Free Technology Workshop

Hacking WiFi

Hands on with wireless LAN routers,
packet capture and wireless security

Organised by Steven Gordon
Bangkadi 3rd floor IT Lab
10:30-13:30 Friday 18 July 2014
http://ict.siit.tu.ac.th/moodle/

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      |__| W I R E L E S S   F R E E D O M
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Sources

- openwrt.org
- wikipedia.org
- and others

Aims

- Understand what is a “wireless router”
- See the internals (hardware)
- Know about (open source) firmware
- Understand what is a “wireless LAN”
- Setup a wireless LAN
- Aware of security features in wireless LANs
- Capture wireless packets (“sniffing”)
- Bypass security features in wireless LANs

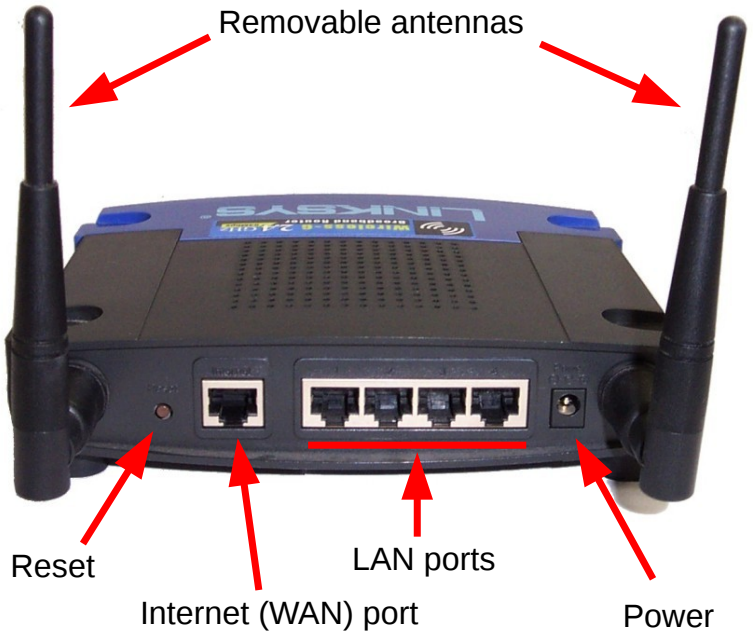
Naming, Acronyms, etc.

- AP - access point
- BSSID - basic SSID — *identifies AP*
- CTS - clear to send
- ESSID - extended SSID — *identifies network (also SSID)*
- LAN - local area network
- MAC - medium access control (layer) — *defines how to share channel with others*
- NAT - network address translation — *allows private addressing in internal network*
- PHY - physical (layer) — *defines data rate, channels, power, signals, ...*
- RTS - request to send
- SSID - service set identifier
- WAN - wide area network
- WEP - wired equivalent privacy — *insecure encryption*
- WLAN - wireless LAN — *also WiFi, IEEE 802.11*
- WMM - wireless multimedia mode — *priority for voice, video packets*
- WPA - WiFi protected access — *secure encryption*
- WRT - wireless router

