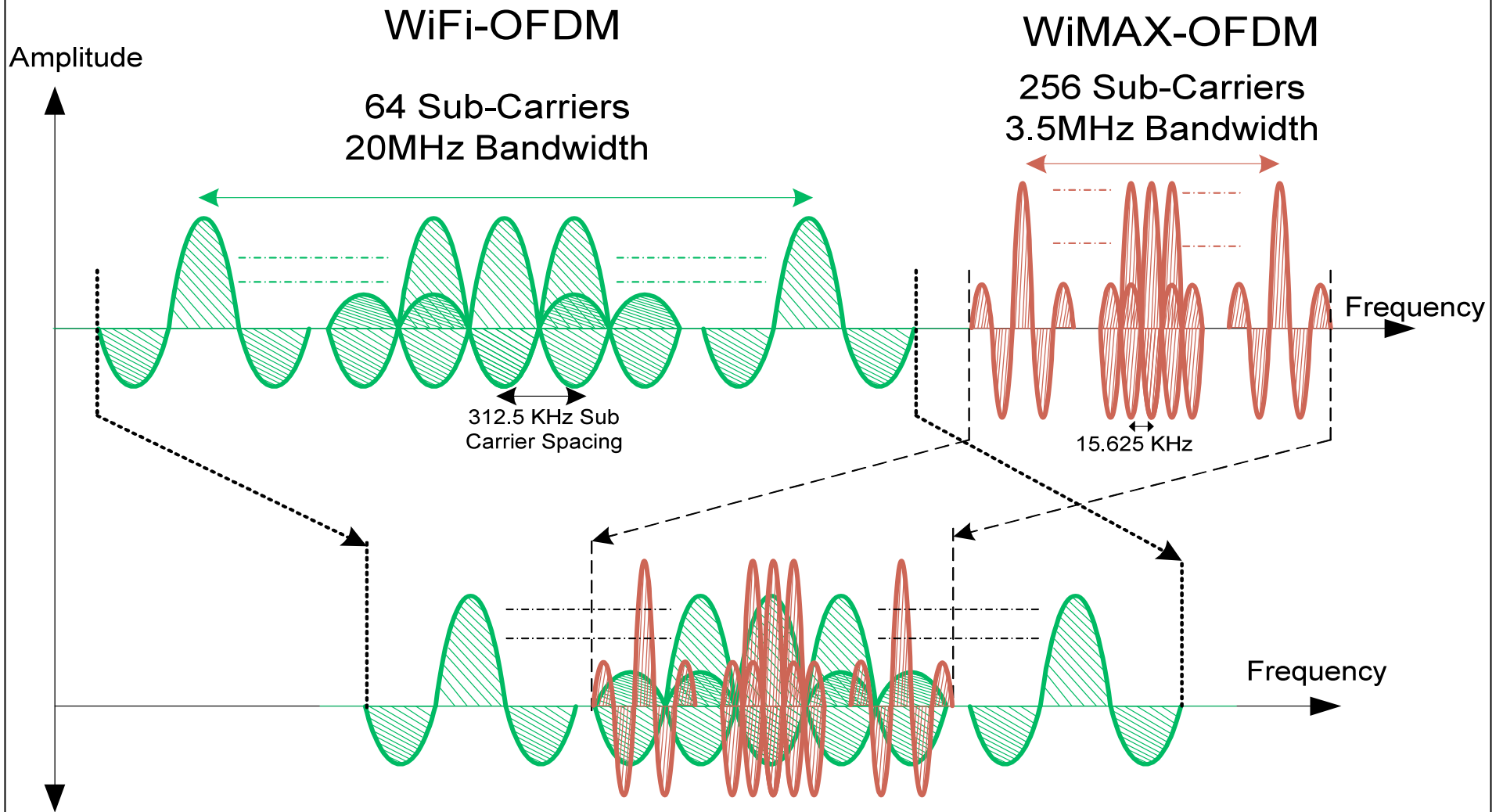
WiFi-OFDM-64 Signal

$$S_1(t) = Re \left\{ e^{j2\pi f_{c1} t} \cdot \sum_{\substack{k=-26 \\ k \neq 0}}^{+26} C_k \cdot e^{j2\pi k \Delta f_1 (t-T_{g1})} \right\}$$

WiMAX OFDM-256 Signal

$$S_2(t) = Re \left\{ e^{j2\pi f_{c2} t} \cdot \sum_{\substack{k=-100 \\ k \neq 0}}^{+100} C_k \cdot e^{j2\pi k \Delta f_2 (t-T_{g2})} \right\}$$

Challenges



RF carrier, Bandwidth, Guard Time, FFT samples and the OFDM duration are the main issues for those physical layer differences that should be harmonized.

