

# A Multi-Radio Unification Protocol for IEEE 802.11 Wireless Networks

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# Motivation

- Utilizing multiple orthogonal channels in a single radio might be cumbersome, typically requiring a sophisticated algorithms
- Multi-radios may not that be expensive
- Straightforward approach: one channel for each radio
  - Inefficient spectrum use
  - Easy to implement and deploy

# Challenge

- Use multiple channels (radios) at the same time?
- Use only a single channel (radio) at a time
- Multiple channels at a time requires
  - A sophisticated mutual agreement (distributed algorithm), tickling your intelligence?
  - Need to improve SSCH!
- Only a single channel at a time requires
  - A virtual network interface layer
  - Easy to implement?

# MUP

- Multi-radio Unification protocol

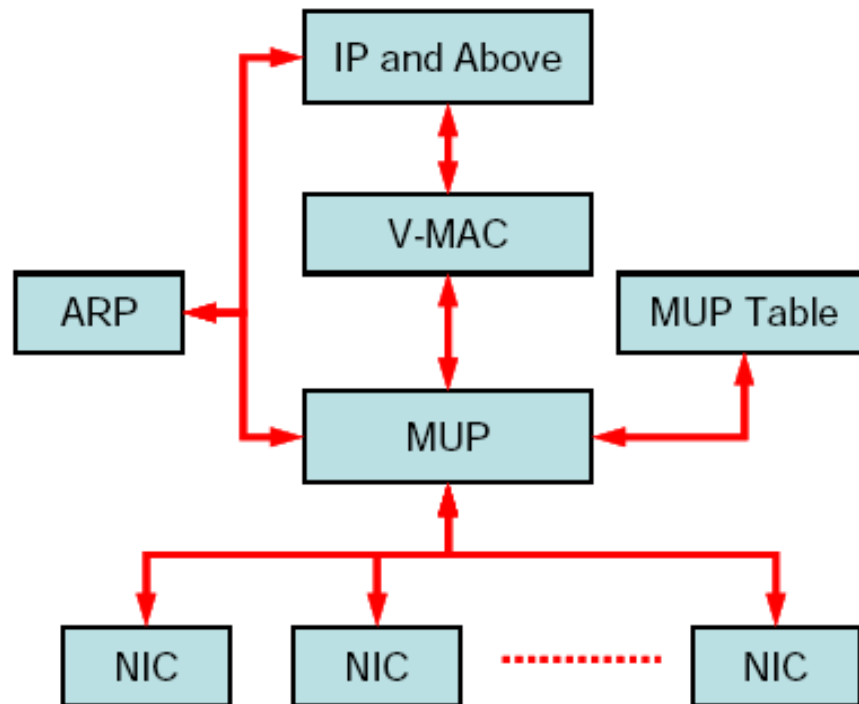


Figure 1: *MUP Architecture diagram*

# MUP Design

- Neighbor discovery and classification

Table 1: *Summary of an Entry in the MUP Neighbor Table*

<i>Field</i>	<i>Description (for each neighbor N)</i>
Neighbor	IP address of the neighbor host
Status	Indicates whether N is known to be MUP-capable
MAC list	MAC addresses associated with N
Quality list	Channel quality values for each MAC address of N
Channel	Current preferred channel to communicate with N
Selection time	Last time a channel selection decision was made
Packet time	Last time a packet was sent or received from N
Probe time list	List of times for unacknowledged probe messages

# MUP Design

- Steady-state MUP communication
  - Selecting the communication channel
    - 802.11e?
    - SRTT (Smoothed Round Trip Time)

$$SRTT = \alpha * RTT_{new} + (1 - \alpha) * SRTT$$

# MUP Design

- Switching channel
  - Period: 10 – 20 seconds
  - Threshold: 10% difference
- 
- Switching strategies
  - Random
  - Channel quality metrics
    - delay?