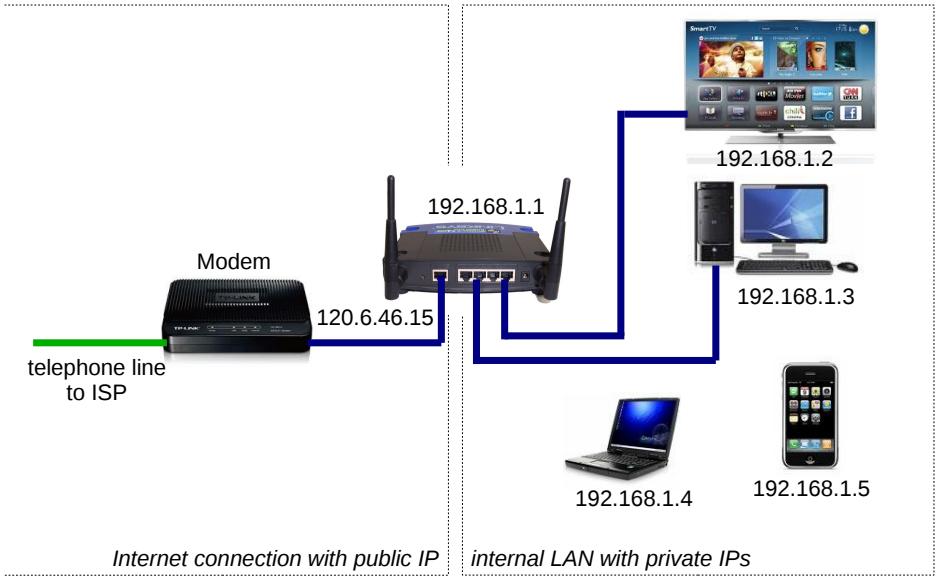
Quick Reference

- Router IP: 192.168.1.1
- Router username: root
- Router password: s11tnetw0rk
- Router name and SSID: ICTR*xx* (*xx*=10, 11, ...)
- iMac username: student
- iMac password: student
- Software: http://ict.siit.tu.ac.th/software/
- Workshop: http://ict.siit.tu.ac.th/moodle/

