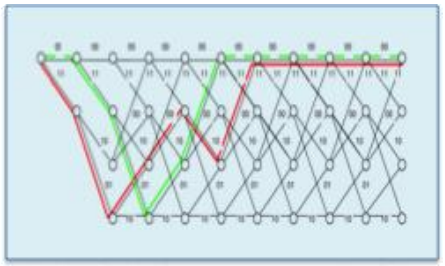
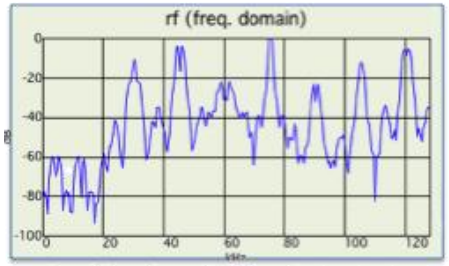
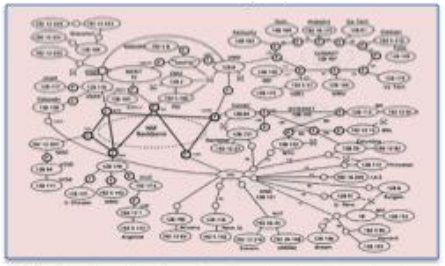






INTRODUCTION TO EECS II

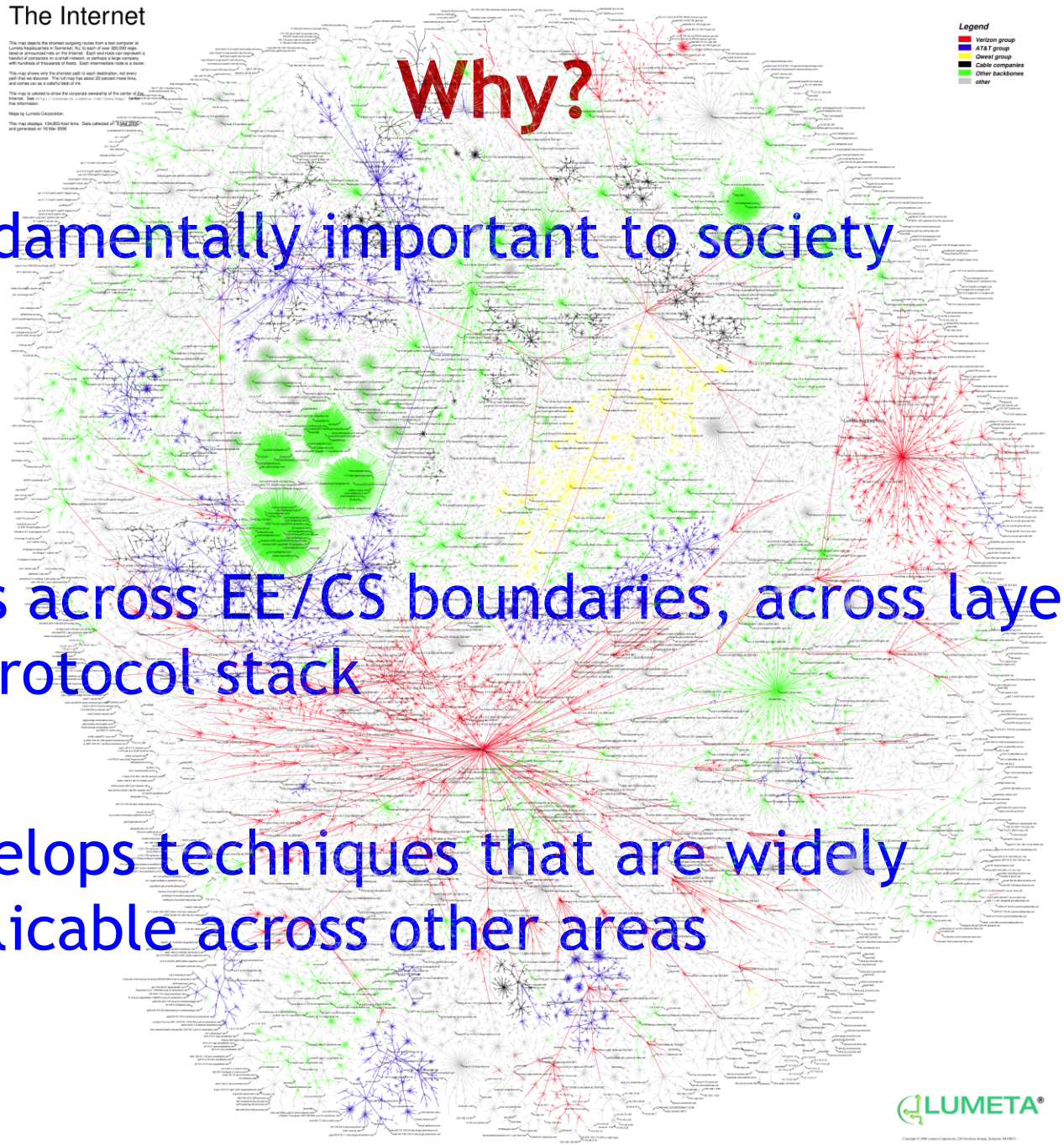
DIGITAL COMMUNICATION SYSTEMS

Lecture 1

Fall 2010

- Communication System and Why Study Them.
- Networks, Links and Channels.
- The 6.02 view of a channel (Bits and Voltage Samples)

Why?



- Fundamentally important to society
- Cuts across EE/CS boundaries, across layers of protocol stack
- Develops techniques that are widely applicable across other areas

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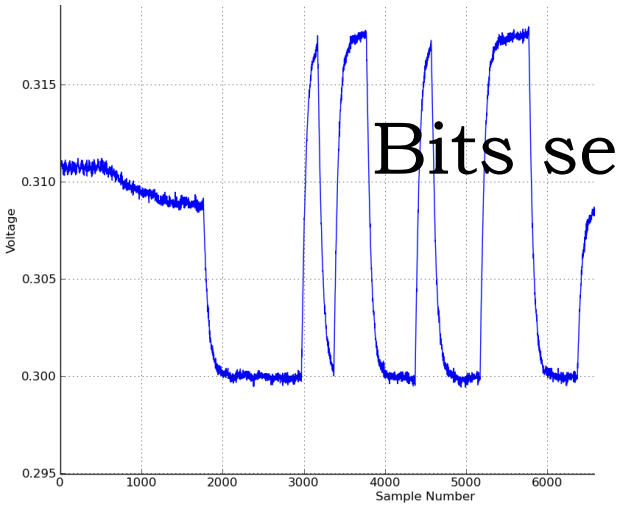
Three Big Challenges

- Fast yet Reliable
  - Communication is hard, many things can go wrong, try to eliminate most errors, fix the rest.
  - 1200 bits/sec over phone in 1980,
  - 100,000,000 bits per second through air in 2010.
- Sharing
  - Dedicated links (e.g. phone lines, TV stations) are impossibly expensive.
- Scalability
  - Successful networks are large; large networks are successful (utility grows with size)
  - Control must be distributed.

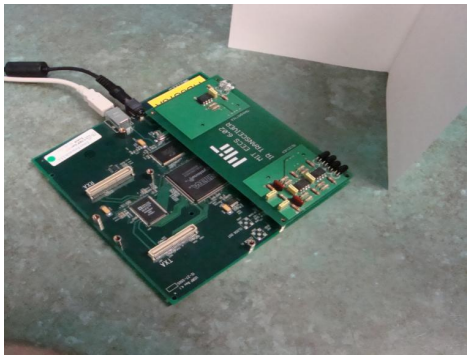
Fundamental Problem: Reliability versus speed.

