CS6458
Systems for programmable optical interconnects

Lecture 1

Rachee Singh

https://www.racheesingh.com/sysoptinterconnect/

Welcome!

Course Staff: Instructor

Name: Rachee Singh

Research area: Optical networking

Previous job: Microsoft Research

Hobbies: Biking, running, baking bread

Professional Website: www.racheesingh.com

Rachee Singh

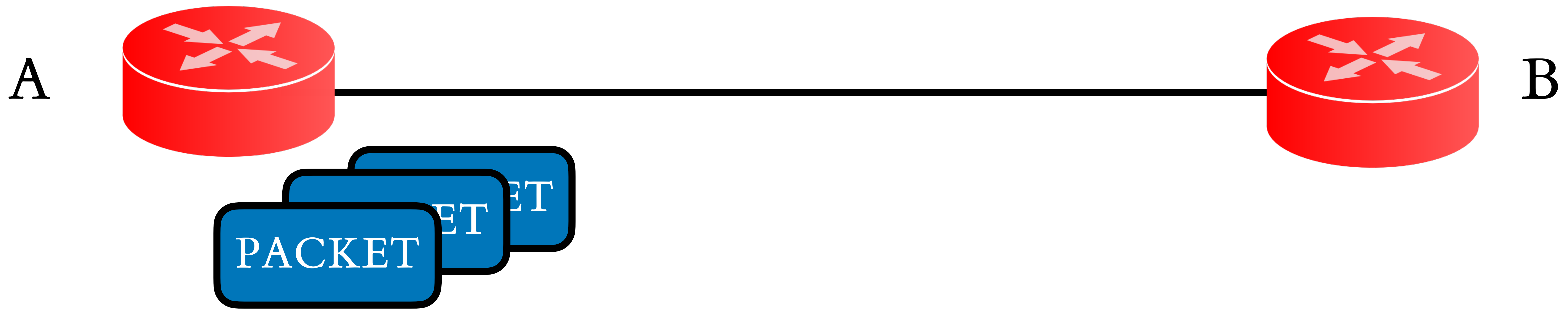
Grading Policy

1. Course Project (50%)
    1. Let's discuss in class and form groups
2. Paper discussions and review (50%)
    1. Details: https://www.racheesingh.com/sysoptinterconnect/discussion/

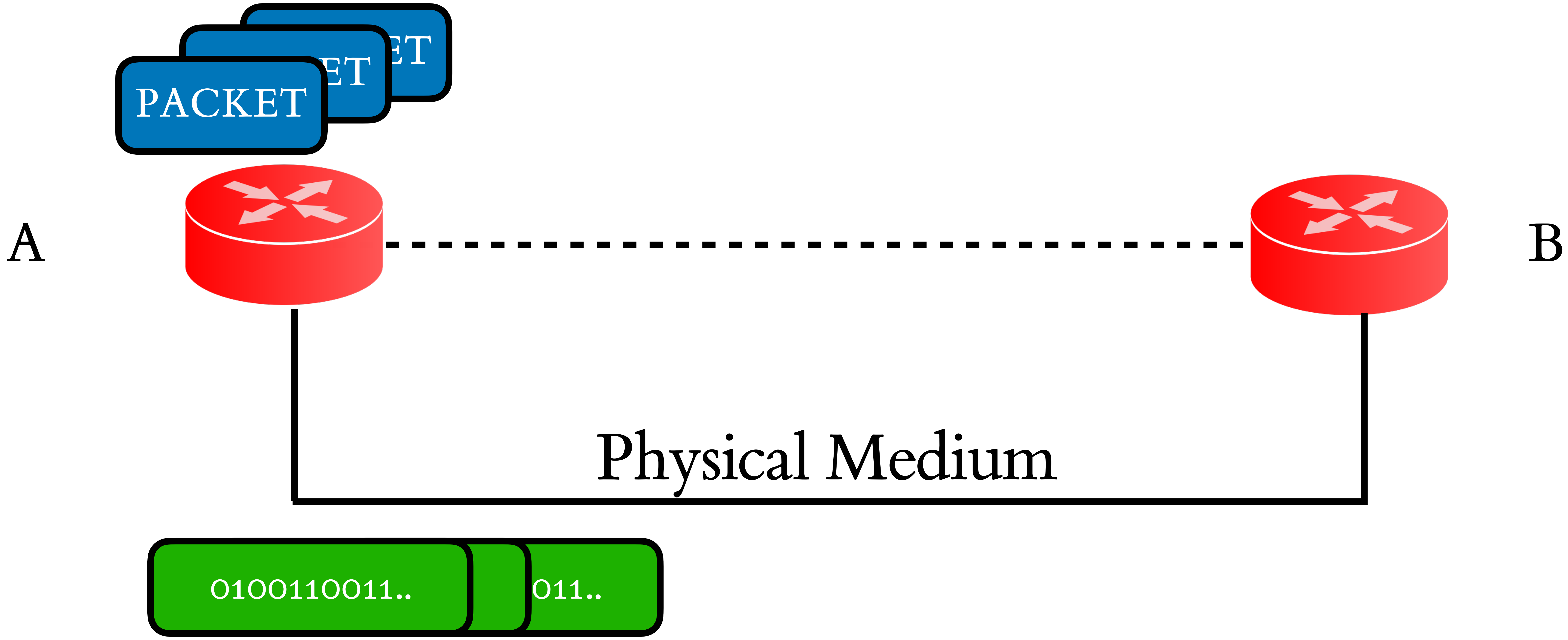
How to succeed in this class?

