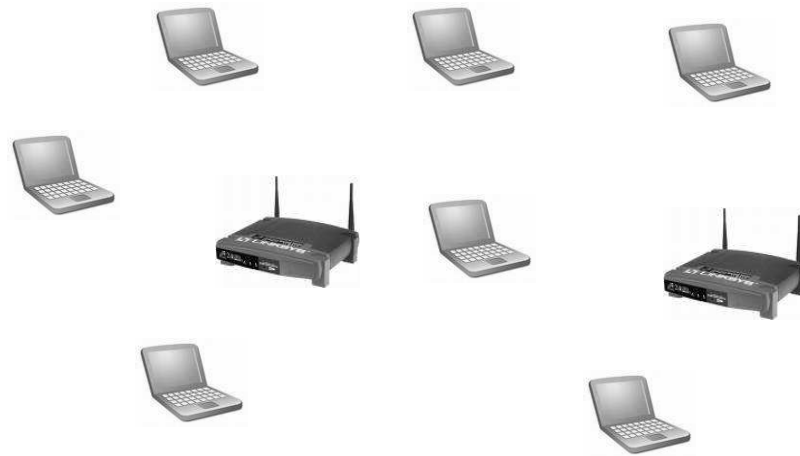# Analyzing the MAC-level behavior of wireless networks in the wild

Ratul Mahajan
(Microsoft Research)

Maya Rodrig, David Wetherall, John Zahorjan
(University of Washington)

Understanding the MAC of an operational network

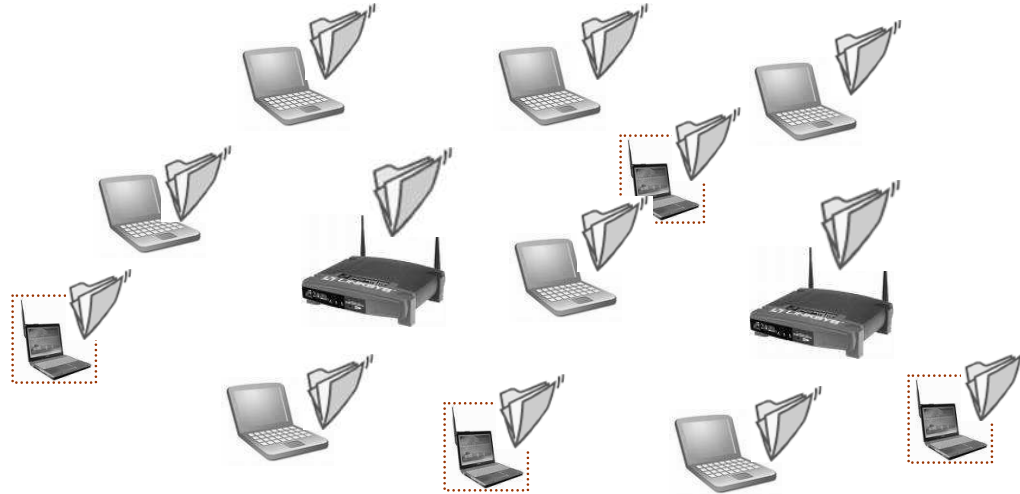How often clients retransmit packets?

Are hidden terminals common? Does RTS/CTS help?

Is the capture effect common?

Does the MAC use the medium efficiently?

How does performance vary with offered load?

Approaches to measure operational networks

Approach	Limitation
Collect packet logs at APs	Not enough detail
Instrument stations	Impractical in many settings
Passively monitor the network	Incomplete information of unknown quality

