

Automating Cross-Layer Diagnosis of Enterprise 802.11 Wireless Networks

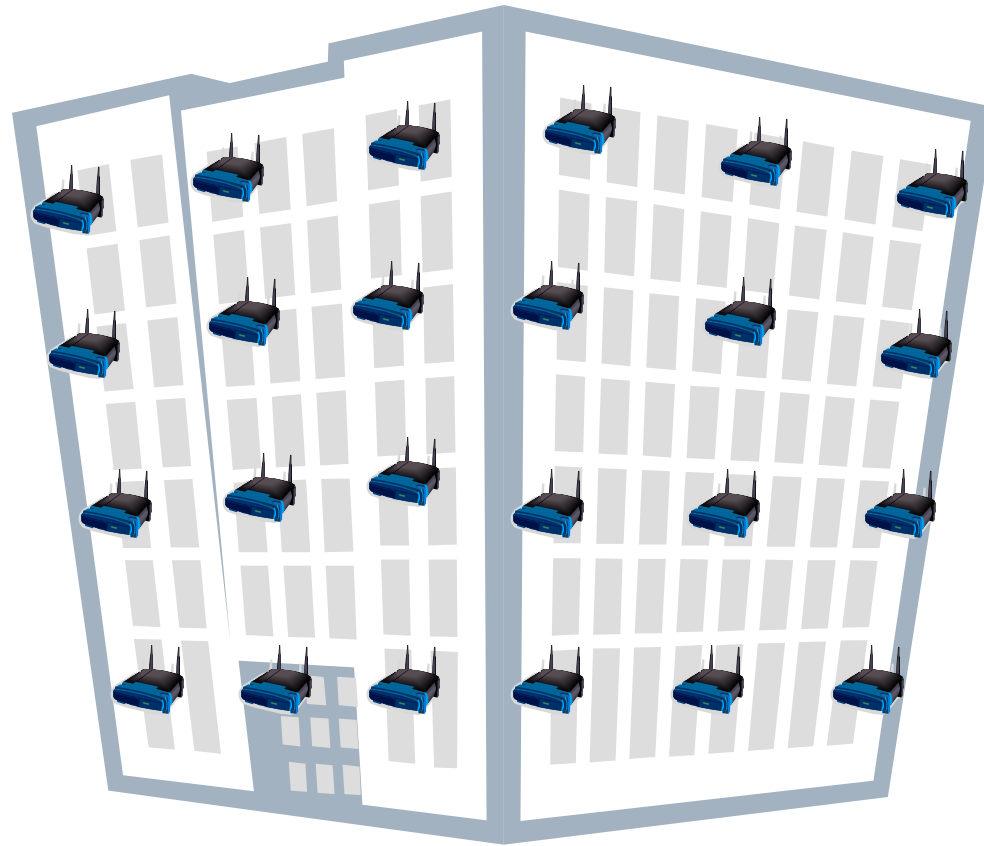
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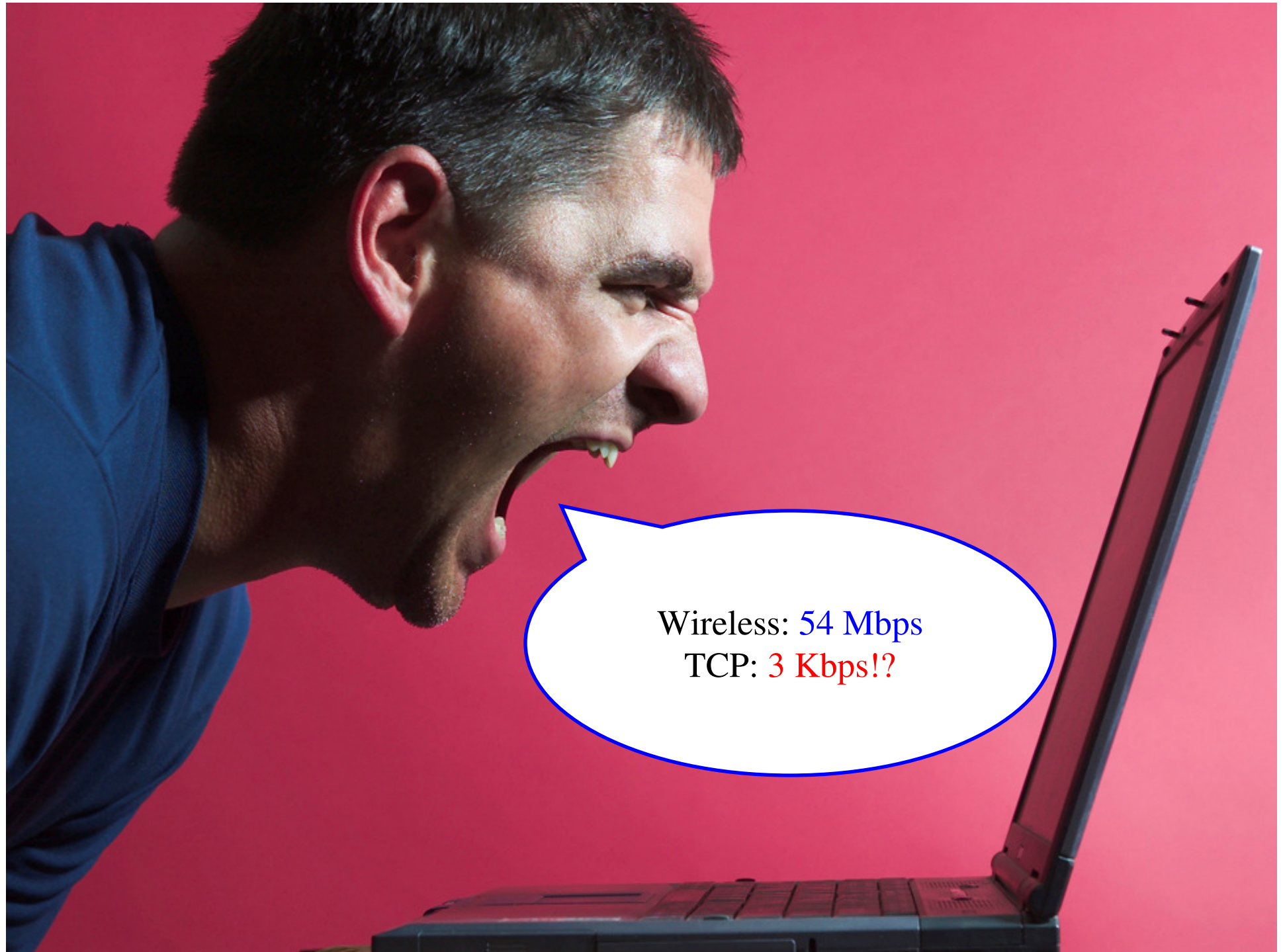
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The Enterprise 802.11 Network



