Low-Level Tools for Diagnosing Wireless Problems

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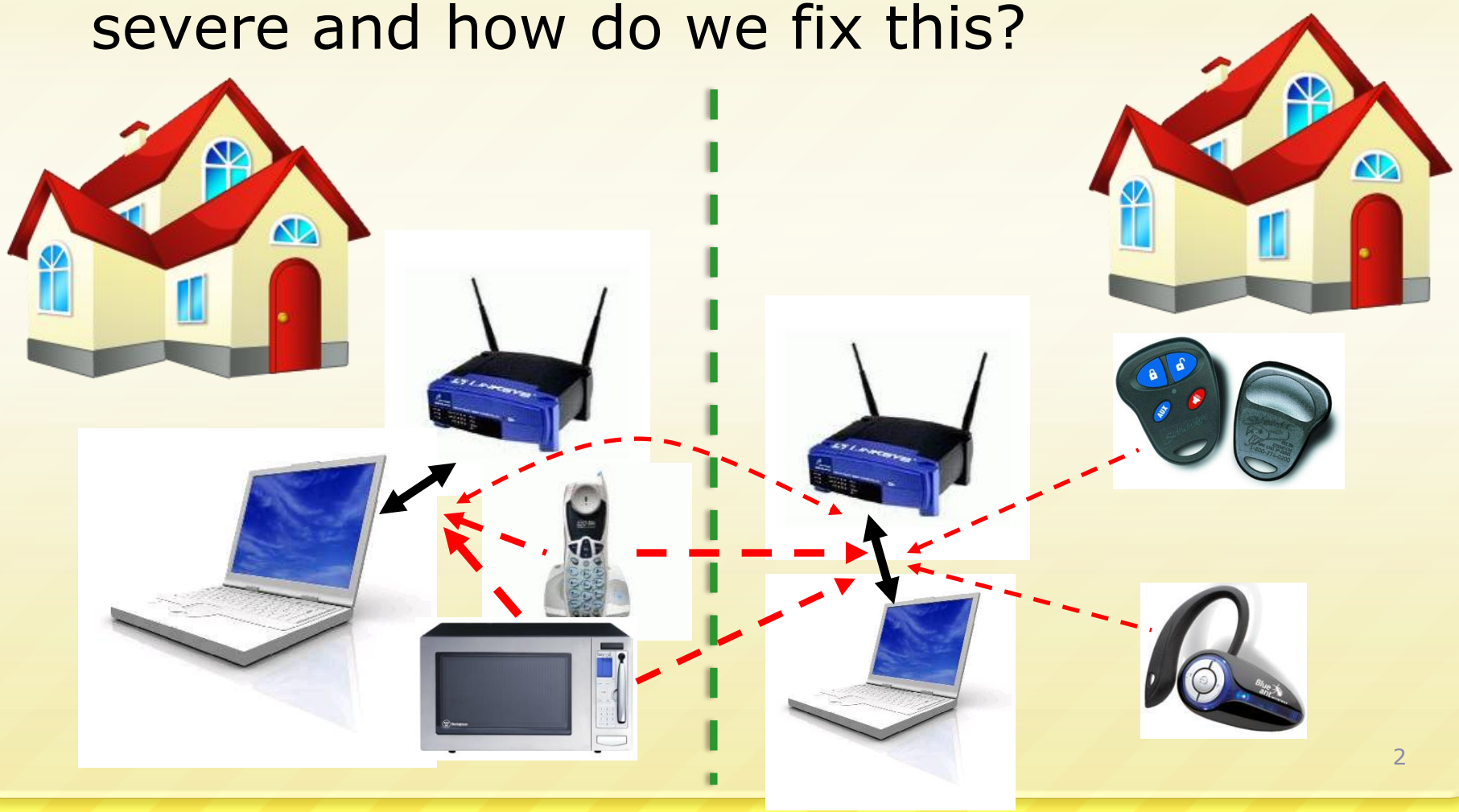
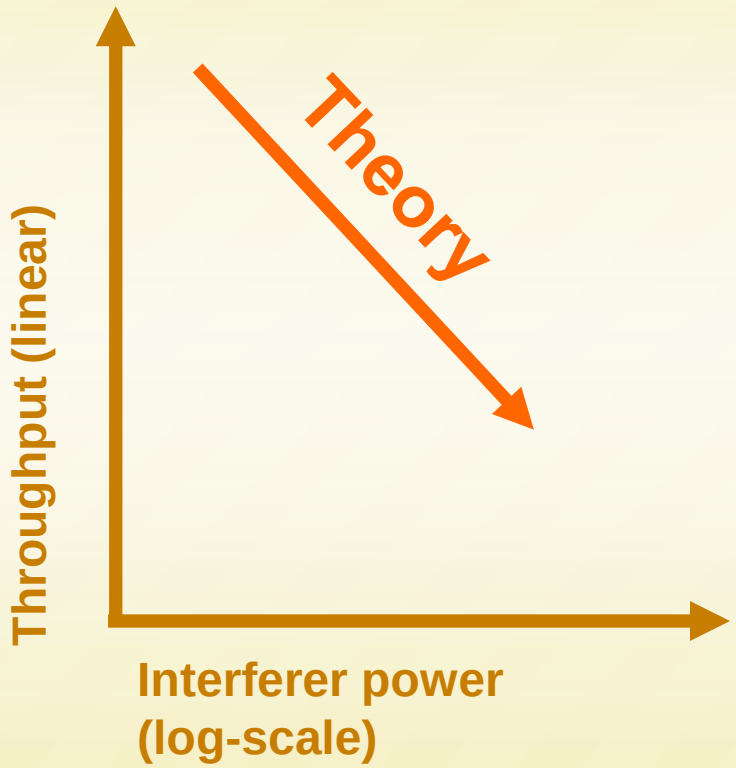
Growing Interference in Unlicensed Bands

