A Cross-Layer Analytical Model of End-to-End Delay Performance for Wireless Multi-hop Environments

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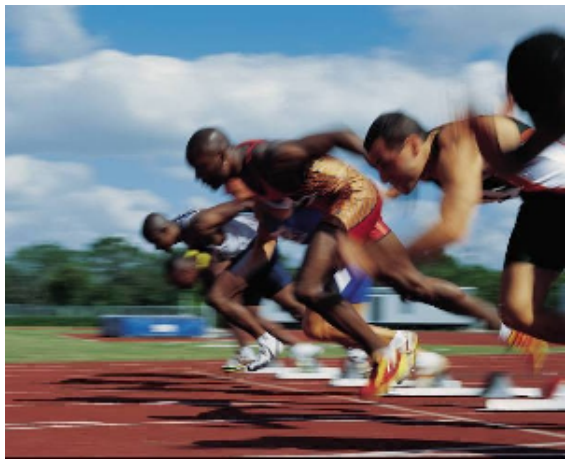
12, September 2010

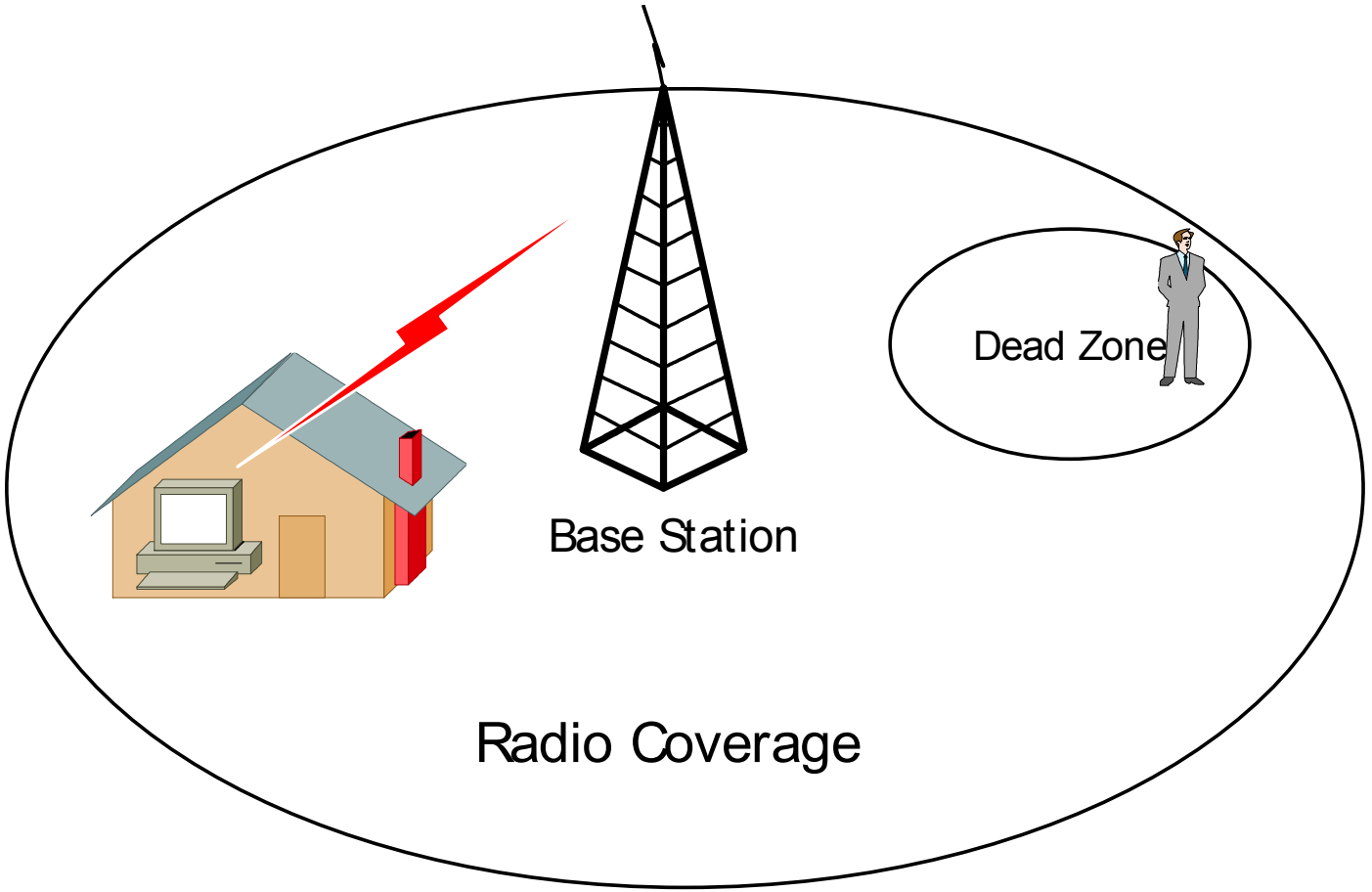
Outline

- Wireless Multi-hop Environments
- System Model
- Single-hop Delay Performance Analysis
- Multi-hop Delay Performance Analysis
- Analytical and Simulation Results



