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Operation Report of WiFi mesh networks at WIDE 2012 Spring Camp Network

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Operation Report of WiFi mesh networks at WIDE 2012 Spring Camp Network

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Abstract

Layer 2 and layer 3 WiFi-based mesh networks were provided as a comodity network infrastructure for participants of the WIDE 2012 Spring Camp meeting from 5th to 8th March 2012. This documents reports the summary of the network configuration information and brief performance measurement results.

1 Background

It is well understood that wireless radio communication technologies are useful technologies for places where landline infrastructure is not well deployed. A conference network or an event network where we need a temporal Internet connectivity, or cases of disasters where we lose most of the existing ground communication infrastructures, are examples. However, in reality, we usually construct wired network backbone for conference and event networks. The only wireless section is the last 1 hop, between a user terminal and a WiFi access point. In disaster cases, a satellite link is the most major communication device to provide Internet connectivity to the damaged area. From the satellite terminal, we extend the network using a Ethernet cable and last 1 hop WiFi access point in most cases.

We know wireless links reduce the network construction burden a lot, however we haven't been using them seriously. There are some reasons of not using wireless links; for example, 1) the performance of wireless networks is much lower than wired networks, 2) management of the invisible links are more difficult than wired links.

We thought that we had to have more experience on the operation of wireless based network construction and to find what were the real sources of the reasons why we though wireless-oriented network was hard to operate.

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2 Specifications

We operated two different kinds of WiFi mesh networks in the WIDE 2012 Spring Camp meeting. The one is a layer 2 mesh network, and the other is a layer 3 mesh network. The devices used to construct these mesh networks are shown in table 1 and 2.

Table 1: Devices used to construct a layer 2 WiFi mesh network

Part	Role
Cisco AIR-2125-K9	Wireless LAN Controller
Cisco AIR-1262N-Q-K9	Wireless LAN Access Point
Cisco AIR-PWRIJN4	Wireless LAN Access Point PoE adapter
Cisco WS-C3560CG-8PC-S	PoE Ethernet Switch

Table 2: Devices used to construct a layer 3 WiFi mesh network

Part	Role
NTTPC Communications MR1200	Wireless LAN Access Point (with customized OpenWRT operating system)

3 Meeting Rooms

Table 3: Meeting rooms

Name	Capacity
Workshop (WS)	for 200 people ($1015m^2$)
Plenary	for 150 ($175m^2$)
BoF1	for 60 (less than $100m^2$)
BoF2	for 60 (less than $100m^2$)
Board	for 20 (less than $100m^2$)

The number of participants of the meeting was 166. There were 5 rooms for the meeting. Table 3 and figure 1 show the rough size of the rooms and their locations.

The WS room was used to host several workshops during the meeting. The plenary room was used to have plenary sessions and some bof sessions. The WS room and the plenary room were the most crowded space since they might have the entire meeting participants, during the workshop sessions or plenary sessions. The BoF1 and BoF2 rooms were used to host bof sessions for working groups. They had roughly 50 members at

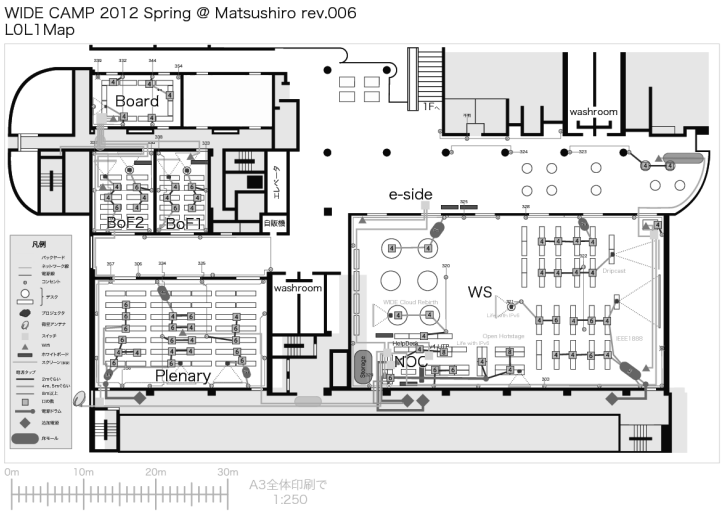

Figure 1: The floor map of the venue (the size of the 2nd floor is $80m \times 50m$)

maximum during the meeting. The board room was a dedicated room for the WIDE board members, and had around 20 members at maximum.