What is the OFDM Convergence Bridge

- ✓ It is a smart modification in the WiFi OFDM Physical layer to enable the WiFi devices to join the WiMAX-OFDM wireless network
- ✓ The convergence idea initiated from the similarities between the WiMAX and the WiFi, however the dissimilarities are still real obstacles to enable them communicates with each other
- ✓ In the standard investigations, it has been discovered that the convergence in WiMAX-WiFi multi-carrier OFDM is a physical layer issue

What is the OFDM Convergence Bridge

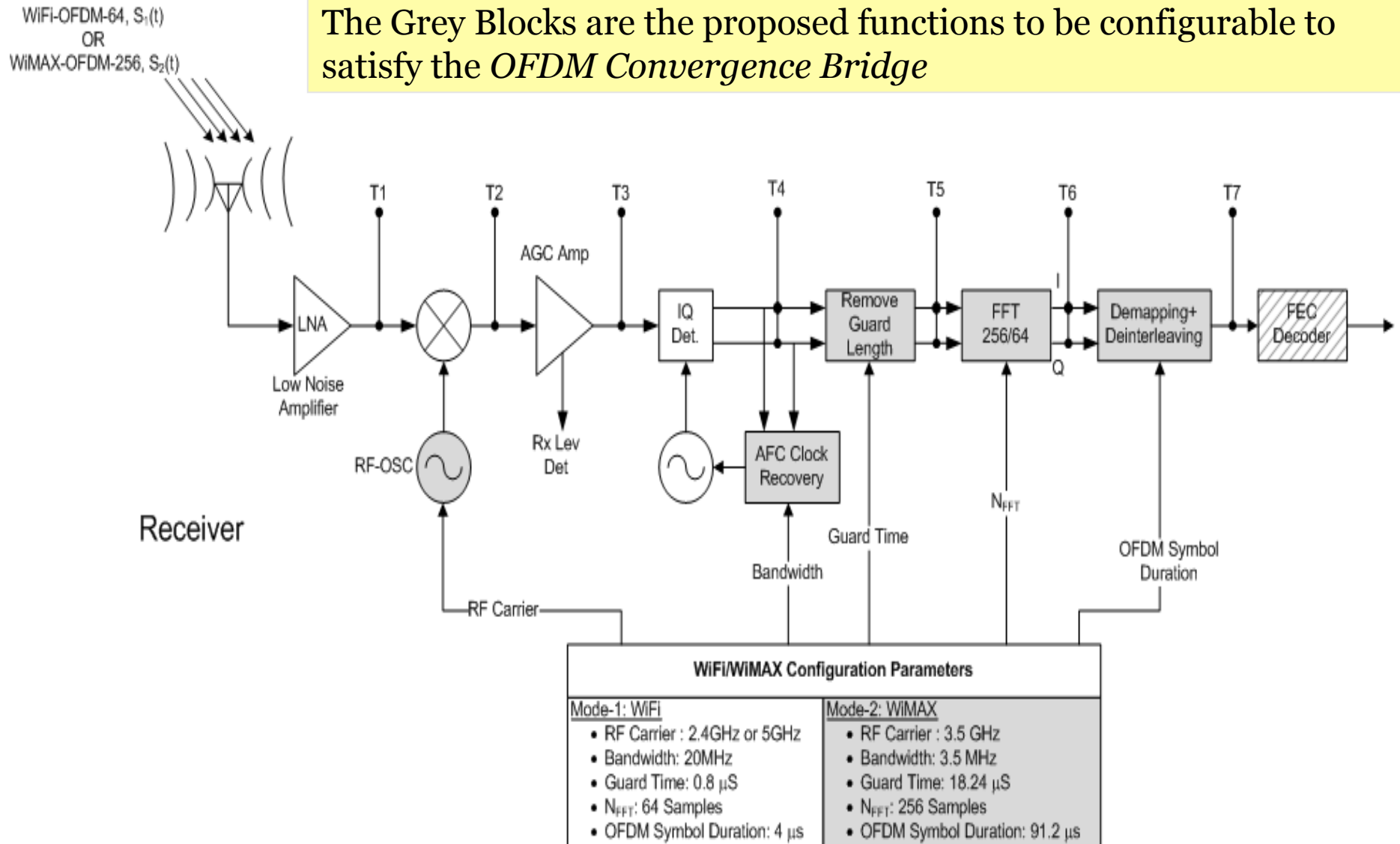
To Satisfy the Convergence:

The proposal **does not** suggest changing the WiFi standard itself but modifying some functions to be **configurable**

