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# Performance Measurement of Wireless LAN Using Open Source



**Vipin M**

***Communication Research Group***

AU – KBC Research Centre

<http://comm.au-kbc.org/>

# Overview

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## – General Network

- Why Network Performance Measurement ?
- Network Performance Metrics
- How Network Performance is Measured ?
- Measurement Methods
  - Ex: Packet Streams & Pair Packet
- Active Probing Tools
  - Ex: Iperf

## – Wireless Network

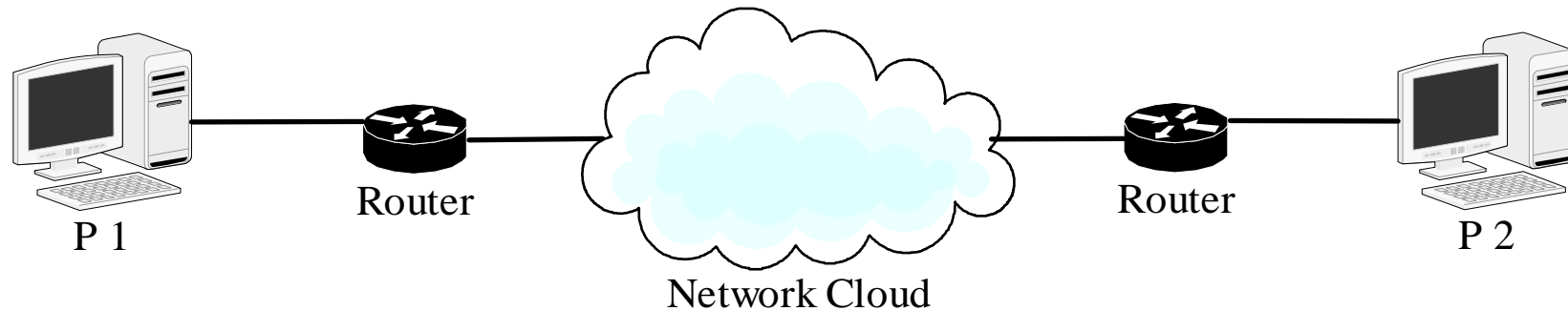
- Performance Measurement In Wireless LAN
- PHY / MAC / Higher layer Measurement
- Measuring Methods and setups

## – Effect in Wireless

- Effect of these Metrics
- Some Results



# Why Network Performance Measurement ?



- The factors affecting network Performance
- How this factors are affecting the Performance
- Impacts for a User / Application because of these



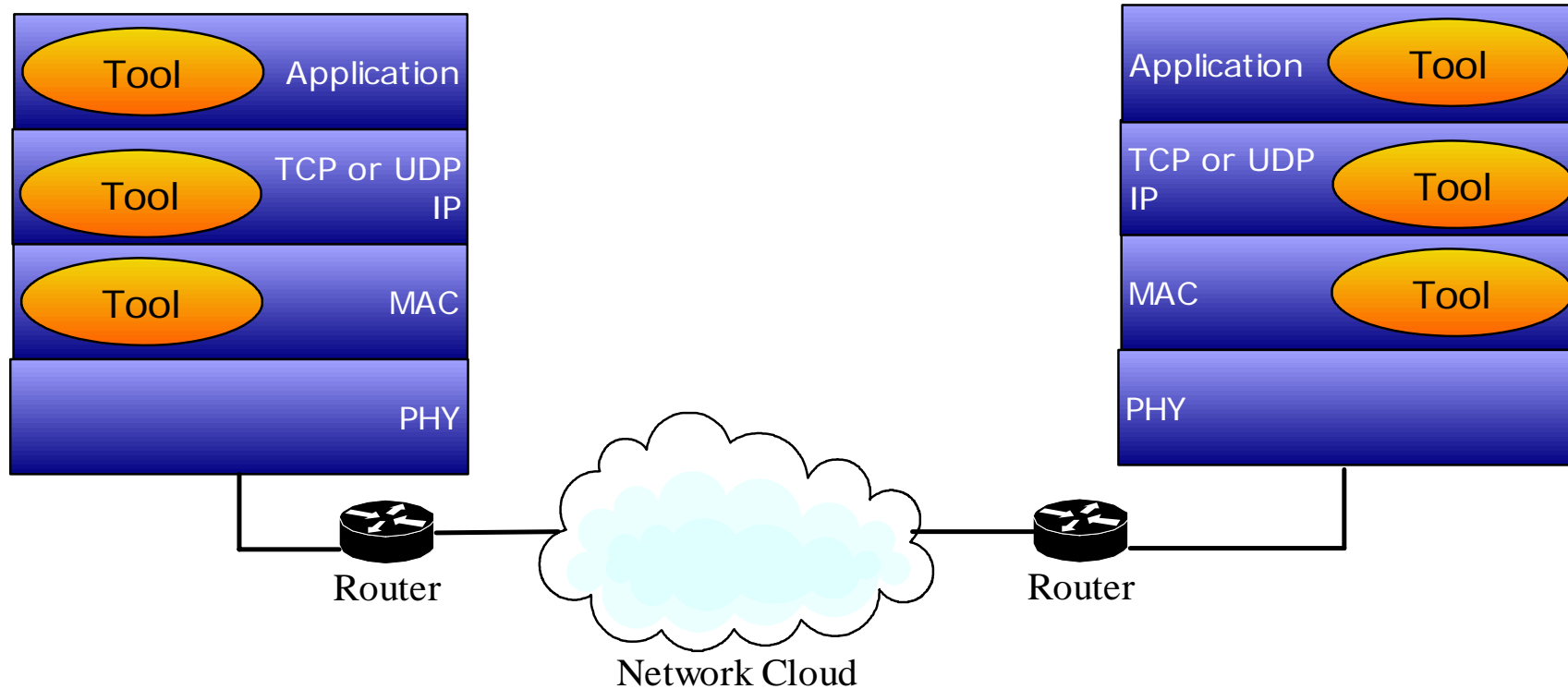
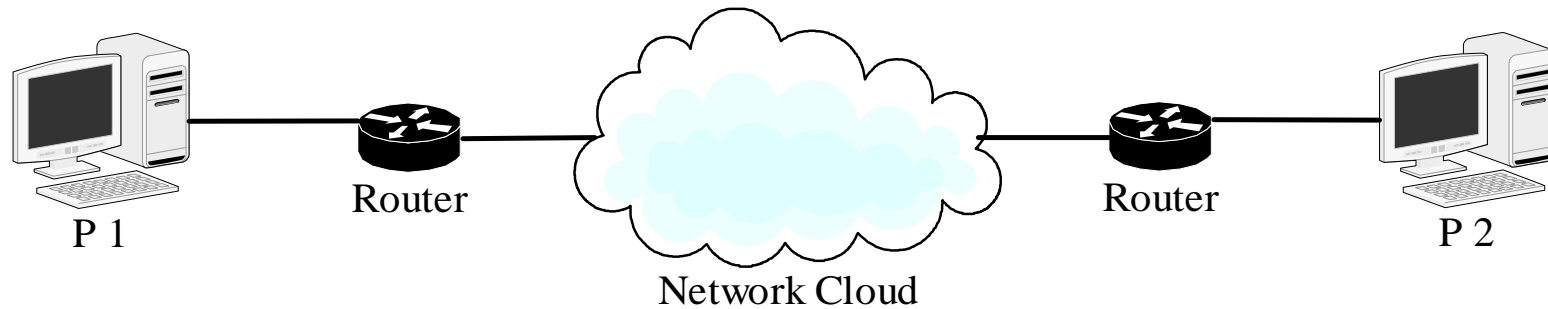
# Network performance metrics

