ITR-4 4th Infocomm Technology Roadmap Seminar

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Trial-based Study of Next Generation Wireless LAN (NGWLAN)

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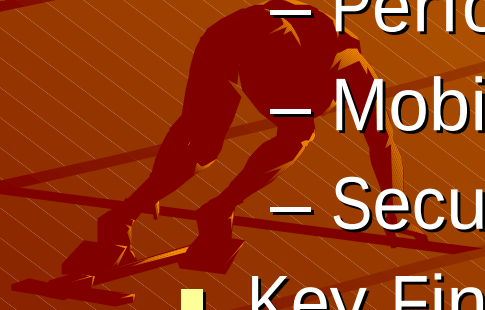
Presentation Outline

- Motivation
- NGWLAN Vision
- Trial Objectives
- Trial Scope
- Trial Test Results
  - Performance
  - Mobility
  - Security
- Key Findings
- Conclusion



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Motivation for NGWLAN project

- **Anticipated proliferation of WLAN**
- **Drawbacks in current WLAN**

- Physical layer issues such as availability of frequency spectrum and interference with other wireless systems
- Performance issues such as deficiency in throughput rate, quality of service and scalability
- Application issues such as security and roaming capabilities

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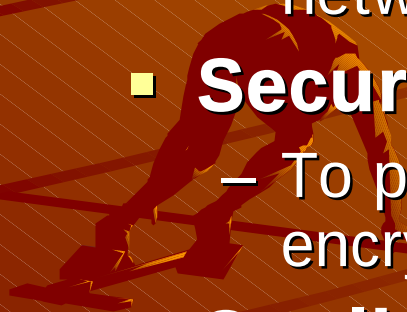
NGWLAN Vision

- **Performance**
  - To provide high data rate
- **Mobility**
  - To provide seamless roaming across different WLAN networks or between wireless LAN networks and cellular networks
- **Security**
  - To provide good authentication and strong encryption
- **Quality of Service (QoS)**
  - To guarantee bandwidth for applications



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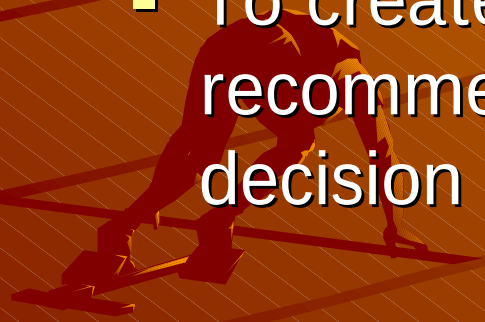
Trial Objectives

- To study and analyze the feasibility of deploying the NGWLAN
- To highlight the issues and challenges when deploying NGWLAN
- To create awareness as well as provide recommendations to assist organization in decision making for deployment of NGWLAN



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Trial Scope

- 6-month trial at NTU campus was conducted by NTU GPS Center and RfNet.
- Performance(IEEE 802.11a), Mobility(Mobile IP), Security (IEEE 802.1x) test were evaluated.
  - QoS was not included – QoS Standard (IEEE 802.11e) is not yet ratified and no implementation is available.
- Technology Assessment, but not Product Evaluation - 4 x wireless LAN equipment vendors, 2 x Mobile IP vendors and 1 x 802.1x vendor participated in the trial.

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Performance – IEEE 802.11a

- Open Environment - Open Field
- Semi-Open Environment - Sheltered Area
- Closed Environment - Office
- Co-Channel Interference
- Adjacent Channel Interference
- Inter-Building Loss
- Inter-floor Signal Loss
- Contention
- Moving Vehicle

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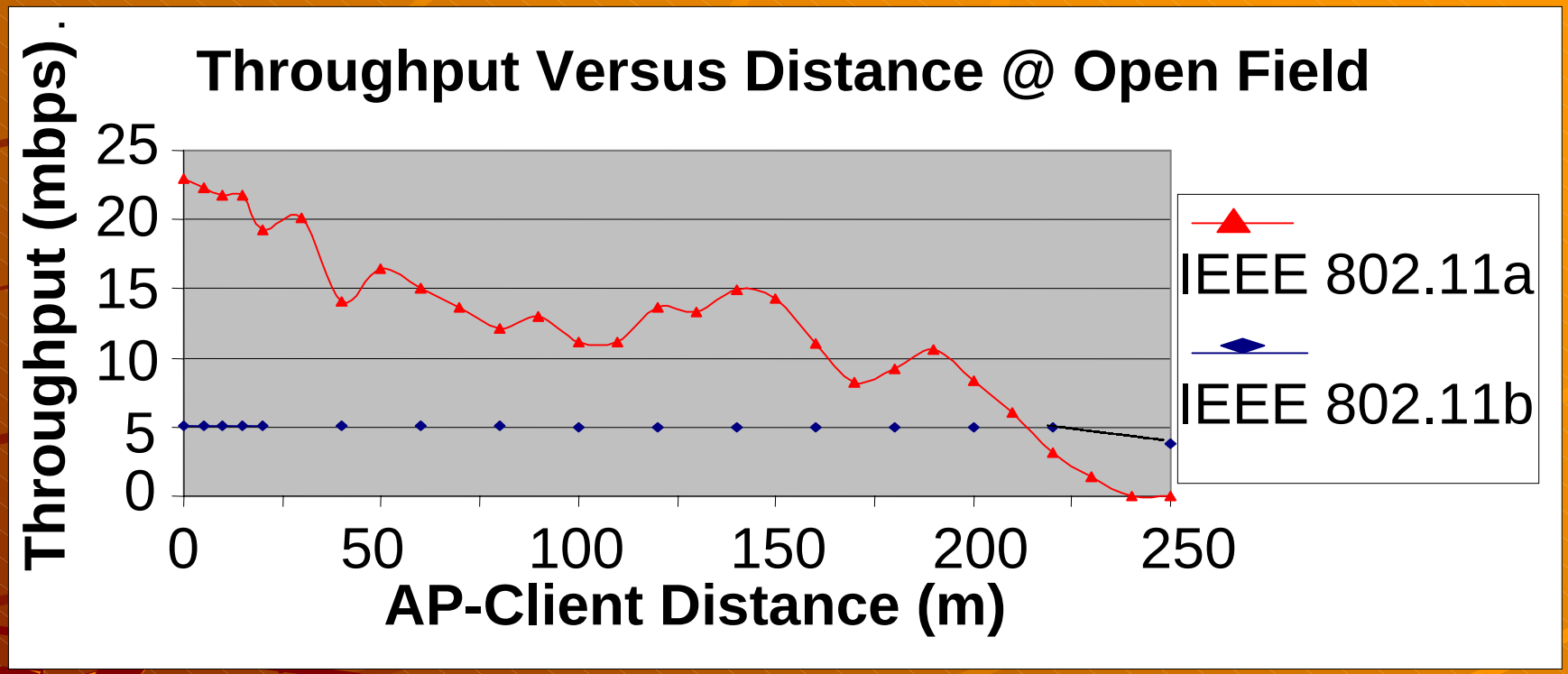
Performance – IEEE 802.11a
Open Environment – Open Field

Performance – IEEE 802.11a
Open Environment – Open Field



- Coverage is around 230 meters
- Throughput at 15m is ~21Mbps dropping at ~1.3Mbps/10m
- Max throughput of 802.11b is around ~5Mbps

