

Emerging Wireless Networking Technologies

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Outline

- ▶ Introduction
- ▶ Wireless Networks
 - ▶ Benefits
 - ▶ How to design
 - ▶ Categories
- ▶ Demos
- ▶ Case Studies
- ▶ Certifications
- ▶ Conclusions

Wireless Personal Area
Networks (PAN)

Wireless Local Area
Networks (WLAN)

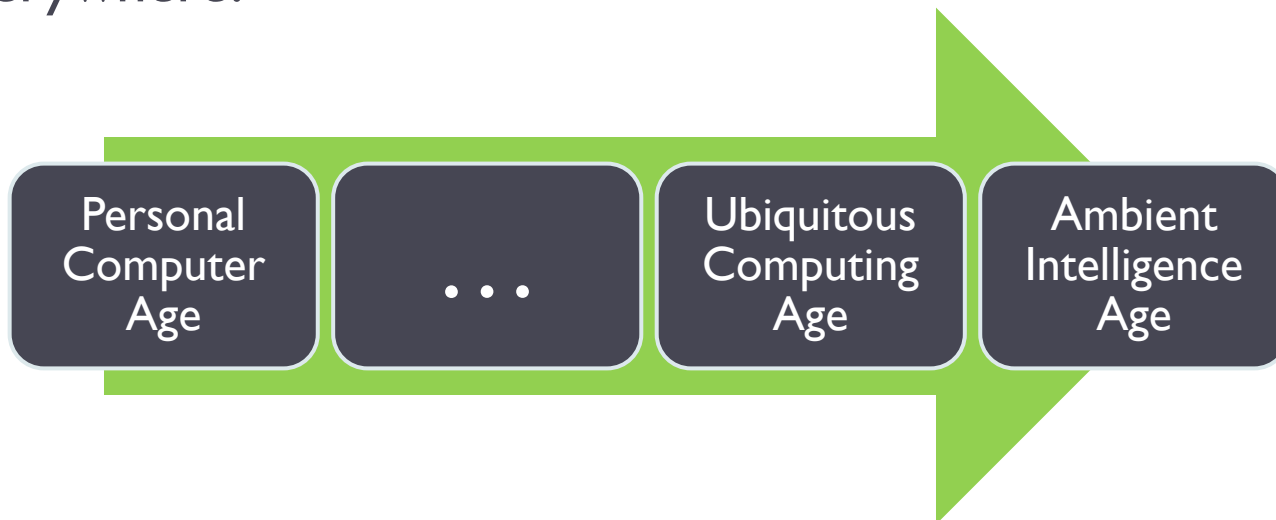
Wireless Metropolitan
Area Networks
(WMAN)

Wireless Sensor
Networks (WSN)

Wireless Mesh
Networks (WMN)

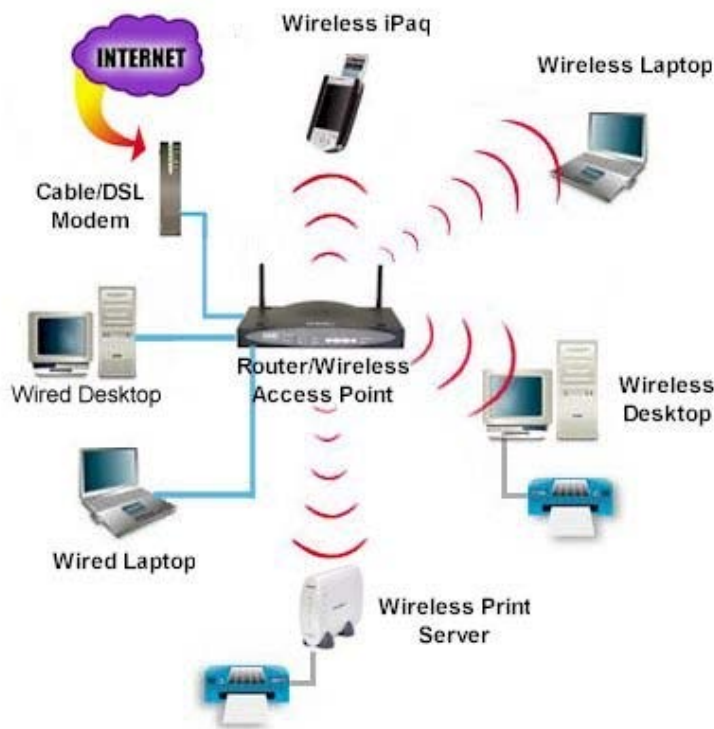
Introduction

- ▶ Why Wireless Networks?
 - ▶ People moves.
 - ▶ Wired Networks vs. Wireless Networks.
 - ▶ People today have more portable devices:
 - ▶ Laptops, PDAs, smartphones, gadgets.
 - ▶ People expect to be connected and use the network everywhere.



Wireless Networks

- ▶ A network that uses radio signal frequencies to communicate among computers and other network devices.
- ▶ One of the most important technologies today!



Wireless Networks: Benefits

Mobility	<ul style="list-style-type: none">• People moves, devices too.
Cost	<ul style="list-style-type: none">• Cheap to develop.
Installation	<ul style="list-style-type: none">• Wireless can install anywhere.
Ease of use	<ul style="list-style-type: none">• Plug & Play.
Transparency	<ul style="list-style-type: none">• Users work similar like wired LANs.
Time savings	<ul style="list-style-type: none">• Temporary networks

Design a Wireless Network: Requirements

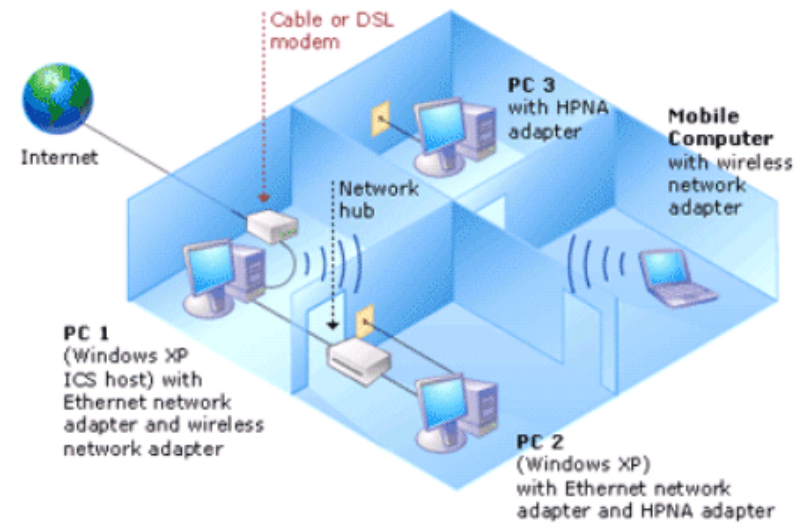
- ▶ Before choosing a wireless networking technology
 - ▶ Try to understand the requirements.
- ▶ Find the right devices.



Design a Wireless Network: Examples

▶ In the office environment:

- ▶ Small coverage
- ▶ Moderate data rate
- ▶ Low cost
- ▶ Moderate mobility
- ▶ Security



▶ In the battle field:

- ▶ Strong planning and design
- ▶ Large coverage
- ▶ High mobility
- ▶ Reliability
- ▶ Strong security





Categories of Wireless Networks

- ▶ Cellular networks
 - ▶ GSM, CDMA, WiMAX.
- ▶ Wireless Personal Area Networks (WPAN)
 - ▶ Bluetooth, Wibree, Zigbee.
- ▶ Wireless Local Area Networks (WLAN)
 - ▶ Standards IEEE 802.11
- ▶ Wireless Metropolitan Area Networks (WMAN)
 - ▶ Standards IEEE 802.16 (WiMAX)
- ▶ Wireless Sensor Networks (WSN)
 - ▶ Based on the wireless networks
- ▶ Wireless Mesh Networks (WMN)
 - ▶ Built with the existing network technologies: WPAN, WLAN, WMAN.

Cellular Networks

Gen.	Technology	Features
1G	<ul style="list-style-type: none">• AMPS	<ul style="list-style-type: none">• Analog Voice Communication only.
2G	<ul style="list-style-type: none">• GSM• IS-95 CDMA	<ul style="list-style-type: none">• Digital voice and data<ul style="list-style-type: none">• Simple email and text messages
3G	<ul style="list-style-type: none">• WCDMA (European)• CDMA2000 (USA)• TD-SCDMA (China)	<ul style="list-style-type: none">• Data transfer rates up to 2.4Mbps• Supports better Internet connections<ul style="list-style-type: none">• Video.
4G	<ul style="list-style-type: none">• WiMAX (USA)	<ul style="list-style-type: none">• Based on Internet technology• Very high speed (>100Mbps)

Wireless Personal Area Networks (WPAN)

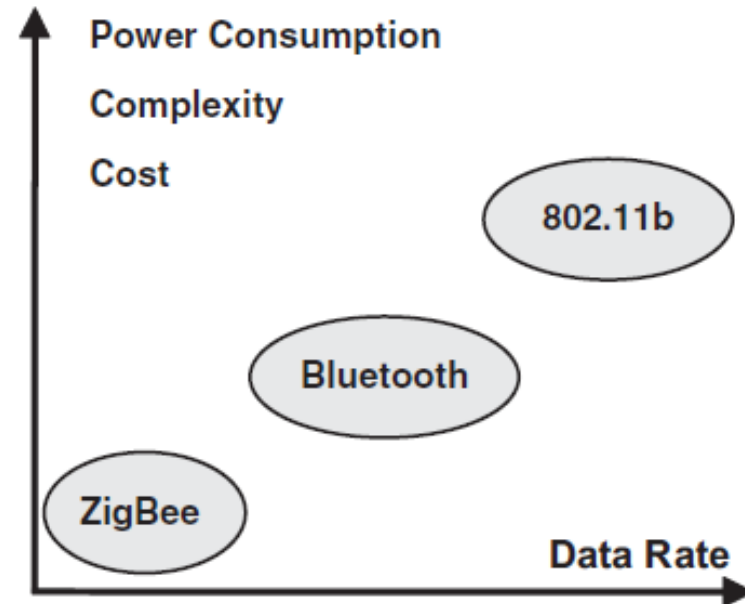
- ▶ Bluetooth, Wibree and Zigbee.
- ▶ Features:
 - ▶ Low Power
 - ▶ Coverage (radius < 10 meters)
- ▶  **Bluetooth™**
 - ▶ Operates in the 2.4 GHz spectrum.
 - ▶ Standards:
 - ▶ IEEE 802.15.1: Bluetooth v1.1
 - ▶ IEEE 802.15.3: High data rate (11~55Mbps)
 - ▶ IEEE 802.15.5: Enable Mesh networking
- ▶  **wibree**
 - ▶ Bluetooth low energy technology
 - ▶ Bluetooth ULP (Ultra Low Power)



Zigbee - IEEE 802.15.4



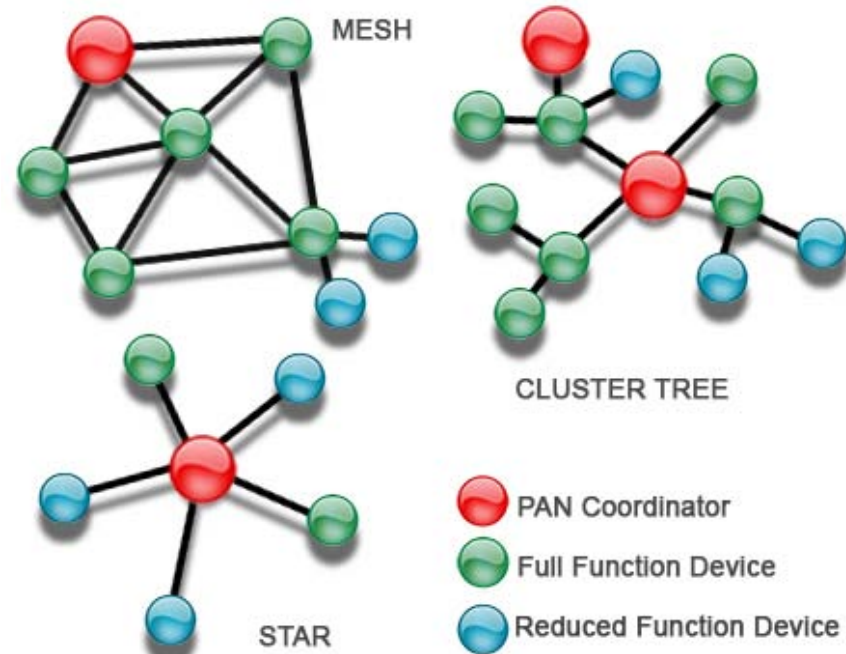
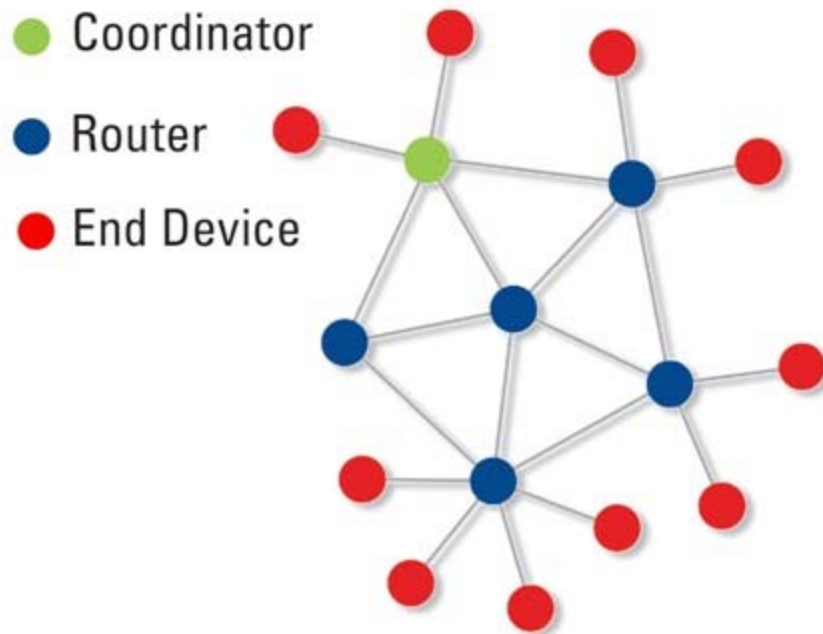
- ▶ Zigbee Alliance
 - ▶ Group of developers, vendors and manufacturers.
- ▶ IEEE 802.15.4 standard
- ▶ Uses 2.4 GHz spectrum
- ▶ Features:
 - ▶ Low cost, power and bandwidth.
 - ▶ Powered by long-life batteries.
 - ▶ Simpler, cheaper than Bluetooth.