Blanket coverage = fast and reliable connection?



Wireless: 54 Mbps
TCP: 3 Kbps!?

Our story at UCSD CSE

SSH is dog
slow!?

...

Cannot
connect in the
last hour!

...

Disconnected
every 5min!

...



Why is it hard to figure out?

- Problems can be anywhere
 - Across layers – protocols
 - Software incompatibilities – implementations
 - Transient or persistent - time
 - Radio propagates in free space and across channels – locations/frequencies
 - APs bridge wireless and wired worlds – infrastructure
- To diagnose the root cause
 - Gather data everywhere
 - Analyze across all layers/interactions
 - Time-consuming task for human



Sys Admin

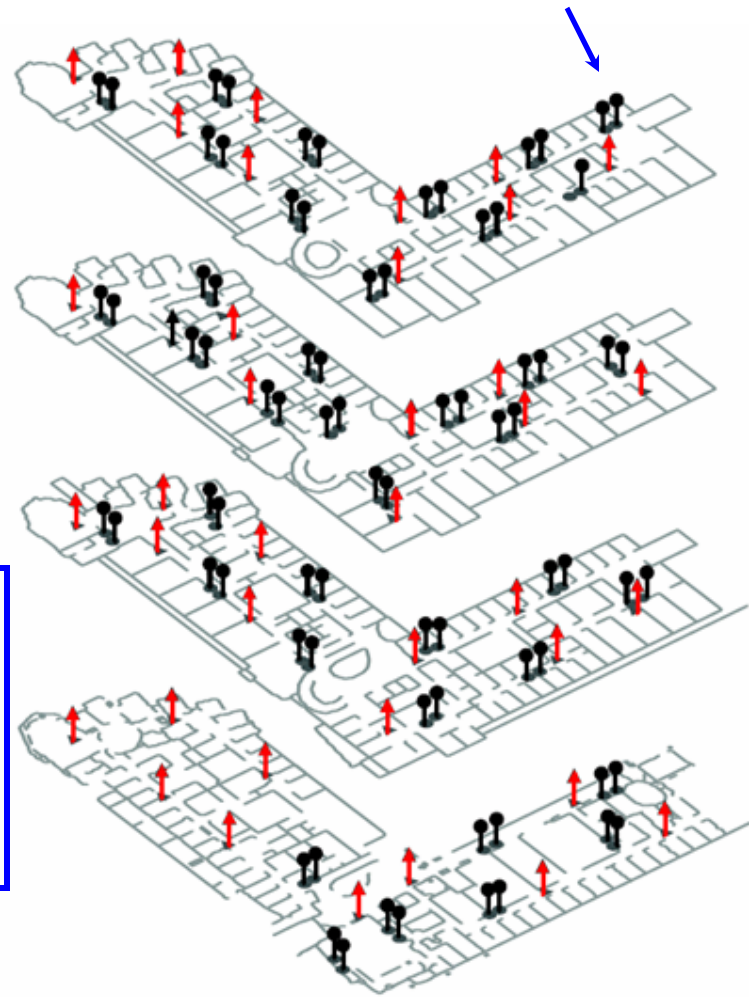
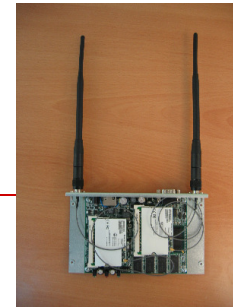
Our goal

- ❑ Automate the diagnostic process to respond to users and admins
- ❑ Have the admins spend **less time diagnosing** and **more of their time fixing**