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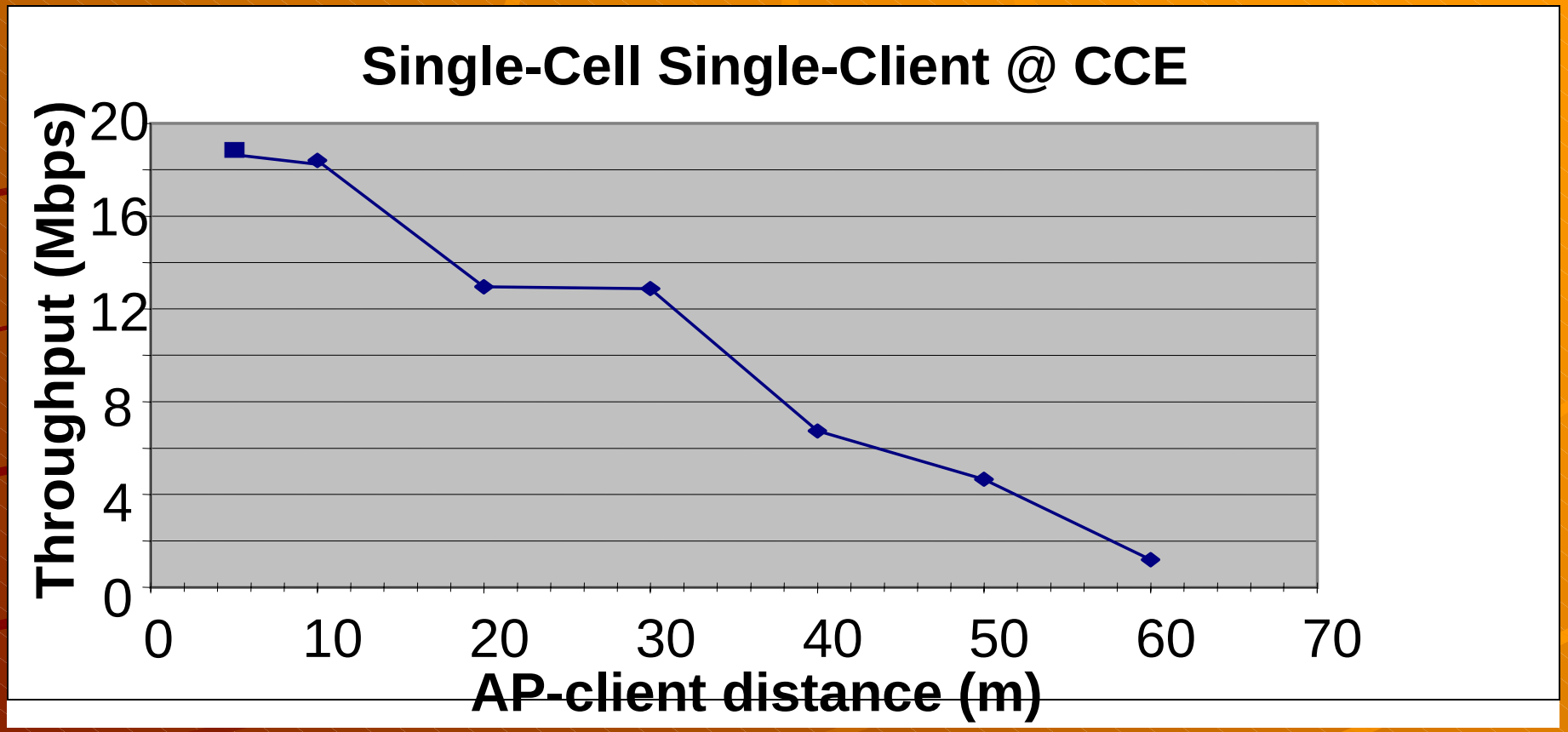
Performance Test
Semi-Open Environment – Sheltered Area

Performance Test
Semi-Open Environment – Sheltered Area



- Throughput at 15m is 17Mbps
- Drop in throughput is around 4Mbps/10m

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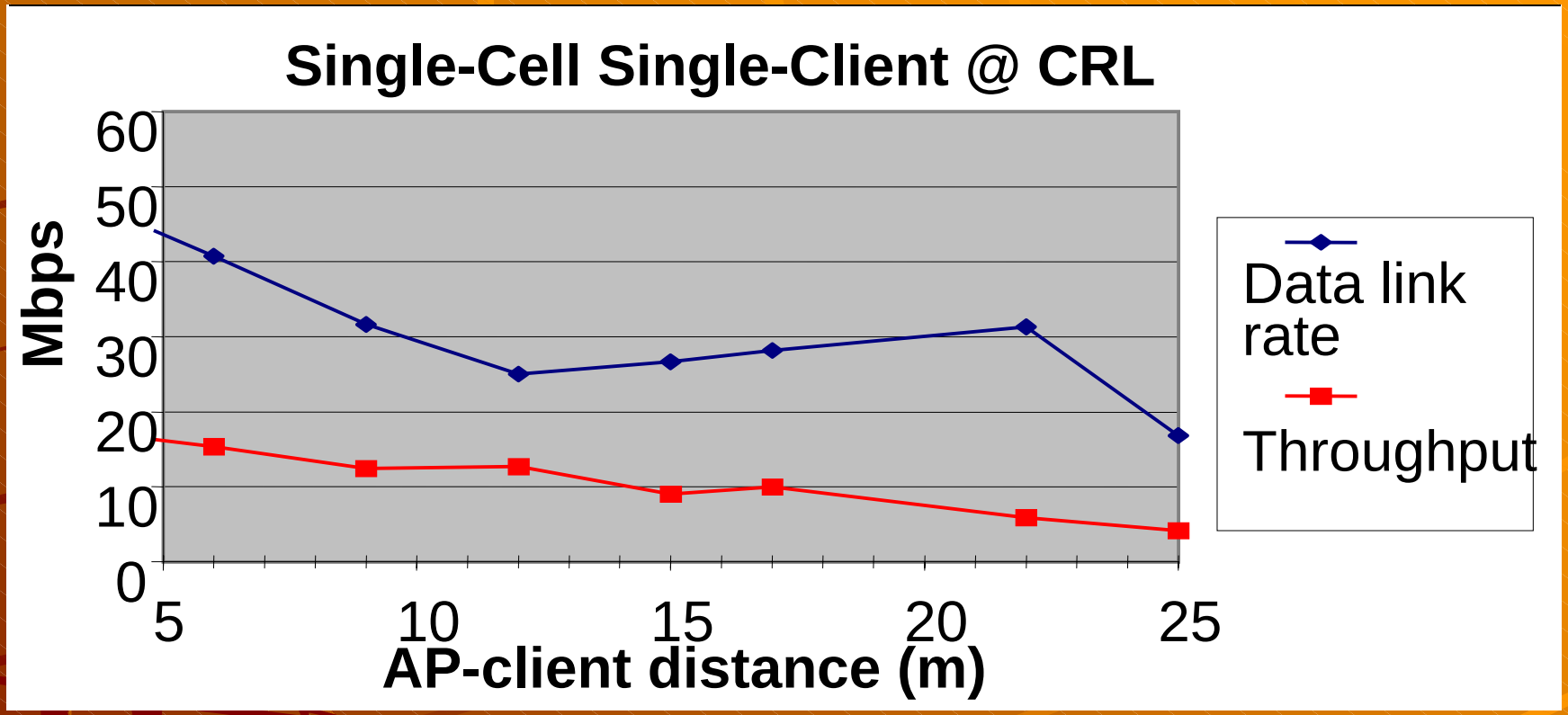
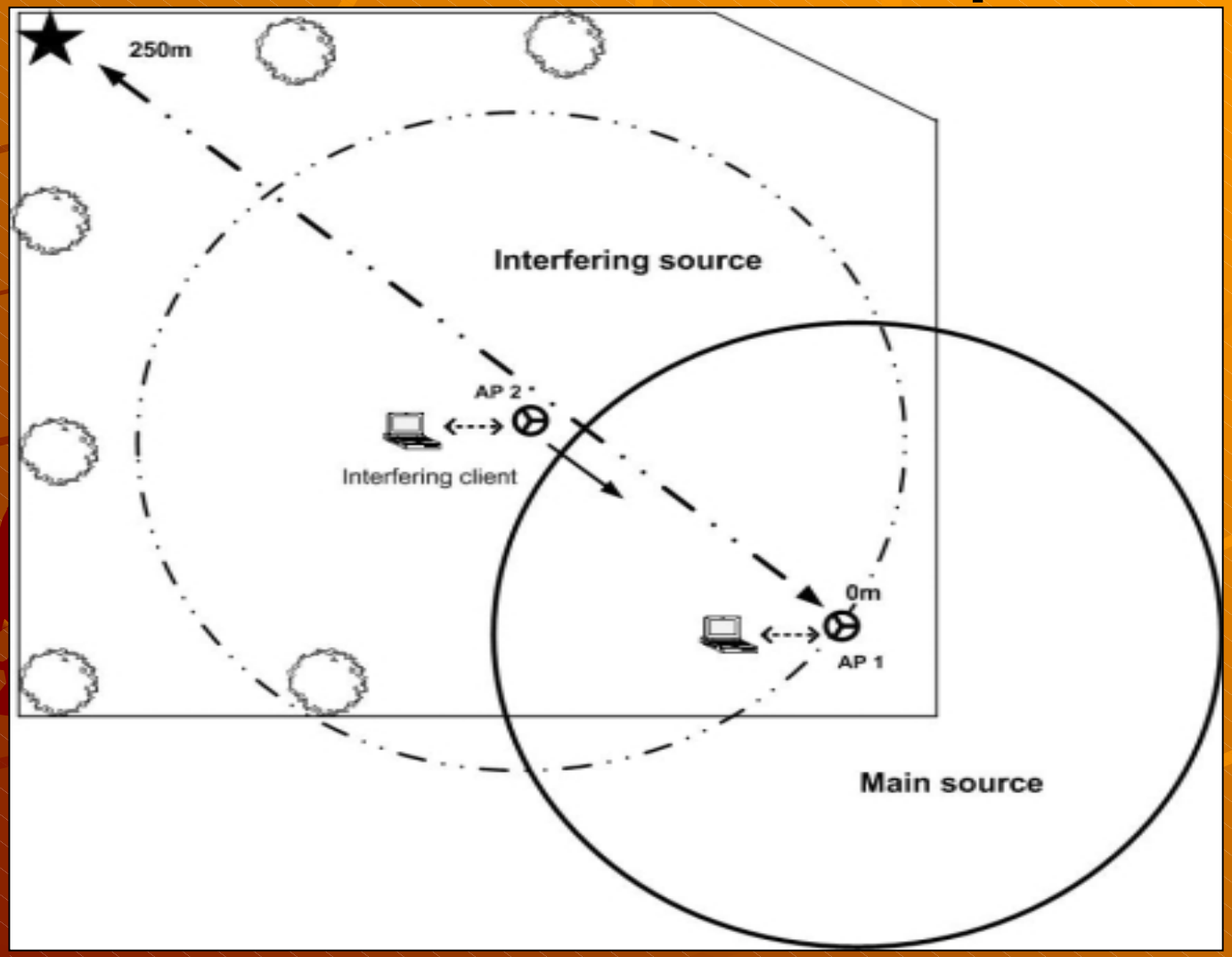
Performance – 802.11a
Closed Environment - Office

