



Architecture and Algorithms for an IEEE 802.11-Based Multi-channel Wireless Mesh Network

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Outline



- Introduction
- Problem Formulation
- Distributed Routing / Channel Assignment Algorithm
- Performance evaluation
- Conclusion

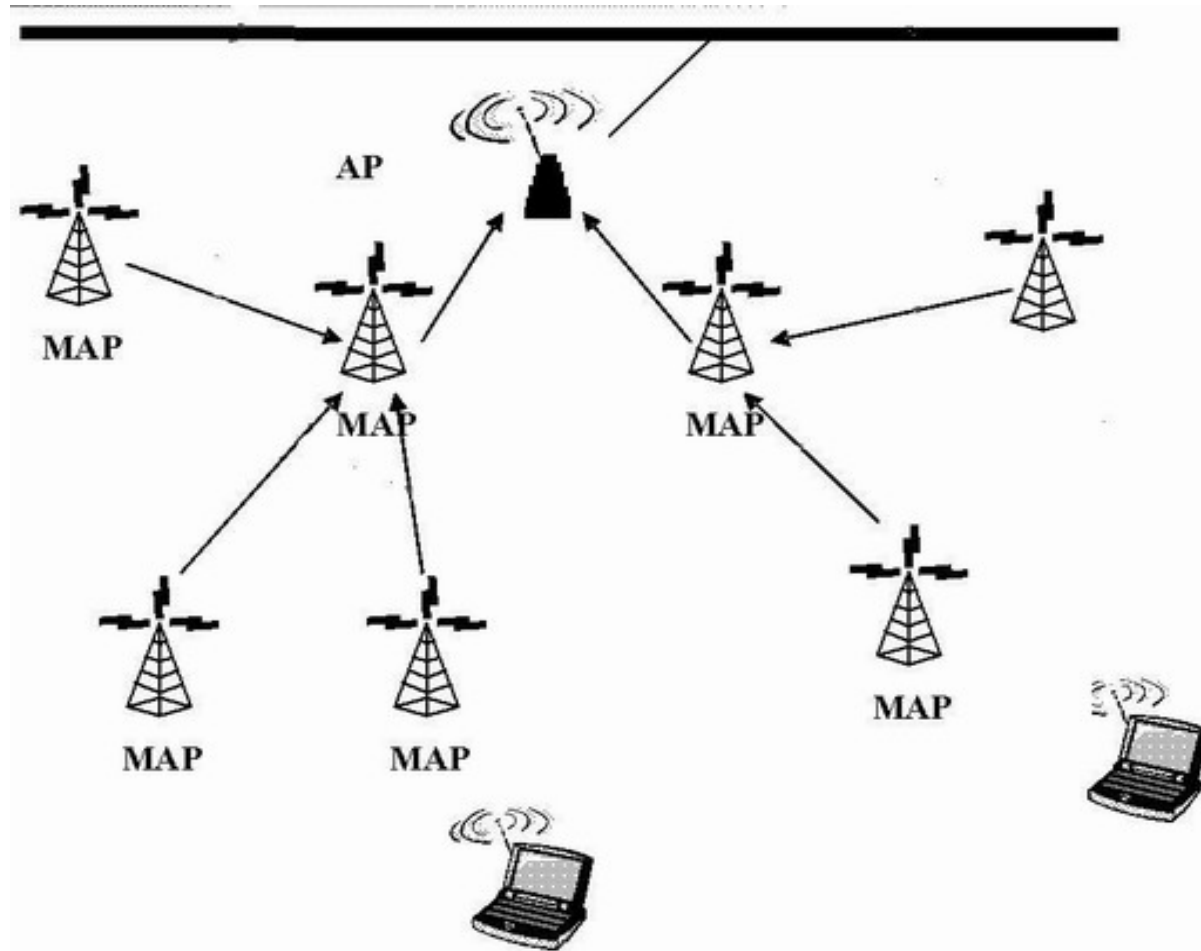
Introduction



- A (WMN) wireless mesh network is similar in concept to a mobile ad hoc network
- There are some differences between ad hoc network and WMN
 - Topology change are infrequent , and occur only due to node failure
 - The traffic characteristics , being aggregated from a large number of traffic flow , do not change very frequently
 - The traffic distribution in a WMN is typically skewed , most of the traffic is directed to/from a wired network