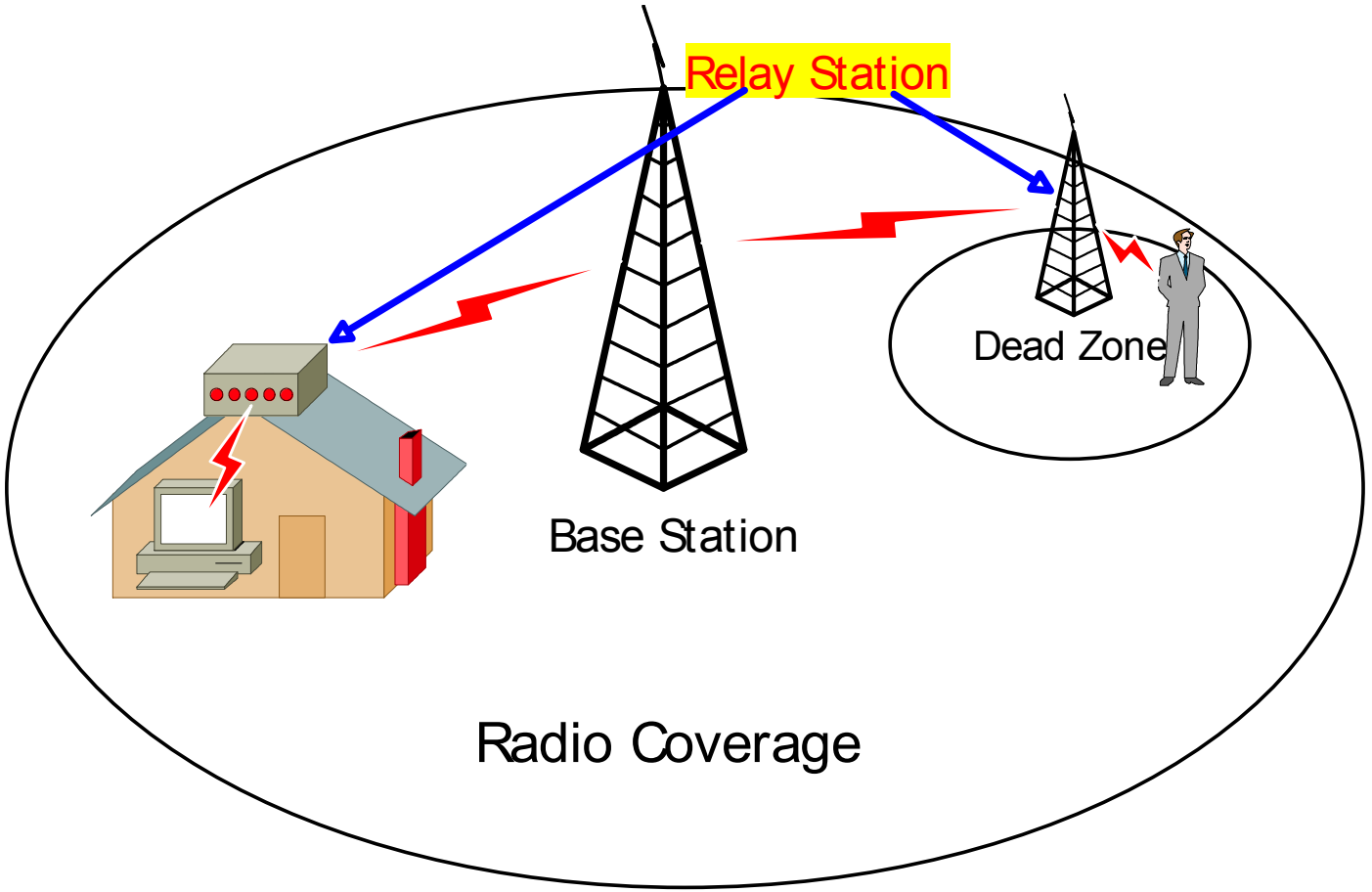
Wireless Multi-hop Environments-1

- One usage scenario



Wireless Multi-hop Environments-2

- One usage scenario



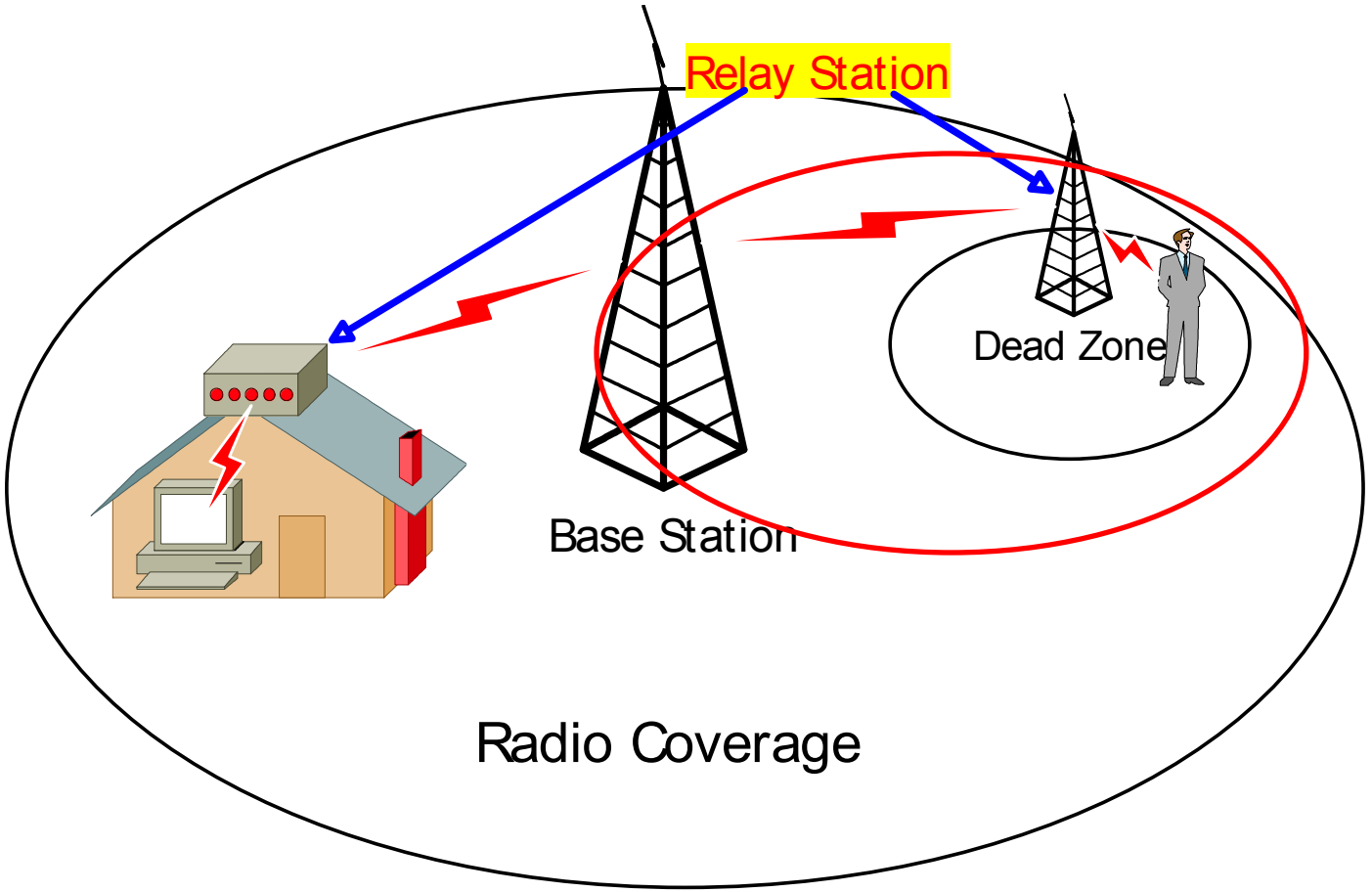
Wireless Multi-hop Environments-3

- Advantages of Wireless Multi-hop Env.
  - Capacity Enhancement
  - Coverage Increasement
- Standards adopted the wireless multi-hop architecture
  - the IEEE 802.11s
  - the IEEE 802.16j
  - LTE-A