Performance – 802.11a
Closed Environment - Office

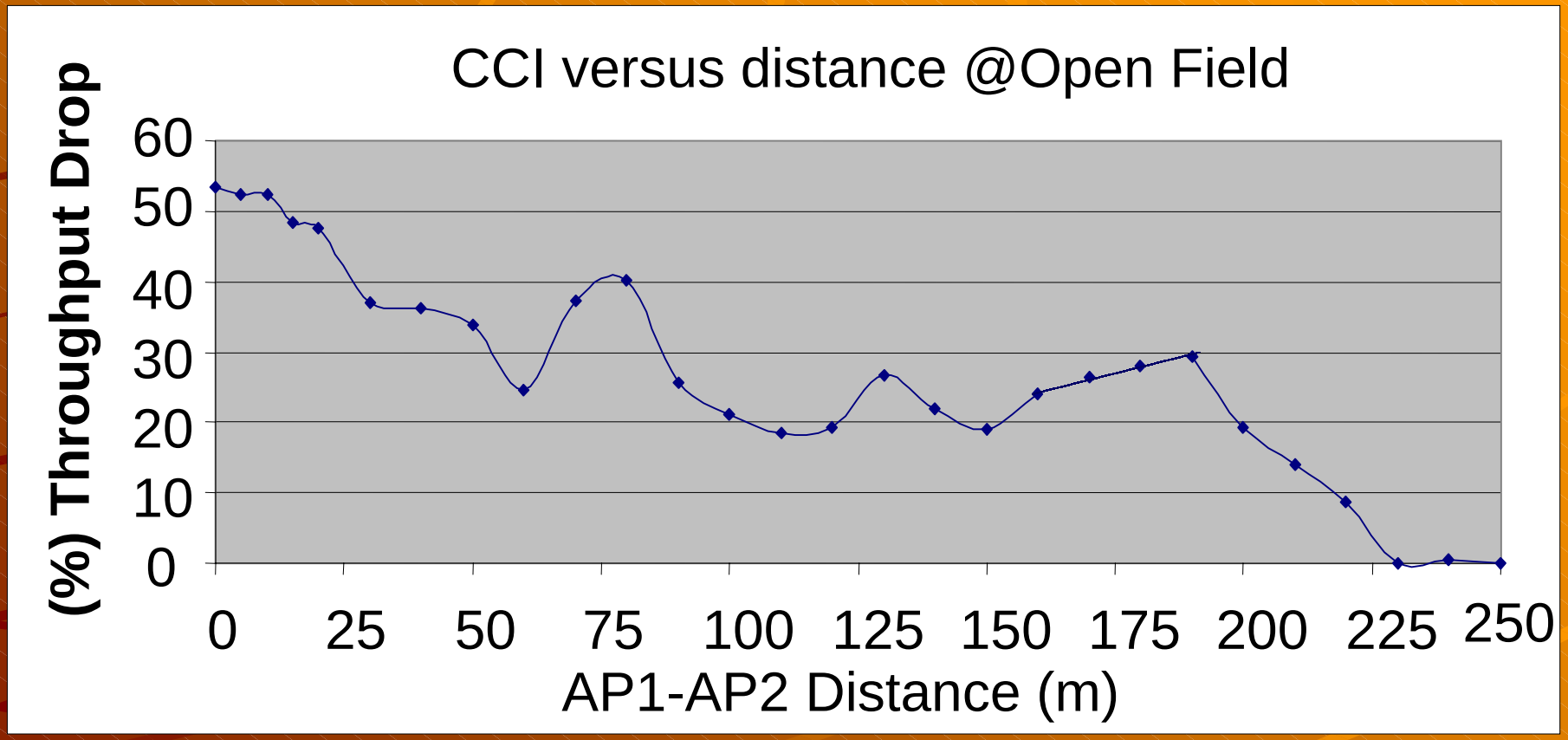


- Throughput at 15m is 10Mbps
- Drop in throughput is around 5Mbps/10m
- Effective throughput is ~40% of data link rate

Performance – IEEE 802.11a
Co-Channel Interference – Open Field

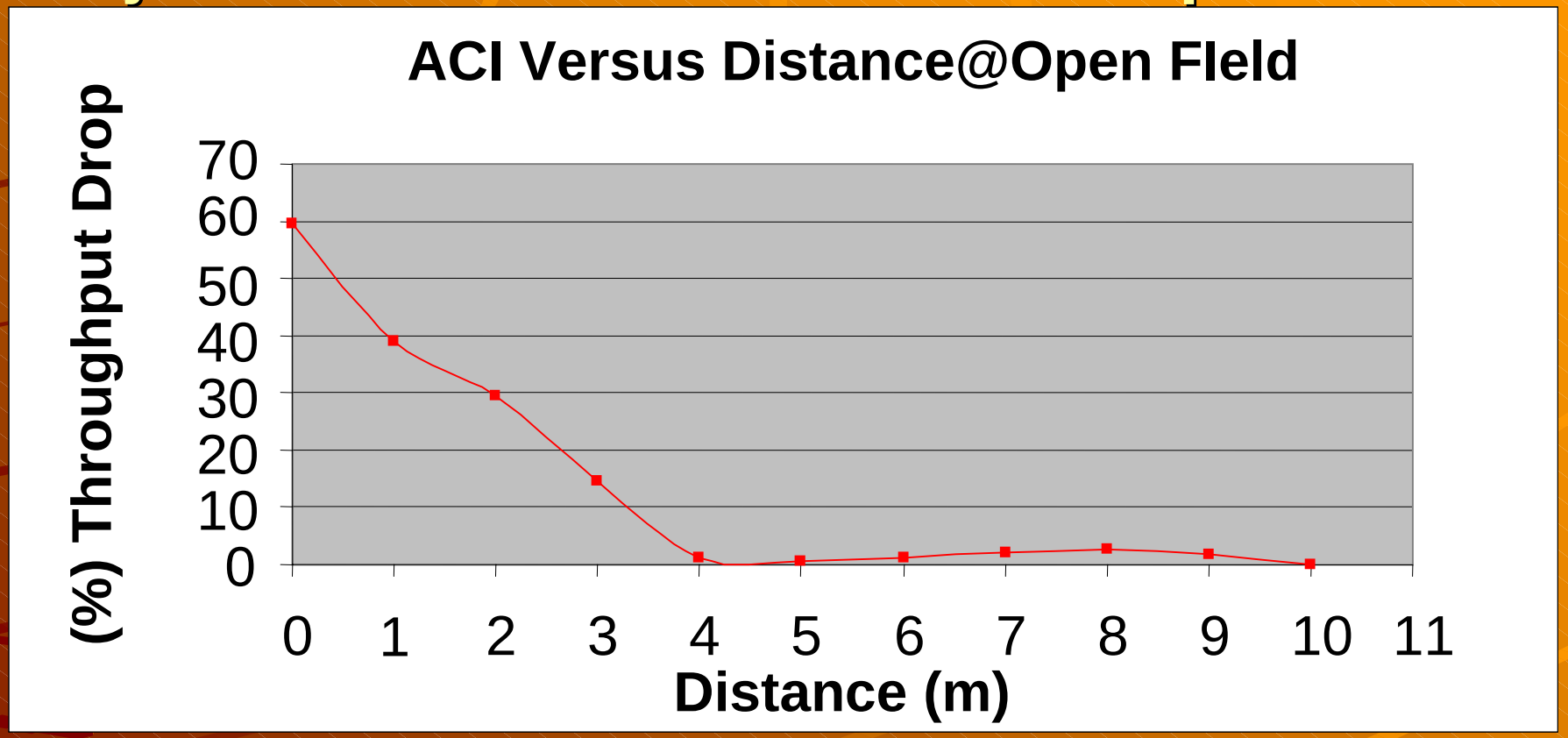


Performance – IEEE 802.11a
Co-Channel Interference – Open Field



- Drop in throughput is around 40% at 75m
- Drop in throughput is around 20% at 200m

