ES2: Managing Link Level Parameters for Elevating Data Rate and Stability in High Throughput WLAN

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Preface

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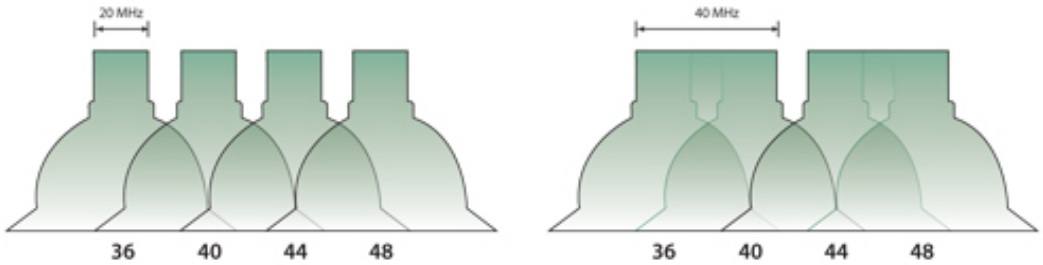

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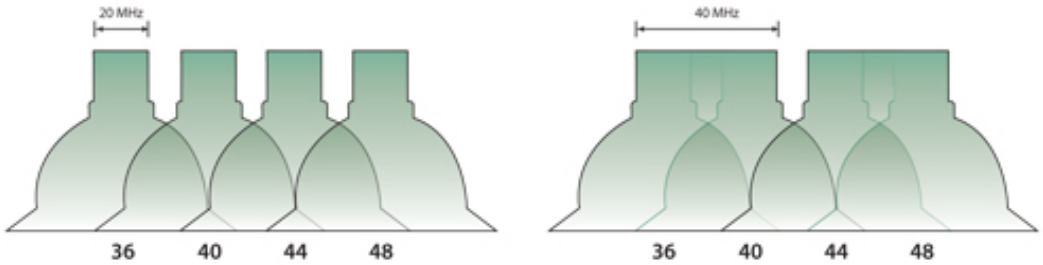

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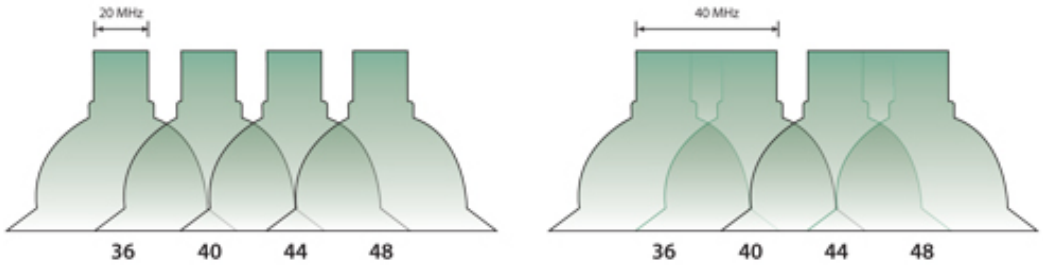

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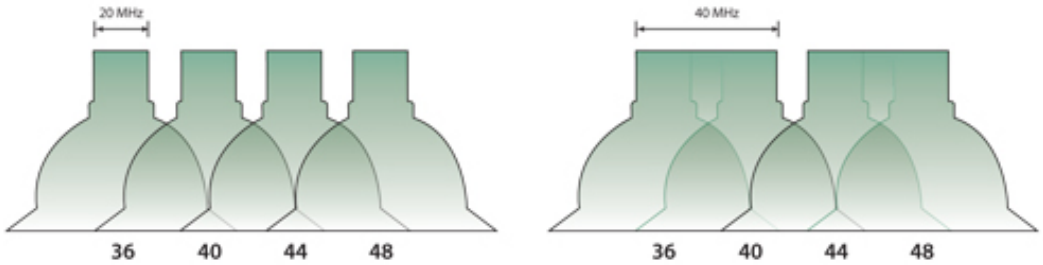

  - Advanced Modulation and Coding Schemes – Supports higher physical data rates
  - Frame aggregation and Block Acknowledgement – Reduce channel access overhead
  - Short Guard Intervals – Saves guard time when interference is less

Link Adaptation: What is the Best Link Configuration?