Dark Room

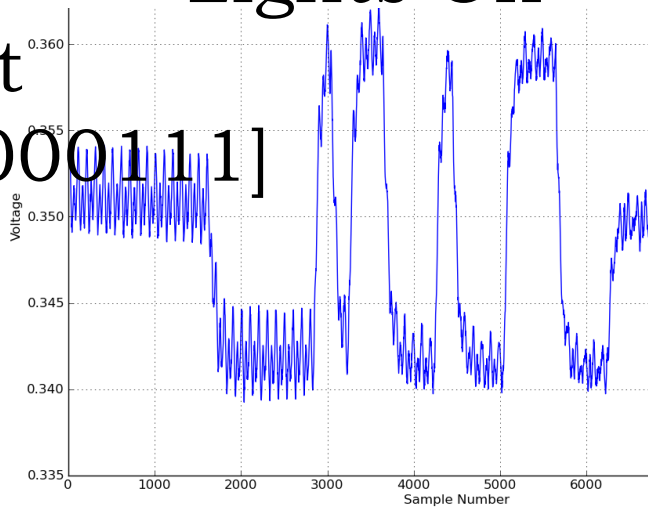


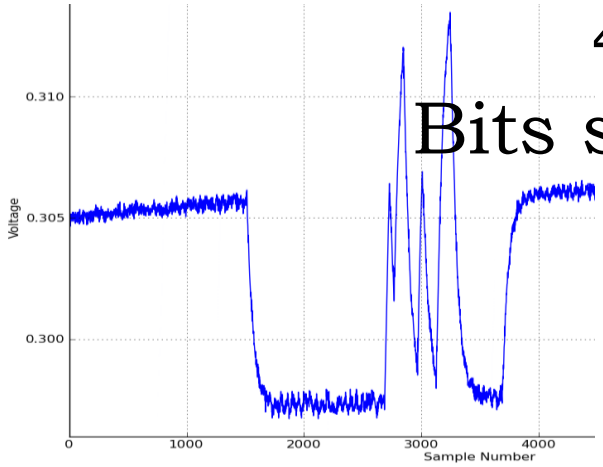
200 Samples/bit

Bits sent = [1011000100011 1]



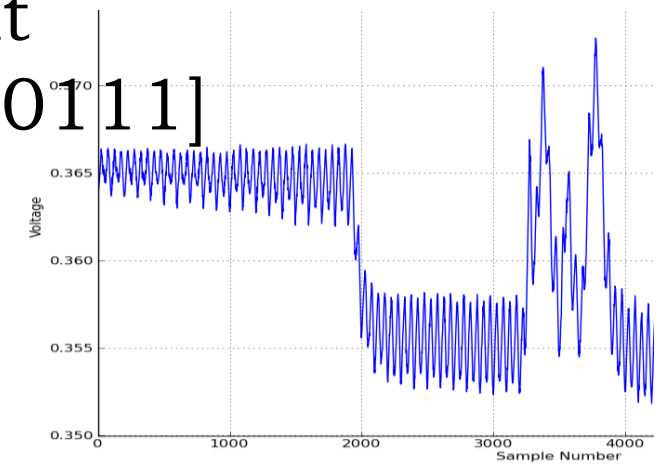
Lights On





40 Samples/bit

Bits sent = [1011010111]



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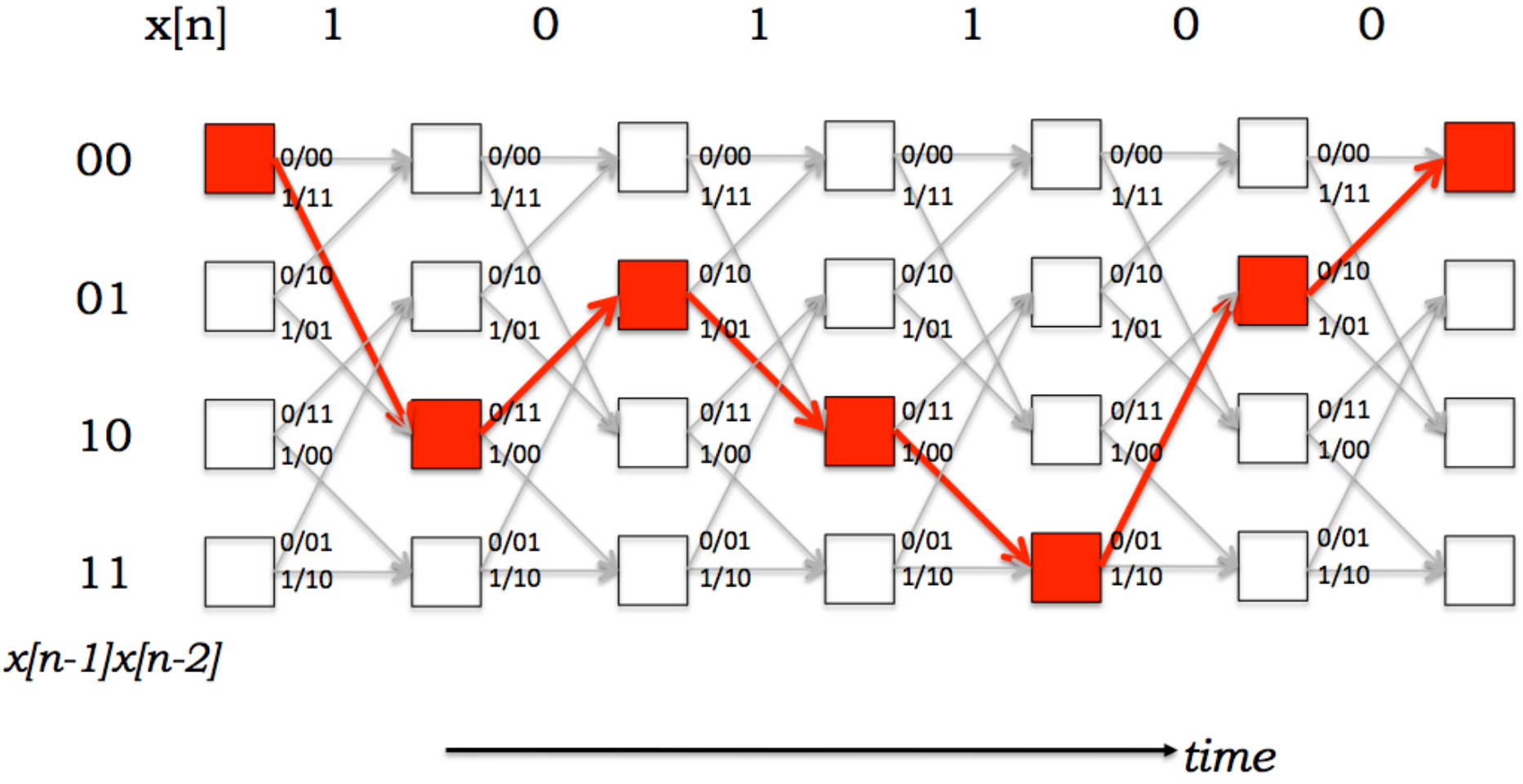
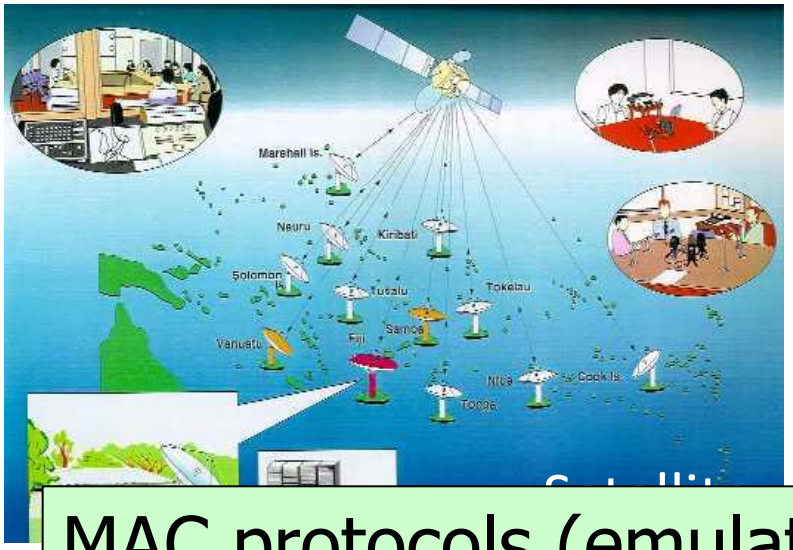
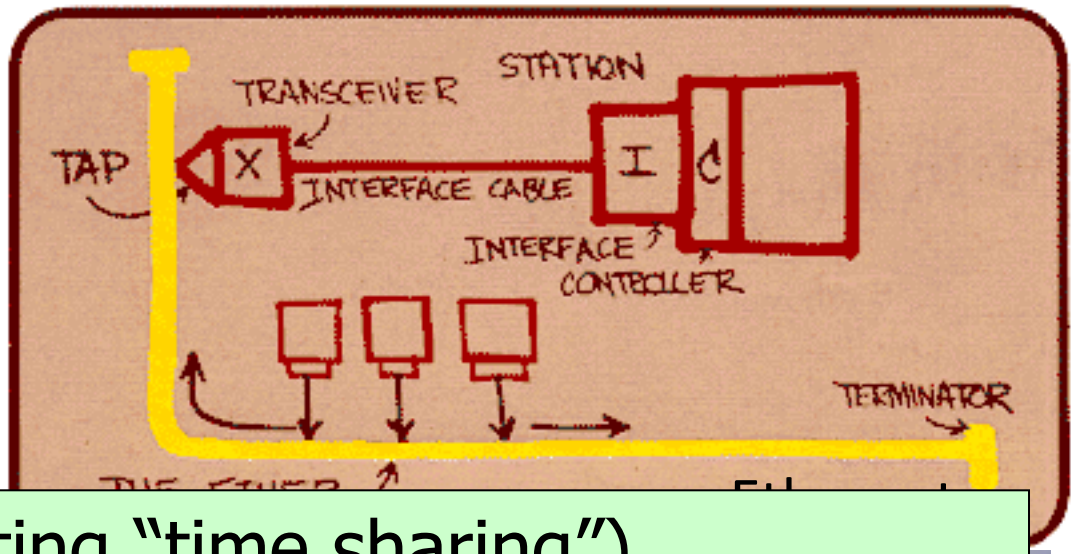
Error Correcting Codes use Redundancy to fix Errors.