# Metric Justification

Table 3: *Spectrum and channels over which the IEEE 802.11 standards operate in the United States*

Standard	Frequency Range (GHz)	Orthogonal Channels	Channel Width (MHz)
IEEE 802.11a	5.15-5.35, 5.725-5.850	13	20
IEEE 802.11b,g	2.400-2.4835	3	22



# Metric Justification

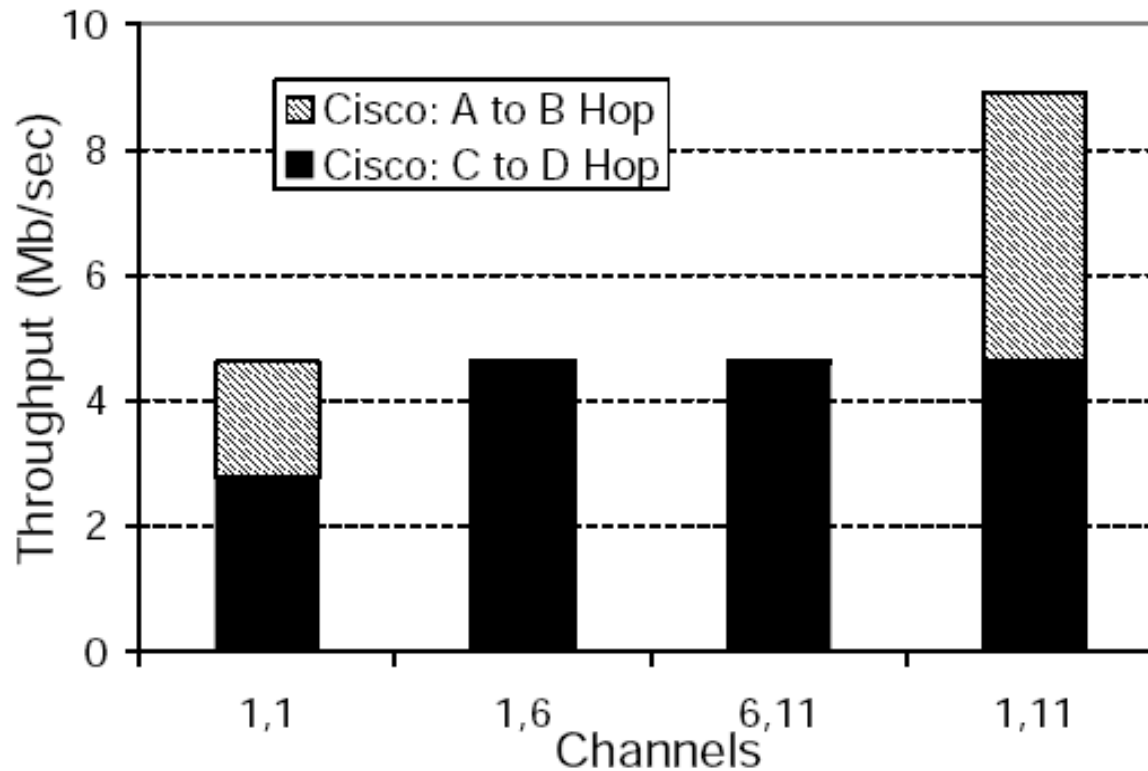


Figure 3: *Interference for 802.11b using Cisco adapters.*