Each room was separated thick walls. The doors were closed while there were meetings in the rooms, except the WS room where most of the doors were kept open.

4 Network Configuration

4.1 Layer 2 WiFi Mesh

In the layer 2 WiFi mesh configuration, we used a wireless LAN controller appliance sold by Cisco Systems (table 1). The WiFi band allocation policy is as follows.

Backhaul 802.11a 5GHz (36 for a single band or 36 and 40 channels for a channel bonding)

User 802.11gn 2.4GHz automatic allocation (1, 6, and 11 channels)

Figure 2 shows the initial location of access points. There were 11 access points (AP-1 to AP-10, and AP-14) located at the venue. AP-1 was the only access point connected via a Ethernet cable since it was acting as a root access point of the entire mesh network. All the access points were under control of the wireless LAN controller (indicated as WLC in the map).

We started with the configuration shown in figure 2, however, when we finished the first plenary session in the plenary room in the afternoon on 5th March, we noticed that that most of the users in the plenary room were connected AP-10 and the AP was overloaded. We moved AP-4 from

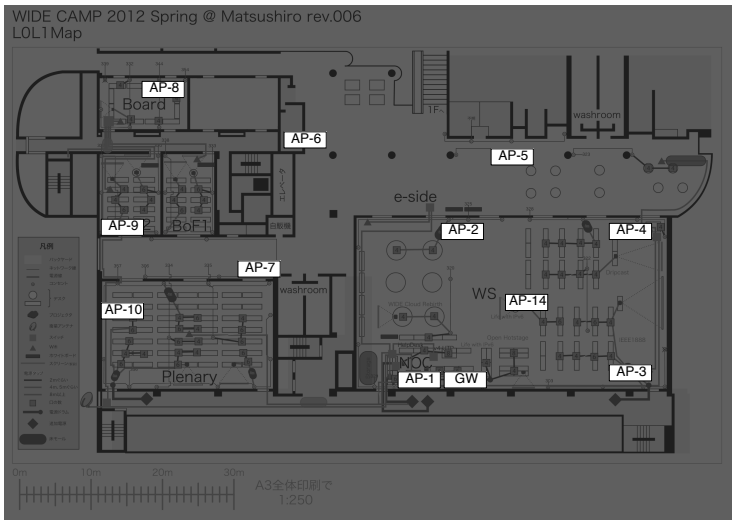

Figure 2: Initial access point location map for layer 2 WiFi mesh network

the workshop room to the plenary room in the evening on 5th and kept the configuration until we finish the meeting. Figure 3 shows the location map we used during the most of the meeting period.

The protocol used to build and maintain the layer 2 mesh topology was AWPP (Adaptive Wireless Path Protocol, which is a proprietary protocol of Cisco).

4.2 Layer 3 WiFi Mesh

In the layer 3 WiFi mesh configuration, we used a OpenWRT-based wireless router provided by NTTPC Communications (table 2). The WiFi band allocation policy is as follows.

Backhaul 802.11a 5GHz (36 channel)

User 802.11gn 2.4GHz static allocation

- AP-1: Channel 1
- AP-2: Channel 6
- AP-3: Channel 11
- AP-4: Channel 1
- AP-5: Channel 11
- AP-6: Channel 6
- AP-7: Channel 1
- AP-8: Channel 1
- AP-9: Channel 6
- AP-10: Channel 11

