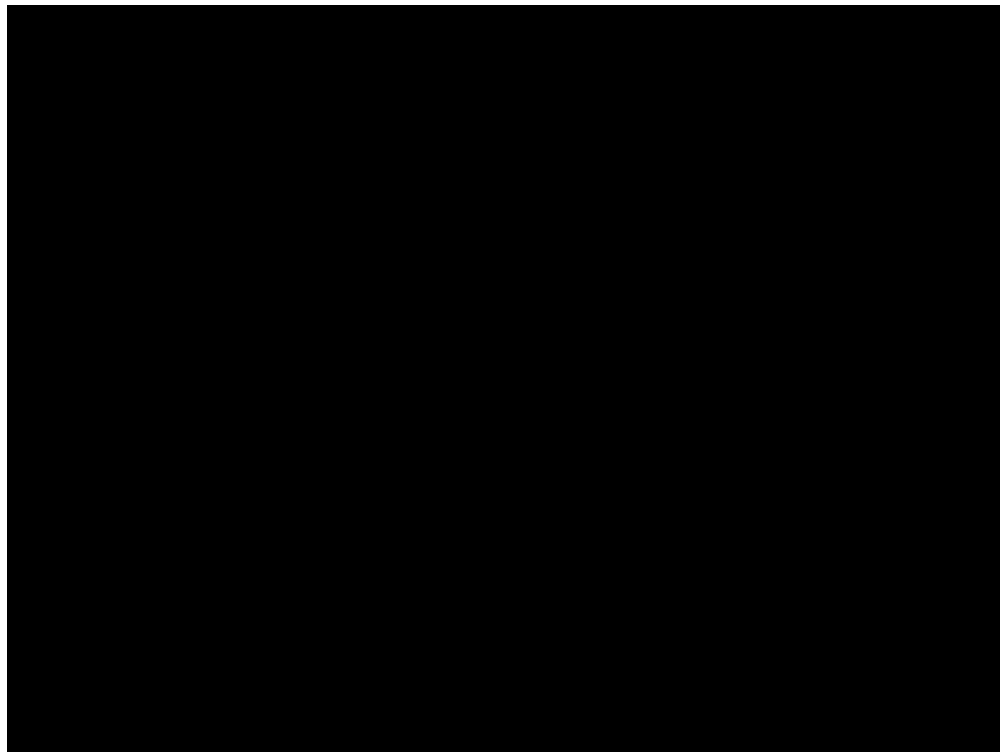


Internet Hardware

How the Internet is Made



What is the Internet?

The Internet is a **network** of **networks**!



What is ~~the Internet?~~ a network?

The Internet is a **network** of **networks**!

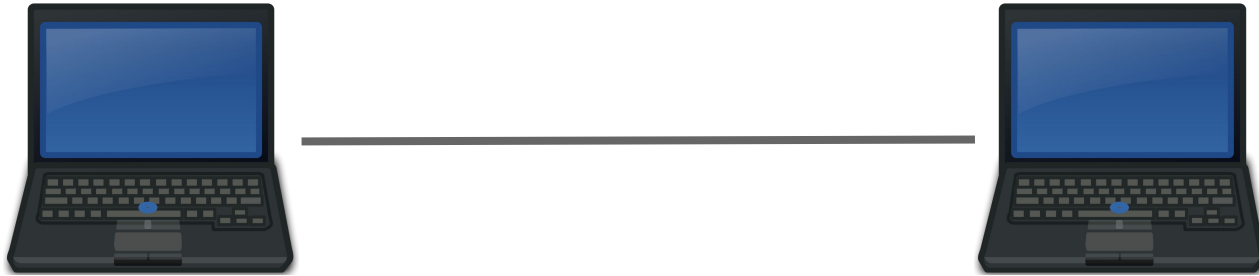
A **network** is a group of 2 or more computer systems linked together.



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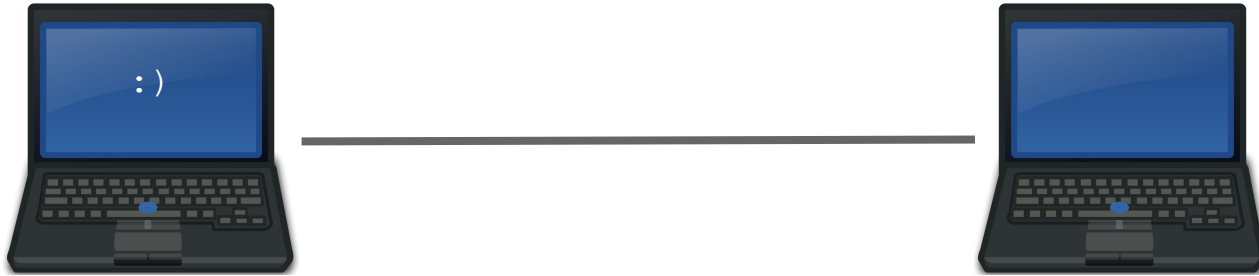
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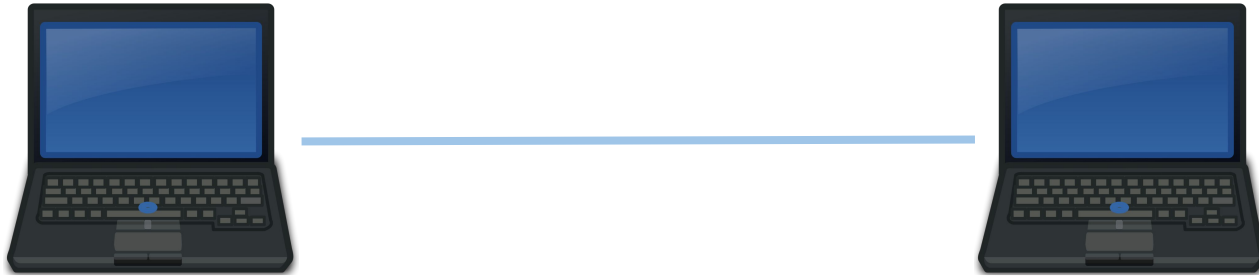
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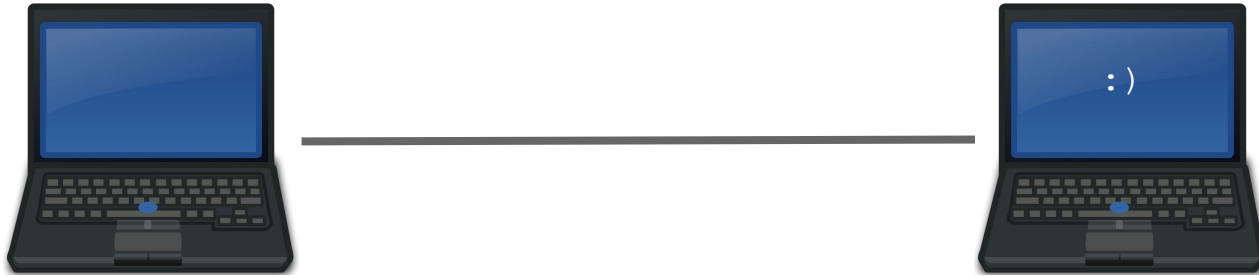
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Scaling Networks



