Enabling Wireless LAN Troubleshooting

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Outline

- Introduction – Motivation
- IEEE 802.11 Pathologies
- Detection Methodology
- Framework Evaluation
- Conclusion and Future Work

Introduction - Motivation

- Poor performance in home WLANs
  - An everyday phenomenon
  - Various causes often “unknown” to home administrators
  - Troubleshooting hard even to the experts

Introduction - Motivation

- Two approaches for diagnosing WLAN pathologies:
  - Application layer frameworks running over commercial WLAN devices
    - Lack of accuracy – Better applicability
  - Driver modifications or even custom hardware for diagnosing in PHY/MAC
    - Better accuracy – Lack of applicability

Introduction - Motivation

- Our proposal : Bridge the gap
  - Take advantage of default driver-level information
    - Rate control algorithm statistics exported to user-level for debugging
  - Define the metrics able to characterize each considered pathology
    - Extensive experimentation in controlled environments
  - Incorporate our findings in a user-level detection framework
    - Evaluate its performance by quantifying the detection accuracy

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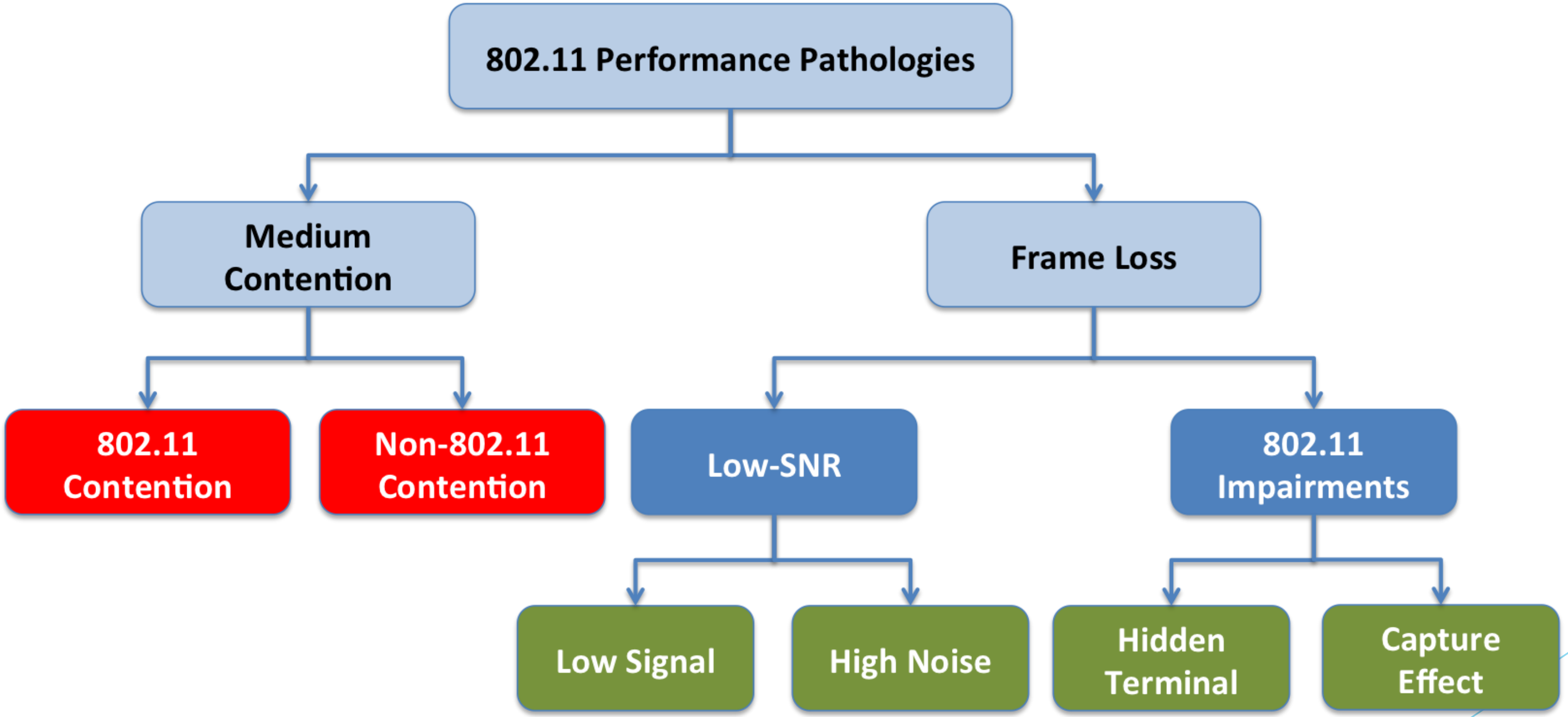
IEEE 802.11 Pathologies

