WIRELESS INSTITUTE
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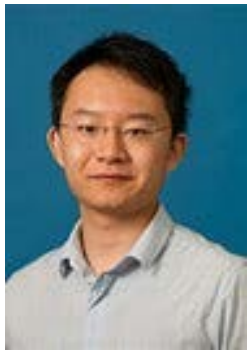
FMNC – Fast Mobile Network Characterization



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Problem Statement

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Sensors

Bodycams

How can we longitudinally test what the network performance would look like in practice?

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Problem Statement

- Determine WiFi quality
  - At this moment
    - Which way should my traffic go?
    - Which SSID / AP is best?
    - Is this WiFi performance acceptable?
  - Longitudinally
    - Check my WiFi performance
      - Every 15 minutes, 10 minutes, 5 minutes, 1 minute

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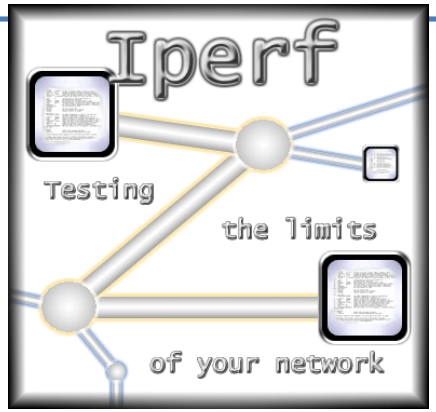
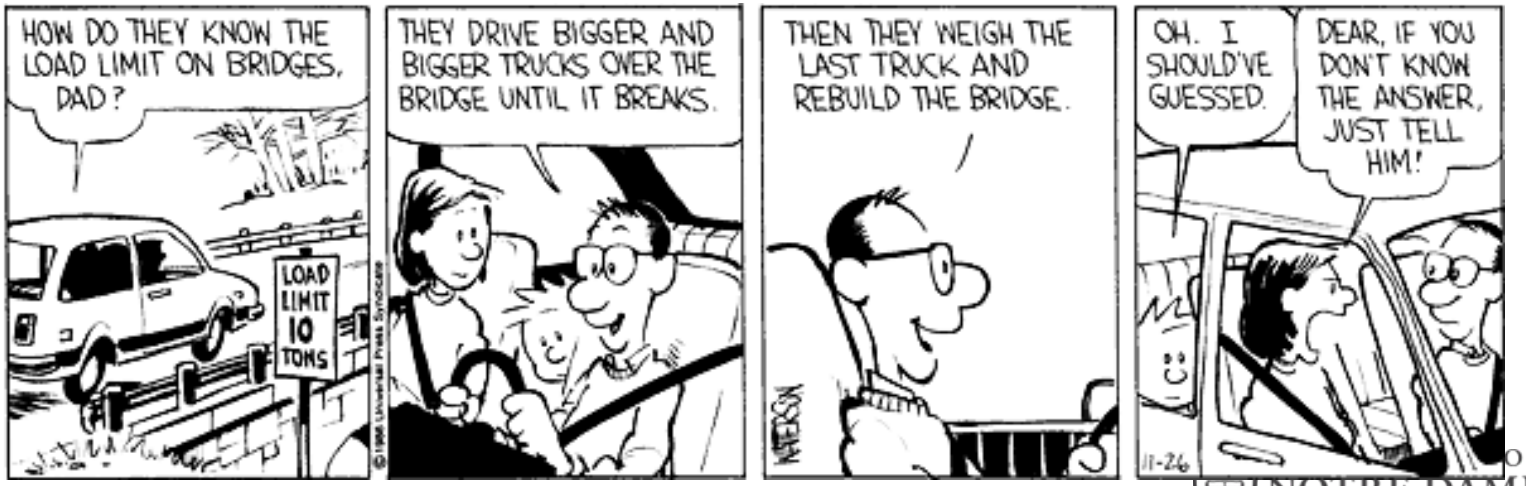
Available Throughput

