Power Control MAC Protocol Analysis and Improvement for Ad Hoc Networks

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Introduction and Related Work

- The Problem

A wireless node in an ad-hoc network has limited battery power.

Solutions

- A power control scheme

At the MAC layer, varies the power at which the control and the data packets are sent

Related Works

- IEEE 802.11

Each packet is sent with the same maximum transmission power

- BASIC scheme

A Control packet (RTS/CTS) is sent with maximum transmission power.

A Data packet is sent with minimum necessary transmission power.

- PCM

The RTS/CTS handshake is sent with maximum transmission power.

A DATA packet is sent with periodically maximum transmission power

Background

- **Transmission Range** (A_{tx})

No collisions

- **Carrier Sensing Range** (A_{cs})

Nodes set their NAV to EIFS.

- **Interference Range** (A_i)

Collisions occur.

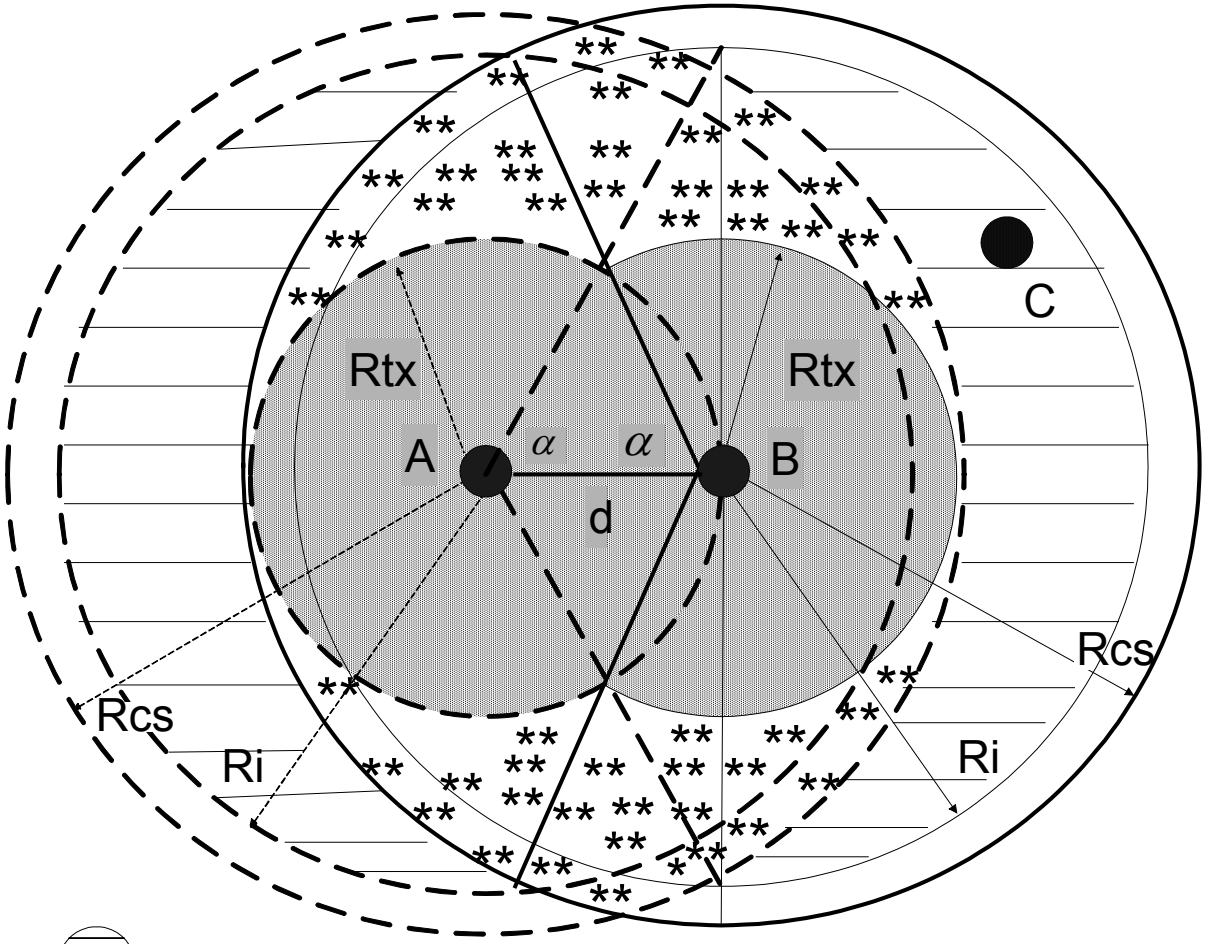
Power Level and Interference Range

- $\mathbf{R_{cx}} = 2\mathbf{R_{tx}}$

- $\mathbf{R_i} = 1.78n^{1/4}d \qquad R_{tx} \geq d \geq 0.56R_{tx}n^{-1/4}$

$P_i = nP_t$ d is the distance from the sender to the receiver.

Effectiveness of RTS/CTS Handshake



ACT interference ranges of nodes A or B

Interference ranges covered by carrier sensing ranges of nodes A or B

Interference ranges covered by transmissions ranges of nodes A or B

$$E_{RTS/CTS} = \frac{Effective \quad Area}{Total \quad Interference \quad Area}$$

$$E_{RTS/CTS} = \begin{cases} 1 & if \quad 0 \le d \le 0.56R_{tx} \\ \left(\frac{1}{2} - \frac{\alpha}{\pi}\right) + \frac{R_{tx}^2}{R_i^2}\left(\frac{1}{2} + \frac{4\alpha}{\pi}\right) & if \quad 0.56R_{tx} \le d \le R_{tx} \end{cases}$$

Conclusion

- The larger transmission power will not help to reduce the interference range (hidden nodes).

- The larger transmission power will reduce throughput.

Analysis of Power Control MAC Protocols

- IEEE 802.11 and PCM

The same number of hidden and deferring nodes.

- BASIC

Two times hidden nodes as 802.11 and PCM have and the same number of deferring nodes.

Efficient Low Power Control MAC Protocol

- Find the minimum necessary transmission power
- Each packet is sent with same minimum transmission power