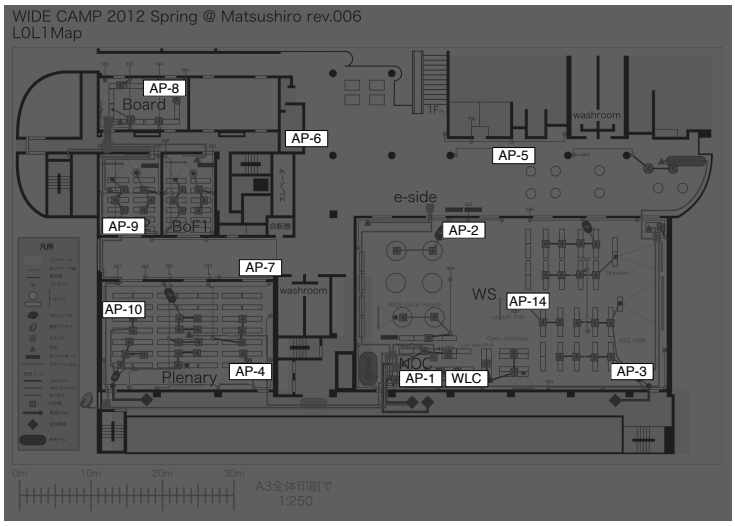

Figure 3: Final access point location map for layer 2 WiFi mesh network

Figure 4 shows the location of each access point. AP-1 acted as an Internet gateway in addition to as an access point and mesh router.

The protocol used to build and maintain the layer 3 mesh network was OLSRv2.

5 Topology Transition

Figure 5 and 6 are the snapshot images of the layer 2 and layer 3 mesh networks as of 20:00 5th March 2012 and 12:00 6th March 2012 respectively.

The red arrows in figure 5 indicate parent access points.

The red arrows in figure 6 indicate next hop access points, and the gray arrows indicate neighboring access points.

The layer 2 mesh topology is simpler than that of the layer 3 mesh network topology. This is because the layer 2 mesh topology is constructed as a tunnel link from each access point to the WLC as an Internet gateway. CAPWAP (Control And Provisioning of Wireless Access Points) [RFC5461] was used to maintain the tunnel links. Thus, all the traffic received from user terminals are once tunneled to the Internet gateway, decapsulated at the Internet gateway, and forwarded for the final destination.

On the other hand, all the access points of the layer 3 mesh network are equal footing each other. Each access point advertises subnet information which is assigned to that particular access point to accommodate users. The subnet information is exchanged among access points and the cost to the destination subnets are calculated based on the OLSRv2 algorithm. Finally each access point will have next hop information to which it should

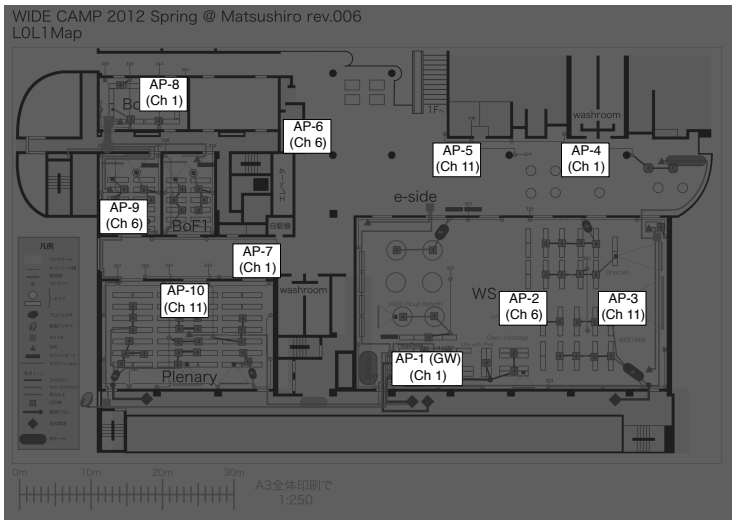

Figure 4: Access point location map for layer 3 WiFi mesh network

send packets received user terminals.

The layer 2 mesh network was operated from 15:00 on 5th to midnight 8th March, except 12:00 to 18:00 on 6th March. The layer 3 mesh network was operated from 12:00 to 18:00 on 6th March. The animated topology transition images for each mesh network are available from the links below.

