

ECE 101: Exploring Digital Information Technologies for Non-Engineers

Distribution and Streaming

Network Links Can Be Viewed as Pipes for Data

Imagine a **pipe** that carries water.

Now imagine that we have

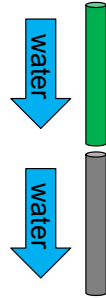
- **10 gallons per minute**
- **flowing** through the pipe.

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.

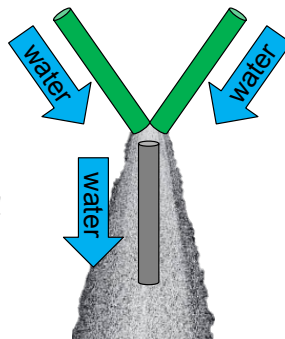


What Happens When a Pipe Can't Handle the Water?

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

Now what happens?

Oops! **Water spills** everywhere!

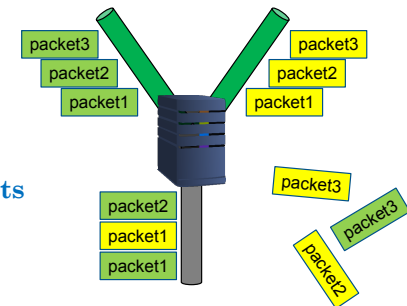


Similarly, Internet Routers May Discard Packets

The **same thing happens**

◦ **when** an Internet **router**

- **receives too many packets**
- for one outgoing link.



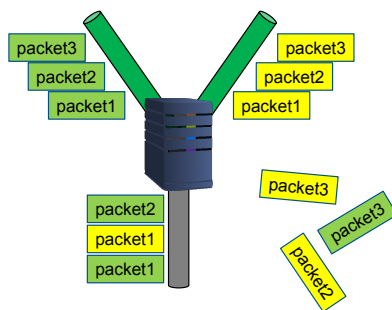
Remember that Internet Only TRIES to Deliver a Packet

That's one reason that

- Internet **packet delivery**
- **is unreliable.**

So that routers

- can discard packets
- without causing problems.



5

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**

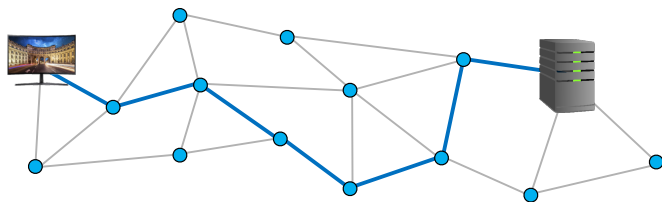
- **does NOT make a good substitute for 911**
- or any other campus/state/country's emergency telephone services.



6

How Quickly Can a Client Communicate with a Server?

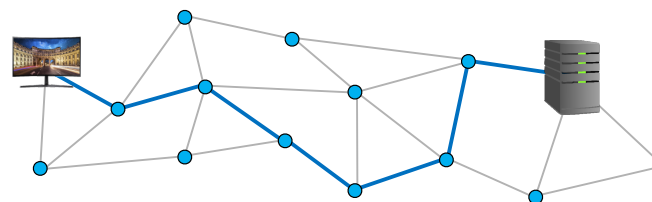
How much data can a client send through the Internet to a server each second?



7

The Answer Varies Over Time

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



8

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.

9

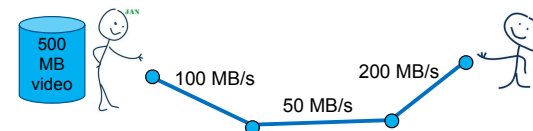
Let's Quantify a Single Transmission

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.



10

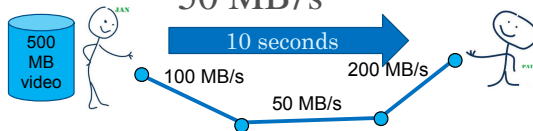
Let's Quantify a Single Transmission

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?