# Why is analysis based on passive monitoring hard?
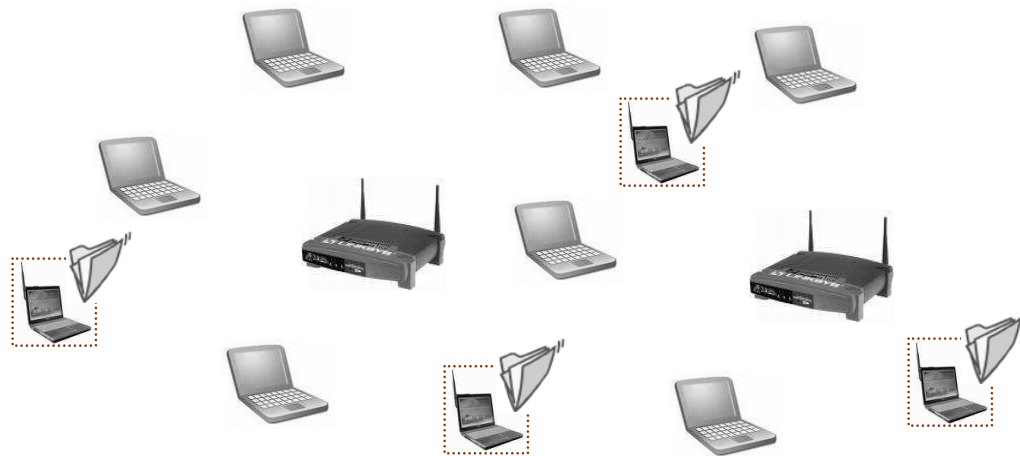
1. Inherently incomplete view of network activity
2. Missing packet reception information
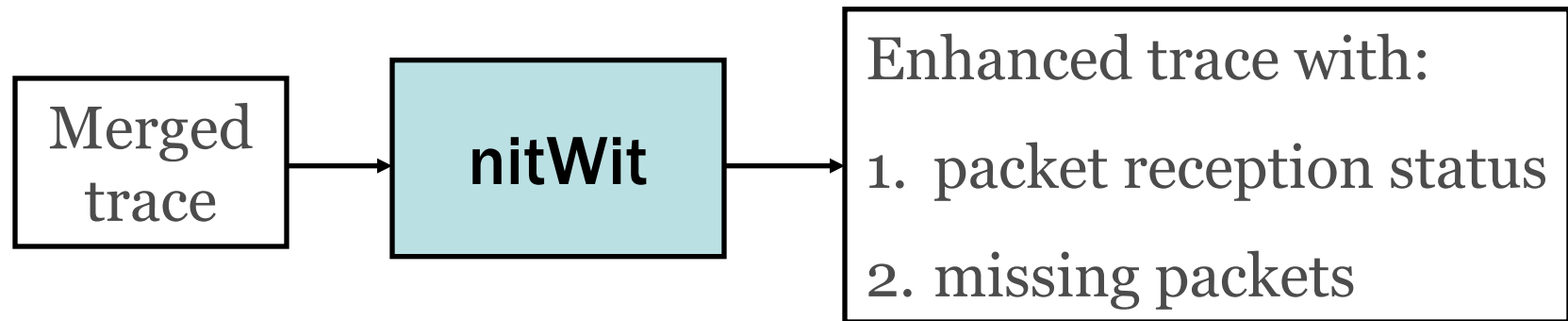3. Missing network-level information

Overview of **Wit**

Merge (**halfWit**)

Infer (**nitWit**)

Derive measures (**dimWit**)