- The pathologies categorization that we followed is based on the way 802.11 protocol functions
  - Carrier Sense (Backoff)
  - Retransmissions policy (CW)
- Medium Contention
  - Multiple 802.11 devices competing for channel access
  - Non 802.11 devices (Microwave ovens, Wireless Cameras, etc.) operating in 2.4 GHz band
- Frame Loss
  - Low-SNR conditions due to Low Signal Power or due to High Noise
  - Symmetric and Asymmetric (Capture Effect) Hidden Terminal

IEEE 802.11 Pathologies



MAC-Layer Statistics

- Our approach is based on two key metrics evaluated across bitrates:
  - Normalized Channel Accesses (NCA): CA/MCA
    - CA: Channel Accesses per sec
    - MCA: Model-Based Channel Accesses per sec
  - Frame Delivery Ratio (FDR): ST/CA
    - ST: Successful Transmissions per sec

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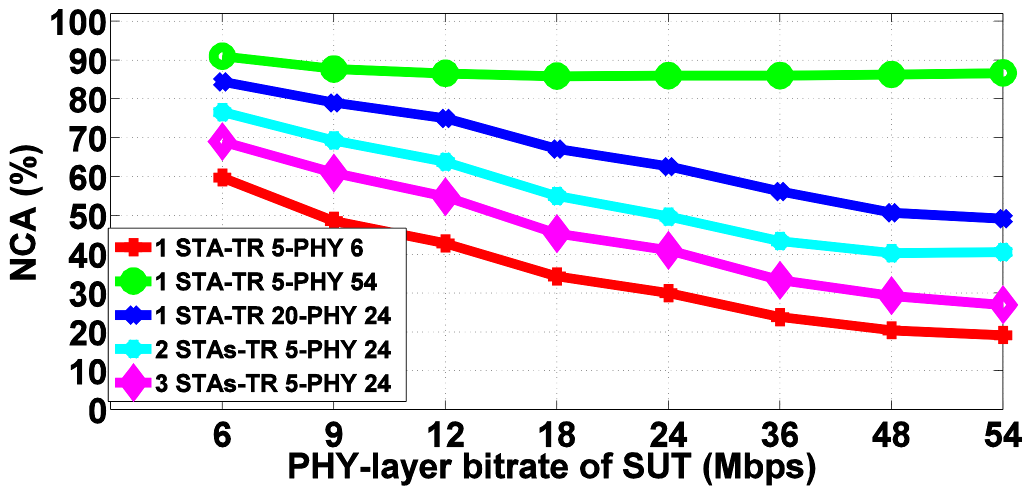
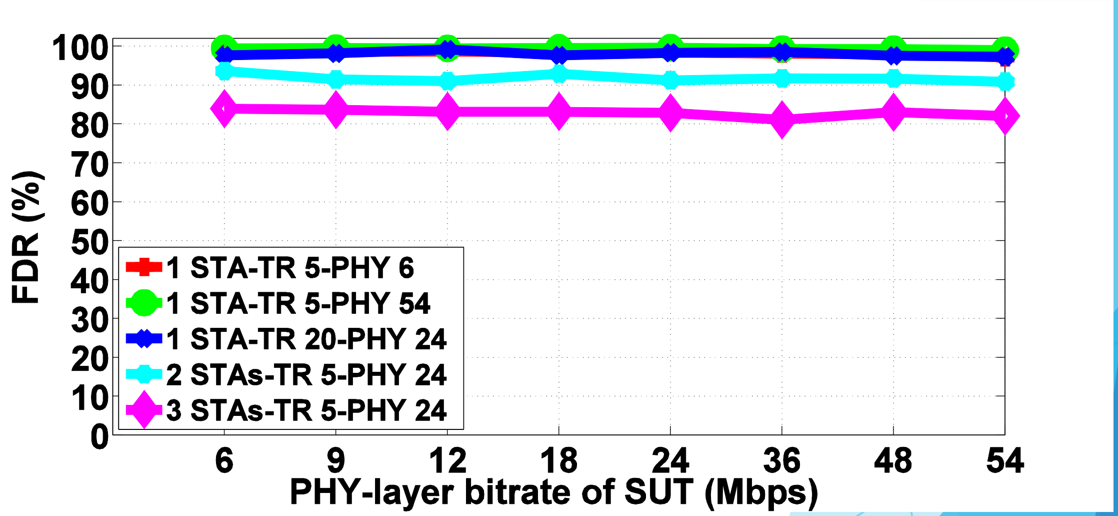
Detection Methodology