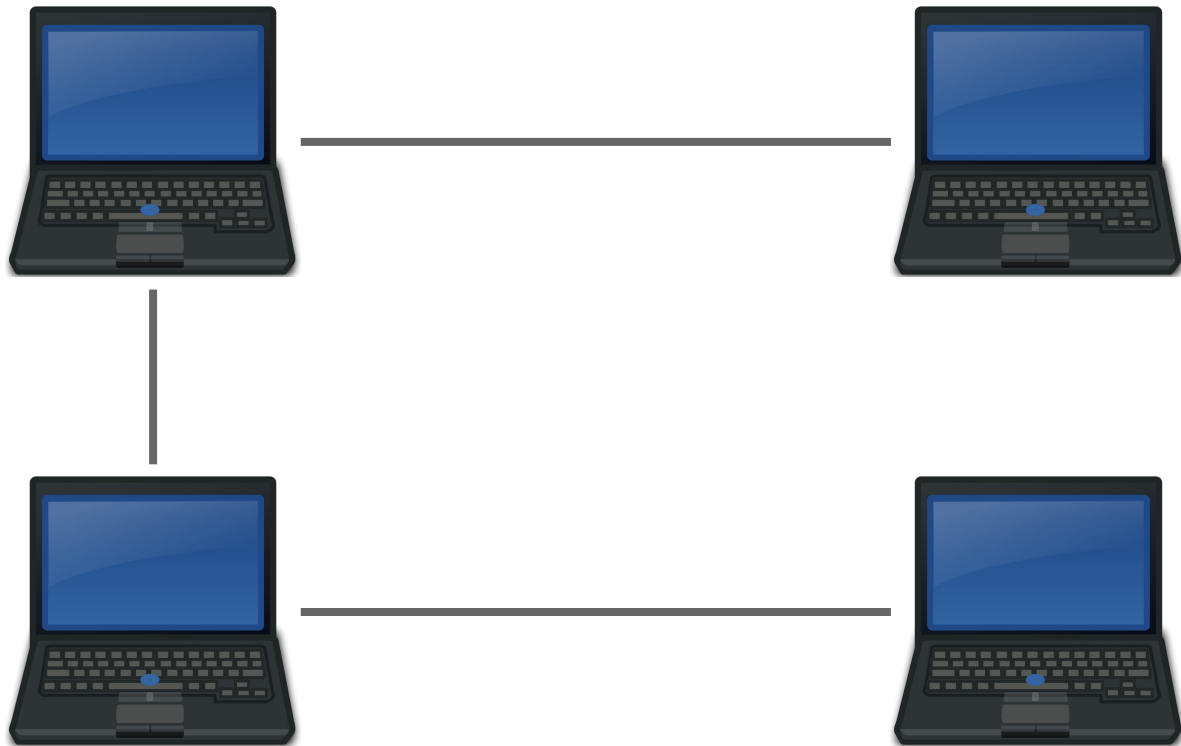
Scaling Networks



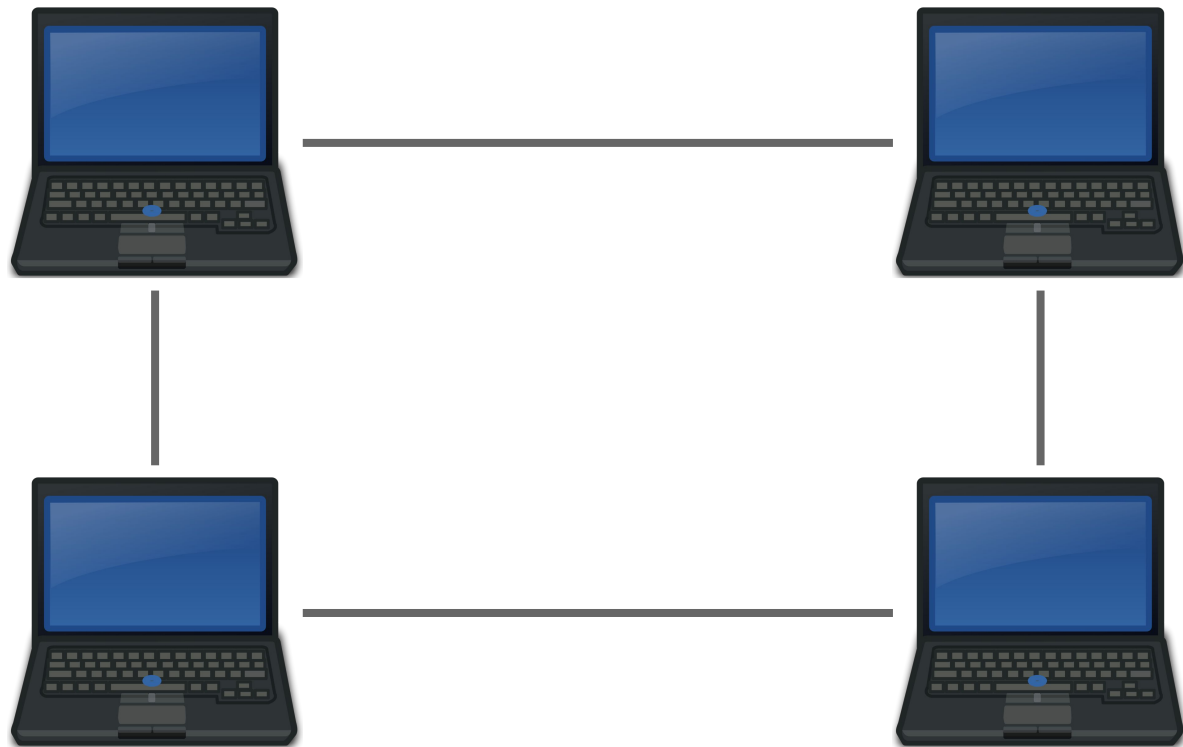
Scaling Networks



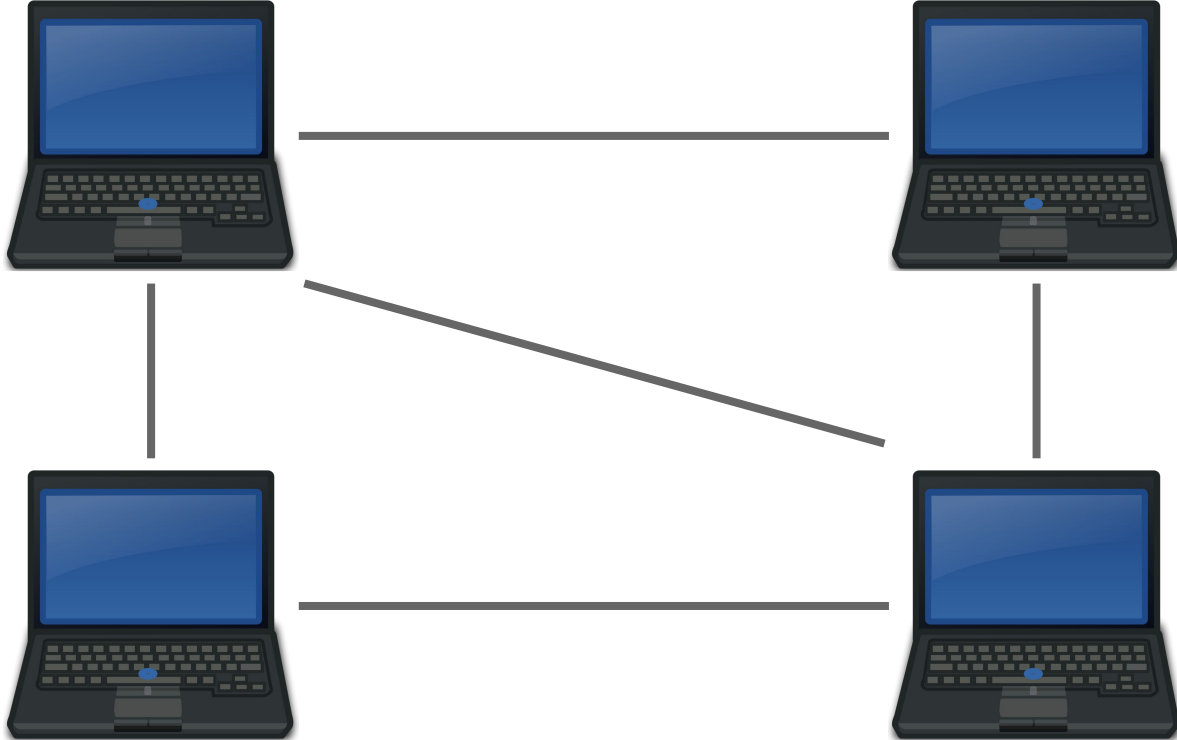
Scaling Networks



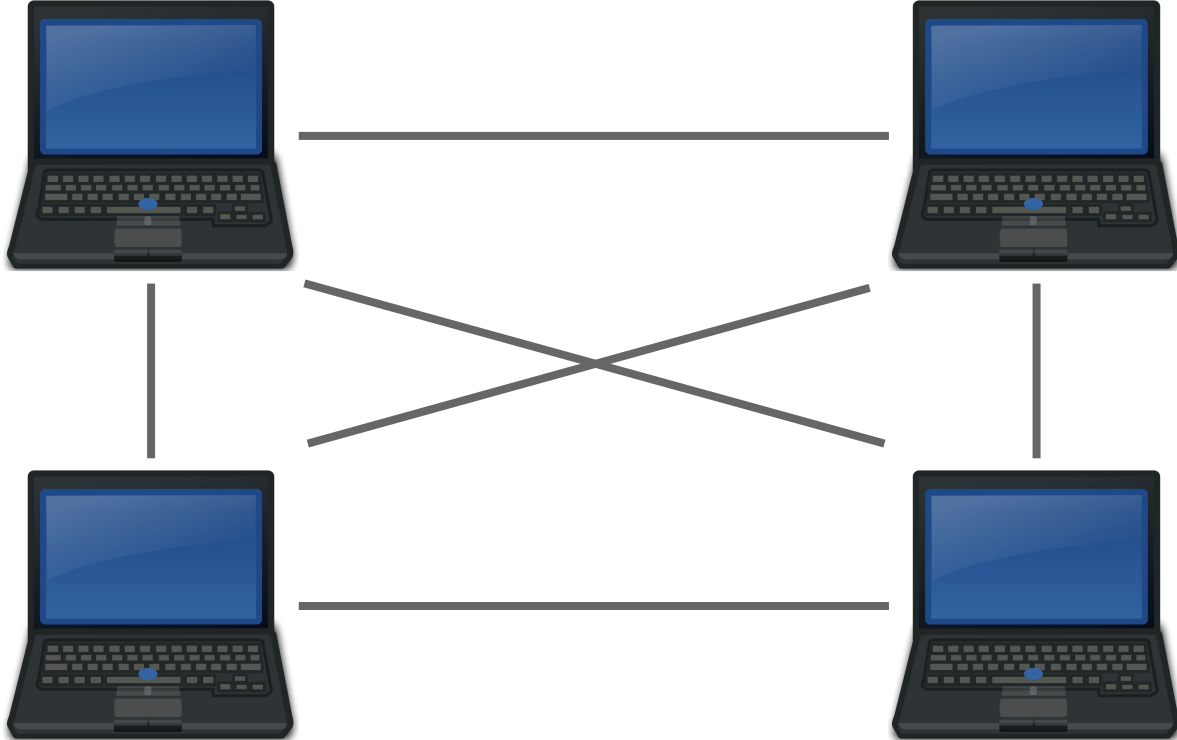
Scaling Networks



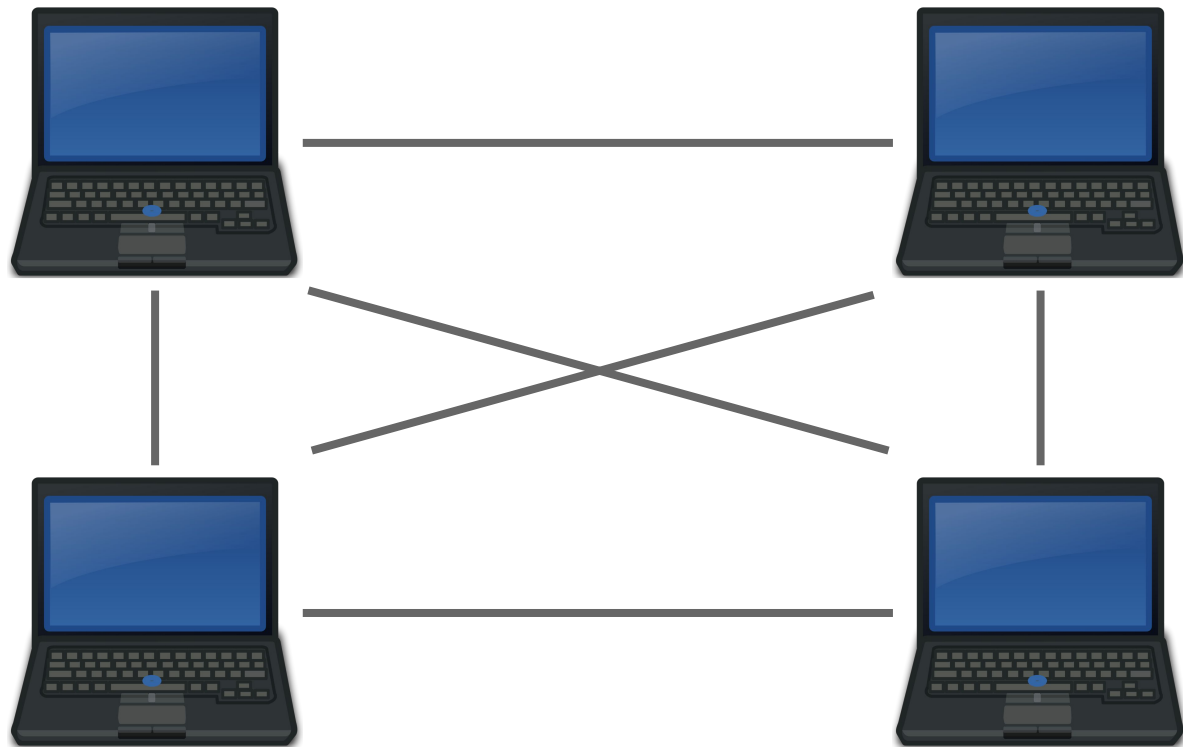
Scaling Networks



Scaling Networks



Scaling Networks

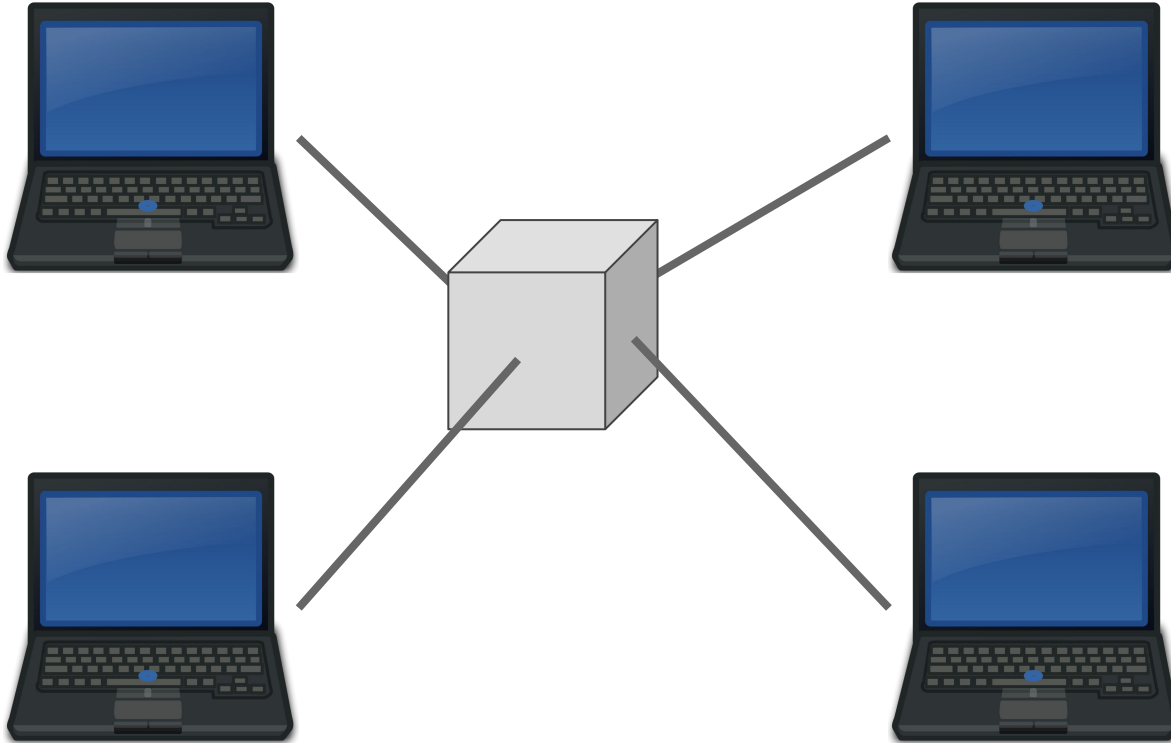


Unfortunately, this solution is not very scalable!