Merging with **halfWit**

Trace from *Monitor 1*

Trace from *Monitor 2*

Trace from *Monitor N*

halfWit

Merged trace: consistent, unified view

Inference with **nitWit**

```
┌──────────┐      ┌──────────┐      ┌──────────────────────────────┐
│  Merged  │ ───▶ │  nitWit  │ ───▶ │ Enhanced trace with:         │
│  trace   │      │          │      │ 1. packet reception status   │
└──────────┘      └──────────┘      │ 2. missing packets           │
                                    └──────────────────────────────┘
```
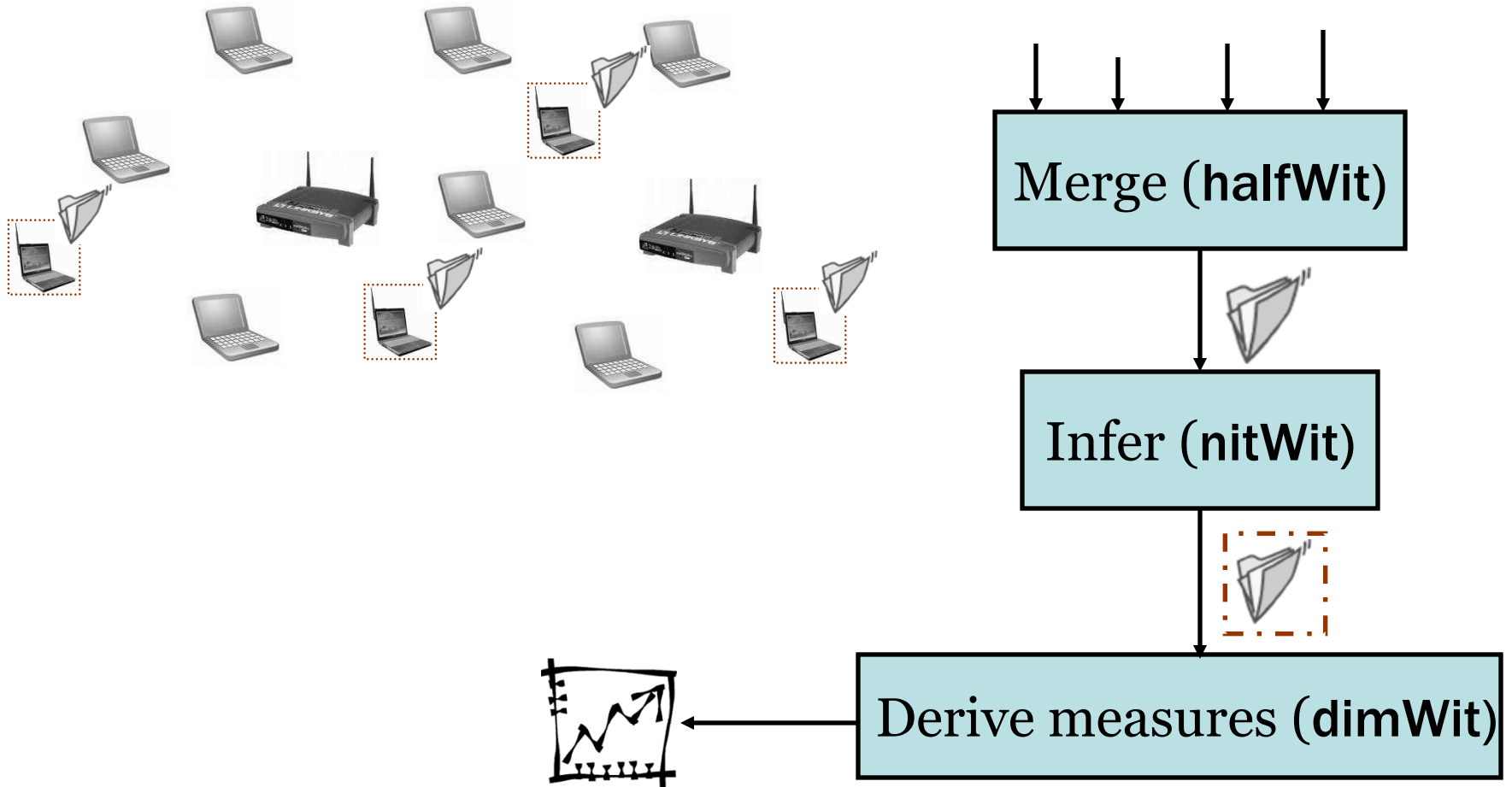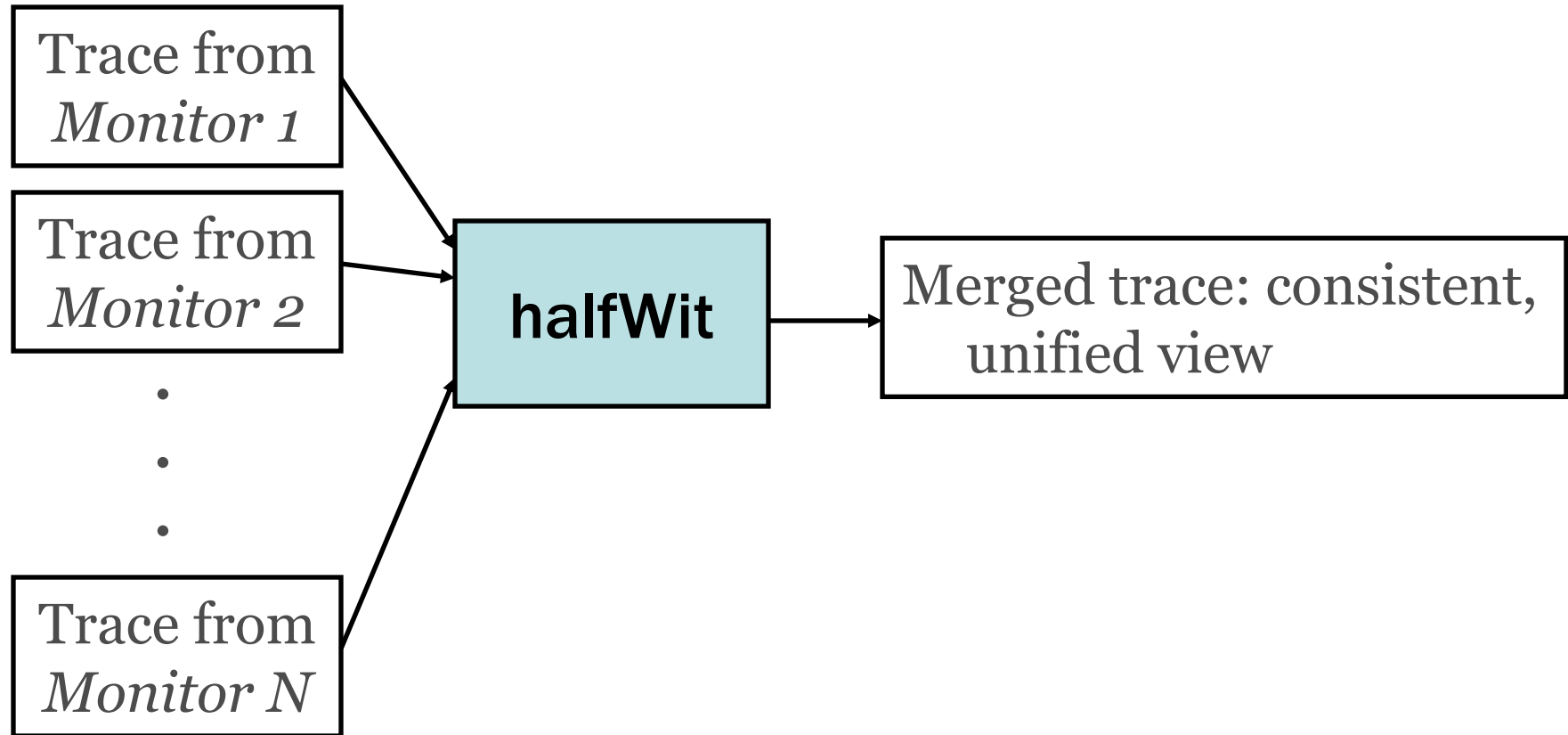
Observation: logged transmissions can reveal both pieces of information