- Initial throughput test for performance estimation
  - Throughput under 80% of max -> Triggers detection mechanism
- Characterize evolution of key metrics across bitrates: NCA and FDR
- Identification of trends across bitrates (Theil-Sen Estimator)
  - Increasing, Decreasing, No Trend and Constant

Detection Methodology

- Contention with 802.11 devices

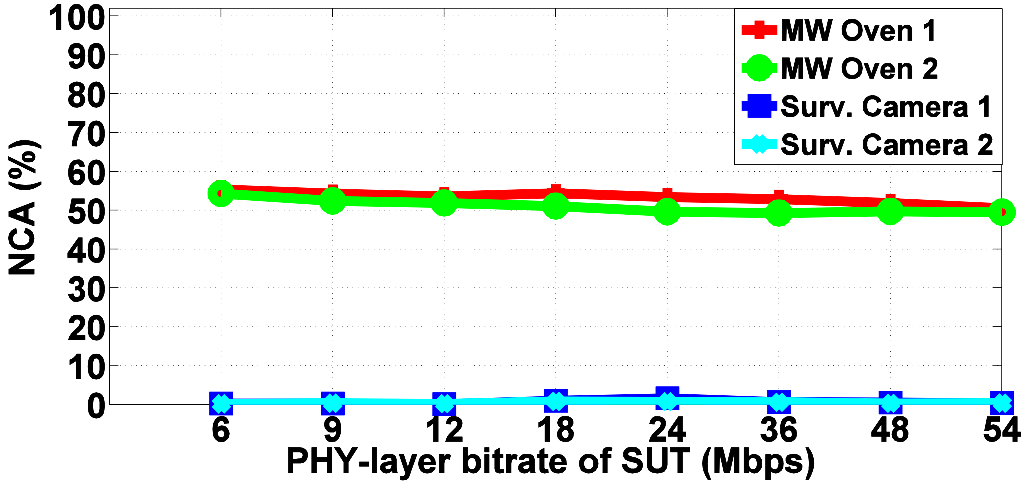


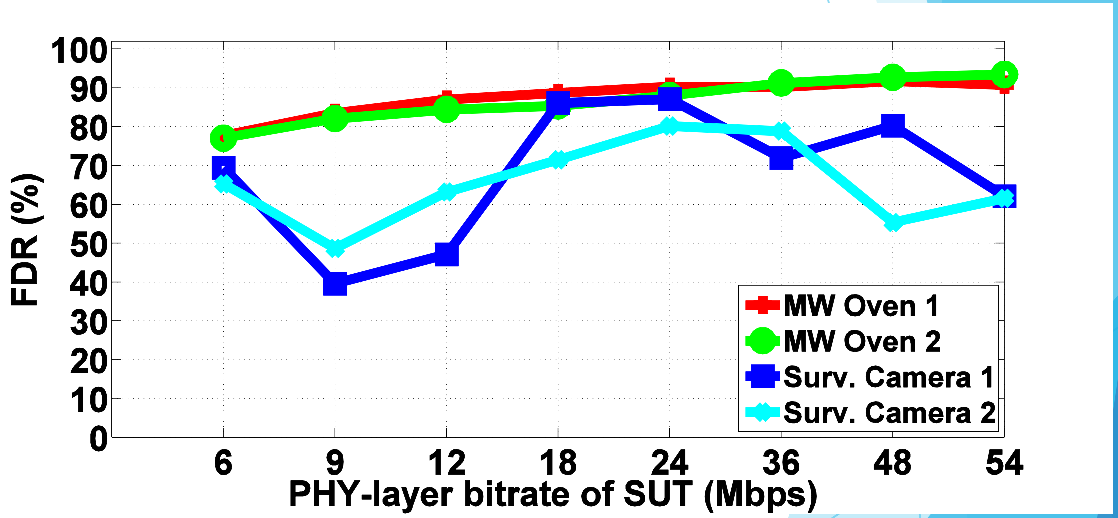