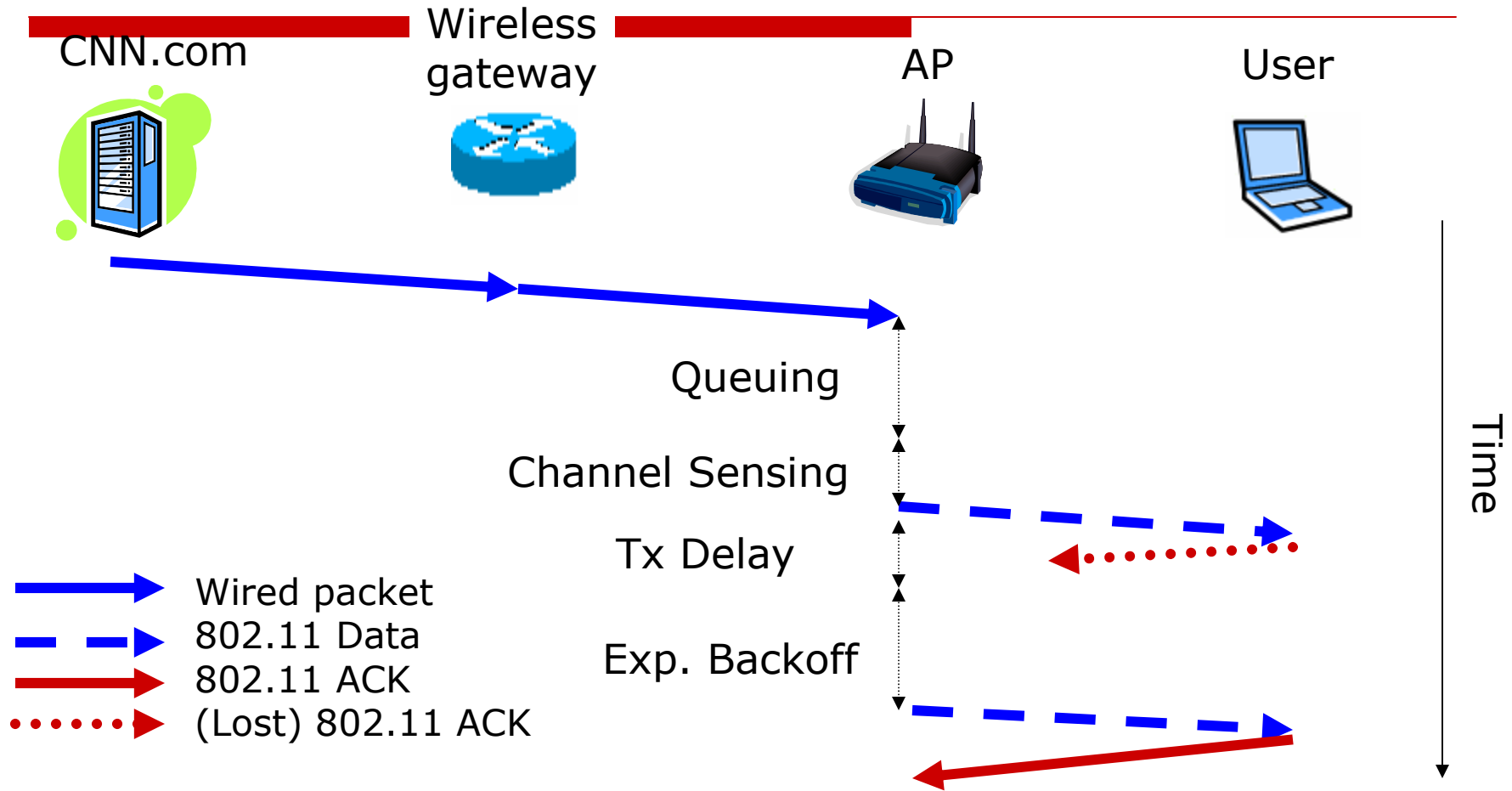
Our approach

- Jigsaw: Monitor the **whole** wireless network [SIGCOMM06]
 - Overlay existing WiFi with passive monitors
 - Trace all packets across location, frequency, time

- Model mobility costs
 - Start-up/roaming overheads
- Model per packet dynamics
 - Infer per packet delay and loss causes
 - Essential for TCP analysis



