Is Random Access Fundamentally Inefficient?

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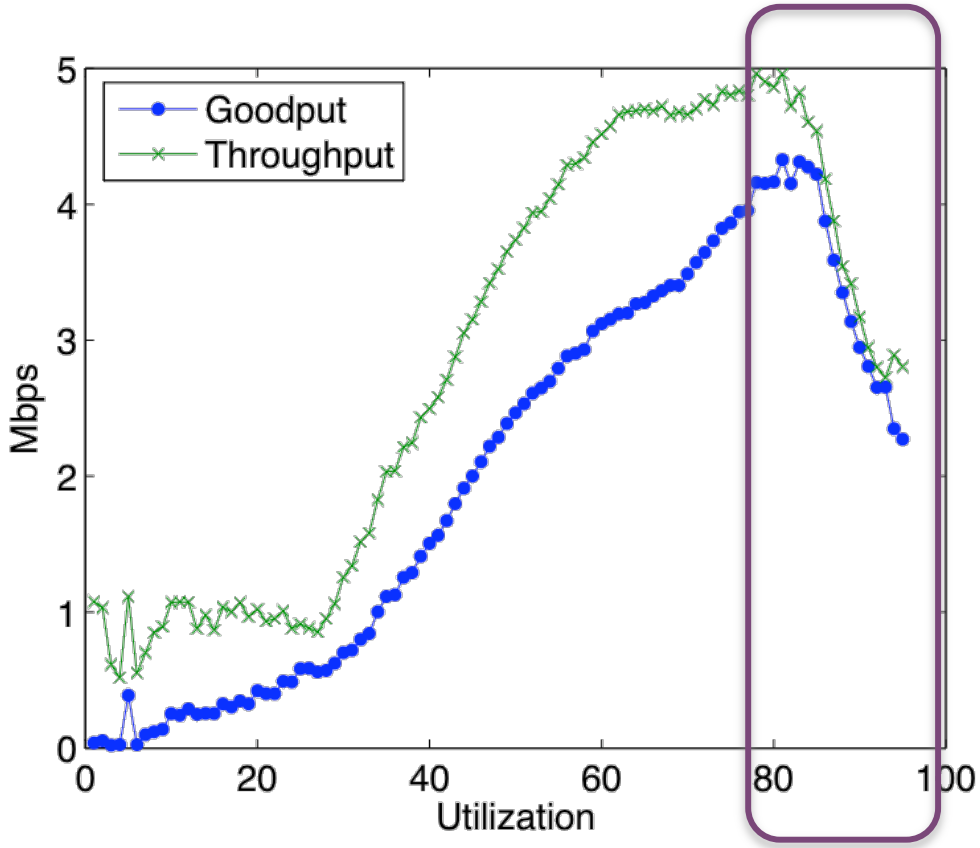
Is random access fundamentally inefficient?

- Yes.
  - It does not prevent collisions.
- No.
  - If there is only one transmitter, it's terrific.
- It depends.
  - Number of transmitters, traffic profile, mobility, etc.
- Whether or not its fundamentally inefficient, our protocols aren't close to optimal and could be doing a lot better.

Why would random access be considered inefficient?

- Collisions.
  - Collisions increase as usage increases, resulting in lower throughput
- Are collisions the only reason for the rate decrease?



Interference challenges in current wireless solutions

- IEEE 802.11: Decreases rate when collisions occur
  - Auto-rate fallback (ARF)