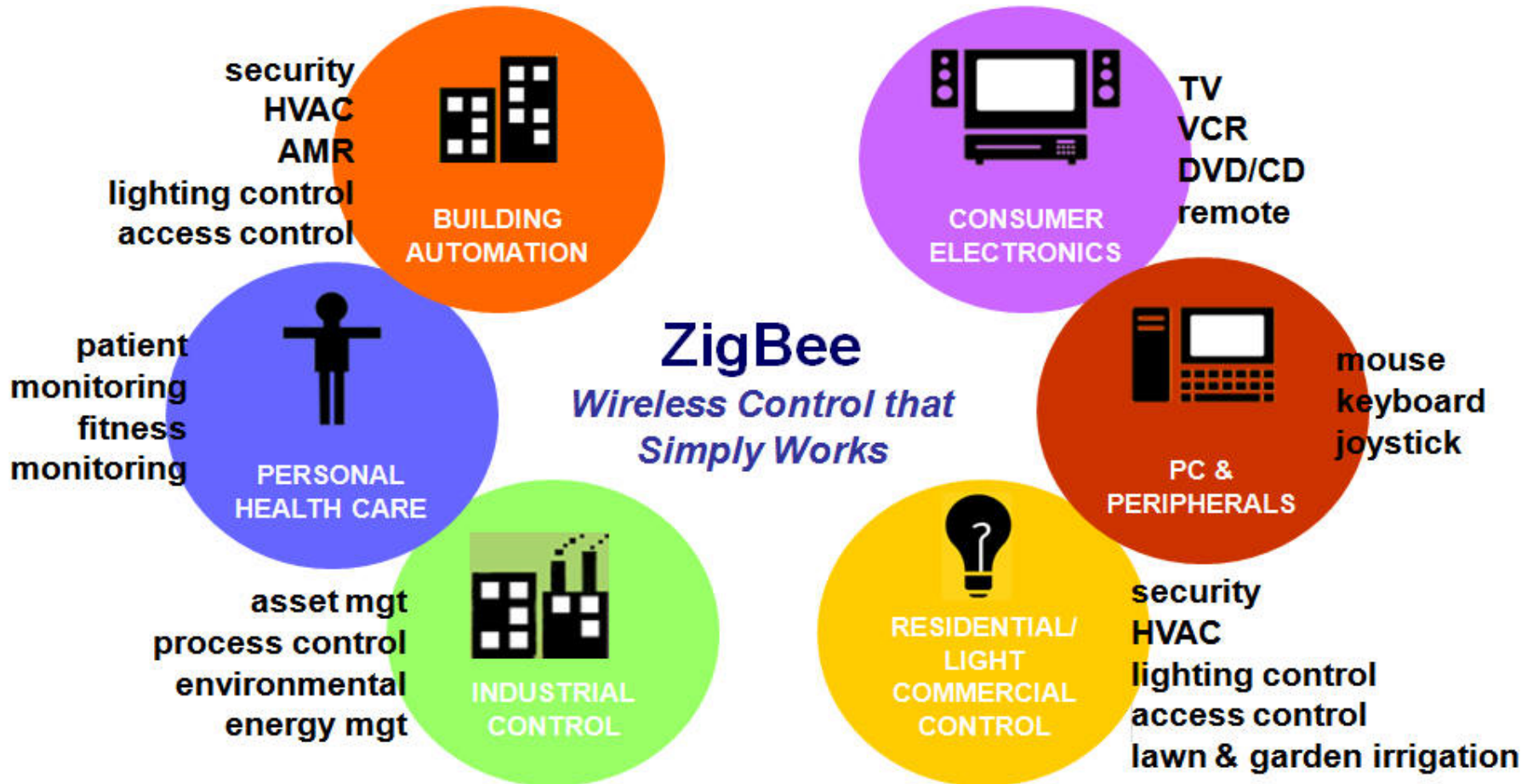
Zigbee: Topology



- ▶ Coordinator (ZC): Only one, Most Capability, functionality.
- ▶ Router (ZR): Passes data among end-devices.
- ▶ End Device (ZED): switches, detectors.



Zigbee: Applications



WPAN: Comparison

	Bluetooth	Wibree	ZigBee
Band	2.4GHz	2.4GHz	2.4GHz, 868MHz, 915MHz
Antenna/HW	Shared		Independent
Power	100 mW	~10 mW	30 mW
Target Battery Life	Days - months	1-2 years	6 months - 2 years
Range	10-30 m	10 m	10-75 m
Data Rate	1-3 Mbps	1 Mbps	25-250 Kbps
Component Cost	\$3	Bluetooth + 20¢	\$2
Network Topologies	Ad hoc, point to point, star	Ad hoc, point to point, star	Mesh, ad hoc, star
Security	128-bit encryption	128-bit encryption	128-bit encryption
Time to Wake and Transmit	3s	TBA	15ms

Wireless Local Area Networks (WLANs)

- ▶ The most popular Wireless network
- ▶ Coverage
 - ▶ Radius < 200~500 meters
- ▶ Wi-Fi
 - ▶ Trademark of the Wi-Fi Alliance.
 - ▶ To certify products based on the IEEE 802.11 standards.
- ▶ Applications: Medicine, Education, Government, Public Access, etc.

Protocol	Release Date	Op. Frequency	Data Rate (Typ)	Data Rate (Max)	Range (Indoor)
Legacy	1997	2.4 -2.5 GHz	1 Mbit/s	2 Mbit/s	?
802.11a	1999	5.15-5.35/5.47-5.725/5.725-5.875 GHz	25 Mbit/s	54 Mbit/s	~50 meters
802.11b	1999	2.4-2.5 GHz	6.5 Mbit/s	11 Mbit/s	~100 meters
802.11g	2003	2.4-2.5 GHz	11 Mbit/s	54 Mbit/s	~100 meters
802.11n	2006 (draft)	2.4 GHz or 5 GHz bands	200 Mbit/s	540 Mbit/s	~250 meters

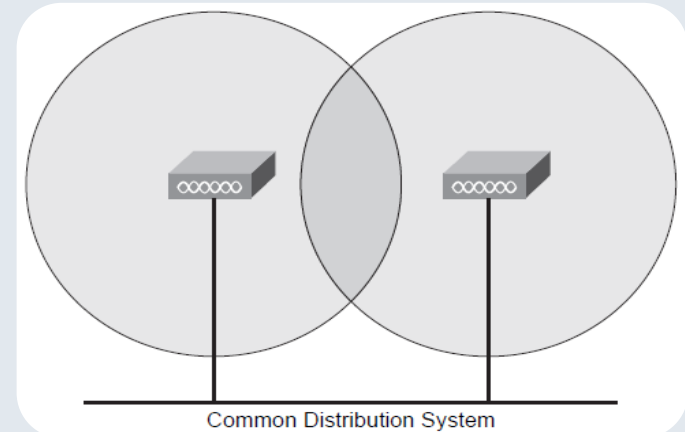
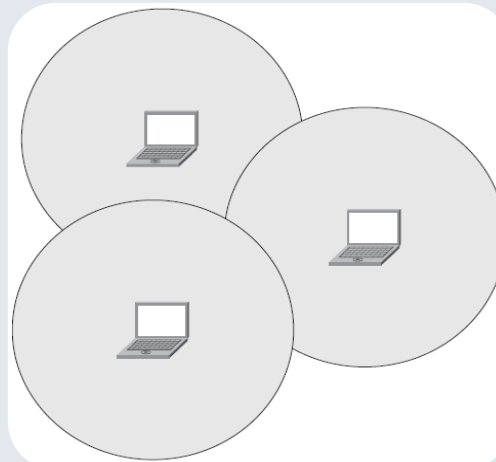
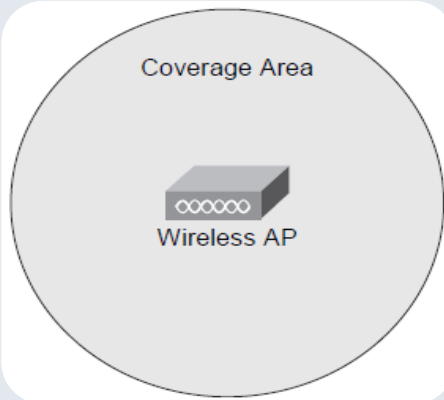
WLAN: More Standards (1)

- [IEEE 802.11a](#) - 54 Mbit/s, 5 GHz standard (1999, shipping products in 2001)
- [IEEE 802.11b](#) - Enhancements to 802.11 to support 5.5 and 11 Mbit/s (1999)
- IEEE 802.11c - Bridge operation procedures; included in the [IEEE 802.1D](#) standard (2001)
- [IEEE 802.11d](#) - International (country-to-country) roaming extensions (2001)
- [IEEE 802.11e](#) - Enhancements: [QoS](#), including packet bursting (2005)
- [IEEE 802.11F](#) - *Inter-Access Point Protocol* (2003) *Withdrawn February 2006*
- [IEEE 802.11g](#) - 54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)
- [IEEE 802.11h](#) - Spectrum Managed 802.11a (5 GHz) for European compatibility (2004)
- [IEEE 802.11i](#) - Enhanced security (2004)
- [IEEE 802.11j](#) - Extensions for Japan (2004)
- IEEE 802.11-2007 - A new release of the standard that includes amendments a, b, d, e, g, h, i & j. (July 2007)
- [IEEE 802.11k](#) - Radio resource measurement enhancements (2008)
- [IEEE 802.11n](#) - Higher throughput improvements using MIMO (multiple input, multiple output antennas) (November 2009)
- [IEEE 802.11p](#) - WAVE - Wireless Access for the Vehicular Environment (such as ambulances and passenger cars)

WLAN: More Standards (2)

- IEEE 802.11r - Fast [roaming](#) Working "Task Group r" - (2008)
- [IEEE 802.11s](#) - Mesh Networking, [Extended Service Set](#) (ESS) (working - September 2010)
- IEEE 802.11T - Wireless Performance Prediction (WPP) - test methods and metrics Recommendation cancelled
- IEEE 802.11u - Interworking with non-802 networks (for example, cellular) (working - September 2010)
- IEEE 802.11v - Wireless [network management](#) (working - June 2010)
- IEEE 802.11w - Protected Management Frames (working - September 2009)
- IEEE 802.11y - 3650-3700 MHz Operation in the U.S. (2008)
- IEEE 802.11z - Extensions to Direct Link Setup (DLS) (August 2007 - December 2011)
- IEEE 802.11aa - Robust streaming of Audio Video Transport Streams (March 2008 - June 2011)
- IEEE 802.11mb - Maintenance of the standard. Expected to become 802.11-2011. (ongoing)
- IEEE 802.11ac - Very High Throughput <6GHz (September 2008 - December 2012)
- IEEE 802.11ad - Extremely High Throughput 60GHz (December 2008 - December 2012)

WLAN: Topologies



Infrastructure

- BSS
 - Basic Service Set
- Needs an AP
- BSSID = SSID
 - Basic Service Set Identifier

Ad-Hoc

- IBSS
 - Independent BSS
- Peer to peer
- AP is not necessary

Extended Service Set

- ESS=BSSs+DS
 - Multiple BSS
 - Distribution System

WLAN: Security

WEP

- RC4 Algorithm
- Vulnerable to attacks
- 64 & 128 bit keys

SSID Hiding

- Do not allow SSID broadcast.

MAC Filtering

- Set up into the router.