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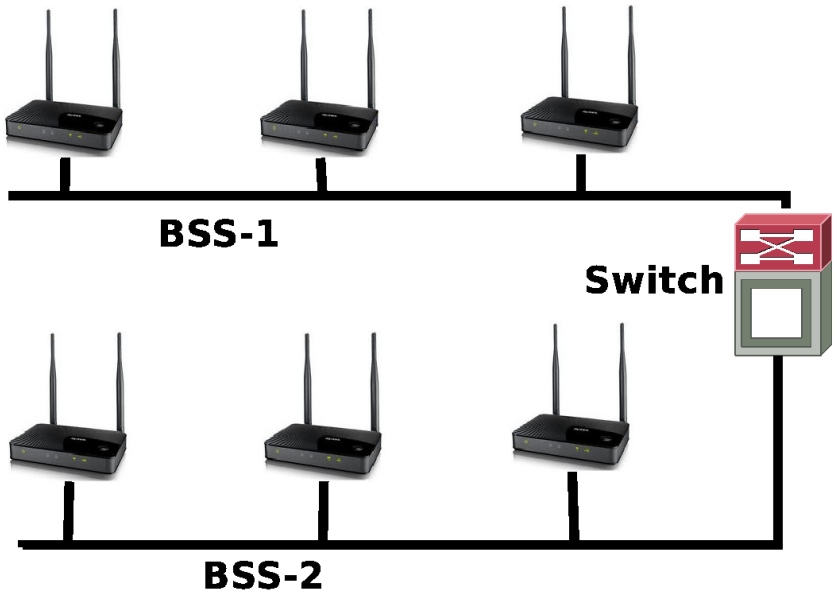
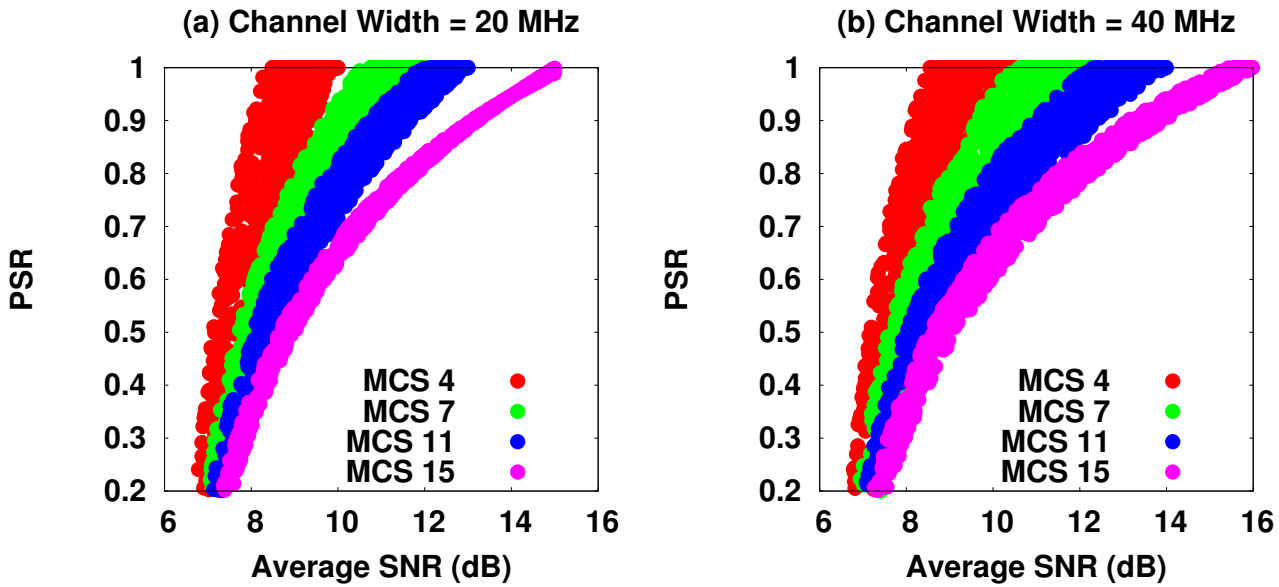
  - **Frame Aggregation:** Frame aggregation may result in high data loss due to channel interference

Some Observations from a Practical Testbed



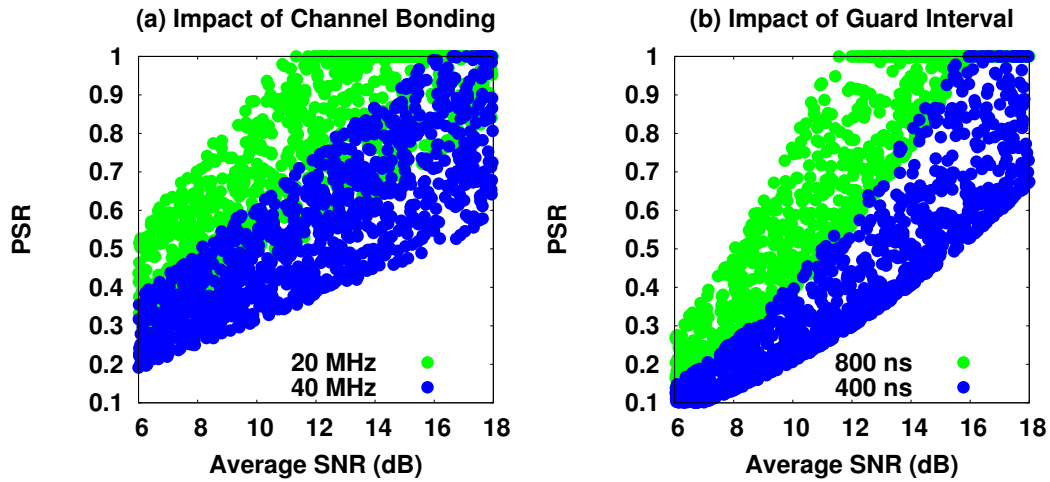
- Testbed Configurations:
  - Ralink RT-3352 Wireless Router-on-chip – supports IEEE 802.11n
  - 2×2 MIMO
  - Supports 20 MHz and 40 MHz at 5 GHz band – 300 Mbps physical data rate
  - Linux Kernel 2.4.12 – openwrt supported

Observation 1: Impact of Modulation and Coding



- Observations:
  - Low modulation and coding levels can sustain at low SNR region – provide better PSR compared to high modulation and coding values
  - High modulation and coding levels provide good PSR at high SNR region
  - PSR variation in significantly more in 40 MHz communication compared to 20 MHz communication.