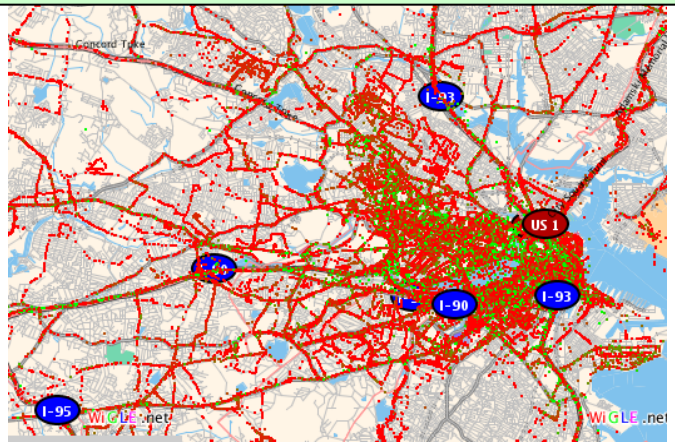
Fundamental Problem: Sharing





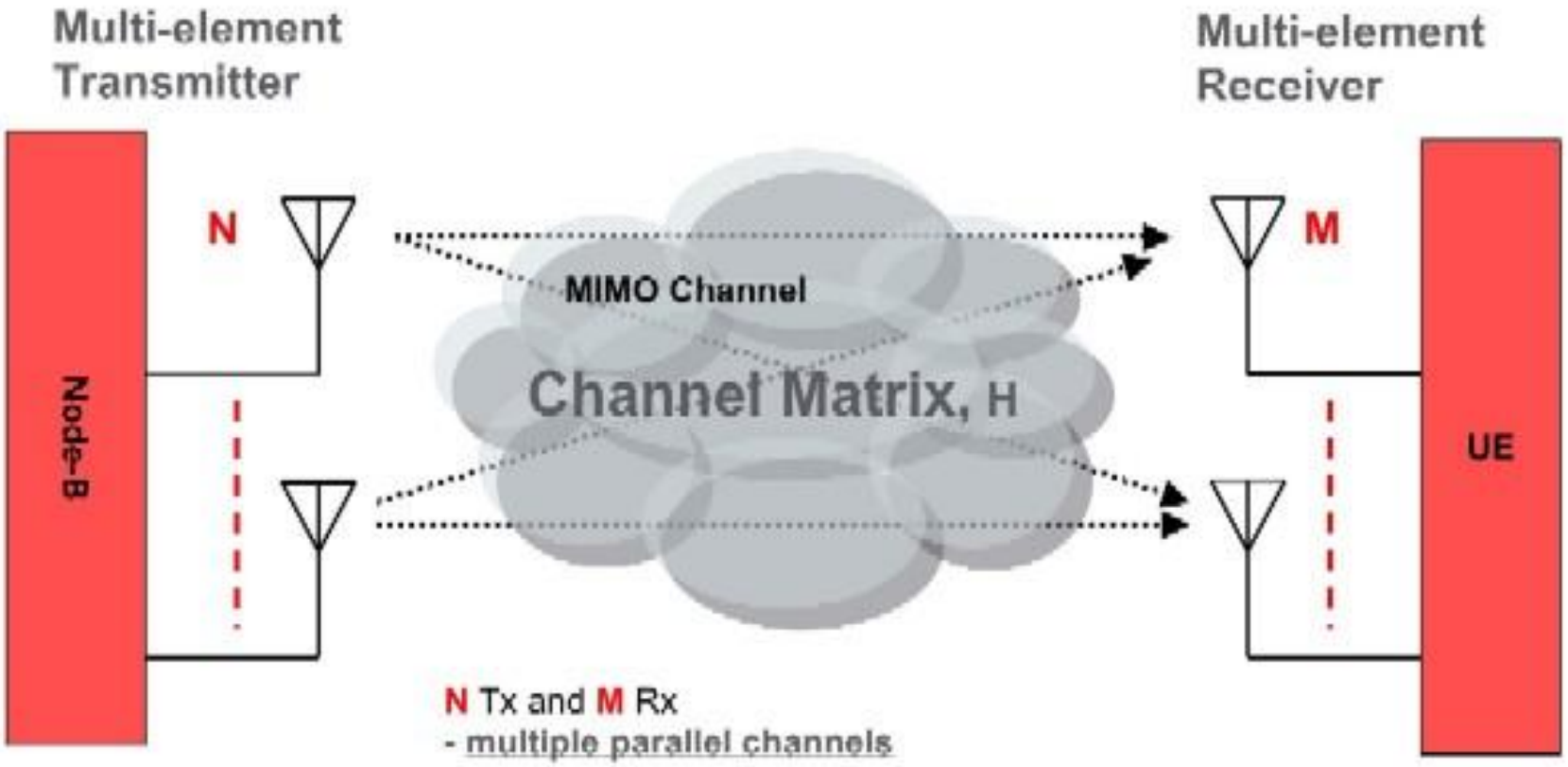
MAC protocols (emulating "time sharing")
Frequency division multiplexing ("frequency sharing)