Introduction

- Mesh access point communicate with each other wirelessly
- Only some of MAP have wired connections to internet

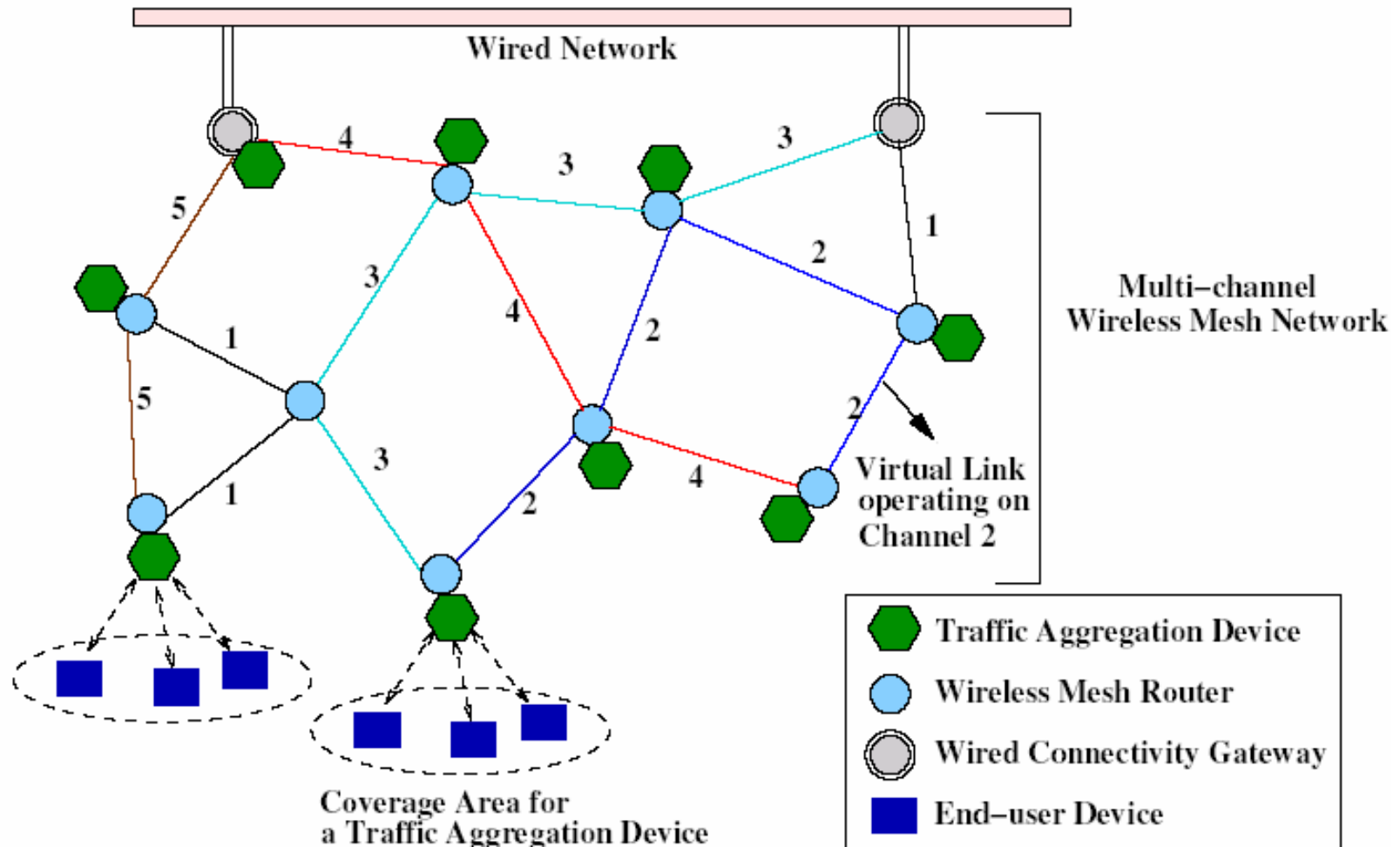


Introduction



- IEEE 802.11 standard provides 3 and 12 non-overlapped frequency channels
- Ability to utilize multiple channels substantially increases the effective bandwidth available to wireless networks
- We propose a set of distributed load-aware channel assignment and routing algorithms in multi-hop wireless access networks

