Routing Protocol in Multichannel Wireless Networks

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2005/5/5

Outline

- Introduction
- Existing routing protocols in multi-channel networks
  - Single-transceiver environment
  - Multi-transceivers environment
- Summary

Introduction

- The main research topic on Multi-channel networks:
  - Multi-channel MAC Design
  - Channel Assignment
  - Routing Protocol

Introduction

- Existing routing protocols such as AODV , DSR do not proper multiple channel networks
  - These protocols select a shortest-path route, which may not be suitable for multi-channel networks
  - These protocols cannot exploit all available channels

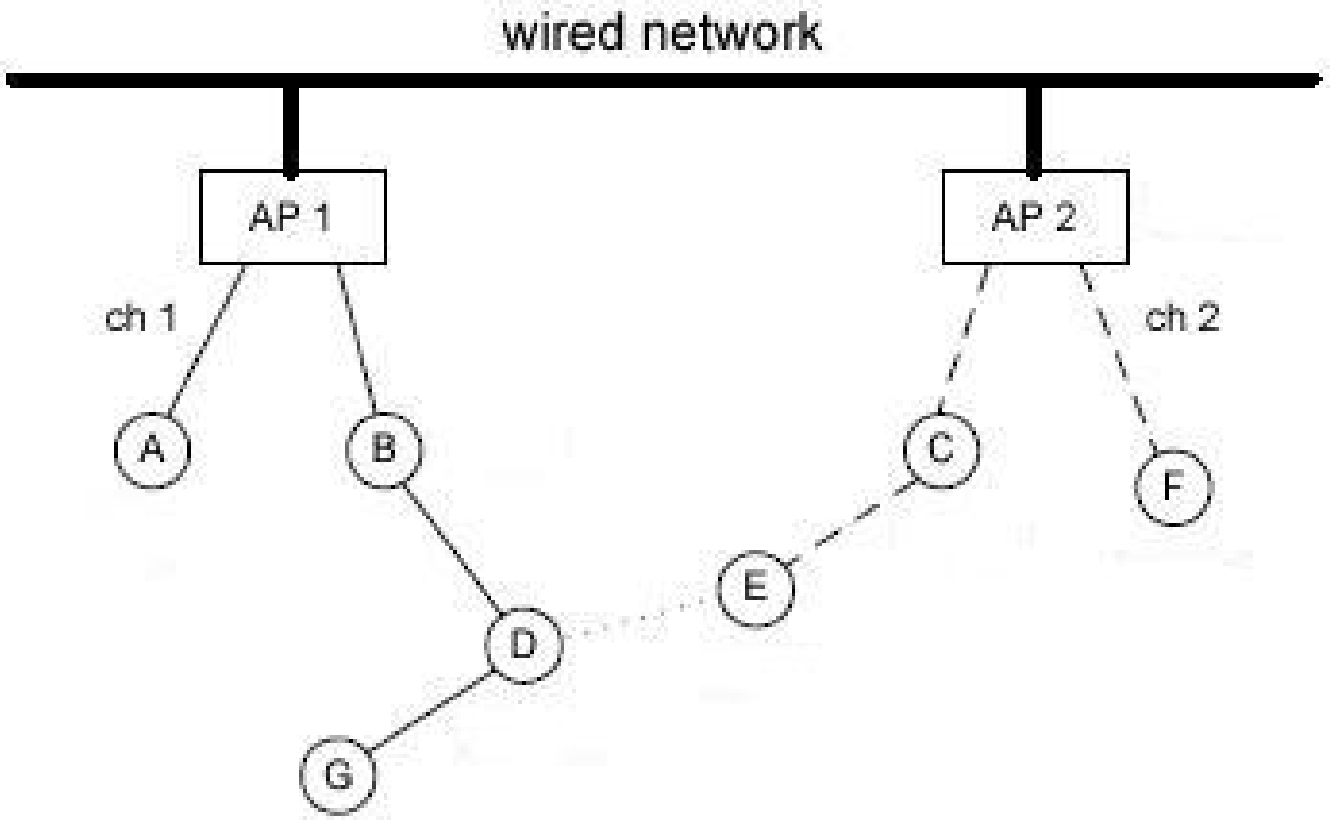
Introduction

- A node may have multiple routes to the destination in multi-channel networks
- How to choose a proper path?
  - Bandwidth
  - Channel diversity
  - Transmission time
  - Hops