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- **One-Way Delay (OWD)**
  - Serialization Delay
  - **Propagation Delay**
  - Queuing Delay
  - Forwarding Delay
- Round-Trip Time (RTT)
- **Delay Variation (Jitter)**
- **Packet Loss**
  - Congestion
  - **Errors**
- Packet Reordering
- Maximum Transmission Unit (MTU)
- **Available Bandwidth ( Throughput )**
- Link Capacity
- Bandwidth Delay Product (BDP)



# How Network Performance is Measured



# Measurement Methods

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## Metric

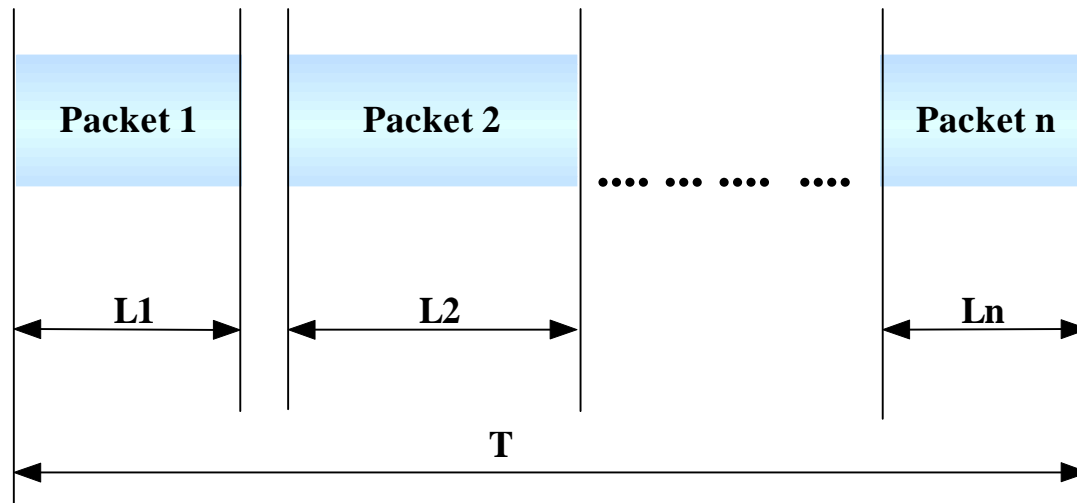
- Distance
  - Per-hop
  - End-to-End
- Values
  - Bulk Transfer
  - Achievable
  - Bottleneck / Minimum

## Methods ( Ex: for IP layer )

- Variable Packet Size
- Packet Pairs / Trains
- Self – Loading Periodic Streams
- Parallel Connection



# Packet Streams



**n** Packets are received at destination  
Within the time period of **T**  
With Sizes of **L1, L2 ..... Ln**

Total Size

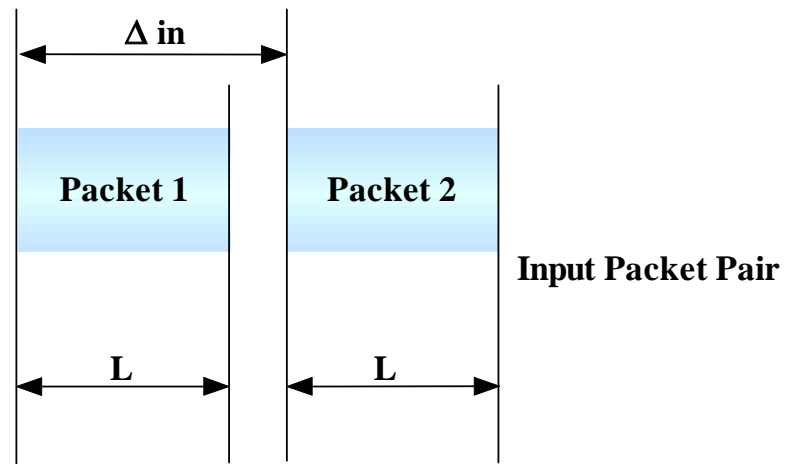
$$L = L1 + L2 + .... + Ln$$

Throughput

$$C = L / T$$



# Pair Packet

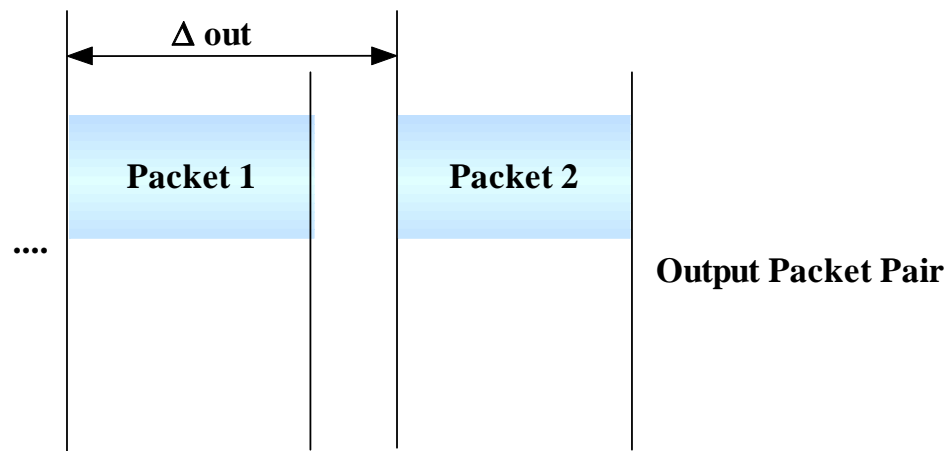


- Two packet of size  $L$  send back to back
- Packets receive with  $\partial$  time space dispersion

