University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 101: Exploring Digital Information Technologies for Non-Engineers

Distribution and Streaming
Part 1

Network Links Can Be Viewed as Pipes for Data

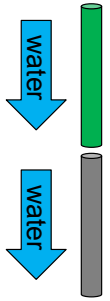
Imagine a pipe that carries water.

Now imagine that we have
- **10 gallons per minute**
- **flowing** through the pipe.

Next, add a **second pipe**
- **with** the **same flow** rate
- and put it above the first pipe.

No problem, right?

Water from the top pipe goes into the bottom pipe.

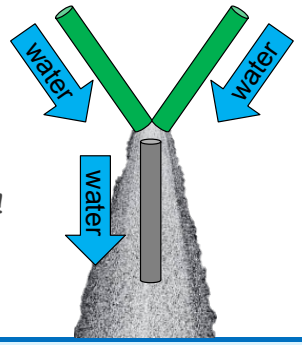


What Happens When a Pipe Can't Handle the Water?

Now let's **add a third pipe…** with the same flow of water.

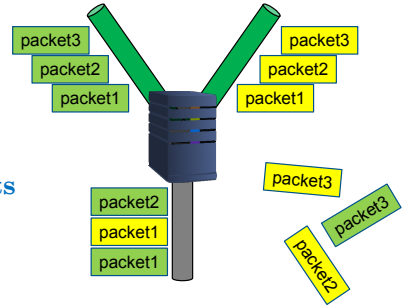
Now what happens?

Oops! **Water spills** everywhere!



Similarly, Internet Routers May Discard Packets

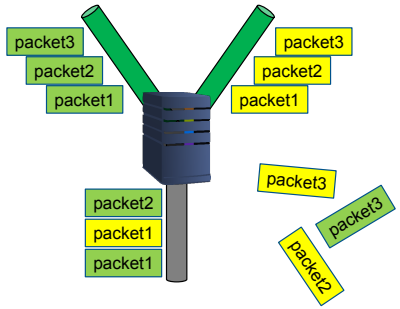
The **same thing happens**
- **when** an Internet **router**
- **receives too many packets**
- for one outgoing link.



Remember that Internet Only TRIES to Deliver a Packet

That's one reason that
- Internet **packet delivery**
- **is unreliable**.

So that routers
- can discard packets
- without causing problems.

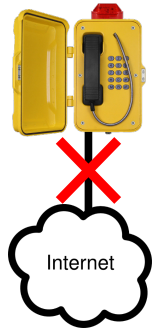


Internet Service Definition Does Not Suit All Needs

A brief aside…

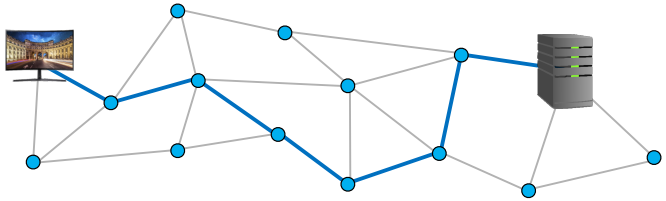
Unreliability raises some major issues that we won't cover.

For example, the **Internet**
- **does NOT make a good substitute for 911**
- or any other campus/state/country's emergency telephone services.



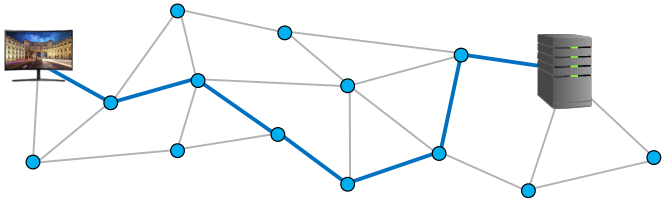
How Quickly Can a Client Communicate with a Server?

How much data can a client send through the Internet to a server each second?



The Answer Varies Over Time

The answer changes constantly
as other computers (TCP connections) use the Internet.



TCP Tries to Estimate How Much Data to Send

TCP constantly tries
- to **estimate** the **achievable data rate**
- **in** bits or **bytes per second**,
- **called bandwidth**.*

Information moves at nearly the speed of light:
- about **130 msec** to the other side of the Earth,
- assuming a straight line through fiber
- along the surface.

More delay means a worse estimate.

*Electrical engineers object to this usage because the term is also used to measure ranges of frequency.

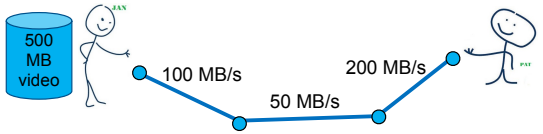
Let's Quantify a Single Tranmission

Let's **quantify a simple problem** with our friends Jan and Pat.

Jan wants to **send** Pat a **500 MB** video.

The route between them goes **over three links**.

Each link has limited **bandwidth**.



Let's Quantify a Single Tranmission

What is the bandwidth from Jan to Pat?

