

TCP Over Multi-Hop Wireless Networks: The Impact of MAC Level Interactions

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Introduction

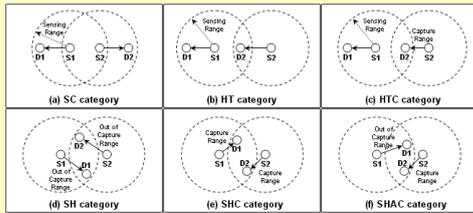
Nodes in a Multi-Hop Wireless Network (MHWN) route traffic among each other to provide connectivity between a source and destination not within transmission range. This sequence of nodes is called a *path* or *chain*. In these chains, the links that do not share a common node can be active simultaneously; these links exhibit different interference interactions. The behavior of a chain varies based on these interactions.

Contribution

- Classify chains based on the interference interactions exhibited by the links in that chain.
- Identify the most frequently occurring chains and how often they occur in a random MHWN.
- Evaluate the performance of TCP over frequently occurring chains.
- Discuss how different chains can affect network performance.

Link Interactions

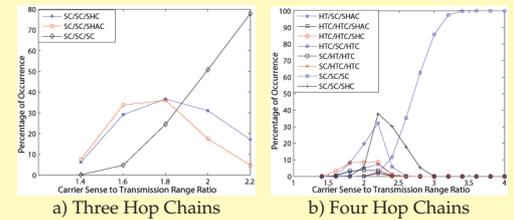
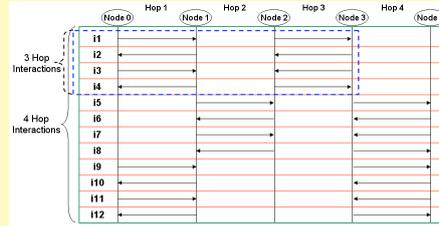
- Two interfering links can interact in several different ways. Given $S1 - D1$ and $S2 - D2$, there exist four secondary links: $S1 - S2$, $S1 - D2$, $S2 - D1$, and $D1 - D2$
- Of the large number of interactions [1] the dominant are:



- Senders Connected (SC):** The sources of the two links are within carrier sense range
- Hidden Terminal (HT):** The source of one link is a hidden terminal for the destination of the other link, but not vice versa
- Hidden Terminal with Capture (HTC):** Similar to HT, except, the destination that experiences interference is able to capture packets destined to it.
- Symmetric Hidden Terminal (SH):** Both sources are hidden terminals to the destinations of the other link
- Symmetric Hidden Terminal with Capture (SHC):** Similar to SH, but both the destinations are able to capture their packets
- Symmetric Hidden Terminal with Asymmetric Capture (SHAC):** Similar to SH, except one destination is able to capture its packets while the other is not.

Chain Interactions

Interactions in three and four hop chains:



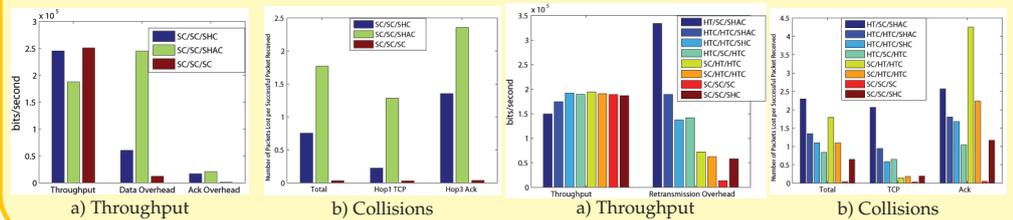
Naming Convention: F/B/C, prominent interaction between links carrying forward, backward and cross traffic.

Occurrence Percentage	Chain Type Forw/Back/Cross	Dominant Interaction		
		Forward	Backward	Cross
7.3	HT/SC/SHAC	i9	-	i3
3.6	HTC/HTC/SHAC	i9	i10	i7
8.4	HTC/HTC/SHC	i9	i10	i3
32.1	HTC/SC/HTC	i9	-	i11
2.3	SC/HT/HTC	-	i10	i11
1.8	SC/HTC/HTC	-	i10	i11
1.6	SC/SC/SC	-	-	-
37.8	SC/SC/SHC	-	-	i11

TCP Evaluation over Chains

Three Hop performance:

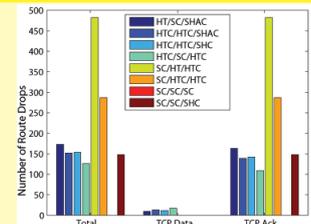
Four Hop performance:



Discussion

Three chain categories identified:

- Weak Interaction in the forward direction
- Weak Interaction in the backward direction
- No significant weak interaction



We consider two chain performance metrics: Route Instability and Interference Generated

Category	Chain Type	Weak Interaction		Interference Generated	Route Instability
		Forward	Backward		
A	HT/SC/SHAC	Yes	Yes	High	Low
	HTC/HTC/SHAC	Yes	Yes	Medium	Low
	HTC/HTC/SHC	Yes	Yes	Medium	Low
	HTC/SC/HTC	Yes	Yes	Medium	Low
B	SC/HT/HTC	No	Yes	Low	High
	SC/HTC/HTC	No	Yes	Low	Medium
C	SC/SC/SC	No	No	Negligible	None
	SC/SC/SHC	No	Yes	Low	Low

Chains with sender connected links perform the best. Chains that have links which are not sender connected and have asymmetric interactions have the worst performance.

References

[1] S. Razak, N. Abu-Ghazaleh, V. Kolar. Modeling of two-flow interactions under SINR model in Multi-hop Wireless Networks In *Proceedings of LCN 2008*