# Metric Justification

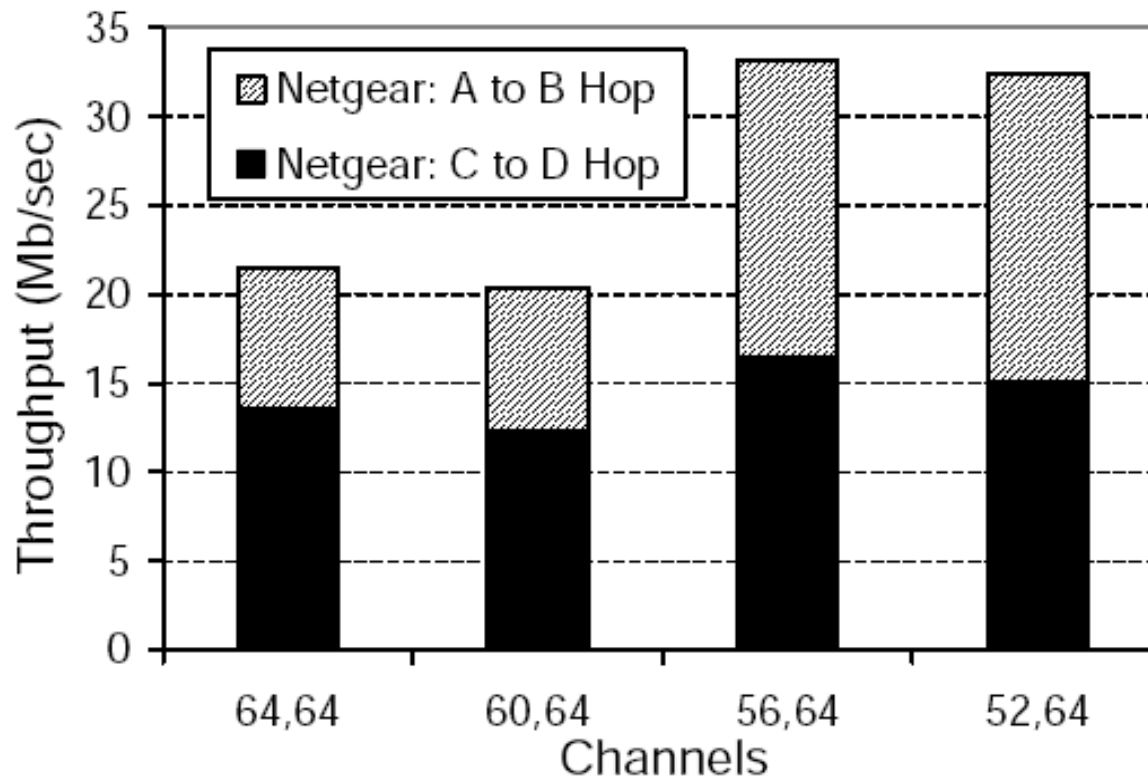


Figure 4: *Interference for 802.11a using Netgear adapters.*

# Simulation Setting

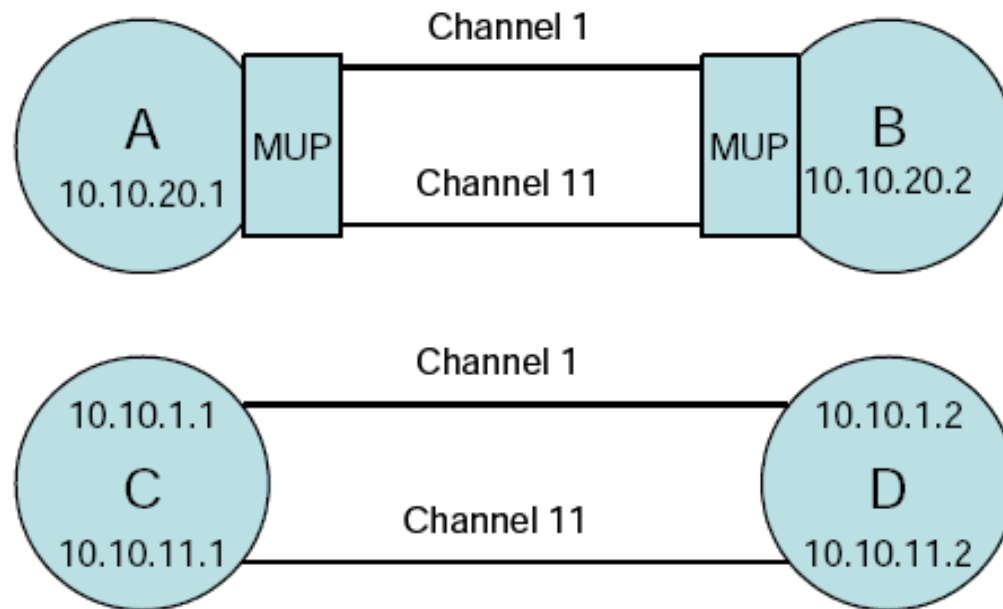


