Measurement-Based Models of Delivery and Interference

in Static Wireless Networks

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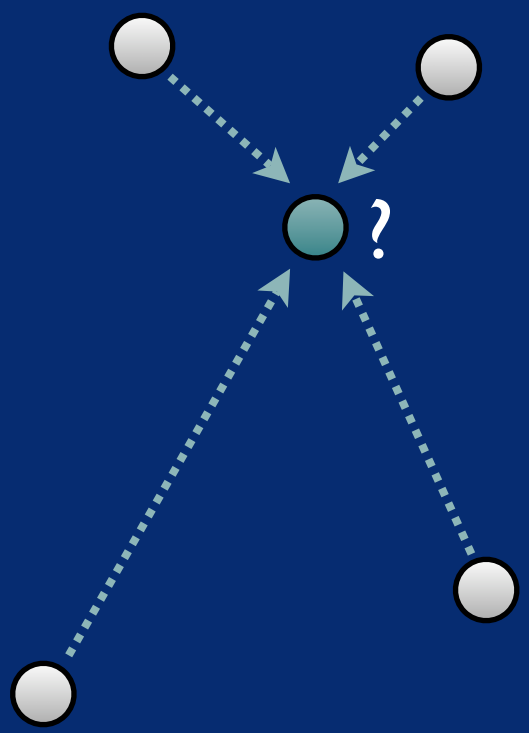
Interference matters



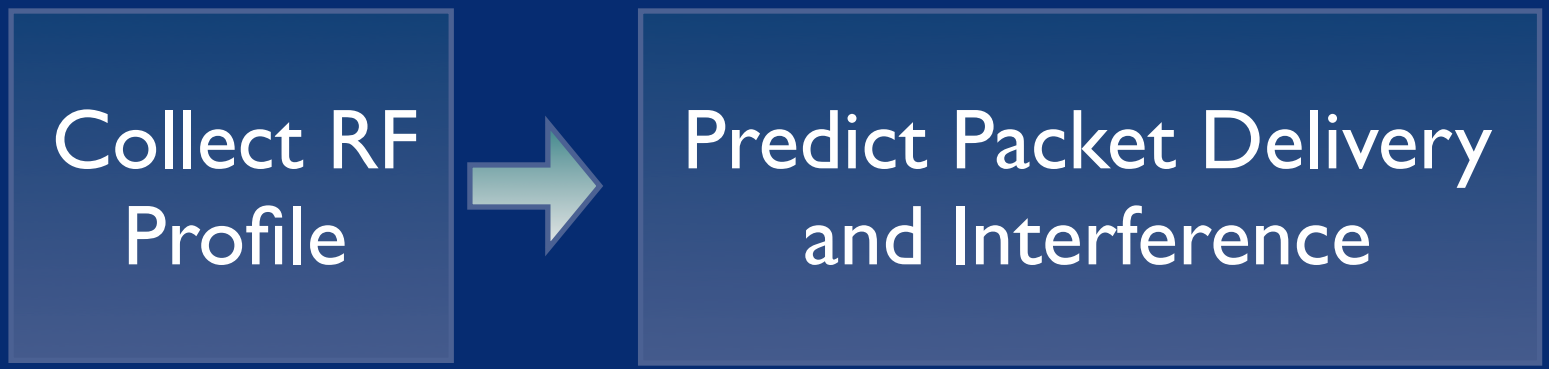
- **Sets wireless apart from wired networks**
- **Important to understand**
  - Designing and evaluating protocols
  - Spatial reuse

Model or Measure?

