

# Advanced Internet Technology II: Internet Operation



## -Wireless Network Operation-

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## Overview

- Learn technologies to develop a wireless network.
  - Summary of IEEE802.11 specification
- Design a wireless network.
  - Hints for successful operation.
- Introduce case studies
  - I learned through wireless network operation at IETF54 and 59.

## Technologies for wireless network



## Current state of wireless usage

- Everything connects with wireless!
    - Notebook computer
    - Personal Digital Assistant (PDA)
    - Printer
    - Media player
    - Handheld gaming system
    - etc.
- have built-in wireless device.



Wireless network printer  
HP P5C2710



Network Media player  
Buffalo PC-P3LWG



Handheld Gaming system  
Nintendo DS

## Background of this trend



- Why is wireless installed in any equipment?  
This reason as follows.
  - Decrease price of wireless devices by mass production.
    - At 1997,
      - PC-card type wireless NIC was \$10000/unit.
      - It have no interoperability with other maker's wireless products.
    - Now
      - wireless PC-card based on 802.11b/g is only \$30.
  - It is able to install wireless device to consumer gaming machines due to low priced wireless chipset.
    - Nintendo DS is \$150, PSP by Sony is \$200.



## Background of this trend(2)



- Miniaturization of wireless devices.
  - Wireless functions packaged to one chip IC. (Not including RF unit)
  - It becomes easy to develop built-in wireless devices.
  - Various size (type) of NIC released.

SD card type  
IEEE802.11b wireless NIC  
By SanDisk



ONLY  
2.4cm

### Background of this trend(3)

- System technology for mobility by manufacturers
  - "Intel Centrino mobile technology".
    - It is a mobile platform configured from of Pentium M, Intel 855 chipset and Intel Pro/wireless network connection.
  - Wireless built-in notebook PC was popularized.



### Background of this trend(4)

- Enrich Hotspot service at public areas.
    - ISP provides Hotspot service, that is wireless connectivity service at public areas.
    - In Japan, many ISP provide hotspot services at airports, railway stations, STARBACKS, McDonalds, etc.
    - Lufthansa provide in-flight internet service "FlyNet" by Connection by Boeing.
- >we can make full use of wireless devices at public area.



### Background of this trend(5)

- Wireless release us from a tangled wire world.
    - In a house, there are a variety of network capable equipment, such as PC, printer, broadband routers, etc.
- > Wireless is able to easy layout of network devices.
- It is not restricted by the length of the cable.
- >Wire instillation is required to take a lot of time and money to equip.

### Background of this trend(6)

- Interoperability are certified by WiFi.
  - WiFi CERTIFIED LOGO means the device passed conformance tests for interoperability with IEEE standard.

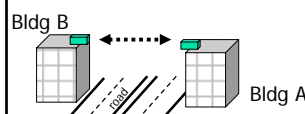


→ This device interoperable with 802.11b device.  
WiFi Certified Logo.

### Technology overview of wirelsss

### Many wireless device released

- Wireless device classify types of media.
  - IR (Infrared light)/Laser type
    - Its are using for high-speed wireless link between bldg.
      - Canobeam · Terabeem · Airfiber etc
      - Link speed is up to 1Gbps.



## Many wireless device released(2)



Netwave Aircrusher

- Microwave (Frequency is over 300MHz-band )
    - Vender specific protocol based.
      - Netwave by Zircom Inc/Netwave-wireless.
      - It is not open standard system.
        - No interoperability for other wireless product.
        - Enclosed system.
    - IEEE 802.11 family protocols.
      - Its are slenderized by IEEE 802.11 WG.
      - Open standard protocol.
- In this lecture, I focus on IEEE802.11b/g/a protocols.

## Before WiFi(802.11b/a/g) age.

- There was no interoperability with other products before 802.11b appeared.
  - The first product of 802.11b appeared in 2000.
- Wireless system was equal "Product enclosed system."
  - No interoperability with other products.
  - If you want to connect manufacture A's wireless access point, use manufacture A's wireless NIC.
    - When you connect B's AP, you buy B's NIC.
  - In Japan, we were required the radio license for using the wireless system by government.
    - And also we had to use wireless system on the restricted area was permitted by the license.