Since there are billions of devices connected to the Internet, it isn't feasible to make every device have a direct connection to every other device!



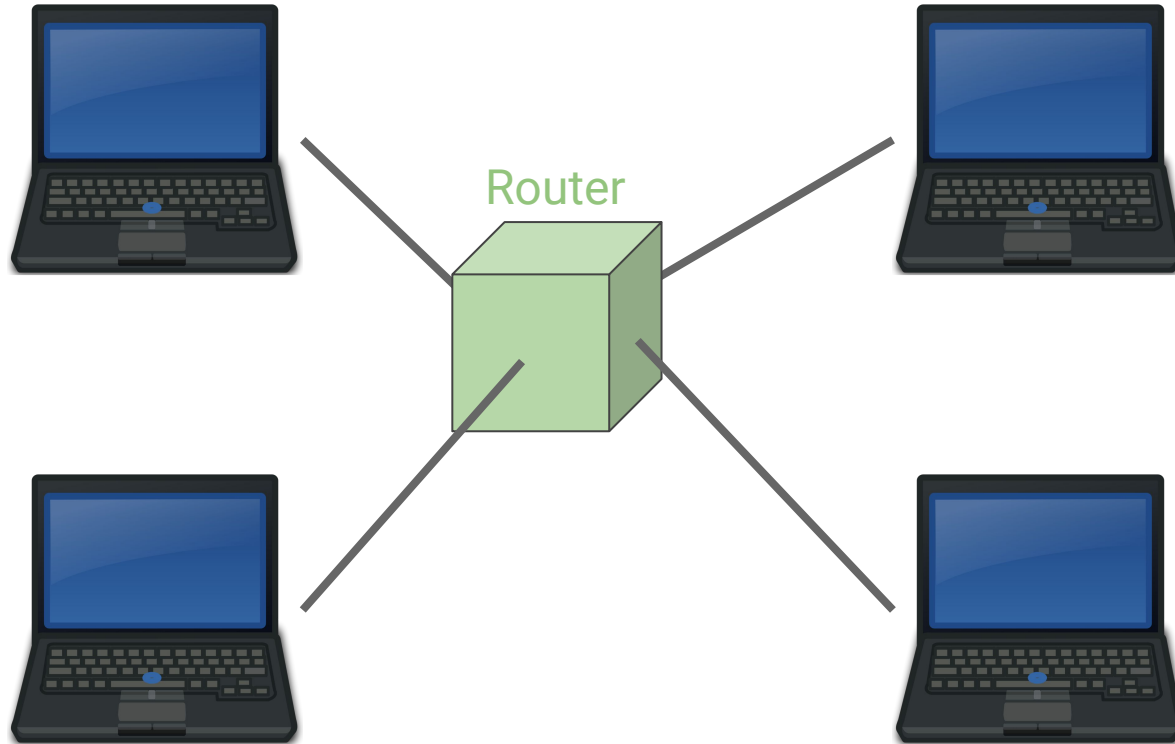
Scaling Networks



The solution to this problem (at least at a small scale) is to connect each device to a central hub!



Scaling Networks

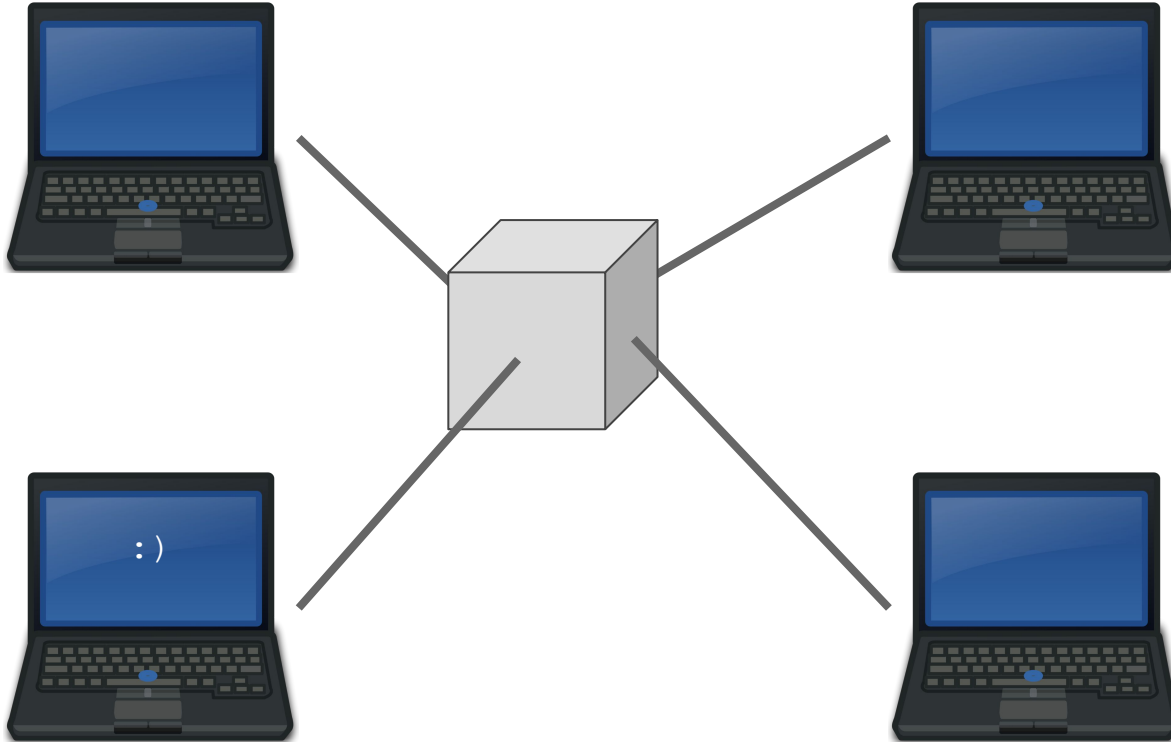


The solution to this problem (at least at a small scale) is to connect each device to a central hub!

