



Wharf T&T Limited

Report of Wireless LAN Technology Trial

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1. Executive Summary

A wireless LAN (WLAN) technology trial was conducted to test the WLAN point-to-point link performance, functionalities, and its potential applications. The WLAN technology is based on the IEEE 802.11b standard, utilizing the 2.4 – 2.4835 GHz frequency spectrum.

A model of WLAN Access Bridge provided by a leading telecommunication equipment vendor was selected in this trial for setting up a point-to-point WLAN link test in an outdoor environment to conduct the evaluation. Brief information about the trial is listed below.

- Trial Location - roof tops of two high rise office buildings in Hong Kong
- Trial period - from 6 August 2003 to 22 September 2003
- Path distance - 600m point to point link

The following general WLAN functionalities were tested in the trial:

- Coverage
- Point-to-Point link throughput
- Transparent VLAN
- Broadband interworking
- Security features

A simple network was established as shown in Figure 1 for the evaluation. Two Access Bridge (AB1 & AB2) were used to setup a point-to-point WLAN link. Three notebook PCs, one with WLAN PCMCIA card and one WLAN USB client, were installed in two notebooks as remote clients. The 3rd notebook PC, which was connected to LAN interface of the Access Bridge (AB2) via a LAN switch, served as a FTP server for data transfer between clients. Internet access and Voice Gateway access were via two separate VLAN through the production Broadband network.

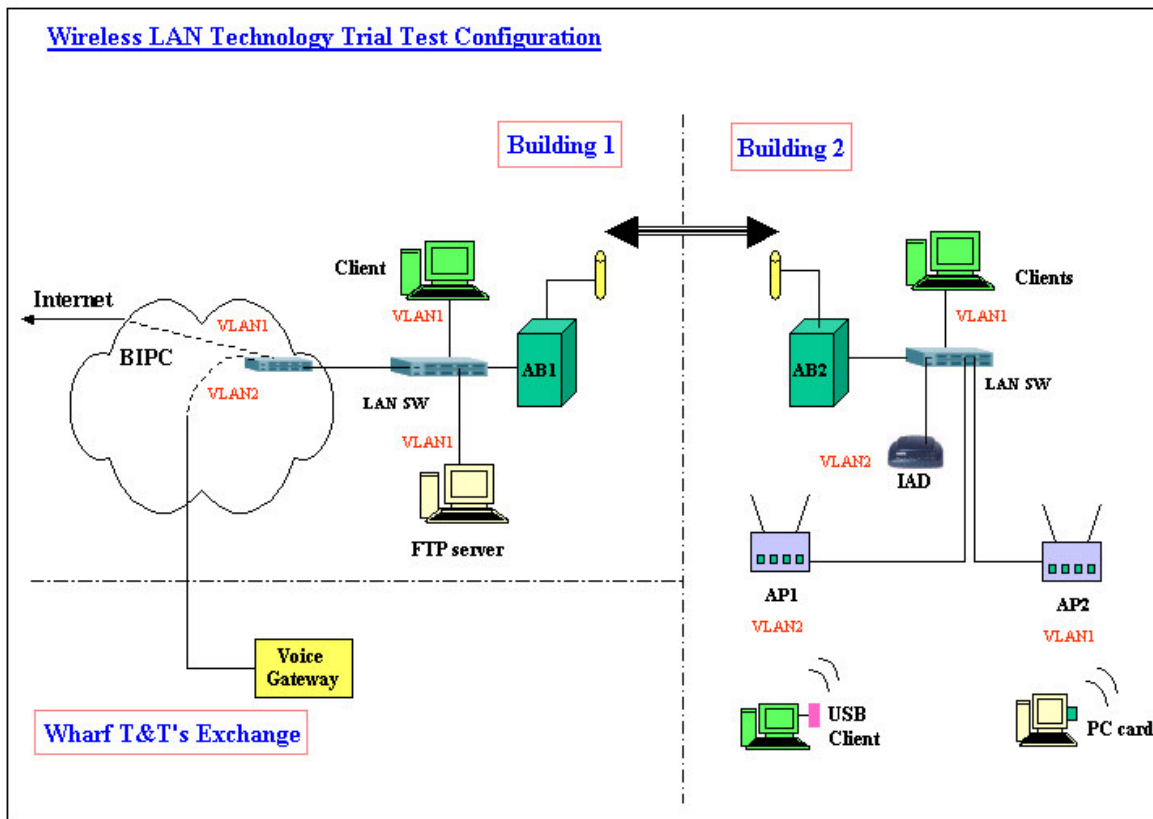


Figure 1: General Test Configuration

Referring to the technical specification, the Access Bridge equipment used in this trial complies with IEEE 802.11b Specification. The trial equipment quantity and its features are listed as follows.