## History of standardization

- IEEE 802.11 commission is working for standardization of wireless network.
- IEEE approved 802.11 at '97
  - Has IR and 2.4GHz-band (microwave) as link carrier.
  - On 2.4Ghz-band, 802.11 has two types of spectrum spread method.
    - FH-SS, Frequency Hopping - Spectrum Spread.
      - Fault tolerance is high, transmission rate is slow.
    - DS-SS, Direct Sequence - Spectrum Spread.
      - Fault tolerance is low, transmission rate is fast.
  - has 1Mbps mode and 2Mbps mode as link speed.
- 802.11 based products released, however, did not popularize.

## 802.11b was appeared.

- IEEE approved 802.11b at '99
- It is extension of 802.11 DS-SS mode.
  - Added 5.5Mbps and 11Mbps as link speed.
    - 11b has the function of dynamically changing link speed to 1, 2, 5.5 and 11Mbps.
      - The speed is depending on a radio signal condition.
  - 11b use 2.4GHz ISM band.
    - ISM:Industry Science Medical band can be used without the radio license.
    - Regulation for ISM-band MAY be different in each country.

## 802.11b products released

- Manufacturers develop wireless chipsets.
  - Lucent/Intersil/Aironet/3Com etc.
- First product released at '00.

## About IEEE802.11a(1)

- IEEE approved 802.11a at 1999, too.
  - Product released at '01.
  - Manufactures released after successful of 802.11b.
- 802.11a use 5GHz-band
  - 11a use more high frequency than 11b.
  - 5GHz-band may have some effect by rain and snow.
- Link speed is 54Mbps.
  - 802.11a use OFDM (Orthogonal Frequency Division Multiplexing) as modulation.
  - OFDM is able to use a radio bandwidth in efficiently than DSSS in 802.11b.
  - Merit of OFDM is strong in phasing and the multipass.

## About IEEE802.11a(2)

- Usage limitation of 802.11a is different each country.
  - In Japan, Permitted frequency from 5.15GHz to 5.25GHz without a license and also indoor use only.
    - Because 802.11a interferes in weather observation system, AMEDAS, that use 5GHz-band.
  - In US, permitted 5.15 ~ 5.25GHz, 5.25 ~ 5.35GHz and 5.725 ~ 5.825GHz-band.
    - US has three times of radio band range than Japan.©
- Country localized products fit each country's law.
  - Japan localized 11a card can't associate with US localized access point.

## About IEEE802.11g (1)

- First product was released at '03.
  - Manufacturers release products while IEEE is finalizing specification of 802.11g from draft.
- 11g uses same frequency band as 11b.
  - 2.4Ghz-band.
- Link speed is up to 54Mbps.
  - 11g use OFDM / PBCC(=Packet Binary Convolution Code) / OFDM-CCK as modulation.

## About IEEE802.11g (2)

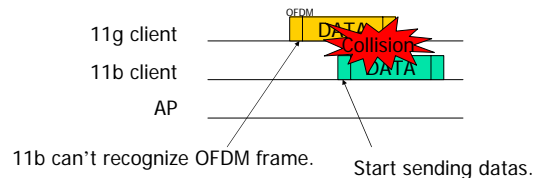
- 802.11b/g combo chipset released
  - It is adopted for a lot of consumer products.
    - Decrease the price of chipset.



Atheros 11b/g combo chip

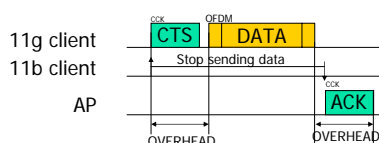
## Compatibility with 11b(1)

- 11b and 11g use same 2.4GHz-band with different modulation architecture.
  - 11b can't recognize 11g's OFDM frame.



## Compatibility with 11b(2)

- 11g use OFDM-CCK modulation to avoid framing collisions between 11b and 11g.
- OFDM-CCK is send CTS (Clear to send) frame with CCK modulation before OFDM modulation and ACK frame after send.
  - 802.11b clients recognize CTS frame and stop to send data until receiving ACK.
- The performance decreases when both of 11g client and 11b client exist in same area because OFDM-CCK has more overhead than OFDM.