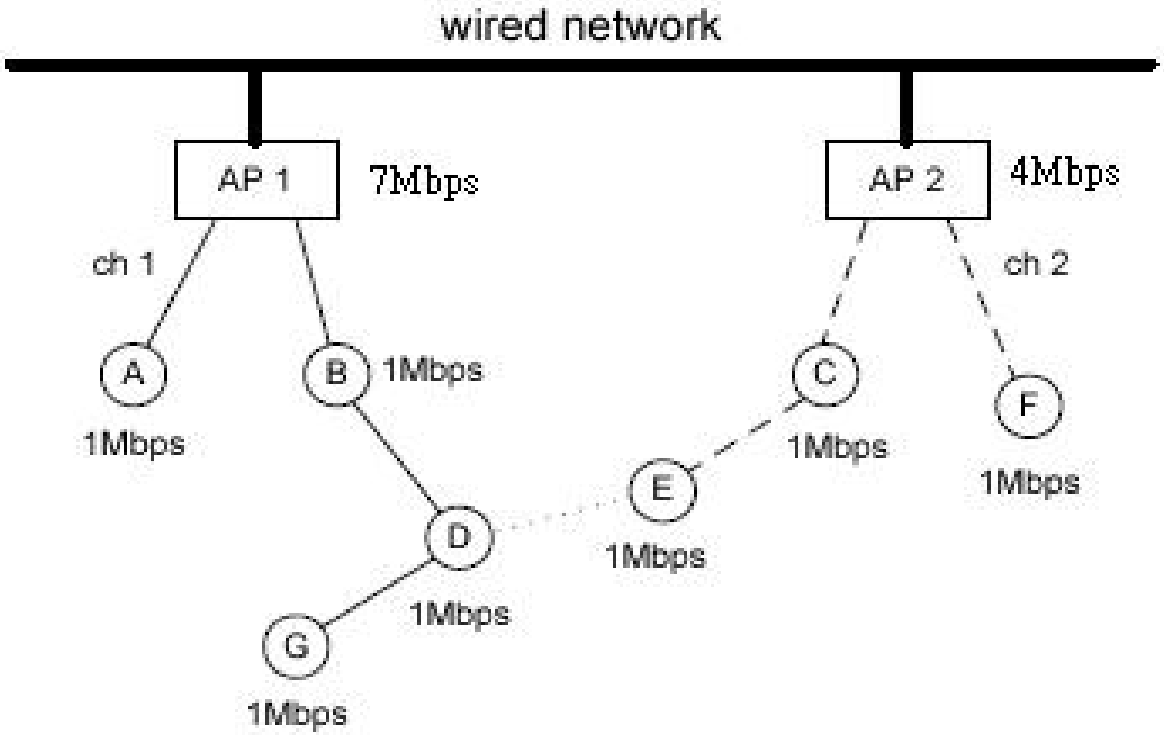
Routing Protocols

- Single Transceiver
  - Multi-channel Protocol with Load Balancing[1]
- Multiple Transceivers
  - Architecture and Algorithm for multi-channel networks[2]
  - MR-LQSR Protocol[3]
  - Multi-channel Routing [MCR] Protocol[4]

Routing Protocol - Single transceiver(1/3)



Routing Protocol - Single transceiver(2/3)