goals

- Reducing energy consumption
- Improving throughput

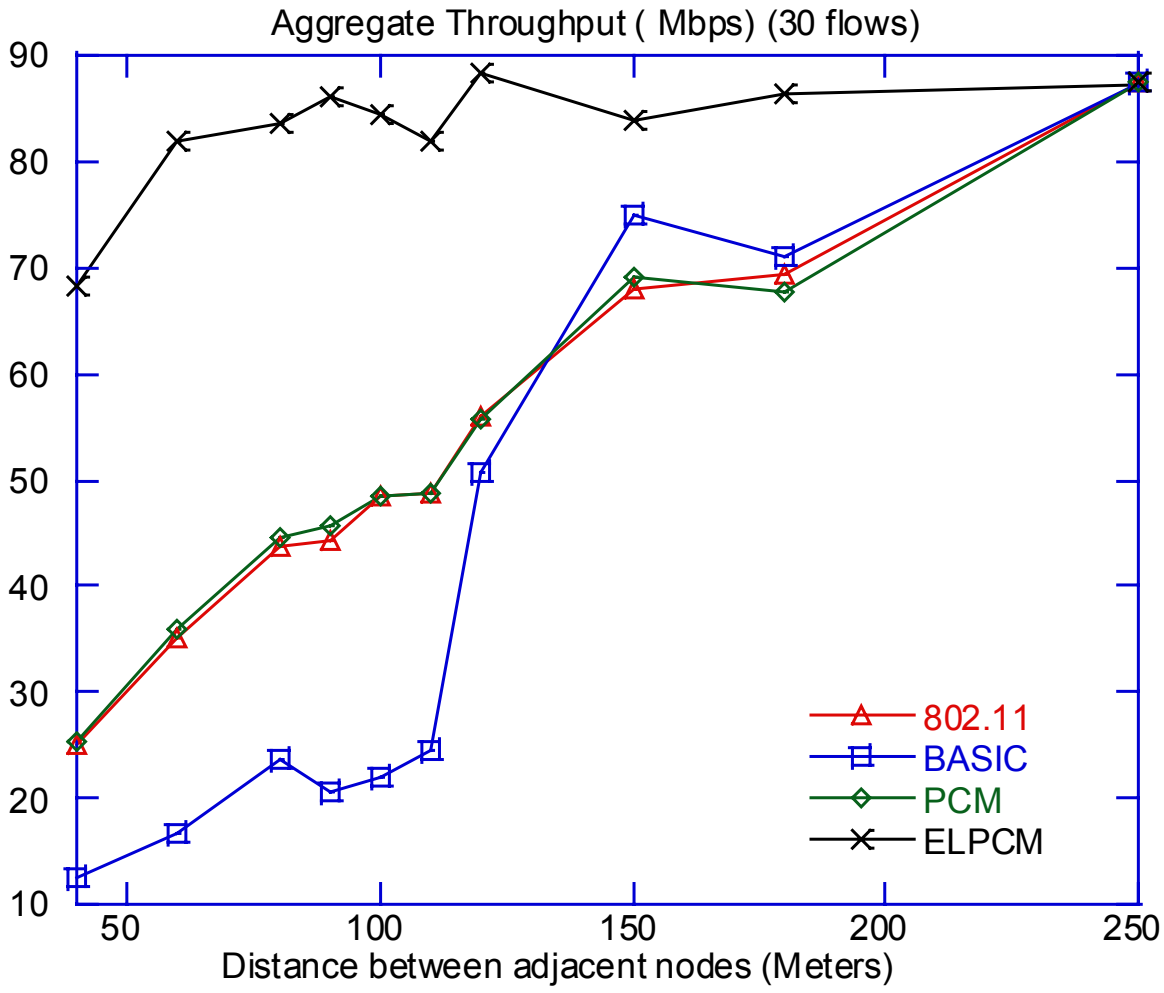
Simulations

- Chain topology
- Random topology (50 topologies)