- Layer 2: http://member.wide.ad.jp/~shima/publications/20120306-wifi-mesh-takeda-route.m4v
- Layer 3: http://member.wide.ad.jp/~shima/publications/20120306-wifi-mesh-uesugi-route.m4v

6 Performance

We performed a simple TCP bandwidth measurement using the iperf tool. Figure 7 and 8 are the measurement results of the layer 2 mesh network. We put 2 client nodes, one is attached to the switch directly connected to AP-1 and the other to attach several access points as shown in the figures. For example, in the rightmost column of figure 7, we put one client near AP-10 and performed the iperf command. The 'UP' means the direction from the leaf area to the Internet gateway, the 'DOWN' means the opposite direction.

From the figures, we can see that the 40Mhz backhaul gives us almost twice as much performance than the 20Mhz backhaul configuration. We also can see the performance decreases as the number of hops is increased basically.

Figure 9 shows the result of the layer 3 mesh network bandwidth measurement. For the layer 3 measurement, we didn't use any client nodes

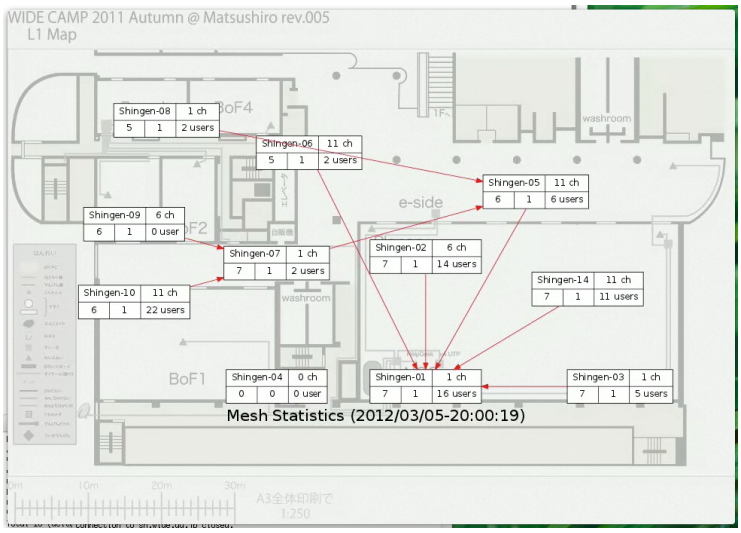

Figure 5: Layer 2 WiFi Mesh topology as of 20:00 5th March 2012

to perform the iperf command. Instead, we used the access point itself to execute the iperf command. So, the measurement environment is different from the layer 2 cases. In this case, the performance quickly decreases when the number of hops increases.

7 Summary

We are now trying to achieve operation experiments to build wireless-based Internet and finding out what are the show stoppers to make it. As a part of the activity, we build two different types of WiFi mesh networks during the WIDE 2012 Spring Camp meeting. One is a layer 2 mesh network built with Cisco products, the other is a OLSRv2-based layer 3 mesh network.

We found that both mesh networks can be built but stability is different. The product level layer 2 network worked well, although the throughput was not ideal (around 1Mbps with 5 hops). We can consider this performance as a reference performance of the current product level devices. The layer 3 mesh networks can build the mesh network however, when the access points start hosting many users, the stability decreases rapidly. In addition to that, the performance degradation when we increase the number of hops is much quicker than the cases of the layer 2 mesh network. We haven't found the real cause of this issue however, our guess at this moment is the design of the wireless chipset and circuit to drive the chip, and traffic management of the backhaul links.

Our next steps are as follows.

- achieve reference performance measurement using a clean environment using wired antennas and attenuaters