1. Attend lectures
2. Actively ask questions and participate in the class
3. Be willing to think actively

Physical links

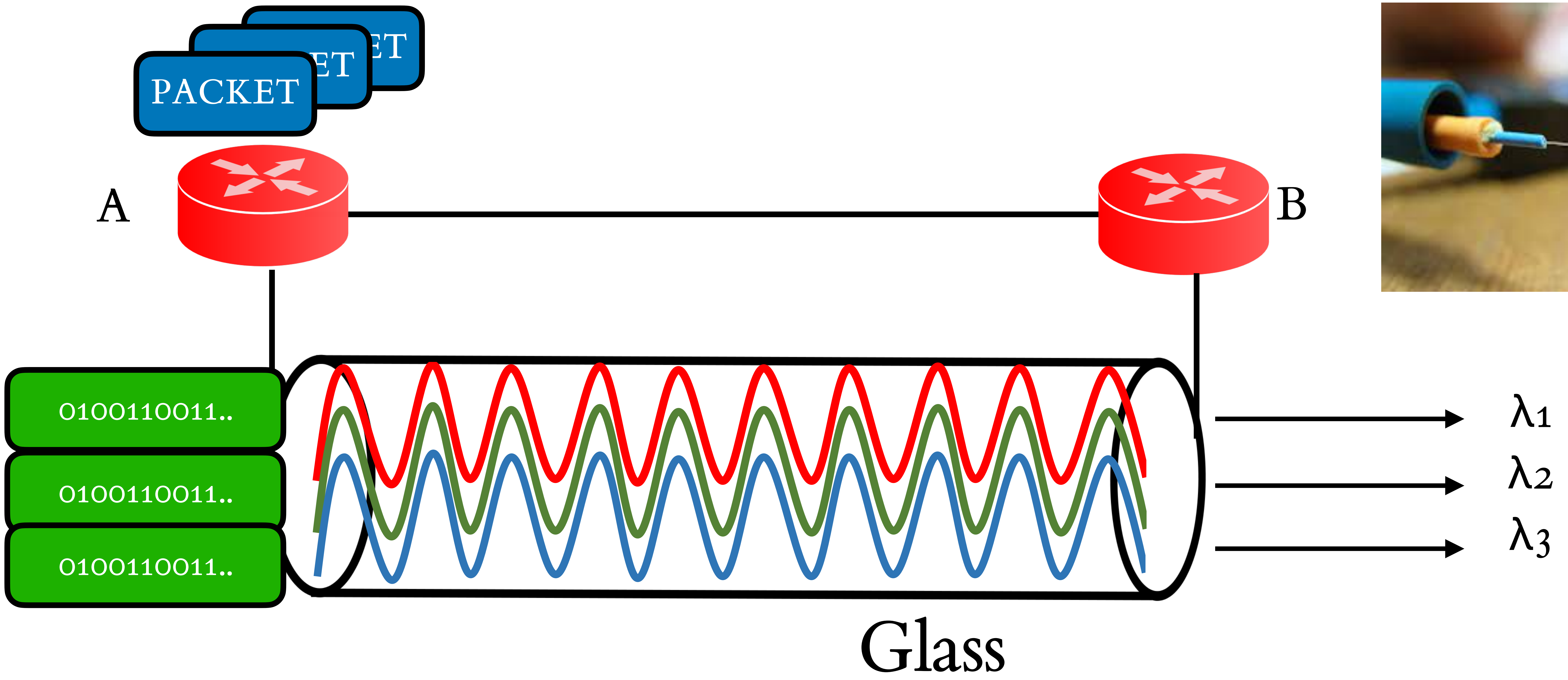


Physical connectivity: basics



Bits in the packets are "encoded" on a signal in the physical medium.

Physical connectivity: basics



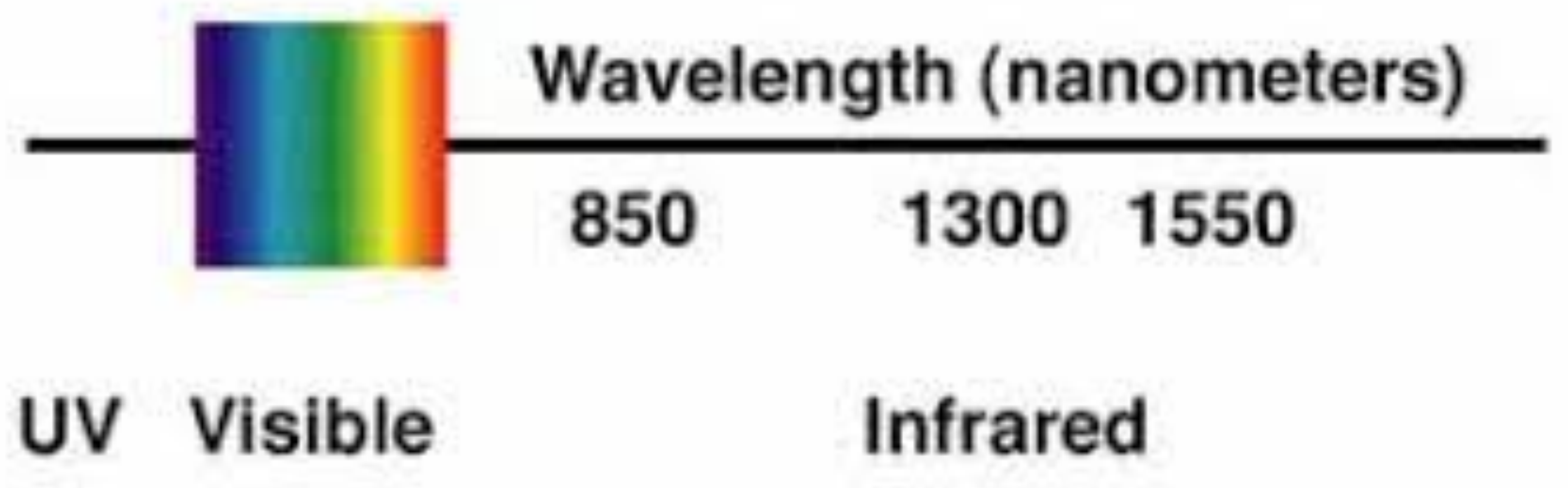
Fiber (glass) is an efficient (low loss) medium for transmitting signals.