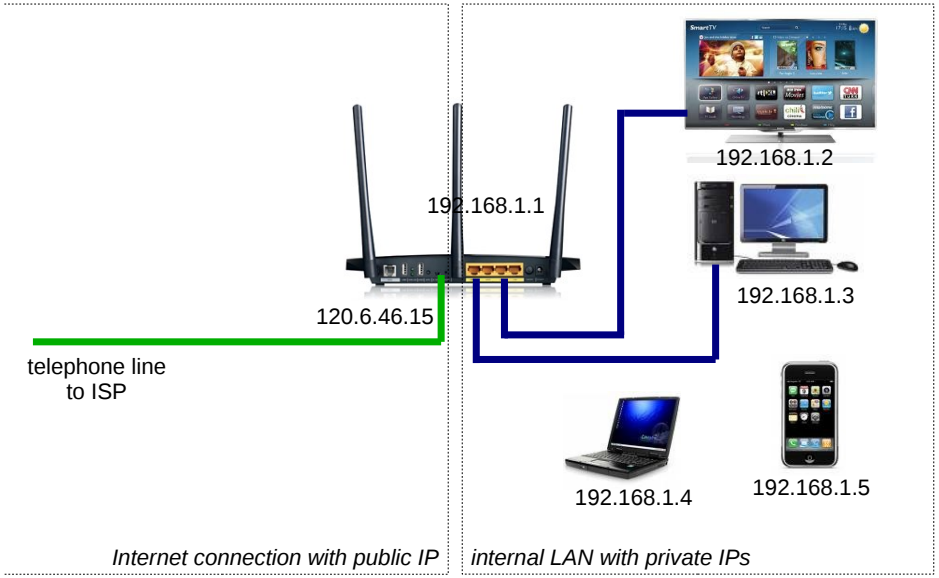
Wireless Routers



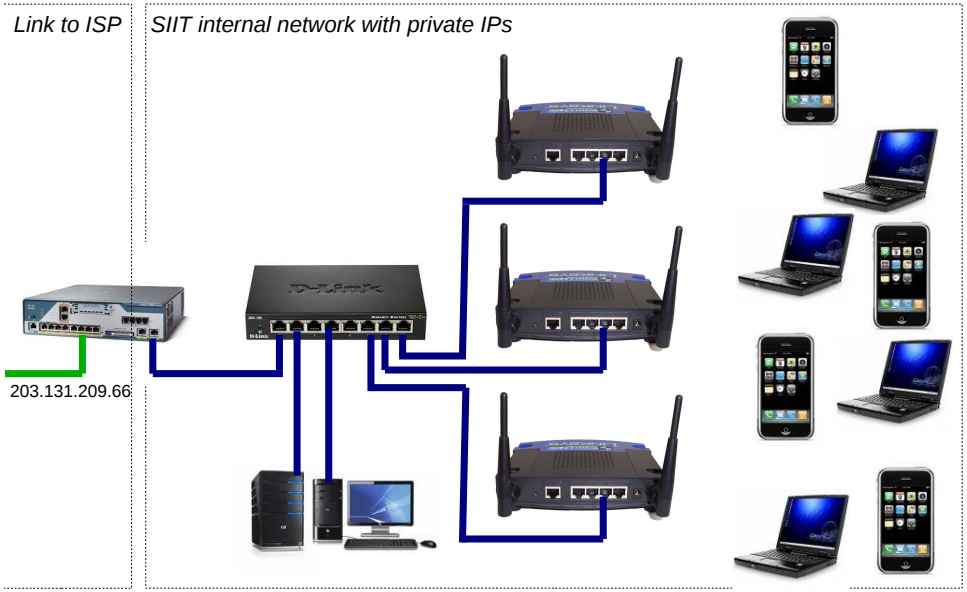
Wireless Router at Home

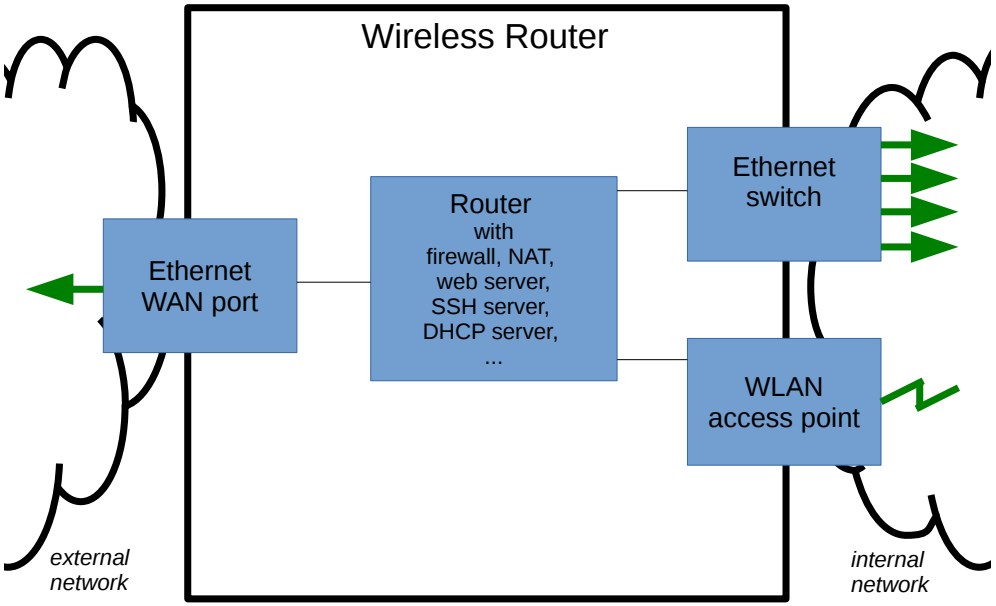


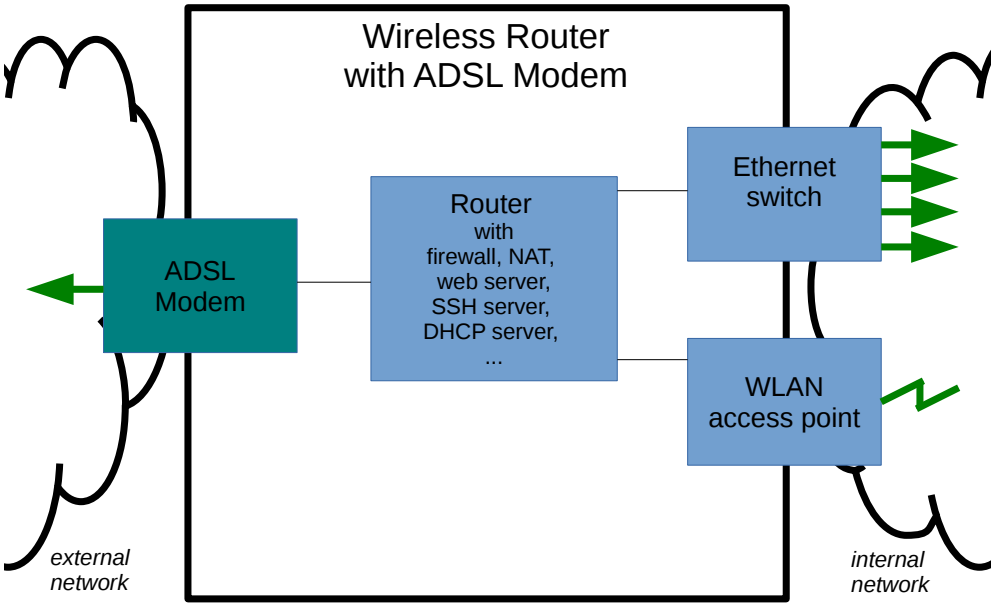
Wireless All-in-one Router at Home

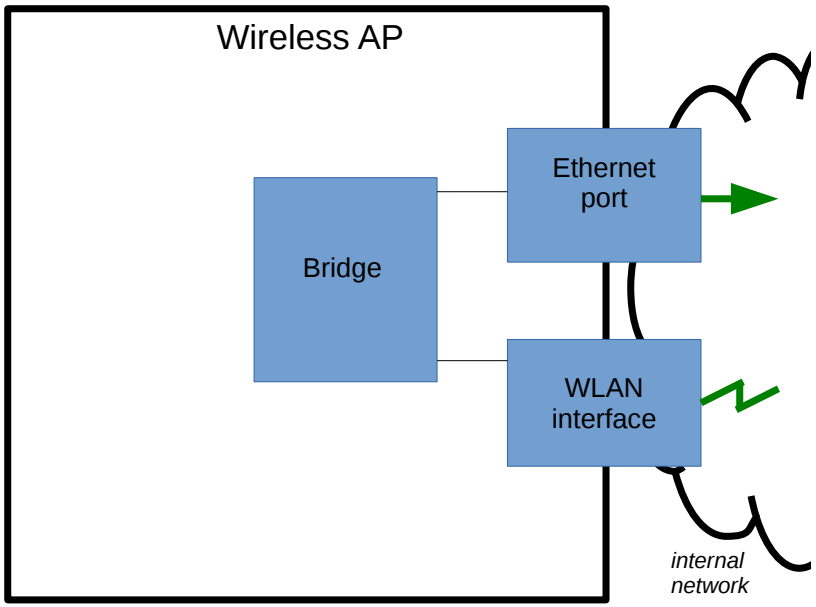


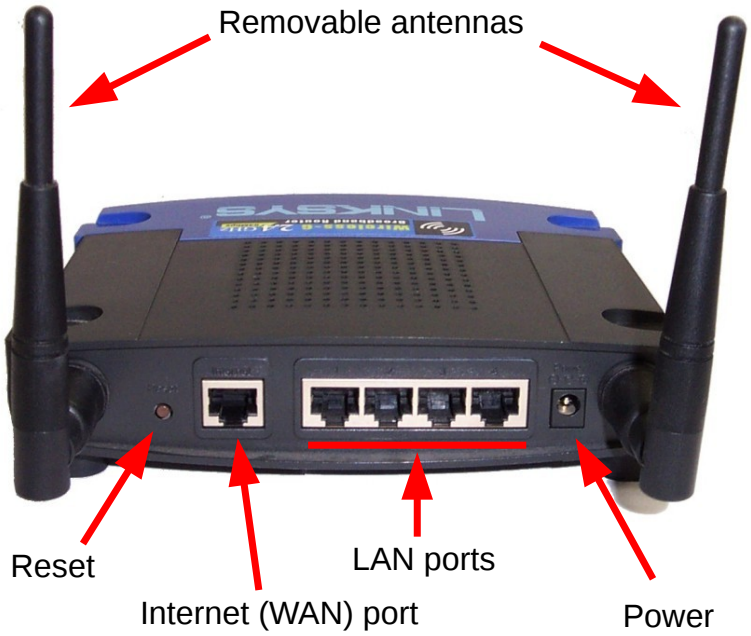
Wireless LAN AP at SIIT







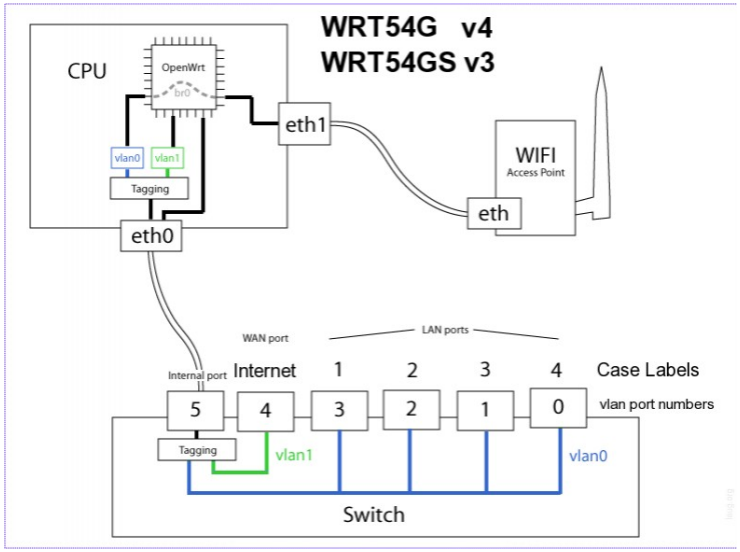


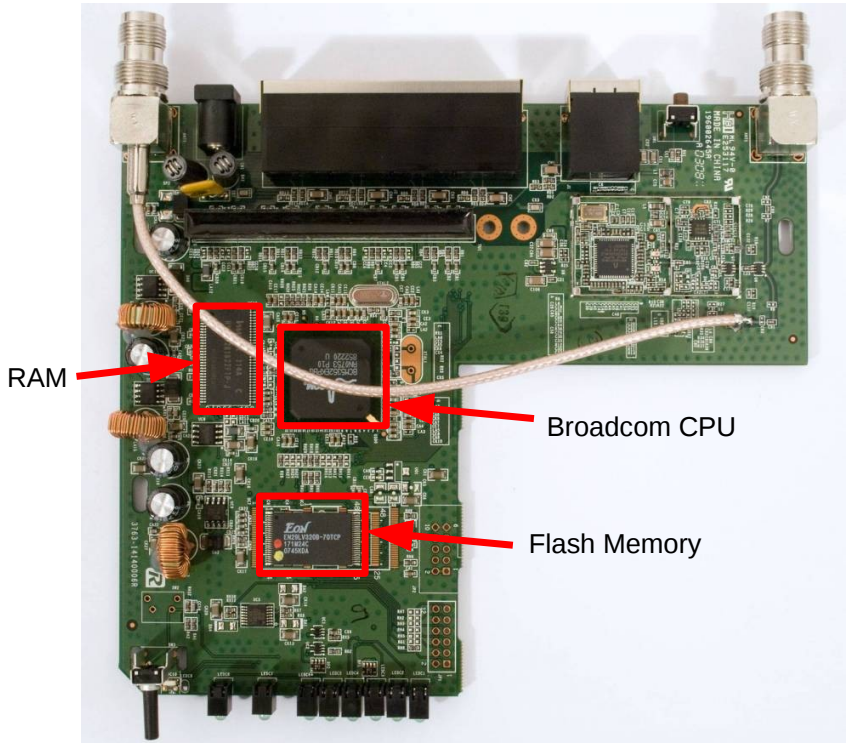