- Bitrate diversity leads to decrease in NCAs while FDR remains constant

Detection Methodology

- Contention with non-802.11 devices

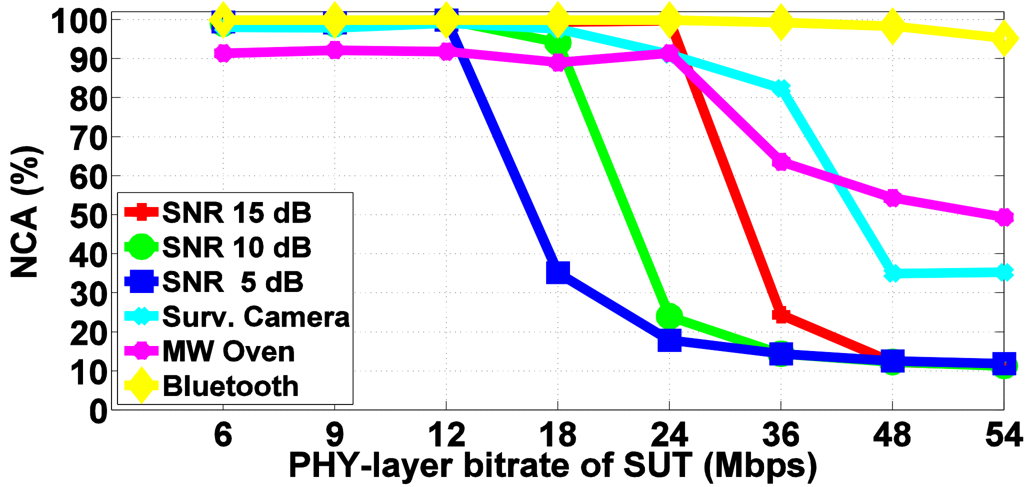


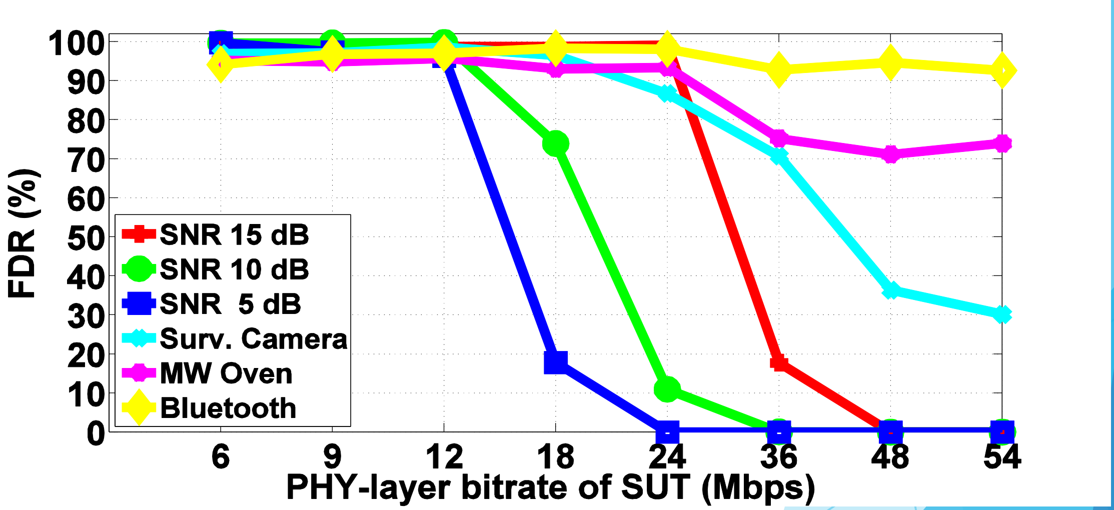


- Constant performance of NCA metric
- Increasing FDR in case of MW – Fluctuation in case of Camera due to almost zero transmission attempts

Detection Methodology

- Low SNR (Low Signal and High Noise)