Wavelength Division Multiplexing

1. Ability to carry multiple channels of light on a single optical fiber
2. Each channel is carried at different optical frequency or wavelength
   1. Different wavelengths do not interfere with each other
3. Dense Wavelength Division Multiplexing (DWDM)
   1. 40+ wavelengths per fiber
4. Coarse Wavelength Division Multiplexing (CWDM)
   1. < 8 wavelengths per fiber

Spectrum on optical fiber

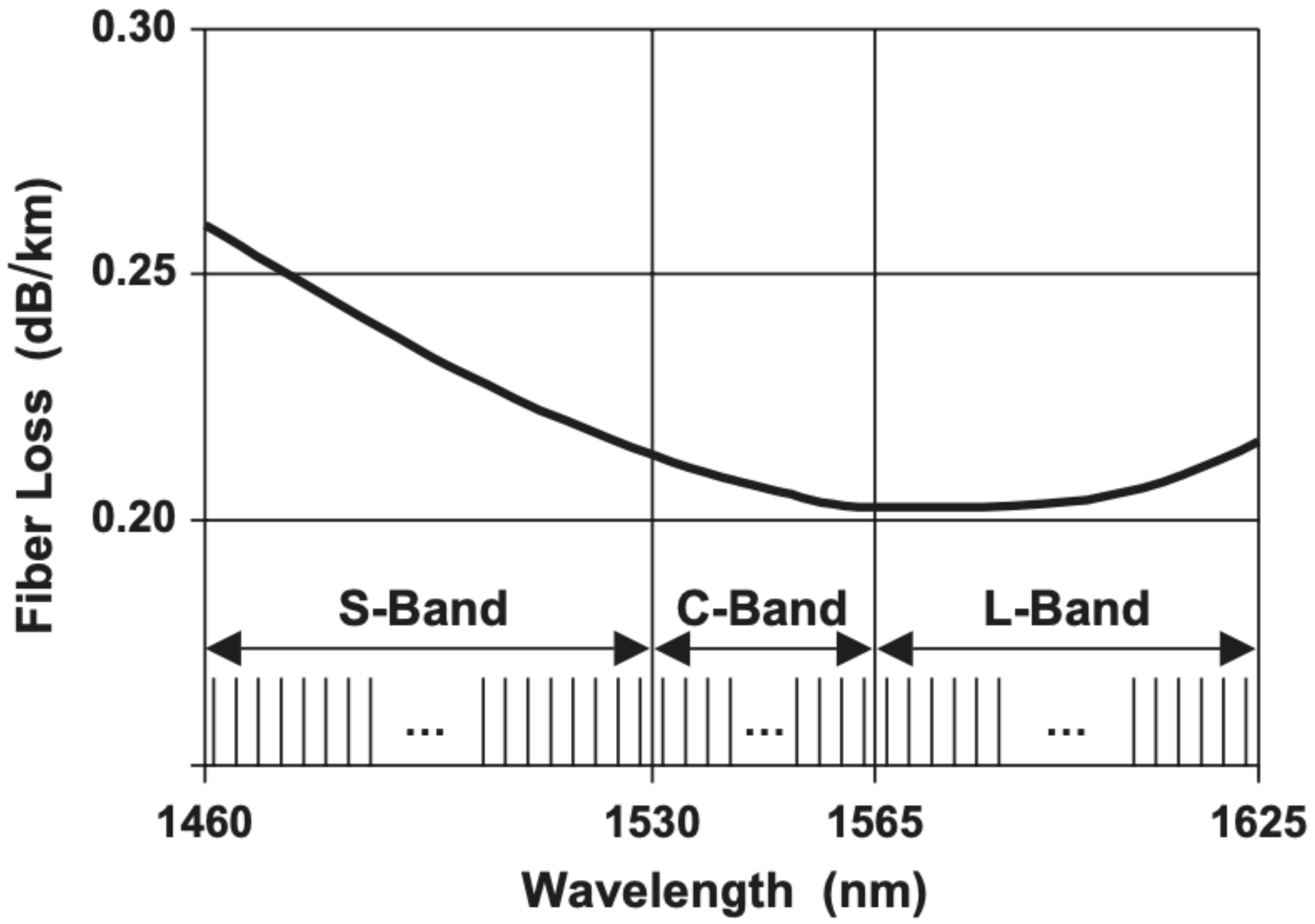
1. Optical spectrum is the range of wavelengths in a fiber
2. Optical spectrum of fiber is in the infra-red range:
   - Wavelengths above 850nm
3. Why use infra-red signals?
   - Lower attenuation (loss of signal) in fiber
4. What causes attenuation?
   - Scattering of light
   - Absorption of light