Linksys WRT54G(L)

Since 2003, popular wireless router with Linux firmware supports 3rd party firmware

• CPU: Broadcom 200MHz	*32-bit MIPS*
• Flash: 4MB	*Non-volatile storage*
• RAM: 16MB	*Volatile storage*
• Wireless chip: Broadcom (integrated)	*CPU + WiFi + Switch*
• Wireless PHY: 11b, 11g	*Up to 54 Mb/s*
• Wireless Tx Power: 63 mW	*Adjustable*
• Antenna: 2 x 2.2dBi dipole	*Removable RP-SMA*
• Wired ports: 5 x 10/100Mb/s	*4 x LAN + 1 x WAN*



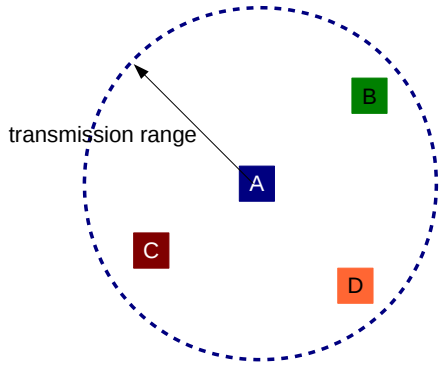


Wireless LANs

Wireless LANs

- IEEE 802.11 (standards), WiFi (marketing)
- Aim: Provide equivalent functionality to wired Ethernet
- Advantages of wireless:
  - No wires
  - Mobility
- Disadvantages of wireless:
  - More errors, varying delay: hard to achieve same performance as wires
  - Spectrum/frequencies available is limited: cannot just add more wires
  - Radio transmissions are broadcast: No “physical” security