- Anecdotal evidence of problems, but how severe and how do we fix this?



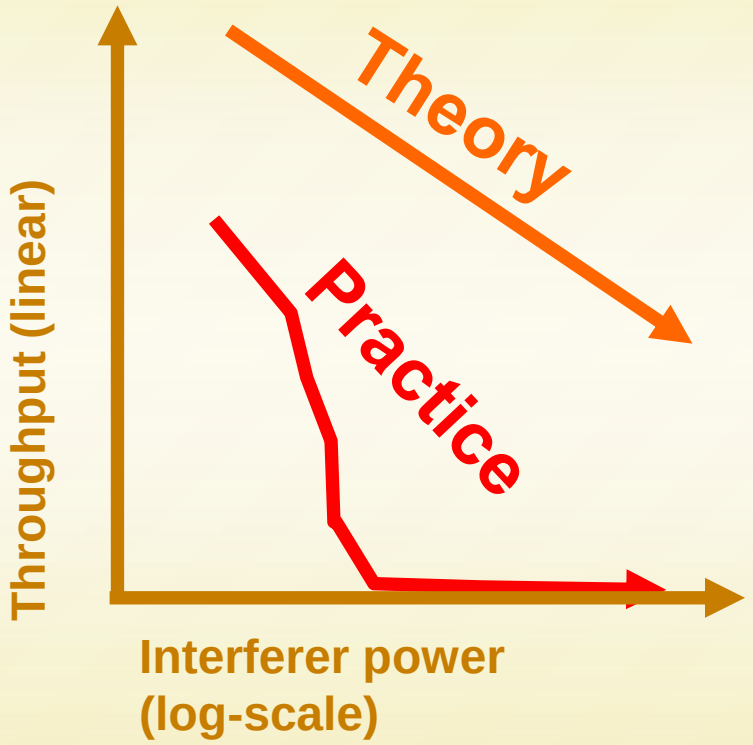
What do we expect?