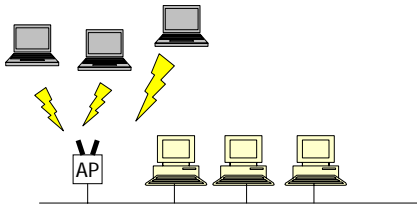


## Three operation mode

- IEEE802.11 has three operation mode.
  - Infrastructure mode
  - ad-hoc mode
  - WDS:Wireless Distribution System mode.

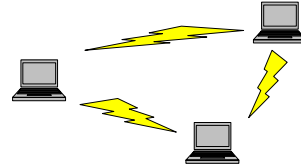
## Infrastructure mode

- Node associate with AP as client.
- Client communicate via access point(AP).
- AP works as bridge.
- This mode is usually used in wireless network.



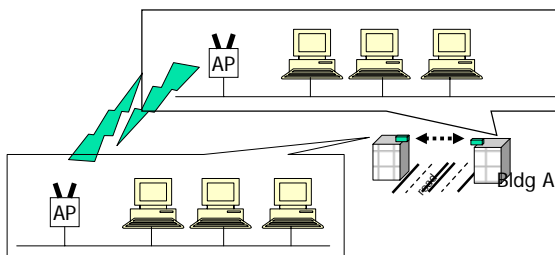
## Ad-hoc mode

- A node communicates other node without AP.
- No AP is required



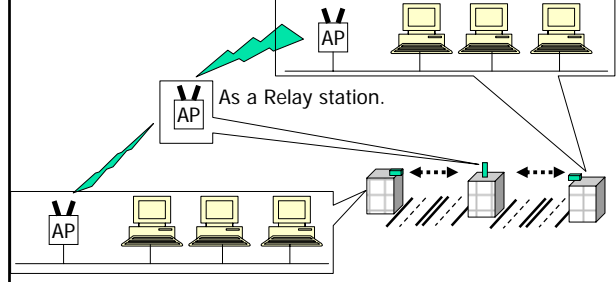
## WDS mode(1)

- Connects between LAN and LAN via AP.



## WDS mode(2)

- AP can work as a relay station.



## Wireless Interoperability

- WECA (Wireless Ethernet Compatibility Alliance) appeared.
  - WECA established to popularize wireless technologies at 1999.
    - Founded by Lucent, Intersil, Aironet(Cisco).
  - Authorizes interoperability of 802.11 device.
    - It is called "Wi-Fi Certified".
- Defines specification for interoperability.
  - Wi-Fi System Interoperability Test Plan
- tests wireless device to interoperable with IEEE 802.11 specification.



Certified Logo

## The effects of WiFi(1)

- Make competitive markets.
  - We are able to choose products based on Wi-Fi
    - It is similar to wired NIC markets.
  - Developing of product is sharply contested
    - Product price is going down from \$150 at '99 to \$30 at '04.

## The effects of WiFi(2)

- Various of NIC type are released.
  - PC-card type for notebook.
  - CF (Compact Flash) type for PDA/notebook
  - SD/IO type for PDA
  - MiniPCI type for notebook



PC-card type



CF type



MiniPCI type

It is used as built-in wireless device on notebook type.

## The effects of WiFi(3)

- The manufacturer develops a good one after another product.
  - Power saving wireless card.
    - More less impact for a battery life on notebook computers.
  - Multi-band wireless card.
    - 802.11a, 11b and 11g combo card released.
- "Enclosed wireless systems" has been to an End.
  - Wireless LAN become open system by WiFi.

## Security technology for wireless(1)

- WEP: Wired Equivalent Privacy
  - Encrypts a data link with a shared key.
  - WEP based on RC4 algorithm.
  - Private key length is 128bit and 64bit.
    - 128bit key is recommended.
    - The key should be changed at periodic intervals.
    - *The risk for leaking the key is proportional to the number of users.*

## Security technology for wireless(2)

- Operate an authentication system for users.
  - ID/Password authentication on the WEB.
  - MAC address authentication.
    - Permitted user's MAC address is registered. to RADIUS server or to AP's local database..
- Separate wireless network from secured network.
  - Operate wireless network with different security policy.
  - Make access control from wireless network to wire network.

