TCP Performance over Wi-Fi

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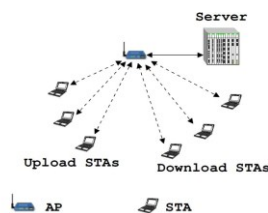
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Introduction and Scope of Research

Setup
Wi-Fi, Up-Downloads.
Infrastructure mode, DCF.
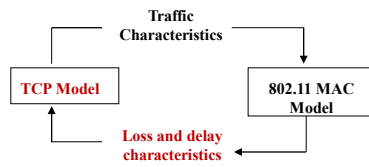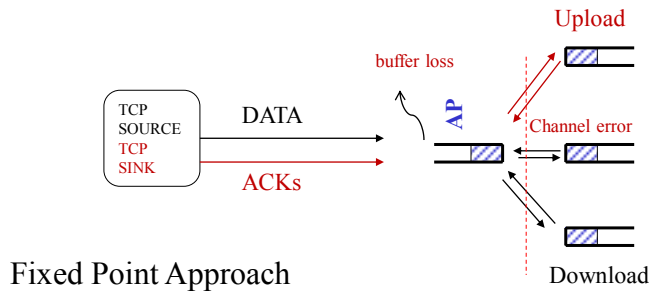Loss-based TCP.

Existing Models
• Models for TCP over Wi-Fi with buffer overflow.
  - Known unfairness between upload and download throughputs.

Our Contribution
• We model the impact of MAC channel transmission errors.
  - Capture TCP dynamics in a lossy Wi-Fi and interaction among up-down flows.
  - Explain throughput unfairness due to channel errors and solve it.

Modeling TCP over Wi-Fi

Fixed Point Approach

Gap in Literature

| Approach	Main References	Relevance
Saturated Models: WLAN entities (AP and STAs) backlogged.	Bianchi et al. (2000), Cali et al. (2000), Kumar et al. (2005)	Unable to capture TCP closed loop: Almost all packets sit at the AP leaving STAs mostly empty
Semi Saturated Models: Extension of saturated models with EMPTY state	Malone et al. (2007), Sakurai et al. (2010), Tickoo et al. (2004)	Gives better estimates for open loop data transfer
Unsaturated Models: Tracking queue length of each WLAN entity	Garetto et al. (2005) Panda et al. (2009) Cristina et al. (2014)	High Computational Complexity. Does not make use of TCP's tight close-loop evolution
Upload Download Unfairness	Wu et al. (2008), Pilosof et al. (2003), Leith et al. (2010)	Buffer overflows explored but channel errors are not
Rate Equilibrium: Balance of flows with rate of success of data and Acks Based on flow control	**Nguyen et al. (2013) Sakurai et al. (2005)**	**Simple and good estimation of MAC throughput but less accurate collision model No Congestion control**
Tracking the Number of Active Stations: Instantaneous tracking of backlogged STAs Packets and using IEEE 802.11 saturated model	Bruno et al. (2004) Kuriakose et al. (2009) Bharadwaj et al. (2009)	Gives better estimates of collision along with throughput
Tracking the Number of Active Stations with two download classes	Krishnasamy et al. (2011)	Considers channel errors but only downloading STAs