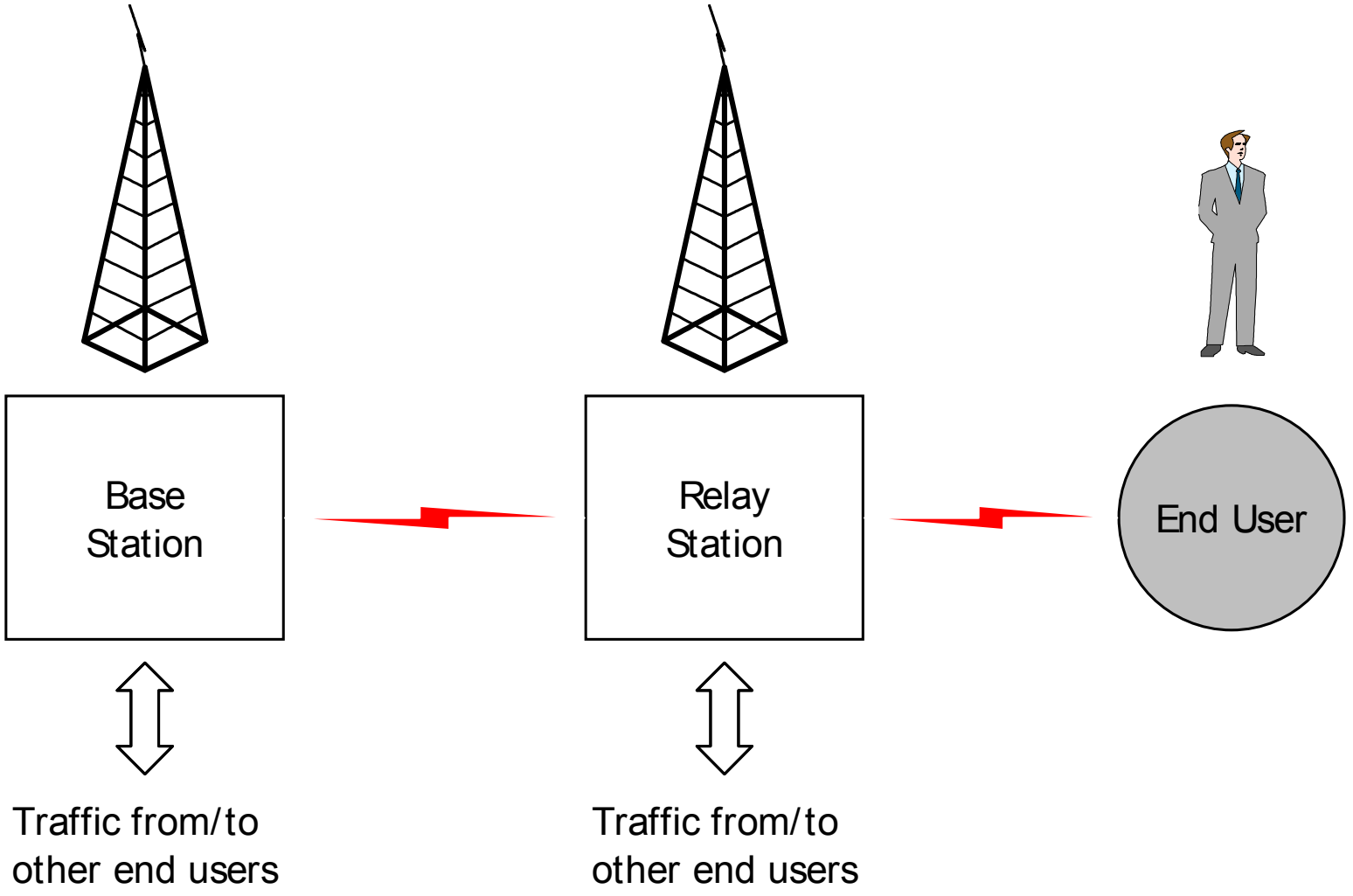
Wireless Multi-hop Environments-4

- Disadvantages of Wireless Multi-hop Env.
  - End-to-end Quality of Service
  - Security
  - Etc.
- Research Objective
  - To analyse, predict and guarantee multi-hop delay performance