Performance – IEEE 802.11a
Adjacent Channel Interference – Open Field



- Drop in throughput is around 40% at 1m
- Drop in throughput is negligible beyond 5m

Performance
Inter-Building Signal Loss

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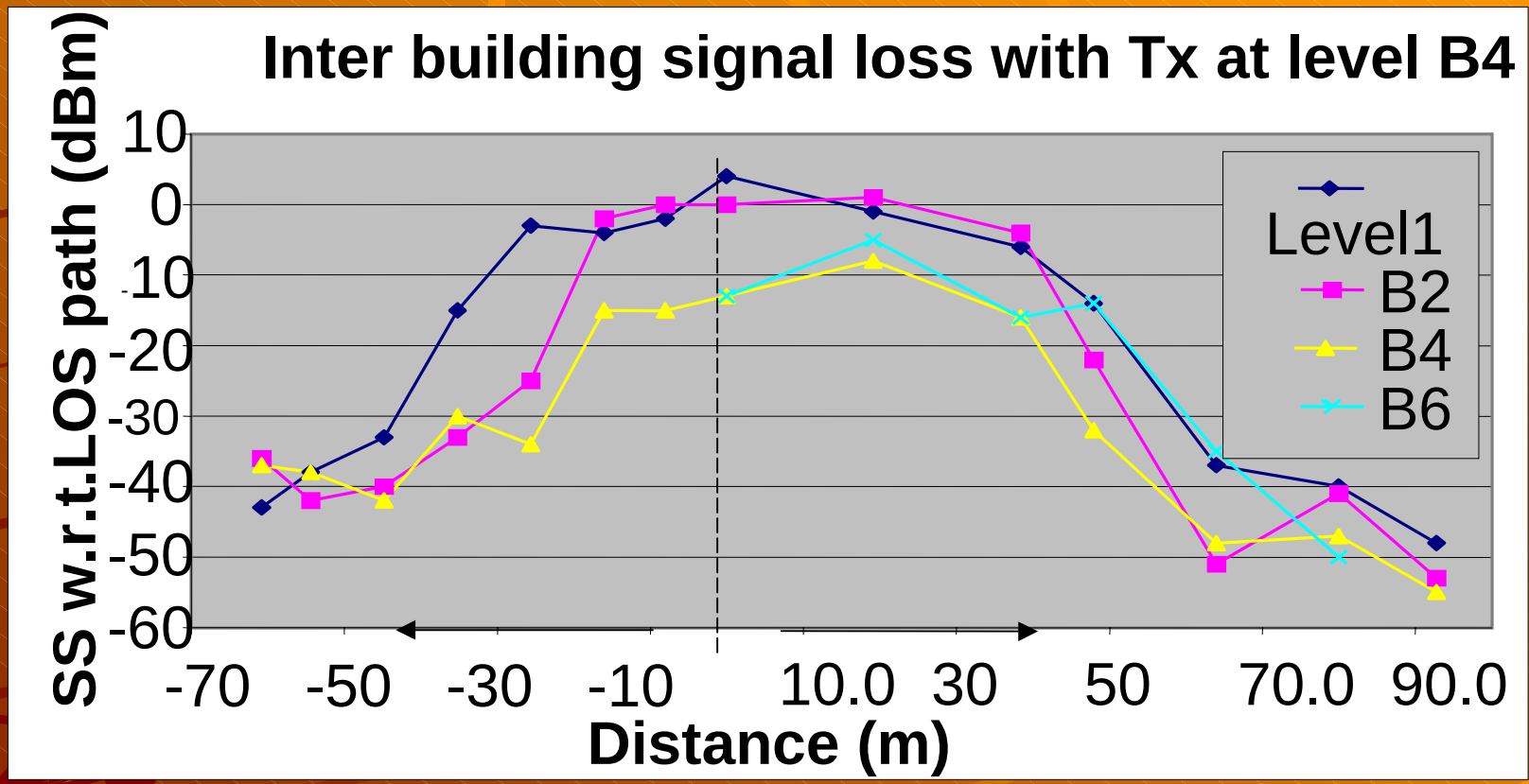
Performance
Inter-Building Signal Loss



- Free space loss is observed at high floors
- Lower floor has around 10dB excess loss due to trees
- Signal drop at the rate of around 15dB/10m when blocked by corner of a building

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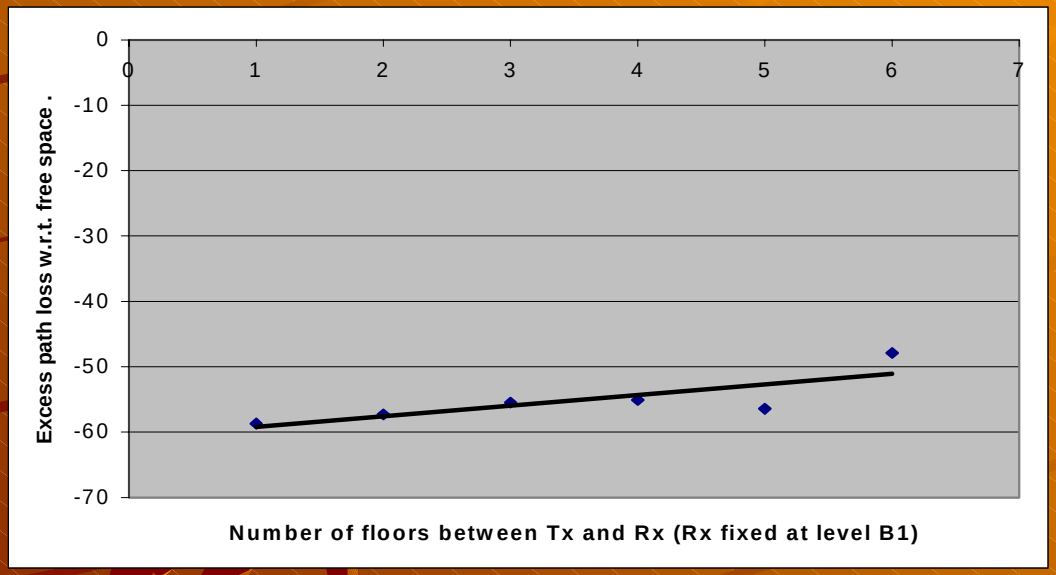
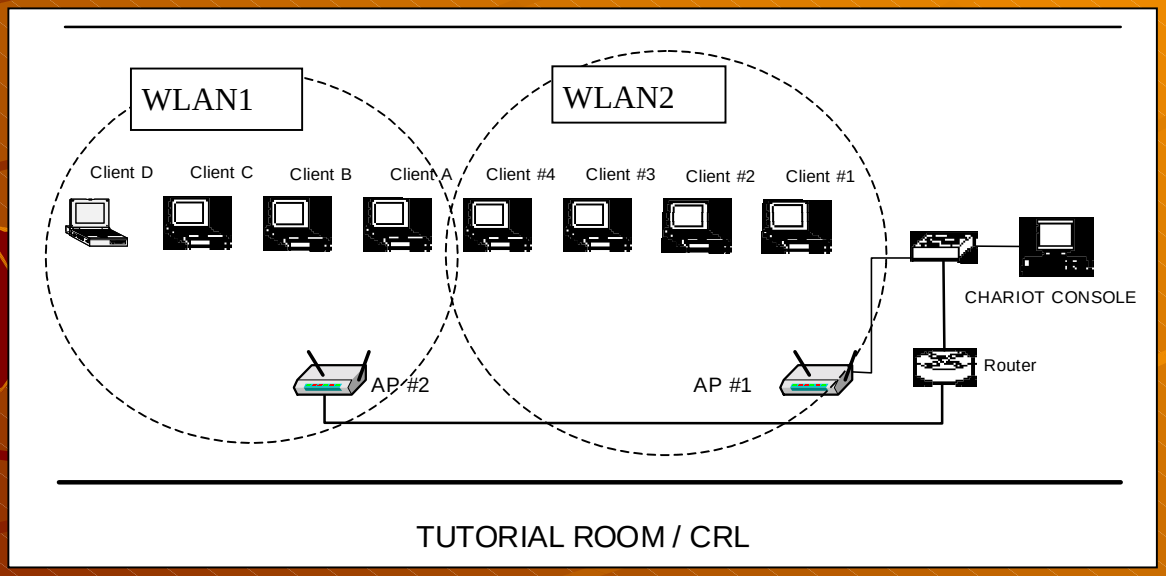
Performance – IEEE 802.11a
Inter-Floor Signal Loss



- Signal loss through floors is more than 50dB
  (Specific to this building: depends on building structure)

Performance – IEEE 802.11a
Contention

- Total Throughput for 8 concurrent clients drop up to 30% as compared with a single accesses