WPA & WPA2

- Replacement for WEP
- WPA2
 - Based on IEEE 802.11i
- Use AES & TKIP

WEP: Wired Equivalent Privacy

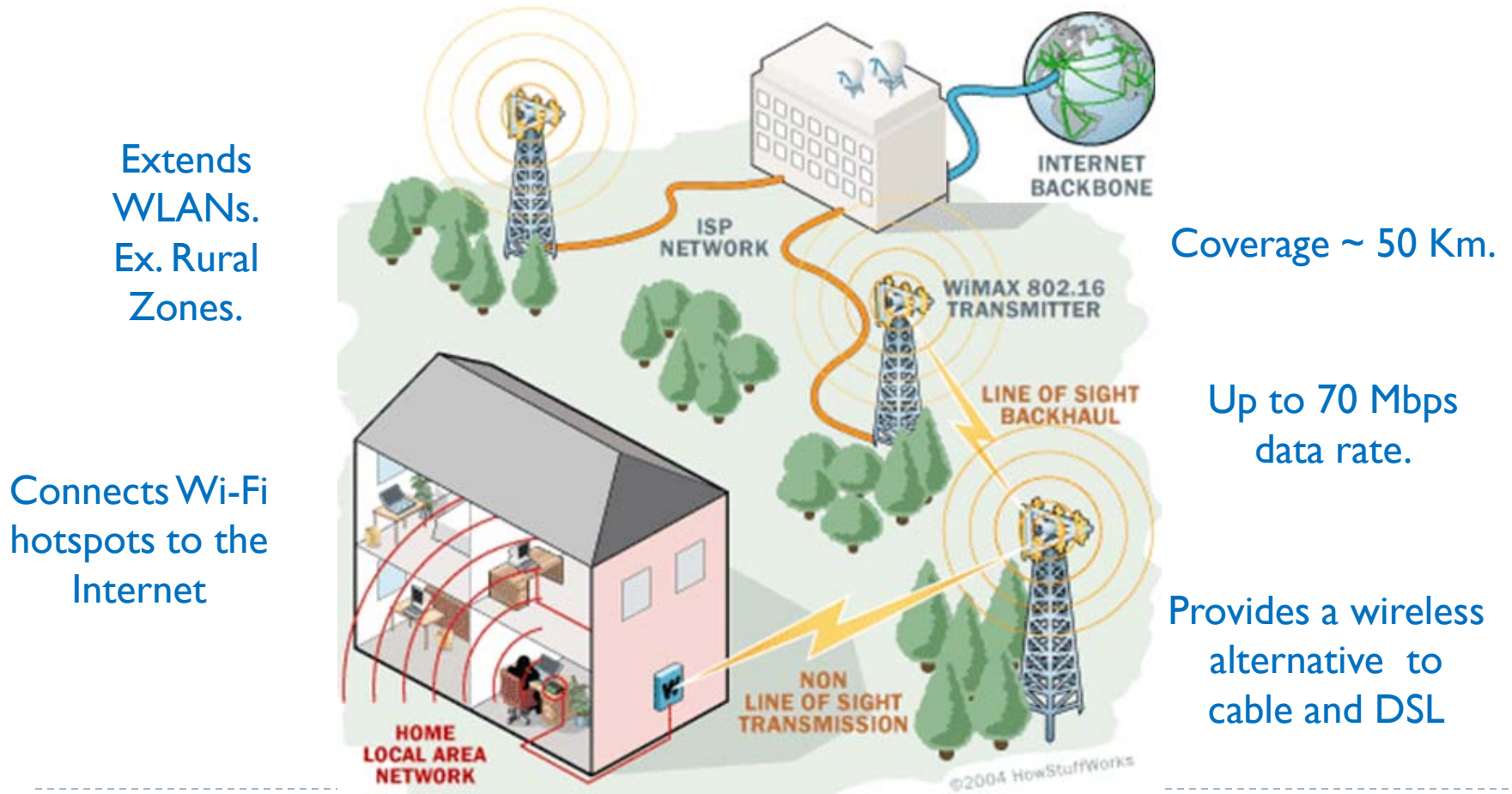
WPA: Wi-Fi Protected Access

AES: Advanced Encryption Standard

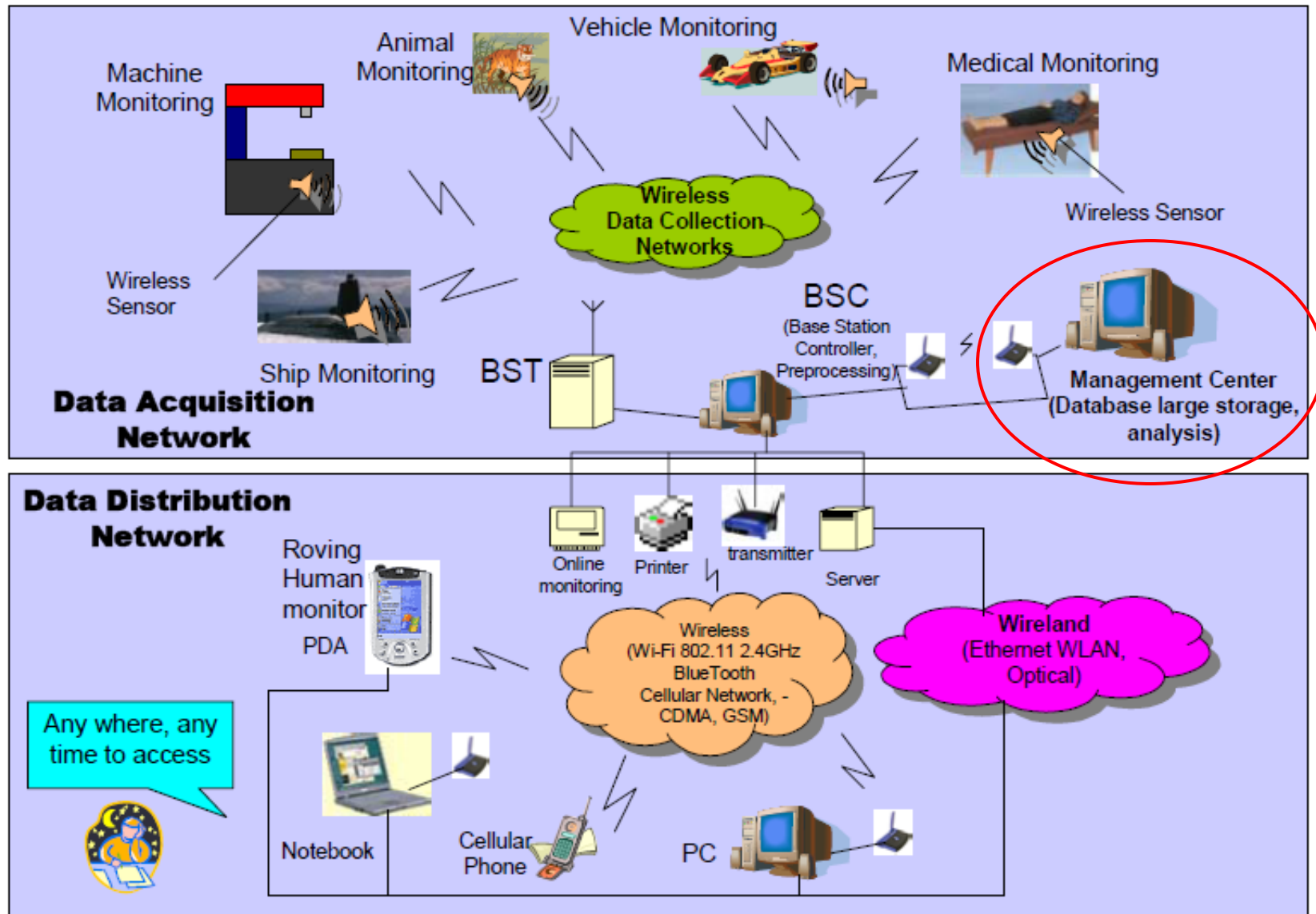
TKIP: Temporal Key Integrity Protocol

Wireless Metropolitan Area Networks (WMAN)

- ▶ IEEE 802.16 (WiMAX, Worldwide Interoperability for Microwave Access)
- ▶ WiMAX Forum: To promote compatibility and interoperability



Wireless Sensor Networks (WSN)

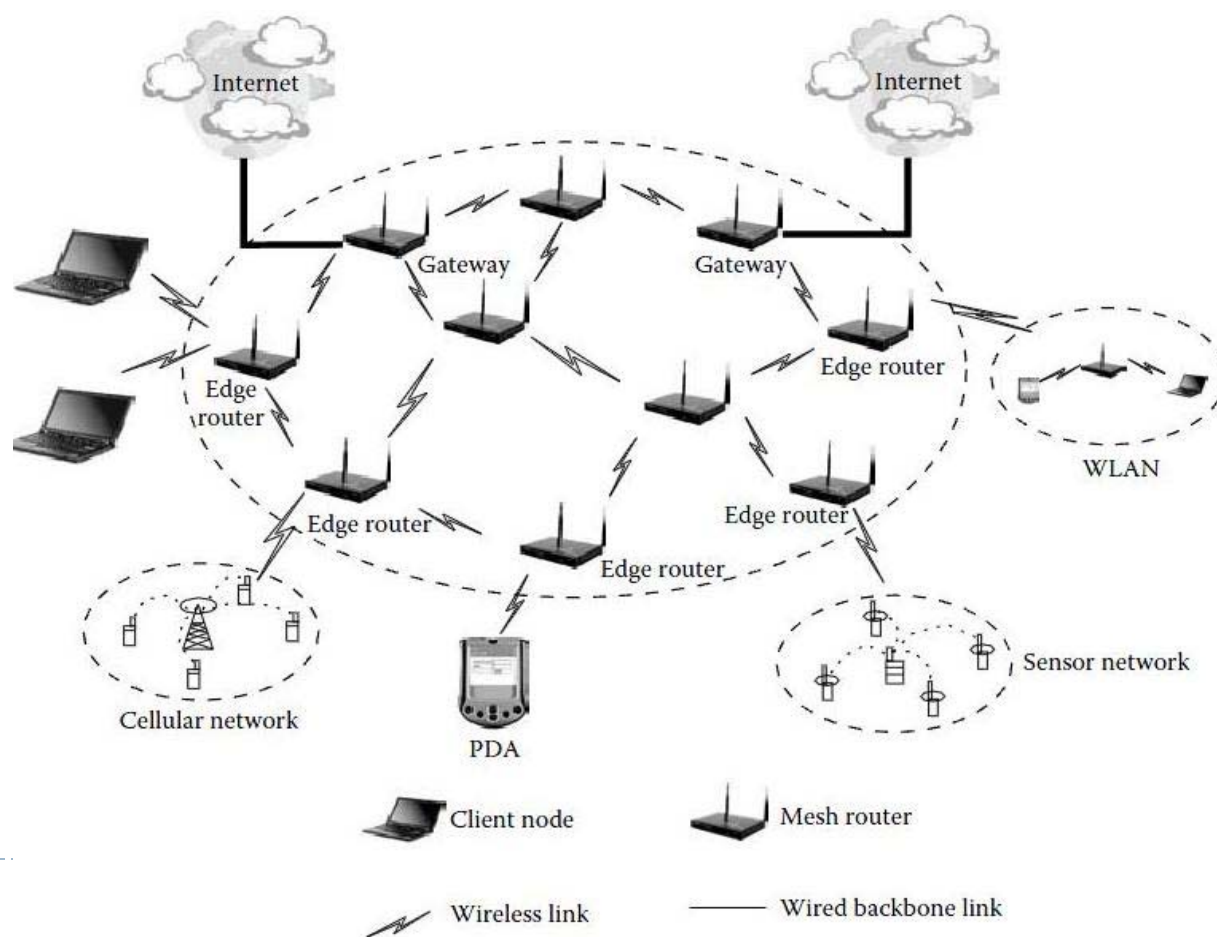


Wireless Mesh Networks (WMNs)

- ▶ Type of Mobile Ad Hoc Network (MANETs).
- ▶ Built with the existing network technologies
 - ▶ WPAN, WLAN, WMAN.
- ▶ Focus:
 - ▶ Multihop communications.
- ▶ **Principal Features:**
 - ▶ Self-forming
 - ▶ Self-healing
 - ▶ Self-organizing

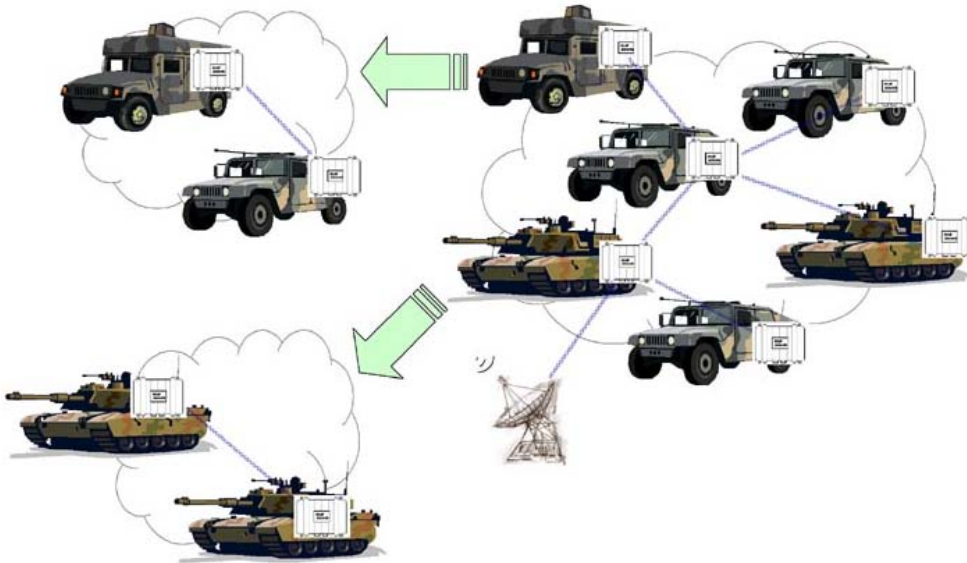
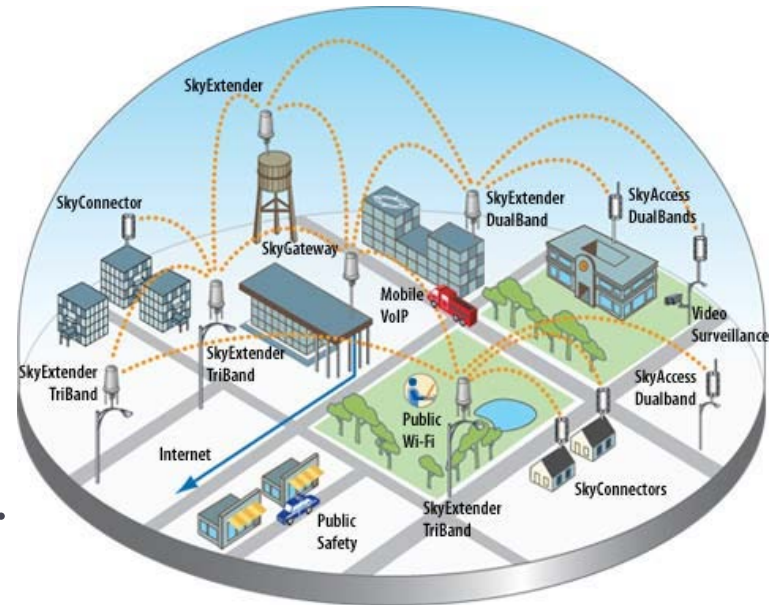
WMNs: Architecture

- ▶ Consist of mesh routers and mesh clients.
- ▶ Mesh routers have minimal mobility and form the mesh backbone for mesh clients.



WMNs: Applications

- ▶ Community networks
- ▶ Municipality networks
- ▶ Defense
- ▶ Emergency networks
- ▶ Intelligent transport systems, ..