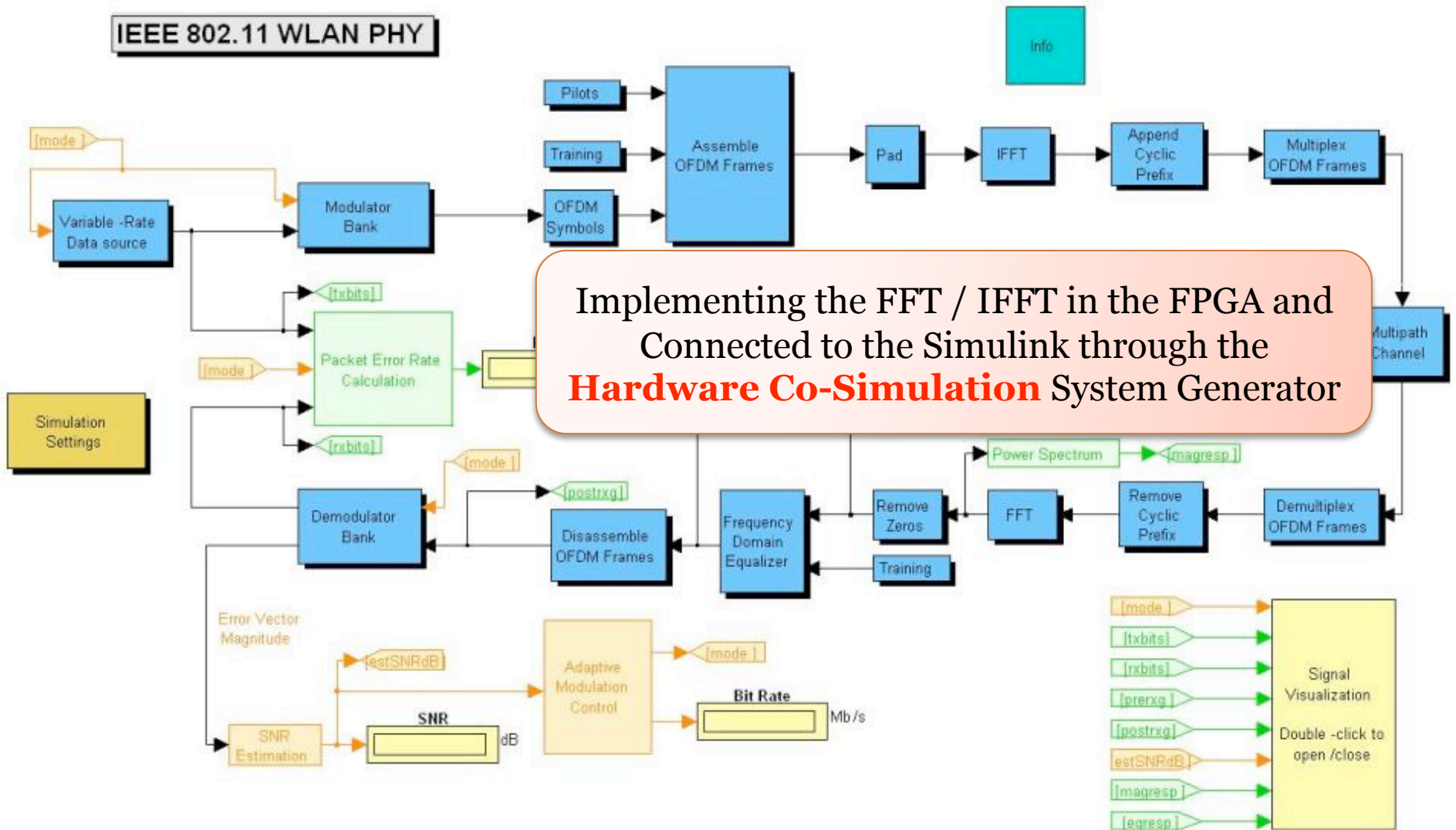
Modified Functions	WiFi Standard	Modified
RF Oscillator	2.4,5 GHz	2.4, 3.5 & 5 GHz
Bandwidth	20 MHz	3.5 & 20 MHz
Guard Time	0.8 usec	0.8 & 18.24 usec
FFT	64 Samples	64/ 256 Samples
OFDM Symbol Duration	4 usec	4 & 91.2 usec