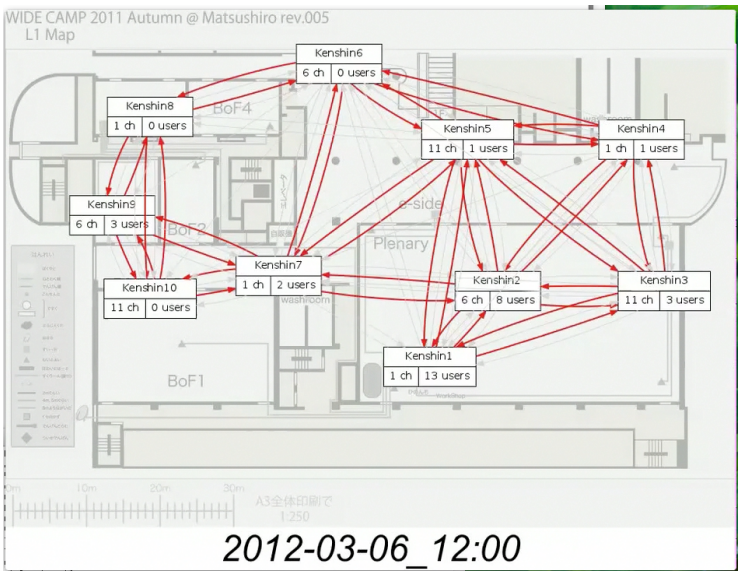

Figure 6: Layer 2 WiFi Mesh topology as of 12:00 6th March 2012

- propose a performance model of WiFi mesh network
- build reference WiFi routers to verify the model
- perform experiments in real environment such as following WIDE meetings

Acknowledgment

We thank Yoshihiro Onodera and Koichi Shibakawa from Cisco Systems G.K. for their great support providing us many Cisco wireless network products and useful advice when configuring the devices. We also thank NTTPC Communications to give us a chance to operate a layer 3 WiFi mesh network using their devices.

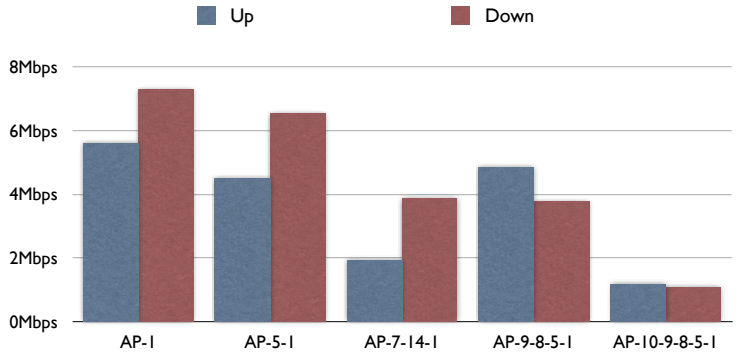

Figure 7: Layer 2 WiFi Mesh throughput with 20Mhz backhaul frequency allocation (from Client-AP...AP-Client)

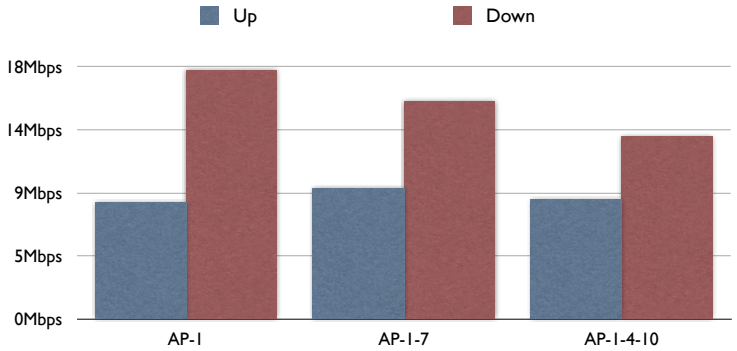

Figure 8: Layer 2 WiFi Mesh throughput with 40Mhz backhaul frequency allocation (from Client-AP...AP-Client)

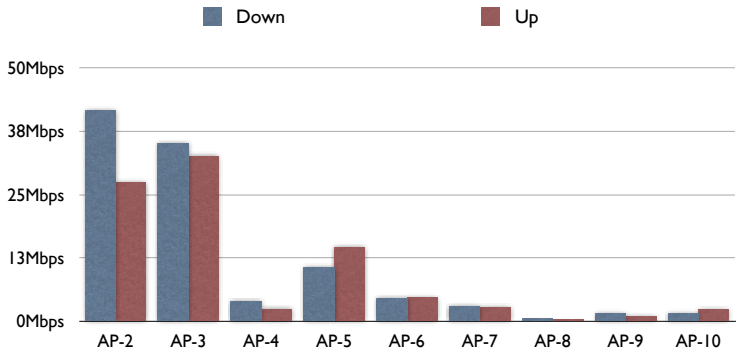

Figure 9: Layer 3 WiFi Mesh throughput (from AP to AP)