Formal-language approach to inference

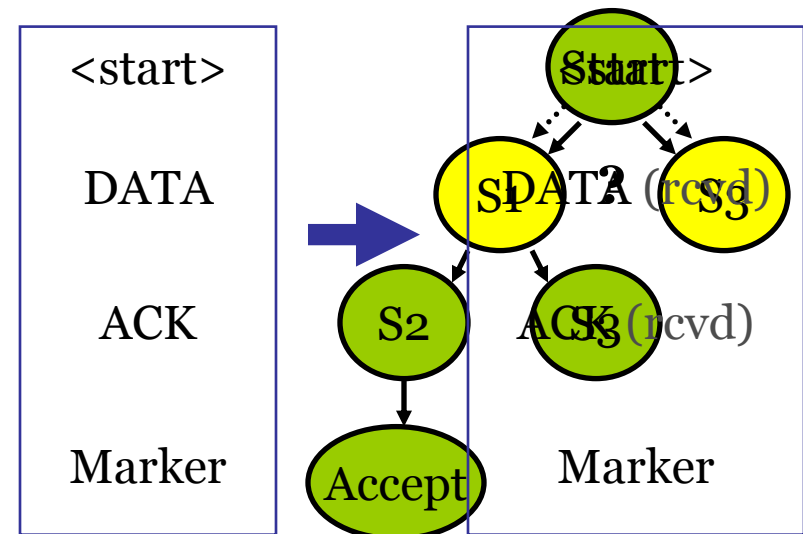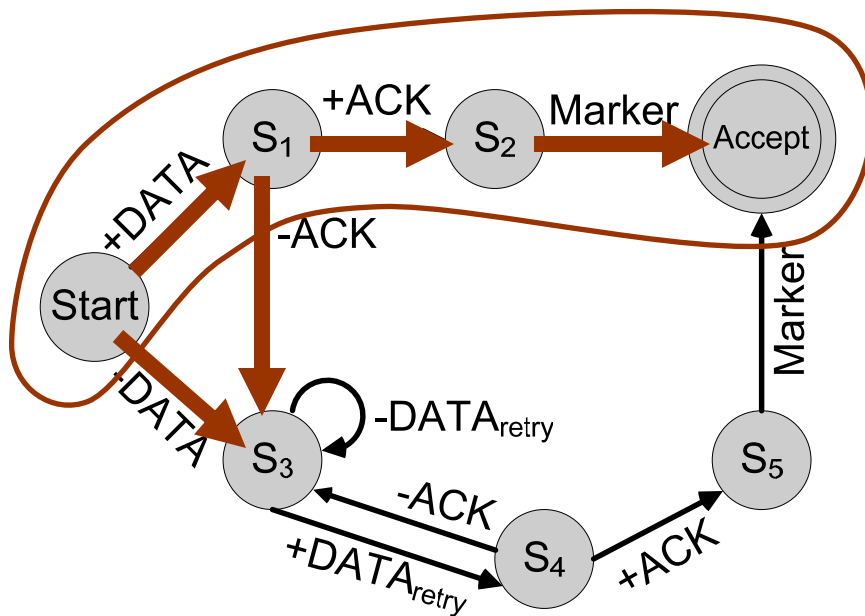If the protocol is a language

- – packets are language symbols
- – logical protocol exchanges are sentences

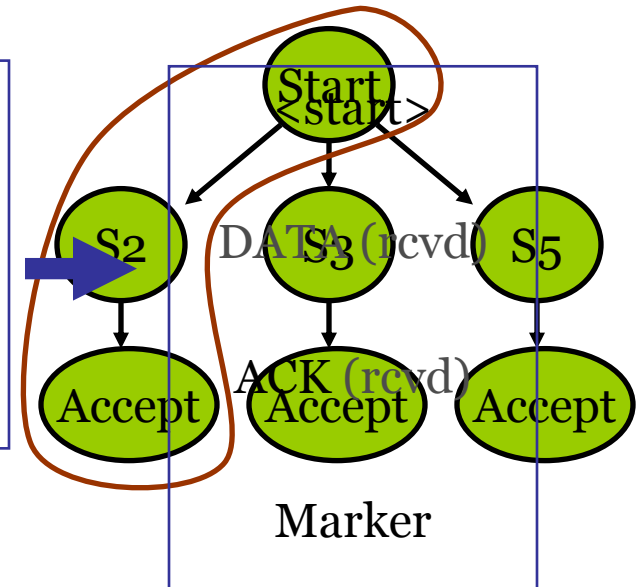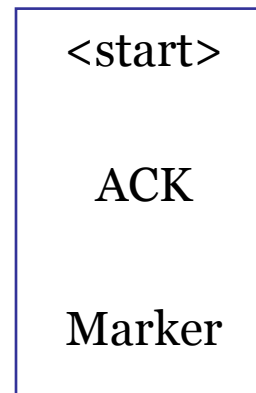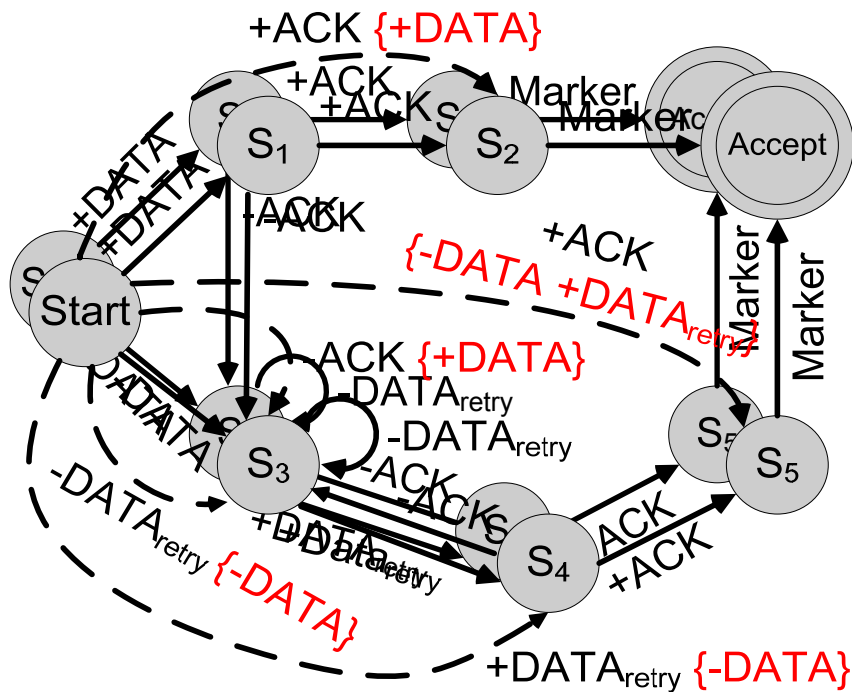Trace contains interleaved, partial sentences