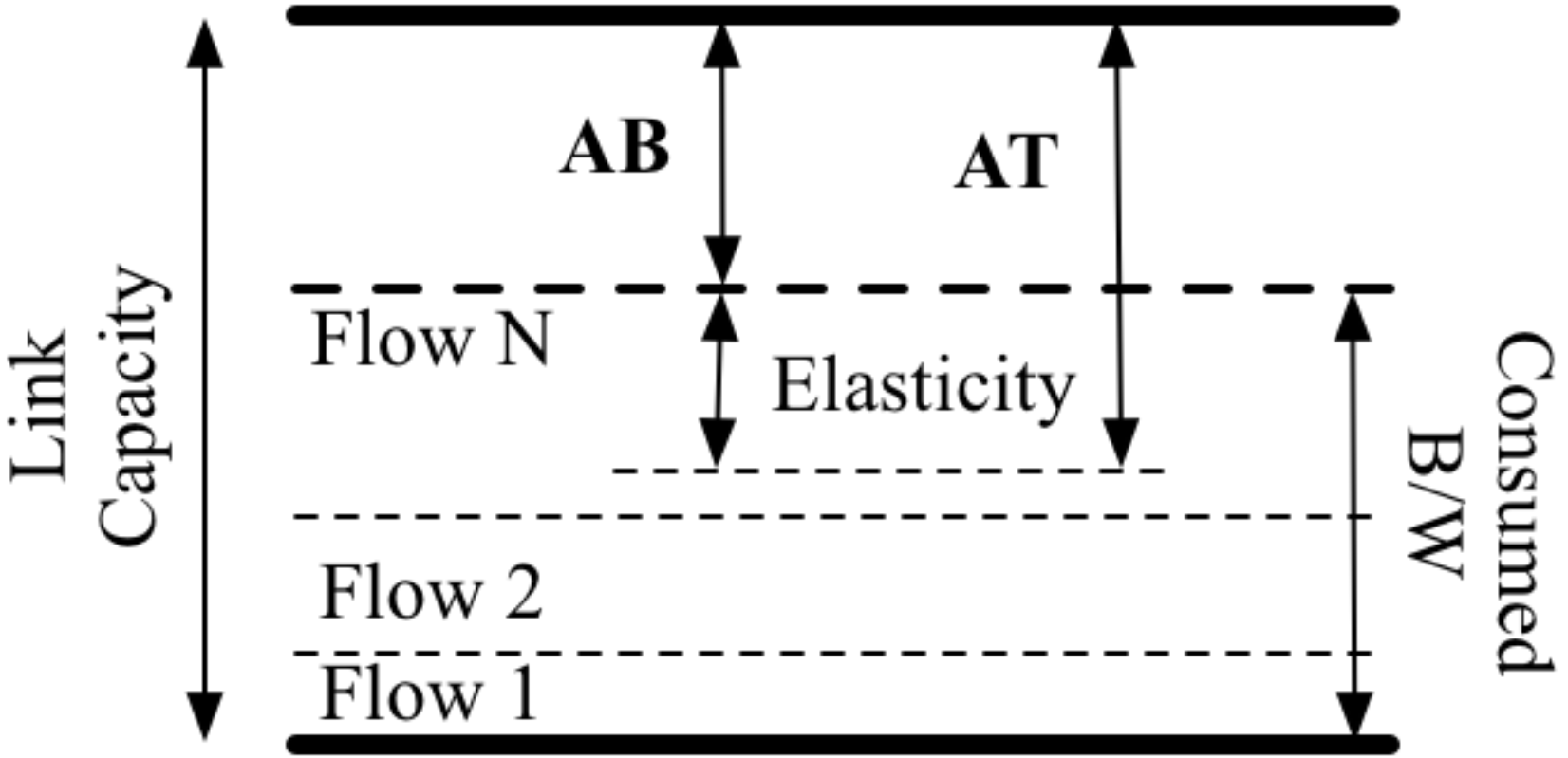


iperf

SpeedTest.net



AB (Available Bandwidth) vs. AT (Available Throughput)



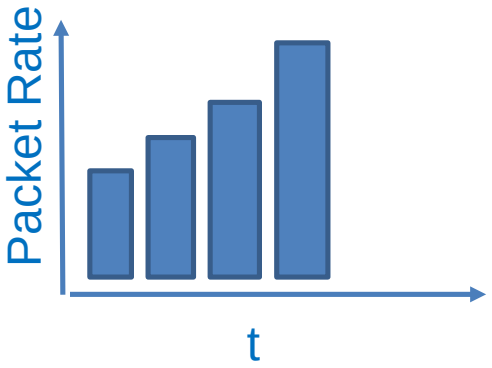
SpeedTest = AT

AB is the floor for AT

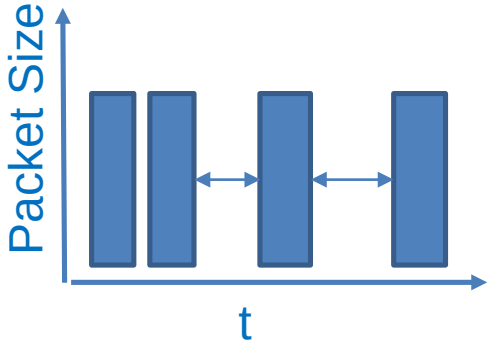
Available Bandwidth (AB)