Our Model
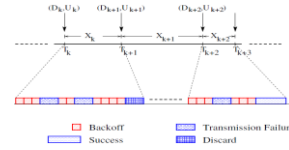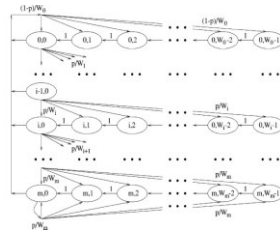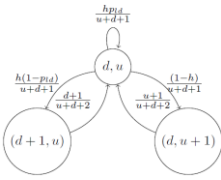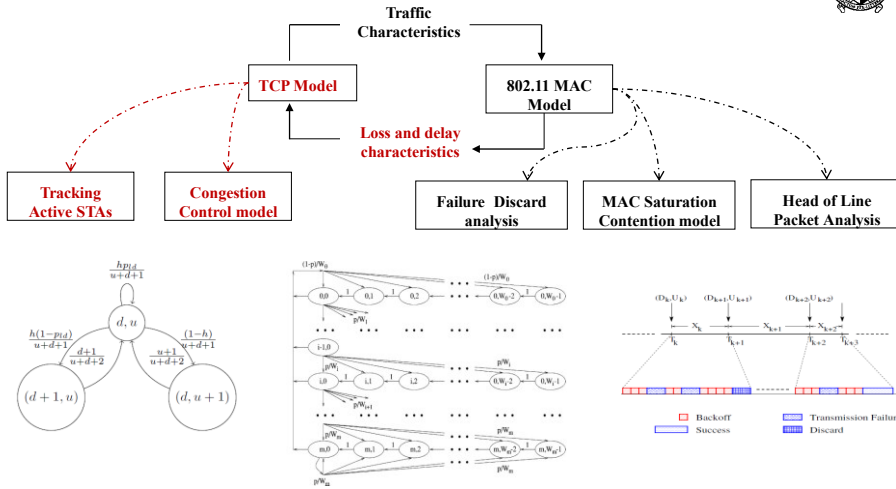
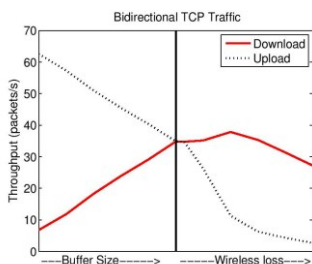# MAC Failures and TCP Loss
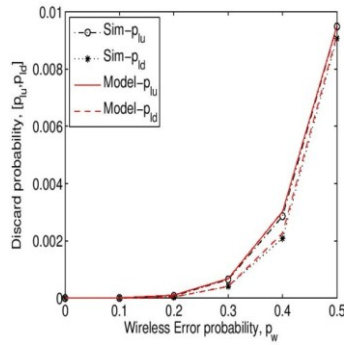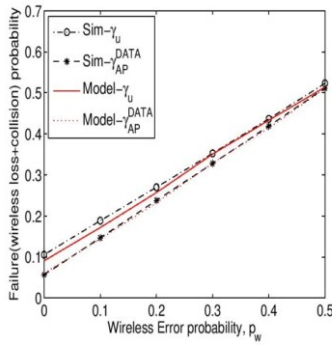
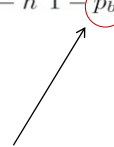# Throughputs
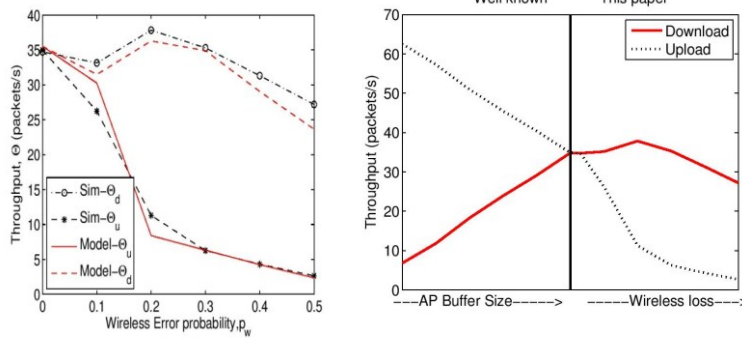
Observations of Unfairness
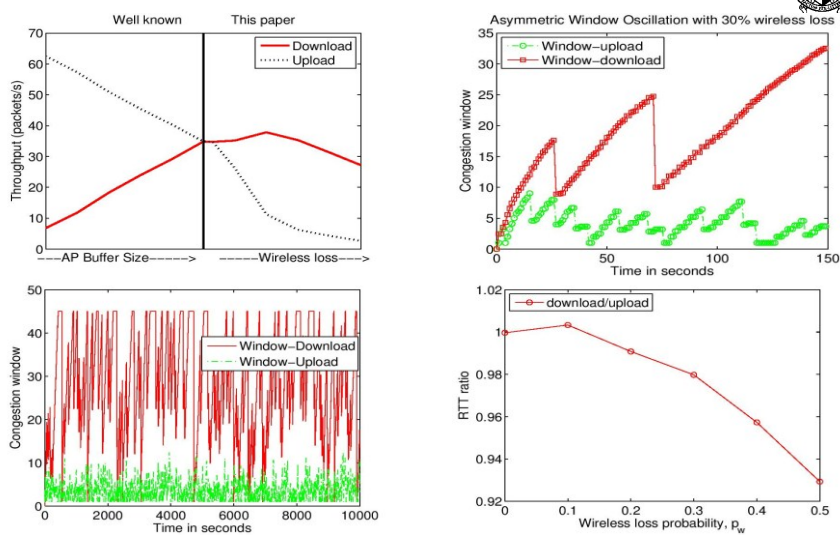
Fairness driven AP Buffering

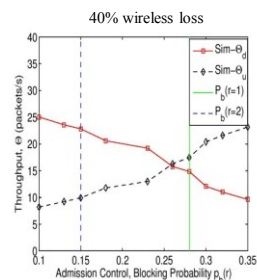Exploiting buffer induced unfairness against channel loss
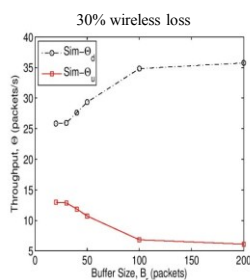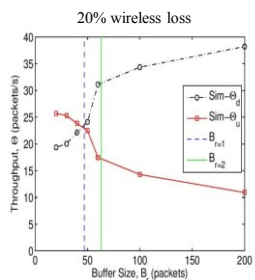

$$r := \frac{\bar{\Theta}_d}{\bar{\Theta}_u} = \frac{h}{1-h} \frac{1-p_{\text{ld}}}{1-p_b}$$

Admission Control
Controlling outstanding packets in Network

Solution to Unfairness

Conclusion

Contributions

• Model of TCP over Wi-Fi: Impact of buffer and channel losses

• Lossy Wi-Fi Channel in addition to throughput degradation causes throughput Unfairness (opposite of buffer overflows).

• Propose two ways to mitigate the unfairness, admission control and buffer sizing.

• Achieve any desired ratio of upload to download throughput.

Future directions

• Extension from loss based to delay based TCP.

• Inclusion of short and mixed TCP flows.

• Adaptive Variation in buffering.

S. R. Pokhrel, M. Panda, H. Vu, and M. Mandjes, "TCP performance over Wi-Fi: Joint impact of buffer and channel losses," *IEEE Transactions on Mobile Computing*, accepted for publication, 7th Jul 2015.

THANKS