50 MB/s – the **minimum of** the **link bandwidths** on the route through the Internet

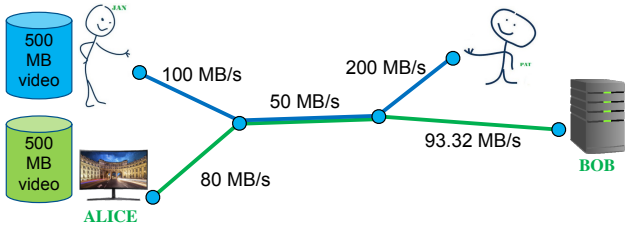
So how long does sending the video take?

$$\frac{500\ \text{MB}}{50\ \text{MB/s}} = \textbf{10 seconds}$$

Connections Share Links in the Internet

What happens if Alice also sends Bob a video?

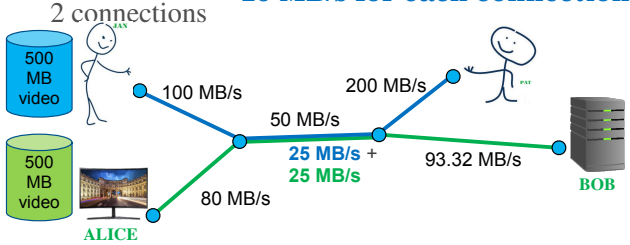
The **two transmissions** must **share** the middle link!



Each Connection May Use an Equal Share

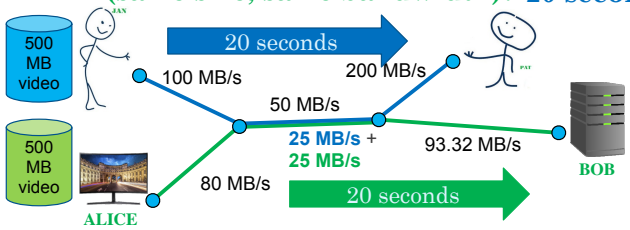
If they share fairly,
what is the link bandwidth for each connection?

$$\frac{50\ \text{MB/s}}{2\ \text{connections}} = \textbf{25 MB/s for each connection}$$



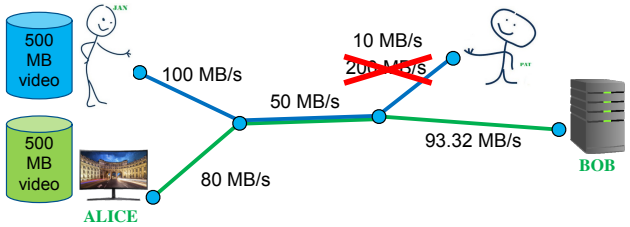
Shared Links Slow Down Transfers

What is Jan's connection bandwidth? 25 MB/s
What about Alice's? 25 MB/s
And how long to send either video
(same size, same bandwidth)? 20 seconds



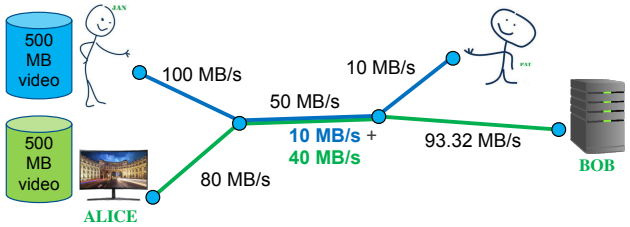
Another Scenario: a Low-Bandwidth Connection

Let's change the situation:
- Pat is now using his phone.
- The last Jan-to-Pat link carries only **10 MB/s**.



Another Scenario: a Low-Bandwidth Connection

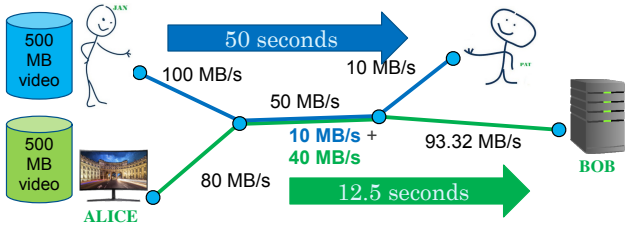
What is Jan's connection bandwidth? 10 MB/s
Alice can use the rest
of the middle link's bandwidth!
So what is Alice's connection bandwidth? 40 MB/s



Another Scenario: a Low-Bandwidth Connection

How long does Jan's transfer require? **50 seconds**

What about Alice's transfer? **12.5 seconds**



Both Video and Network Rates Vary Over Time

The (high) bandwidths in our example
- are more than enough
- to deliver a video in real-time.

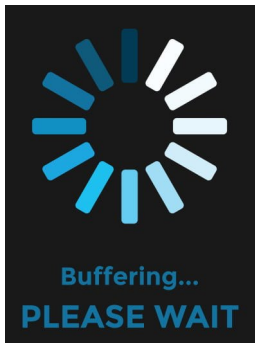
However,
- the **rate of data needed** by a video **varies**,
- and the **bandwidth of** the **network varies**.

simple

complex

Buffering Helps Avoid Need for Video Stalls

To handle variability, video players **use** a technique called **buffering**.
- Before the video starts playing, your computer downloads the first second of video.
- While the first second plays, the computer downloads the second second.
- And so forth.



Buffering Can't Hide Inadequate Bandwidth

Often, a video player starts downloading before you press "Play." That way, the video seems to start instantaneously.

But **you've probably noticed occasional delays**
- for ads, or even for videos,
- **when** network and/or video content **variability**
- **or insufficient** network **bandwidth**
- **made your computer run out of video** to show you!

