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# Wireless LAN Experiments

Computer Network Experiments  
NBL Assisting Session for CIS, NCTU

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# Outline

- About Wireless LAN
  - Introduction to Wireless LAN
  - Variant Wireless LAN Technologies
- Recent Features of WLAN
  - b/g-Mixed Mode Compatibility
  - Wi-Fi Protected Access (WPA) Support
  - Proprietary Throughput Improvement
- The Experiment Approach
- Test Utility Adopted
  - Introduction to NetIQ Chariot
  - Add Pair and Select the Script
  - Run and Get the Throughput

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## Outline (cont.)

- Experiments in Brief
  - Test Coverage for Students in NBL
  - Parameters Configuration (constant conditions)
  - Functionality Tests
  - Interoperability Tests
  - Performance Test
- Test Methodology Design

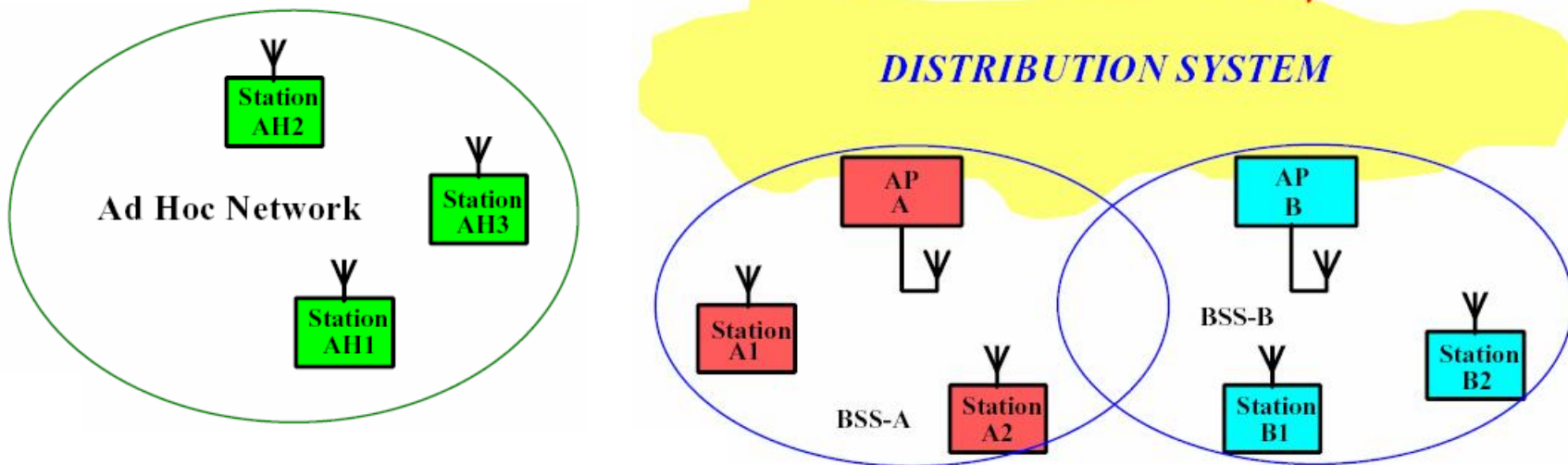
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*The author, Elia Chen, has unconditionally permitted Prof. Yingdar Lin and his teaching assistant to properly modify these slides to be used in the courses of future semesters.*

# About Wireless LAN

## Introduction to the WLAN

- One MAC supporting multiple PHYs
  - PHY: FH, DS, IR, CCK, PBCC, and OFDM (more in the future!)
  - MAC: CSMA/CA (collision avoidance) with optional “Point Coordination”
- Two configurations
  - “Independent” IBSS (Ad Hoc) and “Infrastructure” BSS