IEEE 802.11 -WiFi Physical Layer

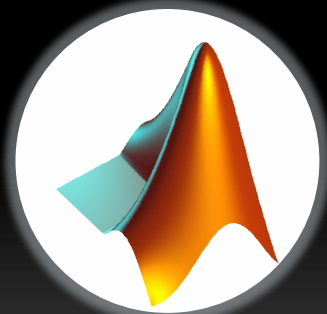
The Grey Blocks are the proposed functions to be configurable to satisfy the *OFDM Convergence Bridge*



WiFi Physical Layer- Simulink



Technical tools For Hardware Co-Simulation



MATLAB

(Mathworks)



Simulink

(Mathworks)



**System
Generator
For DSP**

(Xilinx)



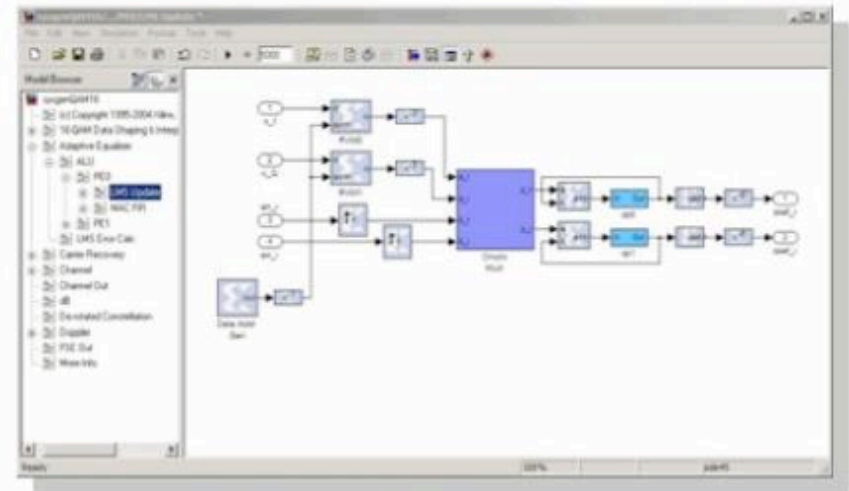
FPGA

(Xilinx)



(Xilinx)

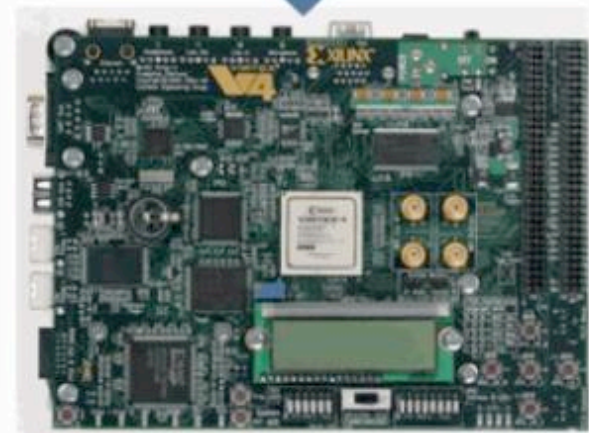
What is the Hardware Co-Simulation



Ethernet ,USB or RS232



This hardware will co-simulate with the rest of the Simulink system to provide up to a **1000x** simulation performance increase.



Part Three – Vision and Future Work

21

The Wireless Convergence between WiFi and WiMAX is an ideal technology that provides the best of both worlds: the new features of the WiMAX and the low cost of the WiFi.

A new vision of the convergence has emerged when two different wireless standards have created the **MESH** topology as vertical developments. WiMAX-WiFi convergence has a good chance to be involved in the mesh topology applications.

IEEE 802.21: the standard supports algorithms enabling seamless **handover** between networks of the same type as well as handover between different network types also called **Media Independent Handover** (MIH)

The standard provides information to allow handing over to and from **Cellular ,GSM, GPRS, WiFi, WiMAX, and Bluetooth** through different handover mechanisms.

Works

Are Both of them Going toward 4G?

Experts in the Industry:

The WiMAX vs. 3G cellular showdown is poised to become

If you can not beat them, join them

Or

“Be in the Middle”

(hopefully, for the better) in the process.

- Intel
- Motorola
- Samsung
- Sprint

WiMAX
802.16



IEEE 802.21,22

Cheap
High Data Rate



3G



4G

High Mobility
High Quality of Service

- Ericsson
- Verizon
- Qualcomm

Current Research : The Cognitive Radio

1. Dynamic frequency allocation techniques for OFDM-based cognitive systems.
2. Different dynamic frequency allocation solutions will be explored.
3. The implementation of a dynamic OFDM system will be carried out, based on a software-defined radio architecture (FPGA)
4. Spectral Efficiency

European Project COST ICo803

**RF/Microwave Communication Subsystems for Emerging
Wireless Technologies**

Thanks to Your
Attentions