**Time = Size ( $L$ ) / Capacity ( $C$ )**

$$C = L / T$$

$$\Delta_{out} = L / C_0$$



$$\Delta_{out} = \text{Max}(\Delta_{in}, L/C_i)$$

**Dispersion  $\partial = \Delta_{out} - \Delta_{in}$**

$$\text{Dispersion } \partial = \text{Max} (L/C_i)$$

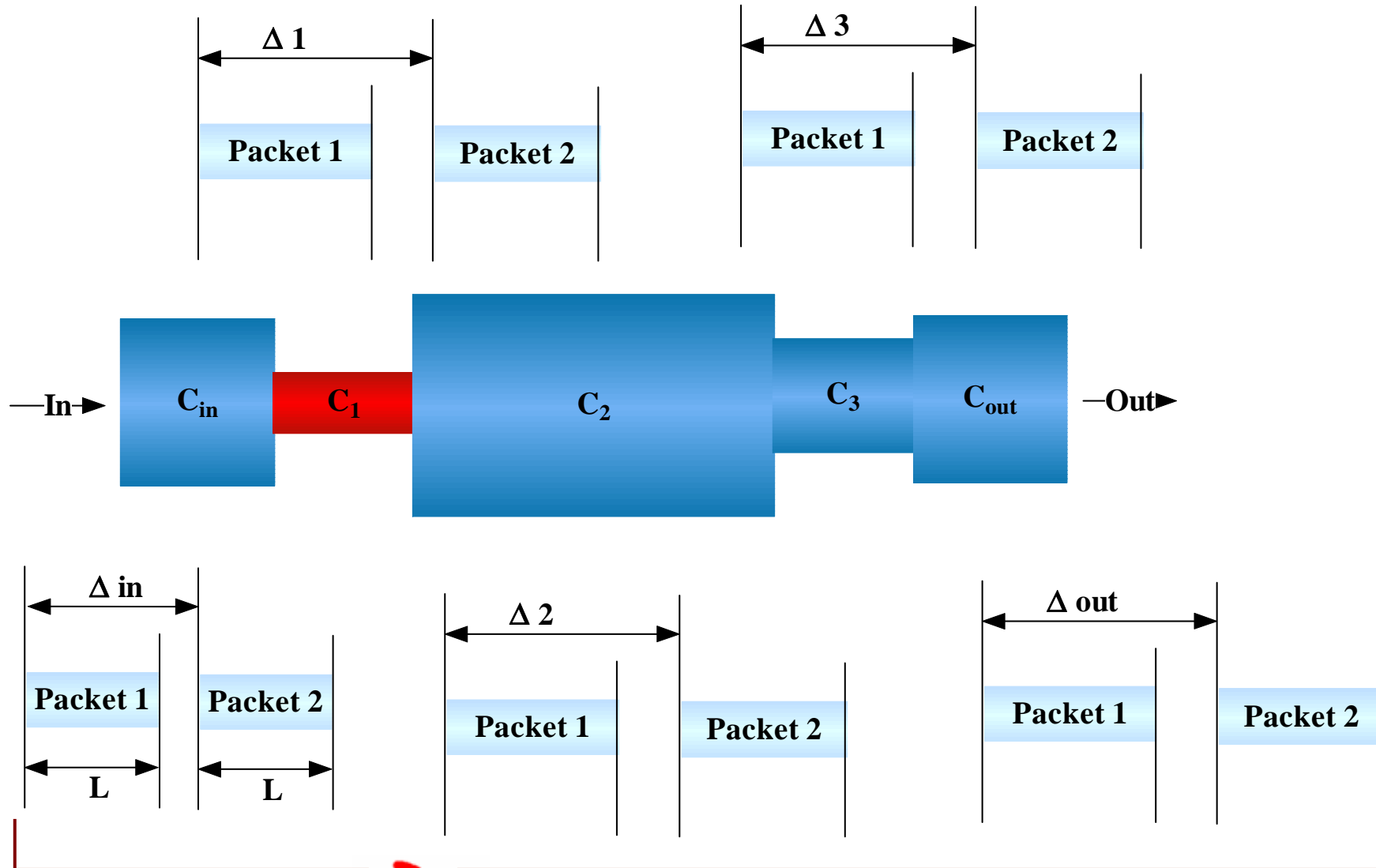
$\text{Min}(C_i) \rightarrow$  end-to-end Capacity

**Capacity  $C = L / \partial$**





# Bottleneck Capacity



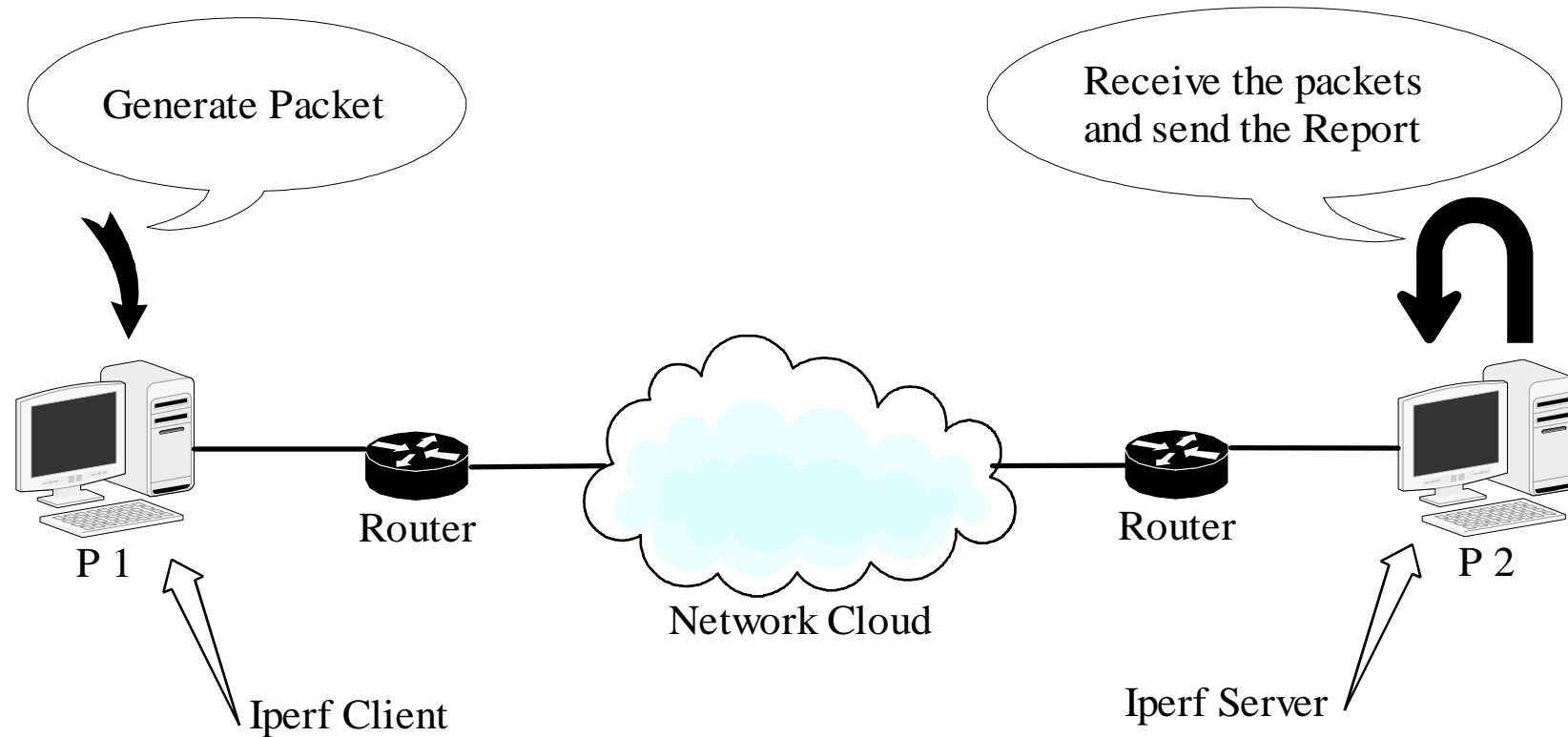
# Active Probing Tools

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- Throughput & Delay Measurement Tools
  - Ping
  - Traceroute
  - **Iperf**
  - Thrulay
- Path Characterization & Bandwidth Estimation
  - pathChirp
  - Pathload
  - ABwE
  - Netperf
  - Nettest