# About Wireless LAN

## Variant WLAN Technologies

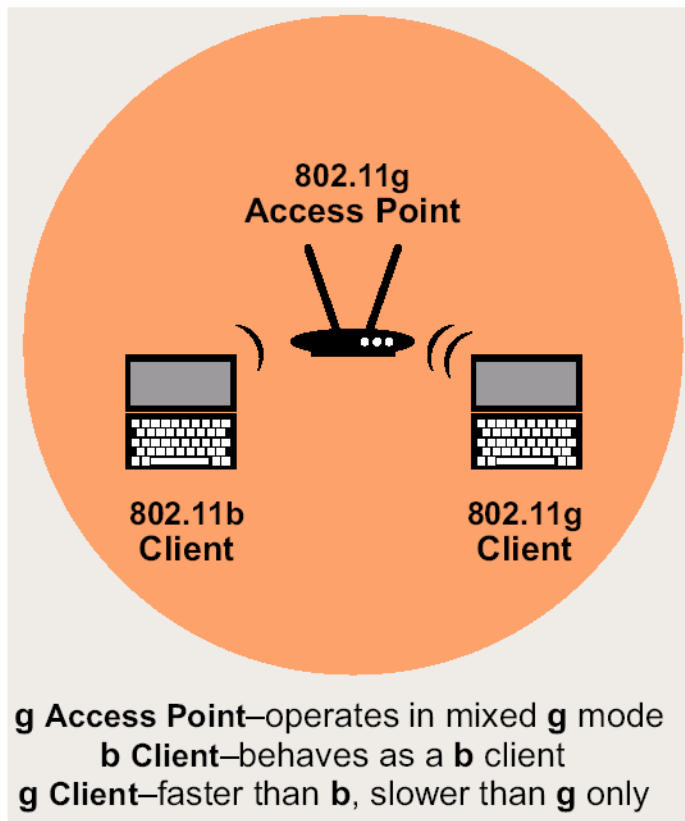
	802.11b	802.11a	802.11g	802.11a/g
<b>Maximum Data Rate</b>	11 Mbps	54 Mbps	54 Mbps	54 Mbps
<b>Frequency Band</b>	2.4 GHz	5 GHz	2.4 GHz	5/2.4 GHz
<b>Channels</b>	3	12	3	12/3
<b>Typical Range</b>	Up to 300 ft.	Up to 180 ft.	Up to 300 ft.	Up to 180/300 ft.
<b>802.11b Compatible</b>	Yes	No	Yes	Yes
<b>Comments</b>	Most widely deployed today	Incompatibility causes limited acceptance	Replaces 802.11b	Highest capacity at price premium

### ❑ Features of 802.11b, 802.11g, and 802.11a technologies

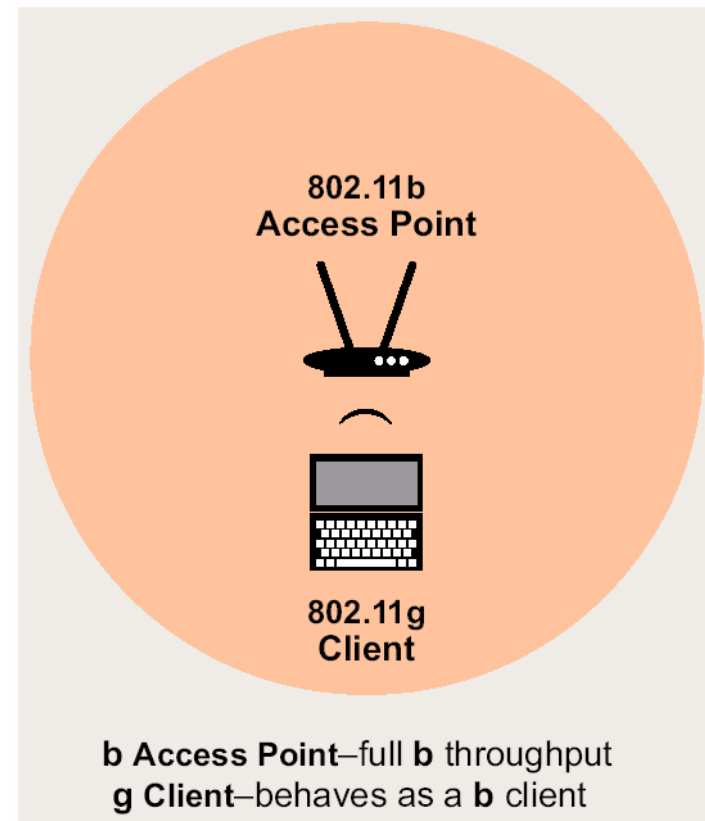
*From: © Broadcom, "The New Mainstream Wireless LAN Standard"*