Wireless LANs



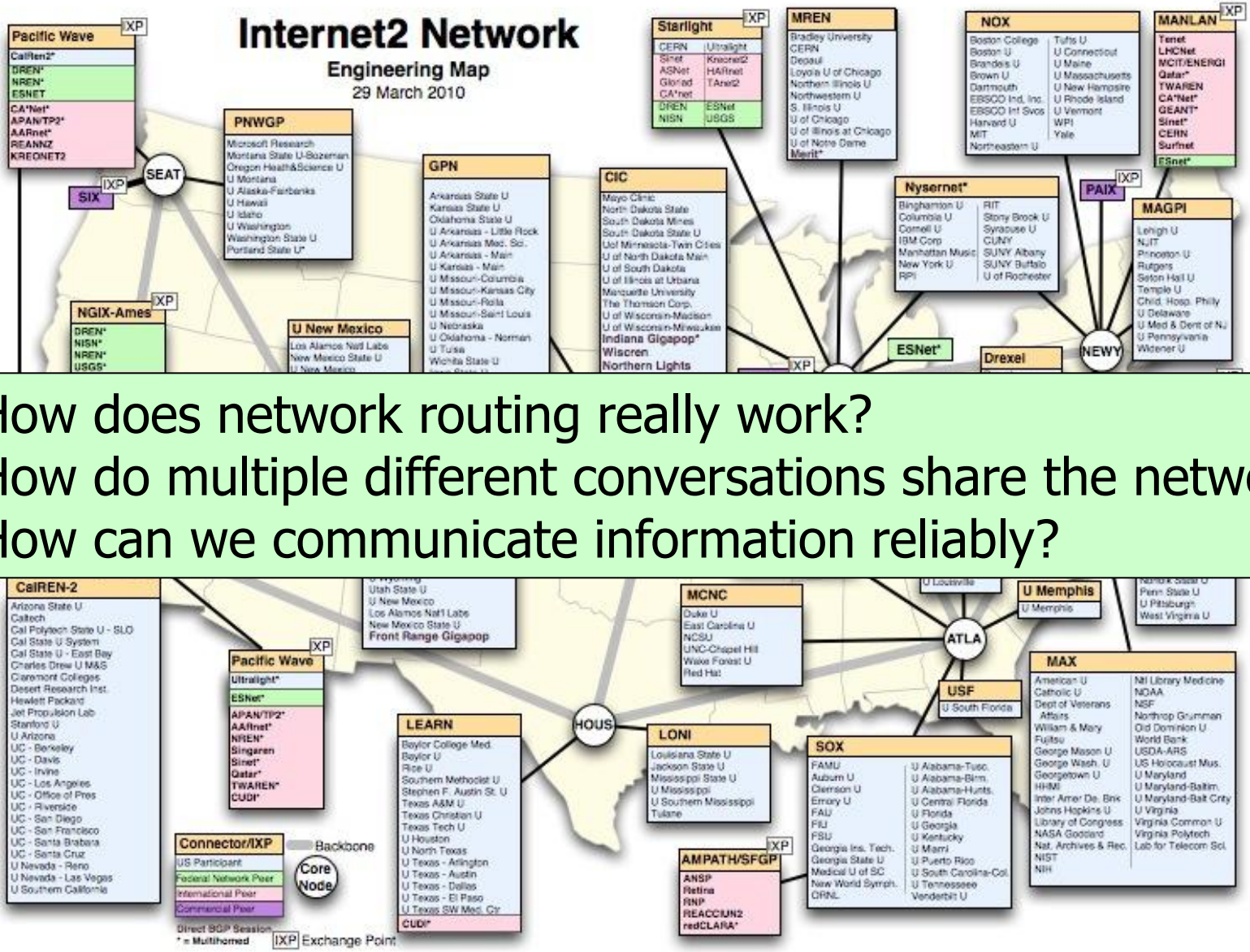
Cellular wireless

MIMO for Superfast Wireless



http://connectedplanetonline.com/wireless/technology/mimo_ofdm_091905/

Multi-Hop Networks



How does network routing really work?
How do multiple different conversations share the network?
How can we communicate information reliably?

Approach

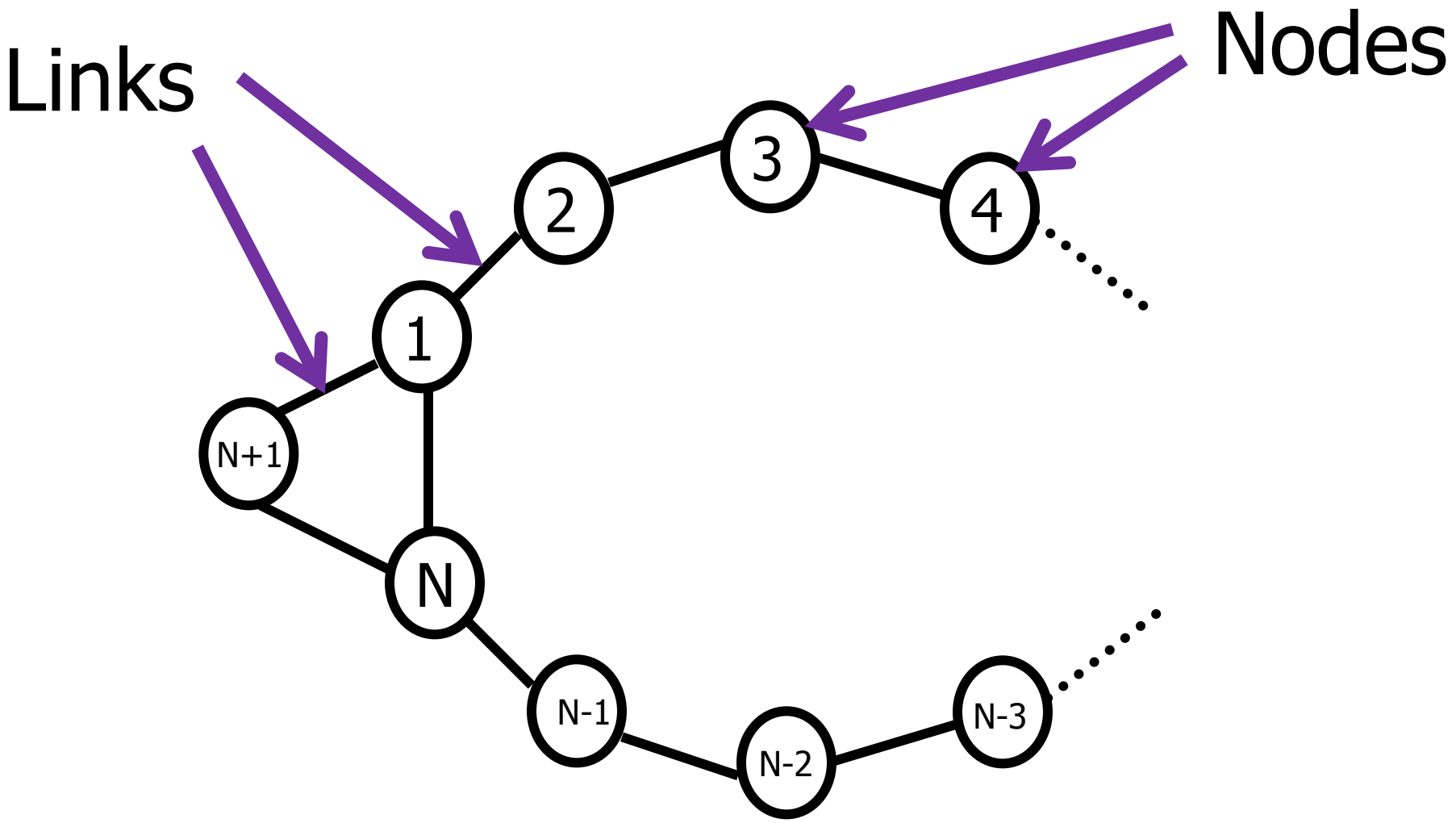
- Understand **tools and techniques**
  - Concepts and principles
  - Labs
  - Small problems