- Measure packet dispersion
  - PathChirp, Spruce, WBest+

Packet Rate Model:



Packet Gap Model:



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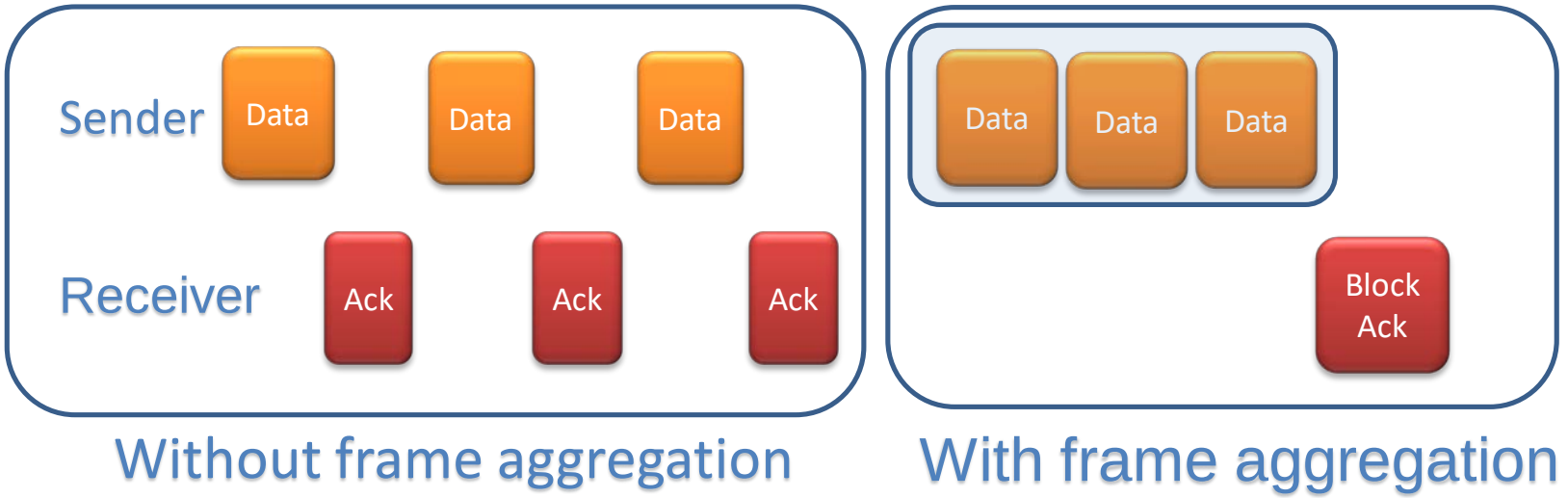
Frame Aggregation (802.11e)



Can we capture the "bursts" of queuing to infer the presence of aggregation?

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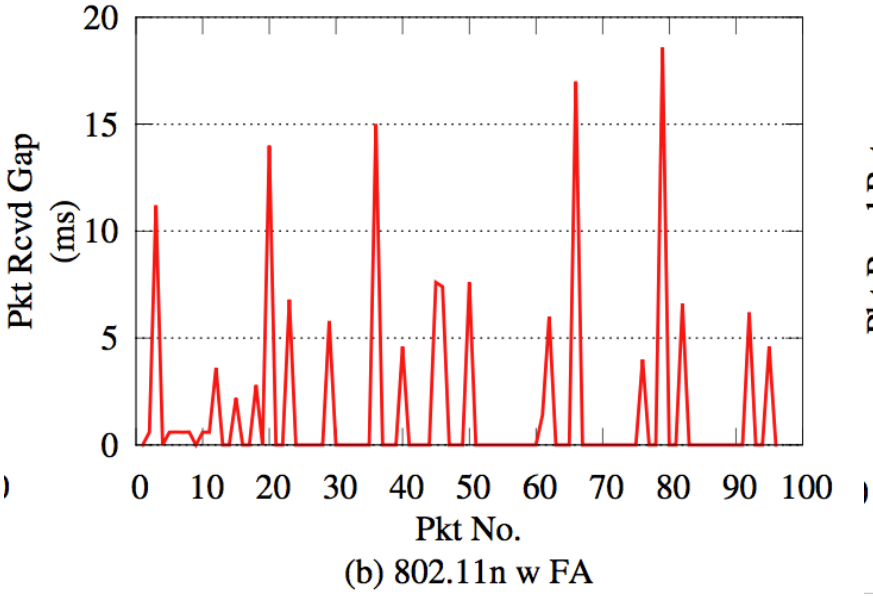
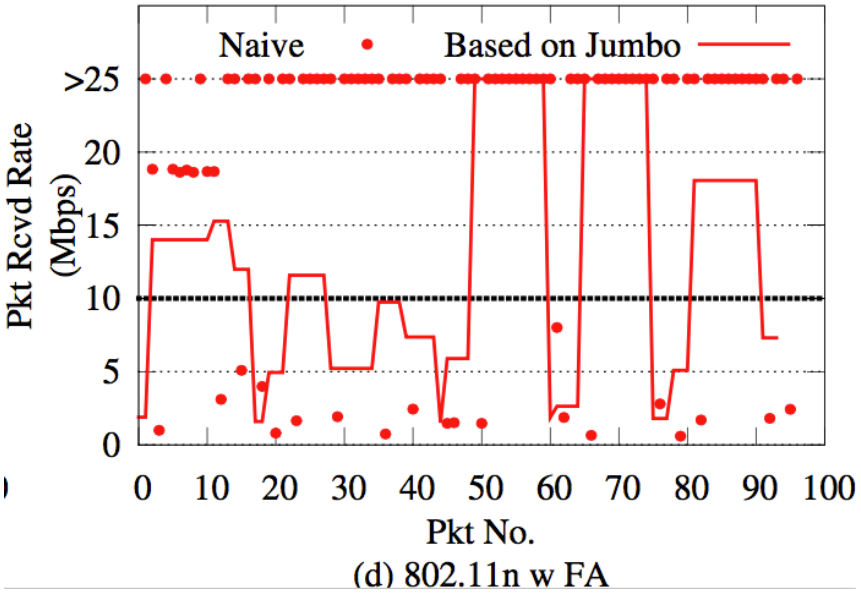
Frame Aggregation vs. AB