- **Simulation flexible but unrealistic**
  - Hard to estimate RF propagation
- **Testbeds have become popular, but...**
  - Combinatorial configurations
  - Poor repeatability, hard to generalize

Finding a Balance

- **Can we measure first, then model?**
  - Eliminate hardest part of modeling



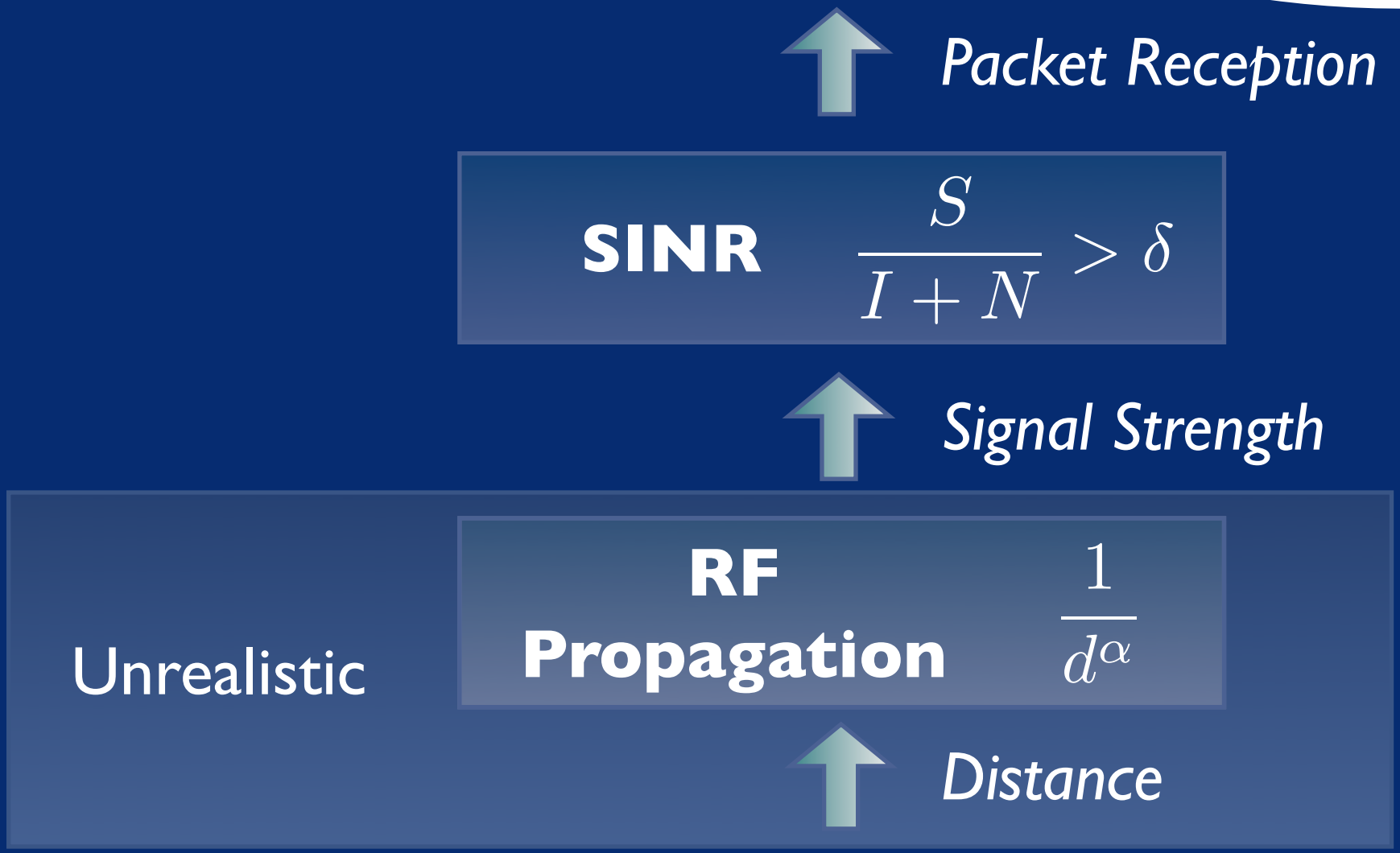
Outline

Measurement-Based Model

How to Measure

Evaluate Predictions

Traditional Modeling



Measure RF Instead

Packet Reception

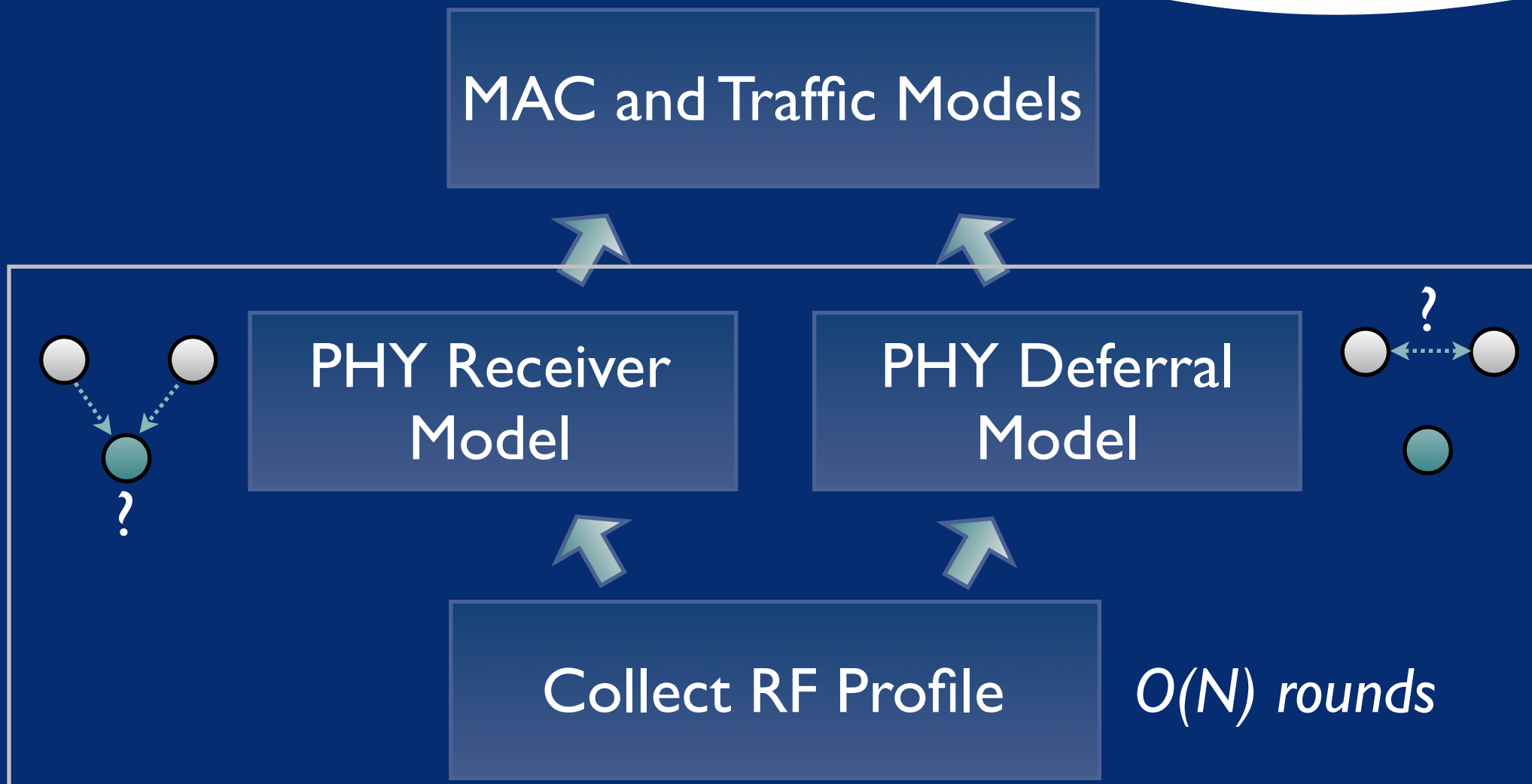
SINR $\frac{S}{I+N} > \delta$

Signal Strength

RF Measurements

	A	B	C
A			
B			
C			