Observation 2: Impact of Channel Bonding and Guard Intervals



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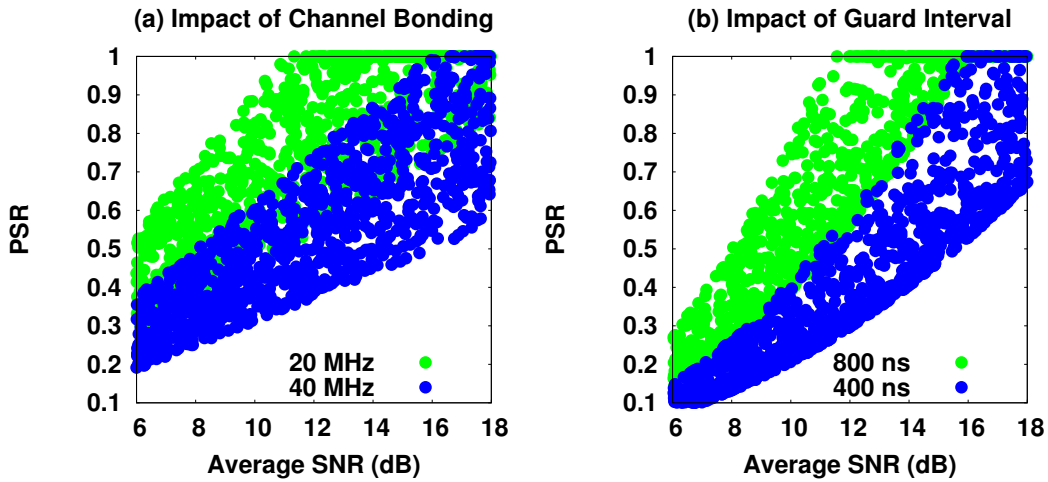


- Observations:
  - 40 MHz gets more affected due to external noise and interference
  - Short guard interval (400 ns) is effective for low interference scenario
- **We need to develop an adaptive link parameter selection mechanism based on channel condition...**

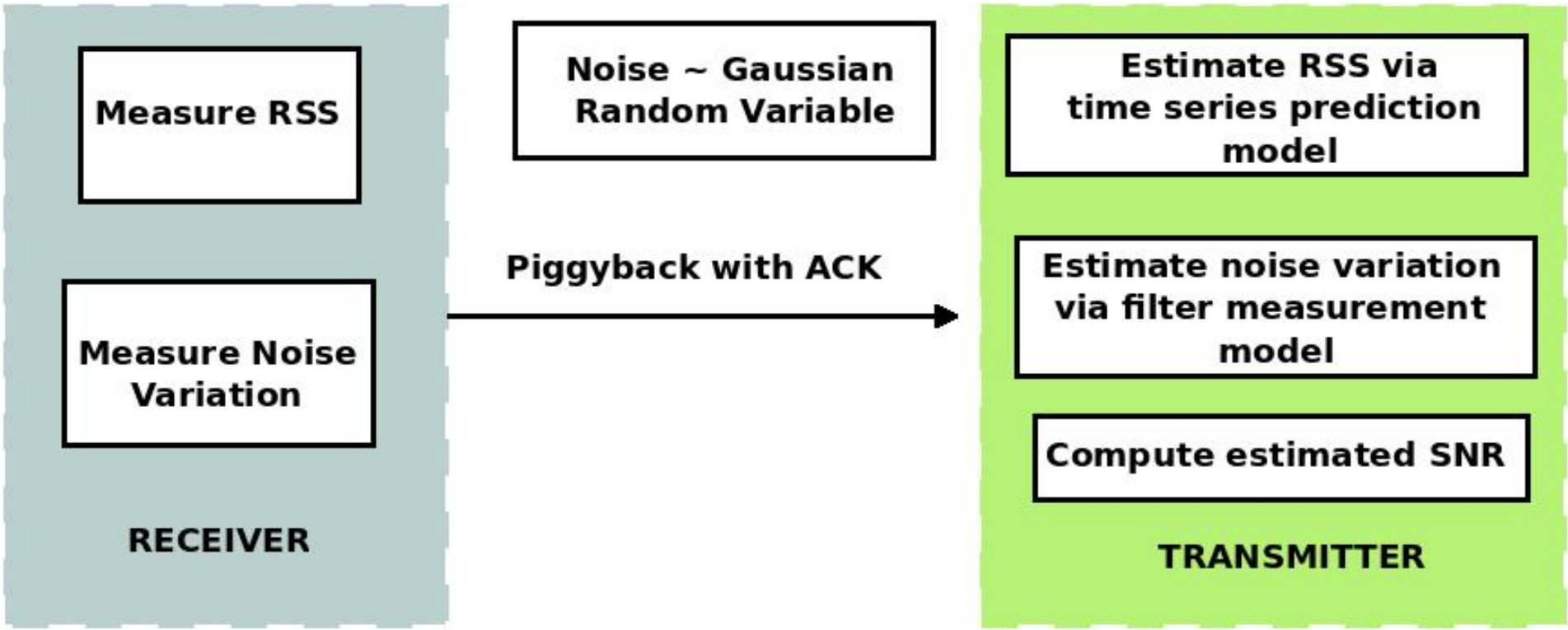
Solution Approach: Estimate, Sample and Select (ES2)