The journey of a packet in 802.11

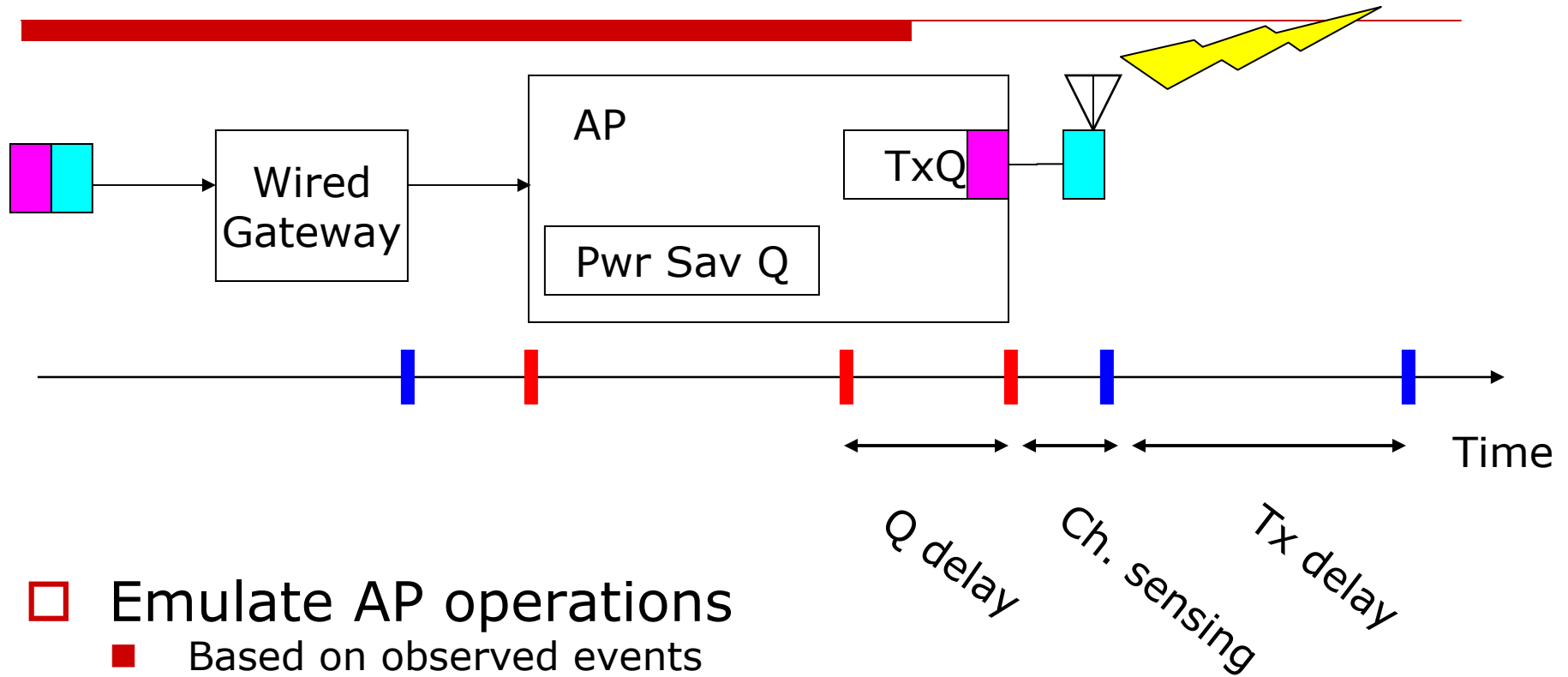


□ Challenge: delays need to be inferred

■ Impractical to instrument the APs and all the clients

■ Most devices do not support such fine-grained measurements

Modeling 802.11 packet delays



□ Emulate AP operations

- Based on observed events
 - At the gateway
 - Transmissions in the air

□ Infer when a packet ...