Multi-Layer Model



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Evaluate Predictions

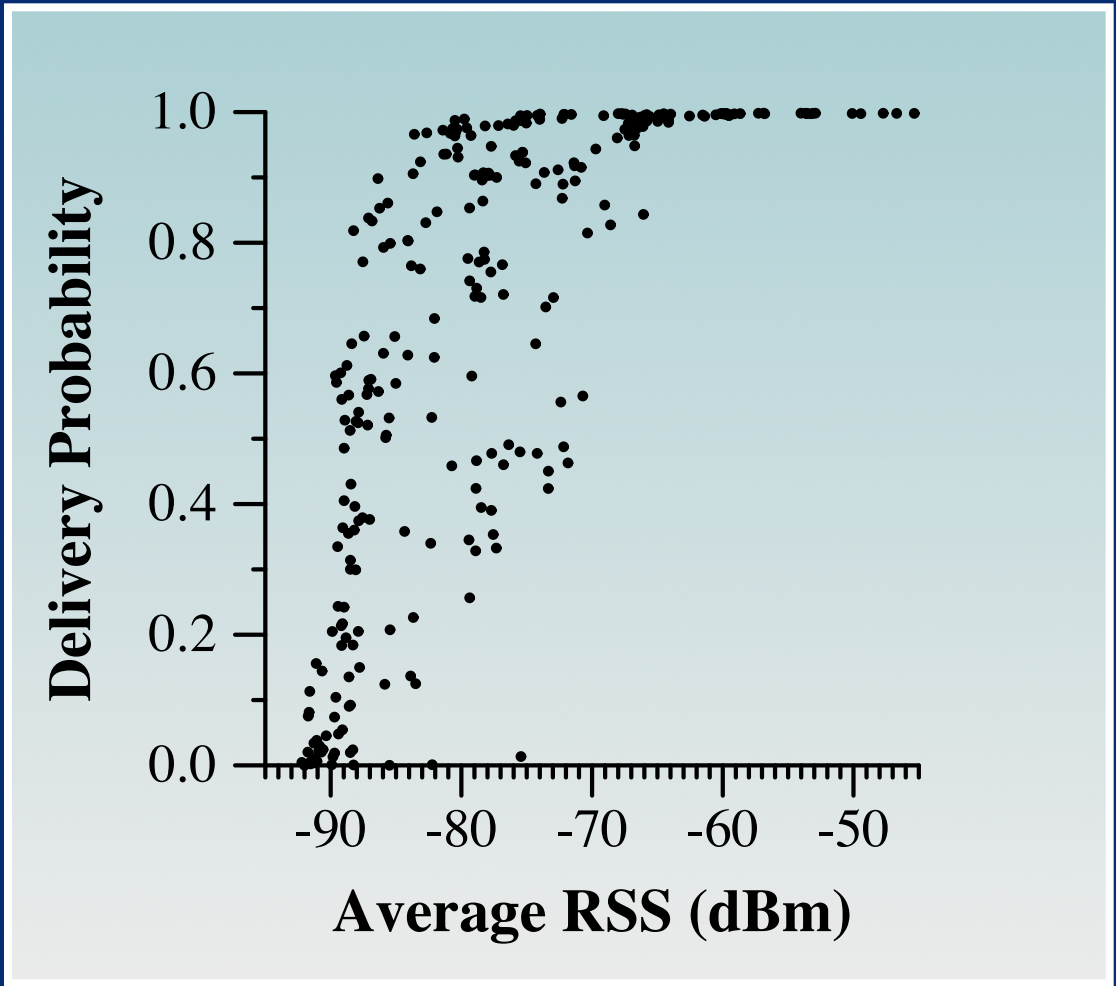
Stuck with Imperfect Data

- **Commodity cards only report RSSI**
  - Energy in air, not signal strength
  - Varies across manufacturers
  - How to use RSSI for modeling?