Figure 5: *Experimental setup to illustrate channel switching*

# Simulation Results

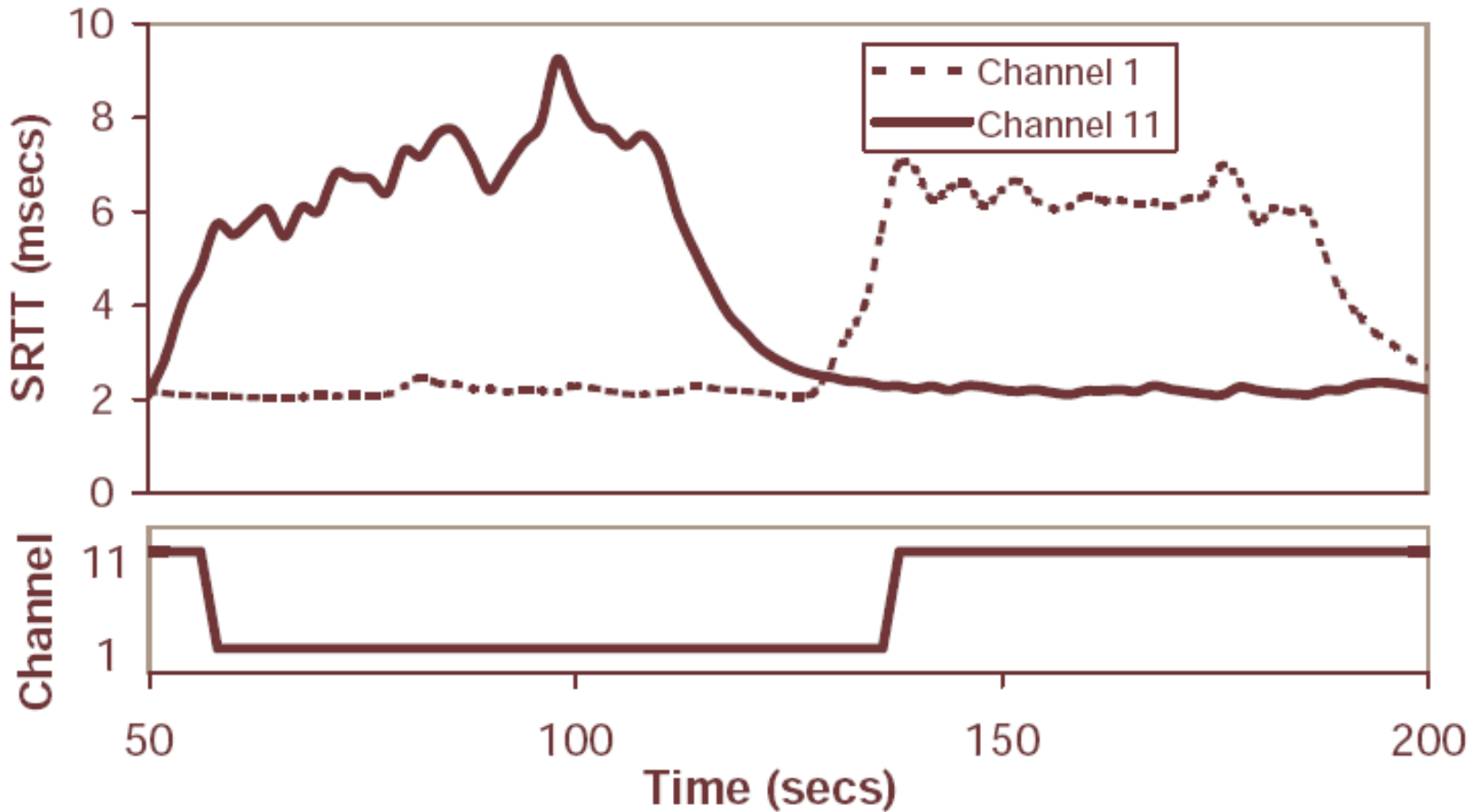


Figure 6: *Channel Switching*