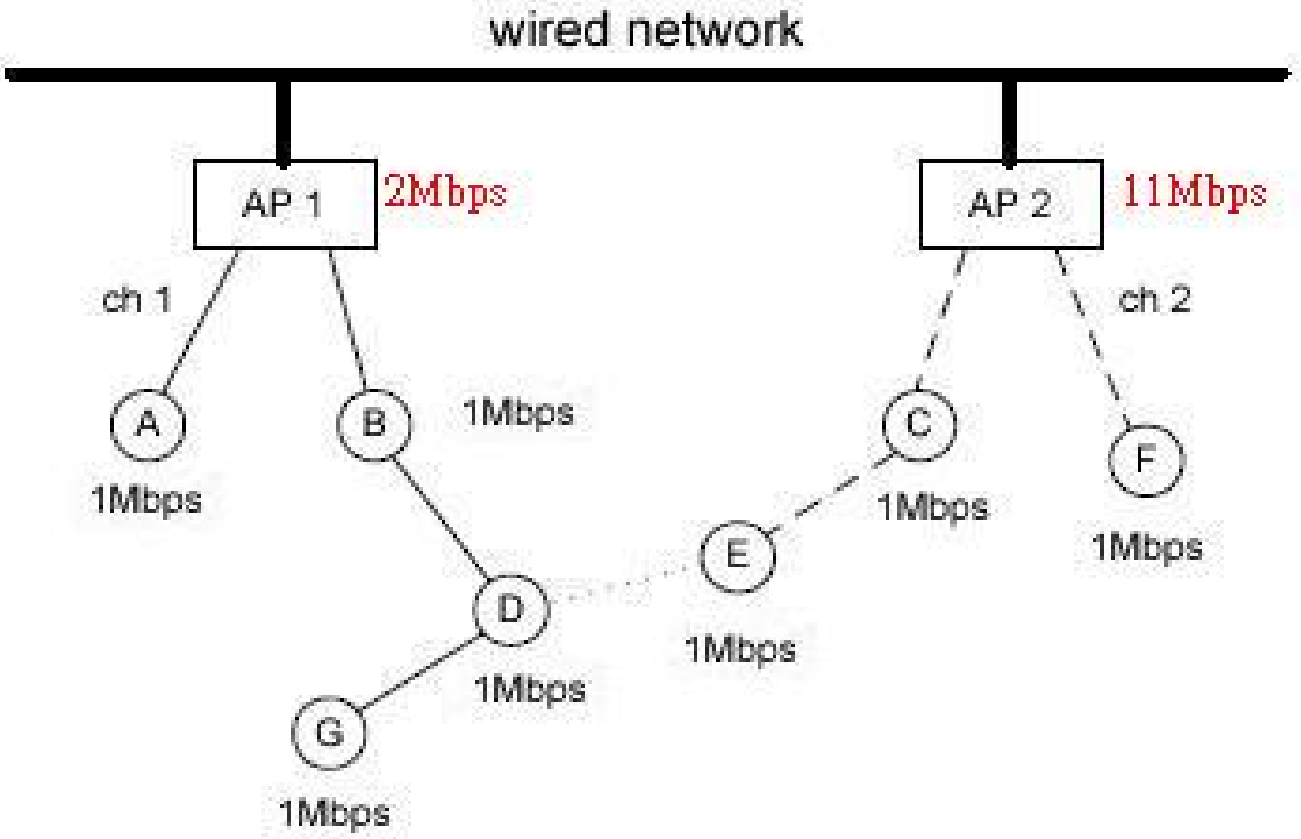


$$L_1 = \sum_i (h_i \times l_i)$$

- hi = hop count
- li= load of node

- AP1 = 1x1 + 1x1 + 1x2 +1x3 =7
- AP2 = 1x1 + 1x1 + 1x2 =4

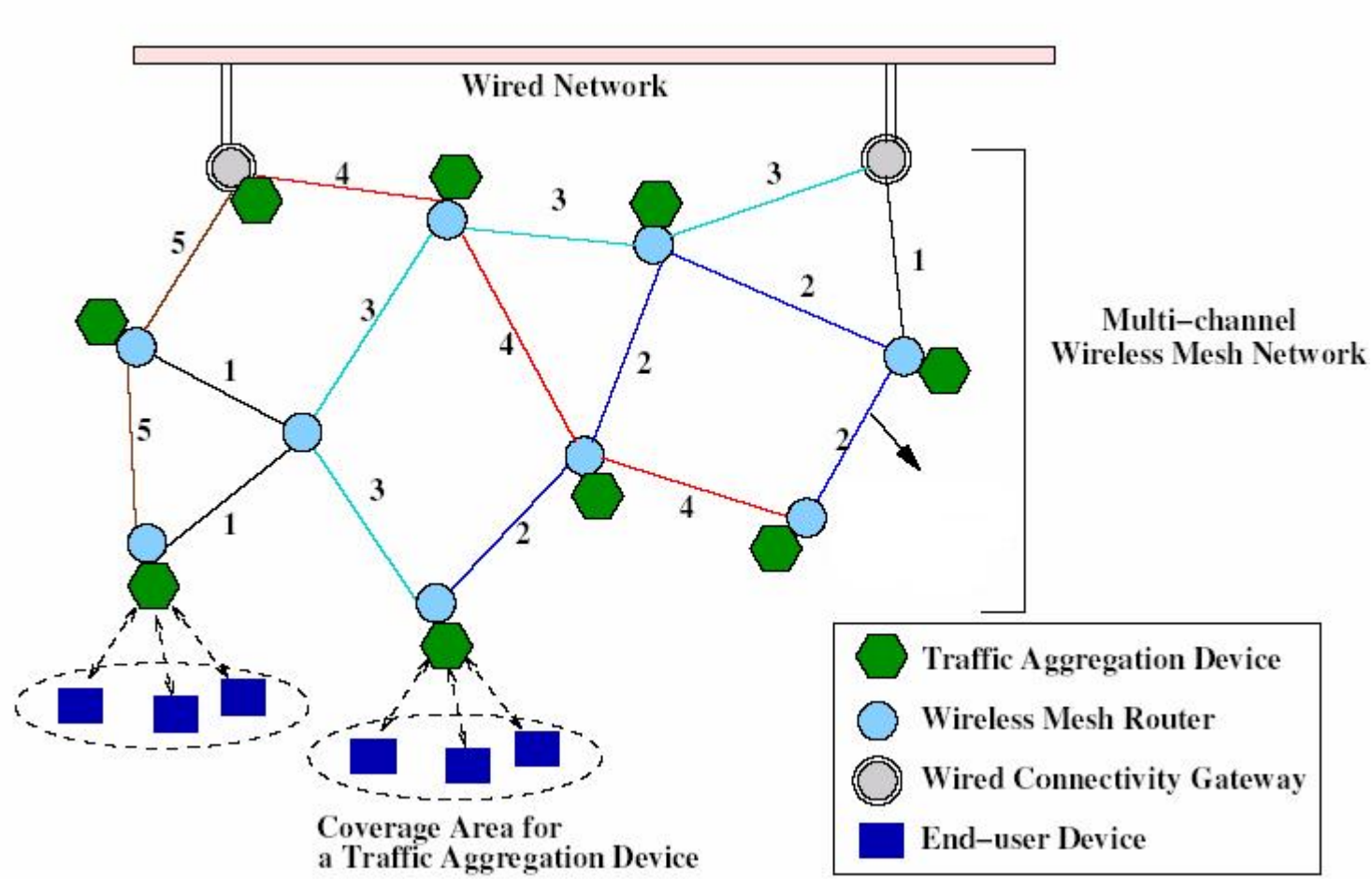
Routing Protocol - Single transceiver(3/3)