Collecting RF Profiles

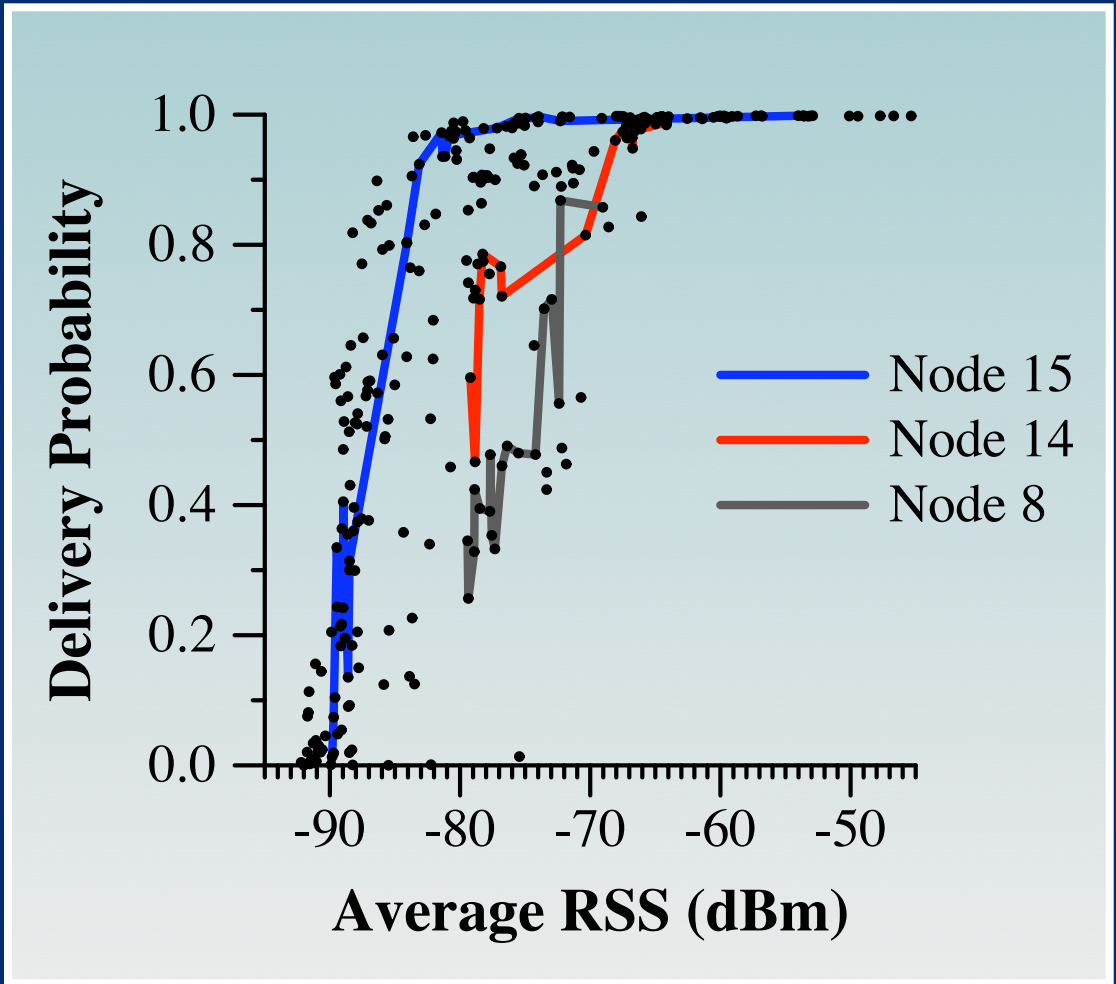
- **Measure RSSI on testbed**
  - Broadcast packets
  - Record RSSI values on received packets

RSSI and Packet Delivery



- **Weak correlation in general**

RSSI and Packet Delivery



- **Weak correlation in general**
- **Stronger in per-receiver data**
  - Localized external interference

Measure RSSI over Intervals

- **Bursty losses, but independent over time**
- **Relatively stationary**
- **Temporary atypical events**

Inputs to SINR

$$\frac{signal}{interference + noise} > threshold$$

Signal	Average RSSI
Interference	Derive from RSSI variation and other senders
Noise	Hardware Constant
Threshold	Derive from RF Profile