- A three step iterative process:
  - **Estimate** the SNR at transmitter from the measured received signal strength (RSS) at the receiver
  - **Sample** the feature sets based on the estimated SNR thresholds
  - **Select** the final data rate from the filtered samples

Estimation of SNR

- Estimation of SNR is non-trivial, because,
  - The noise level significantly depends on parametric settings (like number of spatial streams, channel width etc) $\rightarrow$ Simple subtraction of noise level from signal level does not work.
  - The transmitter needs to figure out link parameter settings, whereas SNR is measured at the receiver $\rightarrow$ SNR prediction is required at transmitter.
    - Piggybacking SNR does not work because the link parameter settings may change!

Estimation of SNR: A Kalman Filtering Approach



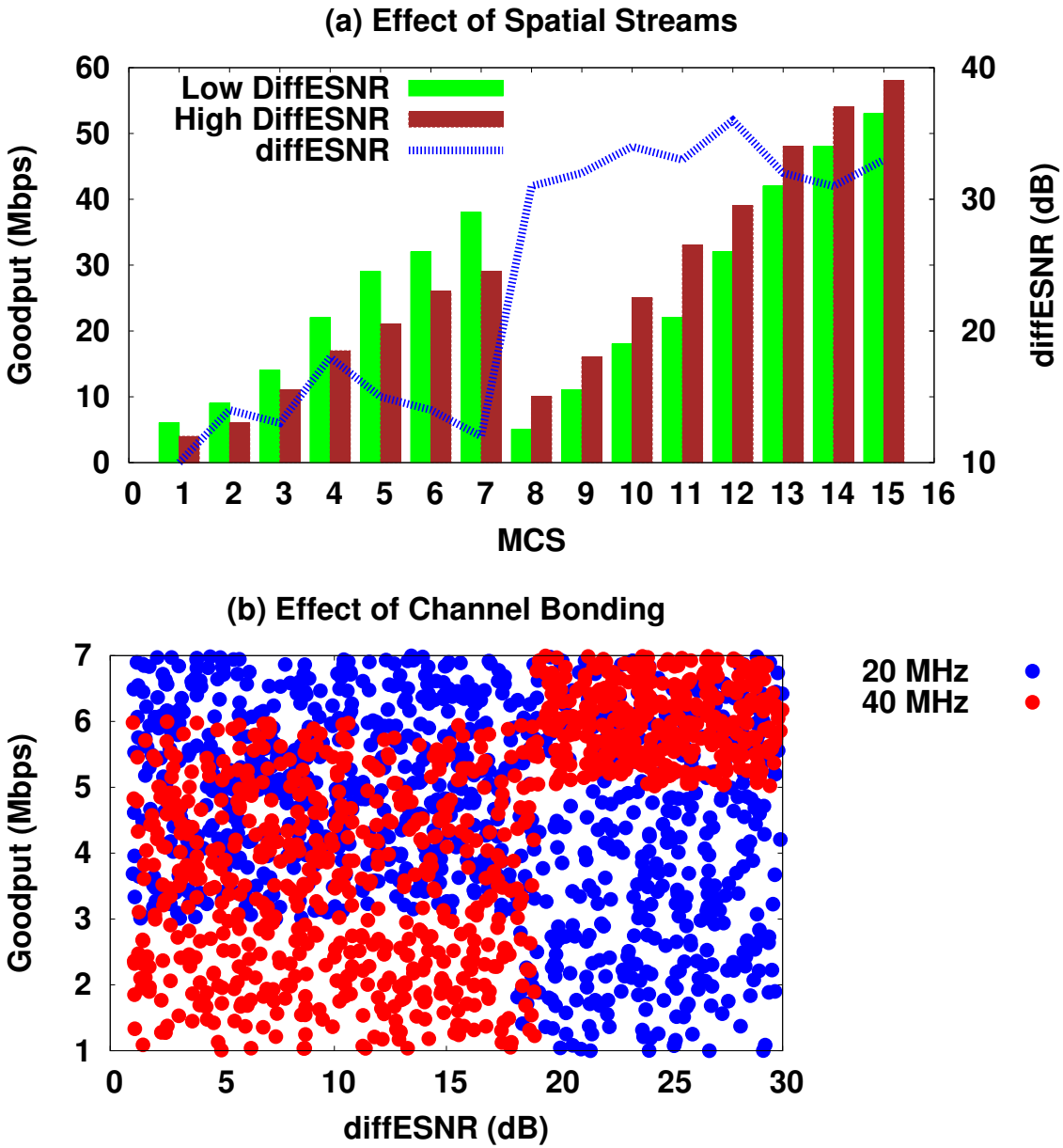
Sample Feature Set

- SNR is quite fluctuating and may not be a good choice for feature sampling.
- We use **diffESNR** –

$$\mathrm{diffESNR}_t = \mathrm{SNR}_t(|\mathrm{SNR}_t^2 - \mathrm{SNR}_{t-1}^2|)$$

- This captures SNR fluctuation as well – if fluctuation is more, some link parameter settings become unstable.