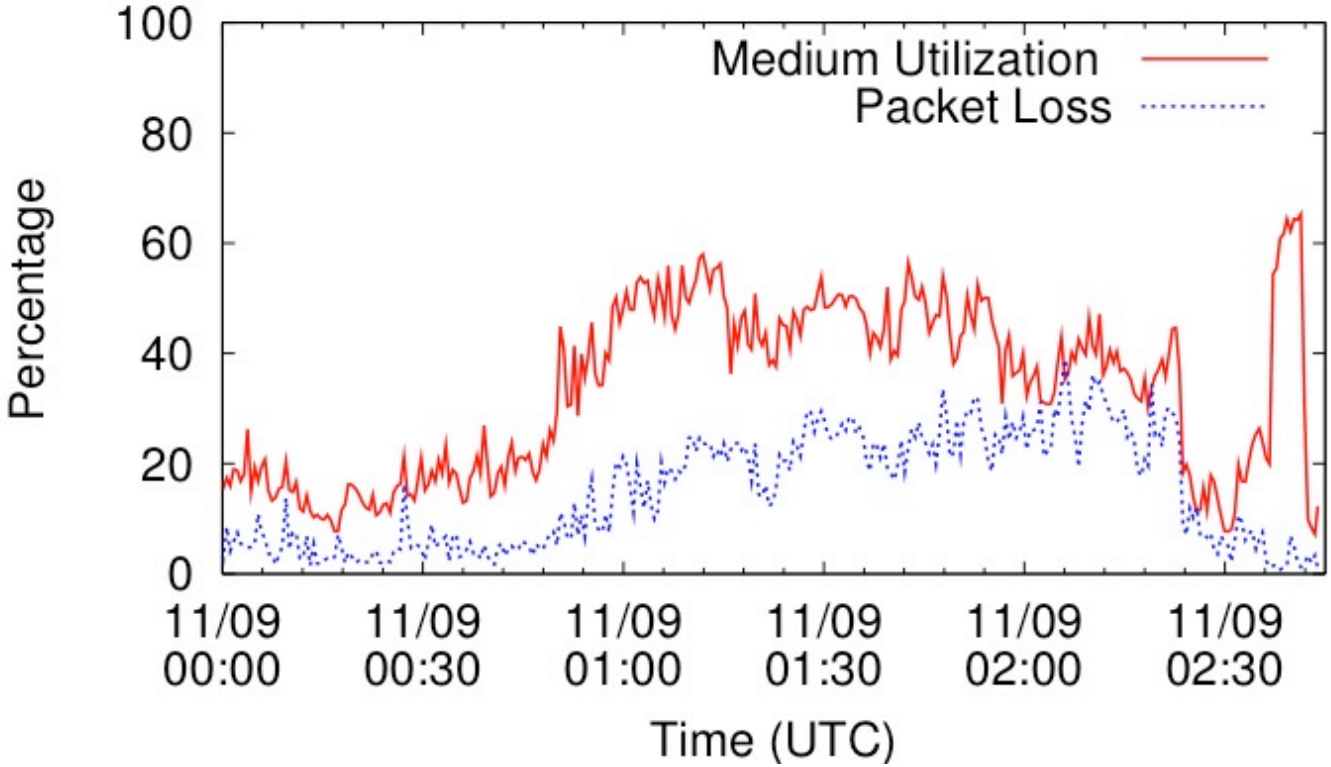
- "Binary" assumption of interference
  - Not true in real networks

Auto-Rate Fallback (ARF)

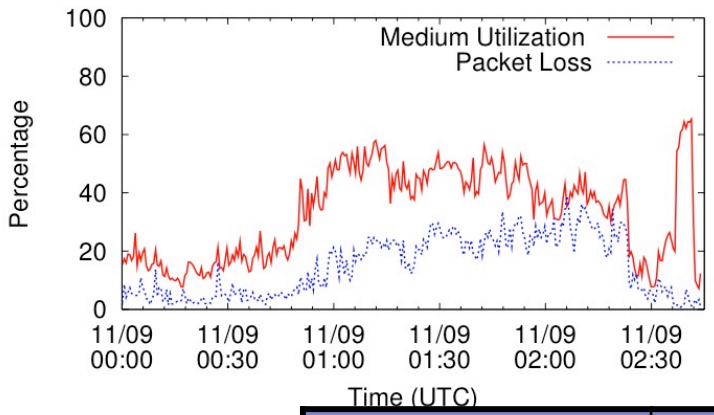
- Designed to respond to poor signal quality
- x consecutive losses results in decrease in data rate
- y consecutive packet receptions results in increase in data rate