# Iperf



## — Modes

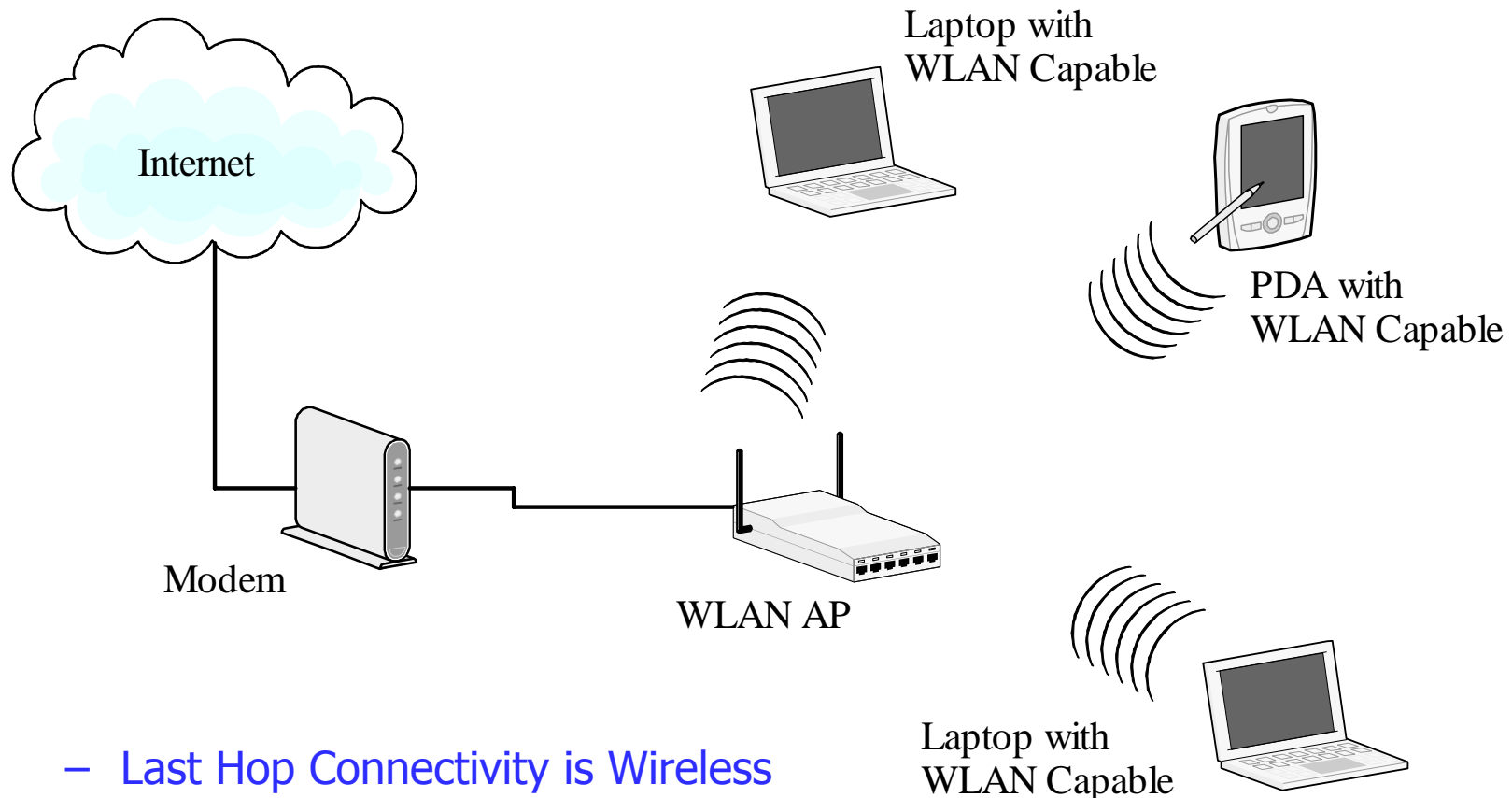
- TCP
- UDP

## — Components

- Server
- Client



# Wireless LAN



- Last Hop Connectivity is Wireless
- Bottleneck will be always at wireless
- What are the Network Parameters that make major effects ?
- How it is effecting ?

# Performance Measurement in WLAN

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## PHY Layer

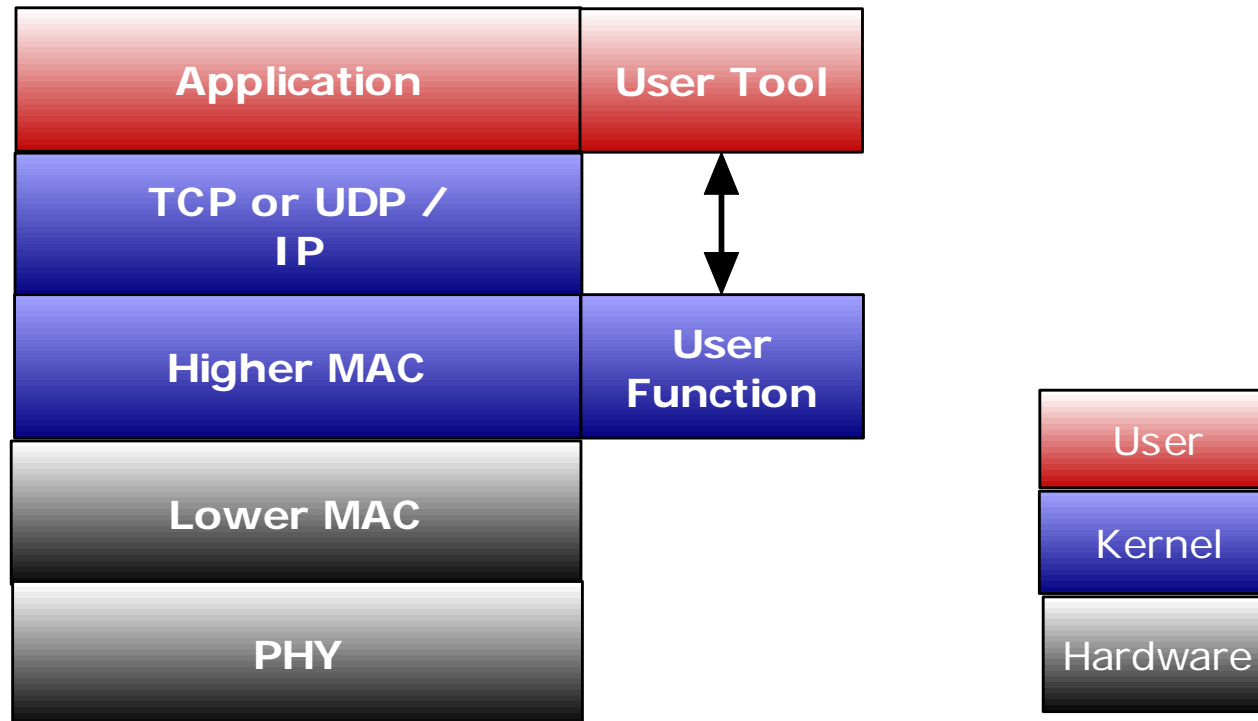
- Received Signal Power
- Signal To Noise Ratio
- Bit Error Rate
- Throughput
- Interference

## MAC Layer

- Throughput
- Retries
- Received Data Rate
- Queuing Delay
- Packet Error Rate
- Power Consumption