- Throughput to decrease linearly with interference
- Easy to understand and predict
- Coexistence between technologies/neighbors easy → just design each link to gracefully adapt to interference level



What we see…

- Hard to predict real behavior
- Effects of interference more severe in practice
  - Hardware limitations of commodity cards, which theory doesn't model
  - Protocols often designed to backoff
    - Most polite or most sensitive protocol loses ☹

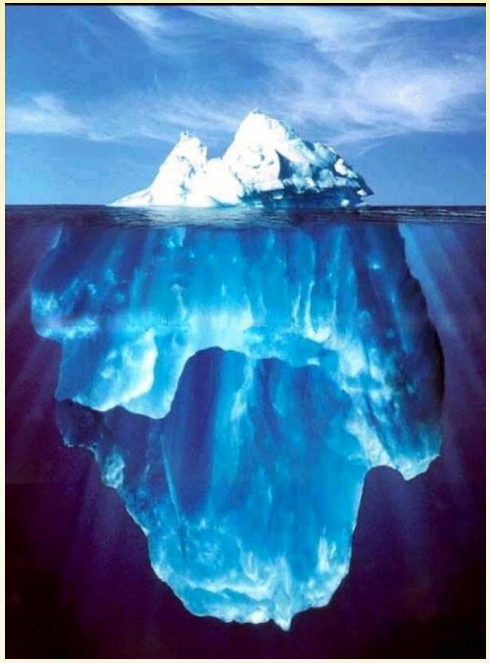


Paths to Solutions

- Pair-wise coexistence
  - Bluetooth/802.11
  - Zigbee/802.11
  - Etc…
- Better coexistence
  - Explicit spectrum management
  - Controlled spatial reuse
    - Transmission power control
    - Directional antennas
  - These techniques also lead to better performance
    - But…. require changes to many parts of protocols
- Better diagnosis

Wireless Diagnosis

- State-of-the-art (DAIR, Jigsaw, Wit)
  - Enterprise settings with dense monitoring
  - 802.11 focus



- Home environments
  - Multiple technologies
  - Multiple administrative domains (i.e. homes)
  - Cheap, inexpensive devices with long lifetimes
  - Often external one-time help like GeekSquad

Diagnosis Tools

Wired Networks

- Ping
- Traceroute
- Tcpdump
- Etc.

- Solve problems related to node and reachability failures
- Led to "connectivity wizards" of today

Wireless Networks

- Alternative: spectrum analyzers
  - Expensive, fail to provide context

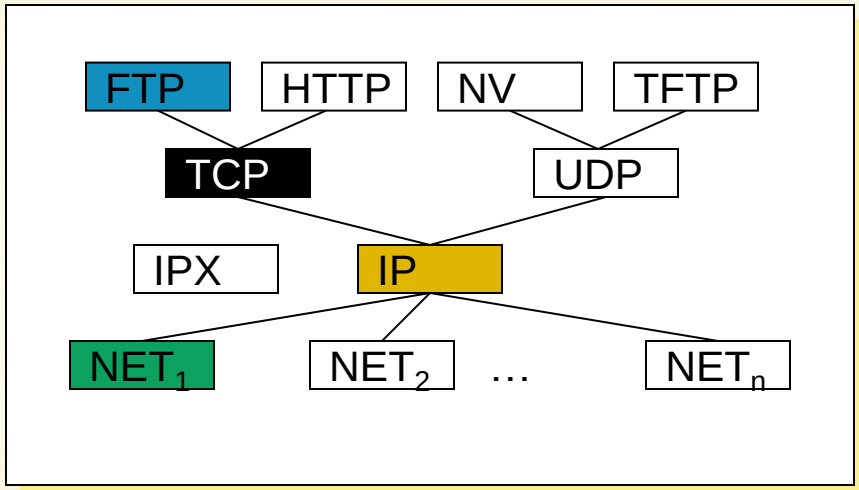
- Existing tools fail to observe source of the problem
  - Problems related to low-level link behavior
  - Interactions between technologies
  - Soft failures