Gaps become spiky.

Rates become bimodal!

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Aggregation Index - AI

- Capture the degree to which packets are aggregated

$$AI = \lceil \frac{\mathcal{D}_{ag} + f(u_x)}{\mathcal{G}_{snd}} \rceil$$

$$\text{subject to} \quad AI \cdot \mathcal{P} \leq \mathcal{P}_{max}, \quad \frac{AI \cdot \mathcal{P}}{\mathcal{R}} \leq \mathcal{T}_{max}.$$

u_x is the bandwidth utilization;

G_{snd} is the sending packet gap;

When we exceed AB with our probing, AI will spike

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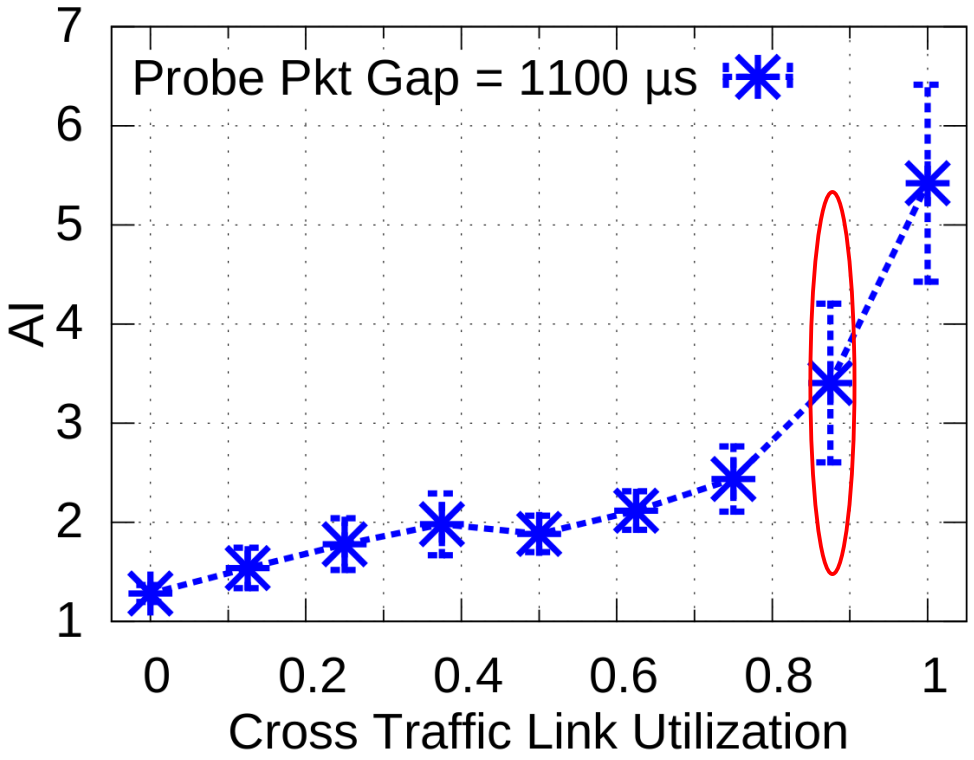
Experimental Validation

Probe traffic causes **0.1** link utilization.