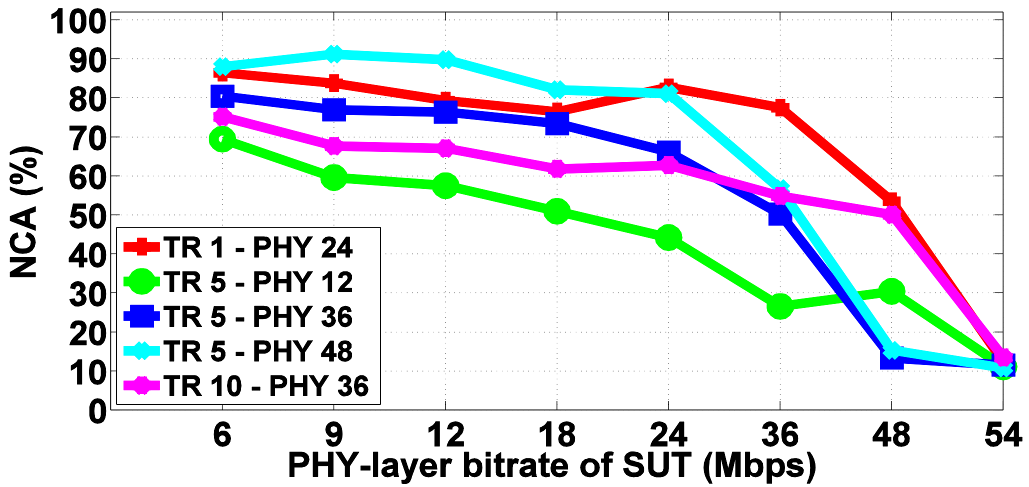


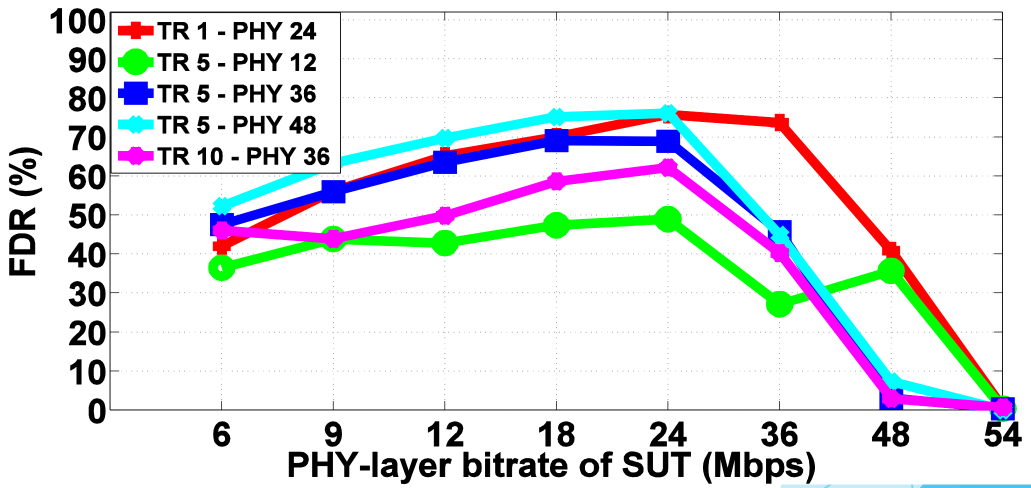


- Decrease in NCA caused of CW doubling
- Decrease in FDR in complex bitrates

Detection Methodology

- Hidden Terminal

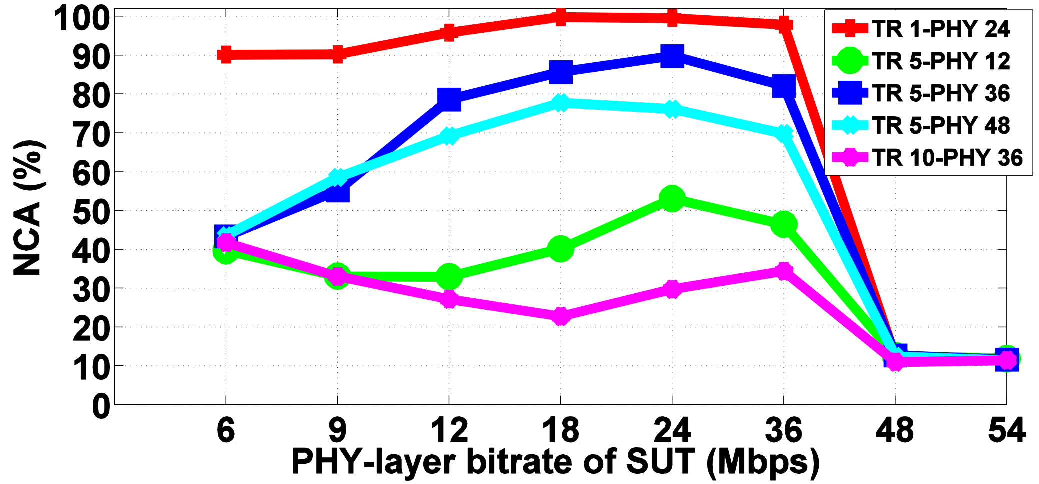


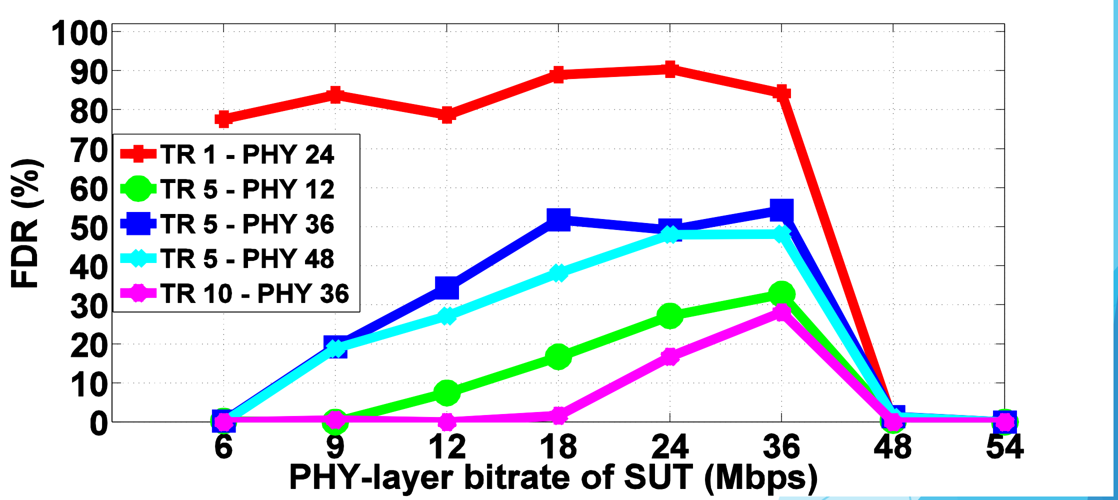


- NCA decreases due to Low SNR coexistence
- A small increase due to shorter duration of frames followed by a decrease in FDR (No Trend)