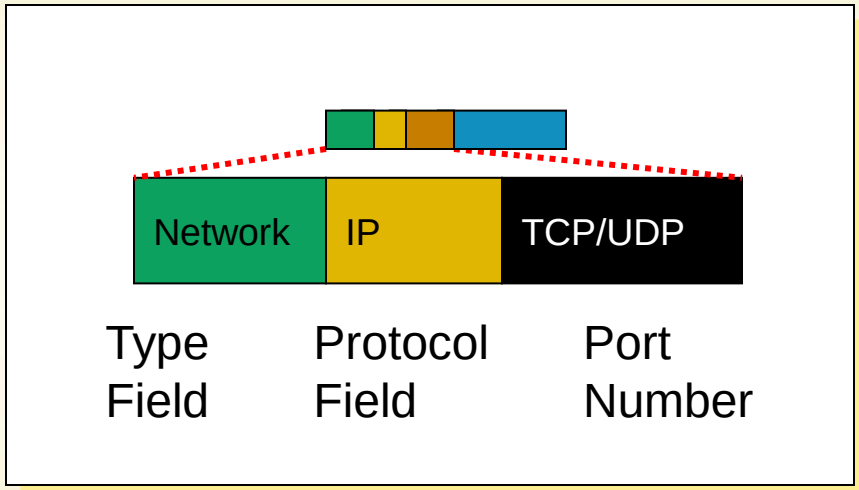
Better Monitoring of Wireless Networks

- Combine tcpdump & spectrum analyzer
- Requirements:
  - Multi-protocol
    - Support at least a small (5-10) number of protocols/RF sources
  - Real-time detection
    - Near real-time throughput requirement
      - Some latency is ok
  - Protocol Extensible
    - Add support for newer protocols

Tcpdump Approach

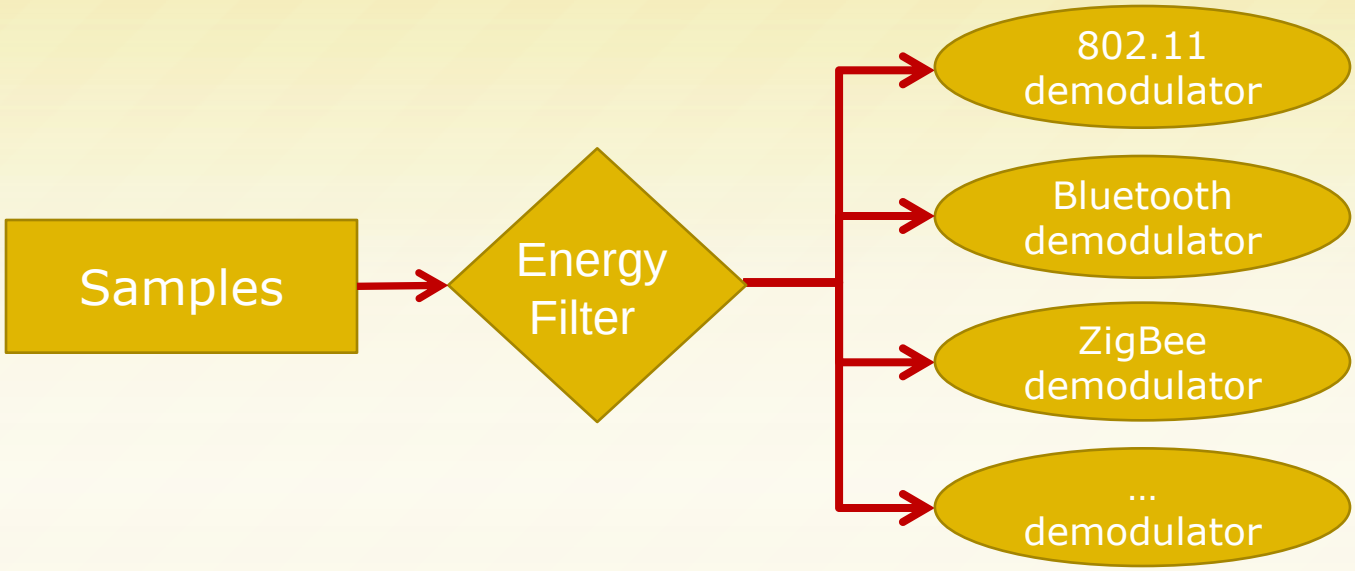
- Tcpdump – easy demultiplexing/decoding
  - Each layer specifies the next layer protocol