Problem Formulation



Problem Formulation



- System Architecture

- A pair of nodes that use the same channel and within interference range may interfere with each other's communication
- The virtual links shown between the nodes depict direct communication between them

- Channel Assignment Problem

- Neighbor-to-interface binding
- Interface-to-channel binding

Problem Formulation

- Load Balancing Routing Problem

- Channel assignment depends on the load on each virtual link , which in turns depends on routing

- Evaluation Metric

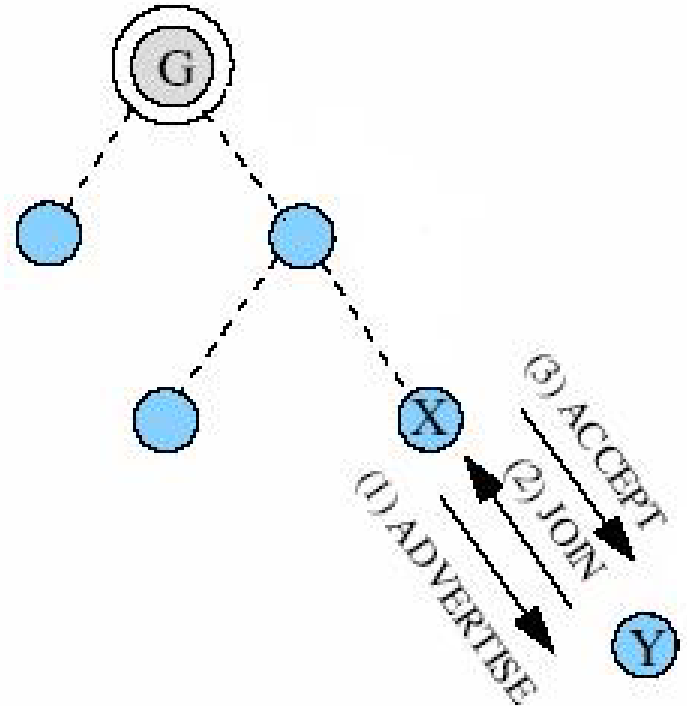
- The goal of the channel assignment and routing is to maximize to overall network throughput

$$X = \sum_a \min(\sum_i C(a, g_i), B(a))$$

Distributed Routing / Channel Assignment Algorithm

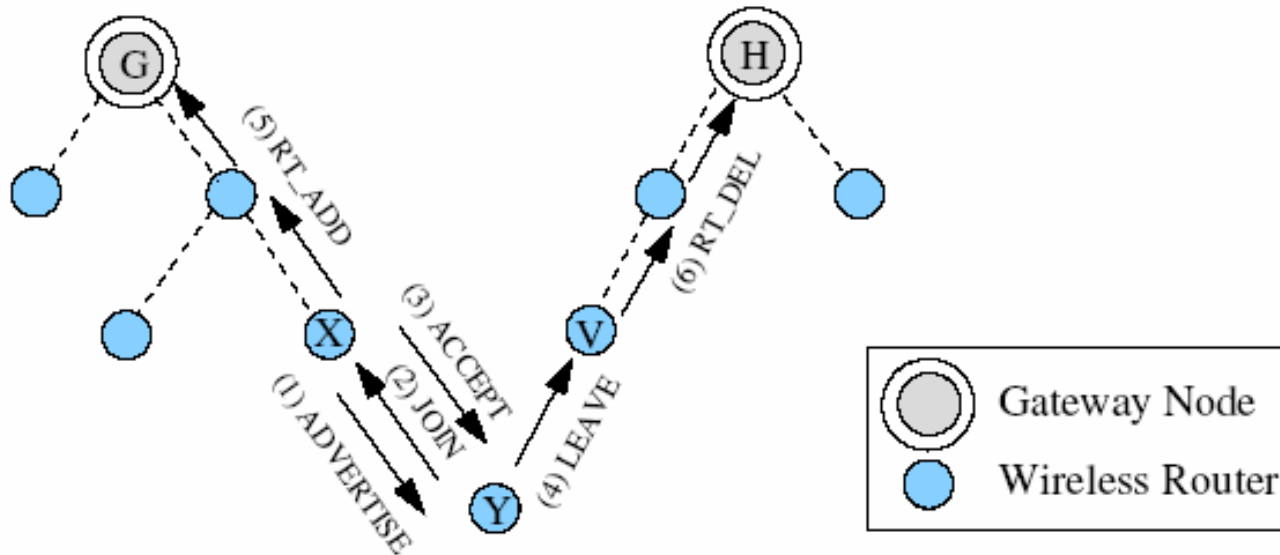
Load balancing routing

- Each WMN node needs to discover a path to reach one or multiple wired gateway node
- Each wired gateway node is the root of a spanning tree, and each WMN node attempt to participate in on spanning tree