Wireless LANs: Broadcast Radio



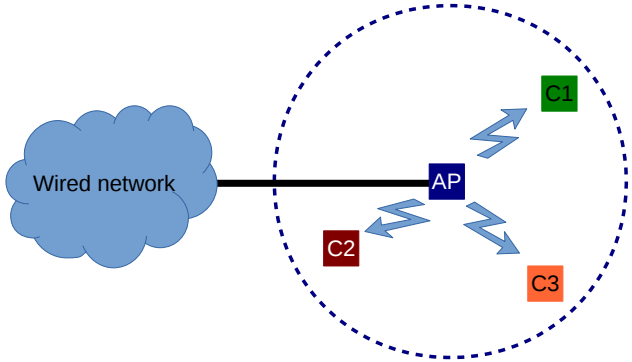
- Transmit signal at center frequency *f*, with bandwidth *BW*
- Devices with receives tuned to frequency *f* will receive the signal (if it has strong enough power)
- "Strong enough power": depends on transmit power, receiver characteristics, antennas, frequency, obstructions
- Assume maximum distance some signal can be transmitted is range

Wireless LANs: Broadcast Radio

- Everyone within range of transmitter receives the signal
- If two (or more) signals received at same time, then neither can be understood
  - Interference, a "collision" occurs
- IEEE 802.11 MAC protocol aims to ensure only one device transmits at a time
  - Good: No (or few) collisions
  - Bad: Each device must wait for other devices before it can send
    - Shared medium: divide the data rate by number of devices wanting to share

IEEE 802.11 Wireless LANs

- Access Point (AP): acts as a bridge between wireless segment (WiFi) and wired segment (Ethernet)
- Client: wireless communications to AP



IEEE 802.11 Wireless LANs

- Physical (PHY) Layer:
  - Defines how to send wireless signals between devices
  - Data rate, frequency, bandwidth, power, modulation, ...
  - Different standards: 802.11a, 802.11b, 802.11g, ...
- Medium Access Control (MAC) Layer:
  - Defines how to efficiently send data between devices while sharing the medium
  - Common across different PHY standards

Wireless LAN PHY Characteristics

TABLE I

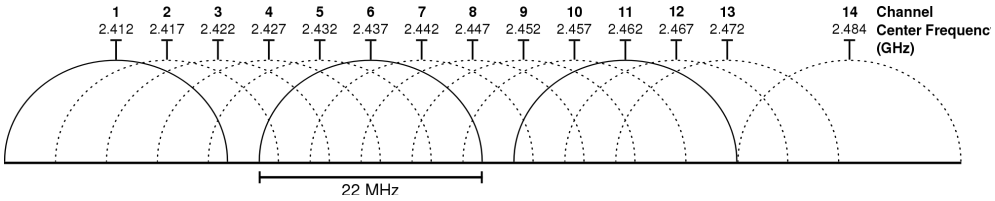
THE EVOLUTION OF THE 802.11 STANDARDS

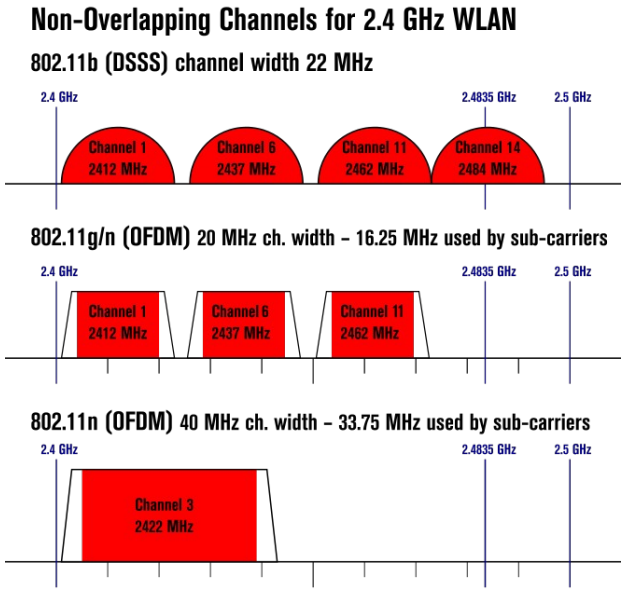
Protocol	Year Introduced	Maximum Data Transfer Speed	Frequency	Highest Order Modulation	Channel Bandwidth	Antenna Configurations
802.11a	1999	54 Mbps	5 GHz	64 QAM	20 MHz	1×1 SISO
802.11b	1999	11 Mbps	2.4 GHz	11 CCK	20 MHz	1×1 SISO
802.11g	2003	54 Mbps	2.4 GHz	64 QAM	20 MHz	1×1 SISO
802.11n	2009	65 to 600 Mbps	2.4 or 5 GHz	64 QAM	20 and 40 MHz	Up to 4×4 MIMO
802.11ac	2012	78 Mbps to 3.2 Gbps	5 GHz	256 QAM	20, 40, 80 and 160 MHz	Up to 8×8 MIMO; MU-MIMO