Our task: infer matching complete sentences
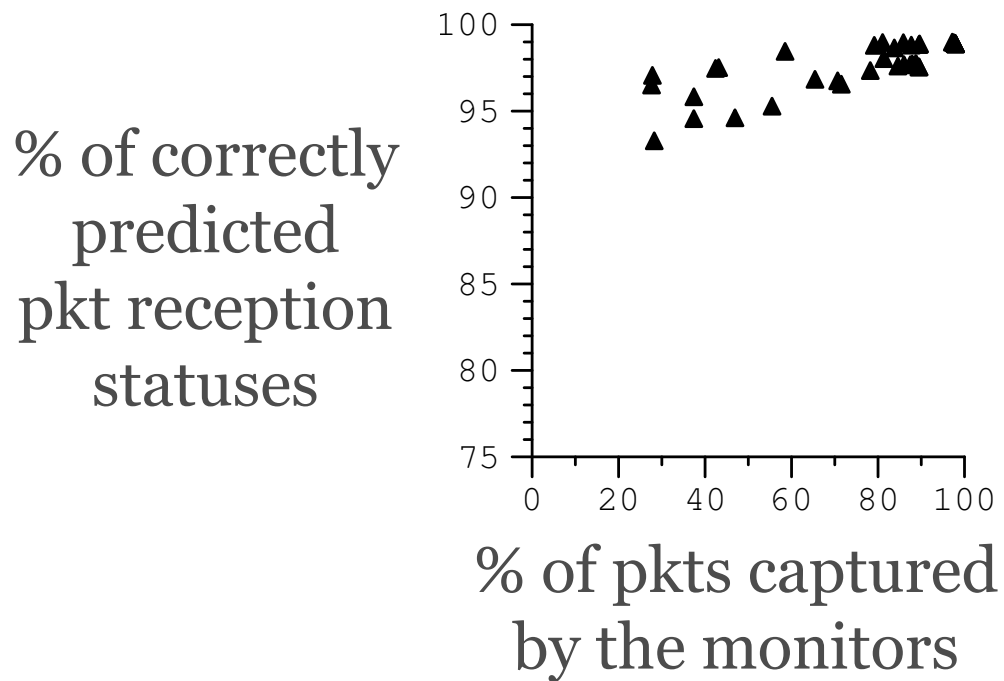
- – we use an FSM-based inference engine

Non-deterministic walk reveals reception status

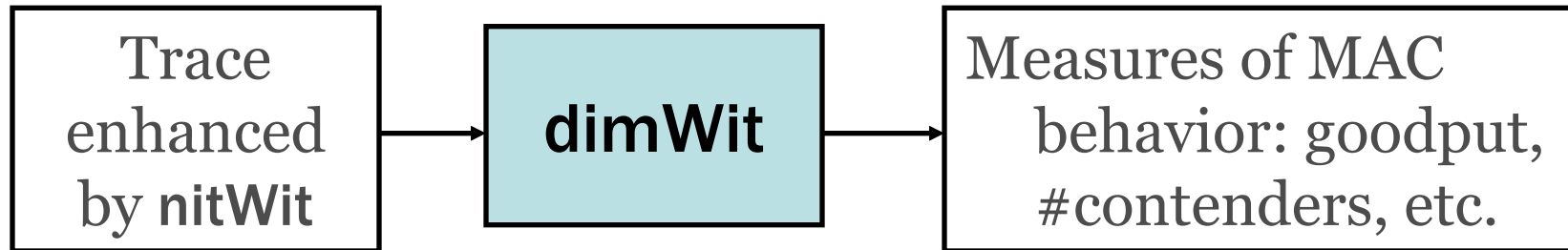# Augmented FSM enables fast inference of missing packets