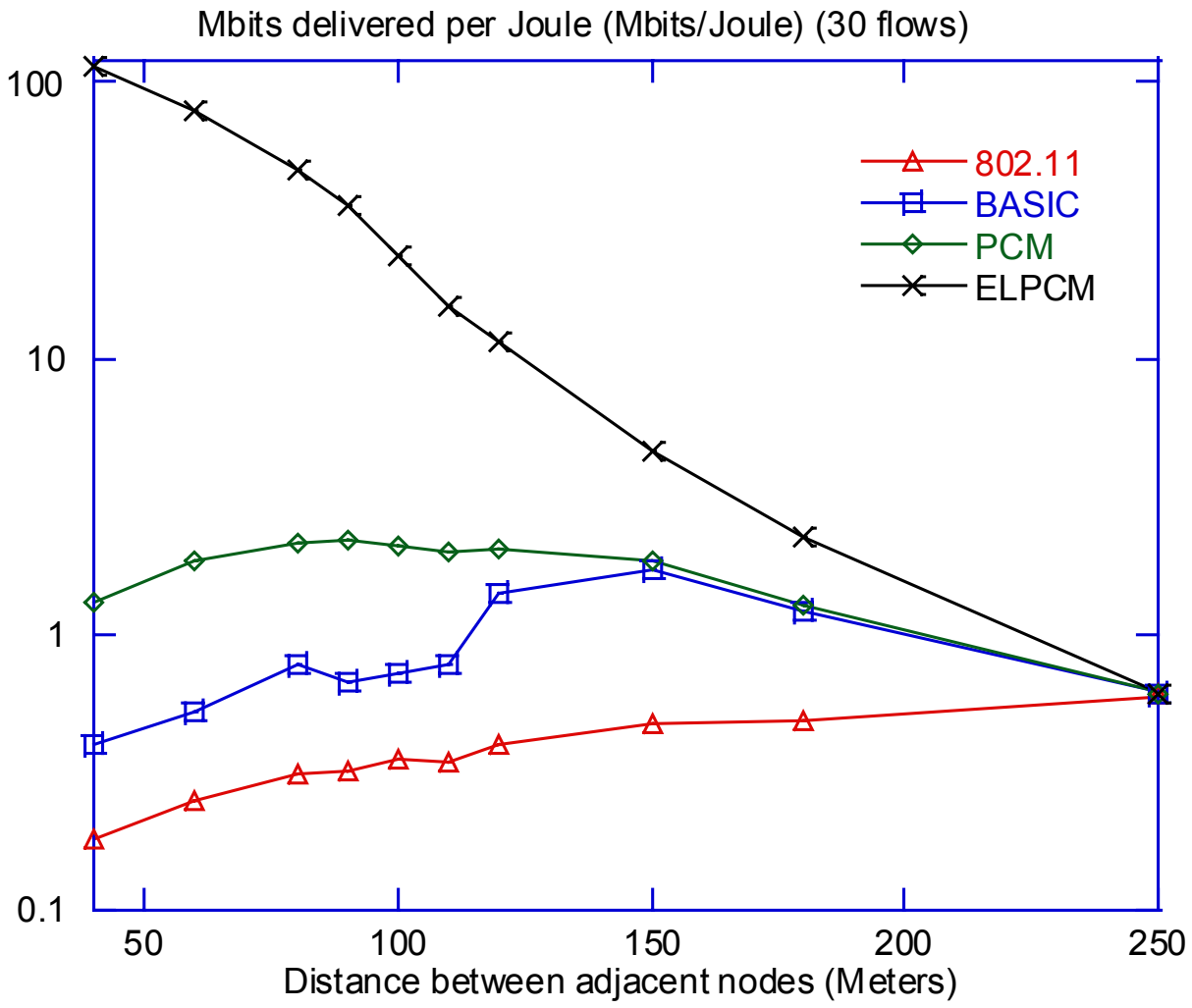
Metrics

- Throughput
- Data delivered per joule