Existing Testbeds

OVERVIEW OF WMNs TESTBED PROJECTS

Project	Nodes	802.11	Software	Routing		Roaming	Config	MANET
				Layer	Protocol			
MIT Roofnet	37	b/g	Linux	RL	SrcRR	—	×	—
Microsoft	21	a/b/g	Windows CE	MAC	MCL	—	×	×
USCB MeshNet	25	a/b/g	OpenWRT	IP	MCL	—	×	—
Purdue	32	a/b/g	—	IP	AODV	—	×	—
Georgia Tech	15	b/g	—	—	AODV,OLSR	—	—	—
Carleton Univ.	??	a/g	μClinux	IP	—	—	×	—
Hyacinth	10	a	Windows XP	—	OLSR	×	×	—
UMIC-Mesh.net	51	a/b/g	Linux	IP	DYMO,OLSR	×	×	×

DEMOs:

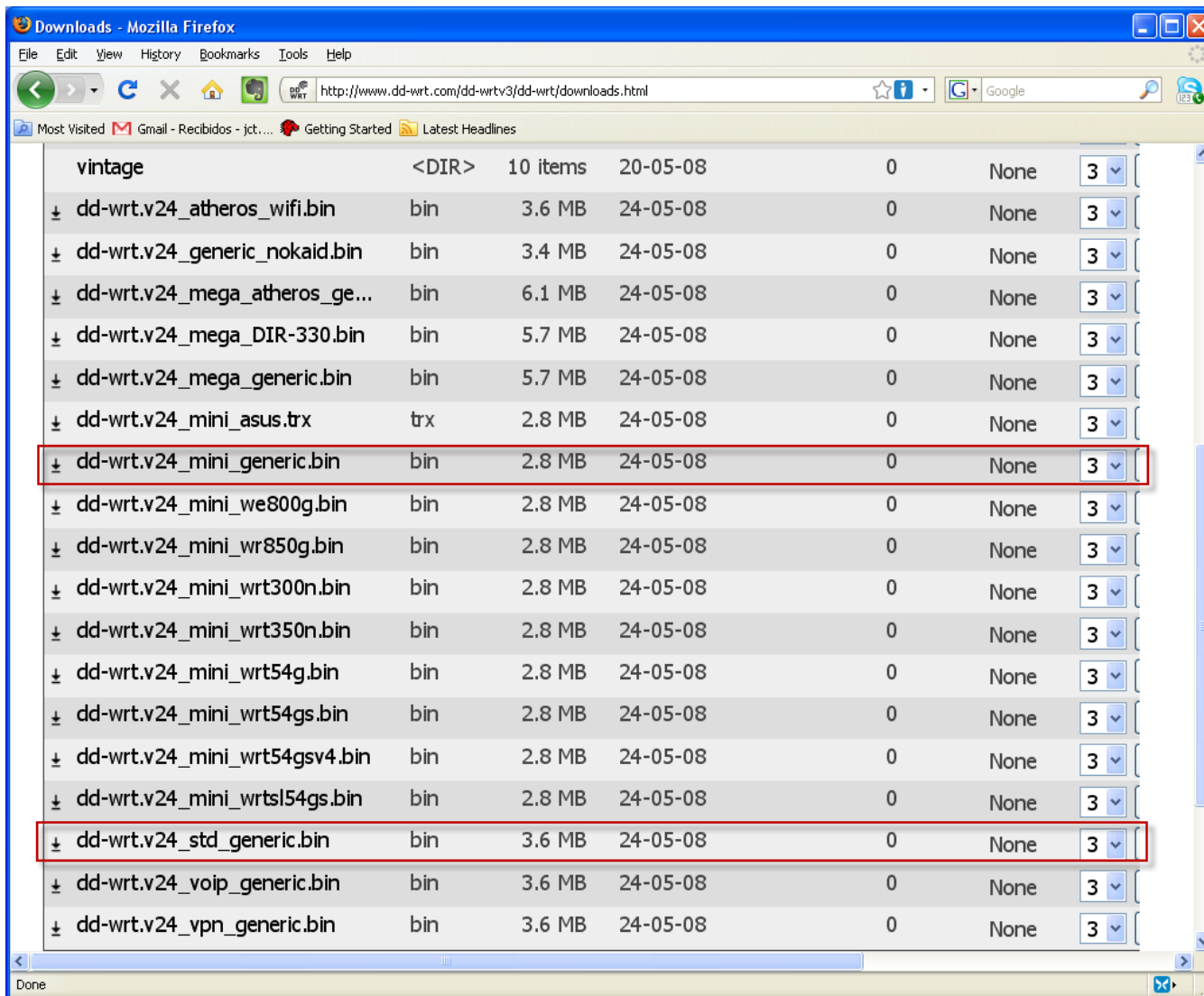


Install
DD-WRT
firmware into the
Linksys WRT54GL
Router

Set up a secure
Wireless Network

Set up a Wireless
Mesh Network
with OLSR

Install DD-WRT firmware: Download files (1)



The screenshot shows a Mozilla Firefox browser window with the address bar displaying <http://www.dd-wrt.com/dd-wrtv3/dd-wrt/downloads.html>. The page content shows a list of firmware files for download. The files are organized into a table with columns for file name, type, size, date, and other details. Two files are highlighted with red boxes: 'dd-wrt.v24_mini_generic.bin' and 'dd-wrt.v24_std_generic.bin'.

File Name	Type	Size	Date	Other
vintage	<DIR>	10 items	20-05-08	0 None 3
dd-wrt.v24_atheros_wifi.bin	bin	3.6 MB	24-05-08	0 None 3
dd-wrt.v24_generic_nokaid.bin	bin	3.4 MB	24-05-08	0 None 3
dd-wrt.v24_mega_atheros_ge...	bin	6.1 MB	24-05-08	0 None 3
dd-wrt.v24_mega_DIR-330.bin	bin	5.7 MB	24-05-08	0 None 3
dd-wrt.v24_mega_generic.bin	bin	5.7 MB	24-05-08	0 None 3
dd-wrt.v24_mini_asus.trx	trx	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_generic.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_we800g.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wr850g.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrt300n.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrt350n.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrt54g.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrt54gs.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrt54gsv4.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_mini_wrtsl54gs.bin	bin	2.8 MB	24-05-08	0 None 3
dd-wrt.v24_std_generic.bin	bin	3.6 MB	24-05-08	0 None 3
dd-wrt.v24_voip_generic.bin	bin	3.6 MB	24-05-08	0 None 3
dd-wrt.v24_vpn_generic.bin	bin	3.6 MB	24-05-08	0 None 3

Install DD-WRT firmware: Original (2)

The screenshot shows the Linksys WRT54GL web interface. The top header includes the Linksys logo and 'A Division of Cisco Systems, Inc.' on the left, and 'Firmware Version: v4.30.11' on the right. Below the header is a navigation bar with 'Setup' as the active tab, and sub-tabs for 'Wireless', 'Security', 'Access Restrictions', 'Applications & Gaming', 'Administration', and 'Status'. The 'Setup' sub-tab is further divided into 'Basic Setup', 'DDNS', 'MAC Address Clone', and 'Advanced Routing'. The left sidebar has 'Internet Setup' and 'Network Setup' sections. The 'Internet Setup' section is expanded, showing 'Internet Connection Type' set to 'Automatic Configuration - DHCP'. Below this are fields for 'Router Name' (WRT54GL), 'Host Name', 'Domain Name', 'MTU' (Auto), and 'Size' (1500). The 'Network Setup' section is also expanded, showing 'Router IP' settings: 'Local IP Address' (192.168.1.1), 'Subnet Mask' (255.255.255.0), 'DHCP Server' (Enabled), 'Starting IP Address' (192.168.1.100), 'Maximum Number of DHCP Users' (50), 'Client Lease Time' (0 minutes), 'Static DNS 1' (0.0.0.0), and 'Static DNS 2' (0.0.0.0). A right-hand sidebar contains explanatory text for the DHCP settings.

LINKSYS®
A Division of Cisco Systems, Inc.

Firmware Version: v4.30.11

Wireless-G Broadband Router **WRT54GL**

Setup

Setup | Wireless | Security | Access Restrictions | Applications & Gaming | Administration | Status

Basic Setup | DDNS | MAC Address Clone | Advanced Routing

Internet Setup

Internet Connection Type: Automatic Configuration - DHCP

Optional Settings (required by some ISPs)

Router Name: WRT54GL

Host Name:

Domain Name:

MTU: Auto

Size: 1500

Network Setup

Router IP

Local IP Address: 192.168.1.1

Subnet Mask: 255.255.255.0

DHCP Server: ☒ Enable ☐ Disable

Starting IP Address: 192.168.1.100

Maximum Number of DHCP Users: 50

Client Lease Time: 0 minutes (0 means one day)

Static DNS 1: 0.0.0.0

Static DNS 2: 0.0.0.0

Automatic Configuration - DHCP
This setting is most commonly used by Cable operators.

Host Name : Enter the host name provided by your ISP.

Domain Name : Enter the domain name provided by your ISP.

More...

Local IP Address : This is the address of the router.

Subnet Mask : This is the subnet mask of the router.

DHCP Server : Allows the router to manage your IP addresses.

Starting IP Address : The address you would like to start with.

username: <blank> & password: admin

Install DD-WRT firmware: Upgrading mini (3)

The screenshot shows the Linksys WRT54GL administration interface. The top header is blue with the Linksys logo and 'A Division of Cisco Systems, Inc.' on the left, and 'Firmware Version: v4.30.11' on the right. Below this is a black navigation bar with 'Administration' on the left and 'Wireless-G Broadband Router WRT54GL' on the right. A secondary navigation bar contains tabs for 'Setup', 'Wireless', 'Security', 'Access Restrictions', 'Applications & Gaming', 'Administration' (selected), and 'Status'. Below these are links for 'Management', 'Log', 'Diagnostics', 'Factory Defaults', 'Firmware Upgrade' (selected), and 'Config Management'. The left sidebar has a black 'Upgrade Firmware' button. The main content area is titled 'Firmware Upgrade' in blue. It contains a text input field with 'D:\Cursos Julio Agosto' and a 'Browse...' button. A red warning message states: 'Warning: Upgrading firmware may take a few minutes, please don't turn off the power or press the reset button.' Below this is a progress bar with vertical lines. A red message below the progress bar says 'Upgrade must NOT be interrupted !'. At the bottom right is a large 'Upgrade' button. On the far right, a blue box contains instructions: 'Click on the browse button to select the firmware file to be uploaded to the router.' and 'Click the Upgrade button to begin the upgrade process. Upgrade must not be interrupted. More...'. The Cisco logo is in the bottom right corner.

LINKSYS®
A Division of Cisco Systems, Inc.

Firmware Version: v4.30.11

Administration | **Wireless-G Broadband Router** | **WRT54GL**

Setup | Wireless | Security | Access Restrictions | Applications & Gaming | **Administration** | Status

Management | Log | Diagnostics | Factory Defaults | **Firmware Upgrade** | Config Management

Upgrade Firmware

Firmware Upgrade

Please select a file to upgrade:

Warning: Upgrading firmware may take a few minutes, please don't turn off the power or press the reset button.

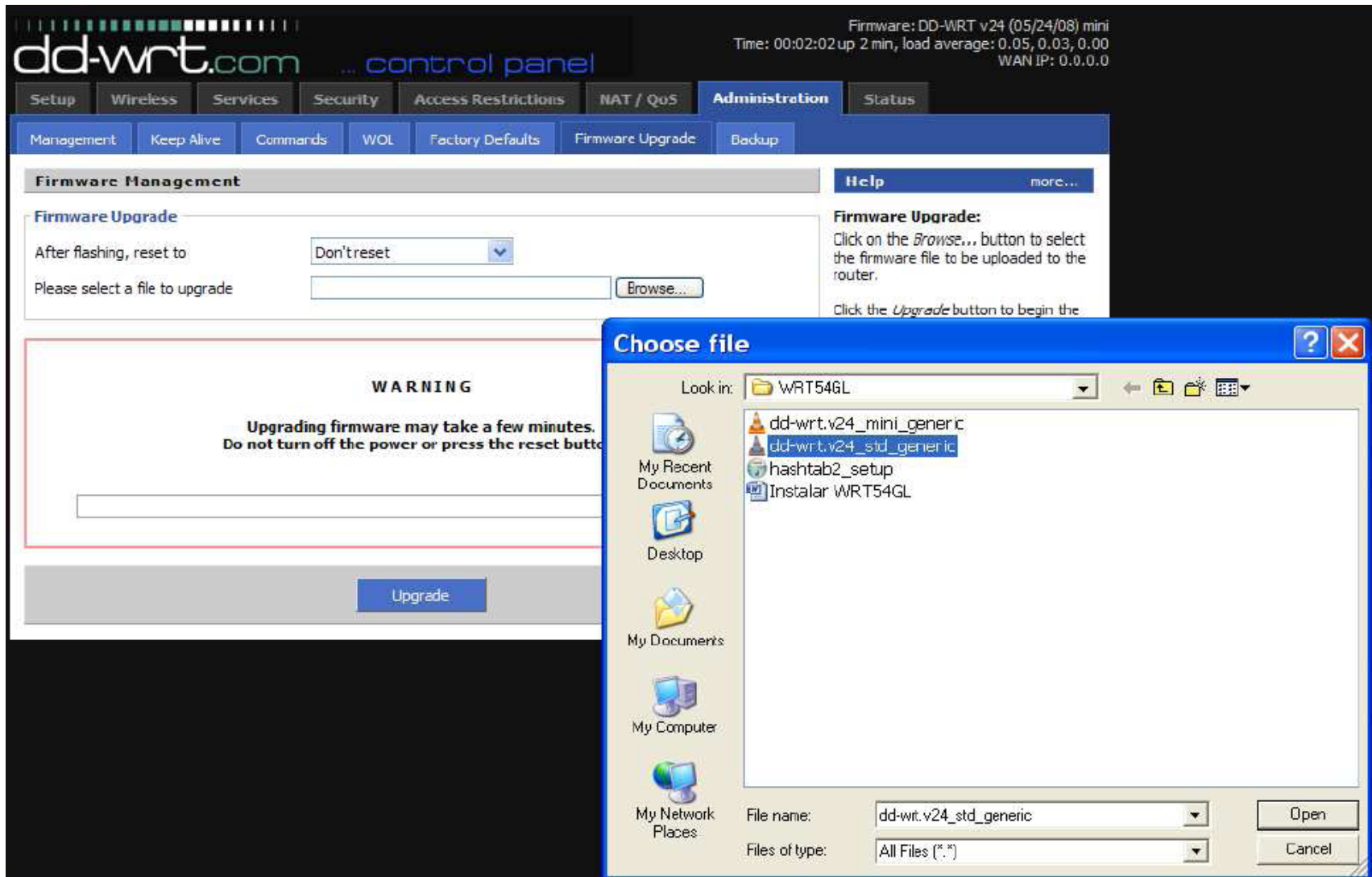
Upgrade must NOT be interrupted !