Performance – IEEE 802.11a
Moving Vehicle

- Average throughput is around 14Mbps over a ~140m drive
- Throughput is independent of speed measured up to 50Km/h

- Handover delay ranges from 0.6s to 3s
- Handover delay is independent of speed measured up to 50Km/h

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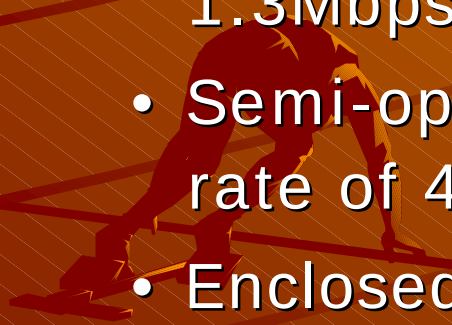
Summary of Performance Tests

- Compared to 802.11b, 802.11a generally has 3 times higher throughput, but shorter range
- Throughput depends on type of operating environment. Eg. for a range of 15m,
  - Open field: 21Mbps and drops at rate of 1.3Mbps/10m
  - Semi-open (Cafeteria): 17Mbps and drops at the rate of 4Mbps/10m
  - Enclosed (office): 10Mbps and drops at the rate of 5Mbps/10m



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Summary of Performance Tests

- Co-channel interference is significant with more than 40% drop in throughput when a second AP is 75m away
- AP with non overlapping channels can co-exist as long as they are separated by >5m
- Results of moving vehicle test show that speed (measured to 50Km/h) does not affect throughput and handover delay of 802.11a system

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Mobility – Mobile IP

- **Roaming Scenarios**
  - Within Enterprise Network
  - Between Enterprise Network and Wireless ISP (WISP) network
  - Between 2 WISP Networks
  - Between WLAN and GPRS Network
- **Tests**
  - Connectivity
  - Handover Delay
  - Application Performance

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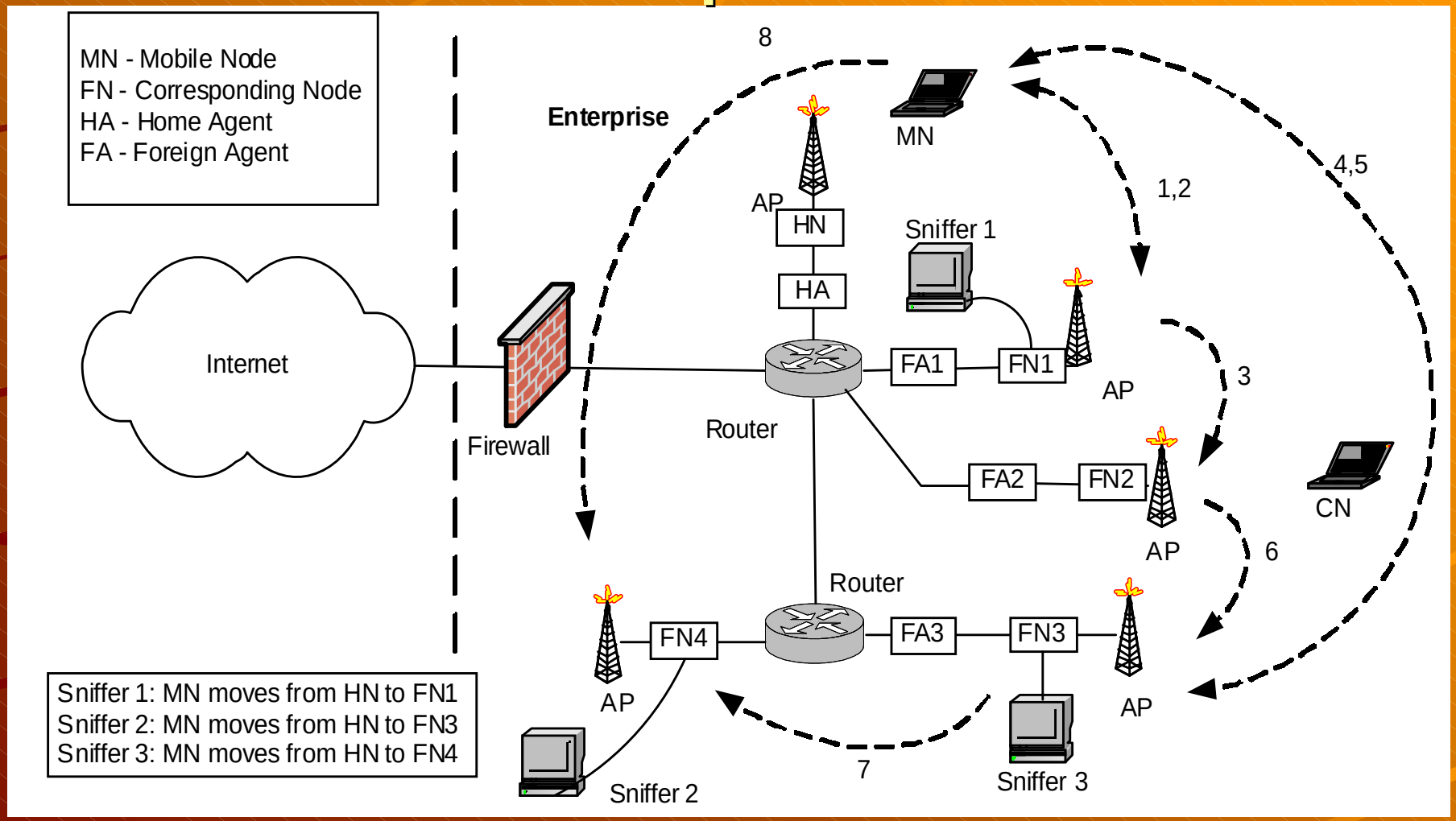
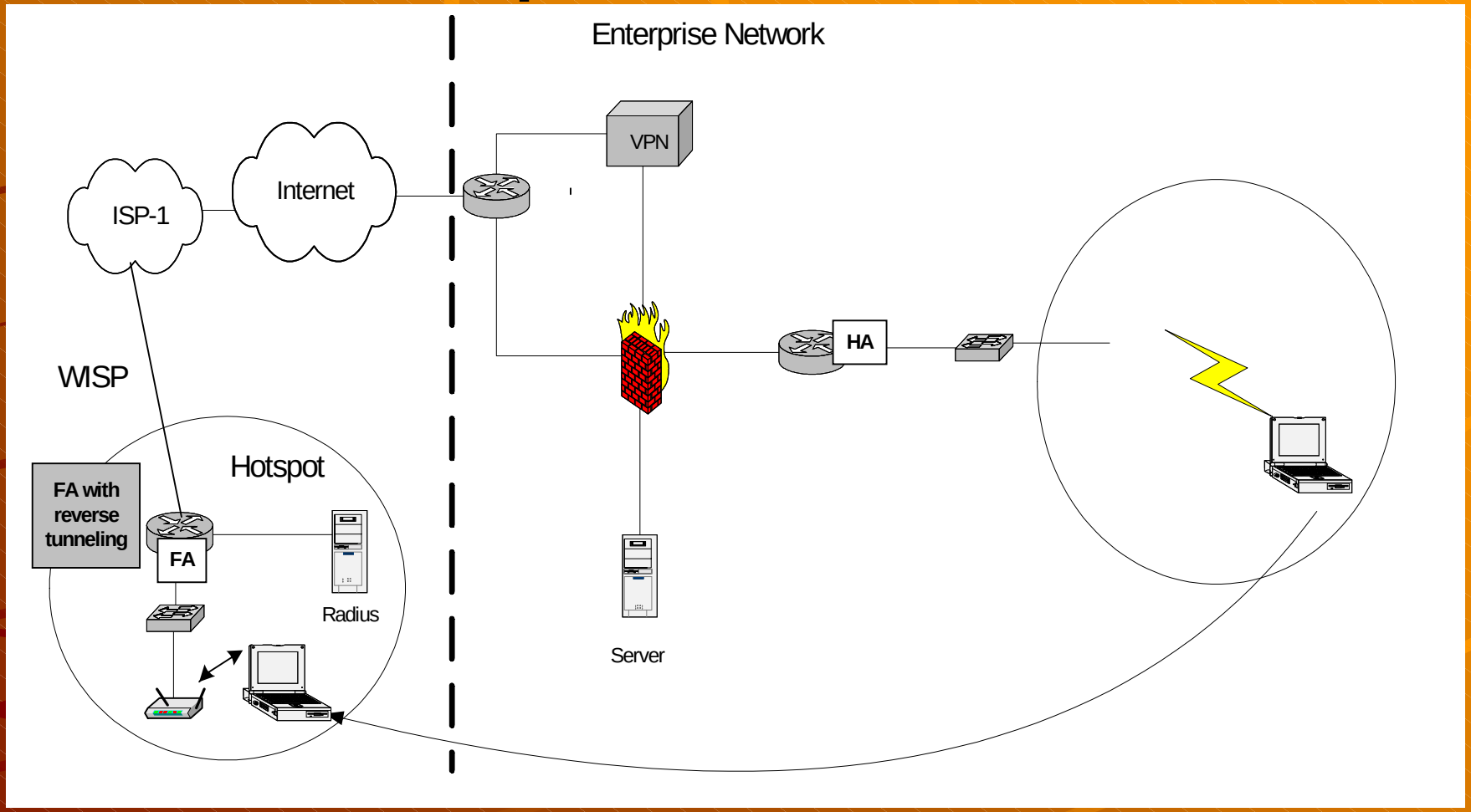
Mobility – Mobile IP
Within Enterprise Network



