Reliable Data Transfer?
Can we apply ARQ Protocols to Human Interaction (Communication)?
- Stop-and-Wait
- Go-Back $n$
- Selective Repeat

Can Apply ARQ in every layer
- Go-Back $n$ ARQ can be used for:
  - Congestion Control
  - Flow Control

One has to be careful when designing a ARQ protocol!
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Review: ARQ Protocols

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One has to be careful when designing a ARQ protocol!
Does it make sense to implement ARQ in more than one layer?
Where are we in the Course?

Basics:
- Network Types (“Hardware”)
- Layered Network Architecture (“Software”)
- Reliable Data Transfer
- Tools for Performance Analysis

Implementation:
- Design of Protocols
- Analysis of the Service provided by Protocols
Quality of Service

Delay

- Processing Delay
- Queueing Delay
- Transmission Delay
- Propagation Delay
Delay depends on $B$, $C$, and $\lambda$
Maximal delay is equal to
Loss depends on $B$, $C$, and $\lambda$
Design Objectives

- Given network resources and a Quality of Service (QoS) requirement, what is the maximal traffic load that we can support?
- Given network resources and a traffic load, what QoS do we obtain?
- Given a QoS requirement and a traffic load, what are the network resources that we need?
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These questions are difficult to answer!
Approach

- Simple Models
- More Qualitative than Quantitative Analysis (Insight !)
- However, sometimes these models work quite well !
Relation between Traffic Load and Delay

\[ \lambda \]

- Delay

- \( \lambda \)
Relation between Traffic Load and Delay

Simple Model
Other Questions

- Average Delay?
- Expected Number of Packets in the Buffer?
- Probability that a Packet is lost?
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- Average Delay?
- Expected Number of Packets in the Buffer?
- Probability that a Packet is lost?

We need a Probabilistic Model
Models

- Packet Arrivals: Poisson Process
- Packet Length: Exponential Distribution
- System: Queueing Theory