# Recent Features of WLAN

## b/g-Mixed Mode Compatibility



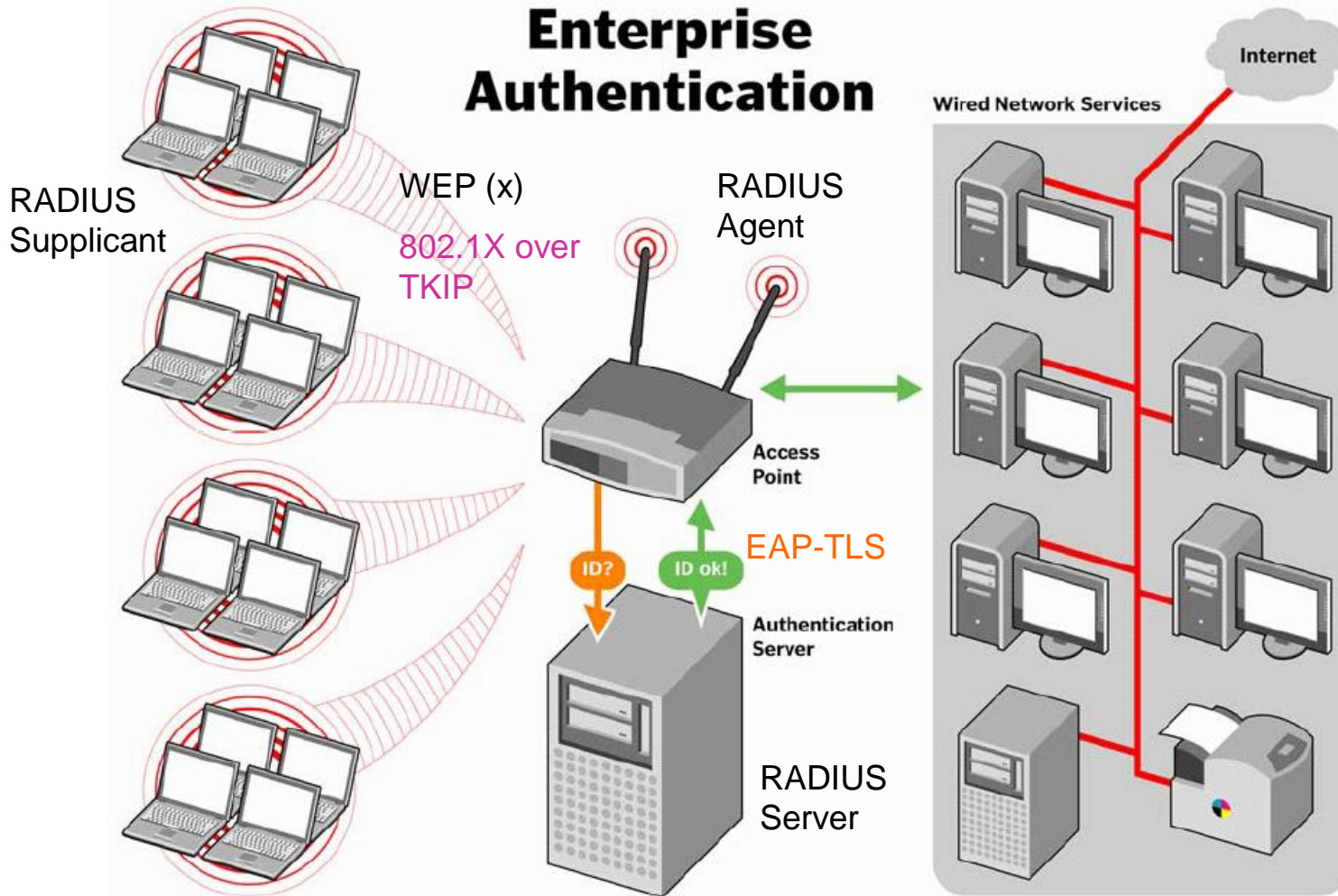
- ❑ 802.11g AP, Mixed Client



- ❑ 802.11b AP, 802.11g Client

From: © Broadcom, "The New Mainstream Wireless LAN Standard"