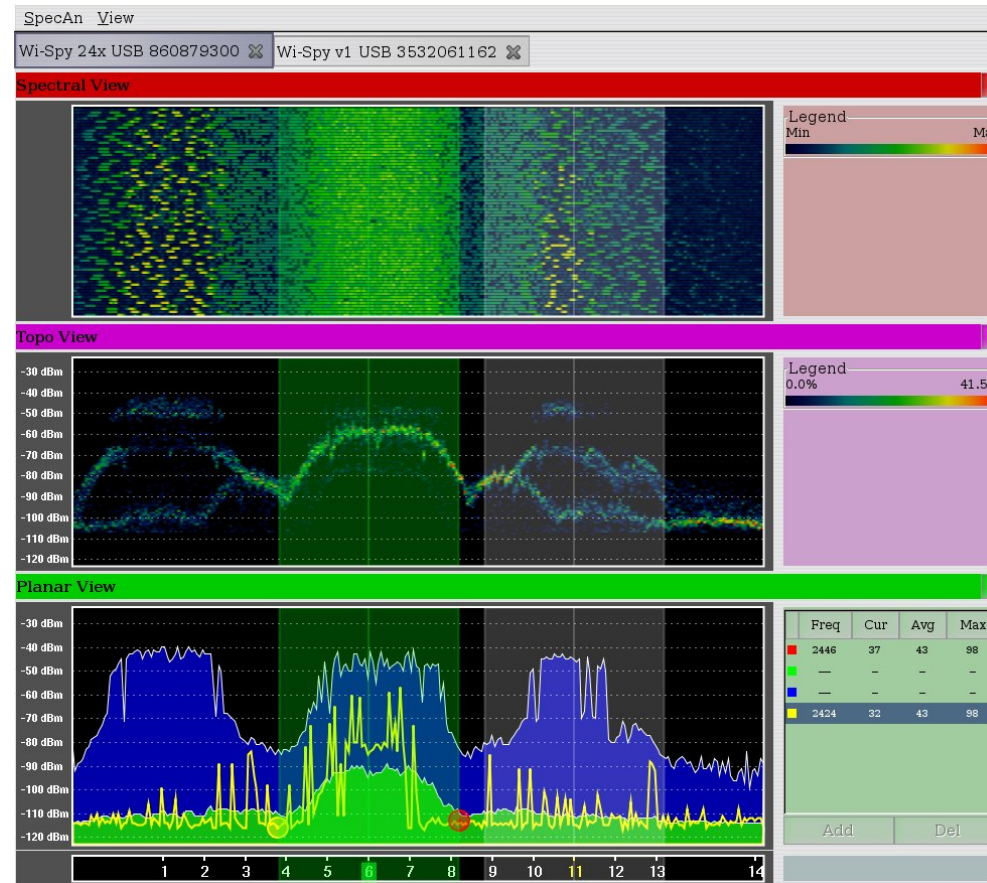
# WLAN PHY / MAC Measurement



- Using MAC Packet injecting / and process Tools
  - Approximate PHY and MAC Parameters can be Measured
  - Depend on the implementation of hardware
- Tools like libmac, netlib 80211b injecting etc.



# WLAN Phy Signal Measurement



Courtesy : Kismet

- Wispy + Spectool-GTK (Kismet)
- Information from lower layer (Modified driver)



# WLAN Higher Layer Measurement

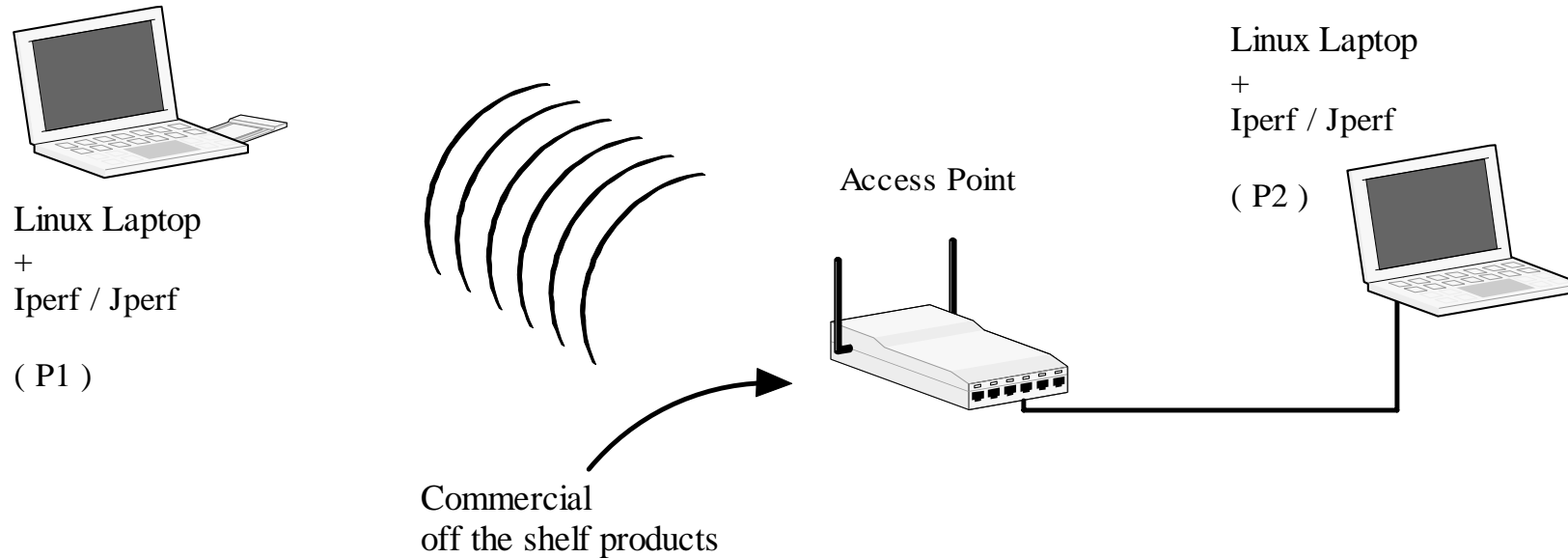
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- This is as similar as the normal wired network
- Then what is the difference ?
- Parameters
  - Jitter
  - Throughput
  - Distance
    - Propagation delay taken as parameter in design