Electromagnetic spectrum

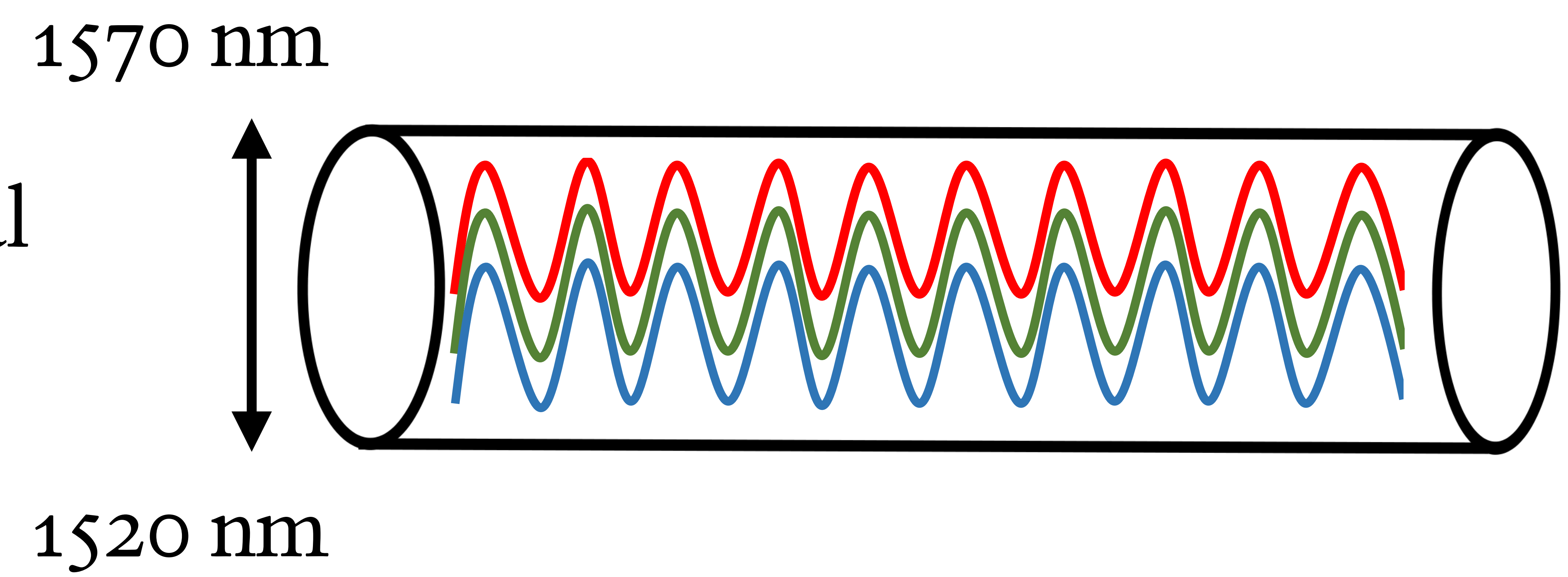
Spectrum on optical fiber

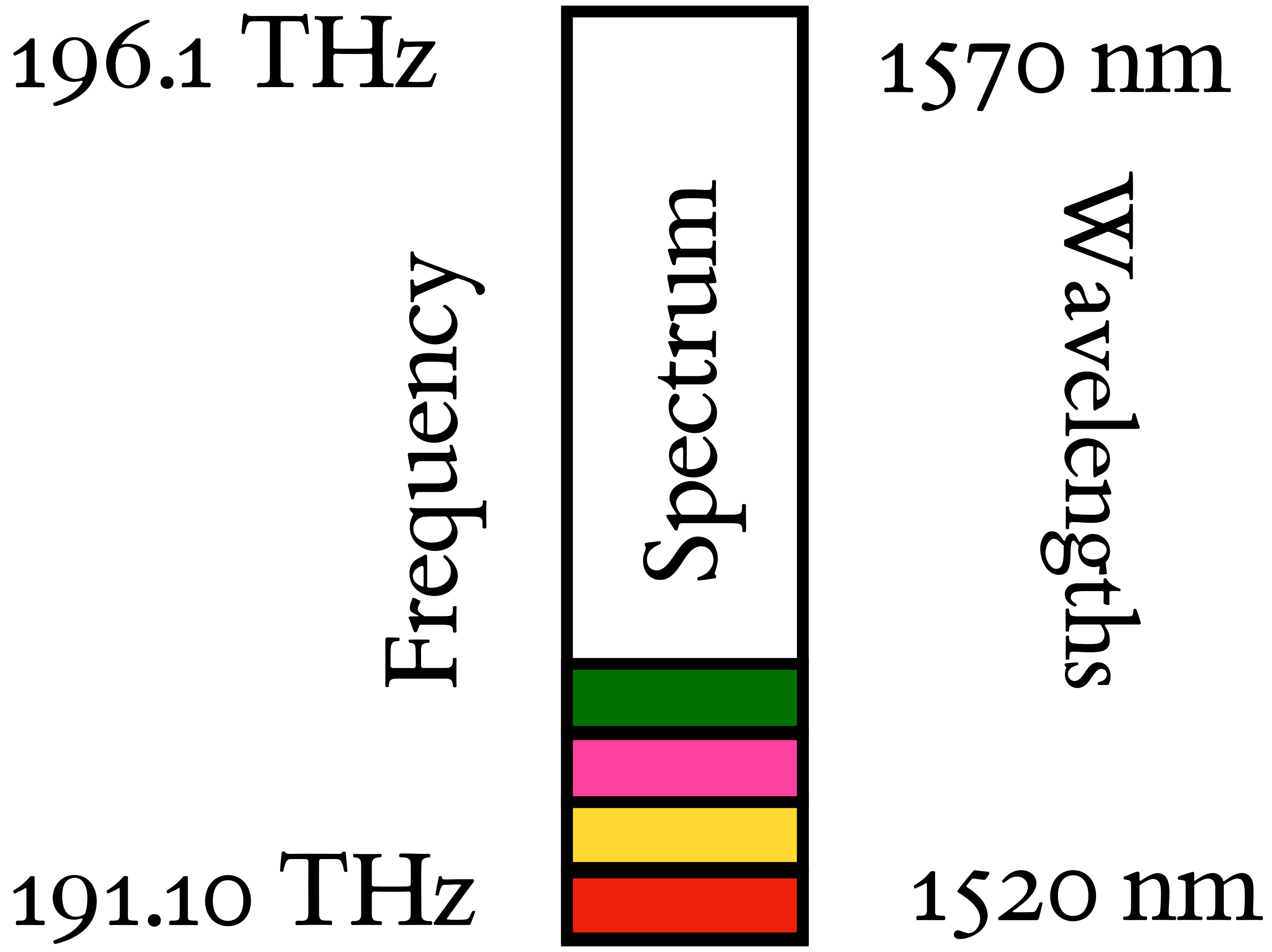
1. “Bands” of spectrum
2. Commonly used one for communication:
   1. C-band or conventional band
3. To increase capacity of the fiber:
   1. Use S (short) band
   2. Use L (long) band