Mobile IP Test Results (Within Enterprise)

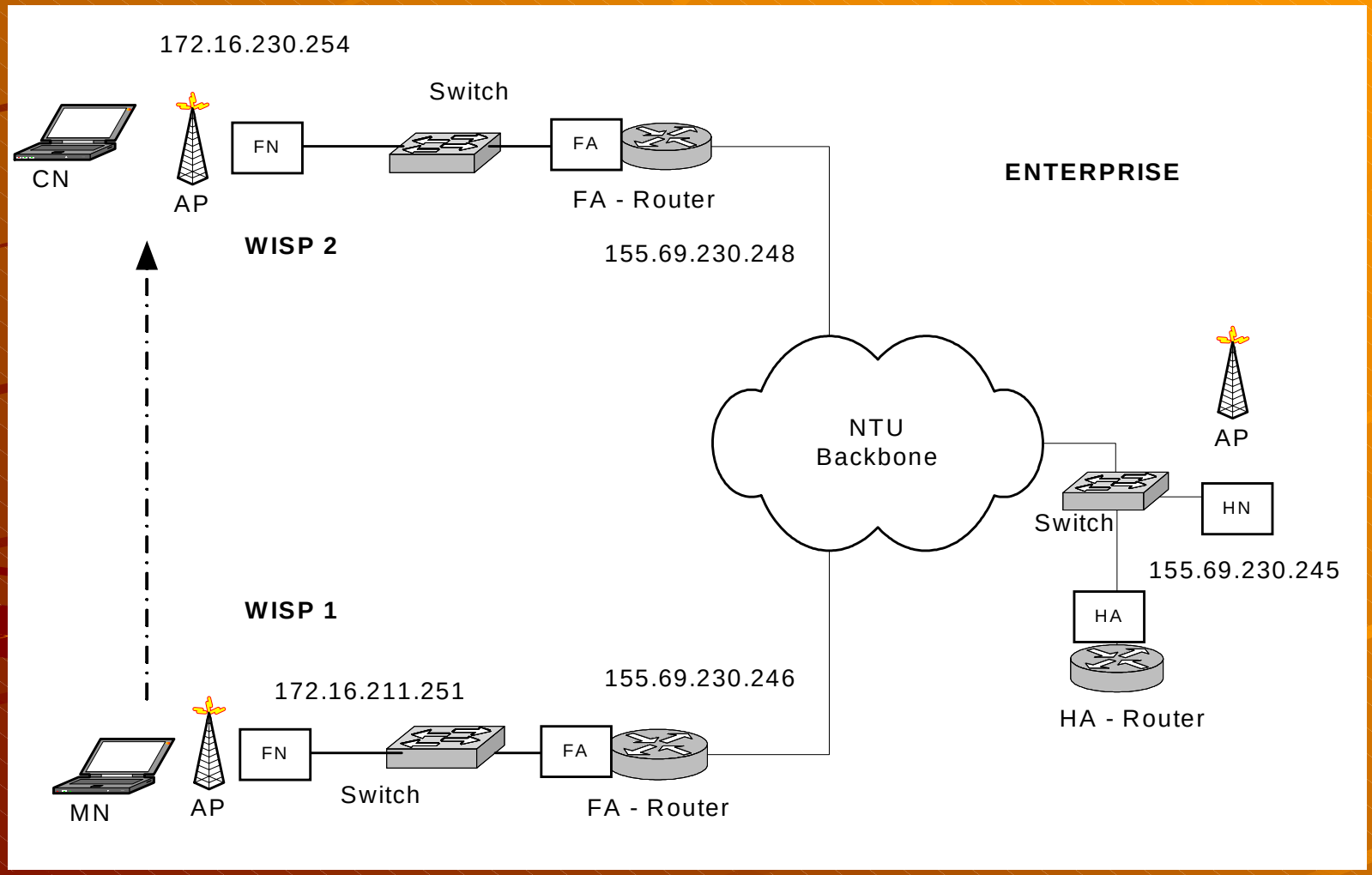
- Handover Delay
  - from Home to Foreign network ~ 4-6 seconds
- Performance in Foreign network
  - Throughput
    - from corresponding node to mobile node ~12% drop
    - From mobile node to corresponding node ~9% drop
  - Real-time application
    - Jitter < 15ms
    - Data lost ~0%
    - MOS maintained at 4.4 “very satisfied”
  - During handover, data loss can be ~90%

Mobility - Mobile IP
Enterprise-WISP Network

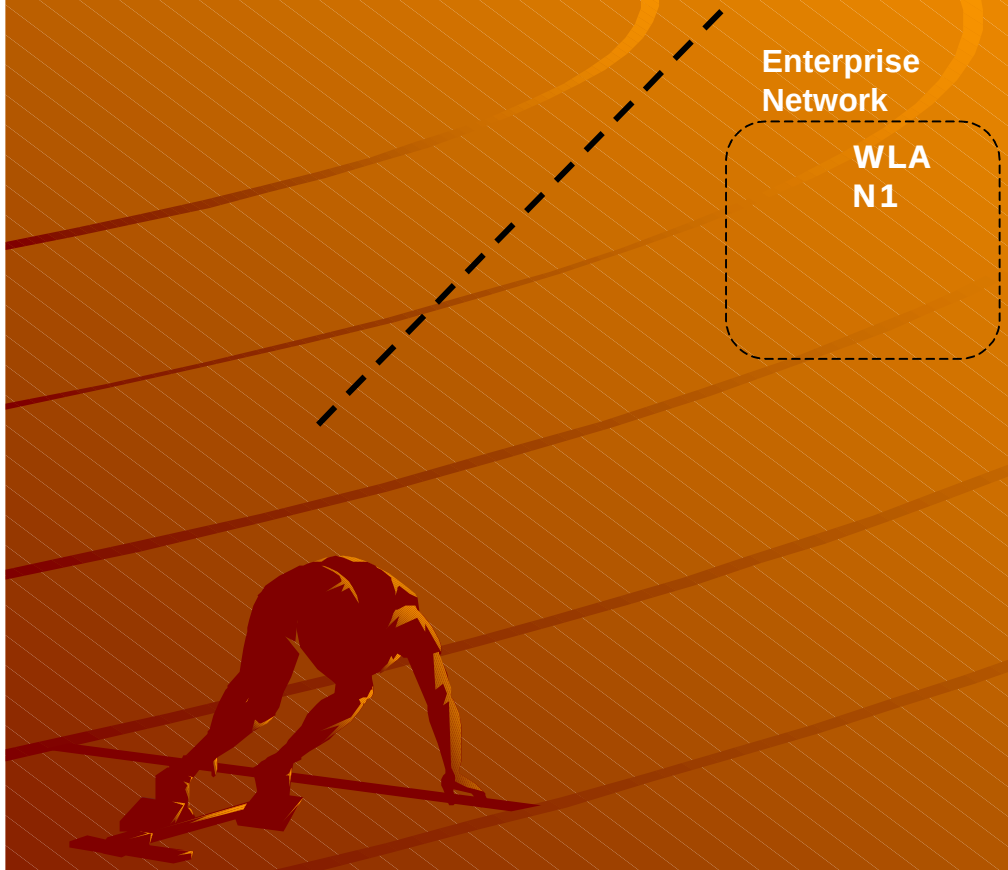


- Firewall traversal worked fine (reverse tunneling feature in FA)
- Integration with independent VPN system is a challenge

Mobility – Mobile IP
Wireless ISP – Wireless ISP Network



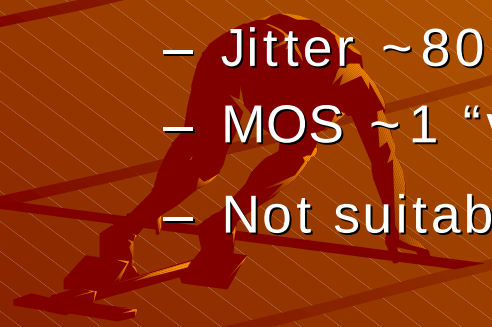
Mobility – Mobile IP
Wireless ISP – GPRS Network