This hub is referred to as a **Router**.



Scaling Networks

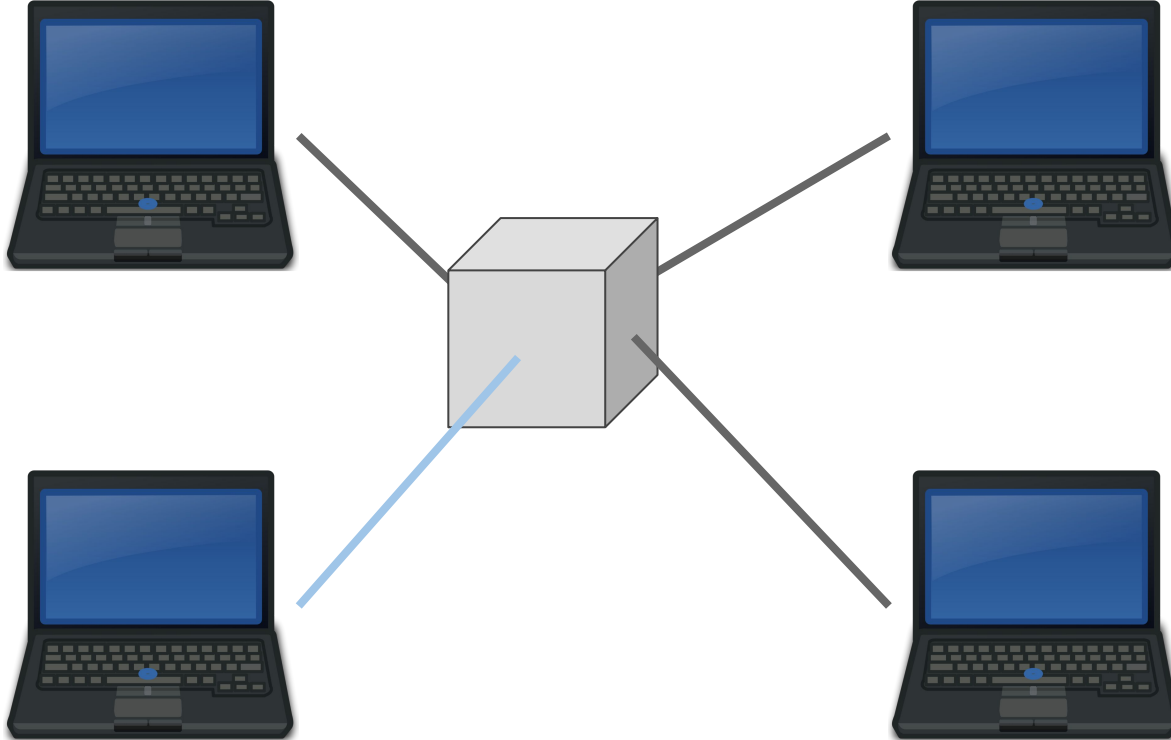


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Scaling Networks

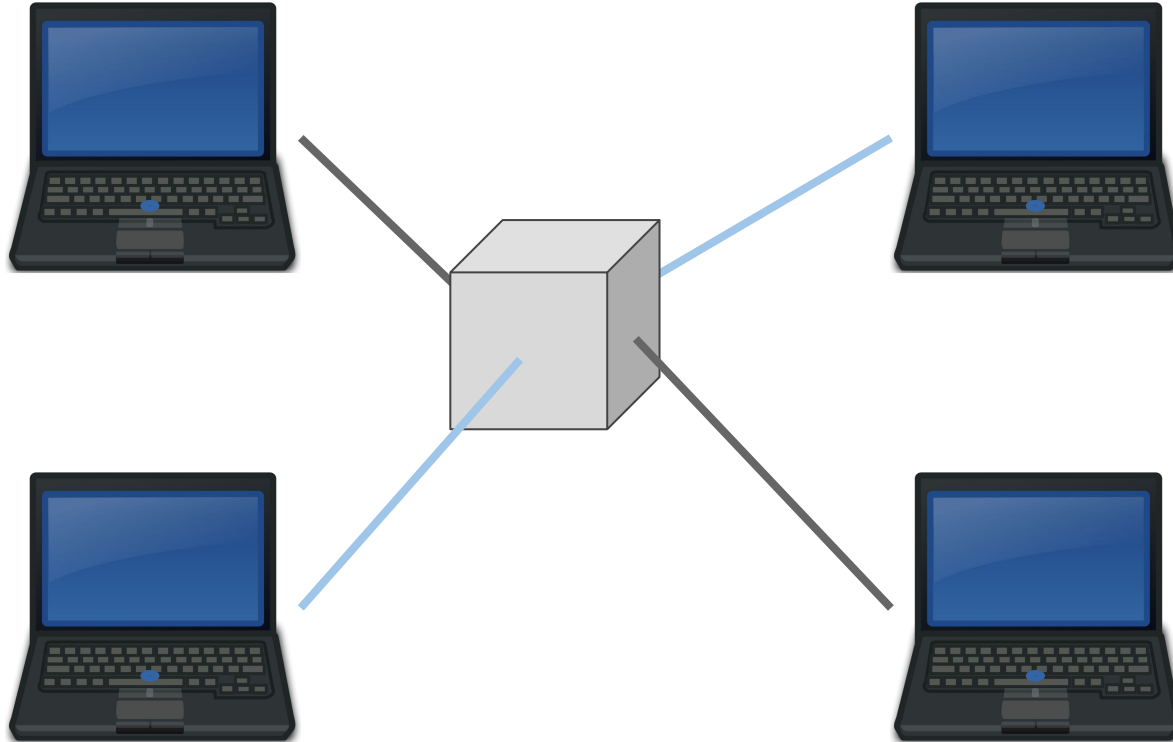


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Scaling Networks

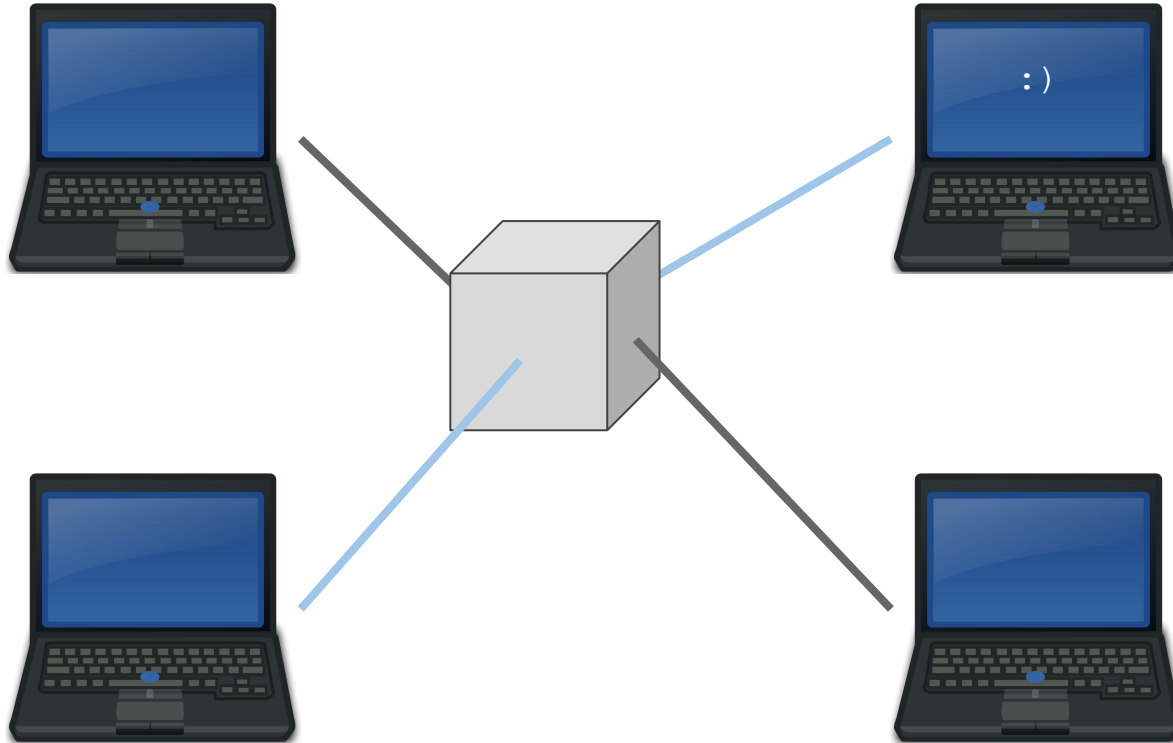


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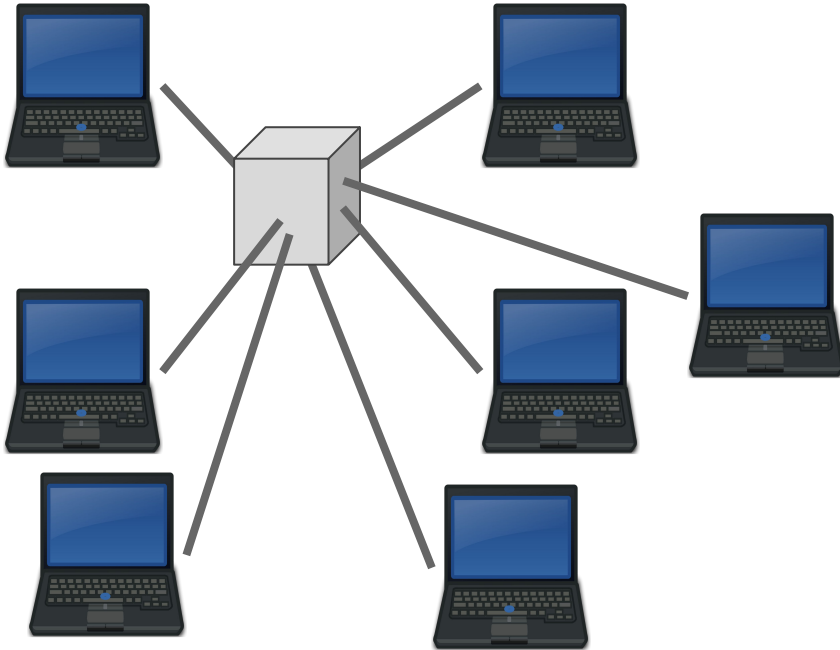