Detection Methodology

- Capture Effect





- Similar to Hidden Terminal but heavier impact leads to no trend in both NCA and FDR

Detection Methodology

- Summarizing

		Frame Delivery Rate (FDR)			
		Constant	**No Trend**	**Increasing**	**Decreasing**
Normalized Channel Accesses (NCA)	**Decreasing**	802.11 Contention	Hidden Terminal	Non-802.11 Contention DC < 1	Low SNR
	No Trend		Capture Effect		
	Constant		Non-802.11 Contention DC = 1		

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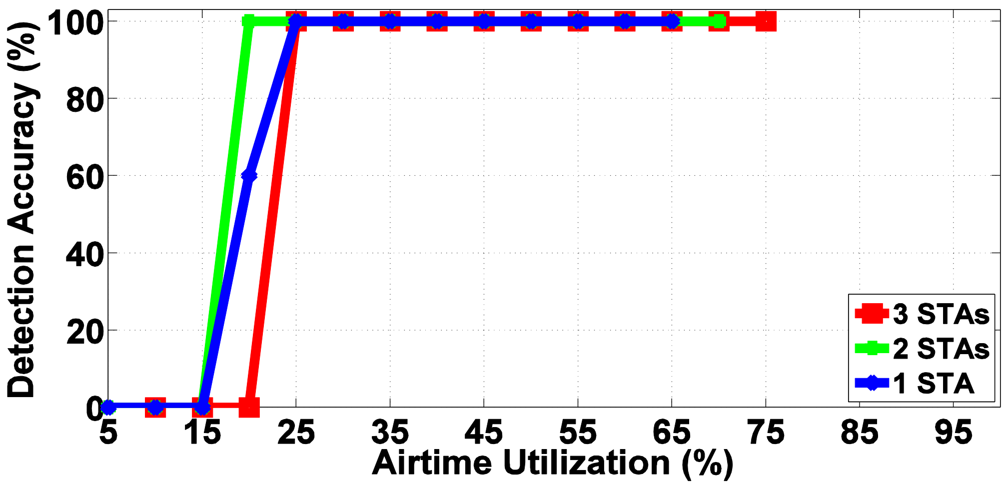
Framework Evaluation

- Contention
  - One, two and three contending stations
  - Varying PHY bitrates
  - Varying traffic loads



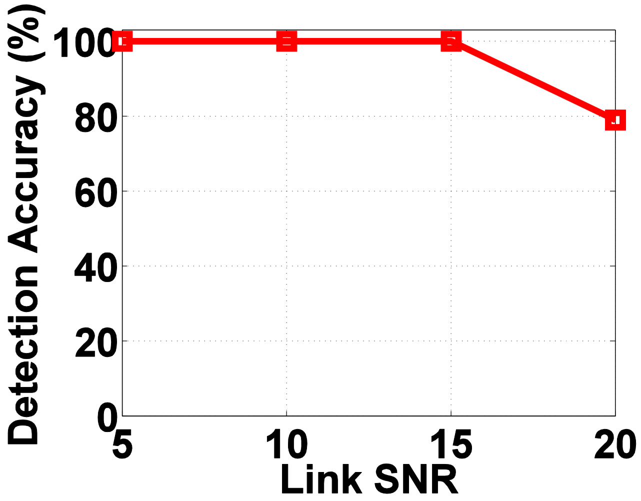
  - Detection accuracy of 100% in cases of performance degradation