Accuracy of nitWit

% of correctly
predicted
pkt reception
statuses

% of pkts captured
by the monitors

Deriving measures with **dimWit**

| Trace enhanced by **nitWit** | → | **dimWit** | → | Measures of MAC behavior: goodput, #contenders, etc. |

# of stations contending for the medium is a measure of instantaneous offered load

- estimation challenge: missing relevant state
- approach: view transmissions through the lens of MAC rules

Accuracy of estimate of #contenders

cumulative % of
pkt transmissions

(actual − **dimWit**)
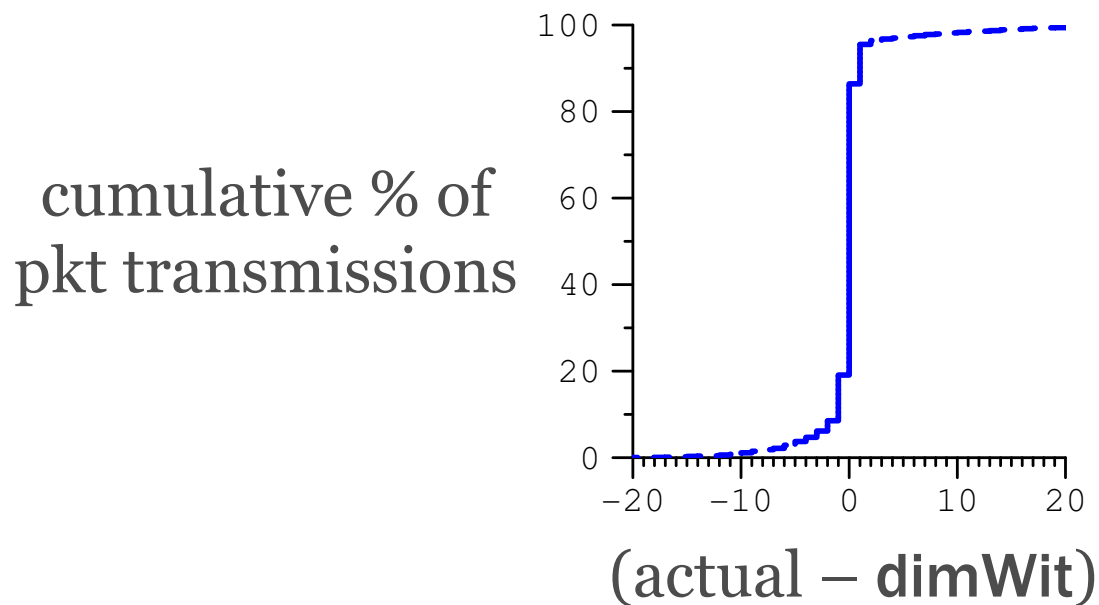
CDF of error in the estimate of # contenders
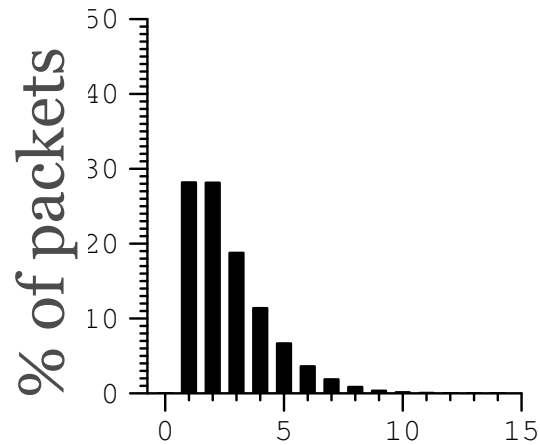
Monitoring the SIGCOMM '04 network
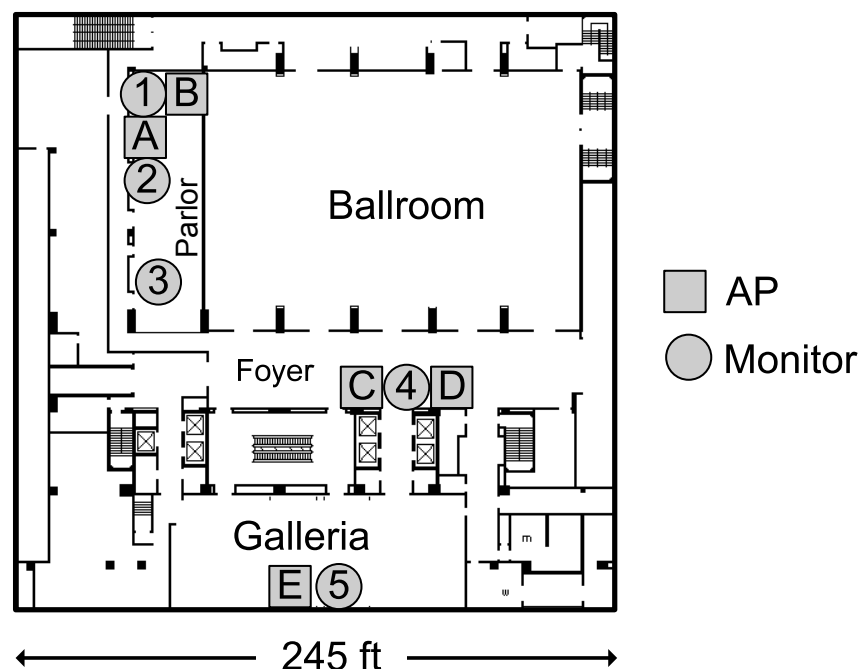
3 days, 500+ users, 5 official APs, 5 monitors
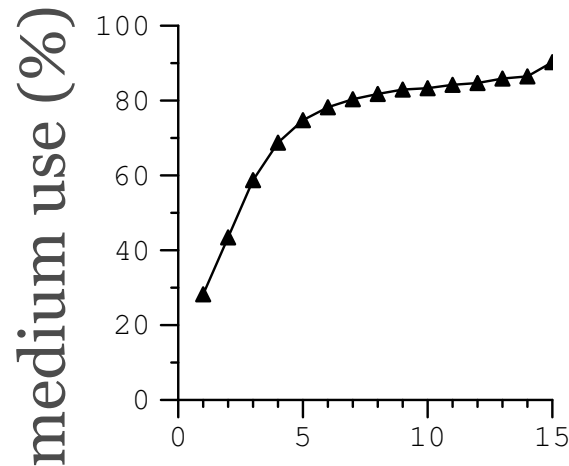
Focus on analyzing Channel 1 in this talk