Table 1: Trial hardware type and Quantity:

Equipment Type	QTY	Spec.	Band (GHz)	Available Interfaces			Antenna
				WAN/LAN (10M/100M)	Wireless (11M)	Console	
Access Bridge	2	802.11b	2.4 to 2.4835	1	1	1	8.5dBi



The test was successfully completed. A summary of the test results is shown in the table below.

Table 3: WLAN Test Result Summary

Test Item	Result	Remark
Coverage	✓	Tested 600m with 8.5dBi antenna (Outdoor)
Throughput	✓	About 32-35% throughput of 11Mbps (3.5 - 3.8Mbps)
Access Control	✓	Through MAC address access control to manage wireless client
Broadband Interworking	✓	Internet
Encryption	✓	64 -bit; 128-bit
RF power measurement	✓	Measurement performed under test mode
Application Test	✓	WWW, FTP, VOIP, TDMOIP



2. Test Result Summary

The trial test results are summarized below. Detailed test setup and configuration are in section 3.

Throughput:

- The Access Bridge Equipment was configured as access bridge mode. The average FTP throughput with encryption enabled and without encryption enabled was 3.5 Mbps and 3.8 Mbps respectively for single user FTP session. Equivalent to a 8% decrease in FTP throughput was observed when encryption was enabled.

- The maximum WLAN channel bandwidth is 11Mbps according to the 802.11b standard. A significant portion of the channel bandwidth was consumed by the Physical Layer Convergence Protocol (PLCP), the transmission flow control and the protocol overhead. The measured payload throughput was only 34.5% of the 11Mbps full bandwidth.
 - IEEE 802.11b bandwidth - 11 Mbps
 - FTP payload throughput - 3.8 Mbps
 - % Protocol overhead - 65.5%
 - Throughput efficiency - 34.5%

Coverage & Transmit Power

- The path distance between two test sites was about 600m with direct line-of-sight. The antenna gain was 8.5dBi.

- Maximum transmit power met OFTA's WLAN requirement
 - Access Bridge's maximum transmit power was 29.6 dBm
 - $29.6 \text{ dBm} = 21.1 \text{ dBm (max. RF power)} + 8.5 \text{ dBi (antenna gain)}$
 - OFTA requirement < 36.02 dBm, i.e. 4W

- It was possible to extend coverage by using higher gain antenna at 14 dBi and the OFTA requirement was still met. The coverage can be extended to 1.3 km according to calculation.



Remark:

It should be reminded that the test results were measured under a small-scale testing environment with limited resources and they should be served for indication only. More accurate results can only be obtainable in real environment with different kinds of traffic starving for different amount of bandwidth.



3. Test Setup and Configuration

3.1 Parameter Setting

The general parameter setting for Access Point Router, WLAN PC card and USB client adapter are listed as follows:

a) Access Bridge equipment setting

AB1

Wireless Mode: Central Bridge
Transfer rate: max. 11 Mbps
Channel: 1 / 6 / 11
Encryption (WEP): Disable / Enable
DHCP: Disabled

AB2

Wireless Mode: Remote Extension Bridge
Transfer rate: max. 11 Mbps
Channel: 1 / 6 / 11
Encryption (WEP): Disable / Enable

b) Access Bridge as Access Point router equipment setting

AB1/AB2

Wireless Mode: Central Bridge
Transfer rate: max. 11 Mbps
Channel: 1 / 6 / 11
Encryption (WEP): Disable / Enable
DHCP: Enable / Disable
NAT: Enable
Mac address filter: Disable / Enable

PC Card/USB Client

Wireless Mode: Infrastructure
Transfer rate: max. 11 Mbps
Channel: 1 / 6 / 11
Encryption (WEP): Disable / Enable



3.2 *Test File Setup*

For single user throughput test, either a PC with WLAN PC card or USB adapter accessed the FTP server on LAN of Access Point router and performed FTP file transfer.