Impact of diffESNR



Estimate, Sample and Select (ES2)

- A three step iterative process:
  - Estimate the SNR at transmitter from the measured received signal strength (RSS) at the receiver
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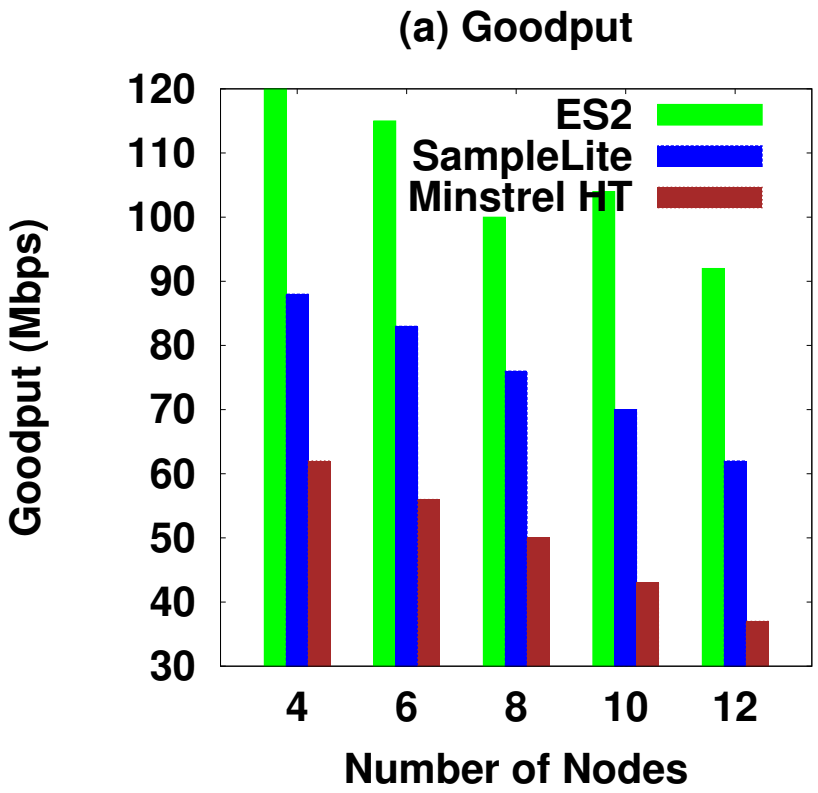
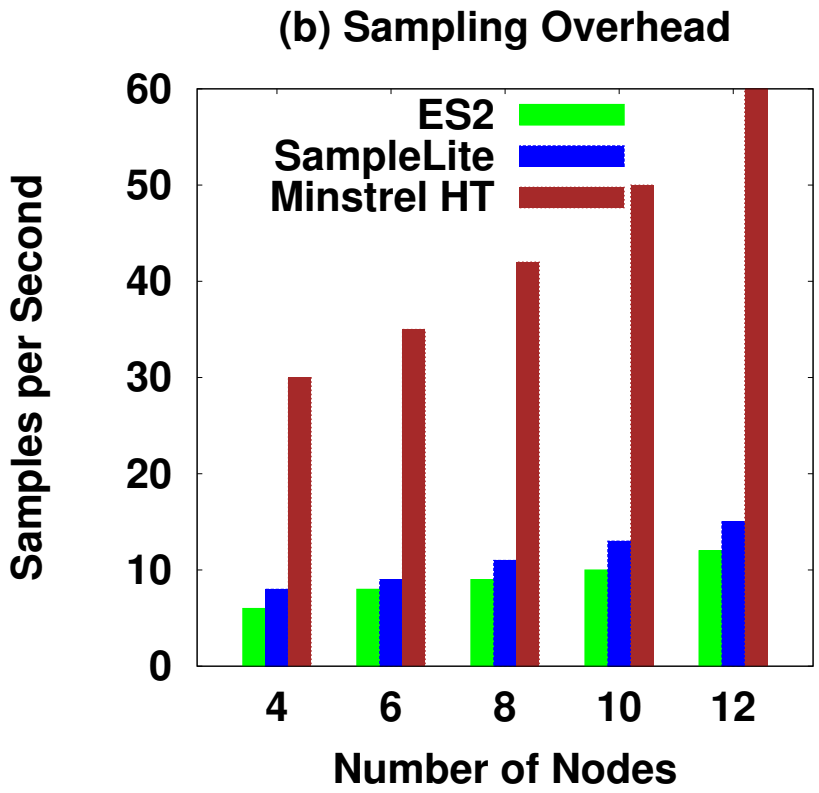
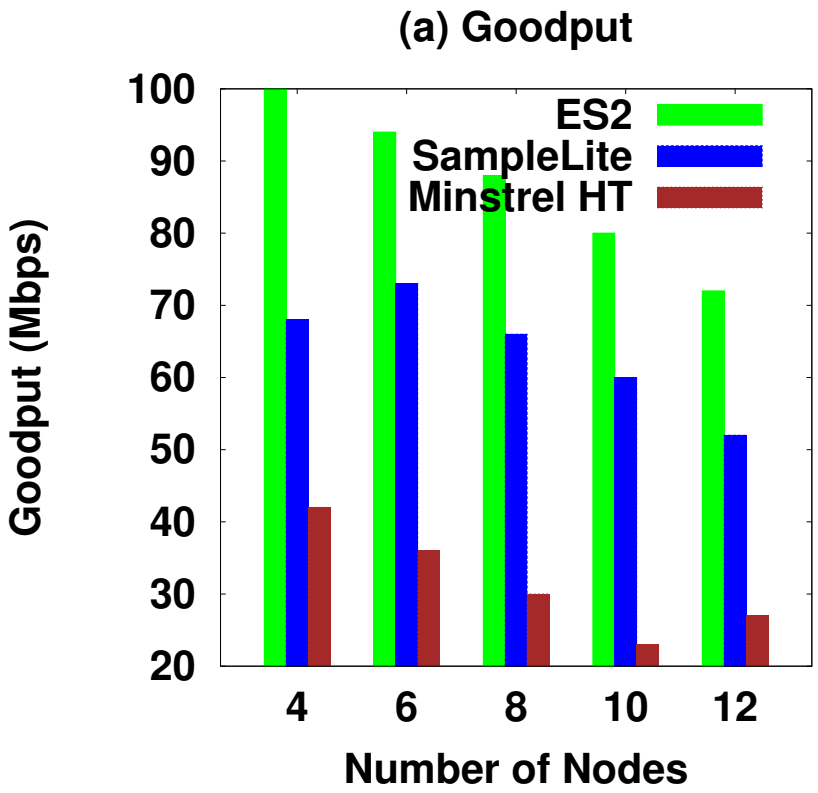
  - **Select** the final data rate from the filtered samples – We are left with only few options! Apply standard rate adaptation...