# Simulation Results

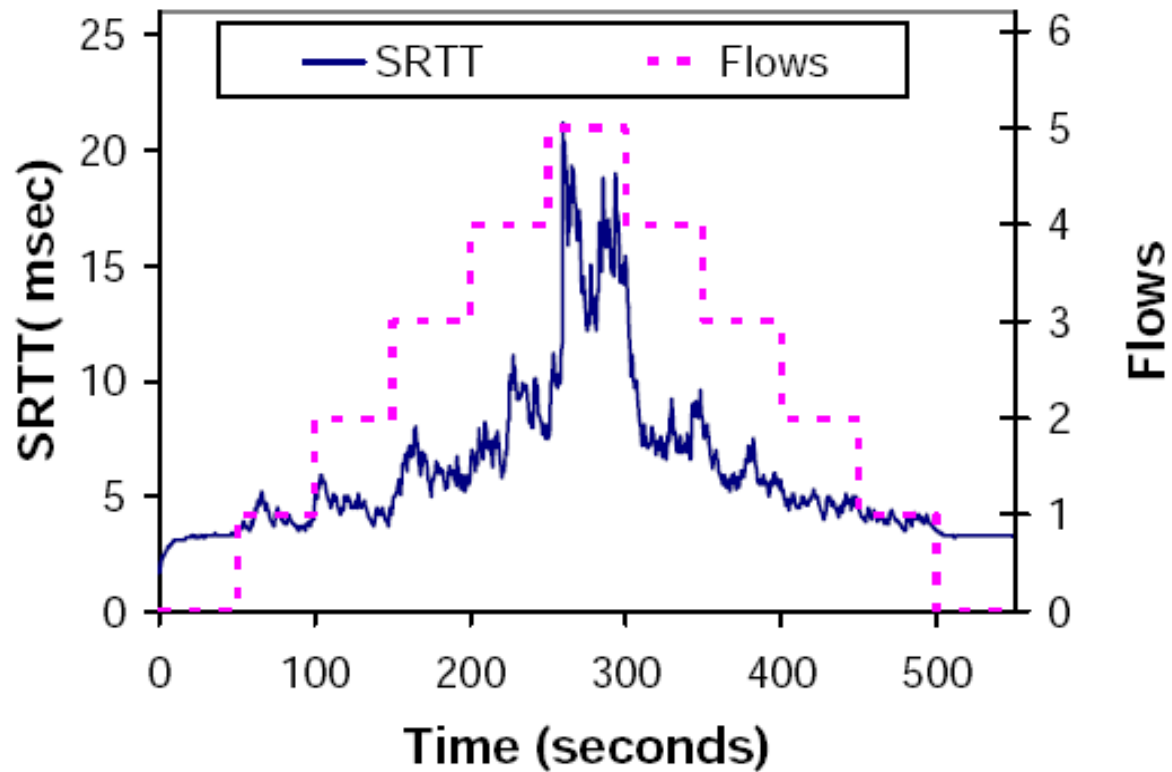


Figure 8: *CBR traffic*,  $\alpha = 0.1$

# Simulation Results

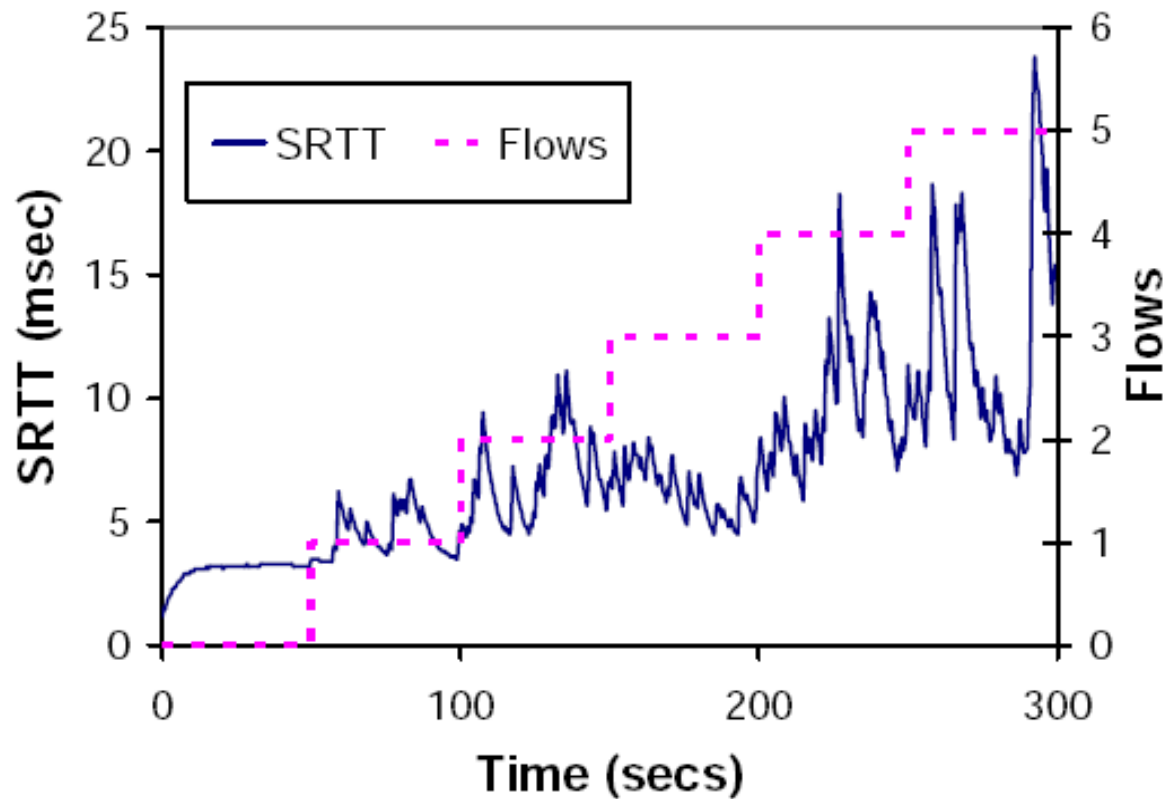
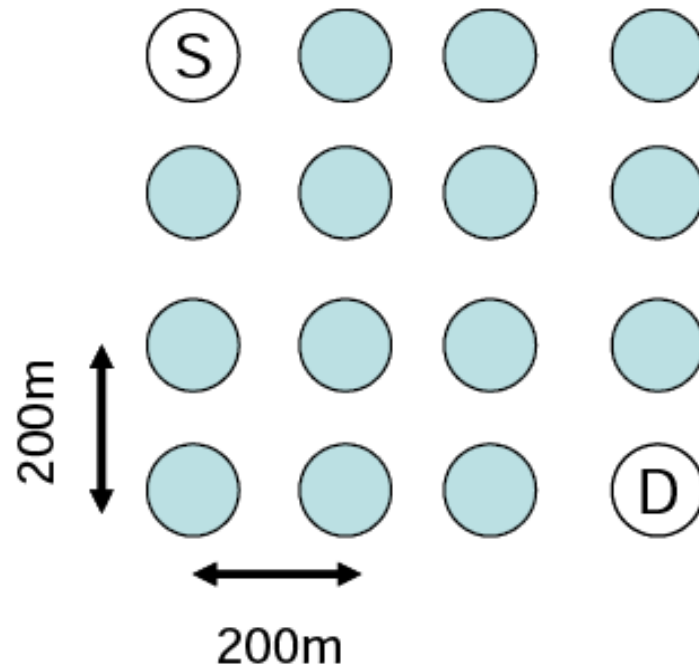


