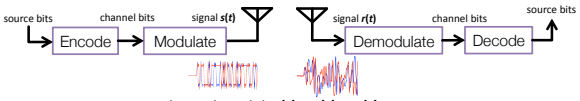
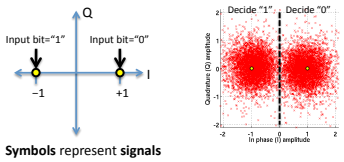
28th Jan	SampleRate: bit rate adaptation in 802.11 wireless networks
30th Jan	MRD: exploiting radio link diversity with multiple access points
Monday	(Lectures cancelled due to weather)
Tuesday	ExOR: wireless mesh opportunistic routing
Today	**SampleWidth: channel width adaptation**
	Interference cancellation for wireless LANs

Recap: additive noise model

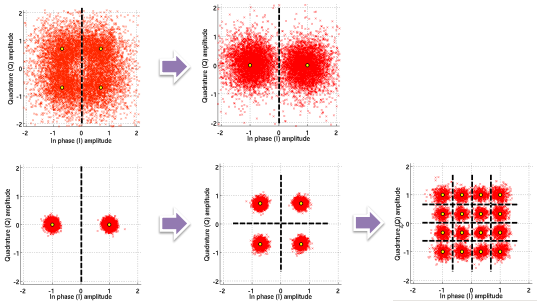


channel model: $r(t) = s(t) + n(t)$



Symbols represent **signals**

Bit rate adaptation by changing modulation

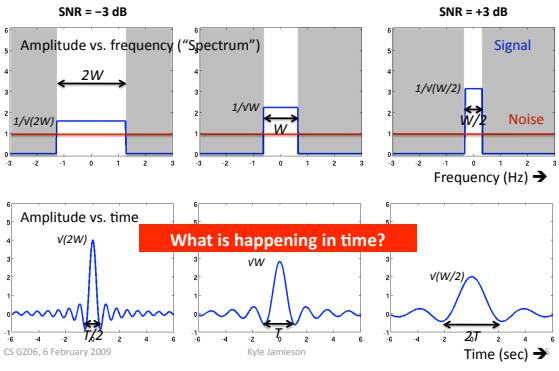


Map b=log$_2$ |C| bits per symbol time T

Agenda

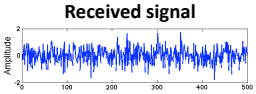
- How to best detect the transmitted signals?
- **SampleWidth** [Chandra et al., SIGCOMM '08]
- Is the channel that simple?
- **Successive interference cancellation** [Halperin, Anderson, Wetherall, MobiCom '08]

Narrower band, higher SNR

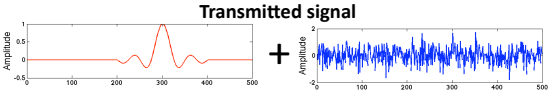


Is it just noise, or a signal in noise?

Received signal

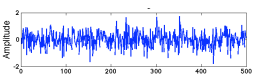


Transmitted signal



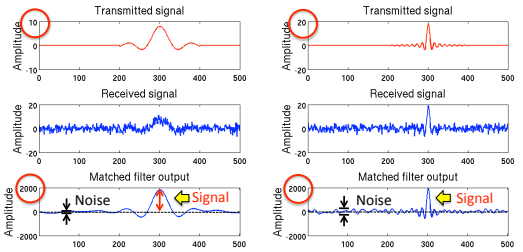
or

0 + ?



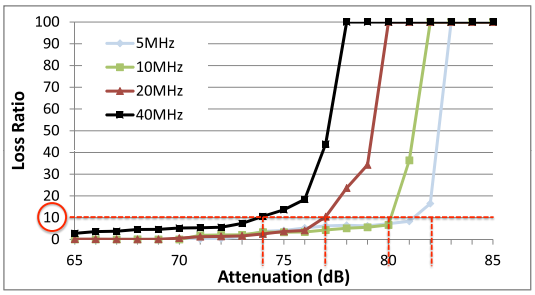
Narrower matched filter reduces noise

Narrower signal ➔ narrower matched filter

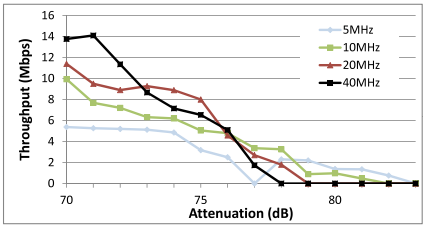


High SNR Lower SNR

Lower channel width, lower loss rate



Channel widths: potential for improvement



Similar motivation to SampleRate: can adapt to stay at best throughput.