## Wi-Fi Protected Access (WPA) Support



# Recent Features of WLAN

## Proprietary Throughput Improvement



	Number of Non-Interfering Channels	Modulation	Maximum Link Rate	Theoretical Maximum TCP Rate	Theoretical Maximum UDP Rate
802.11b	3	CCK	11 Mbps	5.9 Mbps	7.1 Mbps
802.11g (with 802.11b)	3	OFDM/CCK	54 Mbps	14.4 Mbps	19.5 Mbps
802.11g (11g-only mode)	3	OFDM/CCK	54 Mbps	24.4 Mbps	30.5 Mbps
802.11a	19 <sup>1</sup>	OFDM	54 Mbps	24.4 Mbps	30.5 Mbps
802.11a Atheros Turbo Mode		OFDM	108 Mbps	42.9 Mbps	54.8 Mbps



**AirPlus Xtreme G+**



Atheros Super A/G	108 Mbps (60Mbps in Real)
TI Turbo Mode (G+)	90 Mbps (35 Mbps in Real)
Broadcom 125 High Speed Mode	Boost of 35% (30~35 Mbps in Real)
Agere's new chipset	150 Mbps?



From: © Atheros Communications, "802.11 Wireless LAN Performance"  
& Wi-Fi Planet News, "Wi-Fi Marketing's Favorite Numbers"





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# The Experiment Approach

## A Testing Equals An Experiment?

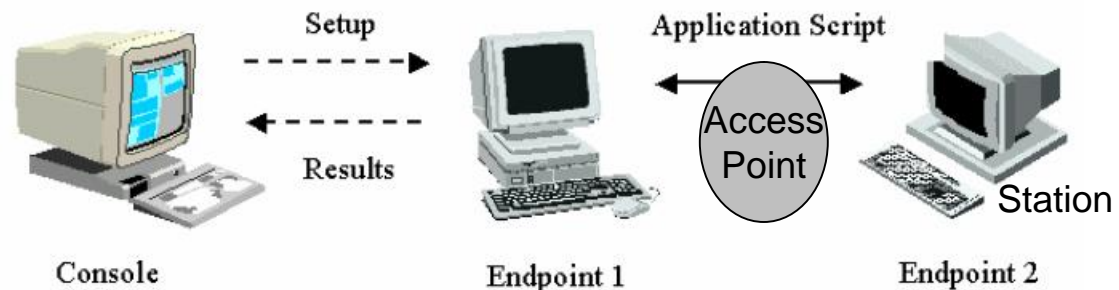
- You can find some examples of network product testing
  - Tests done and published in some famous Magazines?
  - Wi-Fi Interoperability Test in the Agilent Lab?
- An experiment is
  - *"a scientific test which is done in order to discover what happens to something in particular conditions."* by Collins COBUILD Dictionary
- While correctly designed, it ALWAYS consists of
  - exactly ONE control factor related to your hypothesis
  - other constant conditions specified as complete as possible
- 大膽假設 小心求證

# Test Utility Adopted

## Introduction to NetIQ Chariot

- There is an end-to-end solution Chariot, which tests
  - Wireless LAN (Chariot is convenient, and especially, specified by Wi-Fi)
  - Any other network device operates with TCP/IP
- NetIQ Chariot
  - *“evaluates the performance of networked applications on devices”*
  - *“is used to optimize your network and predict the impact of changes”*