# Performance Measurement in WLAN

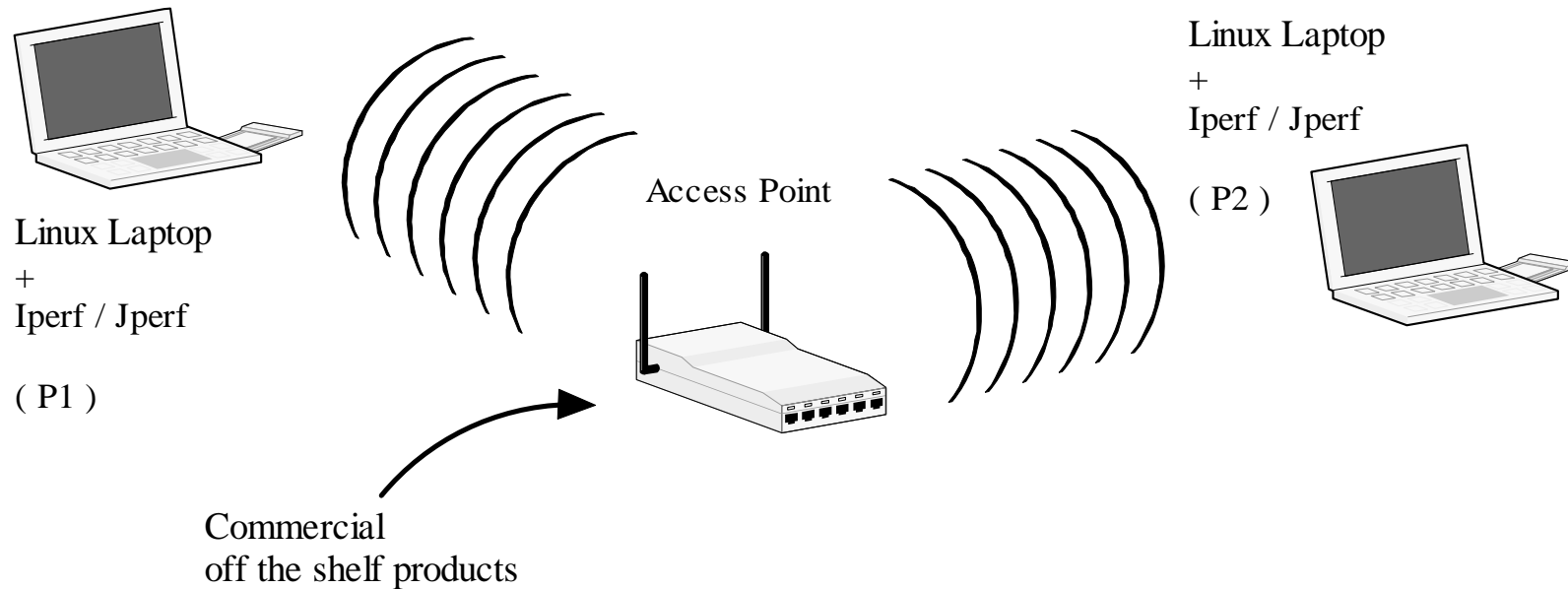


## – Performance Measurement

- P1 in Wireless and P2 in Wired Network



# Performance Measurement in WLAN

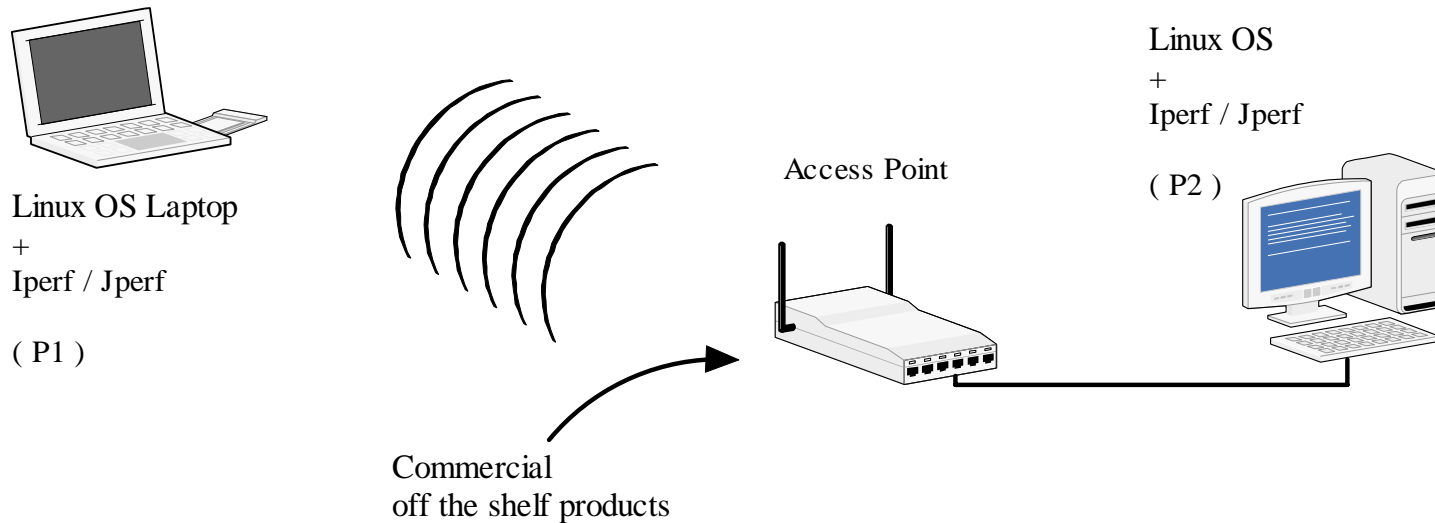


## – Performance Measurement

- P1 in Wireless and P2 in Wired Network
- Both P1 and P2 in Wireless



# Test Setup



**“Iperf -c <host>”**  
**Iperf -c 192.168.2.73**

**-p <num\_streams>** test with parallel TCP streams  
**-w <buffer\_size>** set socket buffer size

**“Iperf -s -D > iperfLog ”**  
**Iperf -s -D /var/log/iperfLog**

**Iperf can run as a daemon**



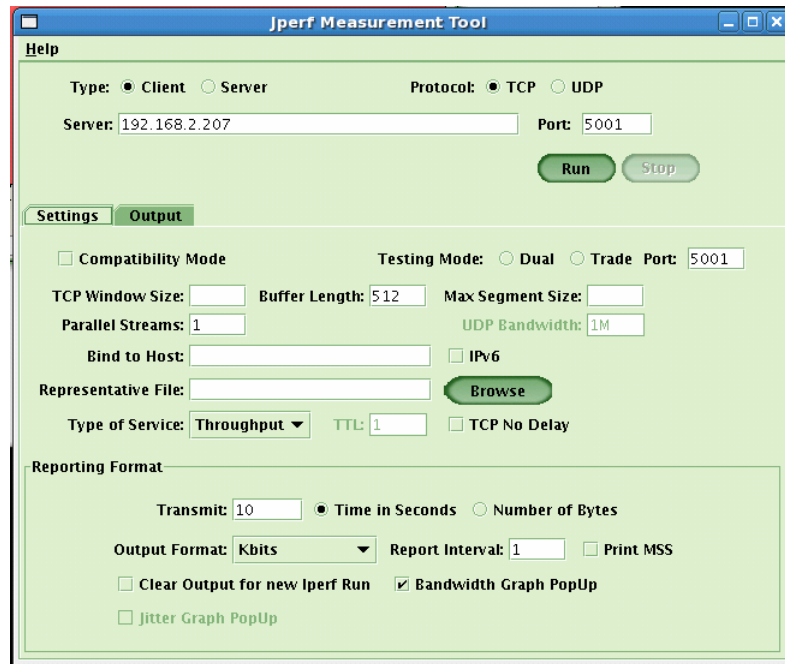
Server

```
designe@server-y:~  
File Edit View Terminal Tabs Help  
[designe@server-y designe]$ iperf -s  
-----  
Server listening on TCP port 5001  
TCP window size: 85.3 KByte (default)  
-----  
[ 4] local 192.168.2.207 port 5001 connected with 192.168.2.165 port 56614  
[ 4] 0.0-10.1 sec 15.9 MBytes 13.3 Mbits/sec
```

Client

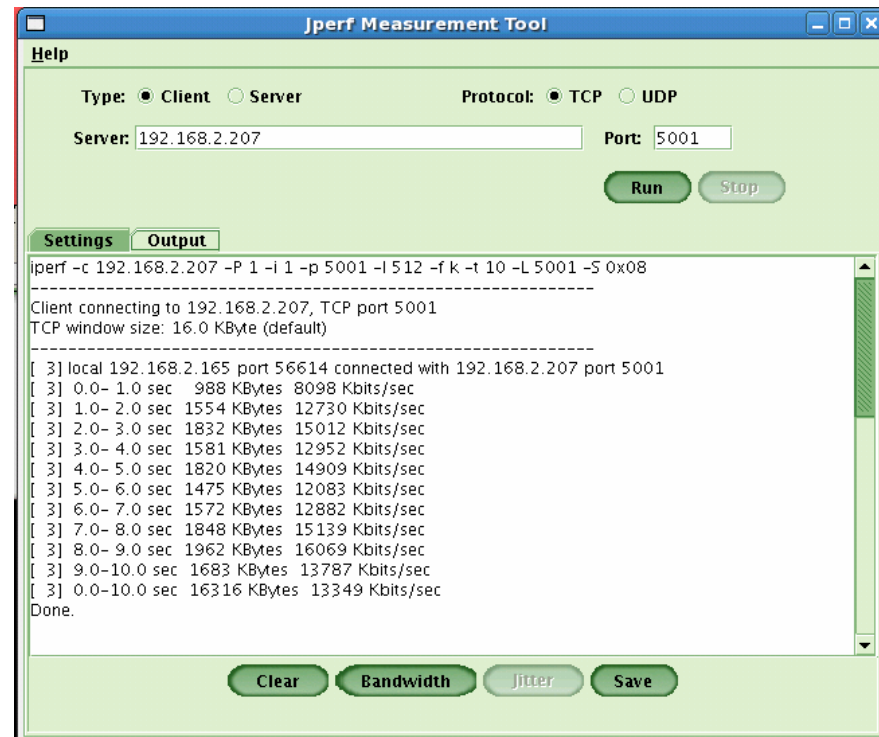
```
root@Cl100:~  
File Edit View Terminal Tabs Help  
[root@Cl100 ~]# iperf -c 192.168.2.207 -P 1 -i 1 -l 512 -t 10 -S 0x08  
-----  
Client connecting to 192.168.2.207, TCP port 5001  
TCP window size: 16.0 KByte (default)  
-----  
[ 3] local 192.168.2.165 port 43675 connected with 192.168.2.207 port 5001  
[ 3] 0.0- 1.0 sec 1.48 MBytes 12.4 Mbits/sec  
[ 3] 1.0- 2.0 sec 1.32 MBytes 11.1 Mbits/sec  
[ 3] 2.0- 3.0 sec 1.38 MBytes 11.6 Mbits/sec  
[ 3] 3.0- 4.0 sec 1.22 MBytes 10.3 Mbits/sec  
[ 3] 4.0- 5.0 sec 1.28 MBytes 10.8 Mbits/sec  
[ 3] 5.0- 6.0 sec 1.46 MBytes 12.3 Mbits/sec  
[ 3] 6.0- 7.0 sec 1.52 MBytes 12.7 Mbits/sec  
[ 3] 7.0- 8.0 sec 1.55 MBytes 13.0 Mbits/sec  
[ 3] 8.0- 9.0 sec 1.28 MBytes 10.8 Mbits/sec  
[ 3] 9.0-10.0 sec 1.42 MBytes 11.9 Mbits/sec  
[ 3] 0.0-10.0 sec 13.9 MBytes 11.7 Mbits/sec  
[root@Cl100 ~]#
```