Figure 10: *Web traffic*,  $\alpha = 0.1$

# New Simulation Setting



# Simulation Results

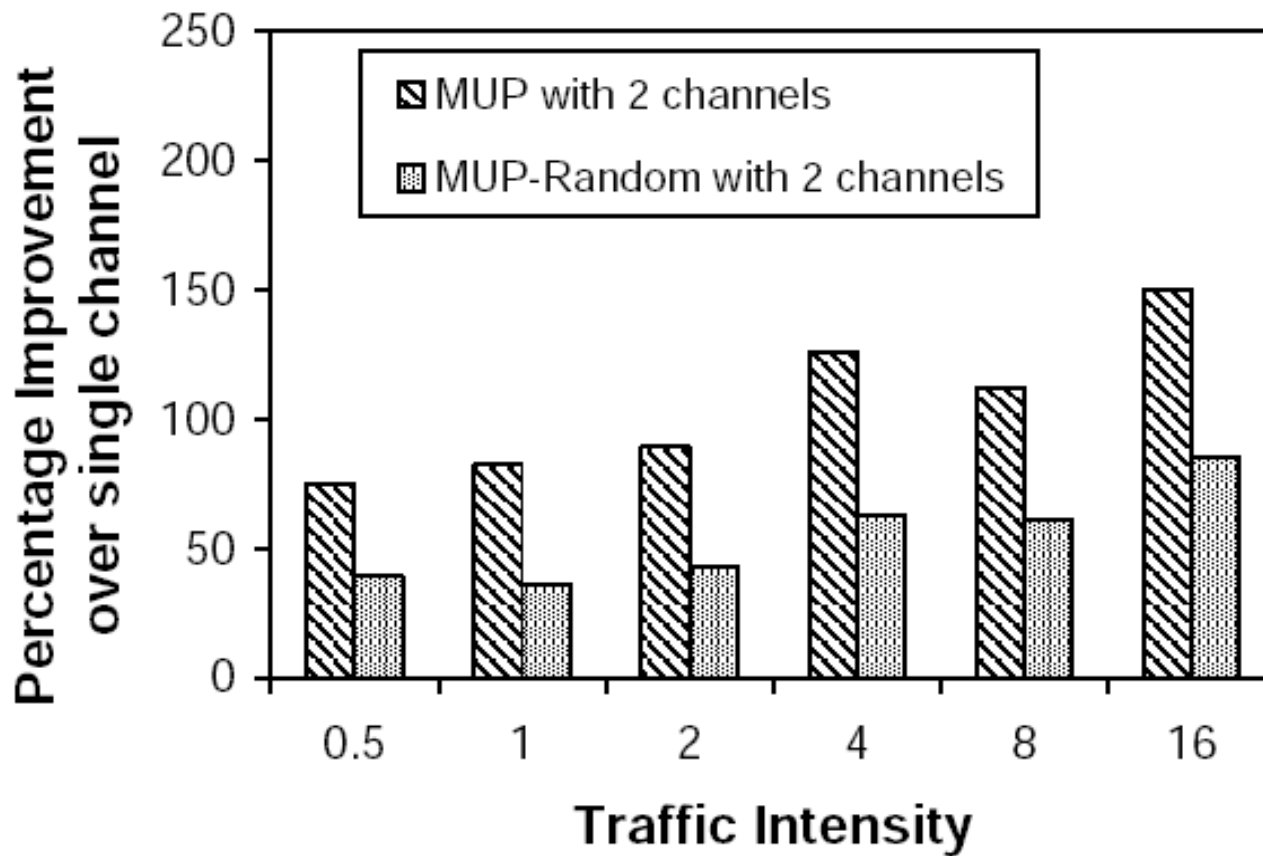


Figure 12: *Intelligent channel selection in presence of legacy nodes*



# Web Traffic

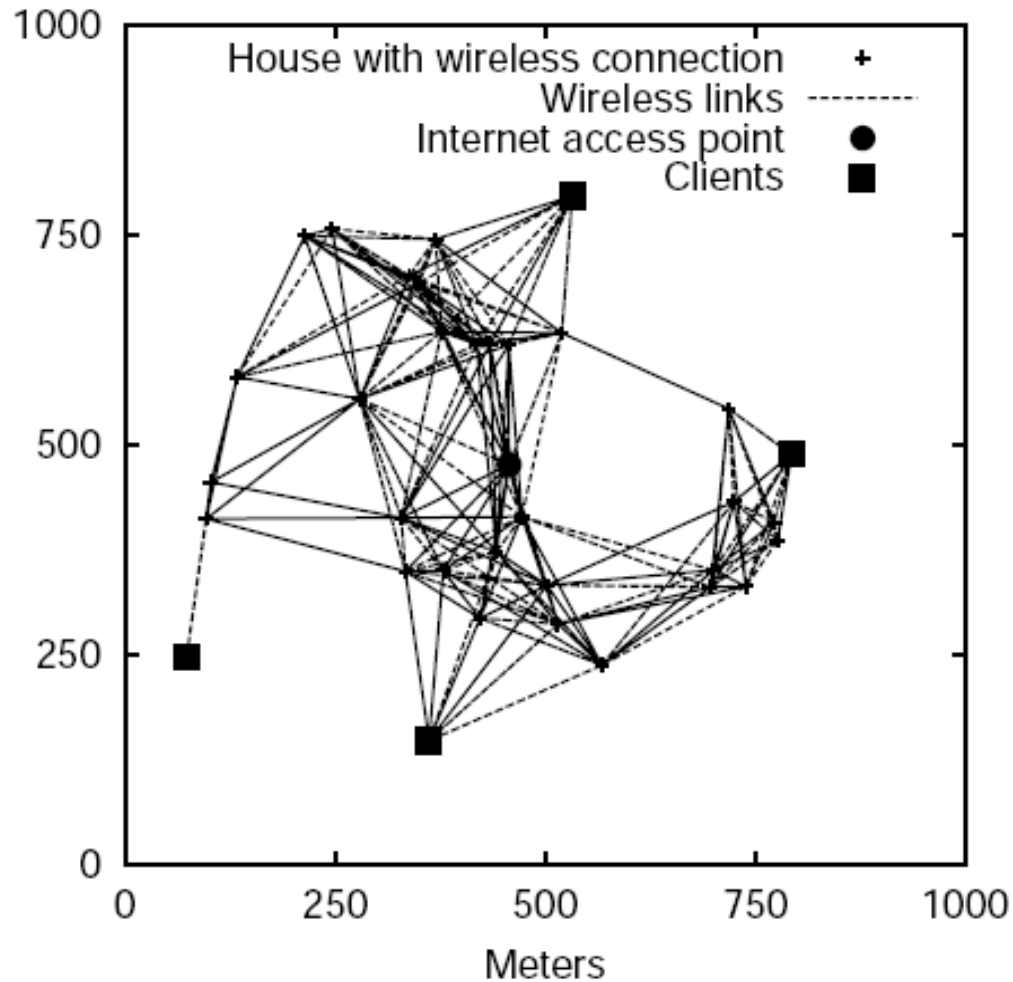


Figure 15: *Mesh network in the suburban neighborhood.*

# Simulation Results

Table 5: *Parameter settings for web traffic generation*

Parameter	Average	Distribution
Time between pages	2 sec.	Exponential
Objects per page	4	Constant
Object Size (KB)	8	Pareto (shape=1.2)

Table 6: *Average throughput*

Scenario	I	II	III
Average TCP throughput (Kbps)	106	136	180