- AP1 = 1x1 +1x1 =2
- AP2 = 1x1 +1x1 + 1x2 +1x3 +1x4 =11

Routing Protocol - Multi transceiver(1/7)

- Architecture and Algorithm for multi-channel networks[2]



Routing Protocol - Multi transceiver(2/7)

- Load Balancing Routing Problem
  - Each node needs to discover a path to reach one or multiple gateway (AP)
- Evaluation Metric
  - How to estimated overall throughput?

$$X = \sum_{a} min(\sum_{i} C(a, g_i), B(a))$$

  - C(a,gi) : available bandwidth between source node and gateway node
  - B(a): requirement bandwidth between source node and gateway node

Routing Protocol - Multi transceiver(3/7)

MR-LQSR Protocol[3]

- Our path metric is called Weighted Cumulative ETT(WCETT)
  - For a path consisting of n hops

$$\mathrm{WCETT} = \sum_{i=1}^{n} \mathrm{ETT}_i$$

  - ETT (Expected Transmission Time)
- Xj is the sum of transmission times of hops on channel j

$$X_j = \sum_{\text{Hop i is on channel j}} \mathrm{ETT}_i \quad 1 \le j \le k$$

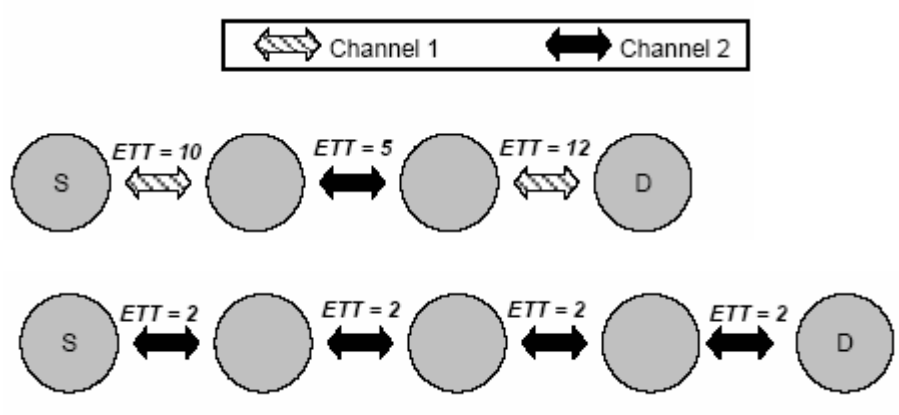
Routing Protocol - Multi transceiver(4/7)

$$\mathrm{WCETT} = (1-\beta) * \sum_{i=1}^{n} \mathrm{ETT}_i + \beta * \max_{1 \le j \le k} X_j$$