- Head of TxQ
- Scheduled to TxQ
- Received by the AP

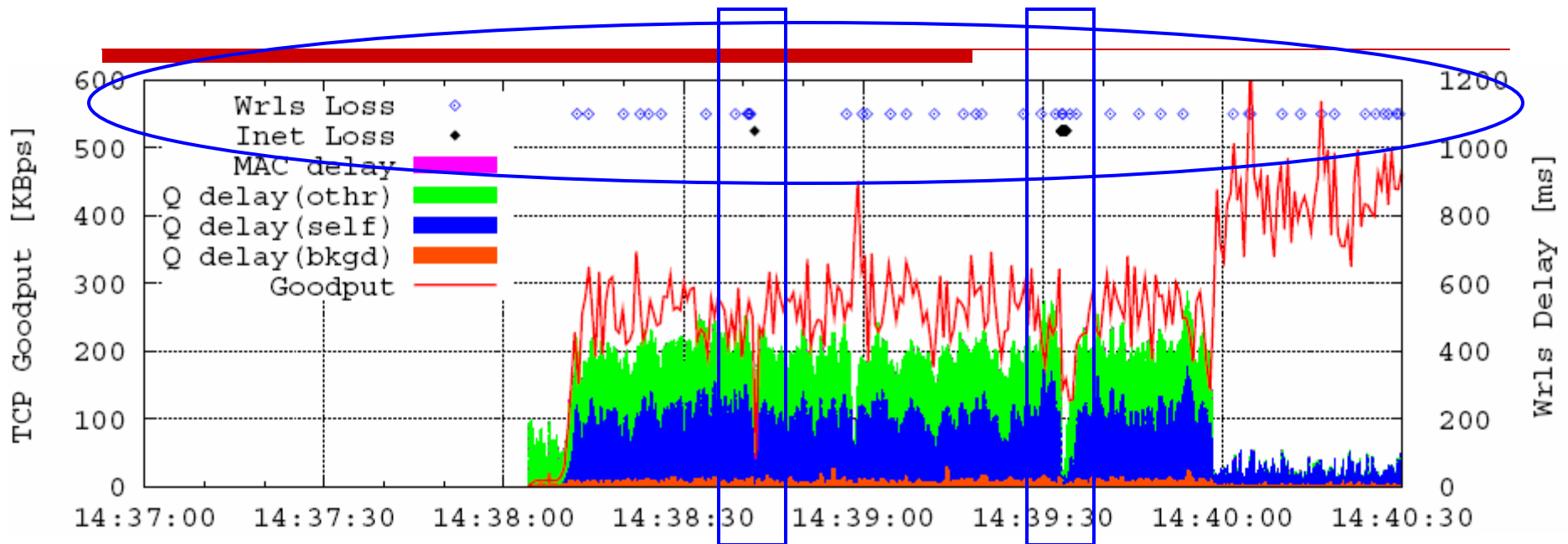
■ Observed Event

■ Modeled Event

Insights

- Model AP-generated packets
 - Observe the request and response, e.g., scan
- Inferring critical configurations
 - By packet timings
 - From product/802.11 specs
- Verification
 - Delay distributions
 - Controlled experiment
- Experience
 - Vendors do not always follow the specs
 - We can model Proxim/Cisco/Atheros APs with slight modifications