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

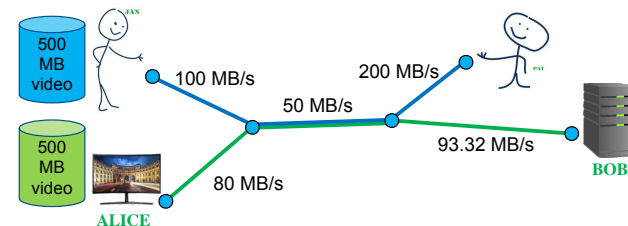


11

Connections Share Links in the Internet

What happens if Alice also sends Bob a video?

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

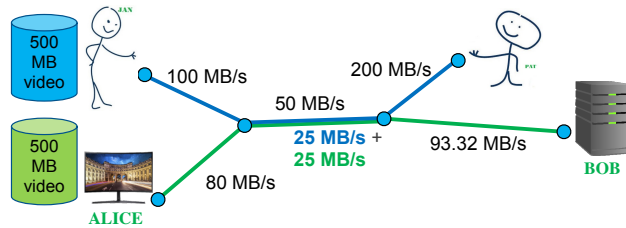


12

Each Connection May Use an Equal Share

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

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



13

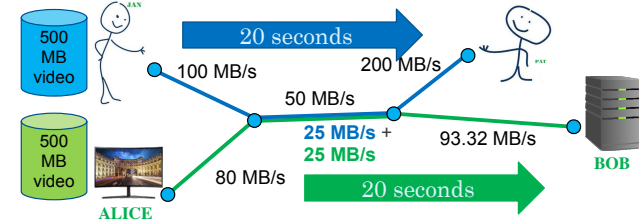
Shared Links Slow Down Transfers

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

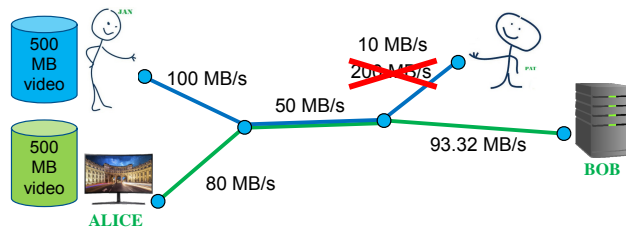


14

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.



15

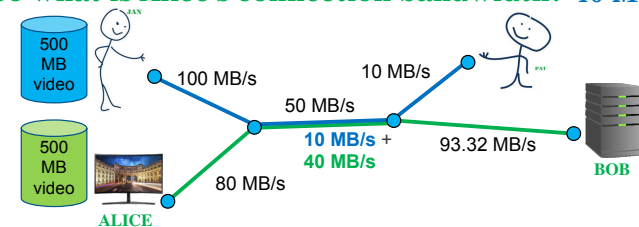
Another Scenario: a Low-Bandwidth Connection

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

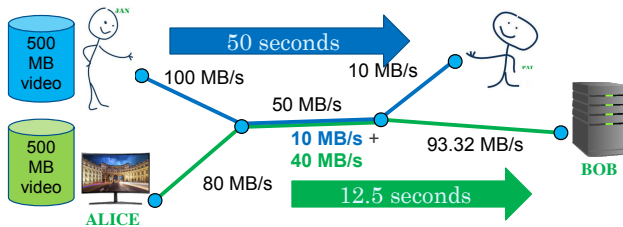


16

Another Scenario: a Low-Bandwidth Connection

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

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



17

Both Video and Network Rates Vary Over Time

The (high) bandwidths in our example

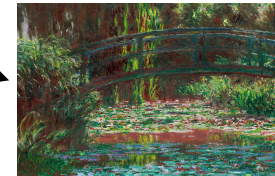
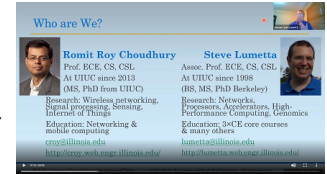
- are more than enough
- to deliver a video in real-time.

However,

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

simple

complex

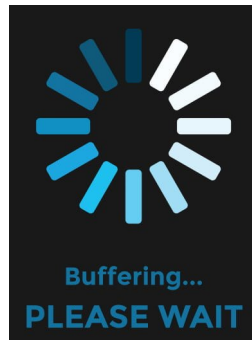


18

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.



19

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!

20