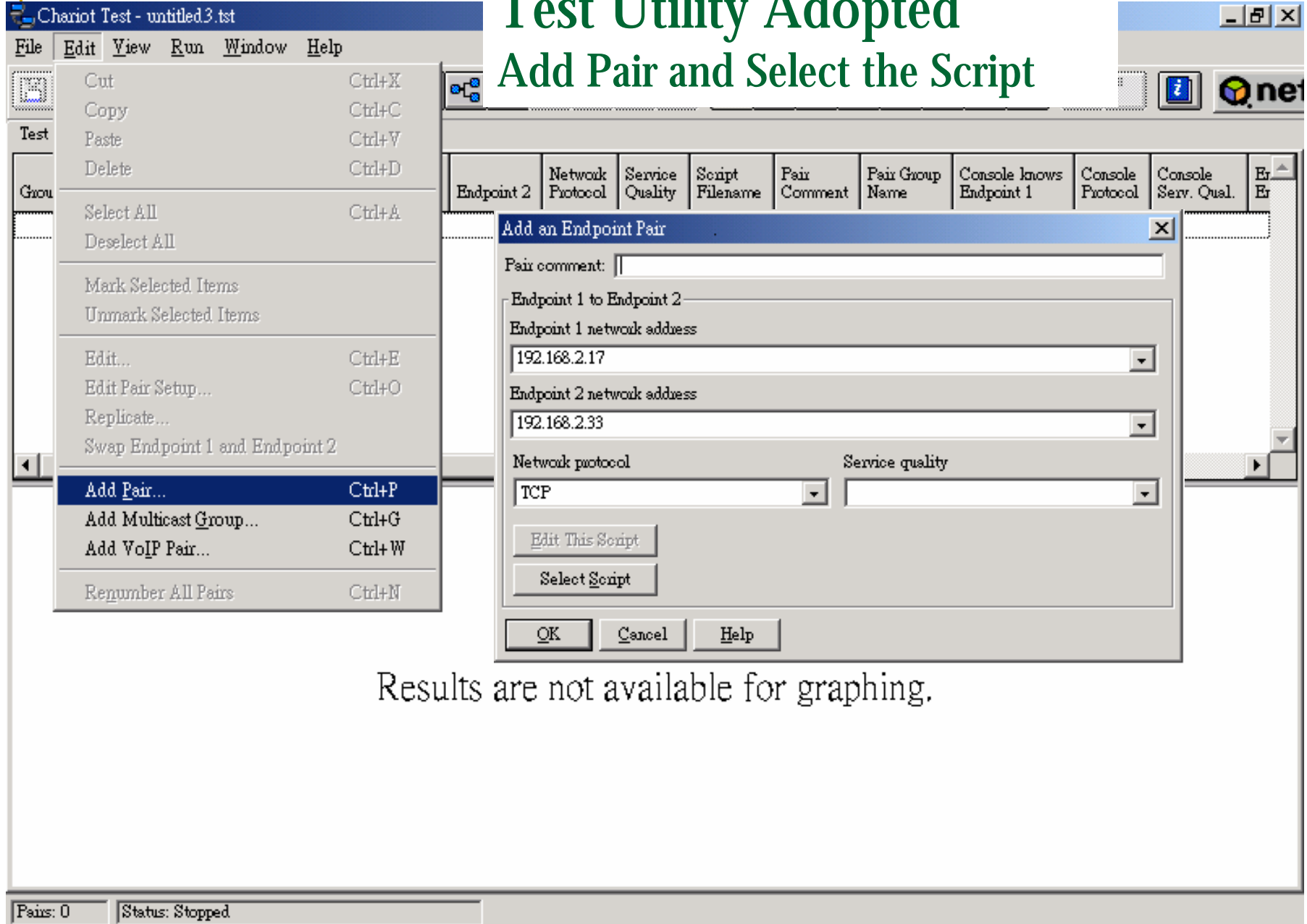
- 工欲善其事  
必先利其器



From: © NetIQ., “User Guide of Chariot”