802.11 Data Rate Usage

- Data from 67th IETF meeting: more than 1000 attendees in a room with 16 APs

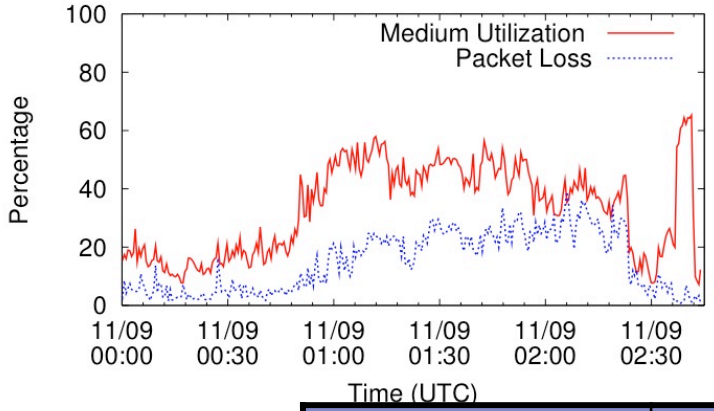


802.11 Data Rate Usage



Rate (Mbps)	Packets (%)	Rate (Mbps)	Packets (%)
11	72.94	36	3.9
12	1.53	48	3.59
18	2.76	54	11.51
24	2.76		

802.11 Data Rate Usage



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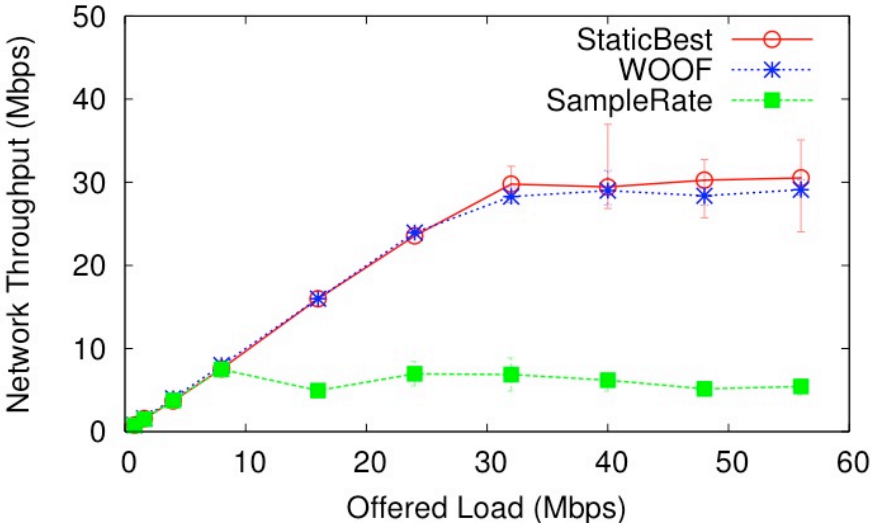
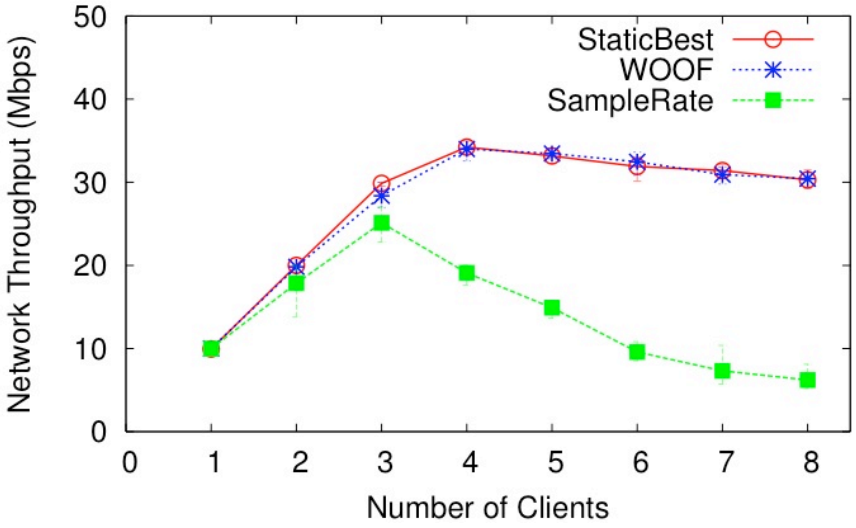
What can be done?