Dicing the spectrum

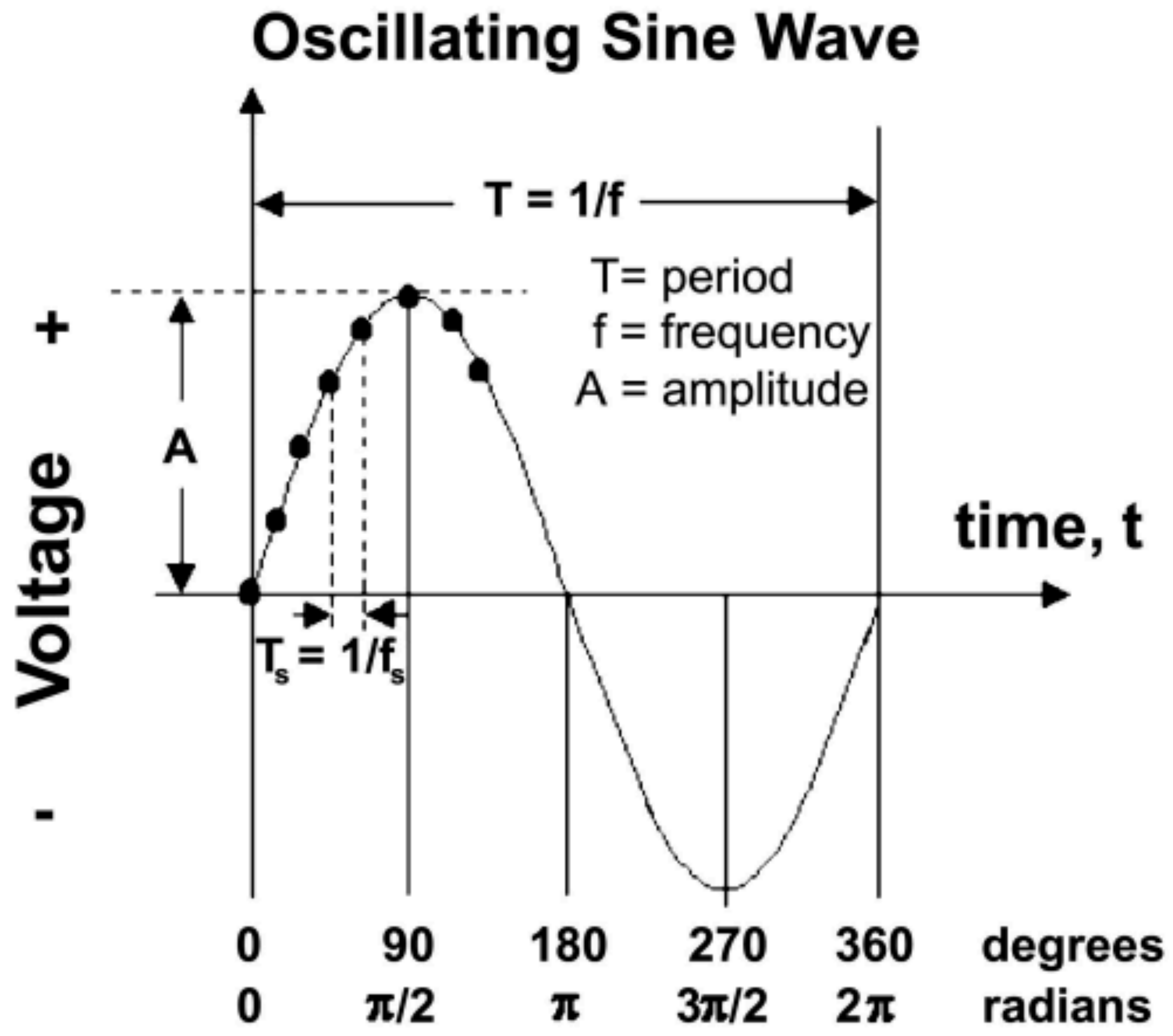
1. A wavelength (λ) carrying bits on fiber is a unit of signal
   - A portion of the optical spectrum
2. Frequency (f) and wavelength (λ) are used interchangeably: $\lambda \propto \frac{1}{f}$
3. Spacing between wavelengths to ensure signals don't overlap at the receiver
4. 50GHz space between wavelengths, total 4THz bandwidth means 80 wavelengths on fiber (4000/50)