# Test Utility Adopted

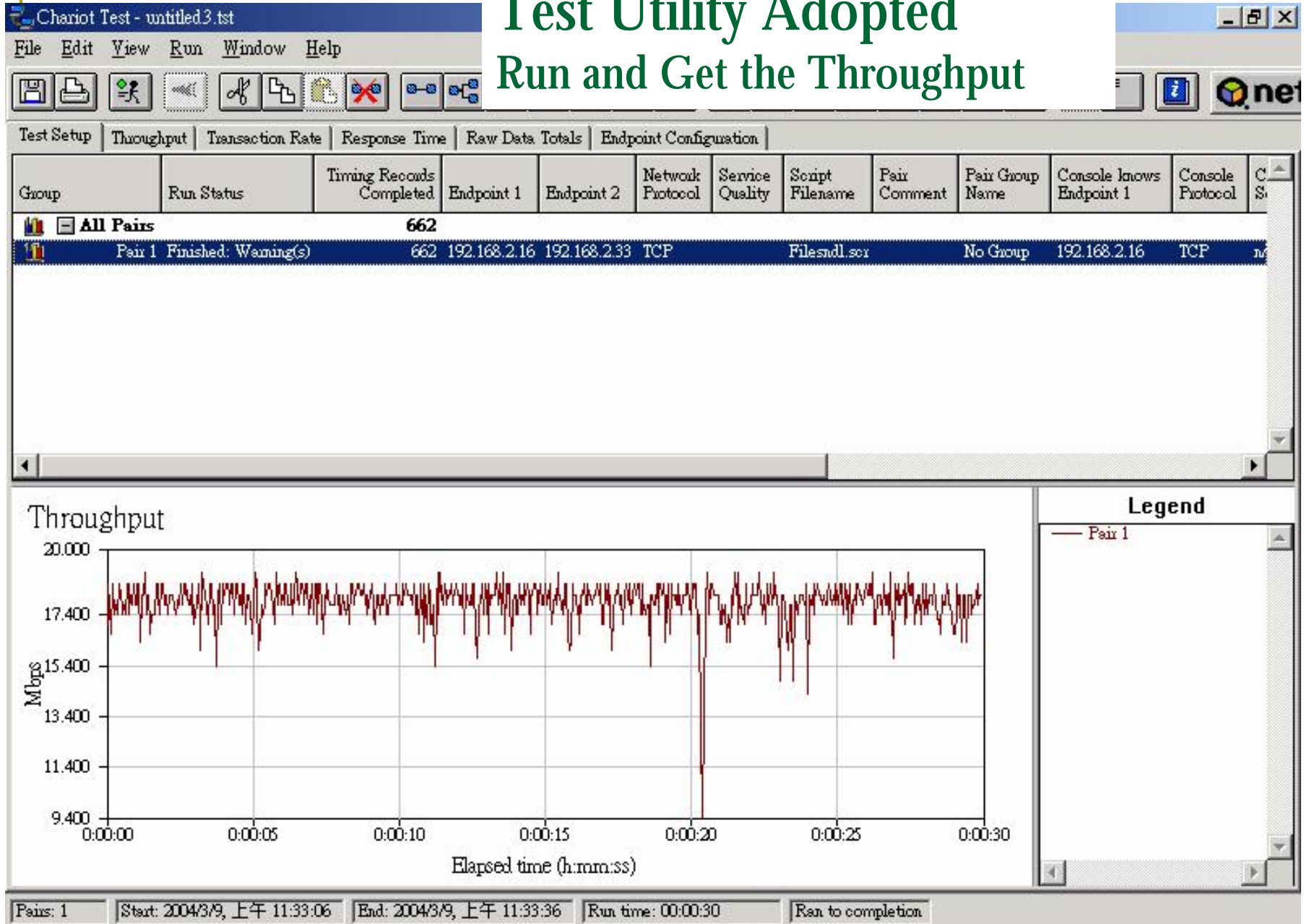
## Add Pair and Select the Script



Results are not available for graphing.

# Test Utility Adopted

## Run and Get the Throughput



# Experiments in Brief

## Test Coverage for Students in NBL

- 6 tests designed for students in NBL (at MIRC 604)
  - Tests cover Functionality, Interoperability, and Performance

Code	Test Name	Subject	Time
FT-1	Functionality Test 1	Basic Settings	60 min
FT-2	Functionality Test 2	Security Modes	
FT-2x	The Extension of Functionality Test 2		
IT-1	Interoperability Test 1 - Wi-Fi Style	(see later)	60 min
IT-2	Interoperability Test 2	b/g Mixed Mode	
PT-1	Performance Test 1	Throughput vs. Chipset	30 min

- Used Platform (Operating System)
  - Station (Client): Windows XP Professional with WPA Support
  - Server: Windows Server 2003, Standard Edition running CA, IAS, IIS

# Experiments in Brief

## Parameters Configuration (constant conditions)

- Settings for AP under test (APUT) and STA under test (STAUT)

APUT Settings	IP Address	192.168.3.11 /24
	Operation Mode	Infrastructure
	Wireless Mode	802.11b/g Auto
	SSID	'NBL'
	Channel	11
	Wireless Security	Disable
	[Other Settings]	[Default]
STAUT Settings	IP Address	192.168.3.21 /24
	Link and Signal Monitor	Enable
	Power Save	Disable
	[Other Settings]	[Same as APUT or Default]

# Experiments in Brief

## Functionality Test 1 (FT-1)

- Hypothesis: Functions of wireless mode and channel are correct
- Utility: Ping; Chariot with 'InquiryL' script for 30 sec
- Control Factor for both APUT and STAUT

1	Wireless Mode	{802.11b/g Auto, 802.11g Turbo, 802.11b Only}
2	Channel	{1, 6, 11}

- Observations if...