Click on the browse button to select the firmware file to be uploaded to the router.

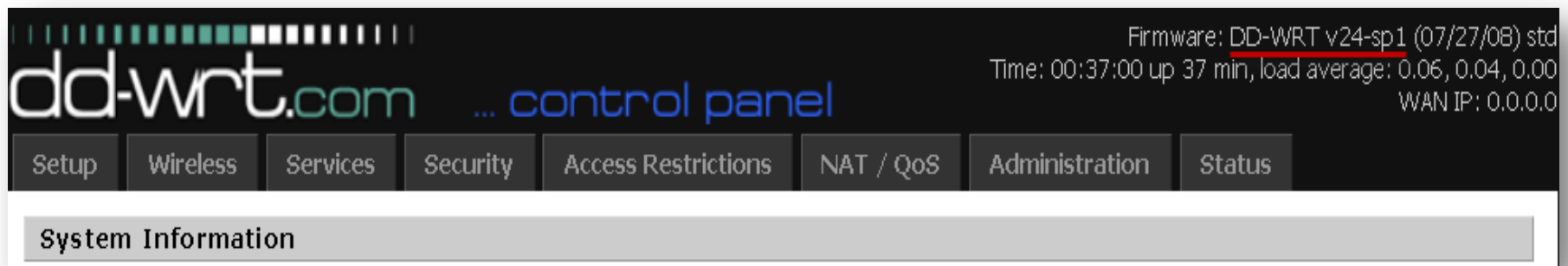
Click the Upgrade button to begin the upgrade process. Upgrade must not be interrupted. More...

CISCO

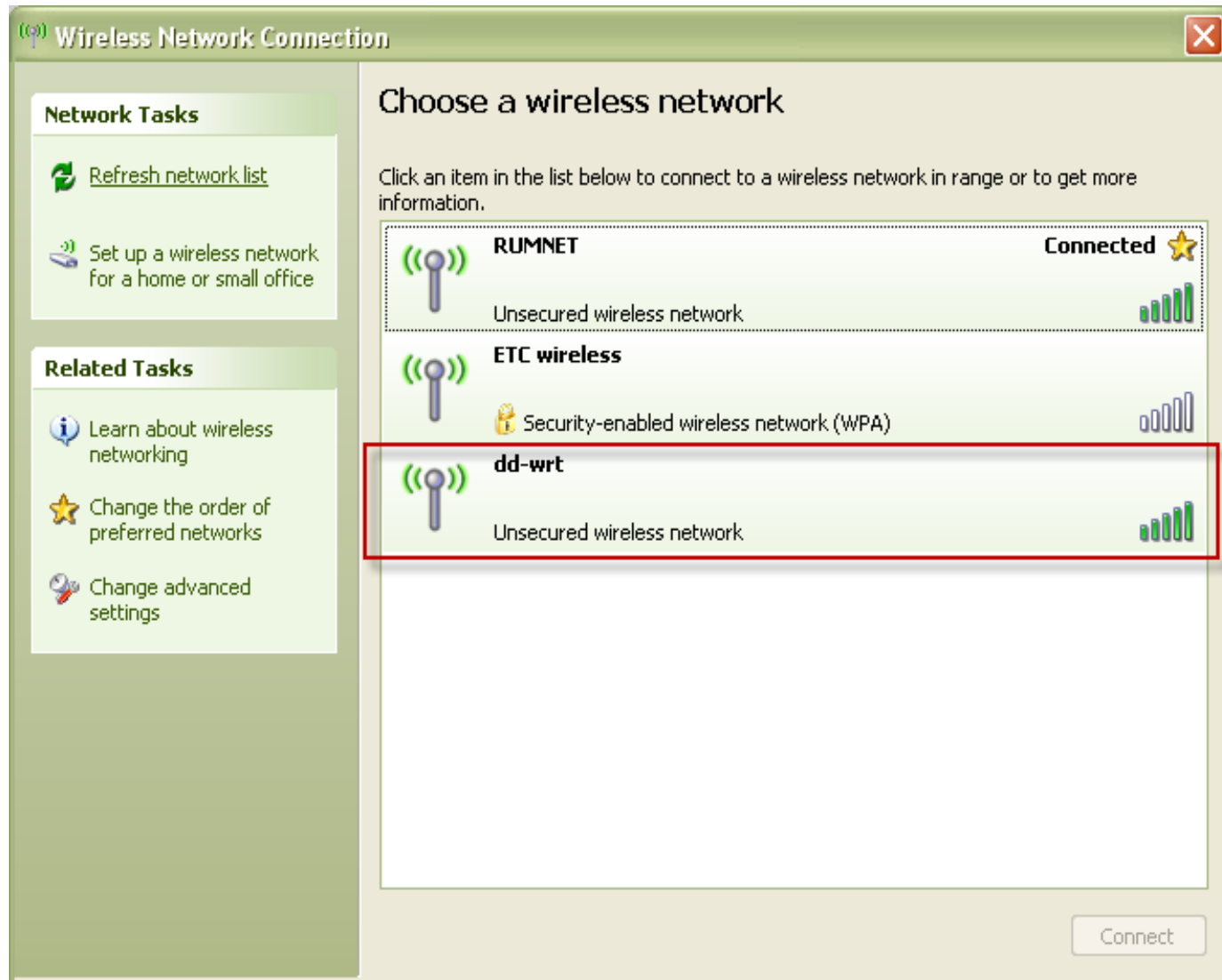
Install DD-WRT firmware: Upgrading std (4)



Install DD-WRT firmware: Done (5)



Set up a secure Wireless Network: ssid



Set up a secure Wireless Network: IP & pwd



dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp1 (07/27/08) std
Time: 00:00:30 up 0 min, load average: 0.41, 0.10, 0.03
WAN IP: 0.0.0.0

Setup Wireless Services Security Access Restrictions NAT / QoS Administration Status

Router Management

Your Router is currently not protected and uses an unsafe default username and password combination, please change it using the following dialog!

Router Password

Router Username	root
Router Password	admin
Re-enter to confirm	admin

Change Password ✓

Set up a secure Wireless Network: New pwd

dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp1 (07/27/08) std
Time: 00:03:51 up 3 min, load average: 0.12, 0.11, 0.04
WAN IP: 0.0.0.0

SetupWirelessServicesSecurityAccess RestrictionsNAT / QoSAdministrationStatus

Router Management

Your Router is currently not protected and uses an unsafe default username and password combination, please change it using the following dialog!

Router Password

Router Username

.....

root

Router Password

.....

@dm1n1

Re-enter to confirm

.....

@dm1n1

Change Password

Set up a secure Wireless Network: info

dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp1 (07/27/08) std
Time: 01:35:54 up 1:35, load average: 0.20, 0.12, 0.05
WAN IP: 0.0.0.0

SetupWirelessServicesSecurityAccess RestrictionsNAT / QoSAdministrationStatus

System Information

Router

Router Name	DD-WRT
Router Model	Linksys WRT54G/GL/G5
LAN MAC	00:21:29:71:41:DC
WAN MAC	00:21:29:71:41:DD
Wireless MAC	00:21:29:71:41:DE
WAN IP	0.0.0.0
LAN IP	192.168.1.1

Services

DHCP Server	Enabled
WRT-radauth	Disabled
WRT-rflow	Disabled
MAC-upd	Disabled
CIFS Automount	Disabled
Sputnik Agent	Disabled

Wireless

Radio	Radio is On
Mode	AP
Network	Mixed
SSID	dd-wrt
Channel	6

Memory

Total Available	12.7 MB / 16.0 MB
Free	3.2 MB / 12.7 MB
Used	9.5 MB / 12.7 MB
Buffers	1.4 MB / 9.5 MB
Cached	4.3 MB / 9.5 MB
Active	3.5 MB / 9.5 MB

Set up a secure Wireless Network: change IP

- ▶ Setup Tab → Basic Setup → Network Setup

Network Setup

Router IP

Local IP Address	192	.	168	.	1	.	100
Subnet Mask	255	.	255	.	255	.	0
Gateway	0	.	0	.	0	.	0
Local DNS	0	.	0	.	0	.	0

Save Apply Settings Cancel Changes




Set up a secure Wireless Network: wireless


Wireless Physical Interface wl0

Physical Interface wl0 - SSID [dd-wrt] HWAddr [00:21:29:71:41:DE]

Wireless Mode:

Wireless Network Mode:

Wireless Network Name (SSID): 

Wireless Channel: 

Wireless SSID Broadcast: ☒ Enable ☐ Disable

Sensitivity Range (ACK Timing): (Default: 2000 meters)

Network Configuration: ☐ Unbridged ☒ Bridged

Network Stumbler - [20090831094407]

File Edit View Device Window Help

Channels

SSIDs

204

326B

II-201

linksys

NECPJ

RUMNET

Filters

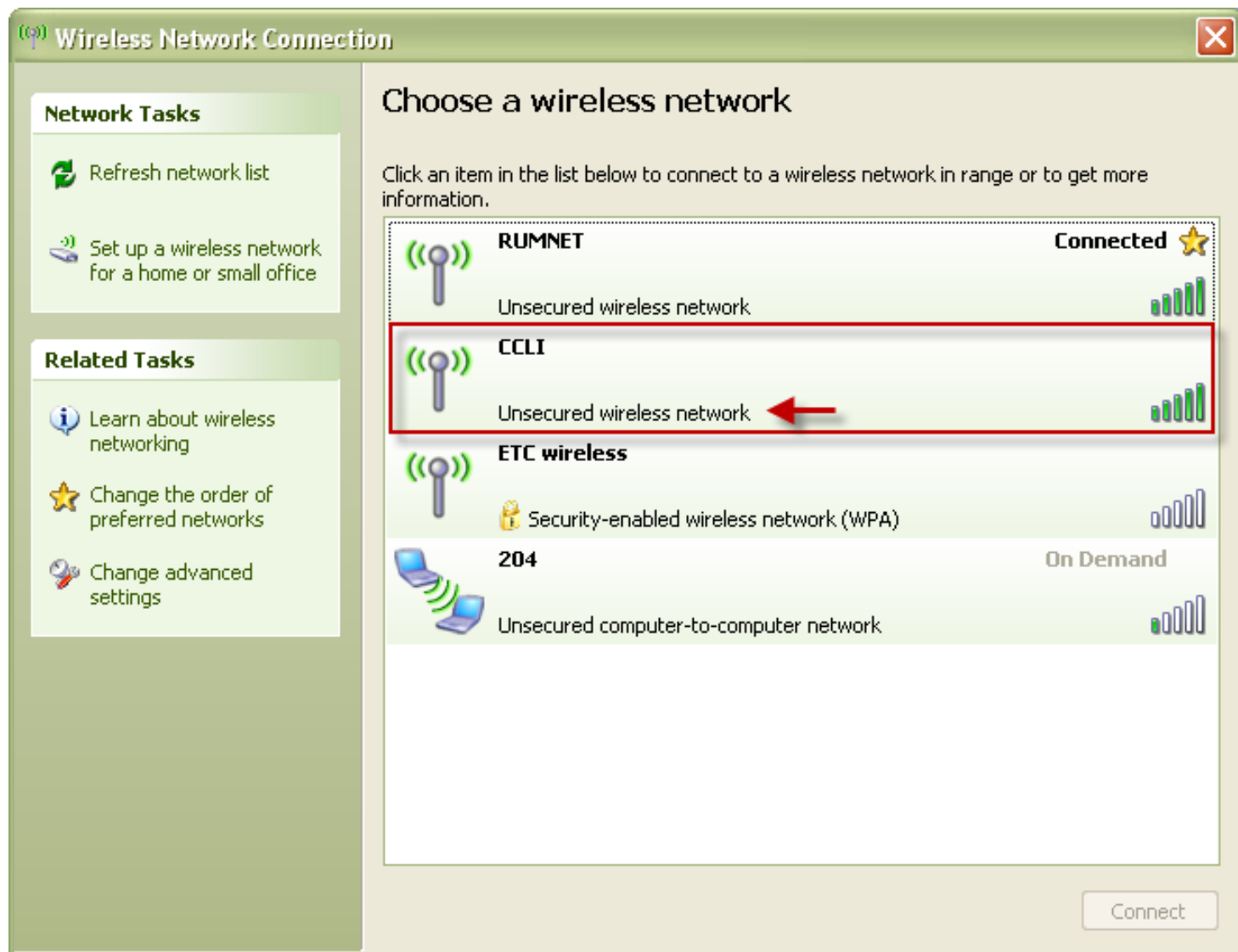
Encryption Off

Encryption On

ESS (AP)