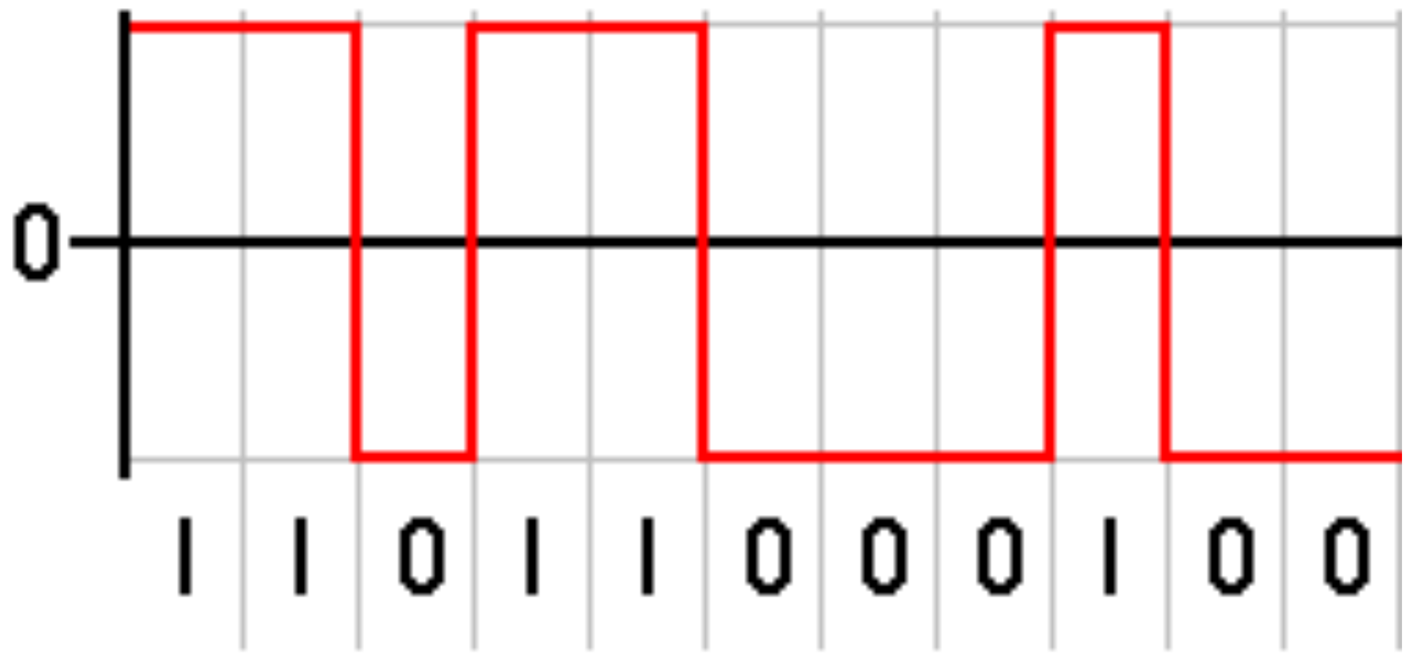
Signal modulation

1. Modulating the light signal
    1. Encode bits on a wave or pulse
    2. By changing the *properties* of the signal
2. Types of modulations
    1. Change *amplitude* of the signal
    2. Change *phase* of the signal
    3. ..