– estimated 90% pkts captured in the merged trace

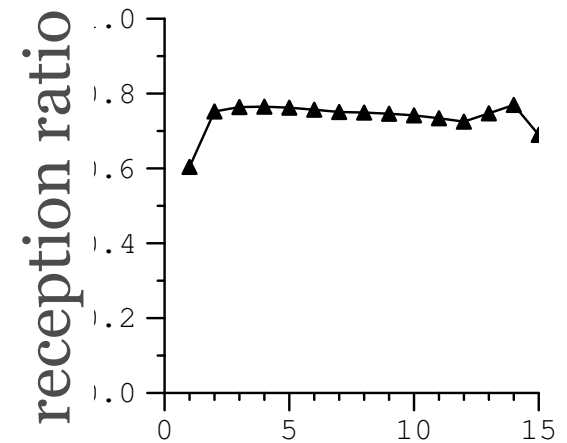# Example results on MAC behavior at the SIGCOMM '04 network

Low contention was dominant

Poor medium usage at low contention

High contention did not reduce reception ratio

Conclusions

Wit enables detailed MAC-level analysis of operational wireless networks

- merging produces a single, consistent view
- inference helps complete that view
- the enhanced trace enables many new analyses

Code and trace data:
http://www.cs.washington.edu/research/
networking/wireless/