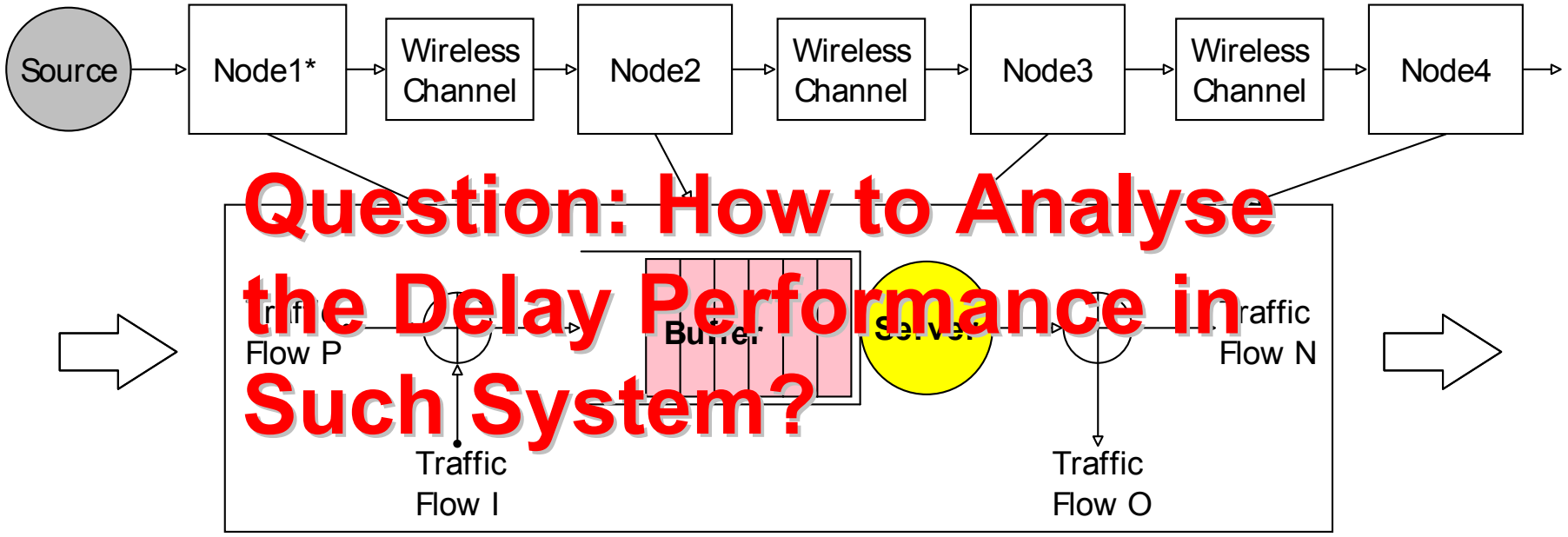
System Model-1



System Model-2



System Model-3 (Queueing Delay)



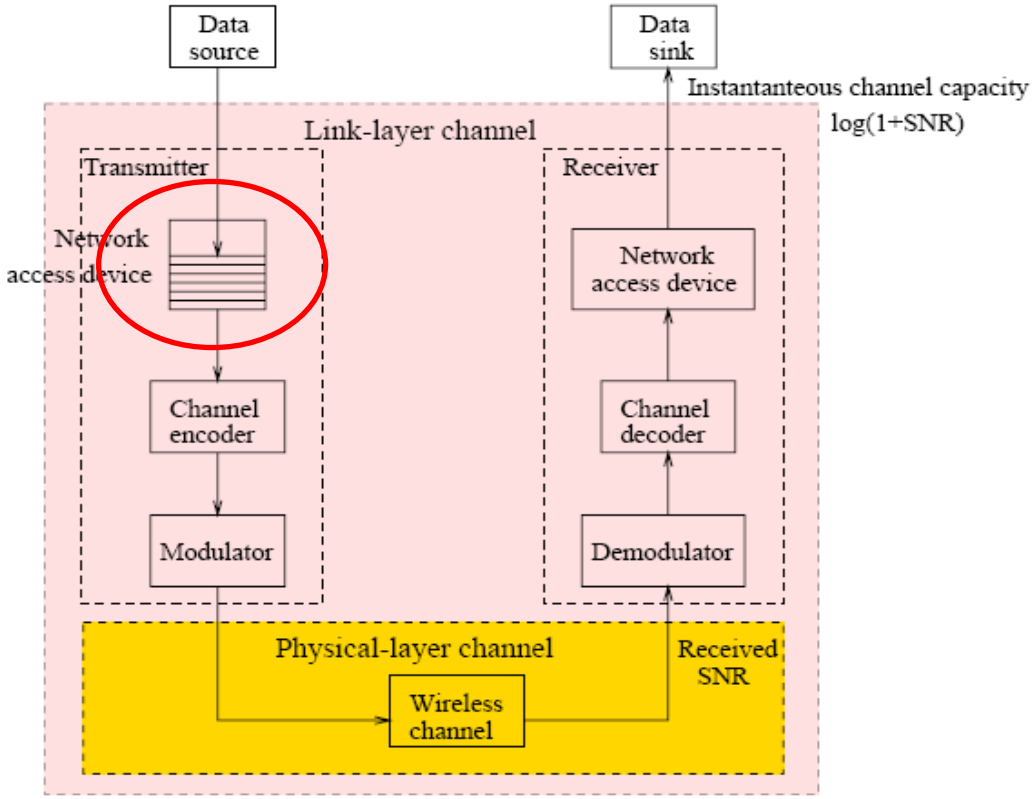
Question: How to Analyse the Delay Performance in Such System?