Signal modulation

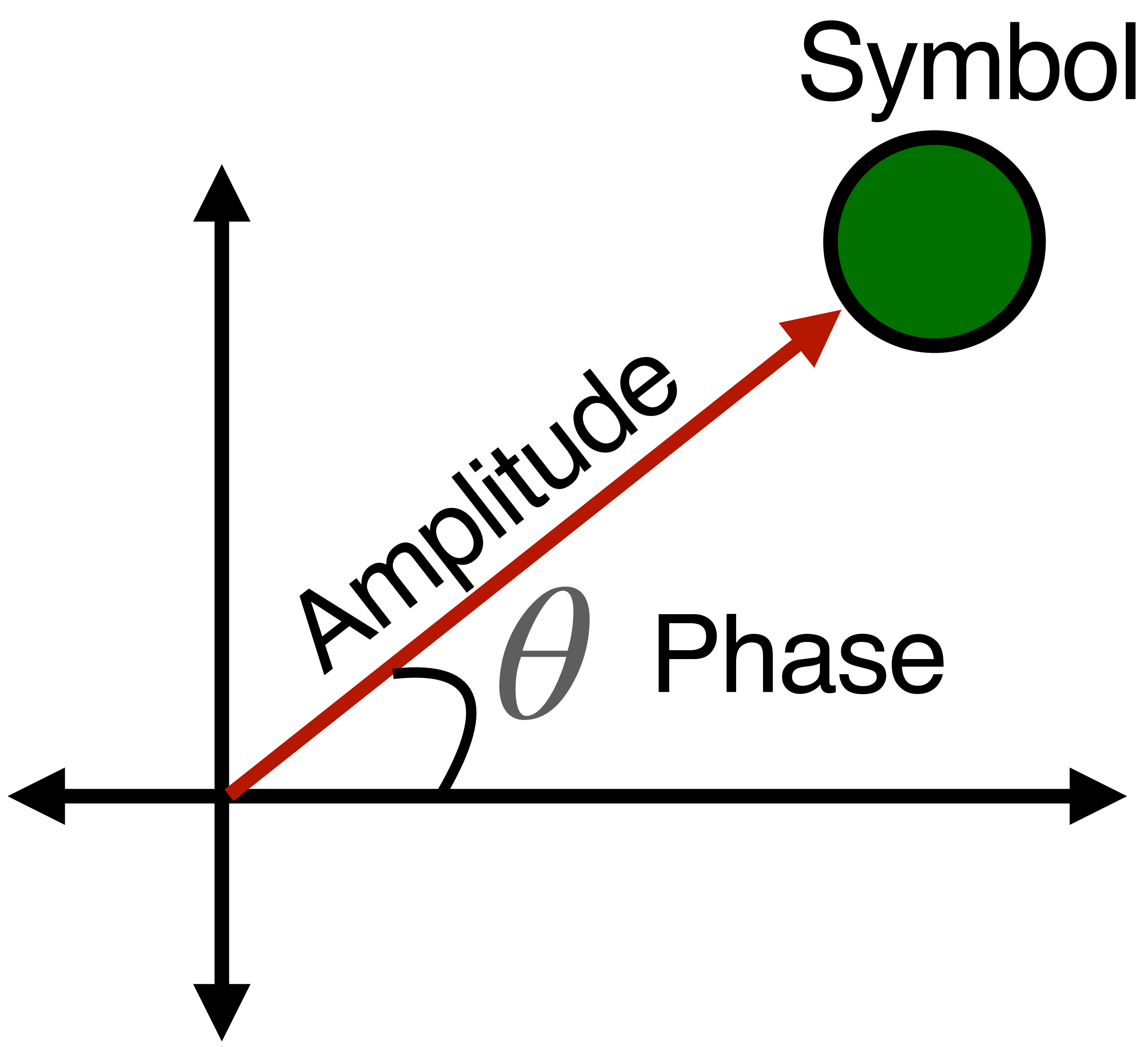
1. Transmitter modulates light signals (wavelengths)
    1. Encode bits on a wave or pulse
    2. By changing the *properties* of the signal
2. Receiver decodes the signal to retrieve bits
3. Digital (bits on transmitter) —> analog (optical signal) —> Digital (bits on receiver)
4. Example modulation format: NRZ