- Begin to understand **trade-offs**
  - The essence of all engineering systems
  - Science, art, or a mix?
  - Principles and tools matter, as do intuition and experience

EECS Ideas

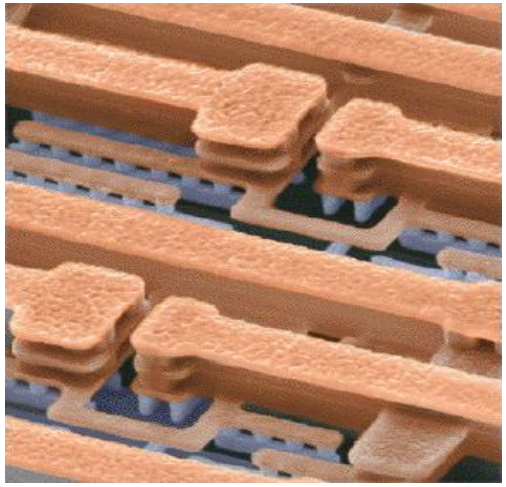
- Signals and systems
  - Linearity and time-invariance, superposition, deconvolution, filters and frequency response, modulation.
- Algorithms, centralized and distributed
  - Trellis decoding (Viterbi), shortest paths (Dijkstra), distance vector routing (Bellman-Ford), compression (Huffman, LZW)
- Computer systems
  - Abstraction and modularity, layering, protocols, hierarchy
- Applied probability (for Noise modeling)
  - Continuous-domain probability (density): error analysis
  - Discrete-domain probability: MAC protocol analysis
  - Basic queueing models: packet switch sharing analysis
- Methods: design, simulation, experimentation

Network (Topology), Links, and Channels



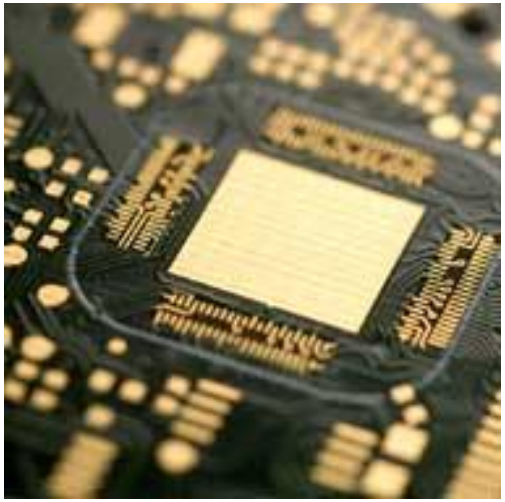
Link's physical connection is the channel

IC Interconnect



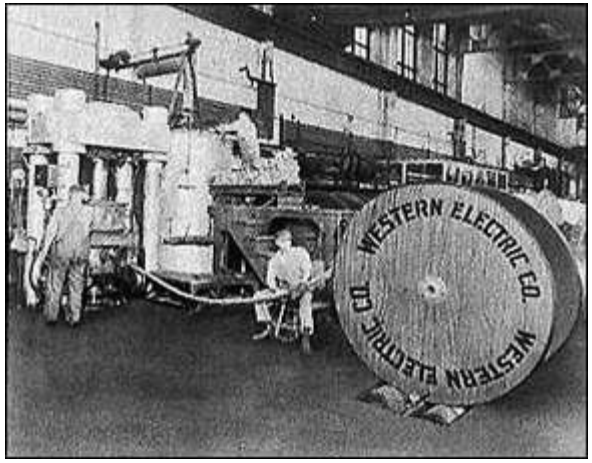
http://materials.usask.ca/images/photos/SEMof3LevelCuInterconP98.GIF

Printed Circuit Board



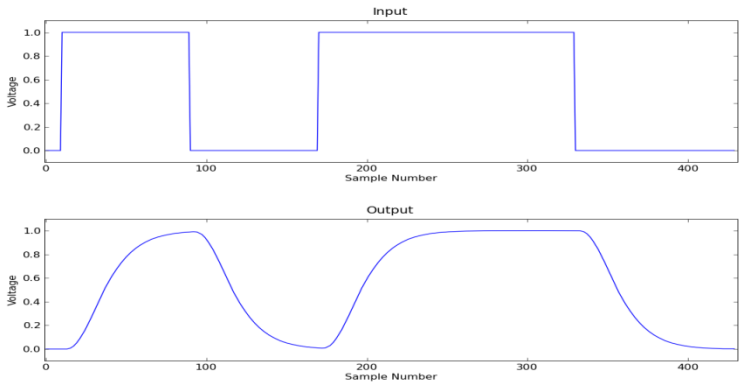
http://www.gpv-pcb.com/Files/Billeder/fabrikker/chemitalic/Chem_pcb_hdi.jpg

Transatlantic Cable

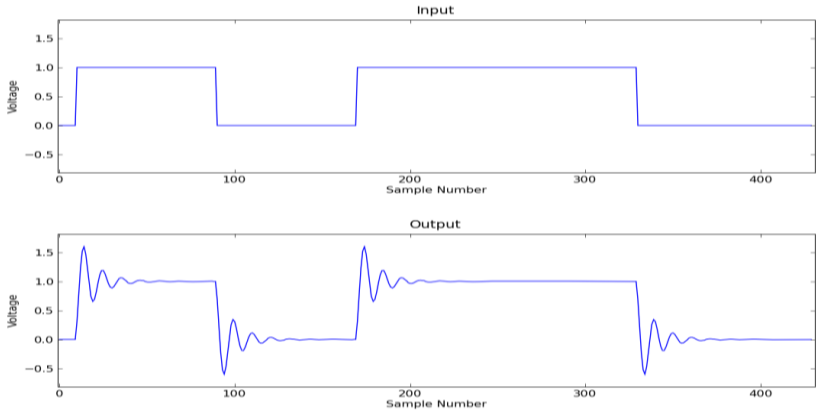


http://www.satamerica.com/imagens/4a27897r1.jpg

Slow Response



Ringing



May also have long delays (Receiver does NOT know)