## Security technology for wireless(3)

- Operate IEEE802.11i.
  - 802.11i is configured an authentication function and a encryption function.
  - The encryption function on 802.11i is called WPA (WiFi protected access). WPA has more strongly encryption than WEP.
  - The authentication function is based on IEEE802.11x.
- Operating 802.11i takes cost though it is very safe.

## Wireless network Design

## Design points

- Wireless network design is quite different from a wire network design.
- Understand characteristics of wireless.
  - Cover range of Access Point.
  - Interference with between channels.

## How to design a wireless LAN

- Fix policy from purposes, requirement of a wireless network.
  - Who use the wireless network?
  - How long is life of the wireless network?
  - What is security level?
  - etc.
- The design of the wireless network is different according to the operation purpose.
  - Operation wireless network on campus.
  - Operation wireless network on enterprise.
  - Operation temporary network on a conference.

The sense of policy balance is important.

## Understanding "Trade-off."

- Operate wireless network with high security level.
  - It is possible to construct it with 802.11i/WPA etc.
  - We can enjoy a safe network.
- BUT
- Management side needs an account work of each user.
- And require to support user side.
  - Assistant settings, distributing account, etc.
- User side is required to install security future capable OS.
  - Linux/FreeBSD/NetBSD support 802.11i?
  - Guys can enjoy the high security wireless network?
  - Only a part of OS supports new security technologies, such as WPA, 802.11i(11x).
- In the compensation for safety, the operation cost is large.

## Security level and operation costs(1)

- Operate wireless network with WEP
  - We can prevent to tapping of wireless network from unauthorized user.
  - Need to provide WEP key and parameters information to authorized users.

## Security level and operation costs(2)

- Operate 802.11i/WPA on wireless network for high security.
  - It's good for a enterprise network.
    - A leakage of information and unlawful computer access are prevented on a enterprise.
  - It is easy to install this security feature in a enterprise network because users and a variety of clients are limited.

## Security level and operation costs(3)

- WEP or 11x are not good for a temporary network on conference.
  - When the distributing information is required to operate secure wireless network,
    - a human cost is also required.
  - We have to care to various OS.
    - Participants use various OS.
  - Can we correspond to the trouble at participant's clients?
    - The workload of the help desk is very large.
    - It might be impossible!
  - When the distributing information is required by a wireless network, a human cost is also required.

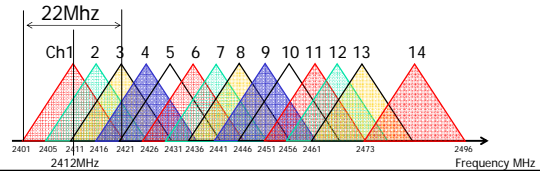
## Security level and operation costs(4)

We have to design a wireless network with thinking profits of both user side and manager side.

There is a right design in the right design.

## 802.11b Channel allocation

- Channel configuration of 802.11b is 2.412GHz(1ch)- 2.484GHz(14ch)
  - The interval of the channel is 5MHz.
  - Bandwidth per channel is about 22MHz.



## 802.11b Channel allocation(2)

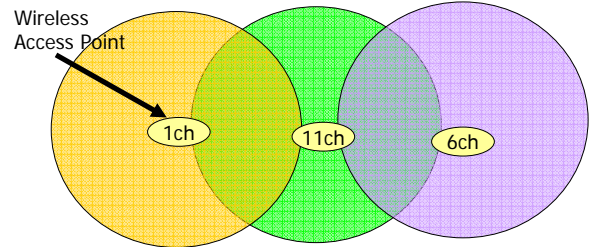
- Combination of channels without interference is limited.
  - The spacing of the channel frequency should be larger than 22MHz.
    - Example for channel combination. Channel 1(2.412GHz) - 6(2.437GHz) - 11(2.462GHz) - 14(2.484GHz)
    - \*channel 14 is only use in Japan.
- Location of access point is decided to avoid overlapping of combination of channels.

Example on next slide.