- Network Address Port Translation (NAPT) Traversal is needed

Mobility – Mobile IP
WLAN – GPRS Network

- Throughput ~18kbps
  - Throughput drop by ~99% WLAN-> GPRS
- Poor performance for Real-time Applications
  - data loss ~90%
  - Jitter ~80ms
  - MOS ~1 “very dissatisfied”
  - Not suitable for real-time application



Summary of Mobile IP

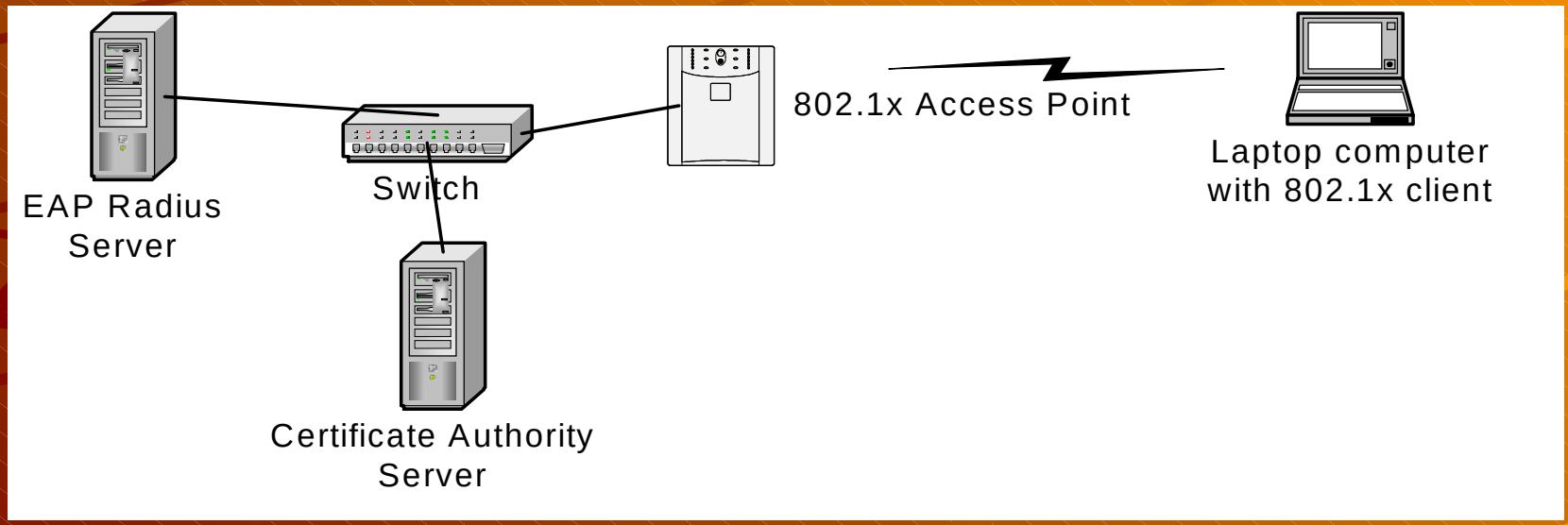
- Portability and seamless roaming demonstrated for both non-real time and real time traffic
- The network throughput in foreign network drops by
  - around 12% for data from CN to MN and
  - around 9% for data from MN to CN
- VPN + MIP
  - Single system with build-in VPN + MIP works fine
  - MIP with independent VPN system still an issue
- FA configured with reverse tunnelling can be used where MN roams out of the firewall
- Seamless roaming between GPRS and WLAN is possible if the HA supports Network Address Port Translation (NAPT) Traversal

Security

- IEEE 802.1x Feature Verification
- Deployment Mode Verification
  - Enterprise Model
  - WISP (Wireless ISP) Model
    - Clearing House Model
    - Bilateral/Multilateral Model
- WEP Impact on Performance

Security - IEEE 802.1x Feature Verification (1)

	802.1x/EAP Compliance	*Mutual Authentication*	*Dynamic WEP Support*
EAP-TTLS	**Yes**	**Yes**	**Yes**
EAP-TLS	**Yes**	**Yes**	**Yes**
EAP MD5	**Yes**	**No**	**No**

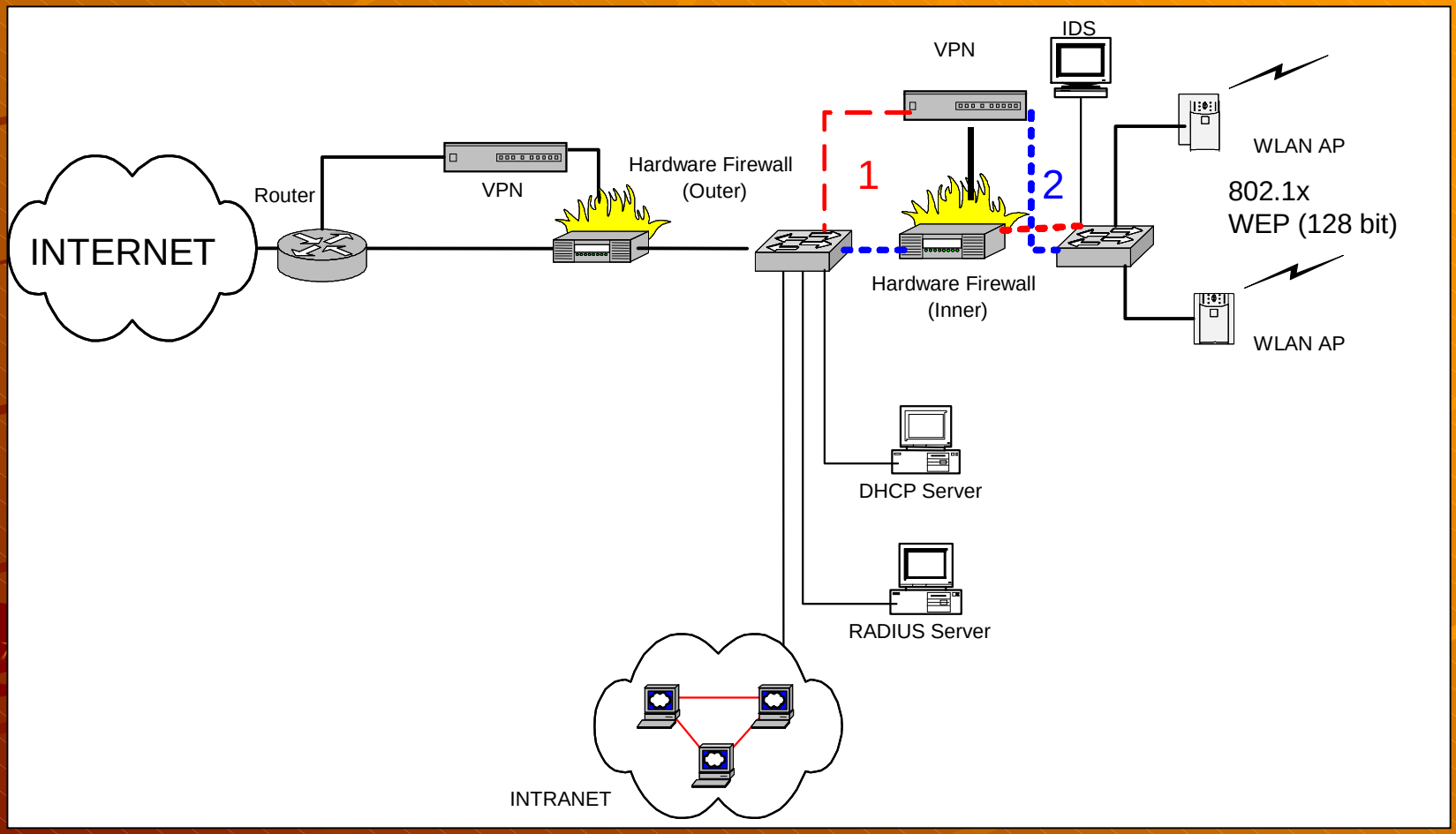


Security - IEEE 802.1x Feature Verification (2)

- **EAP-MD5**
  - Lack of support for dynamic WEP keys
  - Not appropriate to be used in secured implementation
- **EAP-TLS**
  - Supports mutual authentication
  - High administrative overhead - Need to maintain client certificates both in the Radius server and in the client
- **EAP-TTLS**
  - Supports server authentication - Only one certificate is needed on the Radius Server
  - Much less certificate to be managed
  - Not all products support