The SampleWidth algorithm

- Find best channel width over one link
  - Challenge: 2-D search space (with **bit rate**)
- Start at narrowest, adapt when have data
- Probe different widths
  - Probe only adjacent
  - Probe only if disconnection unlikely

SampleWidth: algorithm details

Rule 1:

R_{cur} < α Mbps ➔ probe narrower

R_{cur} > β Mbps ➔ probe wider

Rule 2:

Else, choose B_i: $\max_i \{T_i\}$

B_i	thruput T_i	bit rate R_i
40 MHz	–	–
20 MHz	T_{cur}	R_{cur}
10 MHz	–	–
5 MHz	–	–

Choosing α, β:

$$E_{SW}(\alpha,\beta) = \frac{T_{SW}(\alpha,\beta)}{T_{OPT}}$$

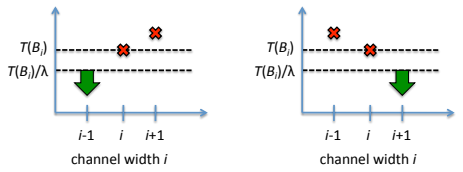
	$\beta = 12$	$\beta = 18$	$\beta = 24$	$\beta = 36$
$\alpha = 6$	0.20	0.20	0.20	0.20
$\alpha = 9$	0.47	0.94	0.70	0.66
$\alpha = 12$	0.47	0.94	0.70	0.66
$\alpha = 18$	0.47	0.91	0.69	0.63

Sampling vs switching

- Probing based on bit rates (<α, >β)
- Switching based on throughput
- Distinguish between:
  - Poor link quality ➔ probe and move narrower
  - High contention ➔ probe but stay wide

Does SW get stuck in local minima?

No local minimum condition (λ > 1):



Smoothness at B_i:

$$S(B_i) = \max\left\{\frac{T(B_i)}{T(B_{i-1})}, \frac{T(B_i)}{T(B_{i+1})}\right\}$$

Smoothness:

$S = \min_i S(B_i) \geq 1$ for convergence

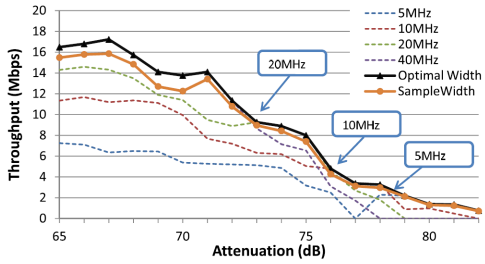
	1	2	3	4	5	6	7	8	9
S	1.50	1.50	1.51	1.53	1.43	1.6	1.47	1.6	1.63

No. ✔

[Slide: Ranveer Chandra]

SampleWidth Evaluation

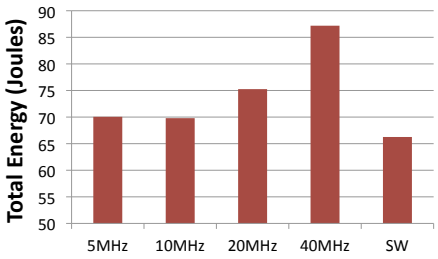
- SampleWidth adapts to best throughput width



[Slide: Ranveer Chandra]

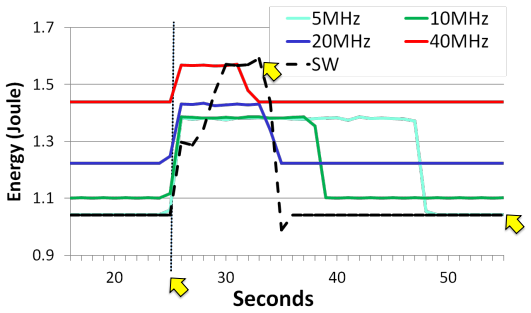
SampleWidth saves energy

Experiment: two laptops; idle 25 seconds, then transfer 20 MB file



[Slide: Ranveer Chandra]

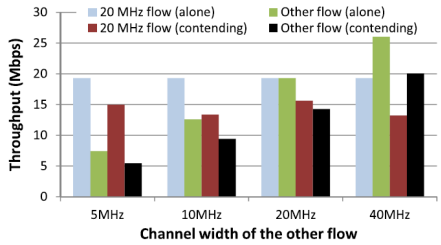
How SampleWidth saves energy



[Slide: Ranveer Chandra]

Interoperability issues

- Virtual carrier sensing will not work
- Can flows on different widths co-exist?



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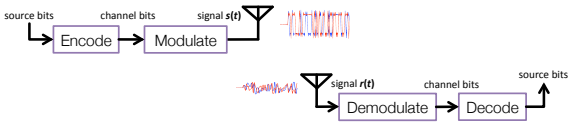
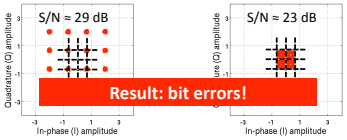
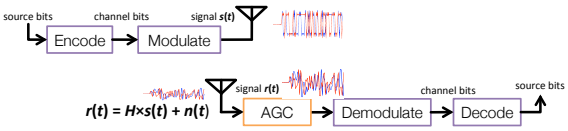
The fading wireless channel



Simple fading channel model: $r(t) = H \times s(t) + n(t)$, ($H$ real)

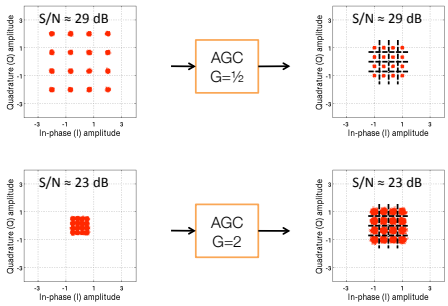


Our revised receiver for the fading channel



AGC output = Gain G × input
SNR stays the same

Automatic gain control example



[Figure: Johnson and Sethares, Telecommunication Breakdown]

Fading varies with time