Distributed Routing / Channel Assignment Algorithm

- Load balancing routing

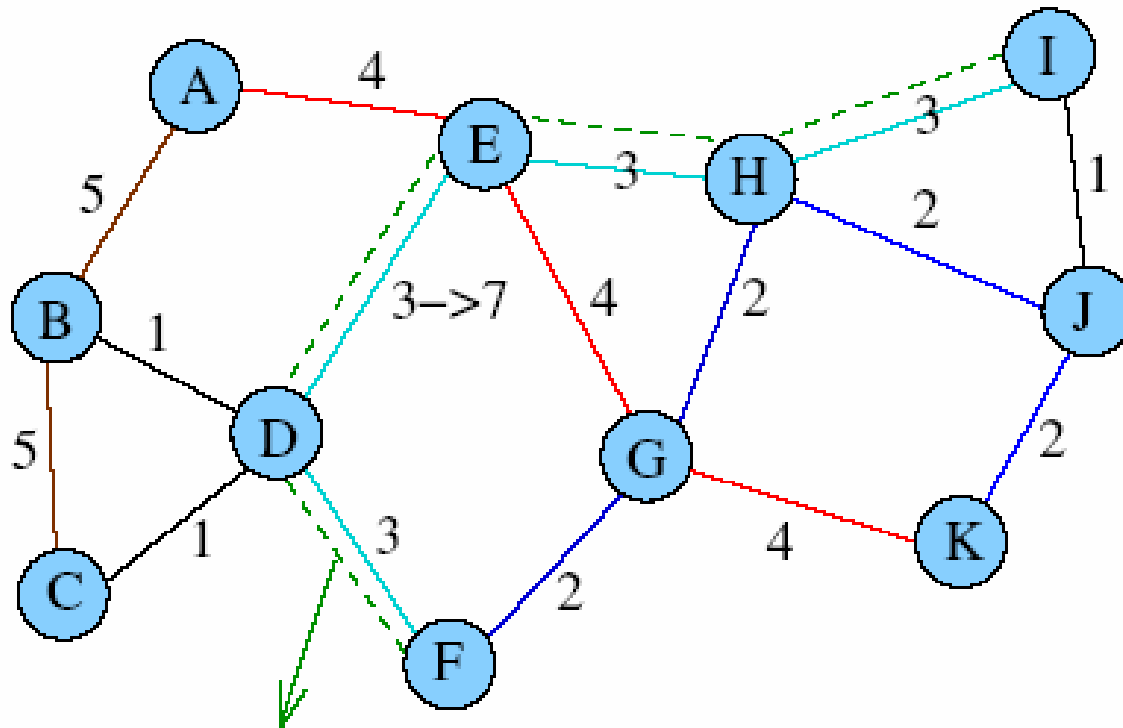


Distributed Routing / Channel Assignment Algorithm

- Routing Metric
 - Hop count
 - Gateway link capacity
 - Path capacity
- Route flap occur when multiple node discover and switch to underutilized path at the same time