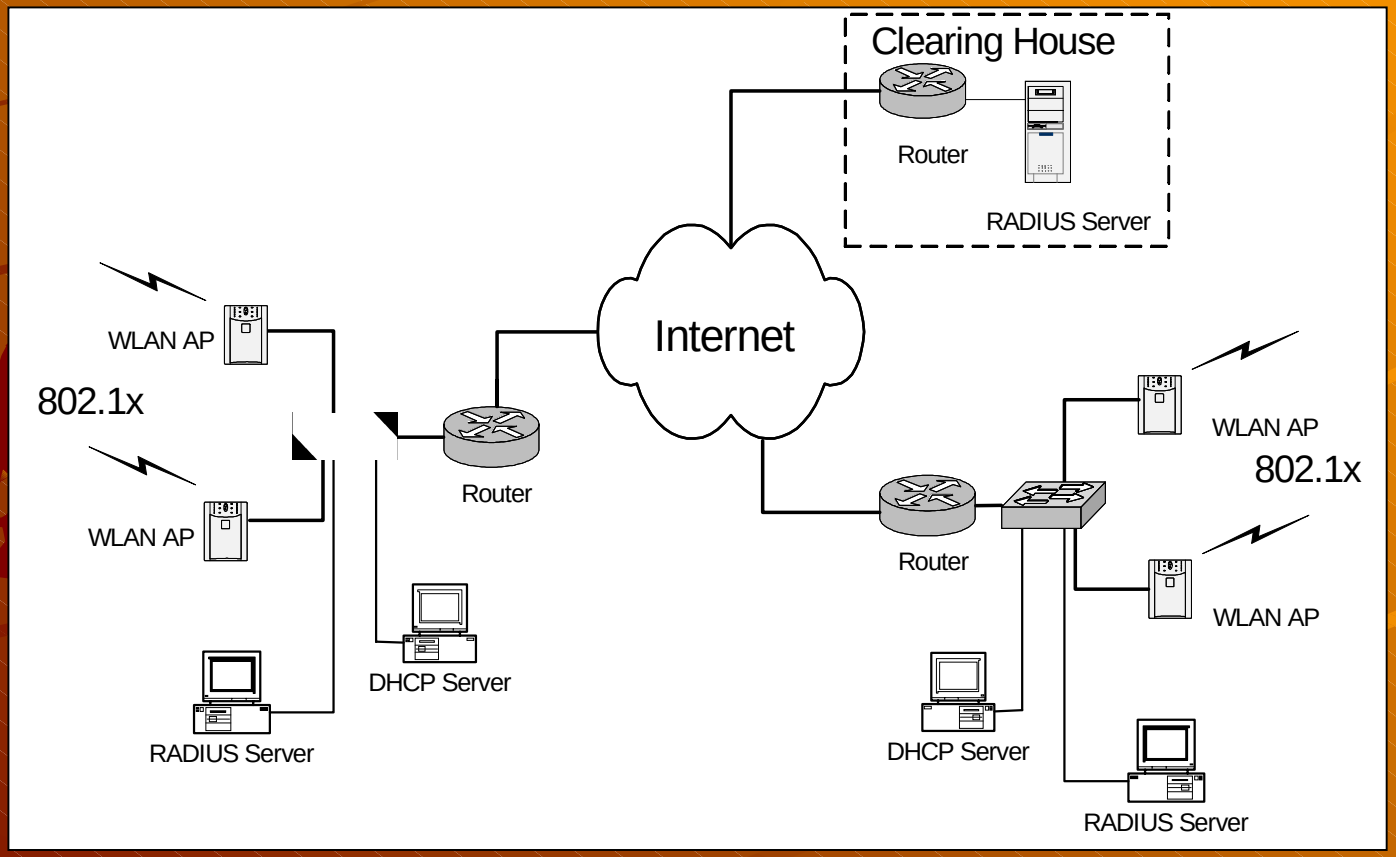
Security - Deployment Model verification

Enterprise Model



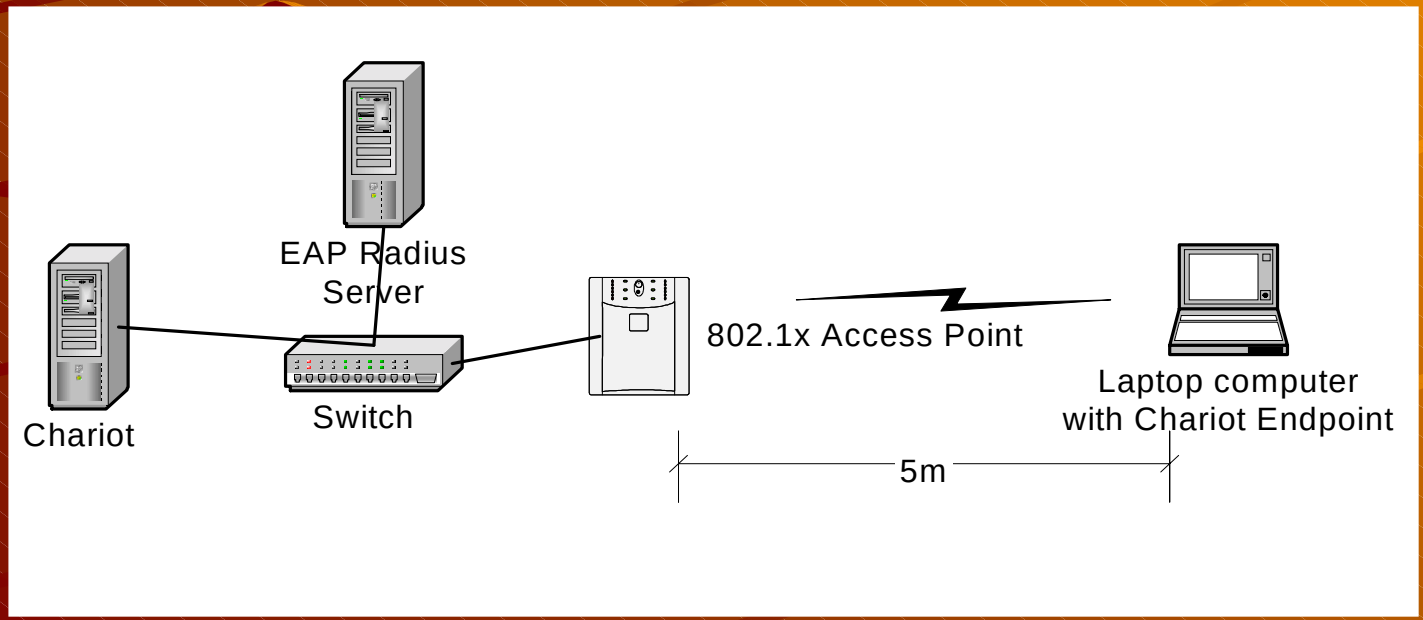
Security - Deployment Model verification
WISP Model

- Clearing House (may be multilevel)
- Bilateral/Multilateral Agreement



Impact of security features on Performance

- Dynamic WEP (128 bit key with EAP-TLS) scheme was evaluated
- No significant impact on performance (key refresh introduce latency <0.7s)
- With VPN/FW: - Throughput drop by ~20%
  - MOS maintained at >4 “Very satisified”



Key Findings (1)

Performance – IEEE 802.11a

- Effective Throughput about 40% of Data Link Rate
- Coverage range is up to ~230 metres in open and un-obstructed environment
- The effect of CCI was very significant - Careful frequency planning should be exercised to avoid performance degradation
- Adjacent Channel Interference can be avoided - Access points had to be at least 5 meters apart

Key Findings (2)

Mobility – Mobile IP

- Feasibility of deploying mobile IP for deployment models was demonstrated
- Roaming between WLAN and GPRS is feasible
- Integration between Mobile IP and independent VPN system is a challenge

Security

- Use of 802.1x-EAP schemes was verified
- Use of Dynamic WEP Encryption Scheme has no significant impact on performance
- Feasibility of deploying typical enterprise and WISP model was demonstrated

Conclusion

The trial serves to provide assessment of the current NGWLAN capabilities but need to note that as wireless technologies are advancing rapidly, these capabilities will change too - The trial serves to provide a snap-shot; as of now.

Trial Project Team

NTU	RFnet	IDA
Assoc Prof Law Choi Look	Mr Lee Chyan	Dr Tan Geok Leng
Assoc Prof Ong Jin Teong	Mr Tan Chin Thong	Mr Lai Fook Nigan
Assoc Prof Erry Gunawan	Mr Tan Moh Chuan	Dr Toh Bee Eng
Assoc Prof Soong Boon Hee	Mr Lee Chee Leong	Ms Yee Poh Cheng
Assoc Prof Tan Soon Yim	Mr Gan Tia Seng	Mr Lai Yoke Yong
Asst Prof Teh Kah Chan		Mr Wong Weng Wah
Asst Prof Guan Yong Liang		Mr Ong Kian Lin
Mr Wong Chee Wah		Mr Ivan Au
Mr Li Kwet Pin Chi Wan		Mr Yong Kuan Loong
Mr Basuki Endah Priyanto		Mr Roi Phua
		Mr Lam Chian Leong
		Mr Quek Jin Shui

End