File size: 10 MB

3.3 *Multiple User Setup*

For multiple user throughput test, set up as follows:

- a) PCs with WLAN PC card/USB adapter
- b) A PC client directly connected to LAN port of access point router,
- c) FTP server connected to LAN of Access Point
- d) All PC clients performed FTP file transfer simultaneously

File size: 10 MB

3.4 *Roaming Test Setup*

Wireless PC client associated with AB1 and ping the FTP server on LAN segment. It moved away from AB1 and moved toward AB2. At a certain point, the client roamed from AB1 to AB2. But it could still ping the server.

3.5 *VOIP Test Setup*

A call generator was connected to IAD or VOIP software running on a PC to generate a number of calls; and recorded down the number of successful calls. At the same time, a wireless/wired client accessed the FTP server and performed file transfer and recorded down the throughput of file upload and download.

3.6 Test Configuration

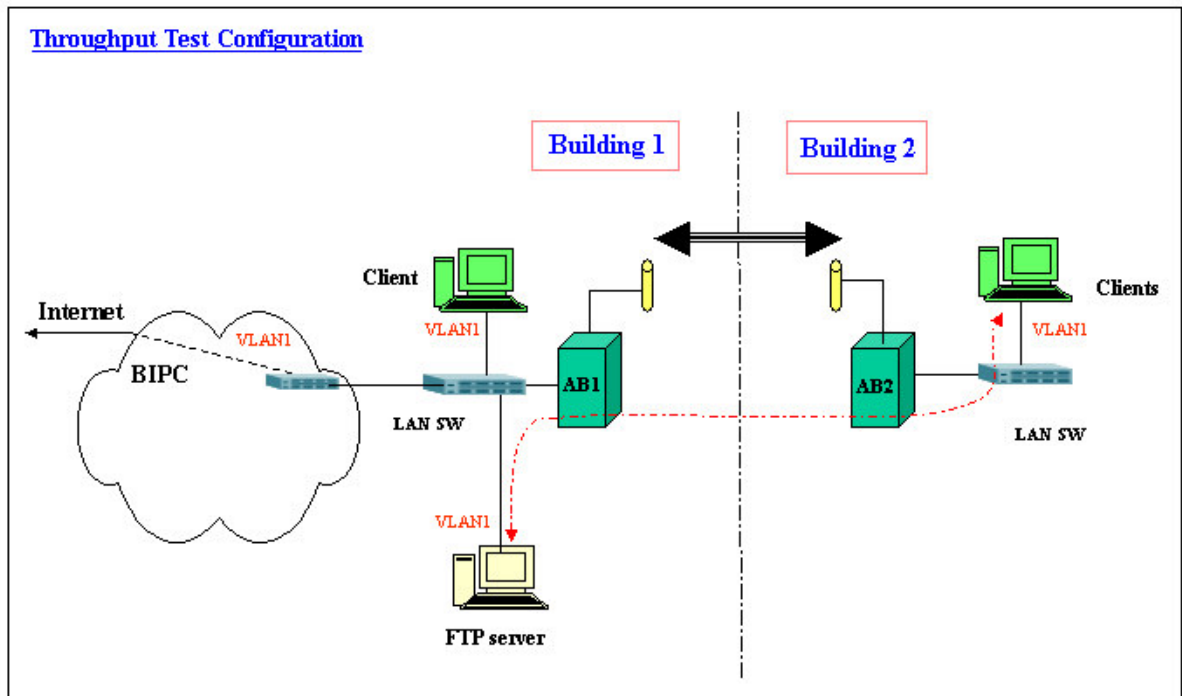


Figure 2: Throughput Test

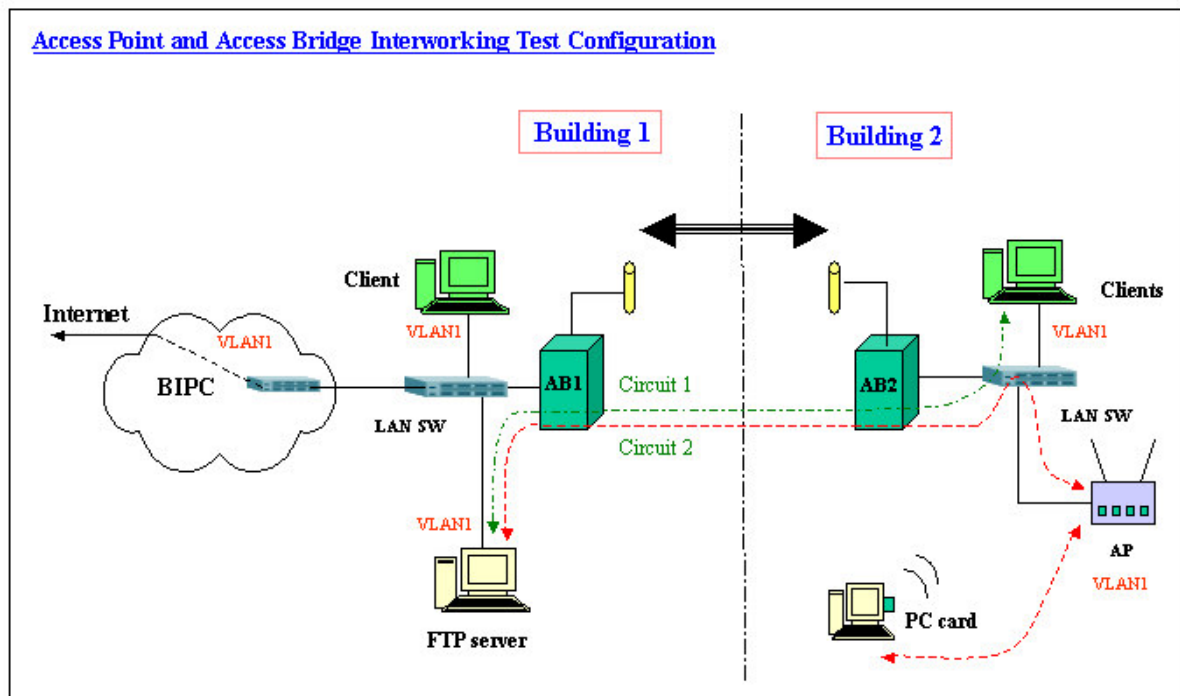


Figure 3: Access Point and Access Bridge Interworking Test

Internet Connection Test Configuration - Access Bridge Acting as Access Point Router