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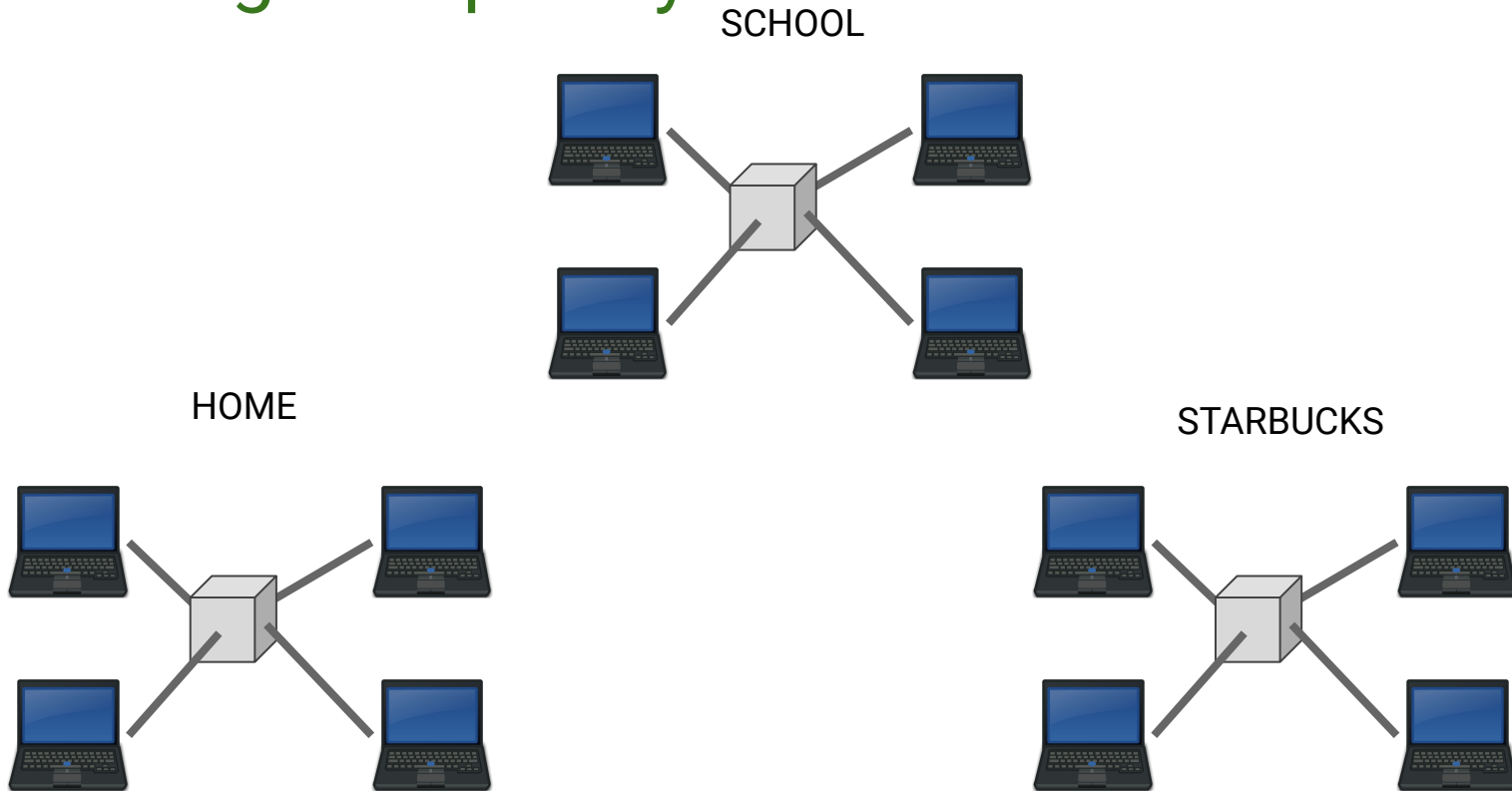
Simple Networks



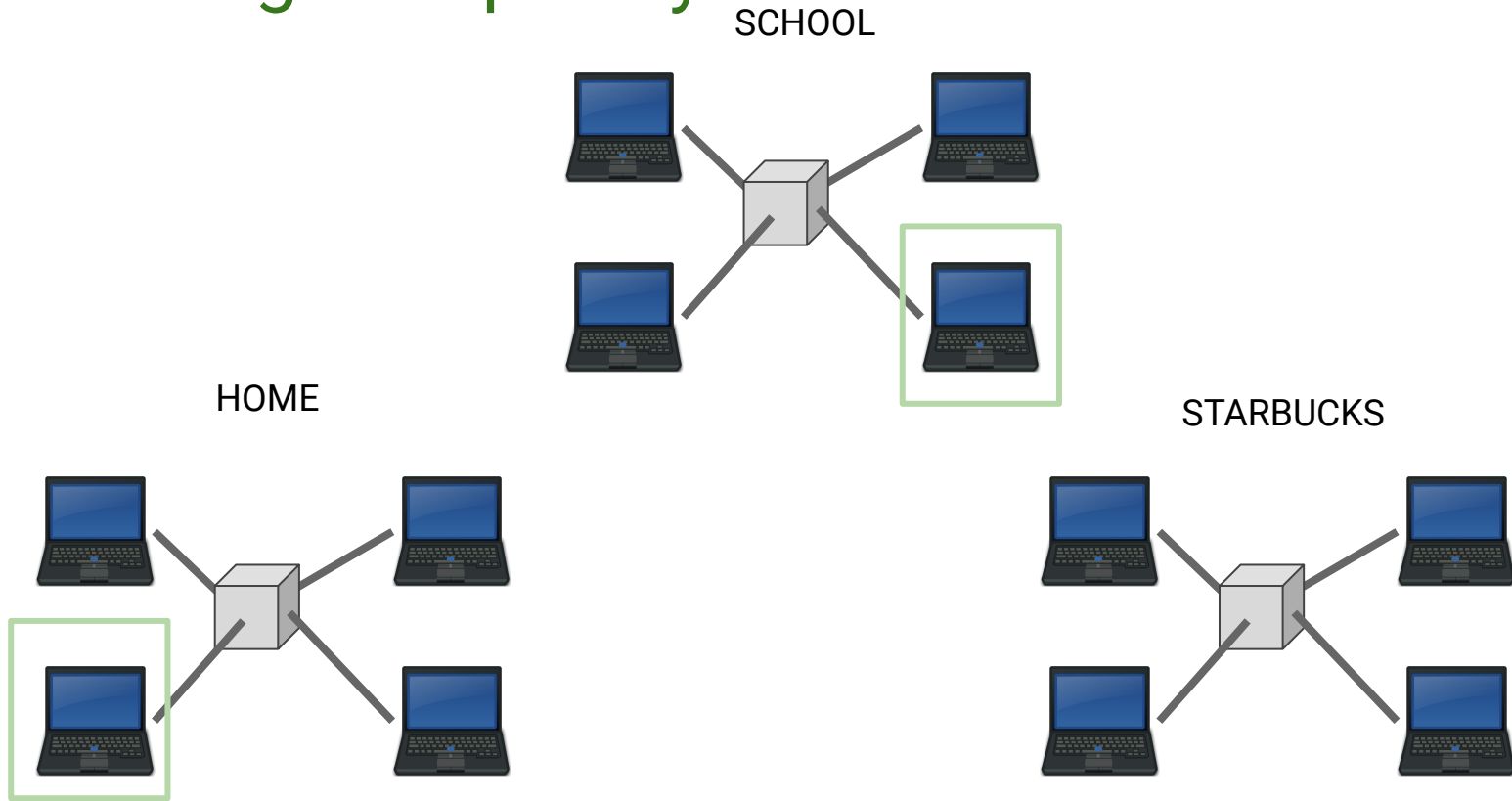
A single router is capable of connecting a good number of devices, provided that they're close enough together. Generally a small network like this will be able to encompass the devices in a single room or building.