MAC	SSID	Name	Chan	Speed	Vendor	Type	Enc...	SNR	Signal+
001EE5250557	326B		1	48 Mbps	(Fake)	AP	WEP	6	160
0013194950D0			5	54 Mbps	(Fake)	AP			-92
A2DCFD44F9A1	II-201		10	48 Mbps	(User-d...	Peer		6	-79
001D7E668142	linksys		6	54 Mbps	(Fake)	AP			-87
0A40E33109FA	204		10	48 Mbps	(User-d...	Peer			-85
001C0E4C8EE0				54 Mbps	(Fake)	AP			-89
00028A5B4854	RUMNET		11	11 Mbps	Ambit	AP		24	-76
DE988FA12FE0	NECPJ		10	48 Mbps	(User-d...	Peer		23	-71
001AE3798D80	RUMNET			54 Mbps	(Fake)	AP		8	-88
002497A4A120	RUMNET			54 Mbps	(Fake)	AP		14	-80
001C0E409ED0			4	54 Mbps	(Fake)	AP		18	-82

Set up a secure Wireless Network: SSID changed



Set up a secure Wireless Network: Security

Wireless Security wlo

Physical Interface wlo SSID [dd-wrt] HWAddr [00:21:29:71:41:DE]

Security Mode

WPA2 Personal Mixed



WPA Algorithms

TKIP+AES



WPA Shared Key

s3curity



Unmask



Key Renewal Interval (in seconds)

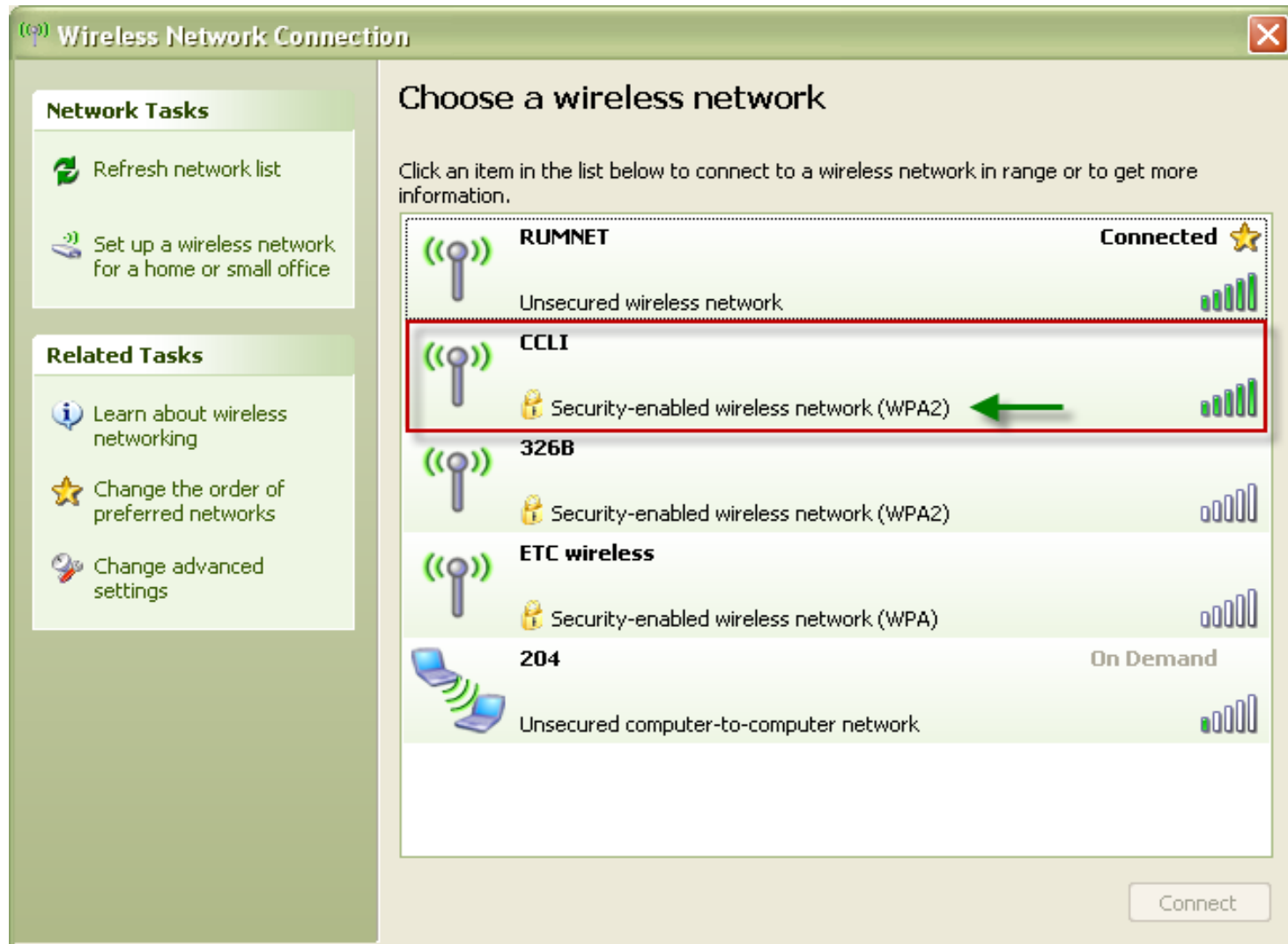
3600

(Default: 3600, Range: 1 - 99999)

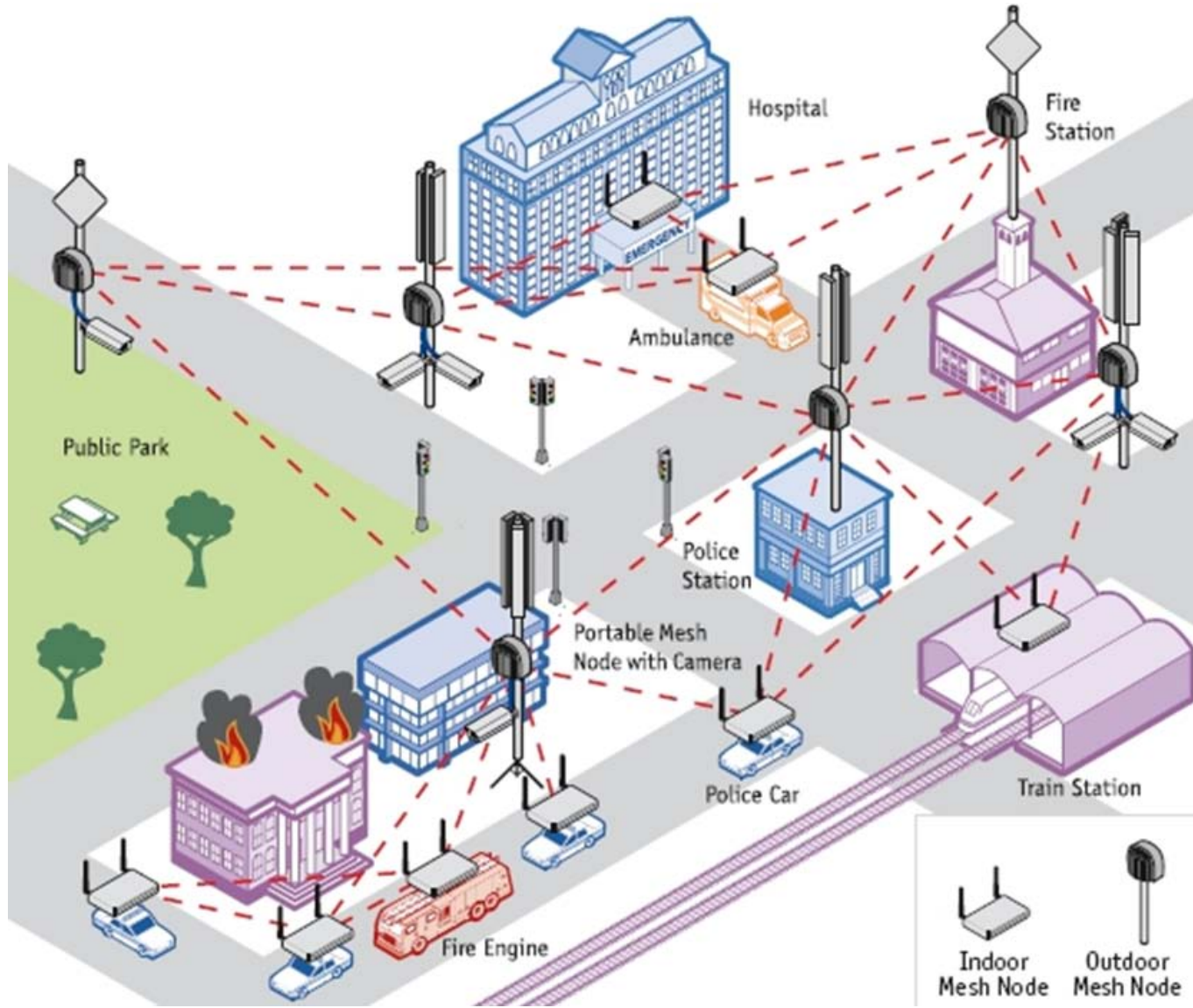
Save

Apply Settings

Set up a secure Wireless Network: Done



Wireless Mesh Network (WMN) Testbed



WMN: Requirements

▶ Hardware

- ▶ 02 Linksys WRT54GL Routers
- ▶ 02 Laptops
- ▶ Ethernet cord

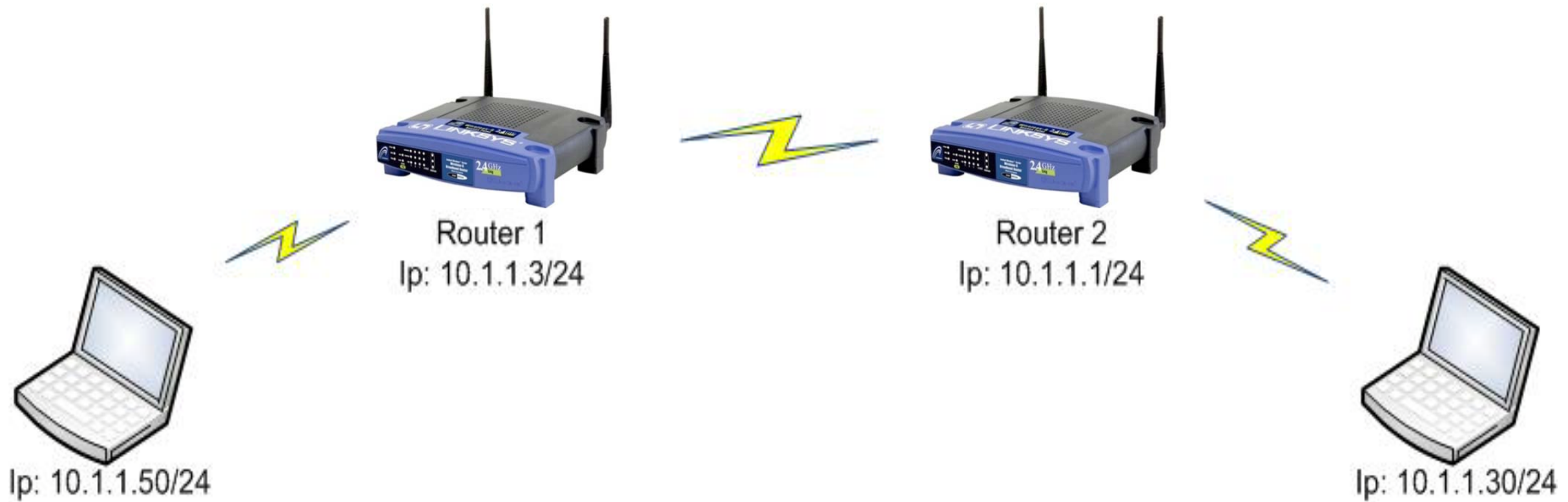


▶ Software

- ▶ Internet Explorer or Mozilla Firefox
- ▶ dd-wrt.v24 sp1
- ▶ OLSR daemon switch 0.5.6
- ▶ Wireshark-1.2
- ▶ Jperf-2.0



WMN: Topology



Install
DD-WRT
firmware

Set up a
WMN with
OLSR

Performance
Tests

Set up a WMN with OLSR: Mesh Routers (1)

dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp1 (07/27/08) std
Time: 00:44:58 up 45 min, load average: 0.03, 0.03, 0.00
WAN IP: 0.0.0.0

SetupWirelessServicesSecurityAccess RestrictionsNAT / QoSAdministrationStatus

Basic SettingsRadiusWireless SecurityMAC FilterAdvanced SettingsWDS

Wireless Physical Interface wlo

Helpmore...

Physical Interface wlo - SSID [dd-wrt] HWAddr [00:21:29:71:41:DE]

Wireless ModeAdhoc

Wireless Network ModeMixed

Wireless Network Name (SSID)dd-wrt

Wireless Channel6 - 2.437 GHz

Wireless SSID BroadcastEnable

Sensitivity Range (ACK Timing)2000 (Default: 2000 meters)

Network ConfigurationUnbridged

Multicast forwardingDisabled

IP Address10.1.1.1

Subnet Mask255.255.255.0

Set all these marked values

Wireless Network Mode:
If you wish to exclude Wireless-G clients, choose *B-Only* mode. If you would like to disable wireless access, choose *Disable*.
Note : when changing wireless mode, some advanced parameters are susceptible to be modified ("Afterburner", "Basic Rate" or "Frame Burst").

Sensitivity Range:
Adjusts the ack timing. 0 disables ack timing completely for broadcom firmwares. On Atheros based firmwares it will turn into auto ack timing mode

SaveApply SettingsCancel Changes

Set up a WMN with OLSR: Mesh Routers (2)

dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp1 (07/27/08) std
Time: 00:38:26 up 38 min, load average: 0.18, 0.07, 0.01
WAN IP: 0.0.0.0

Setup Wireless Services Security Access Restrictions NAT / QoS Administration Status

Basic Setup DDNS MAC Address Clone **Advanced Routing** VLANs Networking

Advanced Routing Help more...

Operating Mode

Operating Mode

OLSR Routing (Optimized Link State Routing)

Host Net Announce

Poll Rate

TC Redundancy

MPR Coverage

Link Quality Fish Eye

Link Quality Aging

Link Quality Dijkstra Min

Link Quality Dijkstra Max

Link Quality Level

Hysteresis

Operating Mode:
If the router is hosting your Internet connection, select *Gateway* mode. If another router exists on your network, select *Router* mode.