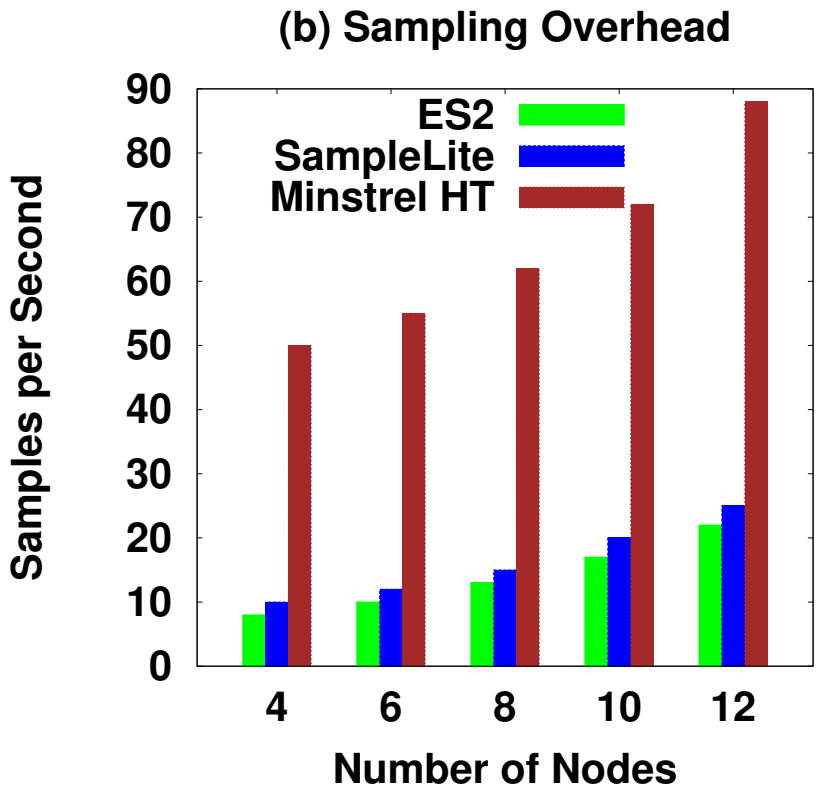
Protocol Performance: Static Network



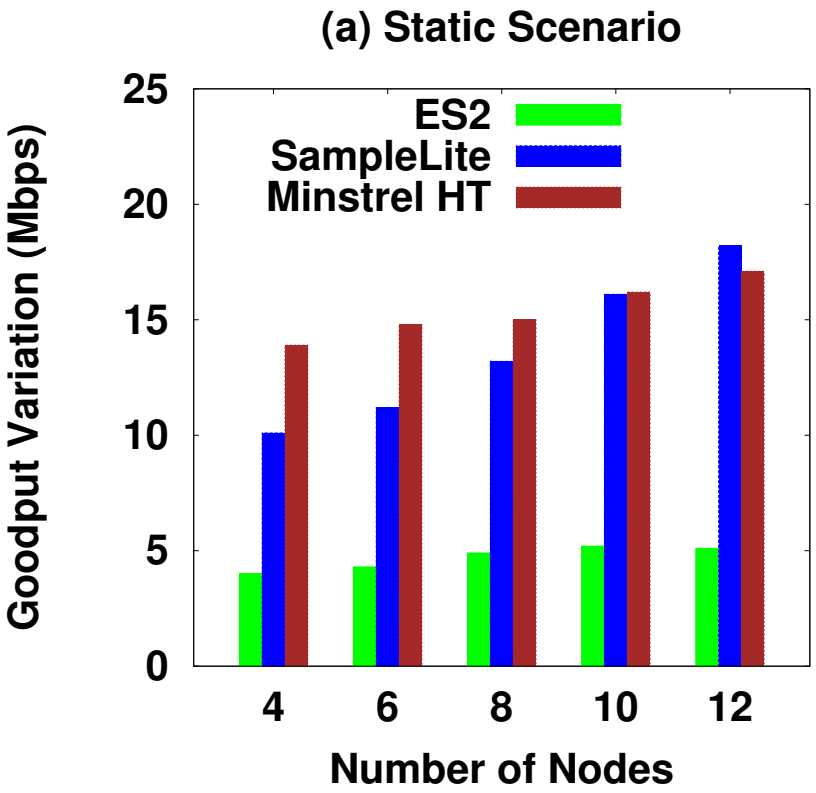


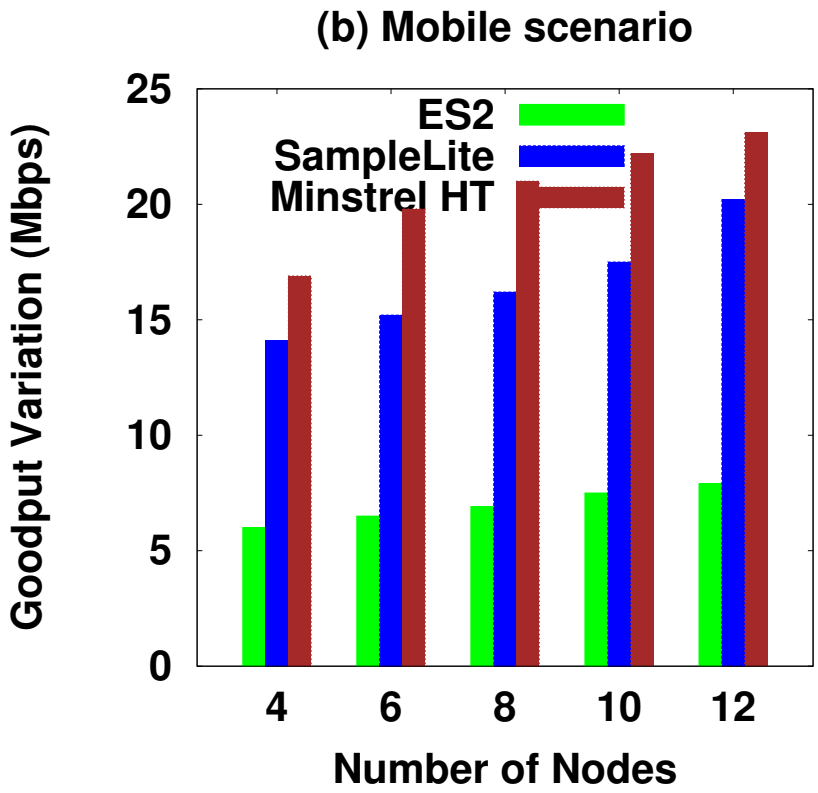
Protocol Performance: Mobile Network





Fairness: Average Link Goodput Variation





Concluding Remarks

- ES2 works well in pure IEEE 802.11n network, but the sampling does not work sometime in a mixed network (IEEE 802.11n + IEEE 802.11b/g)