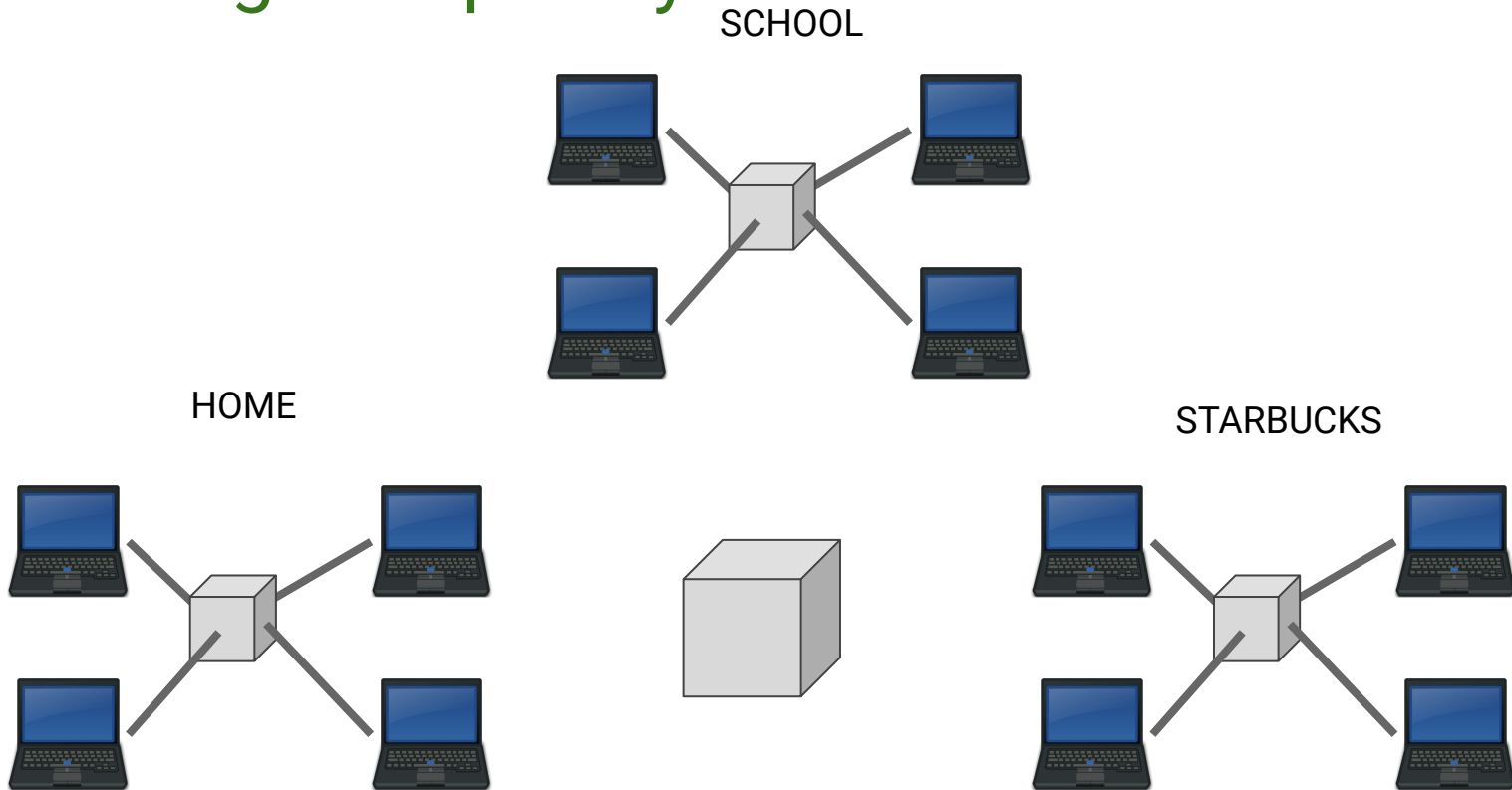
Adding Complexity



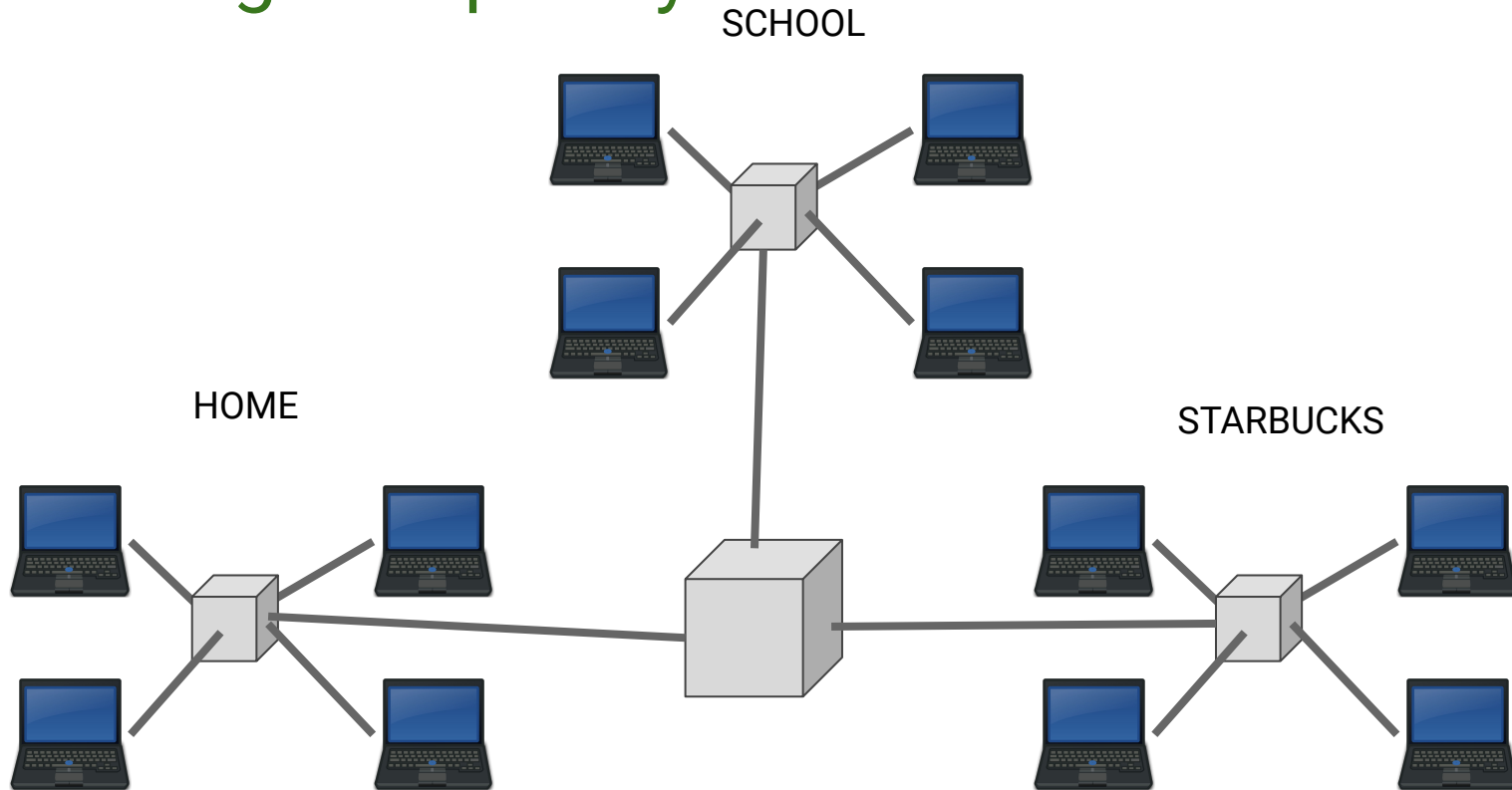
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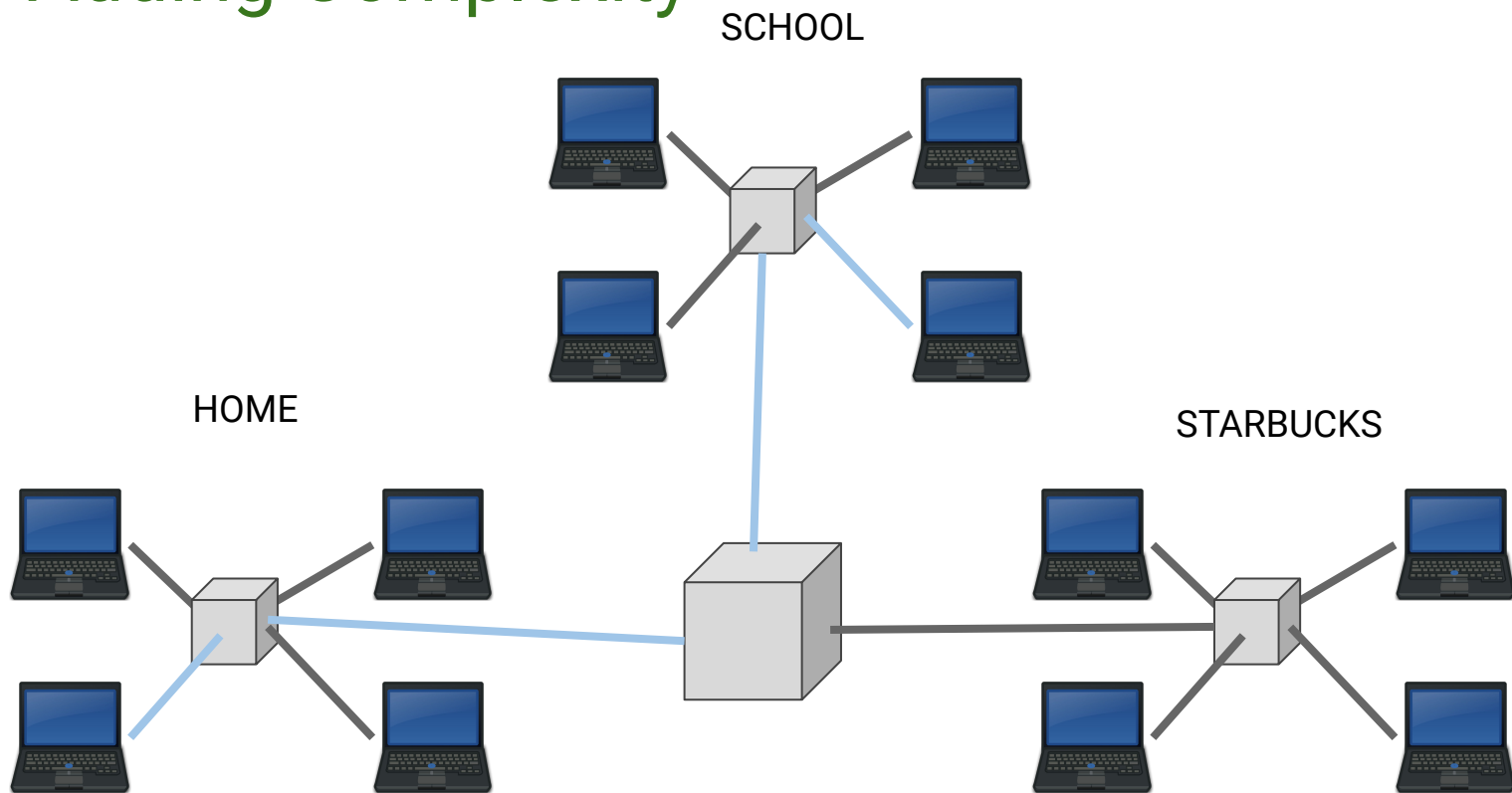
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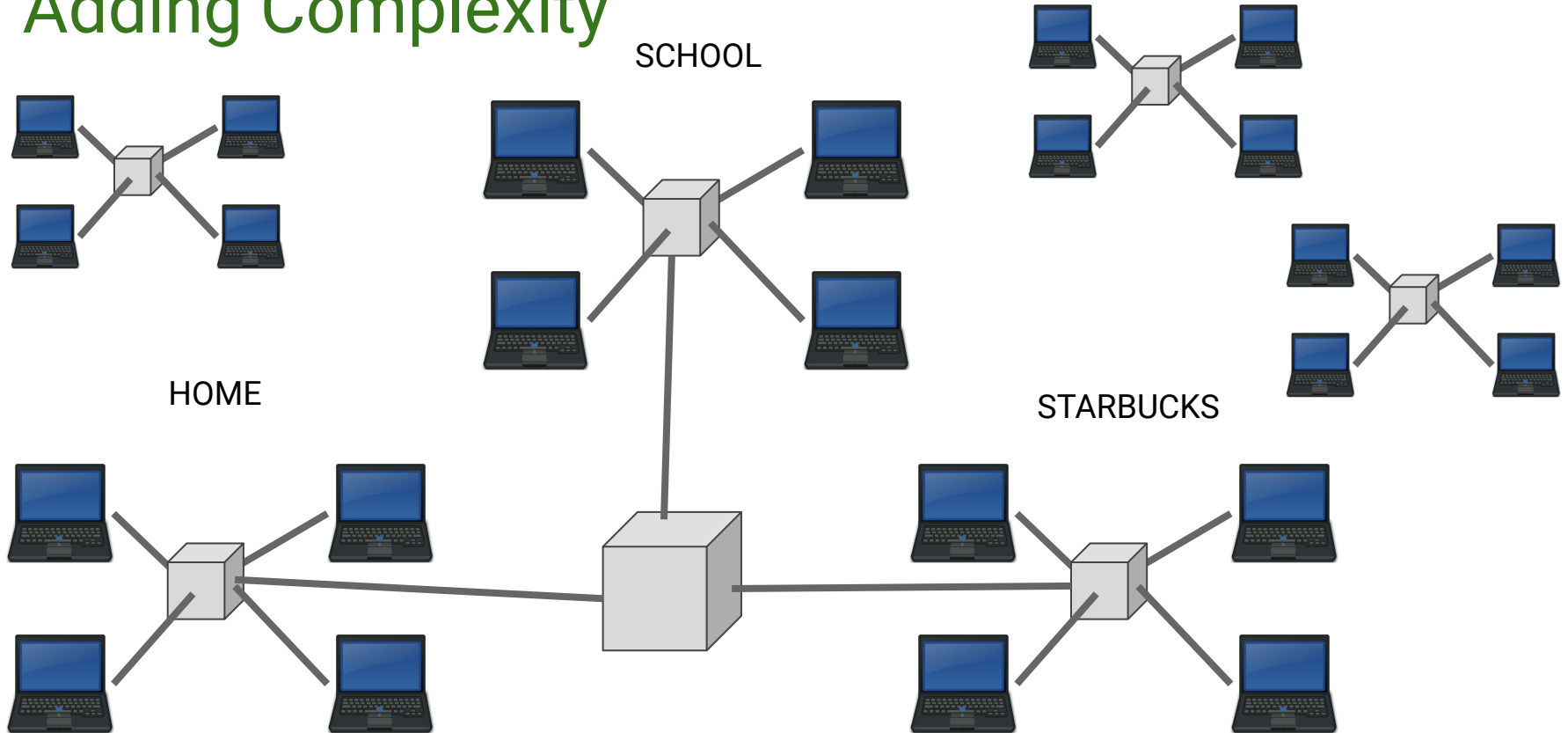
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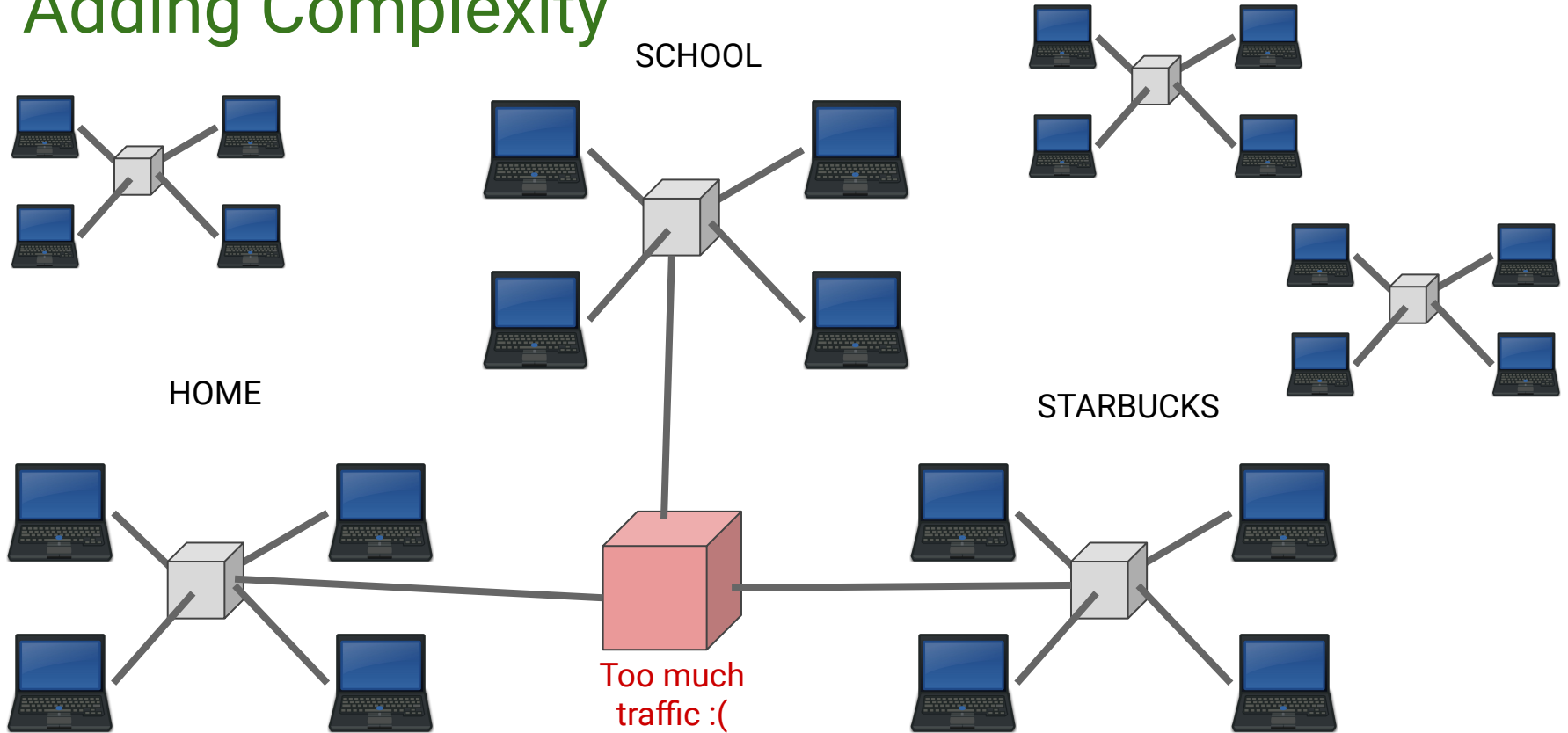
Adding Complexity