www.microwavejournal.com

Channels in 2.4 GHz Band

- 2.4 GHz ISM Band: 2.400 - 2.485 GHz
- Channel Bandwidth: ~20 MHz
- 11n, 11ac use larger bandwidth for higher data rate





5 GHz band allows for more non-overlapping channels and has less interference

Wireless LANs: Key Points

- Data Rate
  - Speed at which data sent between 2 devices
  - Varies according to PHY and distance
- Throughput:
  - MAC Overheads, e.g. headers, ACKs: 20-40%
    - 54 Mb/s - 25% overhead = 4 Mb/s
  - Waiting for others: divide by number of users
    - 10 users associated with AP: 4 Mb/s per user

Wireless LANs: Key Points

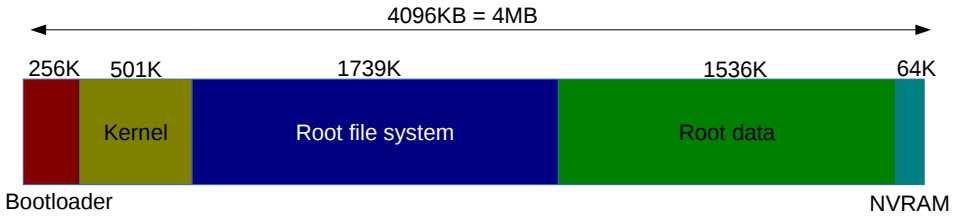
- Frequency Bands:
  - 2.4 GHz: supported by all devices; crowded
  - 5 GHz: not all APs, clients support; shorter range; less interference
- Channels:
  - Important when many nearby APs
  - 2 APs, 20 clients split amongst the APs
  - APs use same channel: 2 Mb/s per user
  - APs use non-overlapping channels: 4 Mb/s per user
  - 2.4 GHz band: channels 1, 6 and 11 (and 14)
  - 5 GHz band: 8 non-overlapping channels

Wireless LANs: Key Points

- Security:
  - None: no authentication or encryption
  - WEP: shared secret key, flawed
  - WPA: shared secret key (client and AP)
  - WPA Enterprise: authentication performed between client and separate server, encryption between client and AP

Wireless Router Firmware

WRT54GL Flash Memory



- Bootloader: loads firmware image into RAM, reads parameters from NVRAM
- Firmware image:
  - Linux Kernel
  - Root file system, e.g. permanent applications and libraries
  - Root data, e.g. config files, installed applications
- NVRAM: configurable parameters only used by bootloader

How to see this info? cat /proc/mtd and/or dmesg

Wireless Router Firmware - Normal Operation

- When router boots, bootloader loads firmware (kernel + root + data) into RAM and executes kernel
- Permanent changes can be written to “root data” on Flash
  - Edit configuration files
  - Install new applications
- Non-permanent changes can be written to temporary file system in RAM
  - Log files

Wireless Router Firmware - Flashing New Firmware

- Bootloader can be used to write a new firmware image
  - Replace kernel + root file system
- Two common options:
  - Existing firmware image has option to replace itself
  - Bootloader includes simple application (TFTP) to allow transfer of firmware image to device upon boot
- Next time the device boots, bootloader loads the new kernel + root file system