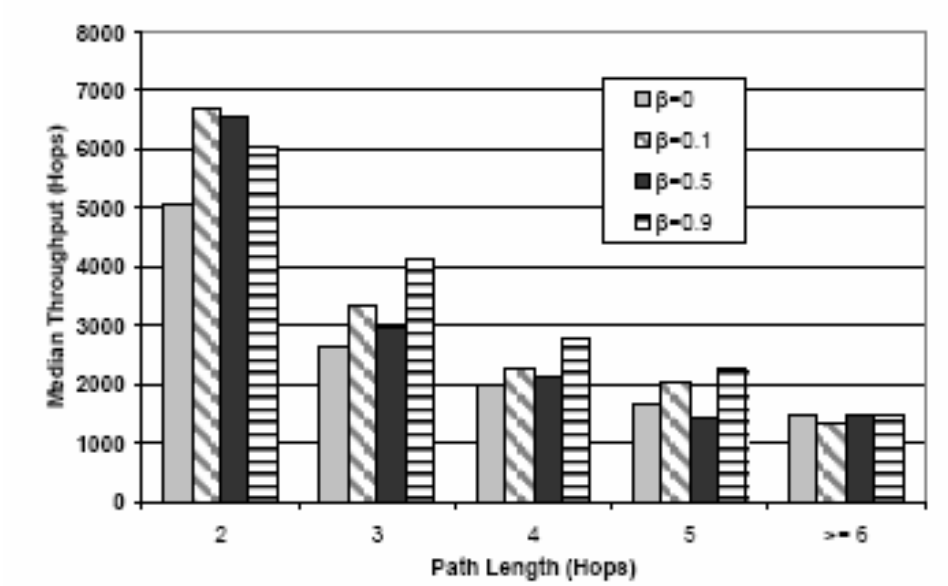
- The first term is the sum of transmission times along all hops in the network. This reflects the total resource consumption along this path
- The second term reflects the set of hops that will have the most impact on the throughput of this path.
- β can be seen as offering a tradeoff between maximizing the throughput of a single flow and the consuming fewer global resource

Routing Protocol - Multi transceiver(5/7)

- Example



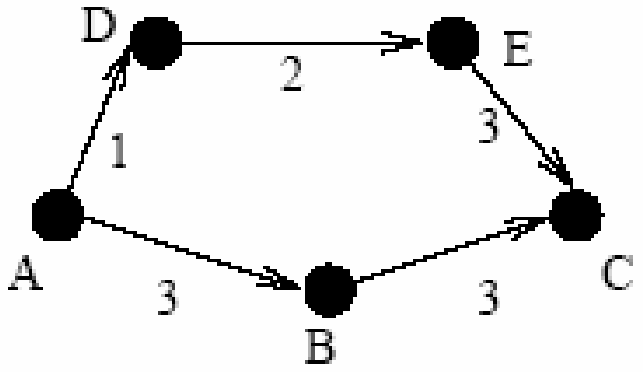
- Simulation



Routing Protocol - Multi transceiver(6/7)

Multi-channel Routing [MCR] Protocol[4]

- Channel diversity
  - Assume that each link can support a maximum data rate ω
  - When link A-B and B-C can not be active simultaneously, the maximum end-to-end throughput is $\omega/2$



Routing Protocol - Multi transceiver(7/7)

- Allowing all links to be active simultaneously, resulting in a maximum end to end throughput of ω
- Maximum diversity cost (DC) of any link along the route

$$DC = \sum_{i=0}^{n-1} \sum_{j=i+1}^{max(i + InterferenceLength,\ n)} I(C(i) == C(j))$$

  - C(i) : the channel be used by link I , suppose there are n links in a path

Summary

- Policies for estimating path metric:
  - Bandwidth[2]
  - Channel diversity[3][4]
  - Transmission time[3]
  - Power

Reference

- [1] Jungmin So, Nitin H. Vaidya, “Routing and Channel Assignment in Multi-channel Multi-hop Wireless Networks with Single Network Interface”, Technical report, April 2005
- [2] Ashish Raniwala, Tzi-cker Chiueh, “Architecture and Algorithms for an IEEE 802.11-Based Multi-channel Wireless Mesh Network”, INFOCOM 2005
- [3] Richard Draves , Jitendra Padhye, Brian Zill, “Routing in Multi-Radio, Multi-hop Wireless Mesh Networks”, MobiCom 2004
- [4] Pradeep Kyasanur, Nitin H. Vaidya, “Routing in Multi-channel Multi-interface Ad hoc wireless Networks”, WCNC 2005
- [5] Ashish Raniwala, Kartik Gopalan, Tzi-Cker Chiueh, “Centralized Channel Assignment and Routing Algorithms for Multi-channel Wireless Mesh networks”, ACM Mobile Computing and Communications Review(MC2R), April 2004