* The input traffic is from Traffic Flow P only

$$\text{Traffic Correlation Index} = \frac{\text{Traffic Flow P}}{\text{Traffic Flow P} + \text{Traffic Flow I}} = \frac{\text{Traffic Flow N}}{\text{Traffic Flow N} + \text{Traffic Flow O}}$$

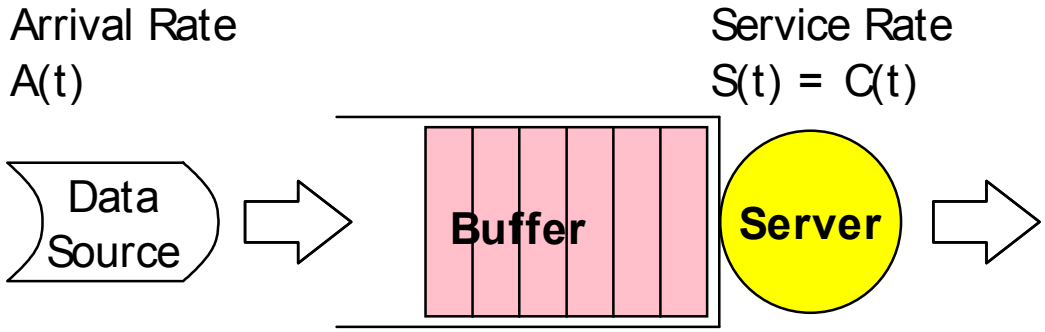
Single-hop Delay Performance Analysis-1

- Effective Capacity (by Prof. D. Wu)