1	Associations occur
2	Good or Excellent status by Link and Signal Monitor indicated
3	Replies of ping from STAUT to Server received
4	'InquiryL' completes without any error

# Experiments in Brief

## Functionality Test 2 (FT-2)

- Hypothesis: Functions of security mode are correct
- Utility: Ping; Chariot with 'InquiryL' script for 30 sec
  - Control Factor for both APUT and STAUT

Security Level	1	WEP Key	0x9876543210
	2	WPA PSK PassPhrase	Random ASCII of Length = {15, 31}
	3	WPA EAP-TLS	-

- Observations if...

1	Associations occur
2	Good or Excellent status by Link and Signal Monitor indicated
3	Replies of ping from STAUT to Server received
4	'InquiryL' completes without any error



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# Experiments in Brief

## The Extension of Functionality Test 2 (FT-2x)

- Hypothesis: Functions of security mode are correct
- Utility: Ping; Chariot with 'InquiryL' script for 30 sec
  - This test uses a different version of driver for STAUT
  - The control factor and observations are the same as FT-2
  - Please be careful that if any thing occurs unexpectedly, do not modify the configurations of Windows XP before noticing Elia (me).

# Experiments in Brief

## Interoperability Test 1 - Wi-Fi Style (IT-1)

### 4.2.2.3 Configuration #A3

PARAMETER	STATION Values	AP Values
Vendor	Broadcom	APUT
<i>RTS Threshold</i>	256	default for AP
<i>Fragmentation</i>	Off	default for AP
<i>Power Save</i>	On, PSP	-
<i>AP Channel</i>	-	3
<i>AP Basic Rate</i>	-	1,2
<i>Security</i>	WEP, Key=0x9876543210	WEP, Key=0x9876543210
<i>Supplicant/Server</i>	N/A	
<i>STA O/S</i>	Windows 2000	

- Data Transfer # means using 1: 'FileSndL' Downstream, 2: 'FileSndL' Upstream, and 3: 'InquiryL' Downstream respectively

Association Test	if association occurs, pass
<i>Data Transfer #1</i>	throughput > A3DT1
<i>Data Transfer #2</i>	throughput > A3DT2
<i>Data Transfer #3</i>	throughput > A3DT3

# Experiments in Brief

## Interoperability Test 2 (IT-2)

- Hypothesis: BSS in mixed mode will operate correct, but the throughput in mixed mode will be lower than in pure mode
- Utility: Ping; Chariot with 'InquiryL' and 'FileSndL', both for 30 sec
  - Control Factor in the BSS

Another Involved STA	{802.11b device, 802.11g device, not exists}
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- Observations

1	Associations occur
2	Good or Excellent status by Link and Signal Monitor indicated
3	Replies of ping from STAUT to Server received
4	'InquiryL' completes without any error
5	Average Throughput of 'FileSndL'

# Experiments in Brief

## Performance Test 1 (PT-1)

- Hypothesis: The throughput of different chipset may differ obviously
- Utility: Ping; Chariot with 'high\_performance\_throughput' for 60 sec
  - Actually this test is a performance benchmarking
  - Control Factor

AP-STA Pair of Different Chipset	{Broadcom BCM94306,TI TNETW1130} with best transmission rate settings
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- Observations

1	Associations occur
2	Replies of ping from STAUT to Server received
3	Average Throughput of 'high_performance_throughput'

# Test Methodology Design

## Especially for Graduate Students

- The left period of 30 minutes is for you to discuss with Elia
  - Define a new test methodology
  - If you can, perform the new test in NBL
- A good methodology which possibly
  - follows the experiment principle (*scientific view*)
  - reflects the issues in WLAN technology and industry (*technical view*)
  - expends properly low cost (*operational view*)
- 最後，請大家別全都選了 WLAN 實驗，還可考慮
  - Network Security
  - Routing and Bridging