G_{snd} fixed

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Design Principles - FMNC

- Zero client modifications
  - Work within existing protocols / stacks
    - TCP/IP, HTTP GET
- Fast → Energy / Impact to other flows
  - Less than 250 ms resolution time
- Accurate in zone that matters
  - 0-11 Mb/s - Red, Yellow, Green
  - Can trigger alternate tests
- Lightweight
  - Less than 100 KB of data

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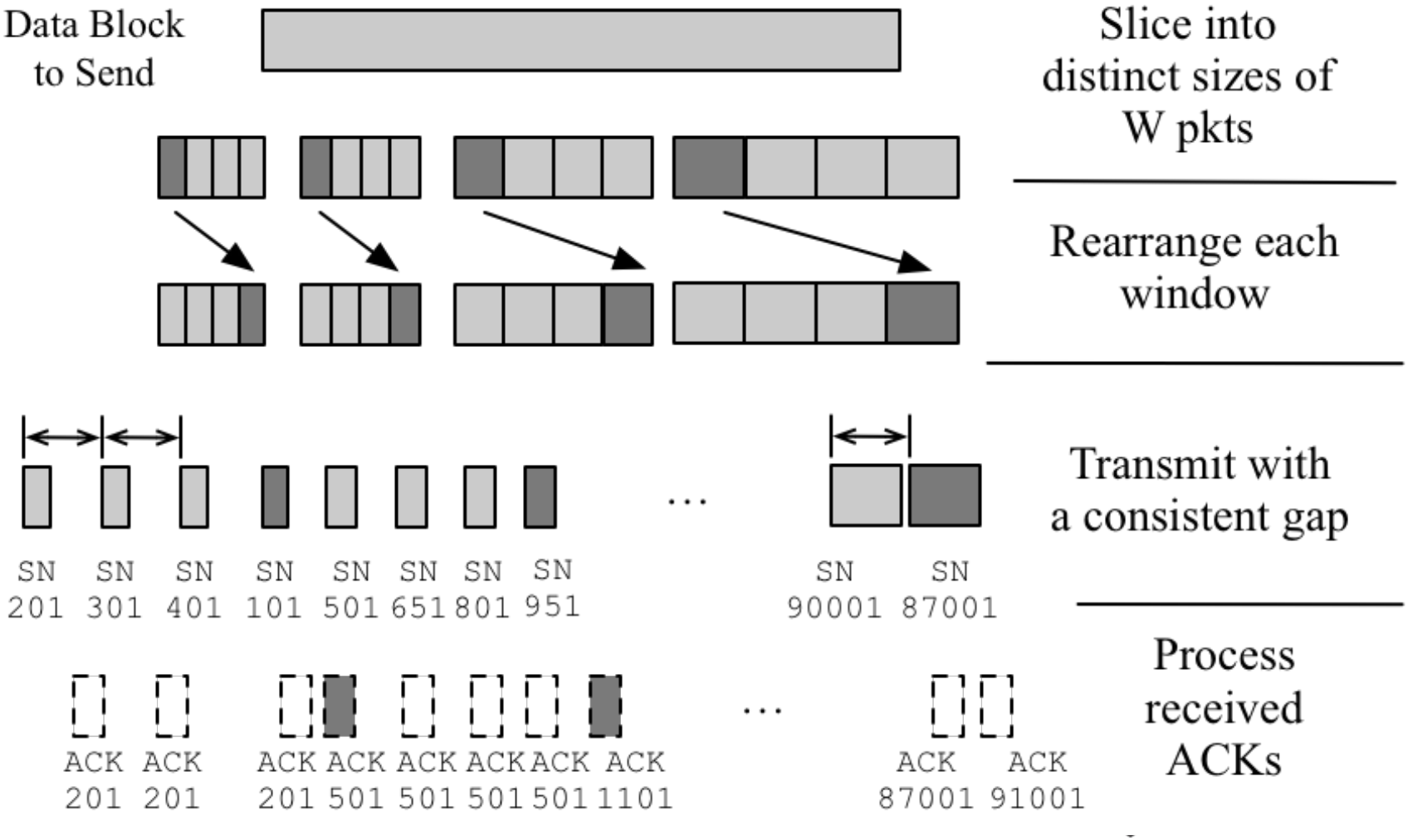
Sliced, Structured, Reordered Packets