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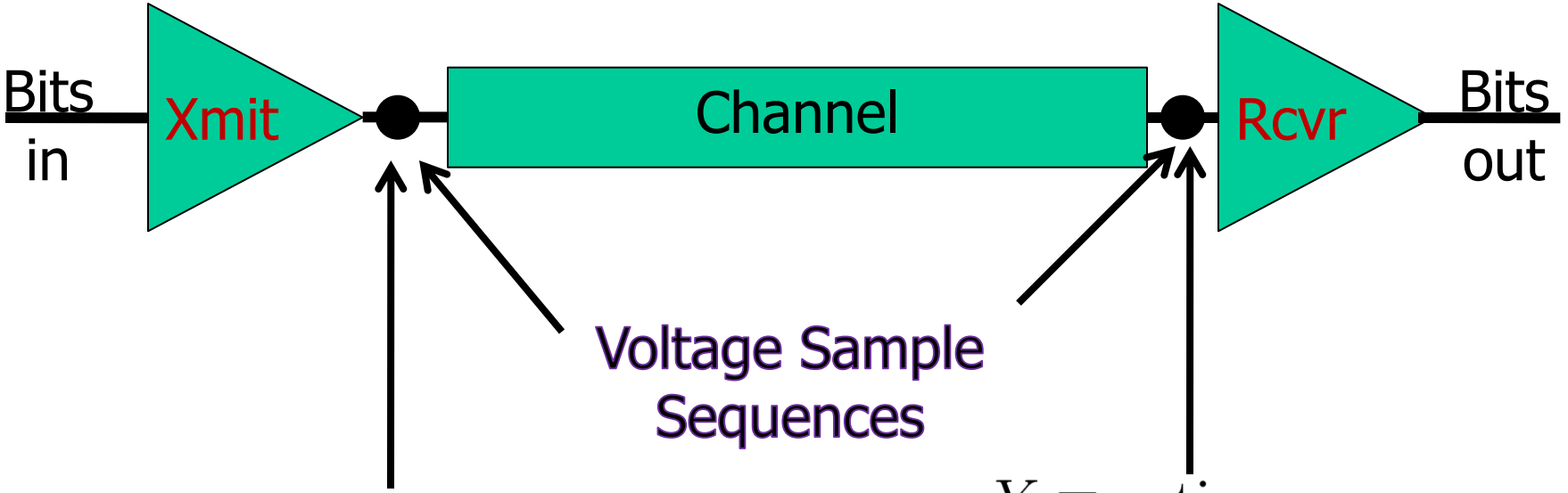
6.02 Channel Setup and Notation



$X \equiv$ entire sequence

$x[n] \equiv n^{th}$ sample value

$Y \equiv$ entire sequence

$y[n] \equiv n^{th}$ sample value

Sample Rates:

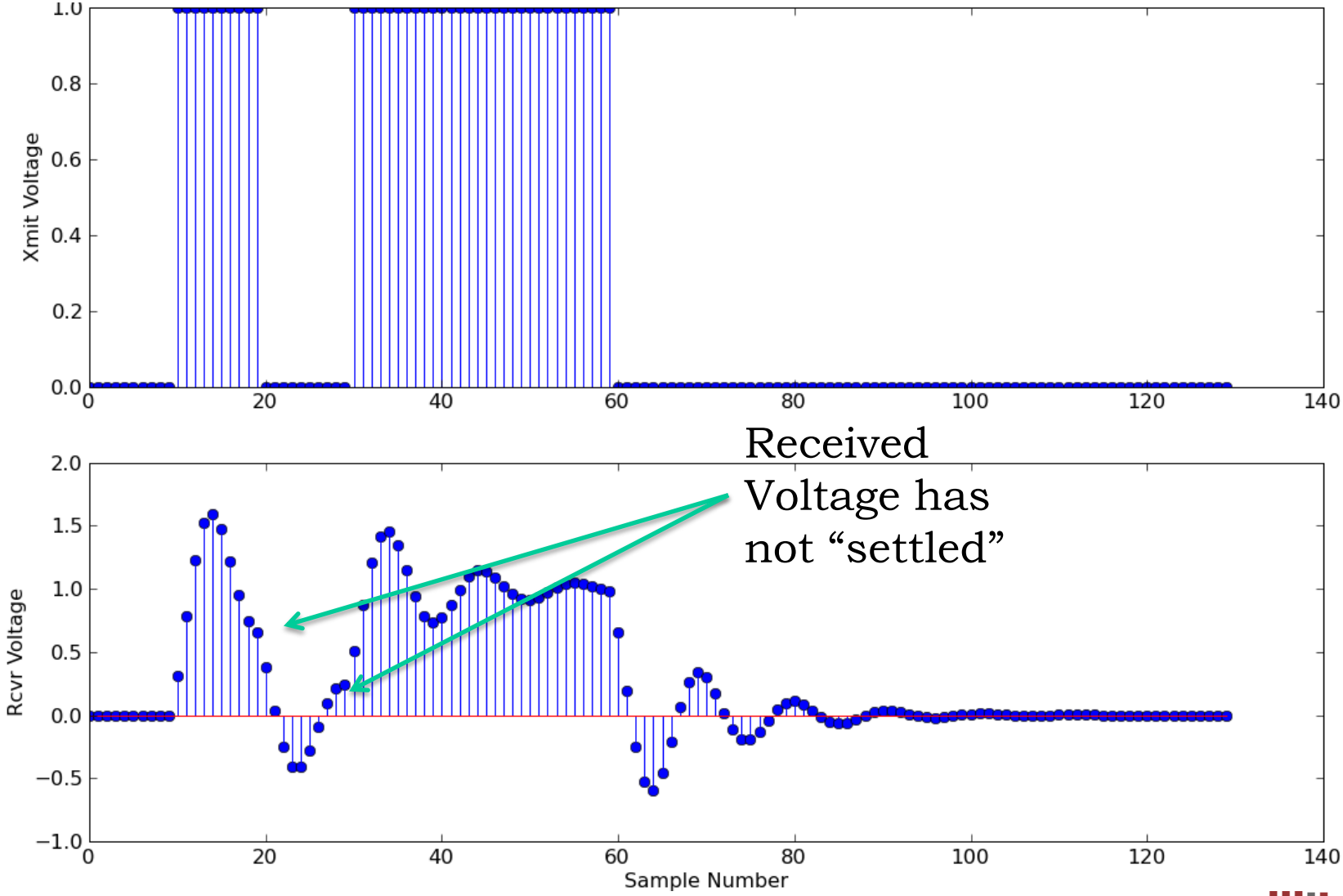
- 4 million Samples/Second (IR Transceiver)
- Up to gigaSamples/Second (Fastest)

Samples, Bit Period, Bit Rate

- Our Hardware
  - Updates transmitter output voltage every ¼ microsecond (4 million times a second).
  - Remeasures receiver voltage every ¼ microsecond (4 million times a second).
- Bit Period and Bit Rate
  - BP = Samples/bit * ¼ microsecond
  - BR = Bits transmitted per second
  - BR = (4 million) / (Samples/bit)
- Slower Bit Rate = Longer Bit Period
  - More time to propagate through channel