- Data packet corruption ratio

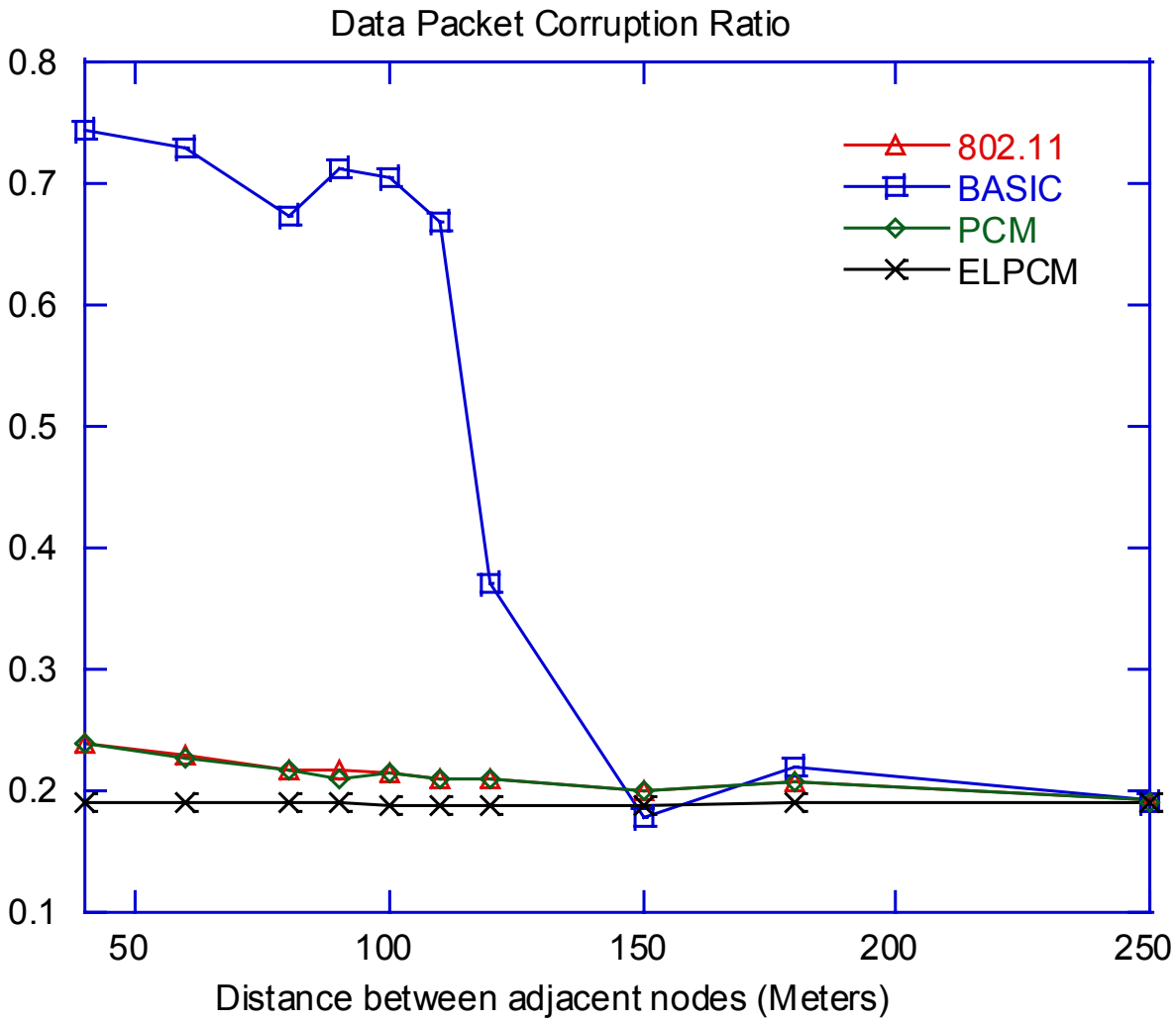
Chain Topology