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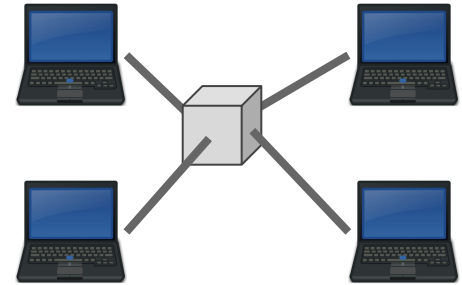
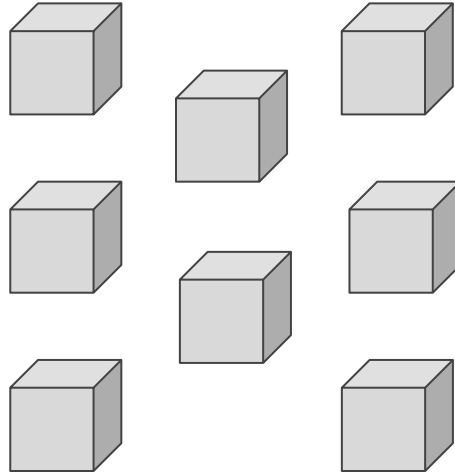
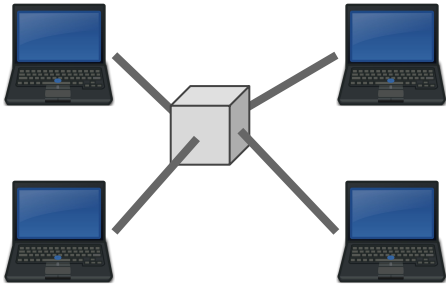


Adding Complexity

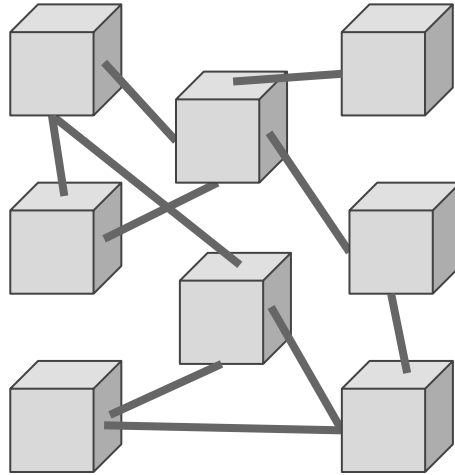
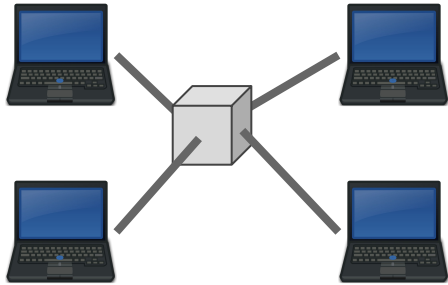


The Internet

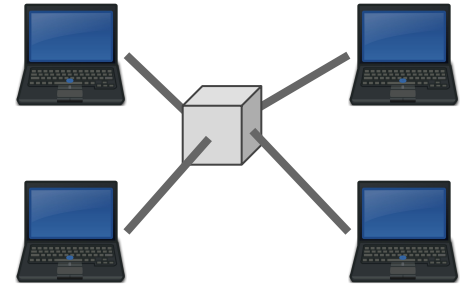
The Internet itself is actually just a huge network of routers!