Sending 0101110, 2.5 microseconds/bit

10 samples/bit, 400,000 bits/sec



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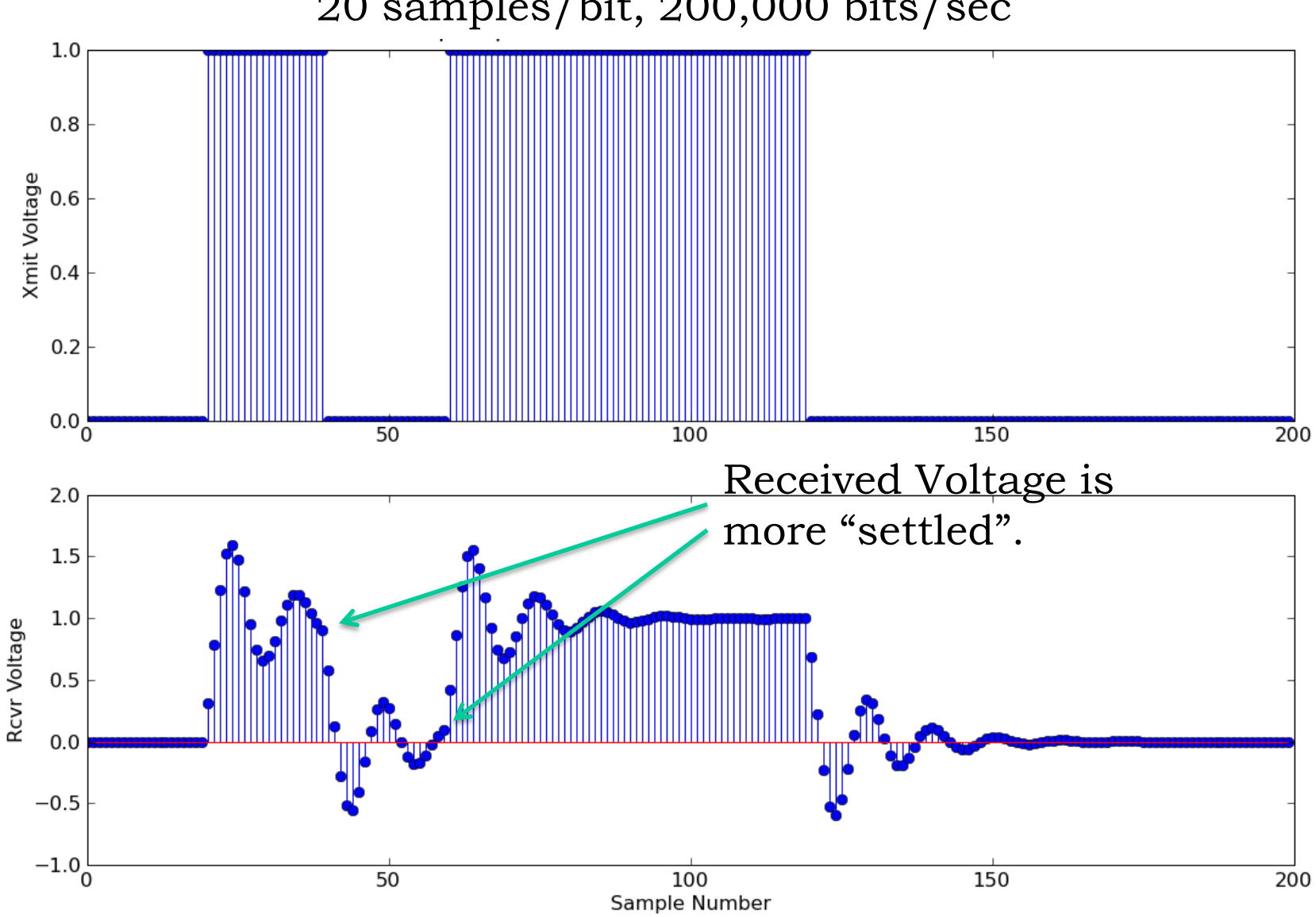
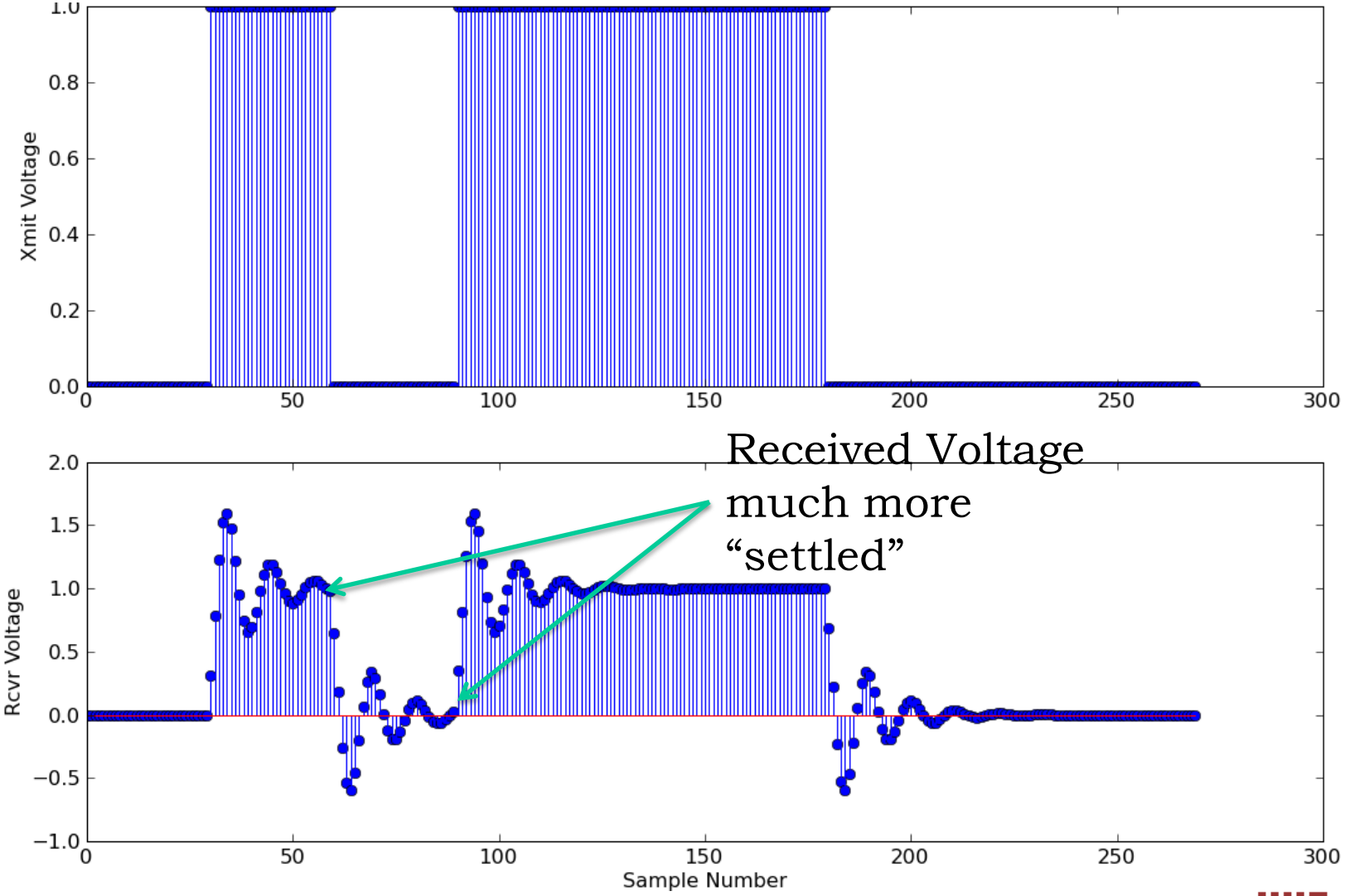
Sending 0101110, 5 microseconds/bit