Wireless Router Firmware

- All wireless routers come with manufacturer provided firmware
  - Based on Linux and other embedded OS
- 3rd party firmware projects, usually Linux-based
  - OpenWRT: configurable with latest developments, free, open source software
  - DD-WRT: based on OpenWRT, ready-to-use, includes proprietary components
  - Tomato: ready-to-use, includes proprietary components
  - and others

OpenWRT

- Open source Linux distribution for embedded network devices
- Base packages provided as downloadable firmware image for many different devices
- Package manager (opkg) allows additional packages to be installed
- Different versions:
  - 14.07 Barrier Breaker
  - 12.09 Attitude Adjustment
  - 10.03 Backfire
  - 8.09 Kamikaze

Challenges with OpenWRT (and other 3rd party firmware)

- Only work for selected wireless routers, primarily those that use Linux-based manufacturer firmware
- Delay between release of new router and firmware image release
- Without open source drivers (or binary drivers provided by chip manufacturers) router features may not work
  - E.g. 802.11ac drivers are not yet common
- Performance with open source drivers may be worse (or better!) then manufacturer drivers

Mac OSX Command Line

Mac OSX File Sharing

- File Sharing
  - System Preferences → Sharing
  - File Sharing: On
- Connect to another iMac:
  - Finder → Shared → iMac_xx
- Public Shared Directory:
  - Yours: `/Users/student/Public`
  - Theirs: `/Volumes/student's Public Folder`
- Create 20 MB random file in Terminal:

```
$ dd if=/dev/urandom of=rand.bin bs=20m count=1
```

Mac OSX Commands

- Time a command on Terminal:

```
$ cd /Volumes/students' Public Folder
$ time cp rand.bin ~/
real  0m8.804s
...
```

- View interfaces (en0 Ethernet, en1 WiFi):

```
$ ifconfig en1
```

- Change MAC address:

```
$ sudo ifconfig en1 ether aa:bb:cc:11:22:33
```

Mac OSX Software Installs

- http://ict.siit.tu.ac.th/software/osx/
- XQuartz (needed by Wireshark)
- Wireshark

Example Wireless Networks

Mac OSX Packet Capture

- Link to airport: (only needed once)

```
sudo ln -s
/System/Library/PrivateFrameworks/Apple80211.fr
amework/Versions/Current/Resources/airport
/usr/local/bin/airport
```

- Search for active channels:

```
$ sudo airport en1 -s
```

- Start capture on channel 6:

```
$ sudo airport en1 sniff 6
```

(Ctrl-C to quit)

- View the .cap file with tcpdump or Wireshark

Setup the Wireless Router

- Explore OpenWRT web interface
  - View Stats: Status → Realtime Graphs → ...
  - Config Wifi: Network → Wifi → Edit → ...
  - Install software: System → Software →...
  - Edit firewall: Network → Firewall → ...

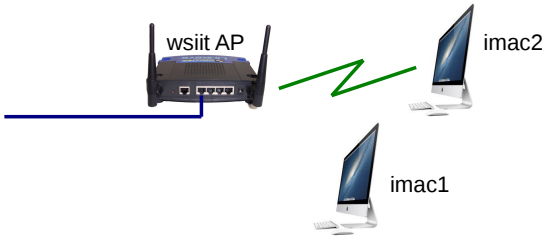
Measure Performance

- Compare delay across Ethernet vs WiFi
  - imac1: `ping 192.168.1.1`
  - imac2: `ping 192.168.1.1`
- Measure throughput across WiFi
  - Setup File Sharing on iMacs
  - imac1: Create 20MB random file in Public directory

    ```
    $ dd if=/dev/urandom of=rand.bin bs=20m count=1
    ```
  - imac2: Copy file from imac1 shared directory to home

    ```
    $ time cp /Volumes/students' Public Folder/rand.bin ~/
    ```

Intercept Other Peoples Data



- iMac1: Start packet capture
- iMac2: Access website (via SIIT internet)
- iMac1: Stop packet capture and view .cap file in Wireshark
  - Filter by 'http' and/or 'ip==10.10.x.y'

Use Wireless Router as Client

- In OpenWRT web interface:
  - Network → Wifi → Scan
    - Join Network
    - Default parameters (wwan, …)
    - Save and Apply
- Now use iMac to access SIIT internet via router

Setup a Rogue AP and Redirect HTTPS Login Web Pages to Unencrypted HTTP Logins

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