Distributed Routing / Channel Assignment Algorithm

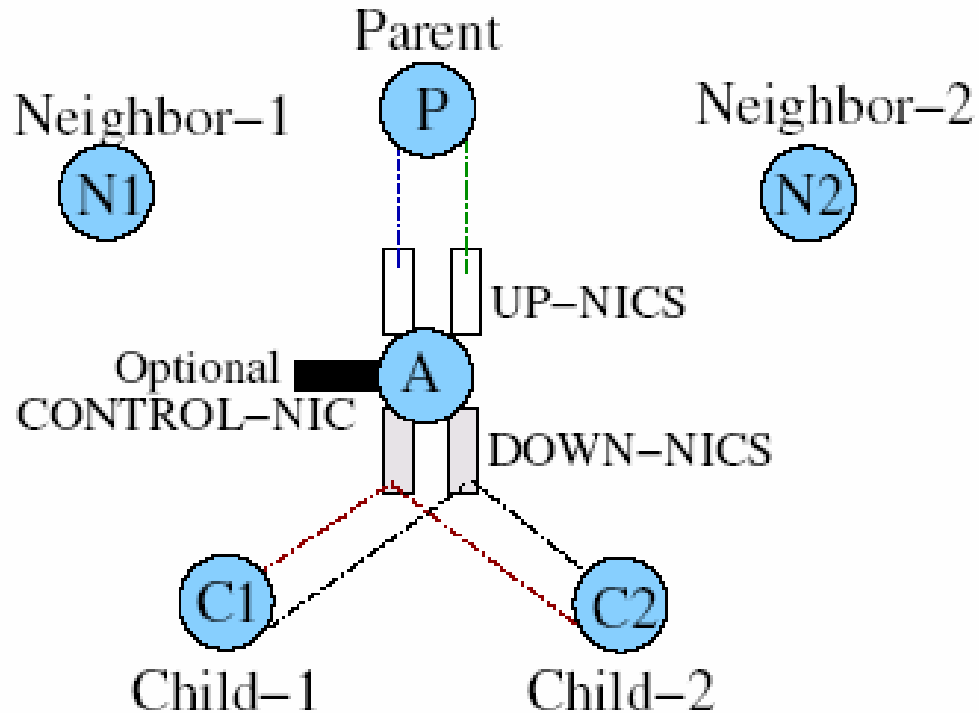
- Ripple effect



Channel dependency among nodes

Distributed Routing / Channel Assignment Algorithm

- Neighbor-interface binding



Distributed Routing / Channel Assignment Algorithm

- Interface-Channel Assignment

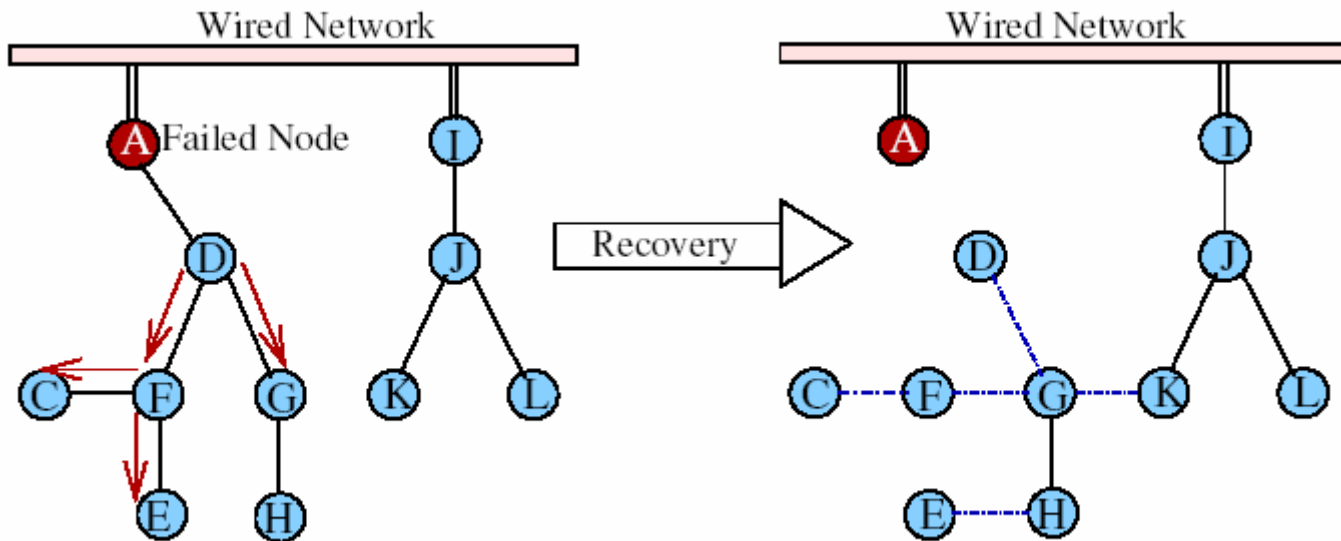
- The channel assignment of a WMN node's UP-NIC is the responsibility of its parent.
- To assign channels to a WMN node's DOWN-NIC depend on that are least-used in its vicinity
- Each node periodically exchange its individual channel usage information as a CHAL_USAGE packet with its $k+1$ hop neighbor

