Lecture #14: “The Cloud”
what even is it
### 1970s:
ARPAnet

<table>
<thead>
<tr>
<th>hosts.txt</th>
<th>distance-vector routing</th>
</tr>
</thead>
</table>

### 1978: flexibility and layering

<table>
<thead>
<tr>
<th>TCP, UDP</th>
<th>OSPF, EGP, DNS</th>
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<tr>
<th>congestion collapse (which led to congestion control)</th>
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</thead>
</table>

### 1980s:
early 80s: growth → change  
late 80s: growth → problems

<table>
<thead>
<tr>
<th>application</th>
<th>transport</th>
<th>network</th>
<th>link</th>
</tr>
</thead>
<tbody>
<tr>
<td>the things that actually generate traffic</td>
<td>sharing the network, reliability (or not) examples: TCP, UDP</td>
<td>naming, addressing, routing examples: IP</td>
<td>communication between two directly-connected nodes examples: ethernet, bluetooth, 802.11 (wifi)</td>
</tr>
</tbody>
</table>

### 1993:
commercialization

|------------------------------------------------------------------------------------------------|

**today:** turning our attention away from the Internet to datacenter networks. what’s different in this environment, and why does it matter?
datacenter networks back many of the services you use every day
Datacenter networks back many of the services you use every day.

Multiple physical machines on a single rack.
Datacenter networks back many of the services you use every day.
Datacenter networks back many of the services you use every day. We need a way to communicate across racks. We control this network, so we can design its topology.
**question:** are there any downsides to this particular topology?

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There's no redundancy here; no backup path in case of a failure.
certain topologies can add a lot of redundancy
this is an example of a clos topology

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Certain topologies can add a lot of redundancy. This is an example of a Clos topology.
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Standard routing protocols will pick a single path and stick to it until something changes; multi-path routing can load-balance across paths.
**datacenter networks** back many of the services you use every day

e.g., imagine this switch round-robins its packets between the two highlighted paths

**question:** suppose we used round-robin scheduling to send packets from a single TCP flow across these two paths. what might happen?
**Datacenter Networks** back many of the services you use every day. Many datacenters use a **centralized controller** to manage routing and other things.

**Multipath Routing** can help us load-balance, but we need to be careful about how we divide traffic across the paths. For example, dividing a single TCP flow across multiple paths will make congestion control more difficult.
each physical machine can host multiple **virtual machines**, which sometimes need to be moved around in the network. Datacenters need to decouple a VM’s name from its physical location in order to make this work.
because datacenter networks are under the control of a single administrative entity, we have a level of control over the network that we simply don't have on the Internet.

Datacenter networks back many of the services you use every day.
A New Surge in Power Use Is Threatening U.S. Climate Goals

A boom in data centers and factories is straining electric grids and propping up fossil fuels.

By Brad Plumer and Nadja Popovich  March 14, 2024

For much of the 20th century, America’s electricity use increased steadily and utilities built plenty of coal, gas and nuclear plants in response. But starting in the mid-2000s, demand flattened. The economy and population kept expanding, but factories, lightbulbs and even refrigerators became much more energy efficient.

Now demand is rising again, for several reasons.

The growth of remote work, video streaming and online shopping has led to a frenzied expansion of data centers across the nation. The rise of artificial intelligence is poised to accelerate that trend: By 2030, electricity demand at U.S. data centers could triple, using as much power as 40 million homes, according to Boston Consulting Group.

In Northern Virginia, one of the nation’s largest data center hubs, at least 75 facilities have opened since 2019 and Dominion Energy, the local utility, says data center capacity could double in just five years.

different networking environments give us different opportunities and impact applications in different ways