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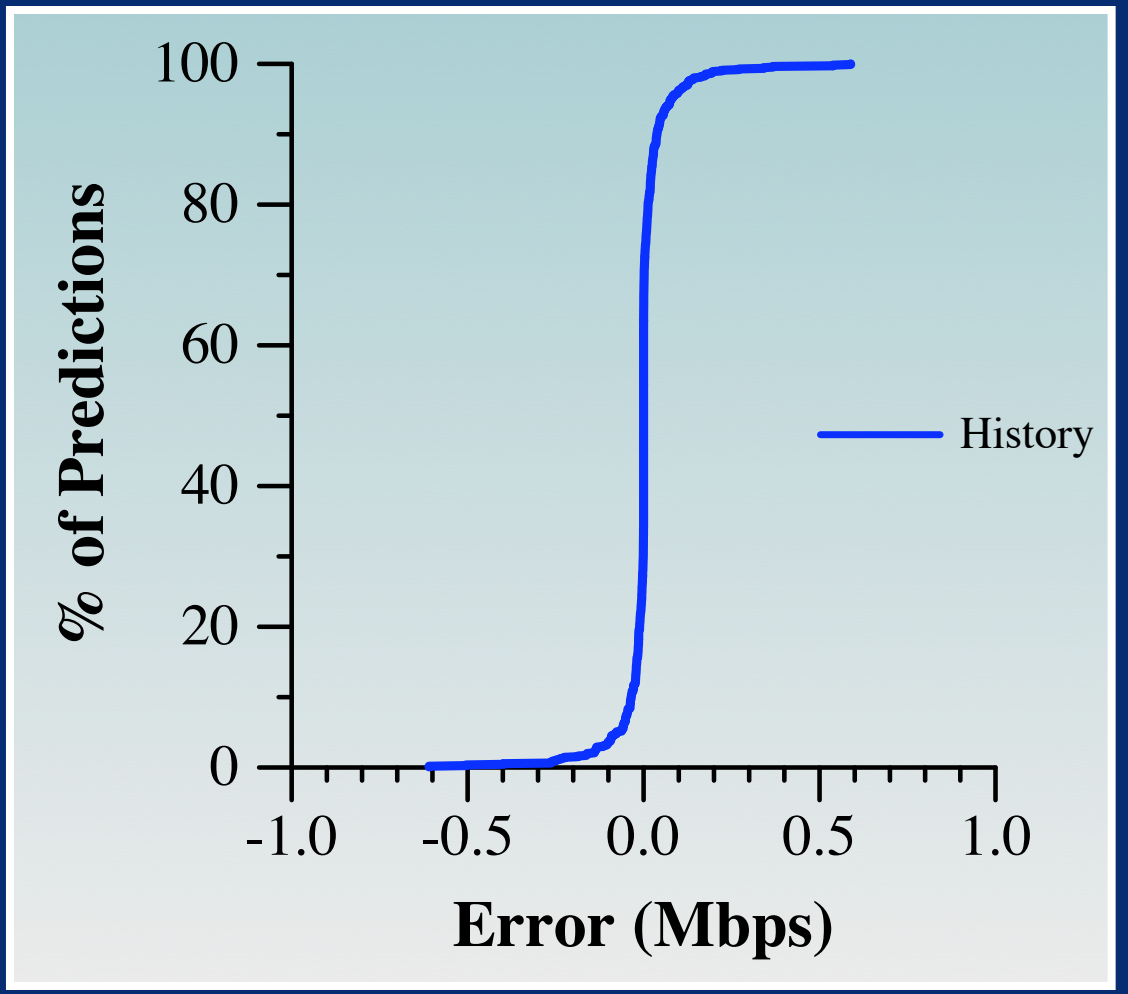
Evaluate Predictions

Evaluate Base Case

- **Collect RF profile (single senders)**
  - Broadcast packets for 2 minutes, 1 Mbps
- **Predict throughput for two senders**
  - Will they interfere?