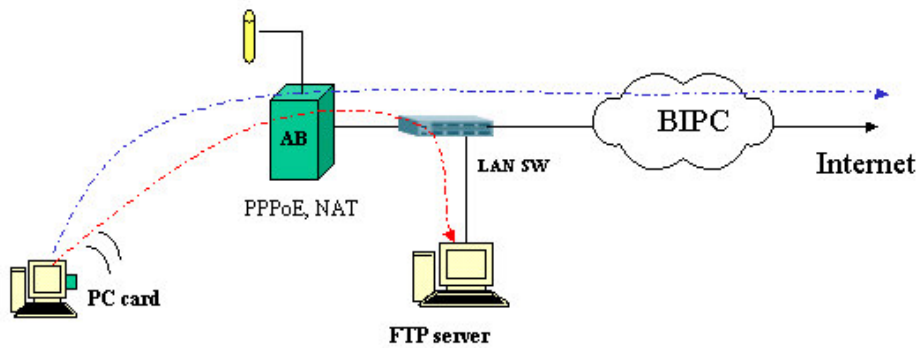


Figure 4: Internet Connection Test

Roaming Test Configuration - Access Bridge Acting as Access Point

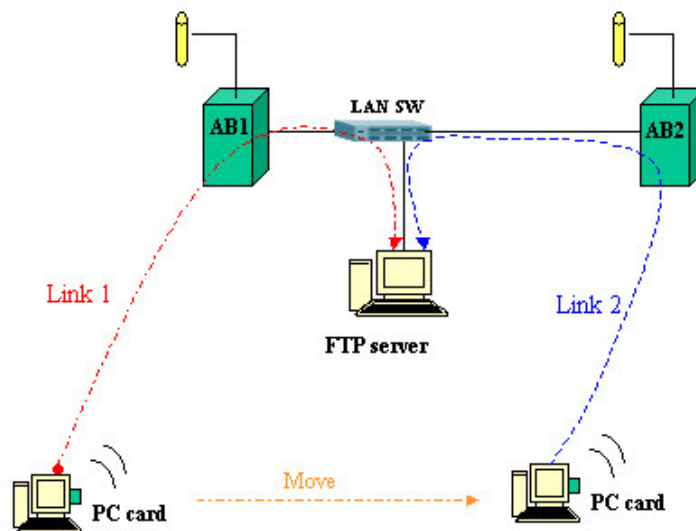


Figure 5: Roaming Test

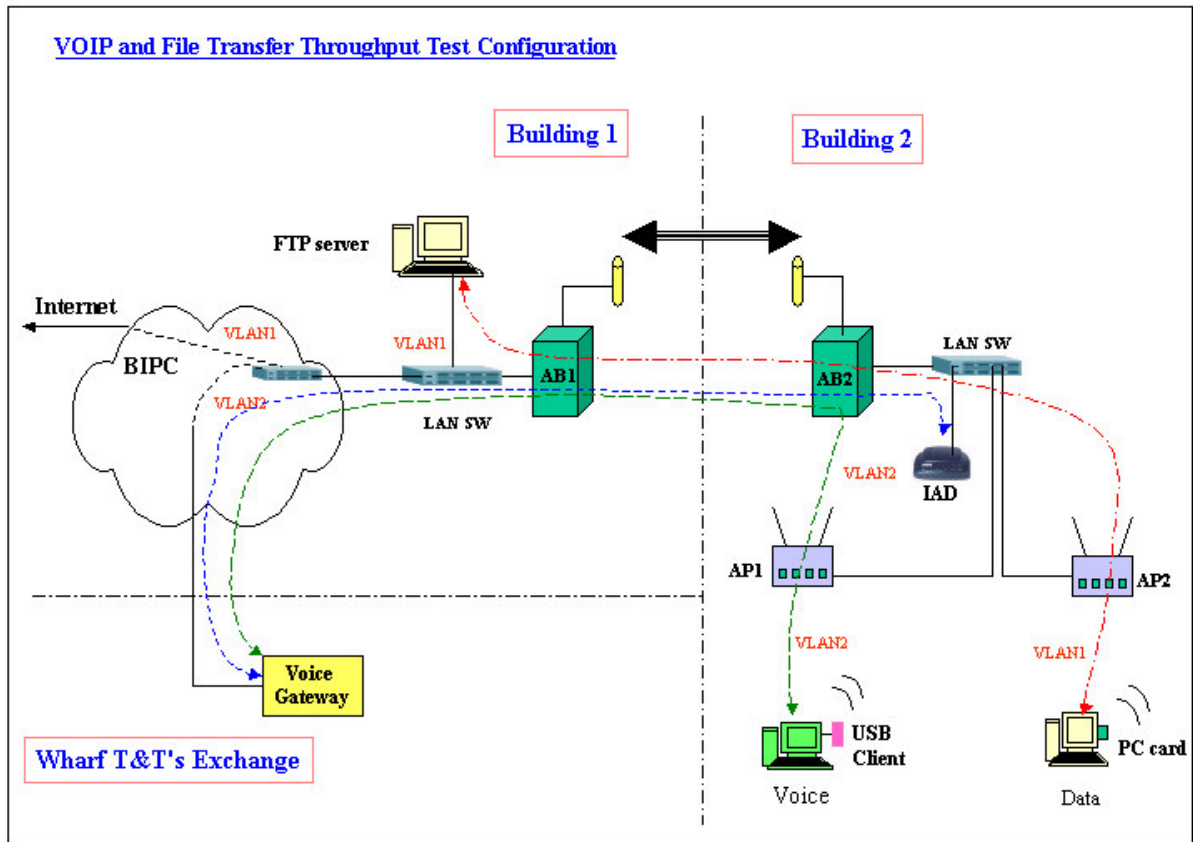


Figure 6: VOIP and File Transfer Throughput Test



Appendix 1: OFTA Technical Conditions in Present Exemption Order

Information extract from NSP-WG Paper No. 13/2002; Overview of Technical Standards for Wireless Local Area Network and Wireless Personal Area Network.

The technical conditions given in the present Exemption Order governing the use of the 2.4 GHz and 5 GHz radio devices are outlined below:

<i>Frequency Band</i>	<i>Radiated Power</i>	<i>Radiated Spurious Power</i>	<i>Modulation Technique</i>
2.425 - 2.475 GHz	100 mW e.r.p.	10 μ W e.r.p.	No restriction
2.400 - 2.4835 GHz	4 W e.i.r.p.	75 nW e.i.r.p.	Spread spectrum
5.725 - 5.850 GHz	4 W e.i.r.p.	75 nW e.i.r.p.	Spread spectrum

Note: e.r.p. for effective radiated power; e.i.r.p. for equivalent isotropically radiated power