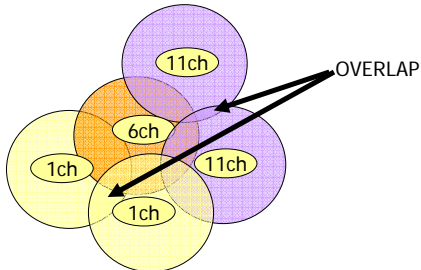
## Example-1

- Decide each position of access point to avoid overlapping.



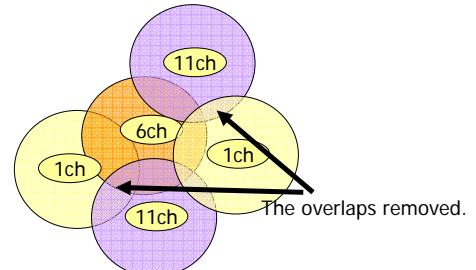
## Example-2: Overlap (BEFORE)

- It is Overlapped!



## Example-2: Overlap (AFTER)

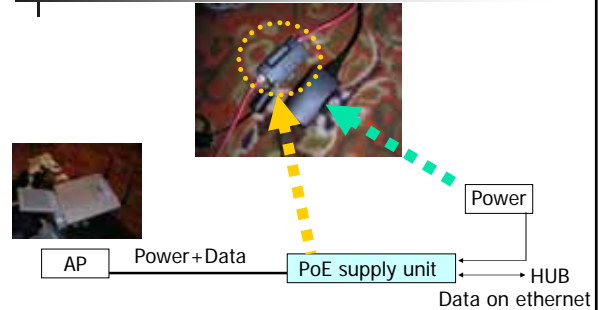
- Swap the position of access points.



## Techniques for setting up APs

- Use PoE, Power over Ethernet, to supply power to AP.
  - PoE specifications are existed.
    - IEEE 802.3af
    - Cisco In-Line Power (Cisco original)
  - Use PoE adapter or PoS capable Ethernet switching to supply.
    - Such as Cisco Catalyst series, Foundry, etc..

## Cisco inline power Adapter



## Benefit for AP with PoE

- The cable wiring for a power supply is unnecessary.
  - PoE decreases the restriction of AP's location at the installation site.
  - Decrease installation cost.

## Class of access point(1)

- AP for consumer usages
  - Retail price is about \$100.
  - Management functions are poor.
    - Most AP supports WEB interface only.
  - The performance of access point is low.
    - Maximum capacity of client under AP is about 30 clients.



## Class of access point(1)

- AP for enterprise/campus usages
  - Retail price is about \$1000.
    - Cisco aironet 1220 including 11a/b/g interfaces.
  - AP has high performance CPU and tuned software.
    - Maximum capacity of client is up to 120 clients.
  - AP has SNMP/WEB/CLI management i/f.
  - Wireless LAN switch system
    - Able to manage entire of wireless APs on wireless switch.
    - It is convenient in a large-scale wireless network.
      - Wireless switch system manufacture is Aruba/Meru/AeroSwitch etc..

## Estimation for number of wireless clients

- AP has the maximum capacity of users.
  - The capacity is depending on the performance of access point.
    - "AP A" is for consumer use can handle 20 users per AP.
    - "AP B" is for enterprise use can handle 120+ users per AP.
  - Estimate maximum number of users.
    - 11b can use three channels per room to avoid interference.
      - If you construct wireless network with "AP A",
        - Maximum capacity is 60 users.
      - If you construct wireless network with "AP B",
        - Maximum capacity is 360 users.
    - POINT: A model of AP is selected expecting the number of users.
- Example
  - A plenary session at IETF meeting, the number of users is up to 500+.
    - If you choose "AP B", You have a lot of troubles.

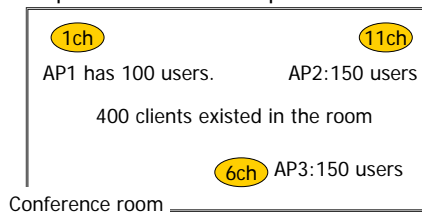
## Case study

## Threat of AP overload condition

- When the number of clients under AP exceeds the limitation of the base station,
    - The following troubles will occur.
      - New associating clients are rejected by AP.
      - Can't manage the AP.
        - Connection to CLI/WEB is refused.
      - reboot
      - Halt, need to restart in manually.
      - Crash with damaged configuration files.
        - need to re-setup access point.
- (Its are based on my experience.)  
No one knows what happens.