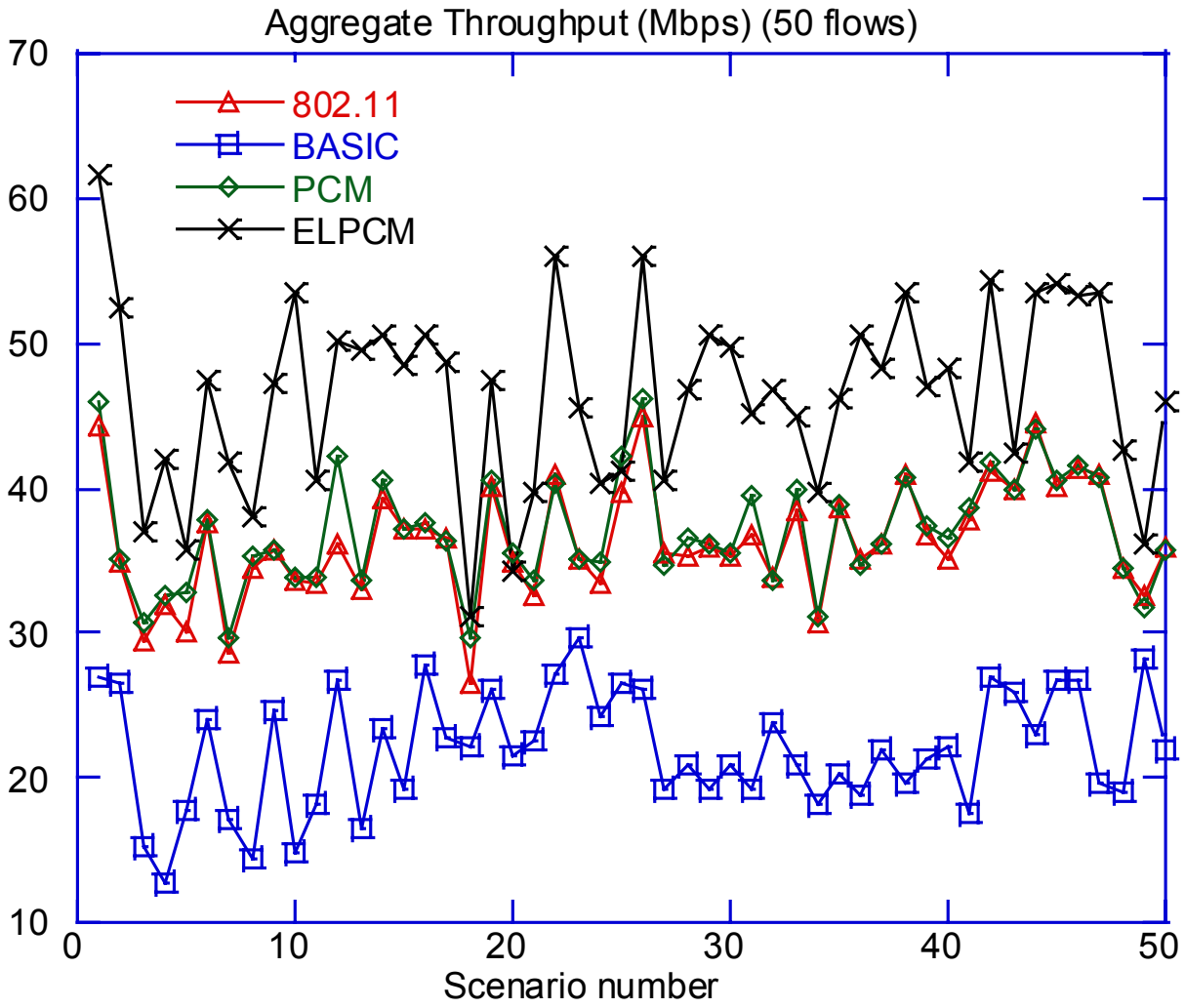
Chain Topology



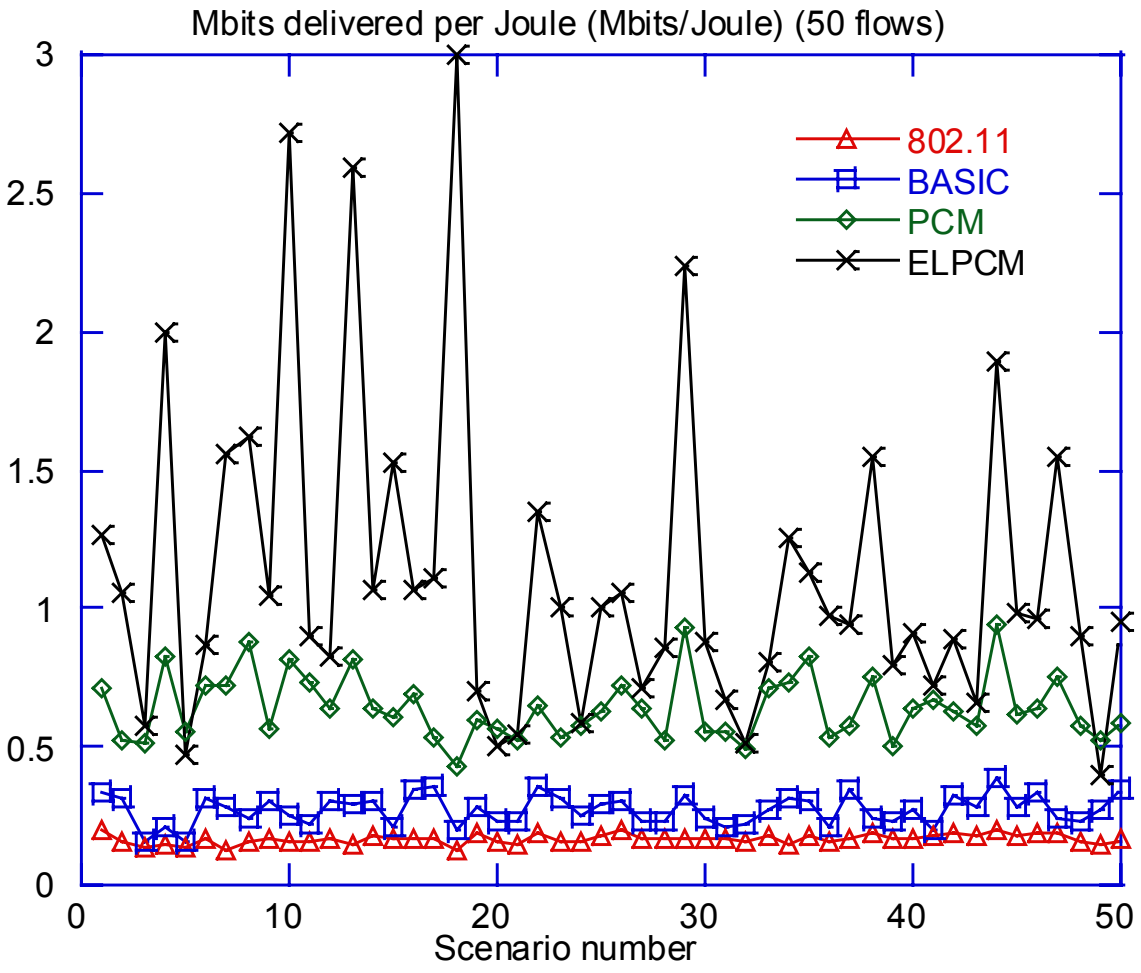
Chain Topology



Random Topology



Random Topology



Random Topology