Select set number:
This is the unique route number, you may set up to 20 routes.

Route Name:
Enter the name you would like to assign to this route.

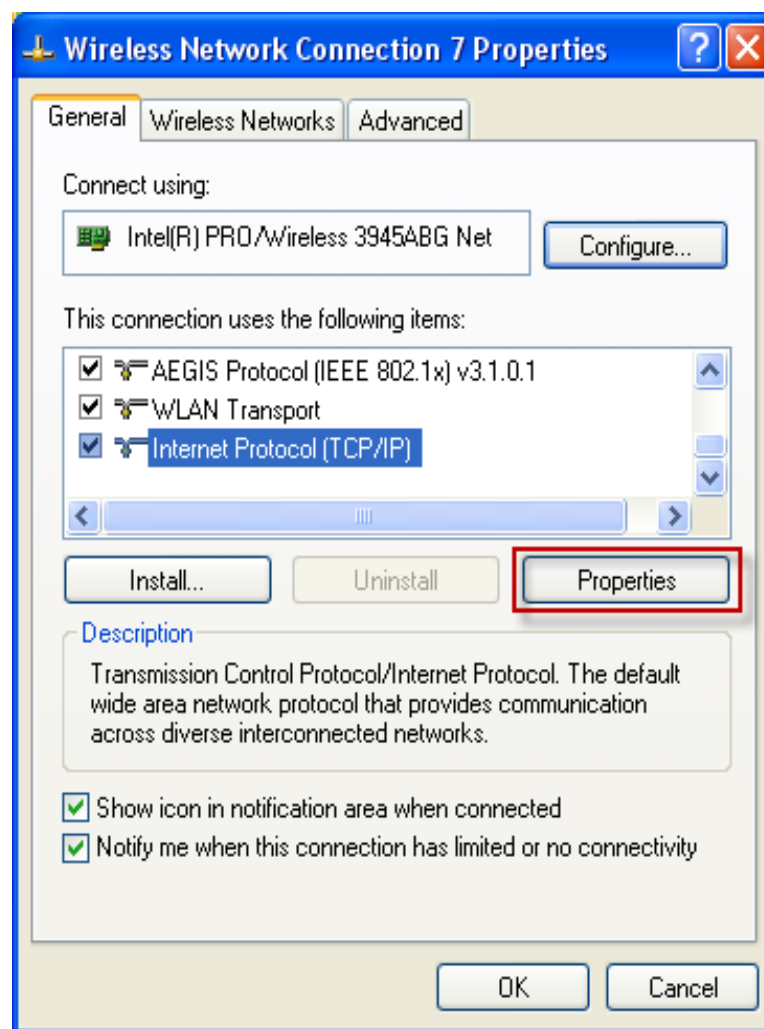
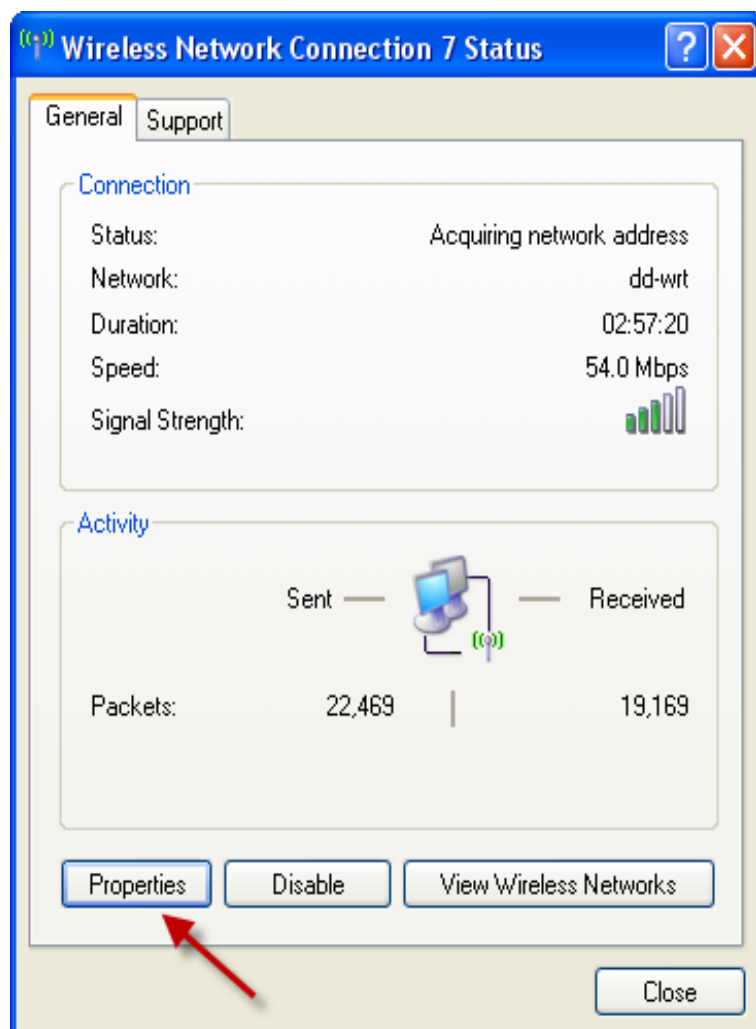
Destination LAN NET:
This is the remote host to which you would like to assign the static route.

Subnet Mask:
Determines the host and the network portion.

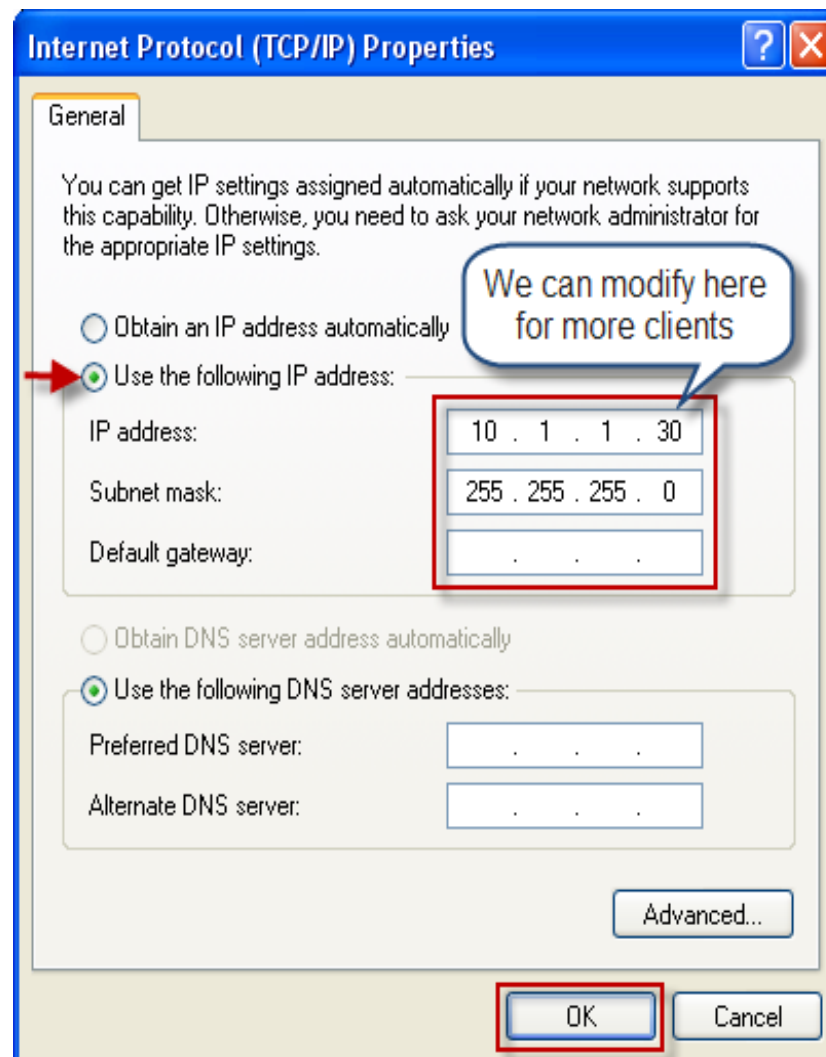
Choose OLSR Router

HERE Left all options by default

Set up a WMN with OLSR: Mesh Clients (1)



Set up a WMN with OLSR: Mesh Clients (2)



Set up a WMN with OLSR: Mesh Clients (3)



olsr.org Switch 0.5.5

Settings Output Nodes Routes

Interface list

- ☐ IF04 - 192.168.56.1
- ☒ IF03 - 10.1.1.30
- ☐ IF02 - 192.168.1.124

HELLO interval: 5.00 sec HELLO hold: 125.00 sec

MID interval: 25.00 sec MID hold: 375.00 sec

HNA interval: 25.00 sec HNA hold: 375.00 sec

TC interval: 3.00 sec TC hold: 375.00 sec

TC redundancy: 2 MPR coverage: 7

Debug level: 0

Enable hysteresis: ☐

Low mark: 0.30 High mark: 0.80

Scaling: 0.50

Poll interval: 0.05 sec

Enable IP version 6: ☐

Offer Internet connection: ☐

Enable ETX link quality: ☒

for MPR selection only: ☐

for MPR selection and routing: ☒

Window size: 100

Enable Fish Eye: ☒

Open Save Reset

Start Stop Exit

Set up a WMN with OLSR: Mesh Clients (4)

olsr.org Switch 0.5.5

Settings | Output | **Nodes** | Routes

Node list

Address	Timeout	MID	HNA
10.1.1.1	21:16:58	no	no
10.1.1.40	21:19:46	no	no
10.1.1.50	21:17:28	no	no
10.1.1.3	21:19:46	no	no

Node information

MPR

10.1.1.1
10.1.1.3
10.1.1.30
10.1.1.40

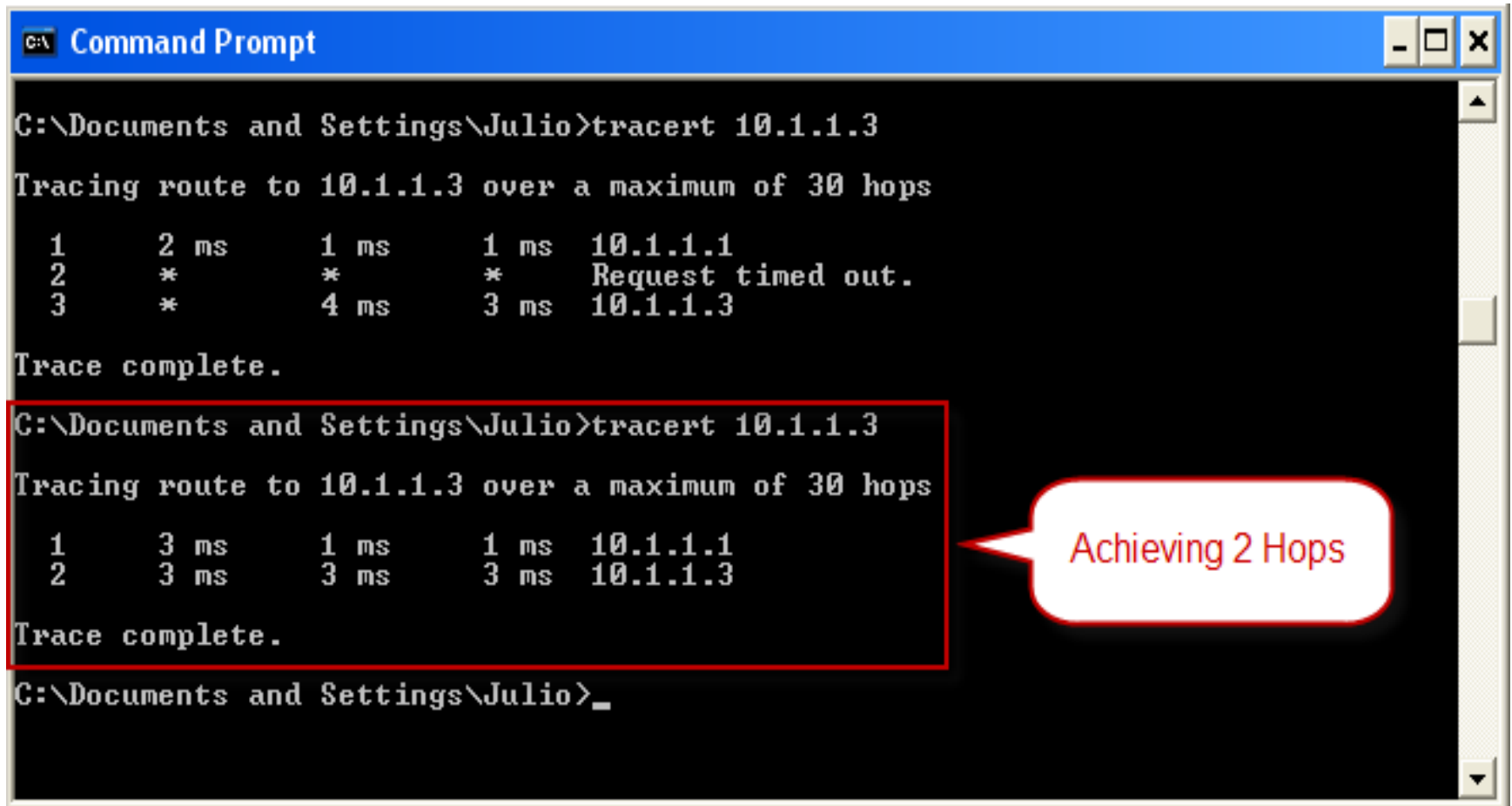
MID

HNA

Start Stop Exit

Here, we can see routers and clients and MPR and MID messages used by OLSR

Performance Tests: Multihop (1)



```
C:\Documents and Settings\Julio>tracert 10.1.1.3

Tracing route to 10.1.1.3 over a maximum of 30 hops

  1      2 ms      1 ms      1 ms      10.1.1.1
  2      *          *          *          Request timed out.
  3      *          4 ms      3 ms      10.1.1.3

Trace complete.

C:\Documents and Settings\Julio>tracert 10.1.1.3

Tracing route to 10.1.1.3 over a maximum of 30 hops

  1      3 ms      1 ms      1 ms      10.1.1.1
  2      3 ms      3 ms      3 ms      10.1.1.3

Trace complete.

C:\Documents and Settings\Julio>_
```