Non-return zero (NRZ) modulation

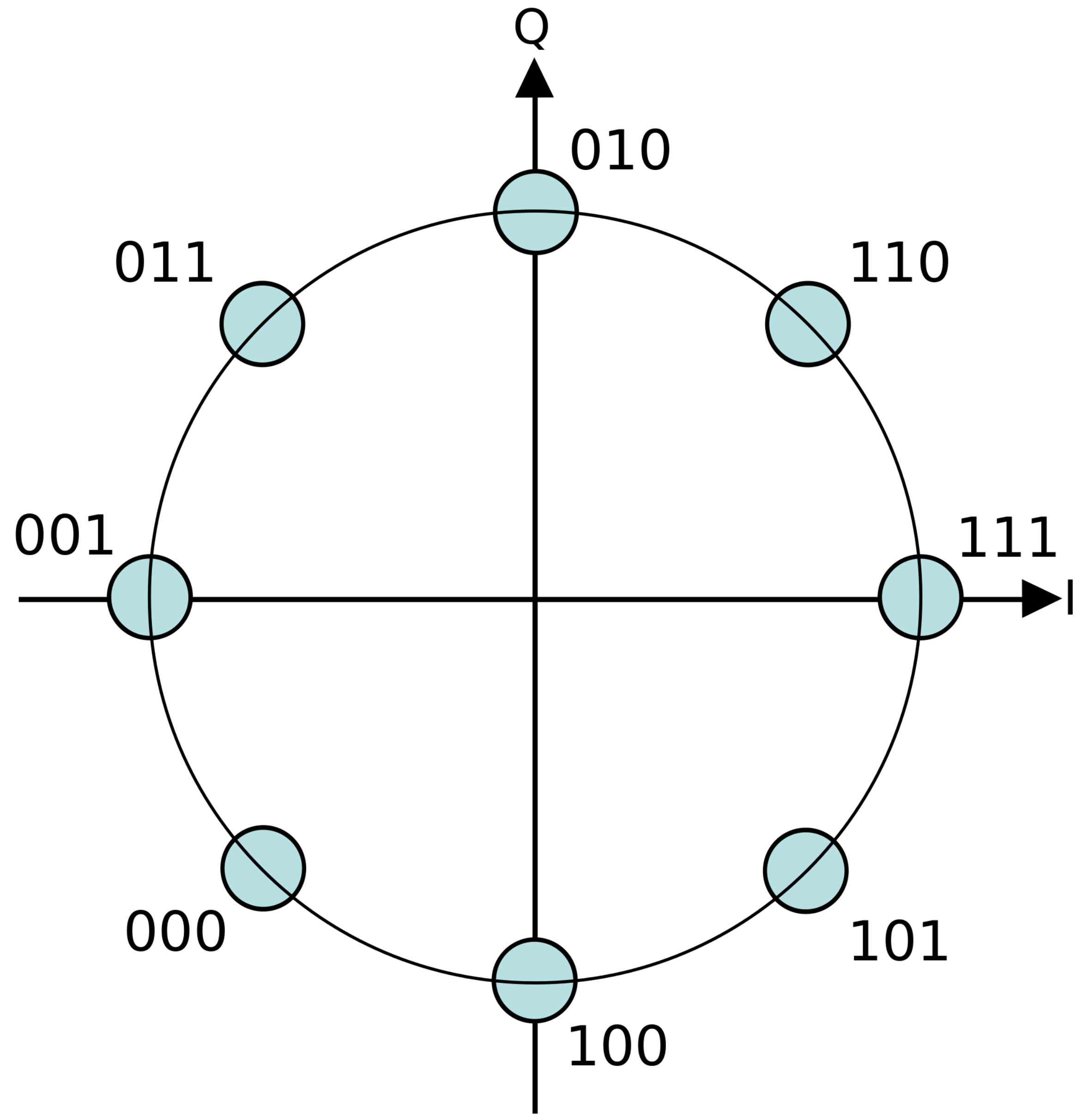
Representing Symbols in Diagrams

1. Finite set of choices for change in properties of the signal
    1. Each choice is called a *symbol*
2. Represent each symbol of the mod. format on a graph
    1. With the amplitude and phase
3. Multiple symbols in a modulation format



Signal modulation

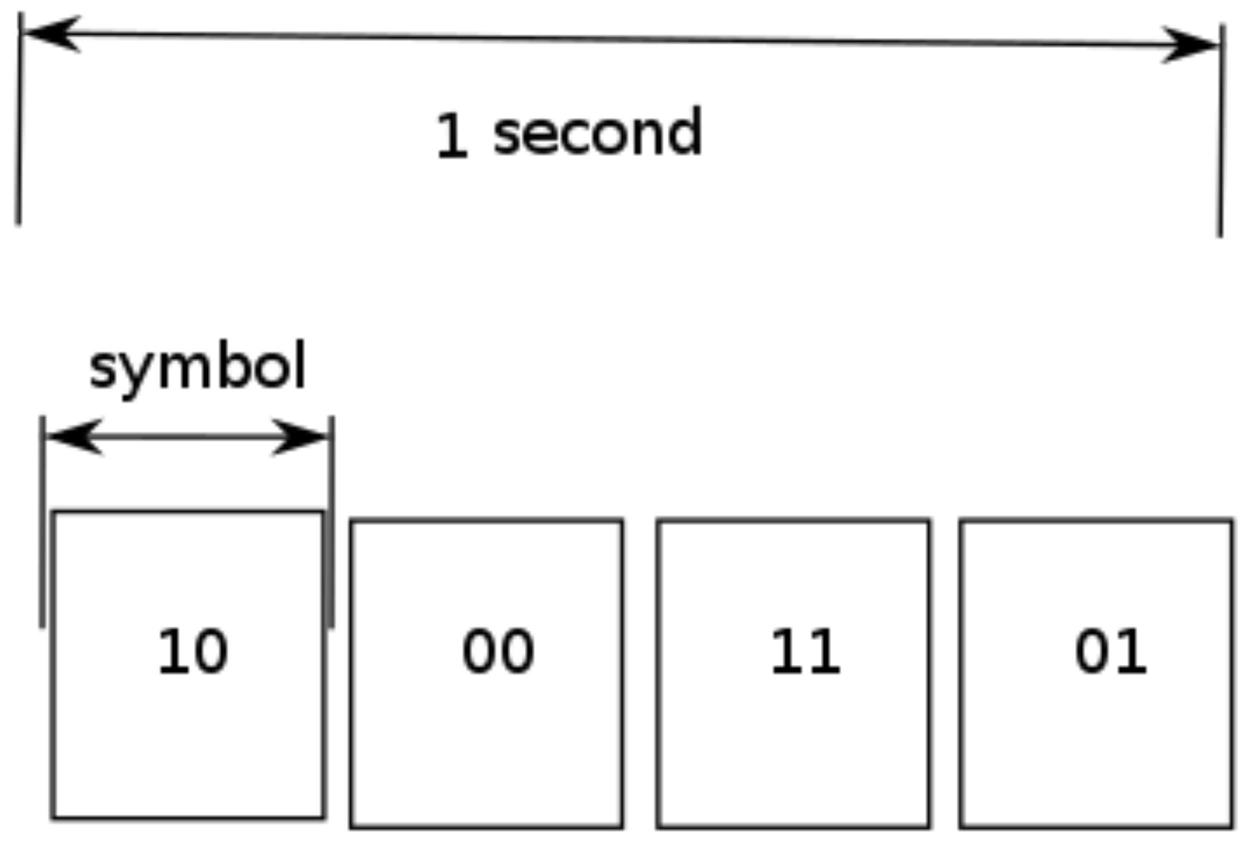
1. Modulation packs bits on a signal
   - Some formats pack more bits than others
2. Types of modulations
   1. Change *amplitude* of the signal
   2. Change *phase* of the signal
3. For example: Phase shift keying (PSK) modulation changes the phase of the signal.



Constellation Diagram of 8-PSK modulation

Signal modulation

1. Modulation format decides:
    1. Changes to the signal from a set of alternatives (symbols)
    2. Each symbol communicates a fixed number of bits
    3. Number of levels in a symbol = M, number of bits per symbol, $N = log_2 M$
2. Symbol rate decides:
    1. Number of symbols per second (baud rate)



Baud rate = 4, N = 2