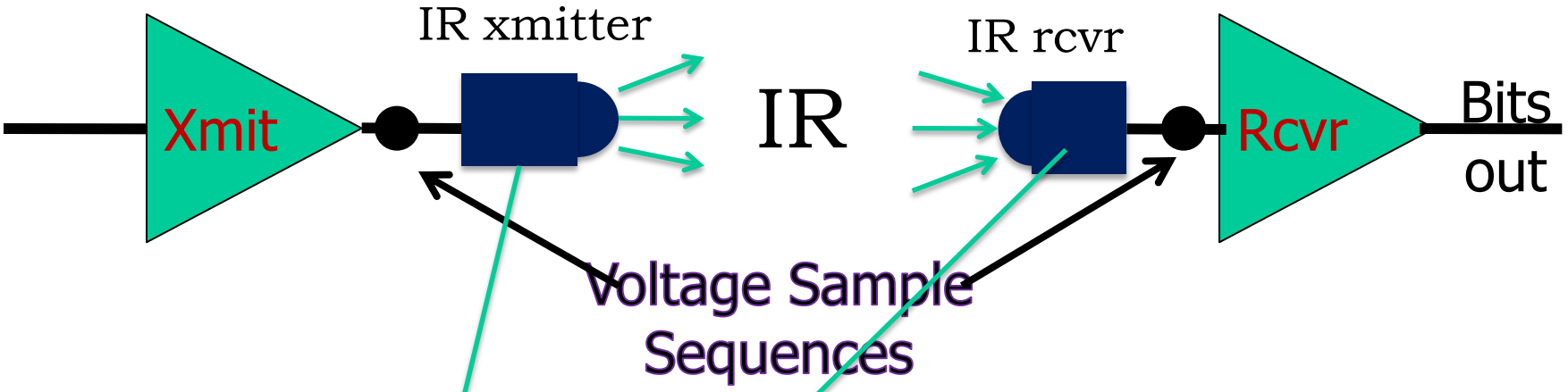


Sending 0101110, 7.5 microseconds/bit

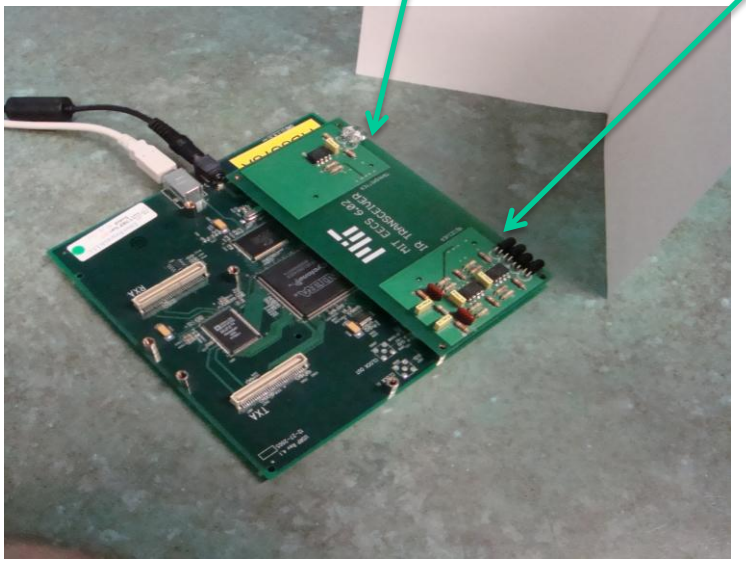
30 samples/bit, 133,333 bits/sec



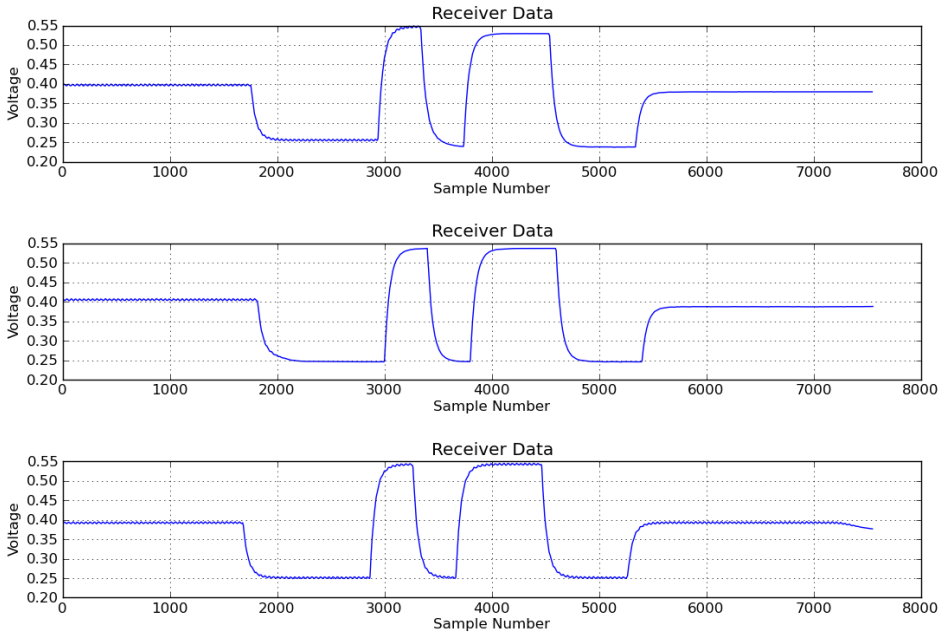
The 6.02 Infrared Transceiver



Loopback Setup

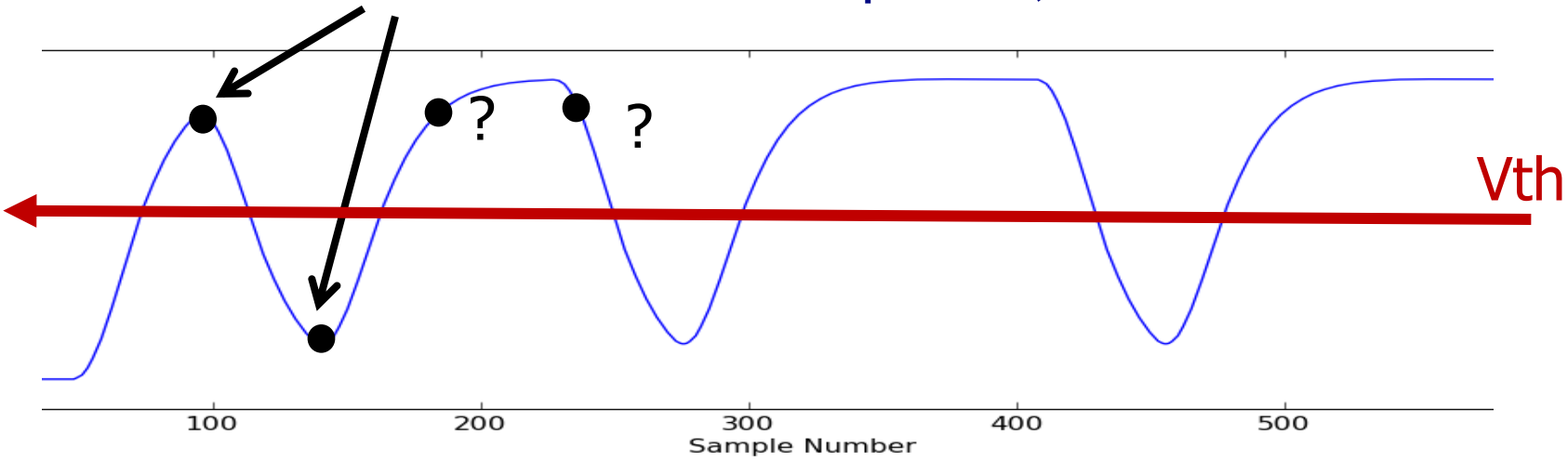


400 Samples/bit



How does Rcvr convert samples to Bits?

- Decide on a threshold voltage
  - Bigger than the threshold is a ‘1’
  - Smaller than the threshold is a ‘0’
- Decide when to detect
  - Receiver knows the bit period, that’s all.



On-line Problem Sets, Labs and Interviews

- Problem Sets are basic questions
  - Get immediate feedback (Due Monday night)
- Labs in Python and sometimes using IR hardware
  - Experiment with concepts.
  - Examine real data.
  - Opportunity to design.
  - Must answer lab questions (All due Wednesday night)
- Interviews
  - You must explain you programs to your TA each week.
  - A chance to show your insights, clarify concepts.