

# In Defense of Wireless Carrier Sense

Ramya Mudduluri

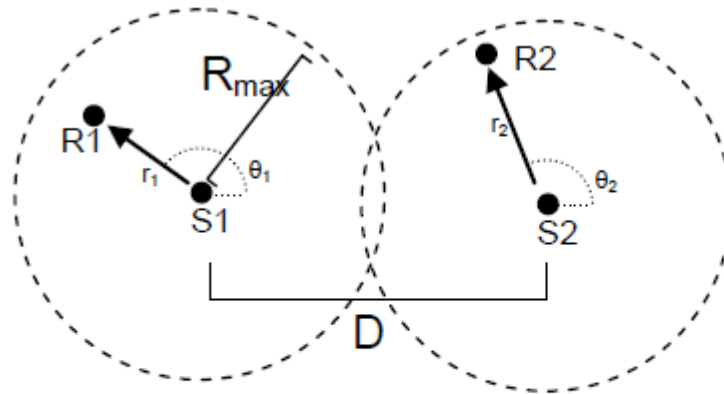
# Introduction

- Carrier Sense uses the feedback from a receiver to decide if the sender should transmit
- For large networks considering to reuse the network, carrier sense fails due to
  - Exposed terminal problem
  - Hidden terminal problem

# Contributions

- Analysis showing Carrier Sense provides nearly optimal throughput in general case
- Identification of several distinct behavioral regimes for Carrier Sense, which perform well except one which typically encounters bad behavior
- A model for high-level properties of adaptive bit-rate radio throughput

# Formal Model



**Figure 1 – Generalized model scenario – two senders and their receivers, illustrating the geometry variables used in the model.**

# Carrier Sense Behavior Limiting Cases

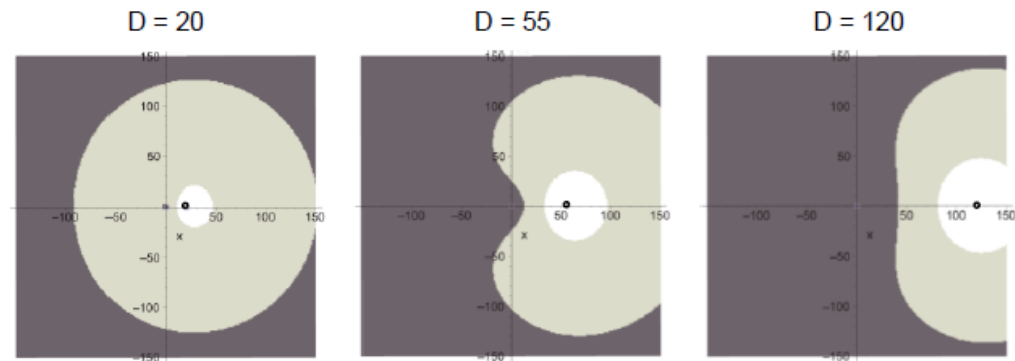
## Long Range Networks

- When the pairs are far apart ( $D \gg R_{\max}$ )
  - Concurrency is optimal for receivers within  $R_{\max}$  (pairs interfere insignificantly)
- When the pairs are very close ( $D \ll R_{\max}$ )
  - Multiplexing is optimal (since SNR would approach 0dB)

## Short Range Networks

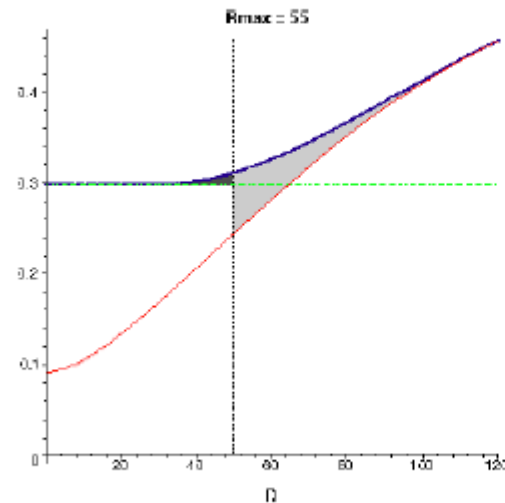
- An interferer who is close enough to cause trouble affects all the receivers. Carrier sense performs well in this case.

# Preference Regions



**Figure 3 – Receiver preference regions: a receiver in the dark shaded areas prefers concurrency, in the light shaded areas prefers multiplexing, and in the white areas prefers multiplexing and will be starved ( $<10\%$  of  $C_{UBmax}$ ) without it. Circle marks interferer position.  $\alpha = 3$ ,  $\sigma = 0$ ,  $P_0 / N_0 = 65\text{dB}$ .**

# Choosing a Threshold



**Figure 5 – Shaded plot of  $R_{\max} = 55$ , non-shadowing. The vertical line marks the carrier sense threshold. Dark shading is inefficiency under multiplexing and light shading is inefficiency under concurrency, of which the light shaded “triangle” below the multiplexing line represents inefficiency due to poor threshold choice.**

----- Multiplexing  
----- Concurrency  
----- Optimal

# A Comparison of Mechanisms for Improving TCP Performance over Wireless Links



# Introduction

- TCP invokes congestion control and avoidance algorithms to provide a reliable transfer

## Problem

- Networks with wireless and lossy links suffer from losses due to bit errors and handoffs significantly
- Even in these scenarios TCP invokes congestion control and avoidance mechanisms which degrades end-to-end performance

# Approaches

- Hide non-congestion-related losses from the sender, so that the problem is solved locally
  - reliable link-layer protocols (AIRMAIL), split connection (Indirect-TCP), TCP aware link-layer (Snoop protocol)
- Make the sender realize that the packet losses are not due to congestion.

# Basic Groups (Solutions)

- End-to-end proposal
  - SACKs, ELN,
- Split Connection Protocols
  - Uses NACKs, SACKs between Base Station and Destination
- Link-layer proposals
  - Forward Error Corrections (FEC)

# Evaluation

- Goodput = Actual transfer size / Total number of bytes transmitted over the path
- Shielding TCP sender from duplicate ACKs caused by wireless losses improves throughput by 10-30%
- SACKs, ELN result in significant performance improvements