Experimental Setup

- Client
  - Periodic FMNC web gets (Android phone)
- Server
  - Custom libpcap-based server
- Wireless links
  - 802.11n
- Cross Traffic
  - UDP via clients sharing same wireless

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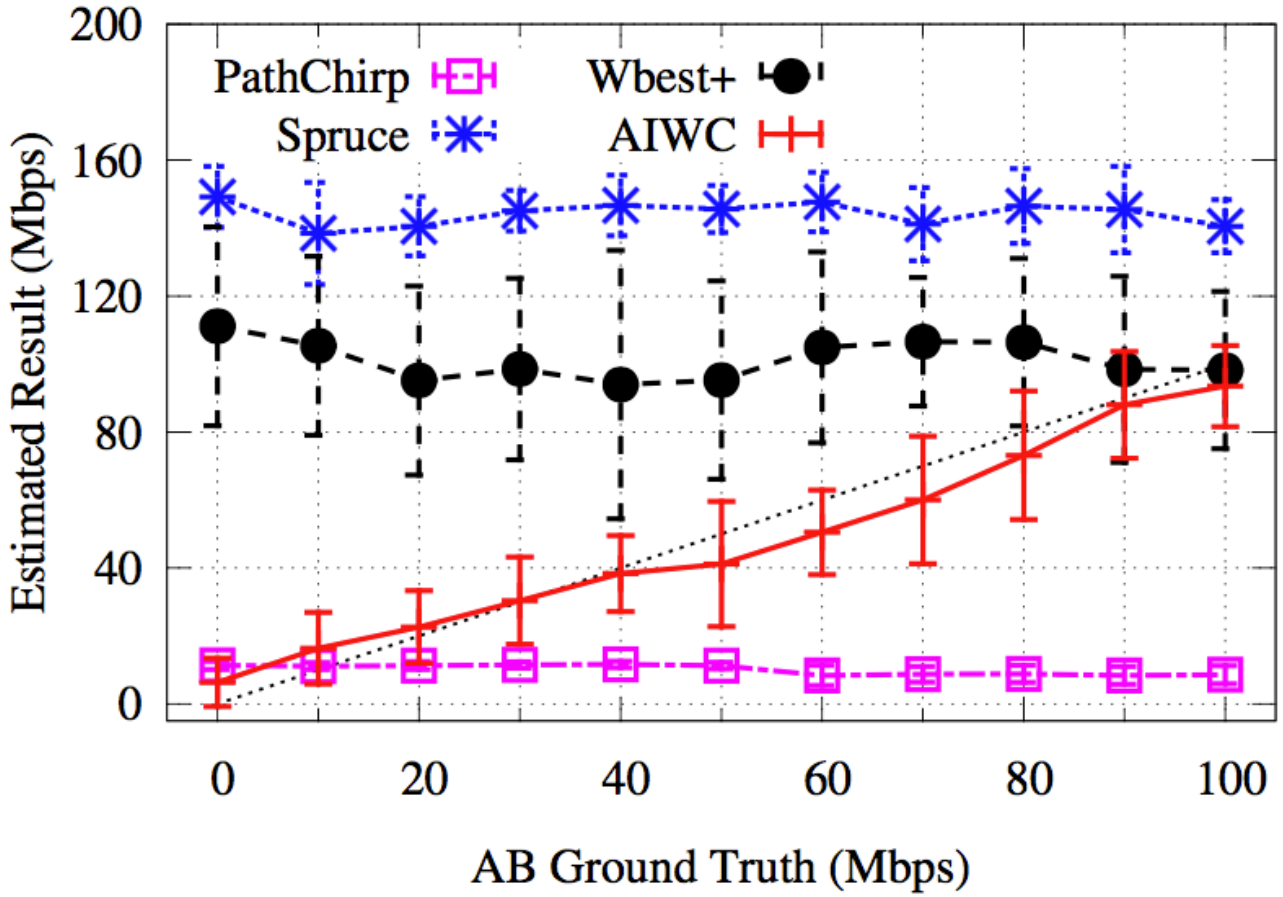
Results - Estimations