Applying 802.11 delays to TCP diagnosis

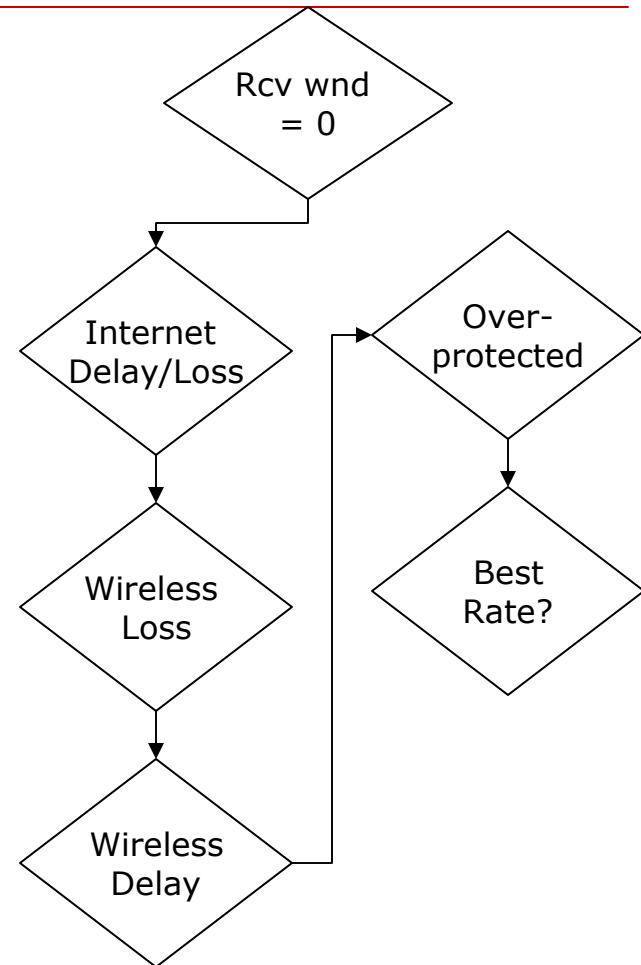


□ Ticket

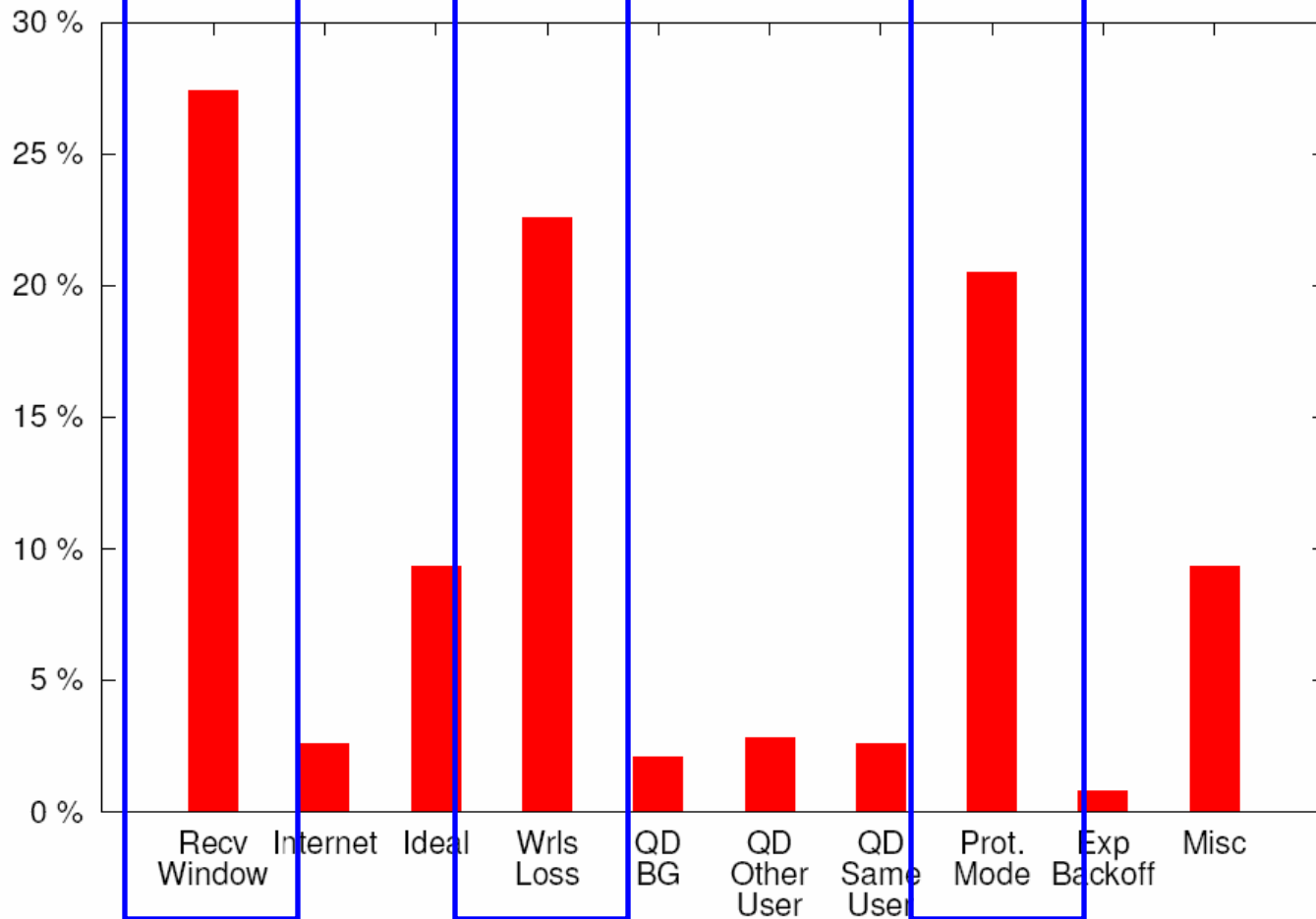
- User A complains about download performance in spite of having 54Mbps 802.11g connectivity
- Another 2 users are downloading large files through same AP from local UCSD site
- Performance of user A is limited by sharing the AP with other users

Bulk TCP performance problems

- ❑ Measure bulk TCP performance bottlenecks
 - Compares actual goodput with modeled ideal goodput [JP98]
- ❑ Blame Model
 - Is connection reaching optimal rate?
 - Is receiver window ever filled up?
 - Is Internet the bottleneck if we remove wireless delay/loss?
 - Is Wireless loss/delay the bottleneck?
 - Is per packet overhead too large?



UCSD CSE bulk TCP problems



The per-packet analysis and blame model capability allow admins to focus on major problems



Conclusions

- Diagnosing Enterprise wireless is challenging
 - Need to account for many factors
 - Need to automate the process
- It is possible to infer per packet dynamics to find root causes
 - Fine-grained delay breakdowns
 - Automatically assign root causes
- Our experience at UCSD
 - Various problems occur, no single anomaly
 - Many vendor implementation issues
- Work-in-progress
 - A complete automatic diagnosis system

Q & A

- Live traffic monitoring
<http://sysnet.ucsd.edu/wireless/>
- Also in our paper
 - What takes your laptop 1 minute to connect every time
 - Why active scanning can be in-efficient and cause severe hidden terminal problems