Single-hop Delay Performance Analysis-2

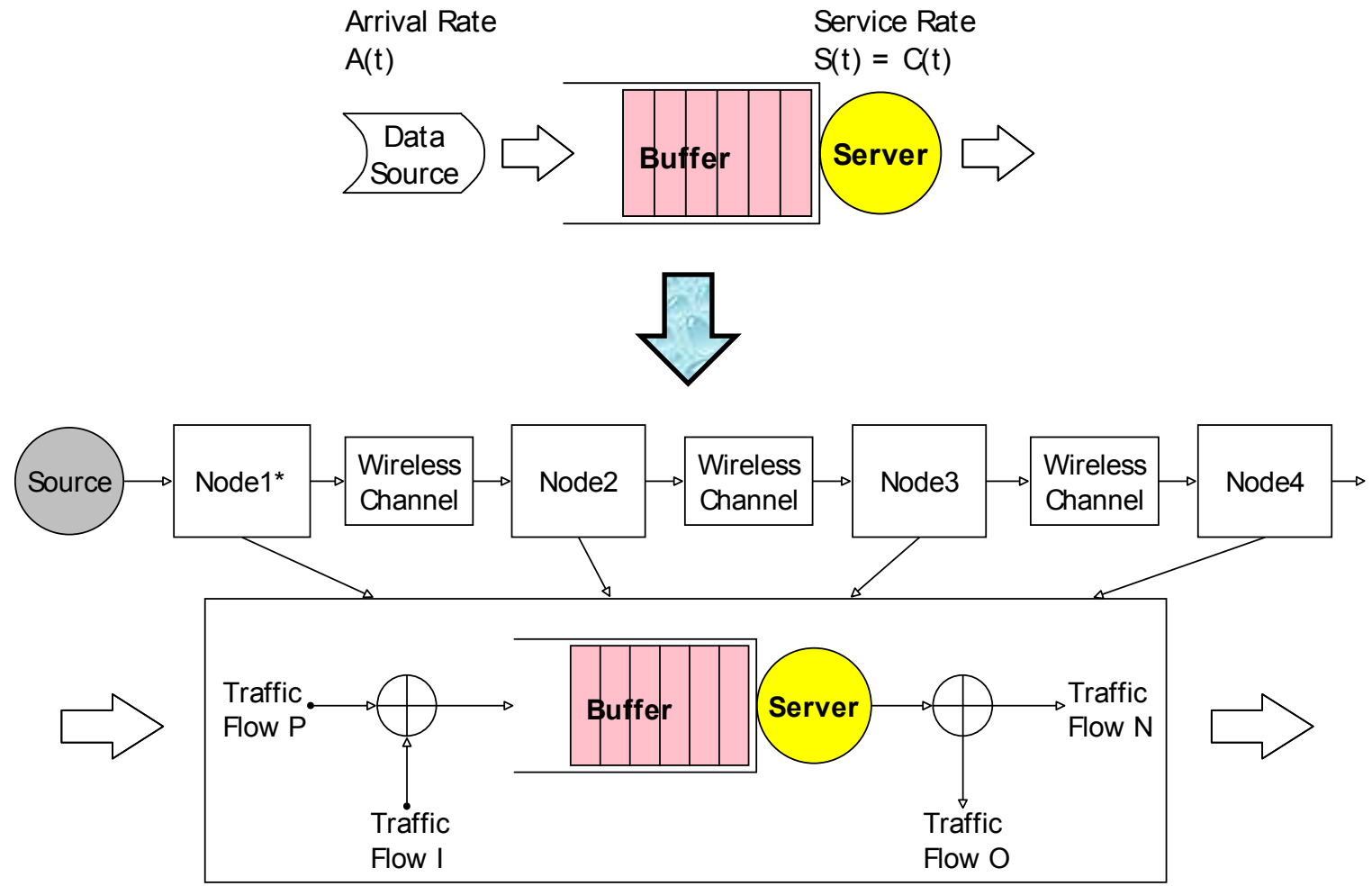
- A data-link layer queueing model



- Delay Bound Violation Probability

$$\Pr(D > x) \approx \gamma \cdot \exp(-\theta \cdot x)$$

Multi-hop Delay Performance Analysis-1



* The input traffic is from Traffic Flow P only

Multi-hop Delay Performance Analysis-2

- Delay Bound Violation Probability in Wireless Multi-hop Environments

$$\Pr\left(\sum_{i=1}^{h} D_i > x\right) = \sum_{i=1}^{h}\left(\prod_{j=1, i\neq j}^{h}\left(1+\frac{\gamma_j \cdot \theta_i}{\theta_j - \theta_i}\right)\right)\cdot \gamma_i \cdot \exp(-\theta_i \cdot x)$$

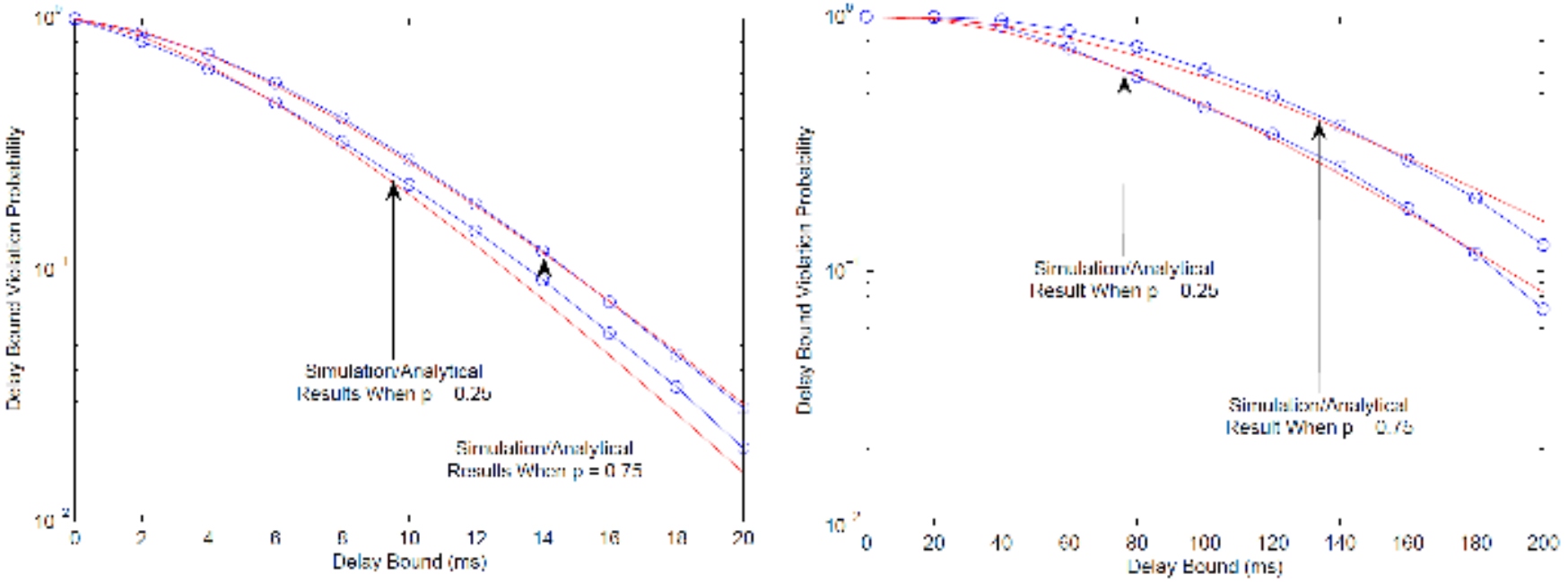
Analytical and Simulation Results-1

- Simulation parameters

Parameters	**Values**
Channel Model	Rayleigh Distr.
Average SNR, SNR_{avg}	15dB
AWGN channel capacity, r_{AWGN}	100kbps
Maximum Doppler rate, f_m	30hz
Average Traffic Load, μ	75 and 85 kbps
Time Step, T_s	$1/\mu$
Traffic Correlation	0.75 and 0.25
Hop Number, h	3