- Differentiate the cause of loss
  - Only reduce data rate when the cause of loss is due to poor link quality, not collisions
- WOOF: Wireless cOngestion Optimized Fallback (WOOF)
  - Use correlation of channel utilization and packet loss rate to help distinguish cause of loss

WOOF Performance



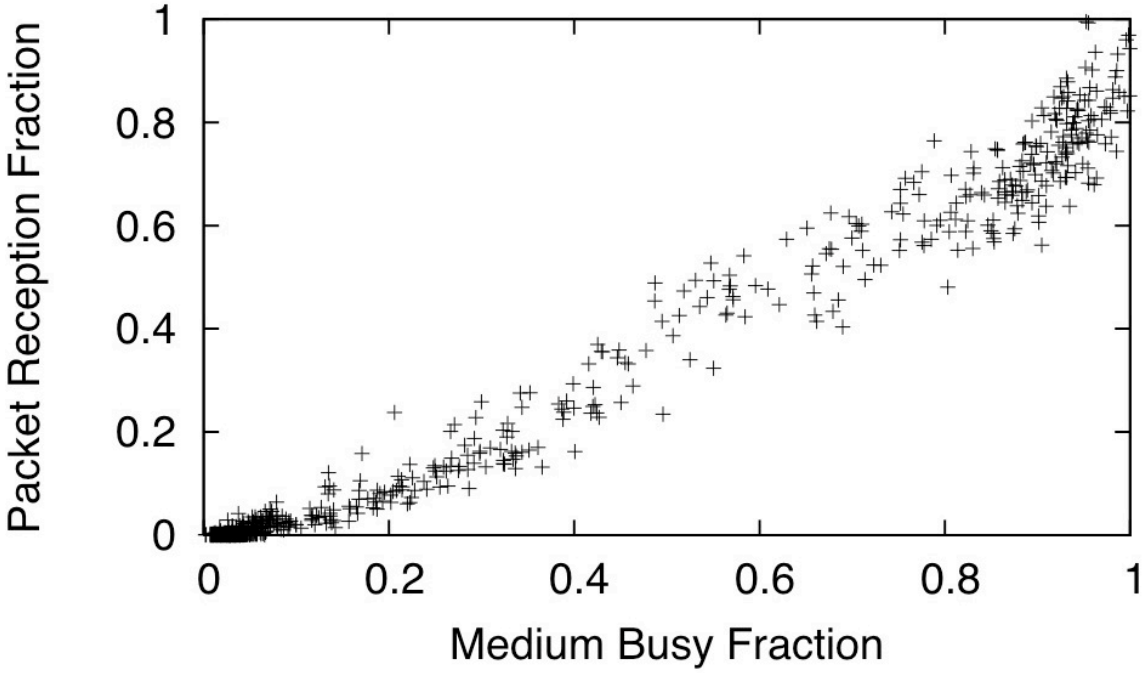


WOOF Data Rates

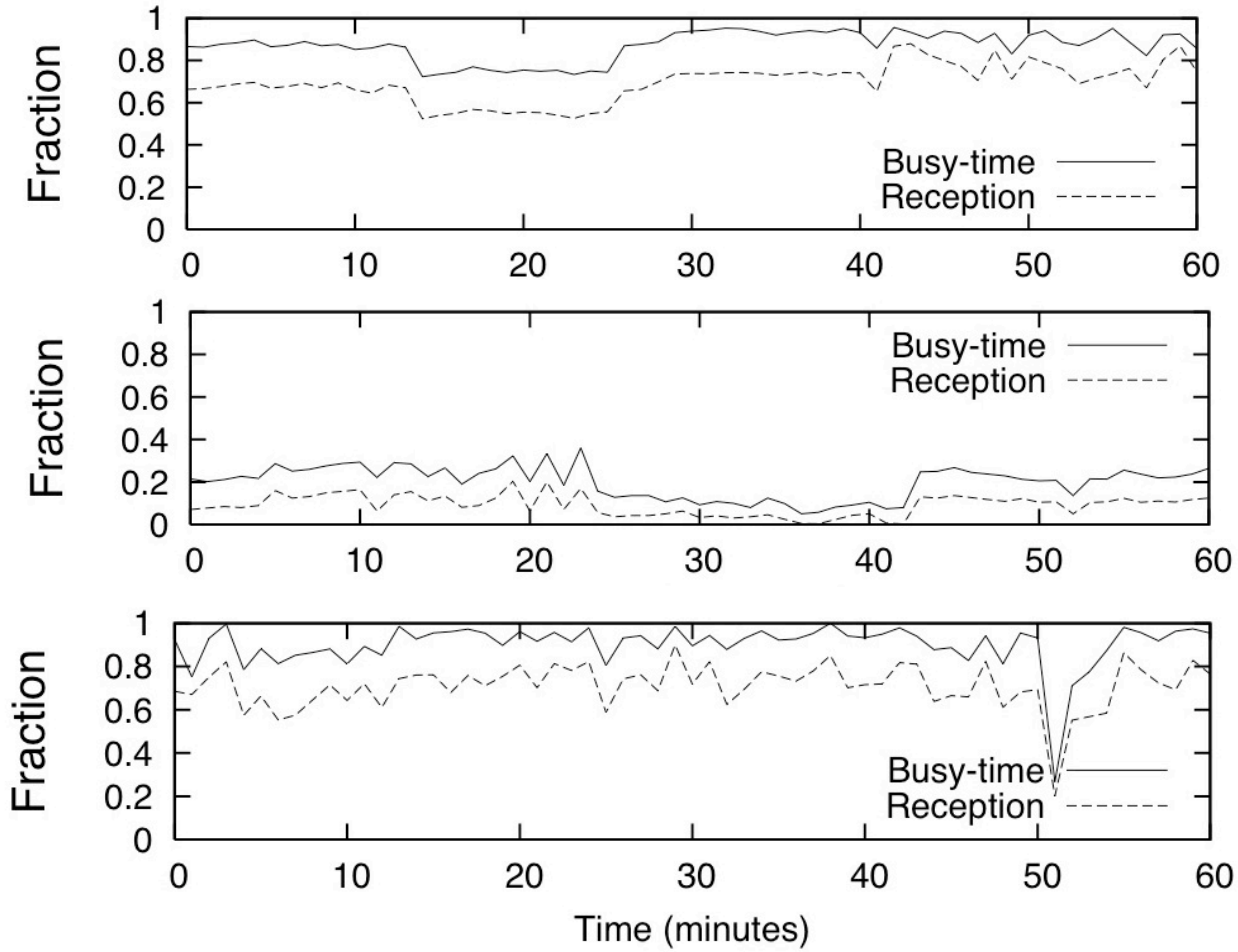
Data Rate (Mbps)	WOOF (%)	SampleRate (%)
1	.001	2.4
2	.009	.02
5.5	.001	1.5
6	.008	21.1
9	0	0
11	.04	20.8
12	.02	6.2
18	.2	6.8
24	.78	9.4
36	5.4	13.4
48	19.7	8.8
54	73.4	9.4

Interference as a binary number

- Commonly used assumption: Interference either exists, or it doesn't
  - If it exists, *all* packets from a sender will interfere with nodes in interference range
- Not true in real networks



Medium utilization and reception behavior for three representative links



How can random access be improved?

- Make collisions work for you, not against you
  - Network coding [Katabi'07]
- Perform interference prediction to know which links will interfere [Padhye'05]
  - Design pseudo-random access solutions so non-interfering nodes transmit at the same time [Mittal'06]
- Don't decrease data rates due to collisions [Acharya'08]
  - Differentiate the cause of packet loss [Acharya'08, Banerjee'08]
- Dynamic TDMA solutions [Singh '07]
  - The best of both worlds
- Add intelligence to high layers
- Others…