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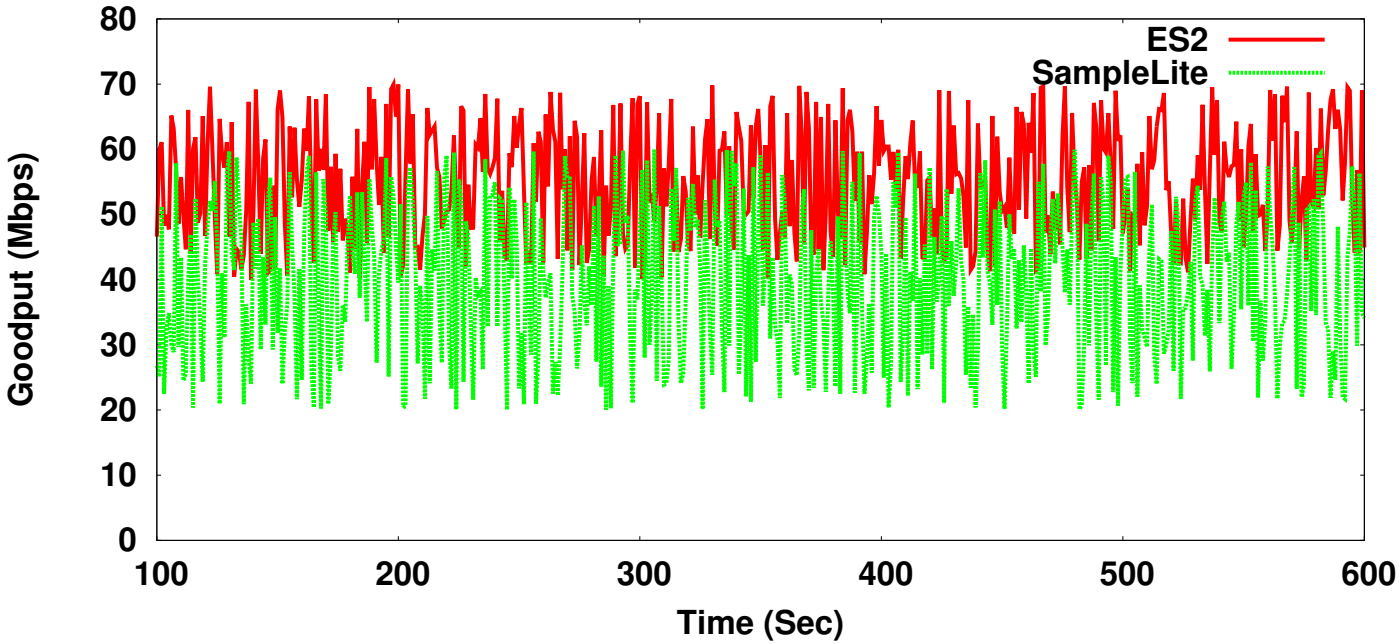

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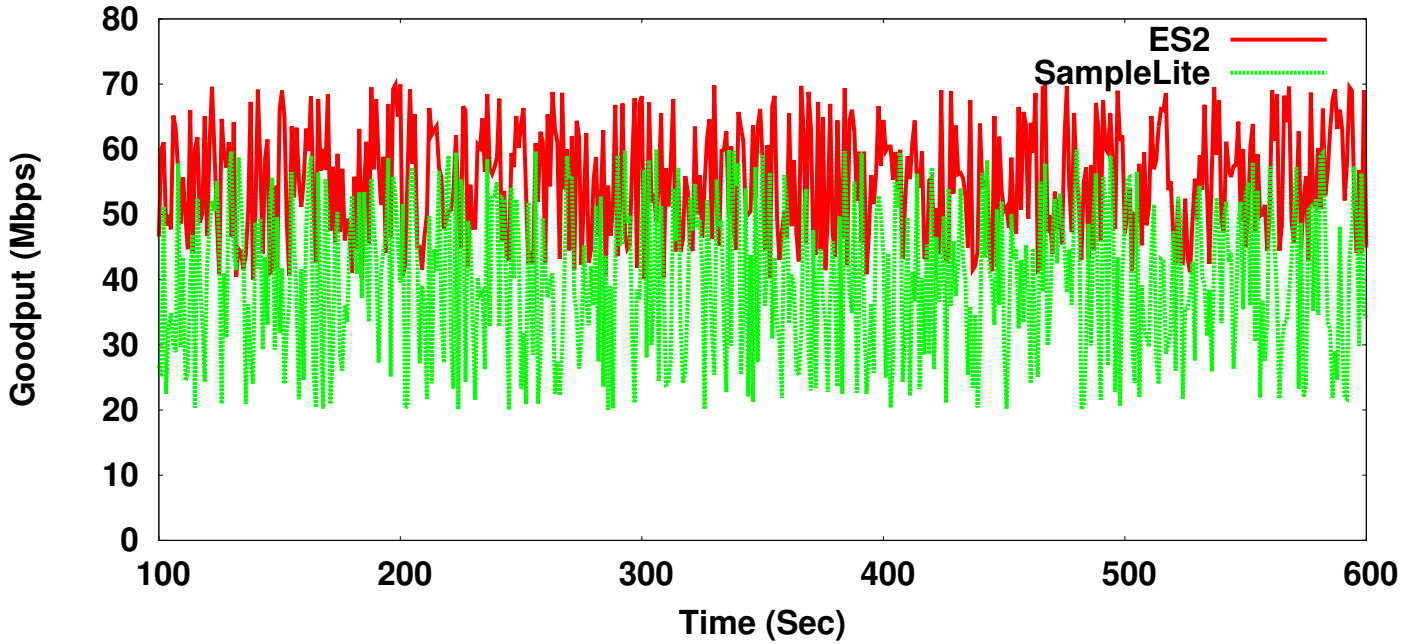

- Can we say something about the interoperability or backward compatibility?

Thank You