Analytical and Simulation Results-2

- Delay Bound Violation Probability for Different Traffic Load

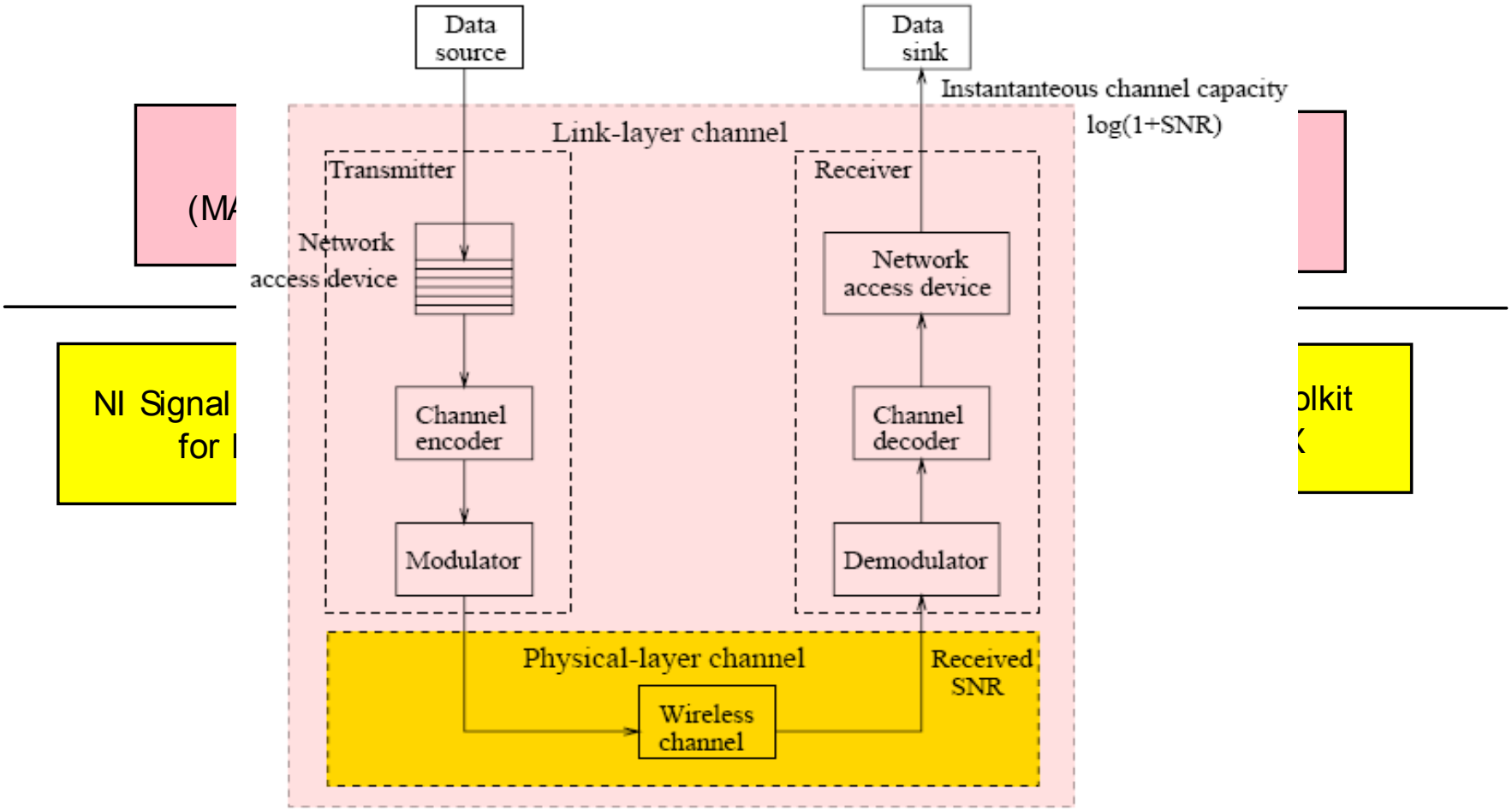


Analytical and Simulation Results-3

❖ Average Delay and Jitter Performance

	Delay Mean	Delay Jitter
Wireless Situation	μ=75kbps and p=0.25	
Simulation/Analytical Results (ms)	6.55 / 6.51	5.13 / 7.14
Wireless Situation	μ=75kbps and p=0.75	
Simulation/Analytical Results (ms)	8.12 / 8.18	5.36 / 7.55
Wireless Situation	μ=85kbps and p=0.25	
Simulation/Analytical Results (ms)	106.00 / 108.59	61.60 / 78.23
Wireless Situation	μ=85kbpsl and p=0.75	
Simulation/Analytical Results (ms)	128.78 / 130.08	57.78 / 66.52

Accuracy Of the Analytical Model in the Real Testbed



Many thanks.

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