Achieving 2 Hops

Performance Tests: Wireshark (2)

The screenshot shows a Wireshark capture of network traffic. The main packet list table is as follows:

No.	Time	Source	Destination	Protocol	Info
12636	1894.902851	10.1.1.30	10.1.1.1	ICMP	Echo (ping) request
12637	1894.904547	10.1.1.1	10.1.1.30	ICMP	Echo (ping) reply
12638	1894.942928	10.1.1.30	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12639	1894.998363	10.1.1.50	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 36 Bytes
12640	1895.008436	10.1.1.40	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12641	1895.077415	10.1.1.3	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 76 Bytes
12642	1895.277999	10.1.1.1	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 124 Bytes
12643	1895.407016	10.1.1.3	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 52 Bytes
12644	1895.726008	Cisco-Li_25:a5:5f	Intel_92:7e:b0	ARP	who has 10.1.1.30? Tell 10.1.1.3
12645	1895.726025	Intel_92:7e:b0	Cisco-Li_25:a5:5f	ARP	10.1.1.30 is at 00:18:de:92:7e:b0
12646	1895.734915	10.1.1.30	10.1.1.3	ICMP	Echo (ping) request
12647	1895.744628	10.1.1.3	10.1.1.30	ICMP	Echo (ping) reply
12648	1895.798413	10.1.1.30	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 60 Bytes
12649	1895.801753	10.1.1.50	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 40 Bytes
12650	1895.811229	10.1.1.40	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 100 Bytes
12651	1895.903765	10.1.1.30	10.1.1.1	ICMP	Echo (ping) request
12652	1895.905253	10.1.1.1	10.1.1.30	ICMP	Echo (ping) reply
12653	1896.109912	10.1.1.40	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12654	1896.266368	10.1.1.1	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12655	1896.286917	10.1.1.3	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12656	1896.509367	10.1.1.30	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 44 Bytes
12657	1896.706929	10.1.1.1	10.1.1.255	UDP	OLSR (IPv4) Packet, Length: 60 Bytes

Annotations in the image:

- 2 Routers:** Points to packets from 10.1.1.30 and 10.1.1.1.
- 3 Clients:** Points to packets from 10.1.1.50, 10.1.1.40, and 10.1.1.3.
- OLSR running:** A cloud-shaped callout pointing to the OLSR packets.
- OLSR uses 698 port:** A red box annotation pointing to the 'User Datagram Protocol, Src Port: olsr (698)' entry in the packet details pane.

The packet details pane for Frame 13316 shows:

- Ethernet II, Src: Intel_92:7e:b0 (00:18:de:92:7e:b0), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
- Internet Protocol, Src: 10.1.1.30 (10.1.1.30), Dst: 10.1.1.255 (10.1.1.255)
- User Datagram Protocol, Src Port: olsr (698), Dst Port: olsr (698)
- Optimized Link State Routing Protocol
 - Packet Length: 84 bytes
 - Packet Sequence Number: 13500
 - Message Type: Unknown (202)
 - validity time: 288.000 (in seconds)
 - Message Size: 40 bytes
 - Originator Address: 10.1.1.40 (10.1.1.40)
 - Time to Live: 1

The packet bytes pane shows the raw data in hexadecimal and ASCII.

File: "C:\DOCUME~1\Julio\LOCAL5~1\Temp\eth... Packets: 13507 Displayed: 13507 Marked: 0 Dropped: 0 Profile: Default

Performance Tests: Jperf (3)

JPerf

Iperf command: `iperf -c 10.1.1.30 -P 1 -i 1 -p 5001 -f k -n 100000000 -T 1`

Choose iPerf Mode: ☒ Client ☐ Server

Server address: Port:

Parallel Streams:

Listen Port: ☐ Client Limit

Num Connections:

Application layer options

☐ Enable Compatibility Mode

Transmit:

☒ Bytes ☐ Seconds

Output Format:

Report Interval: seconds

Testing Mode: ☐ Dual ☐ Trade

test port:

Representative File: ...

☐ Print MSS

Transport layer options

Choose the protocol to use

☒ TCP

☐ Buffer Length: MBytes

☐ TCP Window Size: KBytes

☐ Max Segment Size: KBytes

☐ TCP No Delay

☐ UDP

UDP Bandwidth: MBytes/sec

☐ UDP Buffer Size: KBytes

Run IPerf!

Stop IPerf!

Sun, 17 May 2009 19:49:35

Bandwidth

#3: 393.00KBits/s

Output

[3]	91.0-92.0 sec	16.0 KBytes	131 Kbits/sec
[3]	92.0-93.0 sec	64.0 KBytes	524 Kbits/sec
[3]	93.0-94.0 sec	72.0 KBytes	590 Kbits/sec
[3]	94.0-95.0 sec	80.0 KBytes	655 Kbits/sec
[3]	95.0-96.0 sec	56.0 KBytes	459 Kbits/sec
[3]	96.0-97.0 sec	16.0 KBytes	131 Kbits/sec
[3]	97.0-98.0 sec	80.0 KBytes	655 Kbits/sec
[3]	98.0-99.0 sec	48.0 KBytes	393 Kbits/sec
[3]	99.0-100.0 sec	48.0 KBytes	393 Kbits/sec

Save Clear now ☐ Clear Output on each Iperf Run

Case Studies at UPRM – ICOM/INEL

- ▶ Case 1:
 - ▶ Mobile Electrocardiogram (ECG)
 - ▶ A capstone project in Fall 2008.
- ▶ Case 2:
 - ▶ High data-rate wireless sensor network for environmental monitoring
 - ▶ WALSAIP project.
- ▶ Case 3:
 - ▶ Service-oriented wireless mesh network
 - ▶ An IAP project in 2008.

Certifications: Cisco



General Certifications				
Certification Paths	<u>Entry-Level</u>	<u>Associate</u>	<u>Professional</u>	<u>Expert</u>
Routing & Switching	<u>CCENT</u>	<u>CCNA</u>	<u>CCNP</u>	<u>CCIE Routing & Switching</u>
Design	<u>CCENT</u>	<u>CCNA</u> & <u>CCDA</u>	<u>CCDP</u>	<u>CCDE</u>
Network Security	<u>CCENT</u>	<u>CCNA Security</u>	<u>CCSP</u>	<u>CCIE Security</u>
Service Provider	<u>CCENT</u>	<u>CCNA</u>	<u>CCIP</u>	<u>CCIE Service Provider</u>
Storage Networking	<u>CCENT</u>	<u>CCNA</u>	<u>CCNP</u>	<u>CCIE Storage Networking</u>
Voice	<u>CCENT</u>	<u>CCNA Voice</u>	<u>CCVP</u>	<u>CCIE Voice</u>
Wireless	<u>CCENT</u>	<u>CCNA Wireless</u>	<u>CCNP Wireless</u>	<u>CCIE Wireless</u>



<http://www.cisco.com/web/learning/index.html>



Certifications: Wireless



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CWTS

CWNA

CWSP

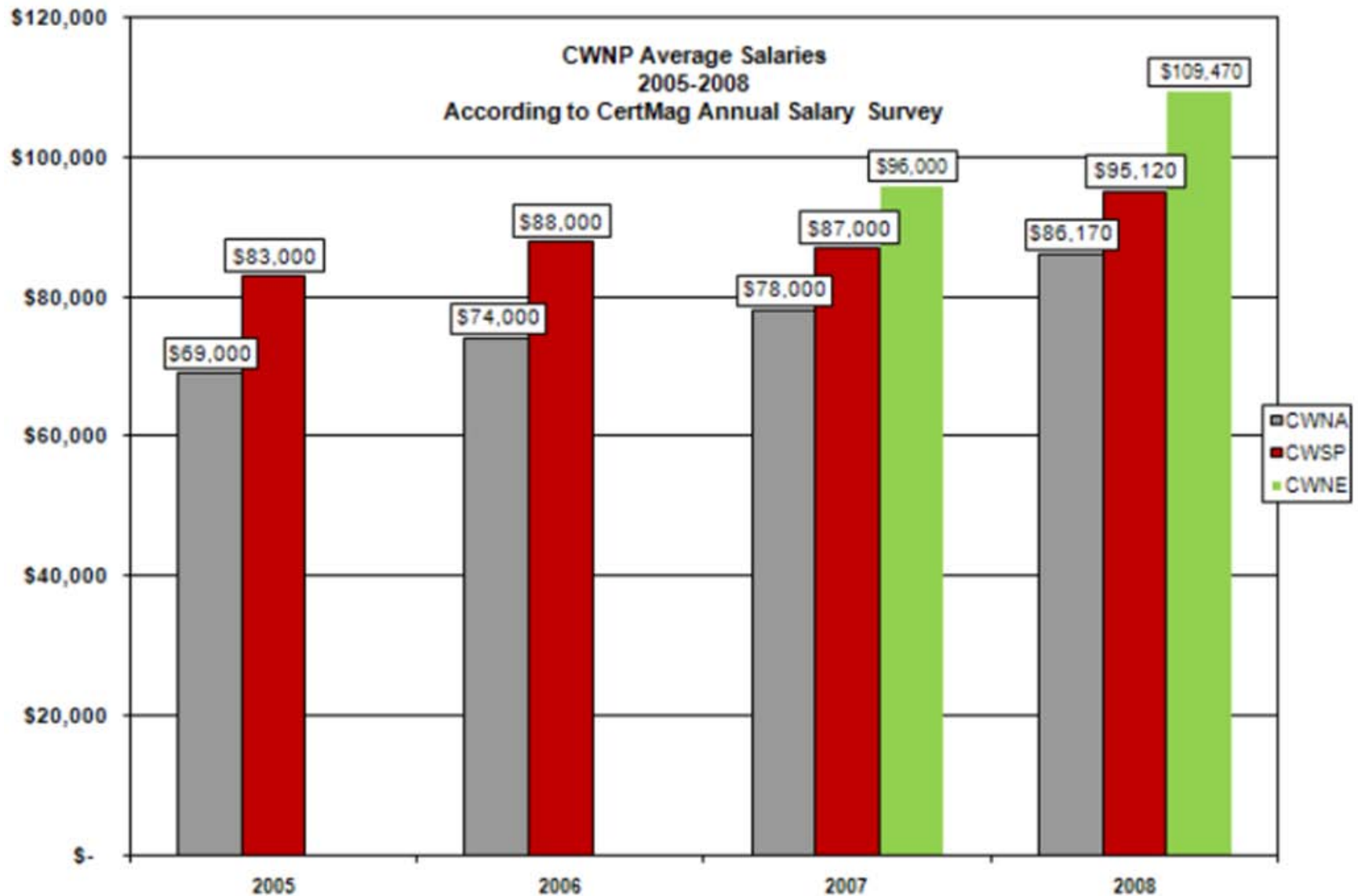
CWNE

CWNT

CWTS - Wireless Specialist
CWNA - Wireless Administration
CWSP - Wireless Security
CWNE - Wireless Expert
CWNT - Wireless Trainer

<http://www.cwnp.com/>

Salaries for CWNPs



Conclusions

- ▶ In this presentation, we have discussed:
 - ▶ Different Wireless Networks
 - ▶ Cellular networks
 - ▶ Wireless Personal Area Networks (PAN)
 - ▶ Wireless Local Area Networks (WLAN)
 - ▶ Wireless Metropolitan Area Networks (WMAN)
 - ▶ Wireless Sensor Networks (WSN)
 - ▶ Wireless Mesh Networks (WMN)
 - ▶ Demos:
 - ▶ Install DD-WRT firmware into the Linksys WRT54GL Router
 - ▶ Set up a secure Wireless Network
 - ▶ Set up a Wireless Mesh Network with OLSR
 - ▶ Case Studies at UPRM
 - ▶ Wireless certifications

References

- ▶ [1] I. F. Akyildiz and X. Wang, “A survey on wireless mesh networks,” *IEEE Communications Magazine*, vol. 43, no. 9, pp. S23-S30, Sept. 2005.
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- ▶ [4] Johnathan Ishmael et al., “Deploying Rural Community Wireless Mesh Networks,” *IEEE Internet Computing* 12, no. 4 (2008): 22-29.
- ▶ [5] David D. Coleman and David A. Westcott, *CWNA: Certified Wireless Network Administrator Study Guide* (Sybex, 2006).
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- ▶ [7] Yan Zhang, Jijun Luo, and Honglin Hu, *Wireless Mesh Networking: Architectures, Protocols and Standards*, 1st ed. (Auerbach Publications, 2006).
- ▶ Webs:
 - ▶ <http://www.cwnp.com/>
 - ▶ <http://www.cisco.com/web/learning/index.html>
 - ▶ http://en.wikipedia.org/wiki/Linksys_WRT54G_series
 - ▶ <http://www.dd-wrt.com>
 - ▶ <http://www.dd-wrt.com/wiki/index.php/Installation#Precautions>
 - ▶ http://www.dd-wrt.com/wiki/index.php/WRT54G_v4_Installation_Tutorial
 - ▶ <http://olsr.org/>
 - ▶ <http://www.e-bulles.be/bubble/Olsr.conf>
 - ▶ <http://axelvigo.com/cisco/InstallOpenWrt.html>
 - ▶ <http://www.shanix.com/security/wifi.html>
 - ▶ www.zigbee.org/
 - ▶ <http://en.wikipedia.org/wiki/Wibree>
 - ▶ <http://arri.uta.edu/acs/networks/WirelessSensorNetChap04.pdf>
 - ▶ <http://www.metrotech-partners.com/Content/PublicSafety/WirelessMesh.aspx>



Thank you !!!

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