Framework Evaluation

- Frame Loss
  - Evaluation Link
    - 20 different locations
    - 4 different levels of transmission power
    - Resulting in 80 different scenarios
  - Interfering Link
    - Fixed location
    - Varying PHY rate
    - Varying traffic loads

Framework Evaluation

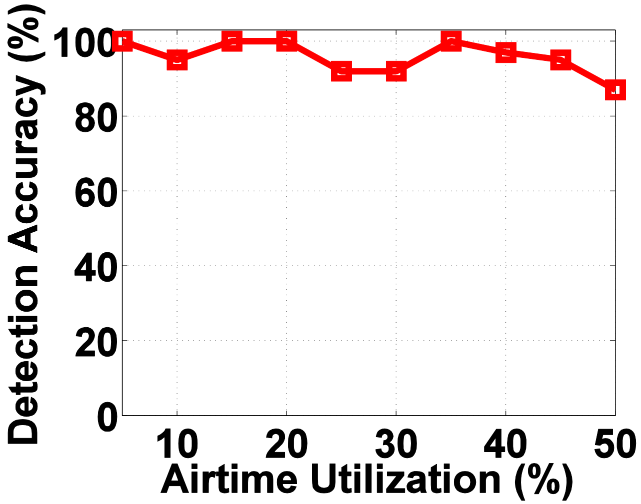
- Low SNR
  - Evaluation when Interfering Link is off



  - 100% accuracy until SNR is not considered Low

Framework Evaluation

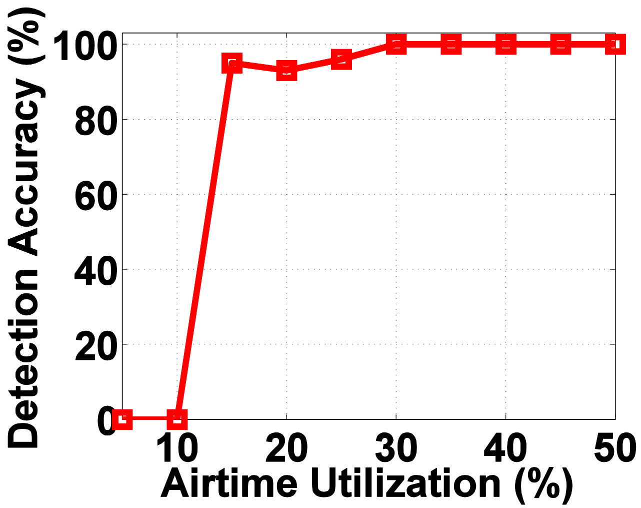
- Hidden Terminal
  - 4 locations exposed to Hidden Terminal



  - Detection Accuracy > 85% for varying Airtime Utilization of Hidden Link

Framework Evaluation

- Capture Effect
  - 9 locations exposed to Capture Effect



  - Low Airtime Utilization leads to similar impact as of Hidden Terminal – Failure in detection

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Conclusion and Future Work

- Based on MAC-layer statistics exposed to user-level
- Defined the key metrics able to characterize common 802.11 pathologies
- Developed our application-level framework for identifying trends of metrics in presence of a pathology
- Achieved high accuracy of detection

Conclusion and Future Work

- Extension of our framework for detection in presence of multiple pathologies
- Large-scale evaluation in real-world environments
- Passive detection for reducing overhead

Thank you!