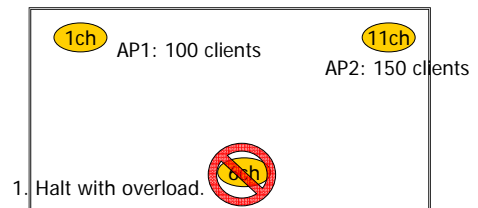
## Case study: Chain of failure

- At IETF54 Yokohama conference room.
  - Operate three access point in the room.



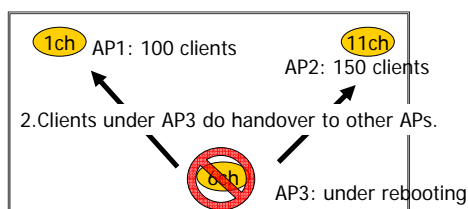
## Case study from IETF54

- AP3 was halted due to overload.



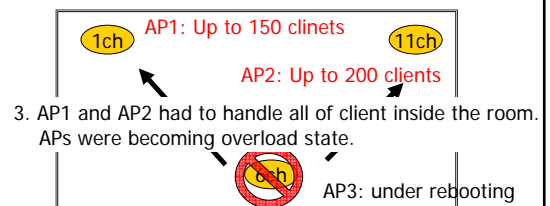
## Case study from IETF54

- Clients under AP3 lost signal from AP3, then search and associate with other APs.



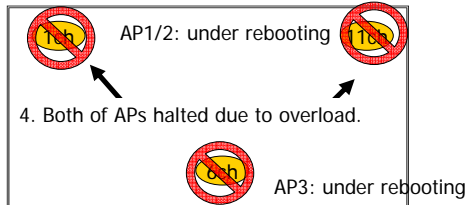
## Case study from IETF54

- AP1 and AP2 should handle the clients under AP3.



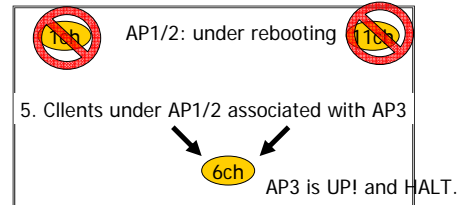
## Case study from IETF54

- Also, AP1 and AP2 halted due to overload.



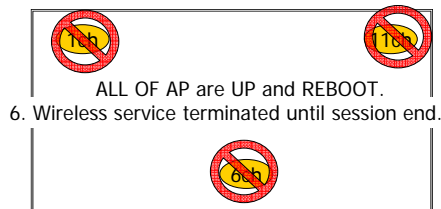
## Case study from IETF54

- AP3 was up but halted again due to associate all of client inside the room.



## Case study from IETF54

- Wireless service had been terminated until the end of session.



## Case study from IETF54

- How to protect from this situation?
  - Set association limit of clients per AP.
    - Some products support for association limit.
      - "Max-association [association limit]" command for cisco Aironet/IOS.
    - We used Orinoco AP1000 and Cisco Aironet at IETF54(2001).
      - Both of them didn't support limitation function.

## Case study: Worm infected nodes.

- Blaster worm generate many network traffic.
  - It use ICMP Echo-request and reply to search active nodes.
  - Many nodes infected Blaster worm connected to wireless network.
    - Some user didn't understand infection.
    - Some user infected on wireless network due to forget applying security patches.
- Infected nodes consume wireless resource.
  - Throughput of Wireless is going down.
  - The load of AP is going up.