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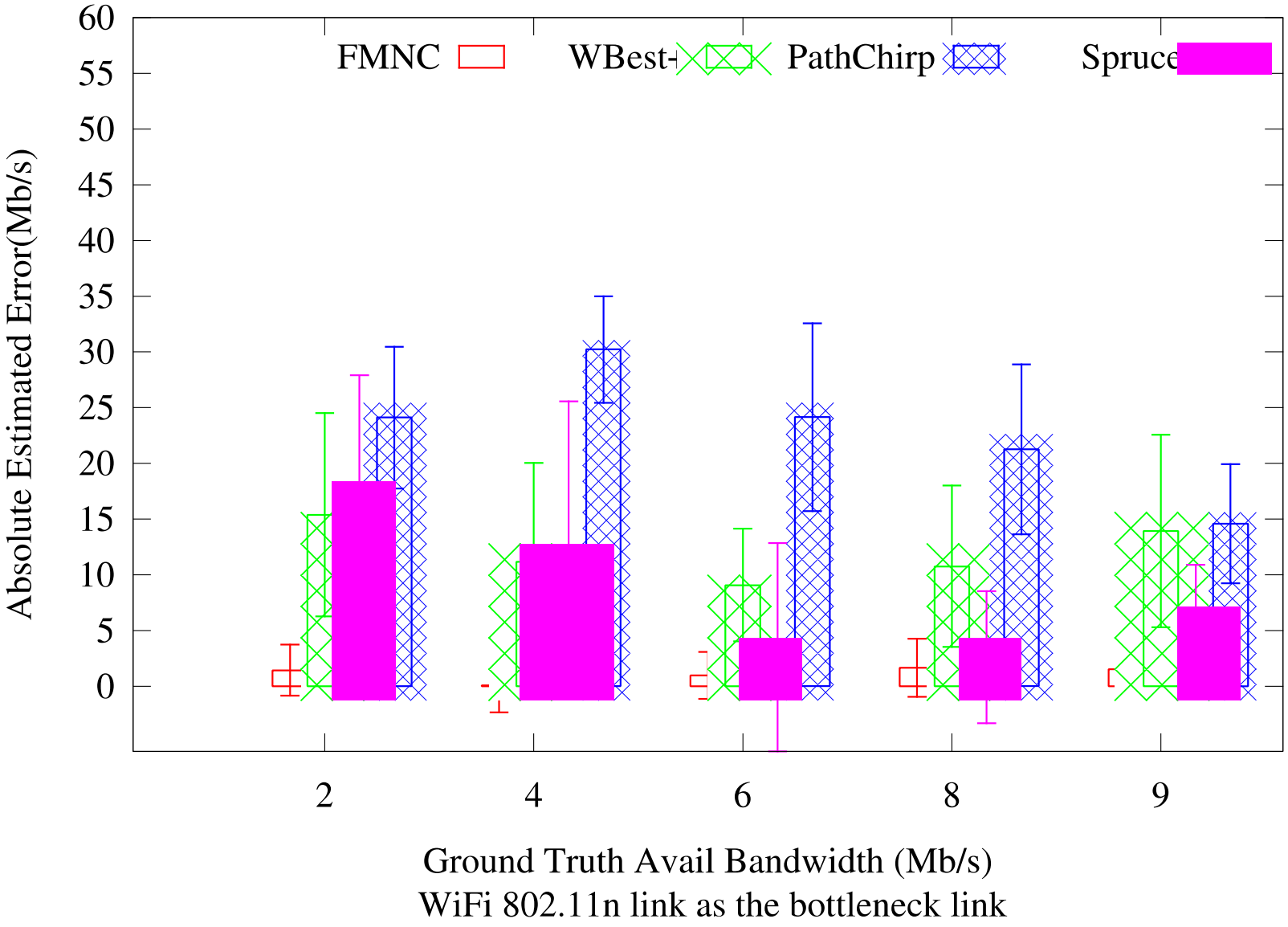
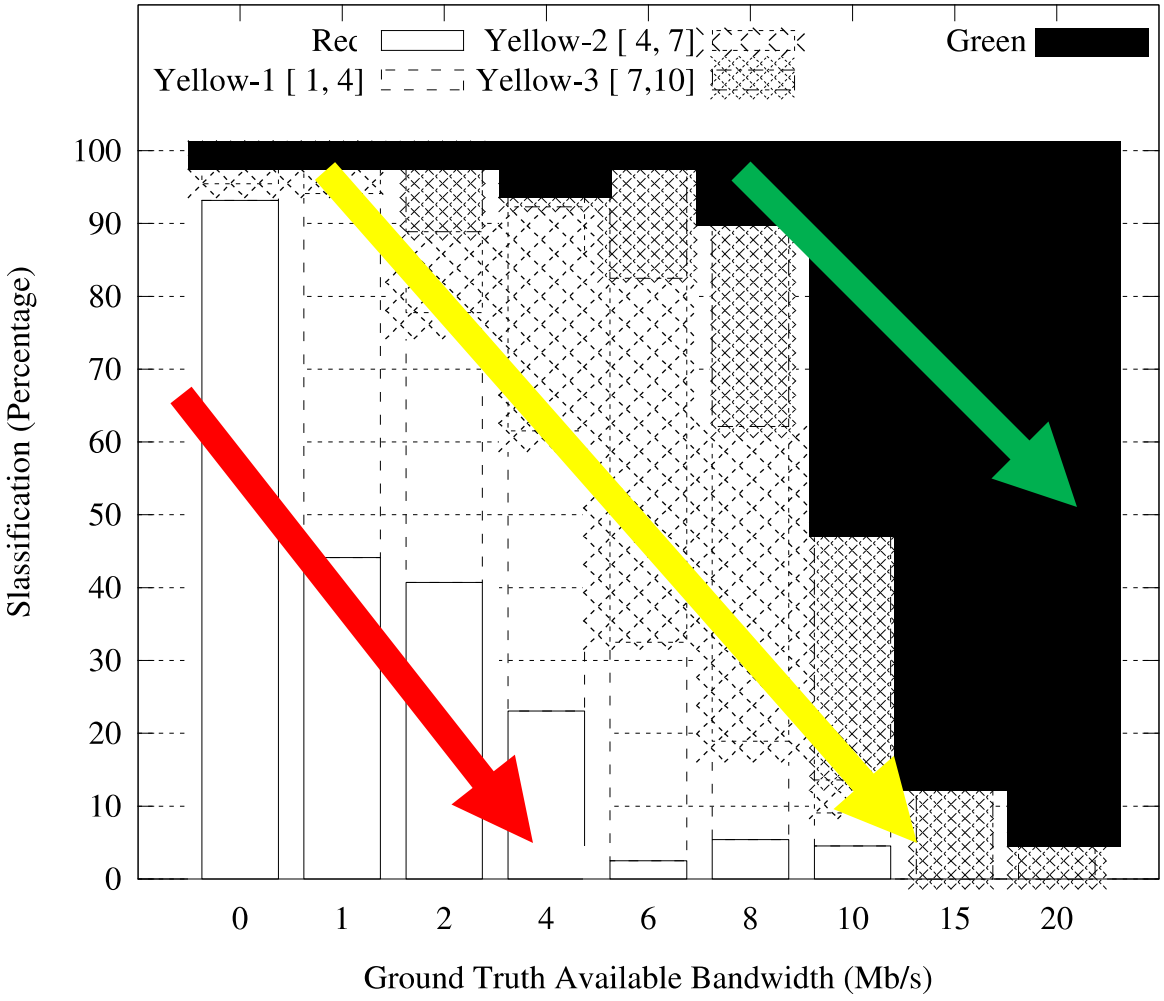
Performance