Distributed Routing / Channel Assignment Algorithm

- Virtual Control network
 - A WMN node need to communicate each control message to its k hop physical neighbor
 - A control message can be delivered through one or multiple hops
 - For efficiency reason, the broadcast control messages are delivered using IP multicast

Distributed Routing / Channel Assignment Algorithm

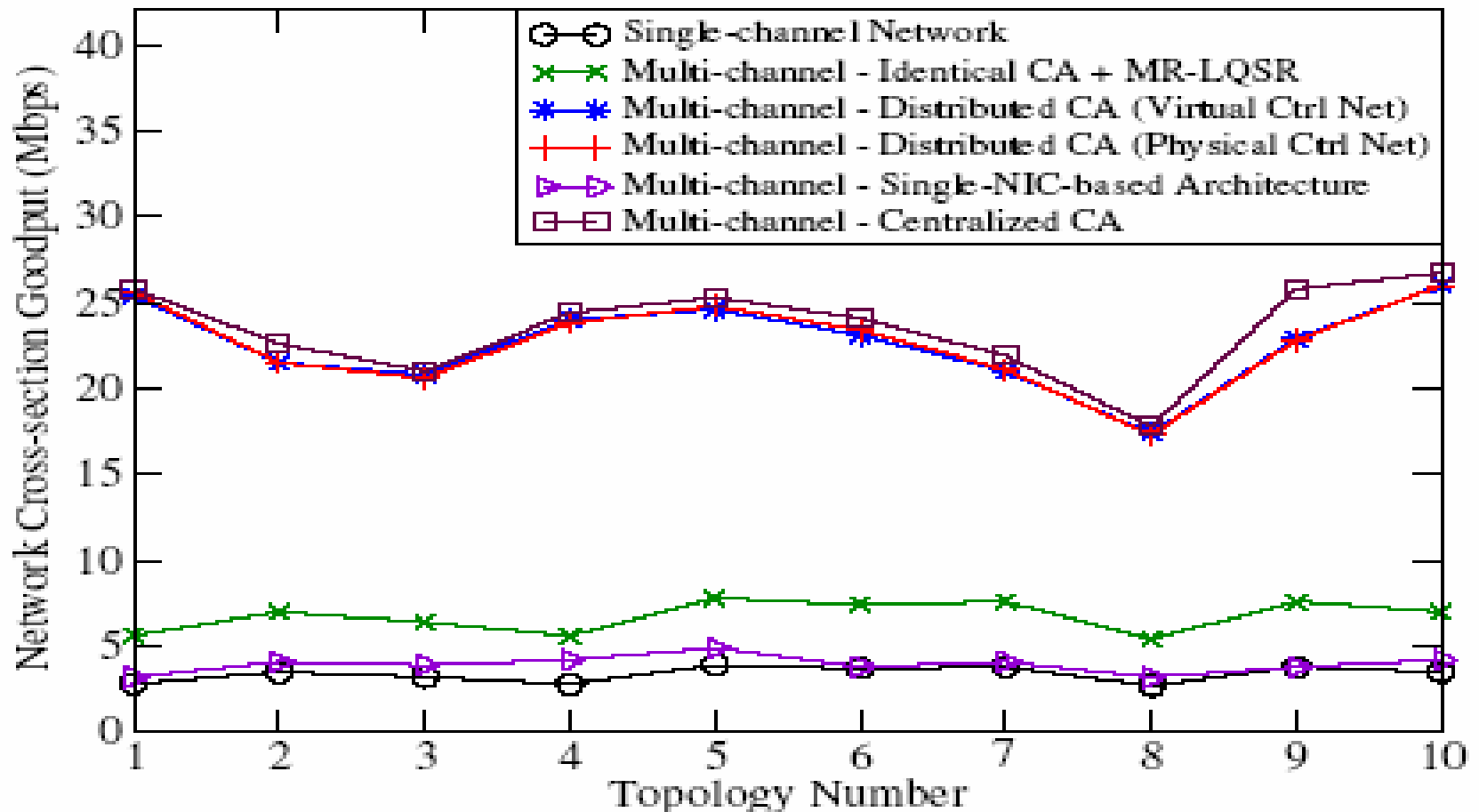
● Failure Recovery



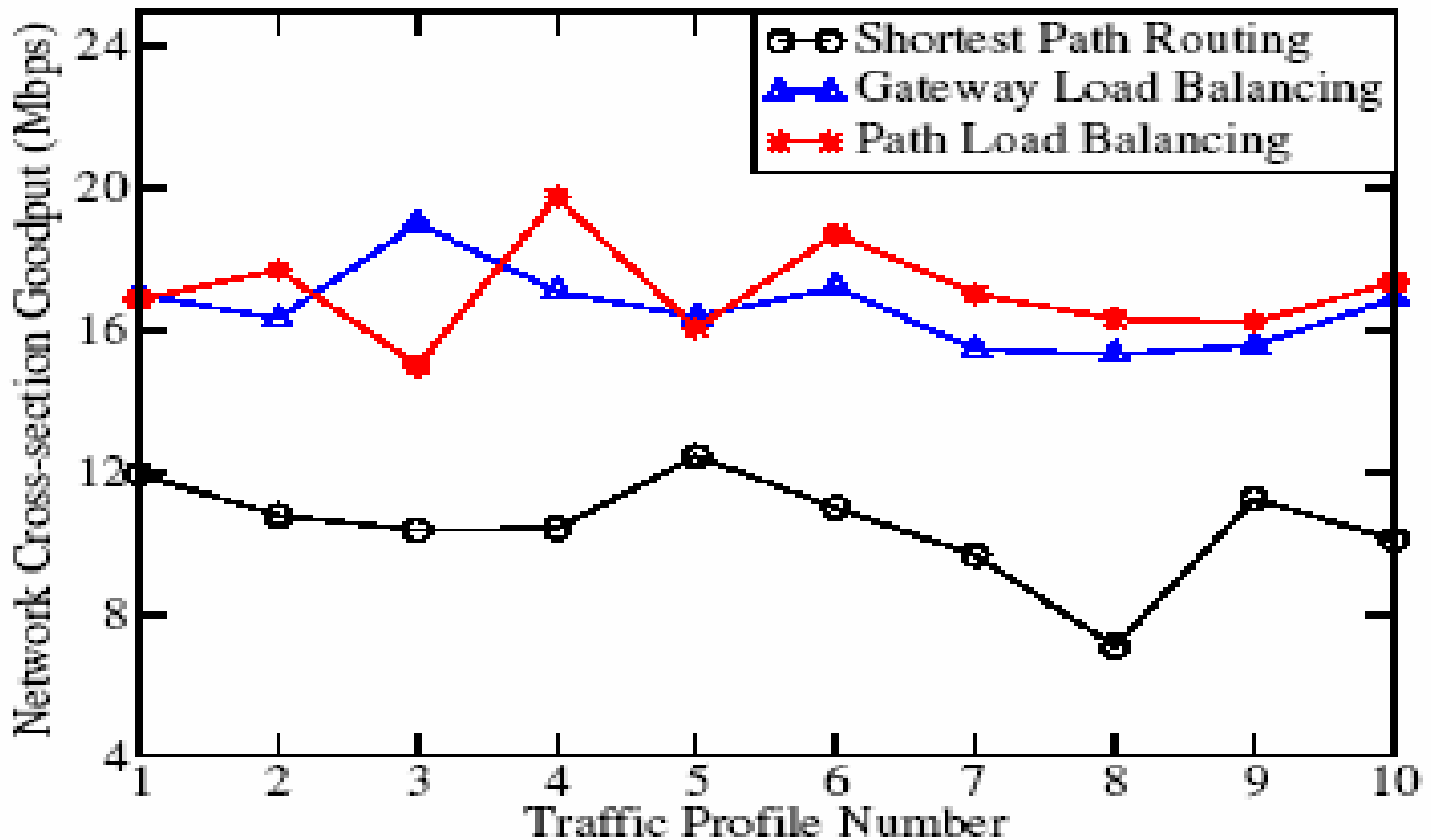
(a) Failure message after node A fails

(b) New connectivity after recovery

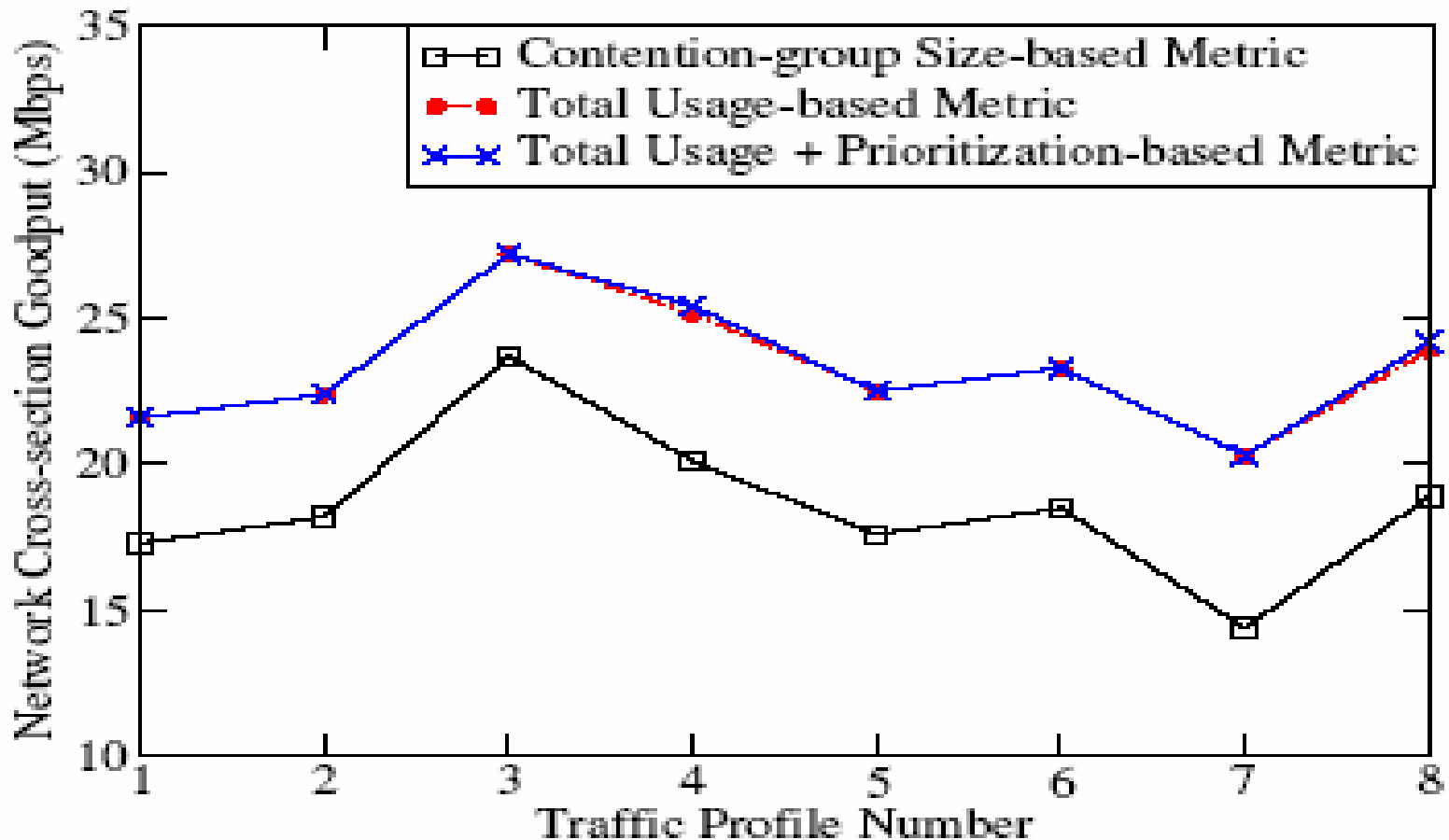
Performance evaluation



Performance evaluation



Performance evaluation



Conclusion



- A channel assignment needs to balance between maintaining network connectivity and increasing aggregate bandwidth
- The distributed channel assignment / routing algorithm we developed for the WMN can achieve a factor of 6 to 7 throughput improvement compared to single channel WMN

Reference



- [1] Centralized Channel Assignment and routing algorithms for multi-channel wireless mesh networks , Ashish Raniwala , Tzi-cker Chiueh , Mobile computer and communication Review , Volume 8