# Jperf (GUI for Iperf)



The screenshot shows the 'Jperf Measurement Tool' window with the 'Settings' tab selected. The 'Type' is set to 'Client' and the 'Protocol' is 'TCP'. The 'Server' is '192.168.2.207' and the 'Port' is '5001'. Under 'Testing Mode', 'Dual' is selected. 'TCP Window Size' is 1, 'Buffer Length' is 512, and 'Max Segment Size' is 1. 'Parallel Streams' is 1 and 'UDP Bandwidth' is 1M. 'Bind to Host' is empty, 'IPv6' is unchecked, and 'Representative File' is empty. 'Type of Service' is 'Throughput', 'TTL' is 1, and 'TCP No Delay' is unchecked. In the 'Reporting Format' section, 'Transmit' is 10, 'Time in Seconds' is selected, 'Output Format' is 'Kbits', 'Report Interval' is 1, 'Print MSS' is unchecked, 'Clear Output for new Iperf Run' is unchecked, 'Bandwidth Graph PopUp' is checked, and 'Jitter Graph PopUp' is unchecked.

Test Settings



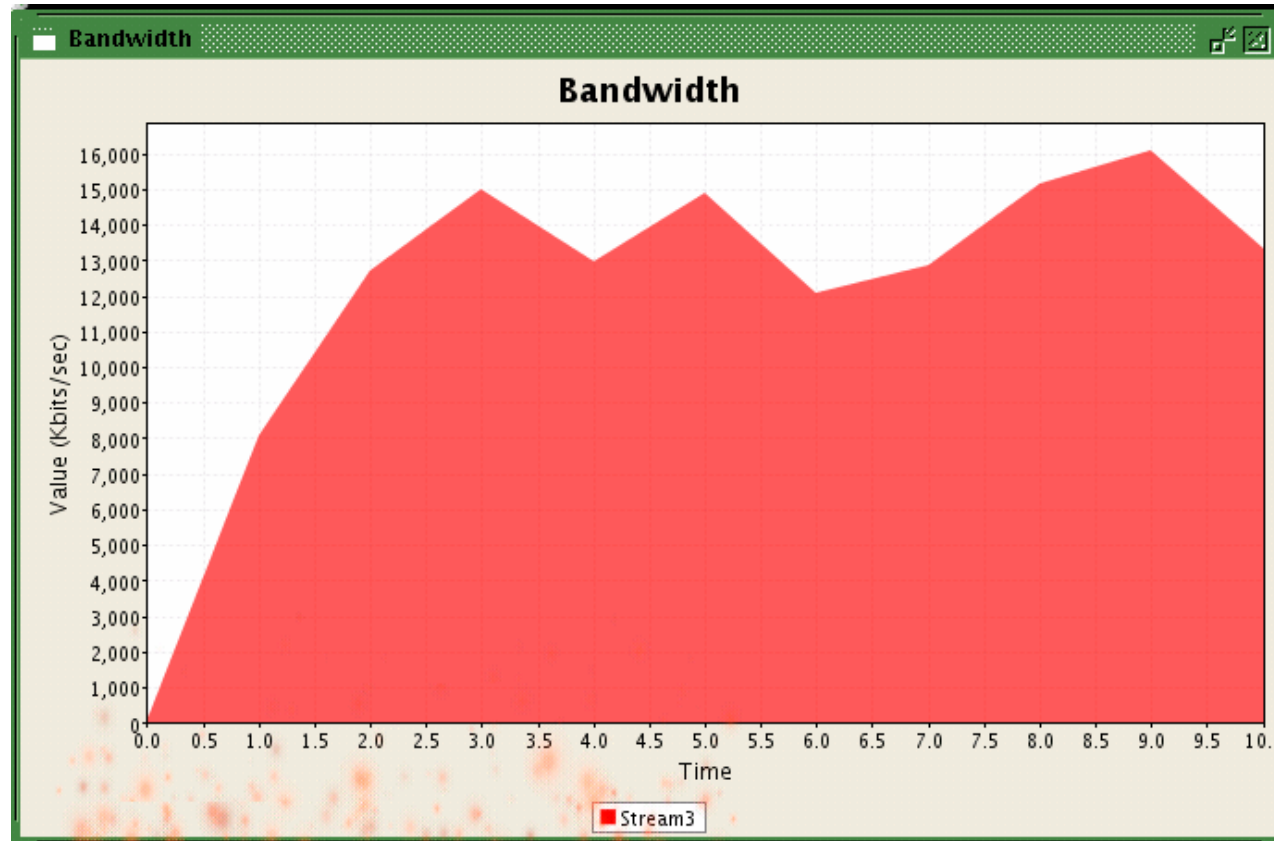
The screenshot shows the 'Jperf Measurement Tool' window with the 'Output' tab selected. The 'Settings' tab is also visible. The 'Output' tab displays the command: `iperf -c 192.168.2.207 -P 1 -i 1 -p 5001 -l 512 -f k -t 10 -L 5001 -S 0x08`. Below the command, it shows the client connecting to 192.168.2.207, TCP port 5001, with a TCP window size of 16.0 KByte (default). The output table shows the following data:

Time Interval	Bytes	Kbits/sec
0.0- 1.0 sec	988 KBytes	8098 Kbits/sec
1.0- 2.0 sec	1554 KBytes	12730 Kbits/sec
2.0- 3.0 sec	1832 KBytes	15012 Kbits/sec
3.0- 4.0 sec	1581 KBytes	12952 Kbits/sec
4.0- 5.0 sec	1820 KBytes	14909 Kbits/sec
5.0- 6.0 sec	1475 KBytes	12083 Kbits/sec
6.0- 7.0 sec	1572 KBytes	12882 Kbits/sec
7.0- 8.0 sec	1848 KBytes	15139 Kbits/sec
8.0- 9.0 sec	1962 KBytes	16069 Kbits/sec
9.0-10.0 sec	1683 KBytes	13787 Kbits/sec
0.0-10.0 sec	16316 KBytes	13349 Kbits/sec

The output ends with 'Done.' and buttons for 'Clear', 'Bandwidth', 'Jitter', and 'Save' are at the bottom.