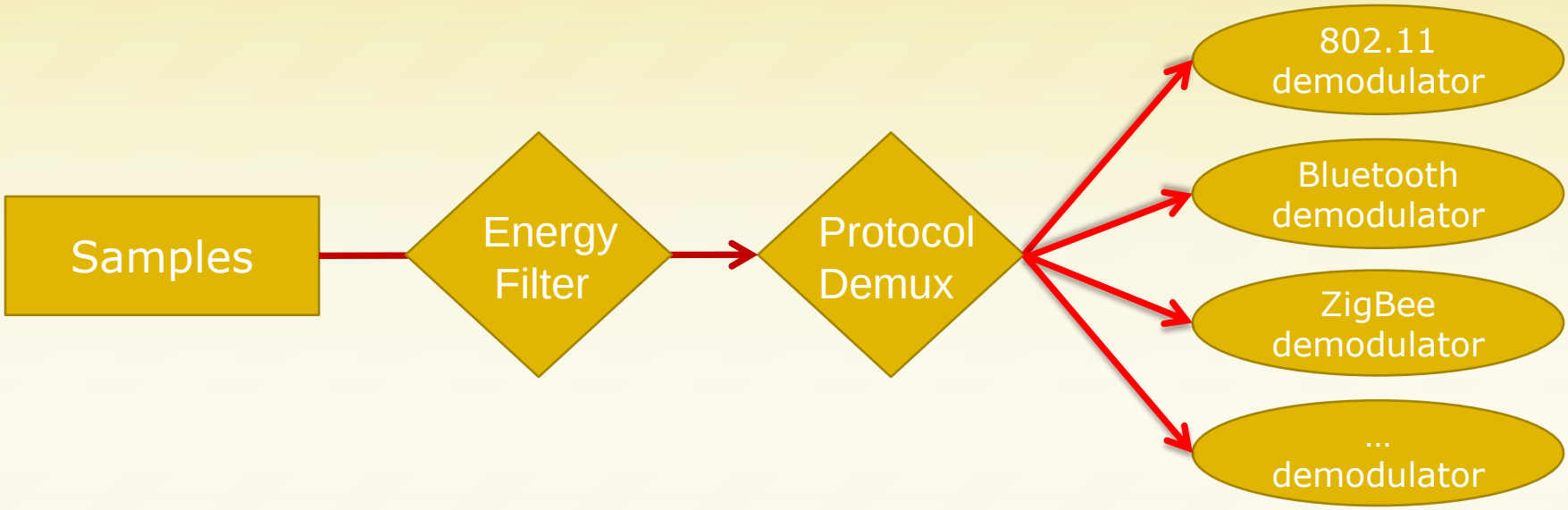
- Wireless medium shared by diverse datalink protocols
  - Physical layer gives no information on the nature of active transmissions

A Solution?



- Start with a software-defined radio
- Why is this unstatisfactory?
  - Demodulation is costly
  - Especially bad if medium utilization is high ☹

An even better solution…



- Protocol demux quickly identifies protocol type
  - Basically adds "protocol" tag that tcpdump can use
- How to build a demux that is less expensive than demodulation?
  - Can accommodate error and latency → enables shortcuts
  - Optimize common techniques

Relevant Features for Detection

Protocol		Timing (μs)		Phase (Modulation)		Channel width
802.11	(Mbps)	Slot	SIFS	Scheme	Spreading	(MHz)
	b (1)	20	10	DBPSK[a]	Barker	22
	b (2)	20	10	DQPSK[a]	Barker	
	b (5.5/11)	20	10	DQPSK[a]	CCK	
	g	9	10	OFDM[b c]		20
Bluetooth		Slot 625		GFSK	FHSS	1
802.15.4 (ZigBee)		Slot 320	IFS 192/600	QPSK		5
Residential Microwave		AC cycle 16667/20000				10-75

[a] Preamble is sent using DBPSK

[b] CTS-to-self packets use one of the 802.11b rates

[c] Uses BPSK, QPSK, 16-QAM or 64-QAM for the subcarriers

So what next?

- Current prototype very limited by SDR hardware
  - Better SDR hardware now available
- Tcpdump != diagnosis
  - Enables collection of data
    - Observation and explanation of adverse interactions
  - Need to still fix things
    - Build signatures of poor interactions and appropriate corrective actions
- Not the only tool needed → e.g. active tests
- 802.11/other wireless cards exposing greater information
  - How far can this get us?
- Is the network working correctly?