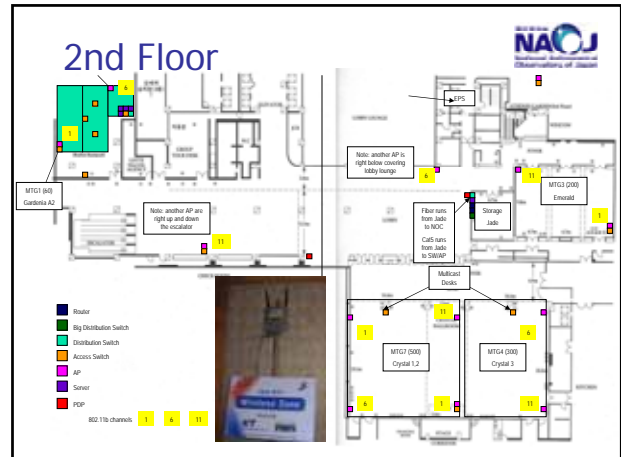
## Case study: unofficial DHCP server

- Client with enabled DHCP server function was existed.
  - Ex) At home, a user enable enable Internet Connection Sharing(ICS) service on the notebook to share a connectivity to the Internet.
    - > ICS enable, DHCP Server service start, too.
    - The notebook connect to the wireless network, then, it start to provide un-official DHCP server service.
  - Other clients is confused, because two or more DHCP server exists on same network.

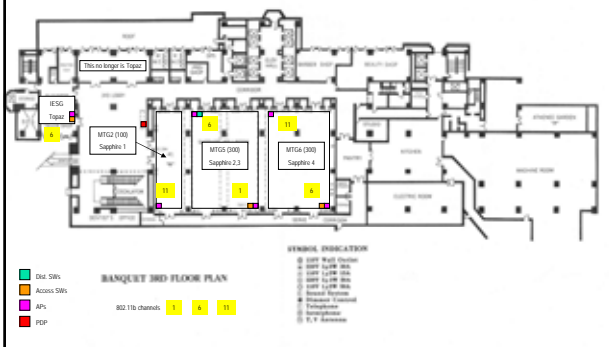
Disassociate illegal clients from network immediately.

## Case study: IETF59

- IETF59(Seoul) held 2004.03 at Lotte Hotel Seoul.
- Provided wireless service to three floors.
- Total number of AP was 32.
  - I used Cisco Aironet 1220 with PoE



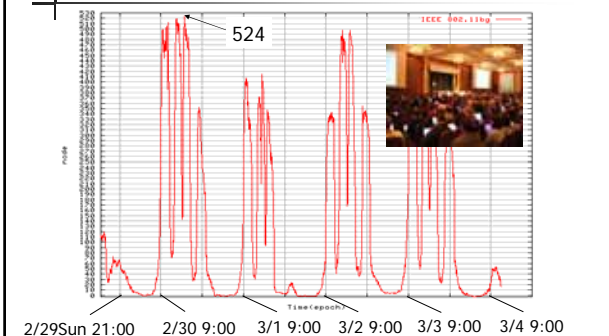
## 3rd Floor



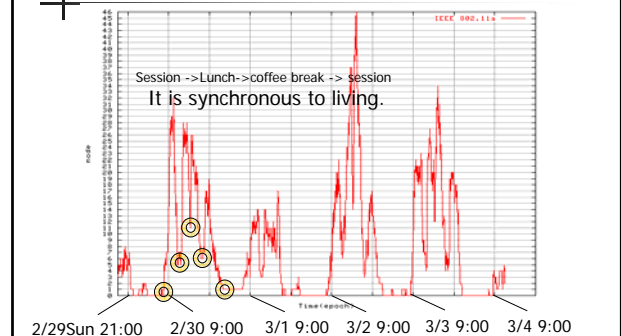
## Operate a monitoring system

- I developed and operated the wireless monitoring system.
- This system can monitor all of AP status.
  - Record association number of clients, associating client's MAC address, load average, etc.
- This system has a function to disassociate a client from entire of wireless network.
  - Illegal clients such as worm infected, un-official dhcp server, RA server and etc are forced out.

## Result: Number of 802.11b users



## Result: Number of 802.11a users



## Results

- Total unique client was 1297.
- Peek of 11b clients was 524.  
Recorded at 2004/3/1 15:51:21
- Peek of 11a clients was 46

## Results

- 10 nodes were shut out from the wireless network.
  - Number of wire-wireless bridging enabled node is 5.
  - Worm infected node : 3
  - RA enabled node : 1
  - DHCP enabled node : 1

It was success in wireless operation.

## The End

Any questions?  
-> [masa@fumi.org](mailto:masa@fumi.org)