802.11n
2.4 GHz
UDP controlled links
40 ms RTT



Performance – Classification



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Deployment

- ND spring break
  - Incentivized participation
    - NetHealth study (500)
    - Approx. 100 unique devices
  - Client for FMNC
    - AirWatch
    - Android Play Store Beta
    - Throughput test + FMNC

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Data Summary

Table 3: Data Summary

Overall	Period	9 days
	Test Instances	47,380
	Packet Pairs	6,168,682
	Unique Users	96
	Unique SSIDs	154
	Unique APs	992
AT	Valid	43,236
	>10 Mb/s	71.2%
	Estimated Throughput	
	50th Percentile	20.38 Mb/s
	75th Percentile	41.17 Mb/s
	90th Percentile	57.89 Mb/s
FMNC AB	AB >10	60.7%
	AB = 0	7.2%
	PDR >0.9	82.7%
	Resolution Time	
	50th Percentile	123.2 ms
	75th Percentile	172.5 ms
	90th Percentile	239.8 ms
Cost	FMNC AB	4.1 GB
	iperf	1,100.9 GB

Highlights

Average B/W
20.38 Mb/s

Resolution Time
239.8 ms (90th Percentile)

Bandwidth Cost
250x savings vs. iperf

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Energy: 2.18 mAh for iPerf (10s) vs. 0.003 mAh for FMNC

Example Result (Simple HTML Output)

FMNC Test Result for 2016-03-24 18:22:35

User Profile	Client App	iOS
	Client ID	7CA750E1-79F8-4C81-94AC-C2D924DEC466
	SSID	ND-secure
	BSSID	d0:c2:82:f7:6e:1e
	Longitude	-86.2349233204928
	Latitude	41.7041357683612
FMNC Measurement	RTT (ms)	2.41122
	PDR	1
	Available Bandwidth (Mb/s)	> 10 Mb/s
	AB estimation Time (ms)	117.065
	Elasticity Index	0.027503
	Uplink Pearson Correlation	0.491399
Achievable Throughput	Download Size (MB)	7.2
	Download Time (ms)	1198
	Average Throughput (Mb/s)	48.0801

Questions?

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