Throughput Prediction

- Inherent variability in environment

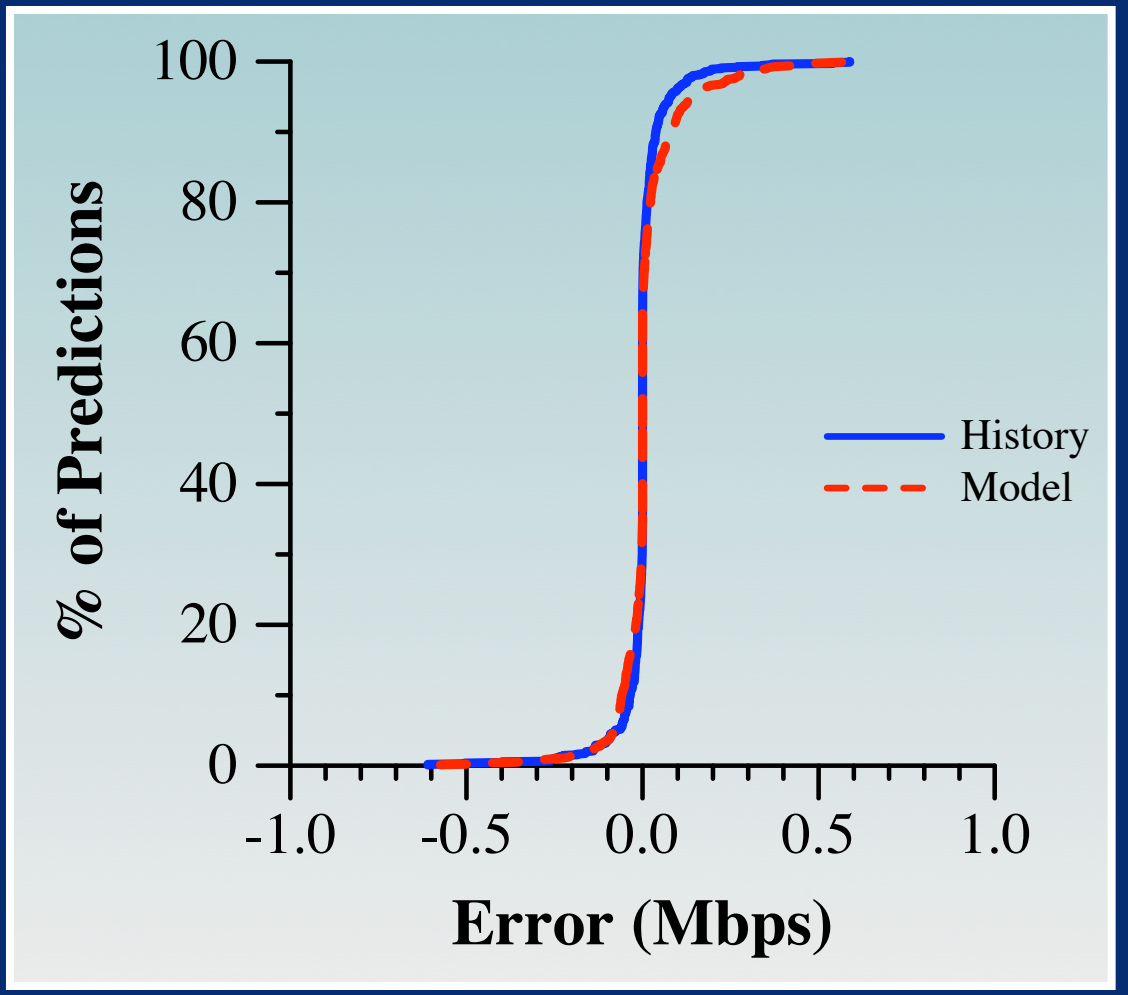


RMSE:

History	7%

Throughput Prediction

- Inherent variability in environment
- Model almost as good



RMSE:

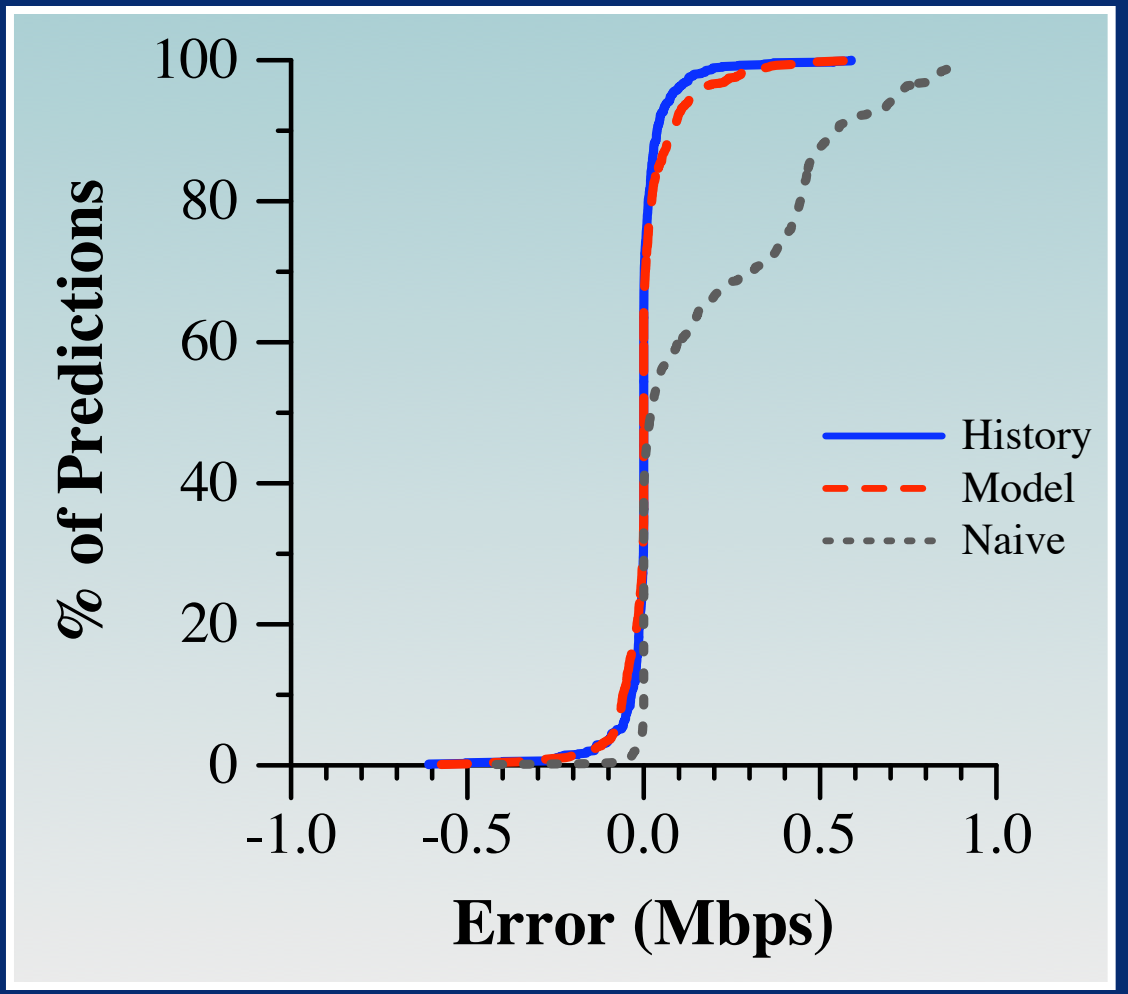
History	7%
Model	9%

Throughput Prediction

- Inherent variability in environment
- Model almost as good
- Ignoring interference does much worse

RMSE:

History	7%
Model	9%
Naive	31%



Moving Forward

- **Conflict graph prediction**
- **Evaluate more scenarios**
  - More senders, bit rates, packet sizes, environments
- **Build new MAC and traffic models**

Conclusions

- **Need to account for interference**
- **Combine measurements and models**
  - **RF profiles** balance realism and flexibility
  - RSSI *can* have predictive power