Test output

# Bandwidth Graph



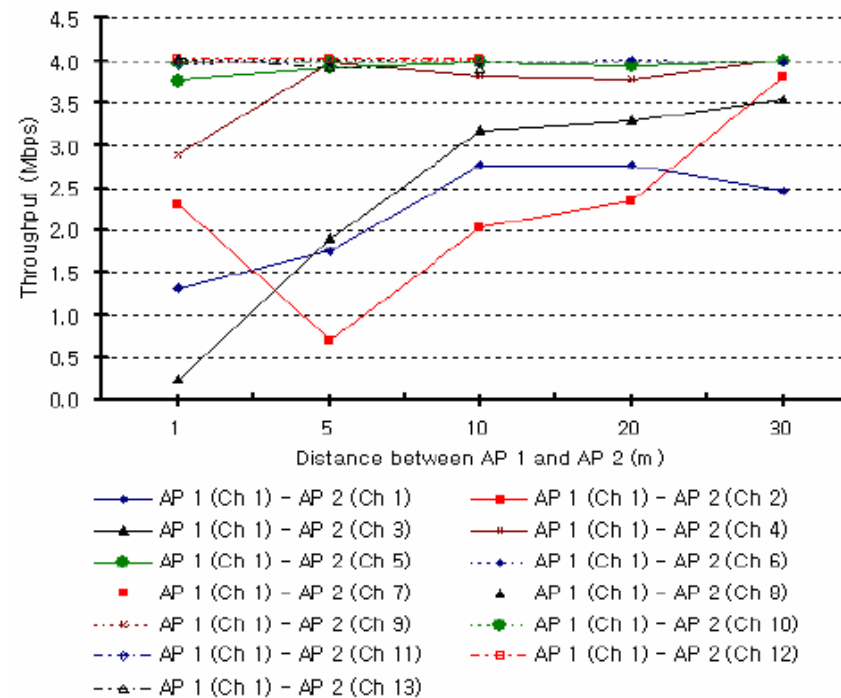
TCP Throughput for 512 bytes

# Effect of these Metrics

- Major parameters effecting the WLAN
  - PHY
    - Interference
    - RSSI
    - SNR
    - Data Rate
  - MAC
    - Queuing Delay
    - Packet Loss / Errors
    - Available Bandwidth ( Throughput )
  - IP
    - Delay Variation (Jitter)
    - Available Bandwidth ( Throughput )



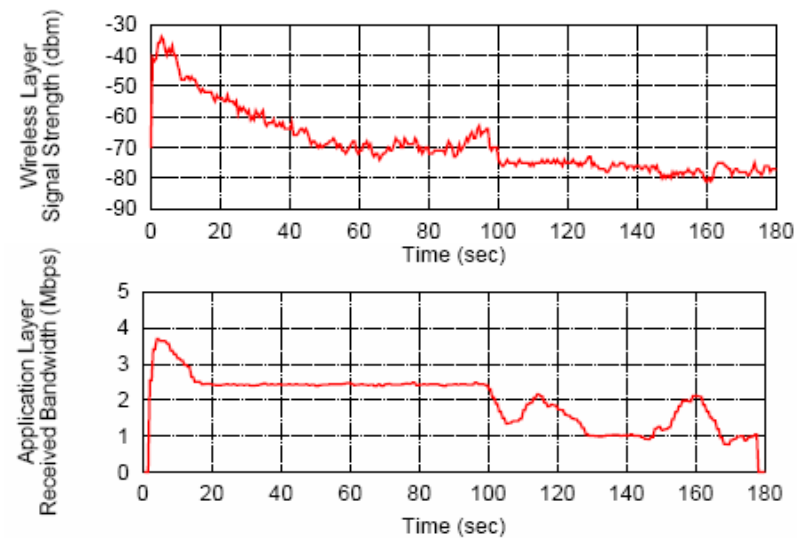
# Channel Interference



Courtesy : [3]

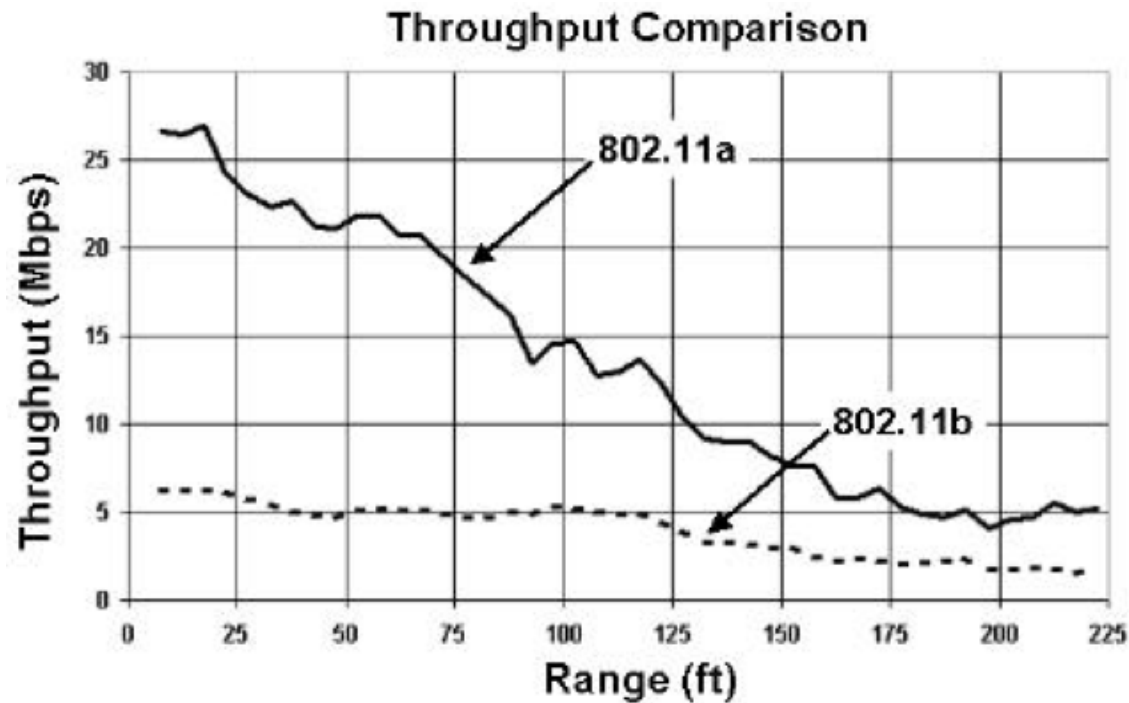


# Signal Strength Vs Received Rate



Courtesy : [2]

# Distance Vs Throughput



Courtesy : Atheros

# References

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1. IEEE 802.11,a,b,g,n IEEE Standard
2. Bandwidth Estimation: Metrics, Measurement Techniques, and Tools, Ravi Prasad CAIDA
3. Enhancement of a WLAN-Based Internet Service, Youngkyu Choi, Multimedia & Wireless Networking Laboratory, School of Electrical Engineering, Seoul National University, Korea.
4. Throughput Measurement for UDP Traffic in an IEEE 802.11g WLAN, Alexander L., Department of Computer and Information Sciences Towson University.
5. Measured Performance of 5-GHz 802.11a Wireless LAN Systems, James C. Atheros Communications, Inc.
6. Iperf <http://dast.nlanr.net/Projects/Iperf/>



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# Thank You

## Questions ?

Contact : [vipintm@au-kbc.org](mailto:vipintm@au-kbc.org)  
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