The Internet



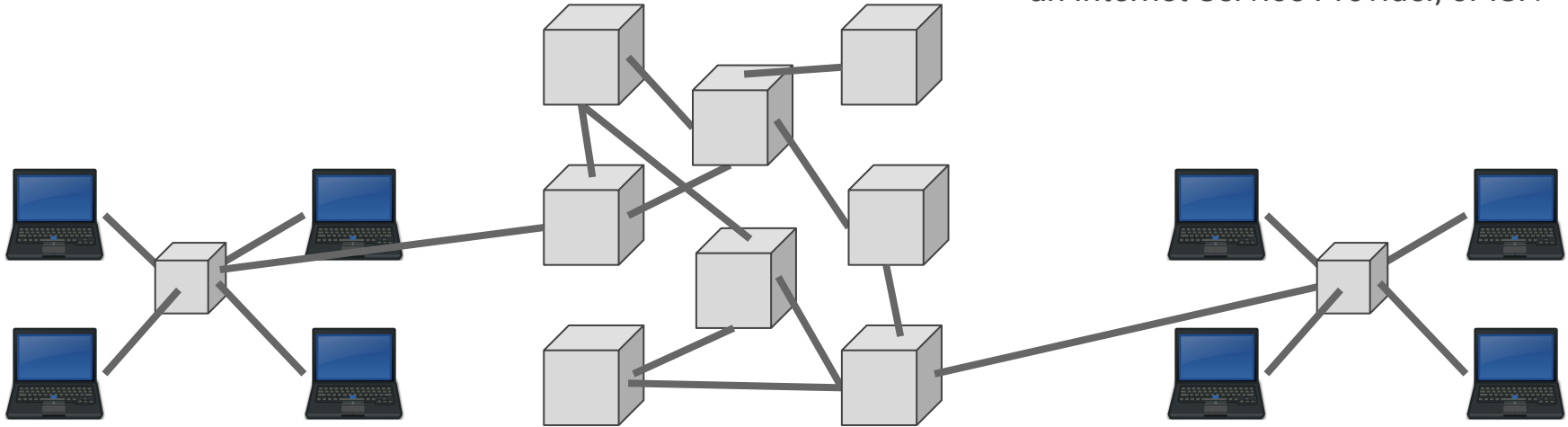
Not every router is connected to every other router - each one is connected to a few others, but they're all interconnected eventually!



The Internet

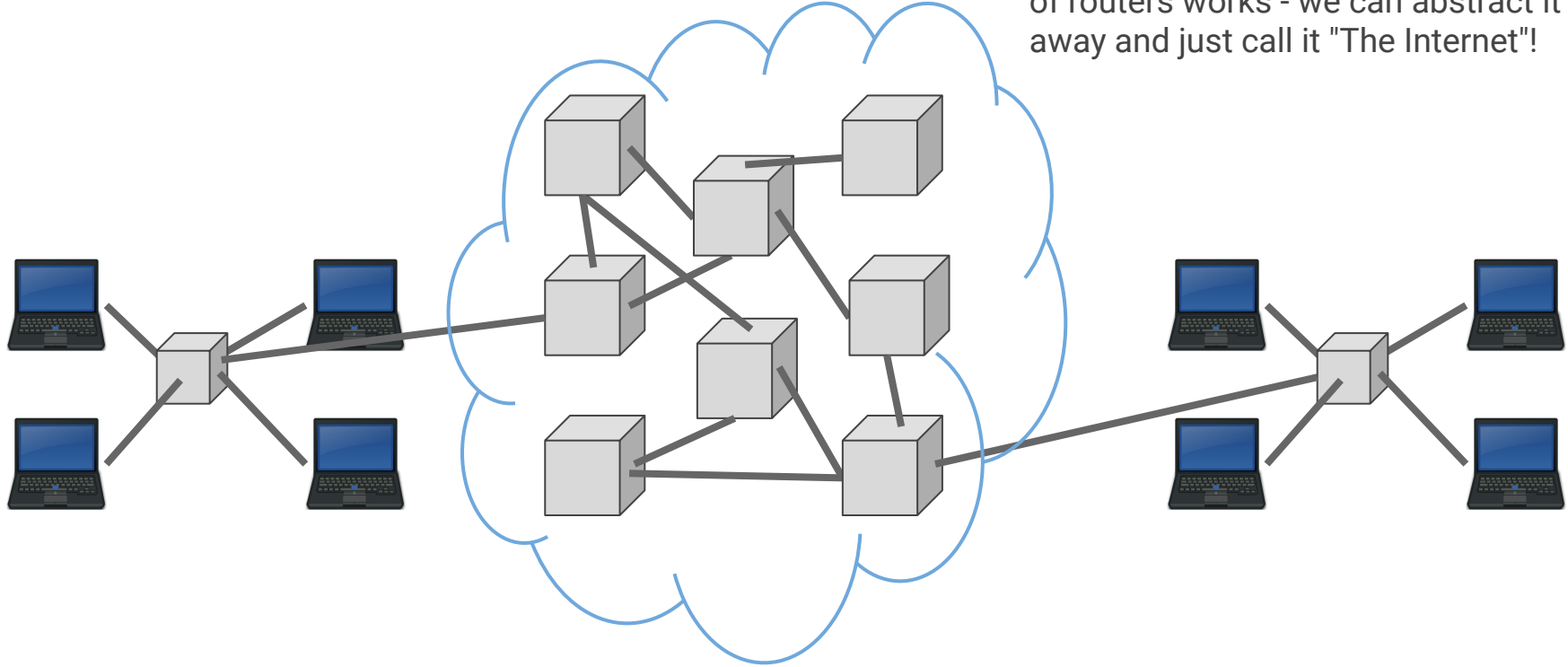
Individual networks can then connect to the Internet by connecting to a single router!

This connection is often facilitated by an Internet Service Provider, or ISP.



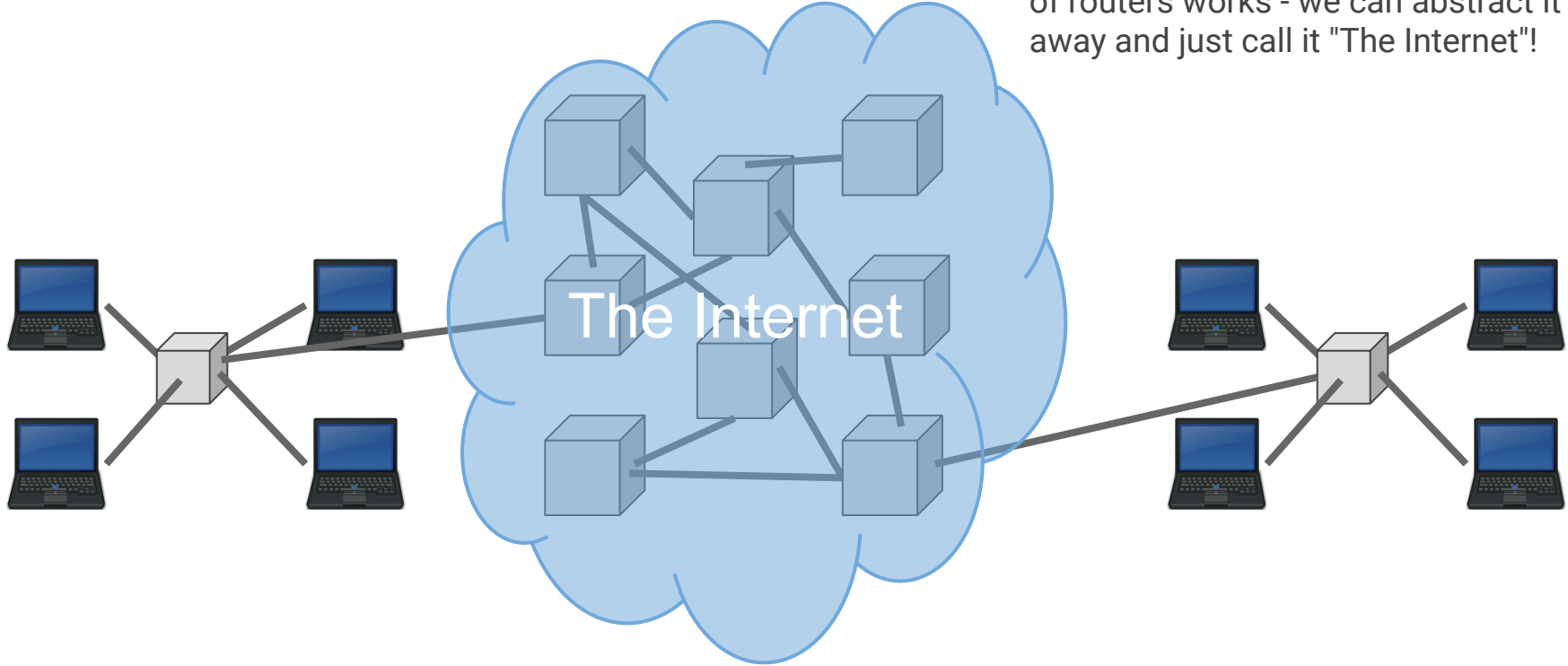
The Internet

Right now, we don't really need to focus on how this huge interconnected cloud of routers works - we can abstract it away and just call it "The Internet"!



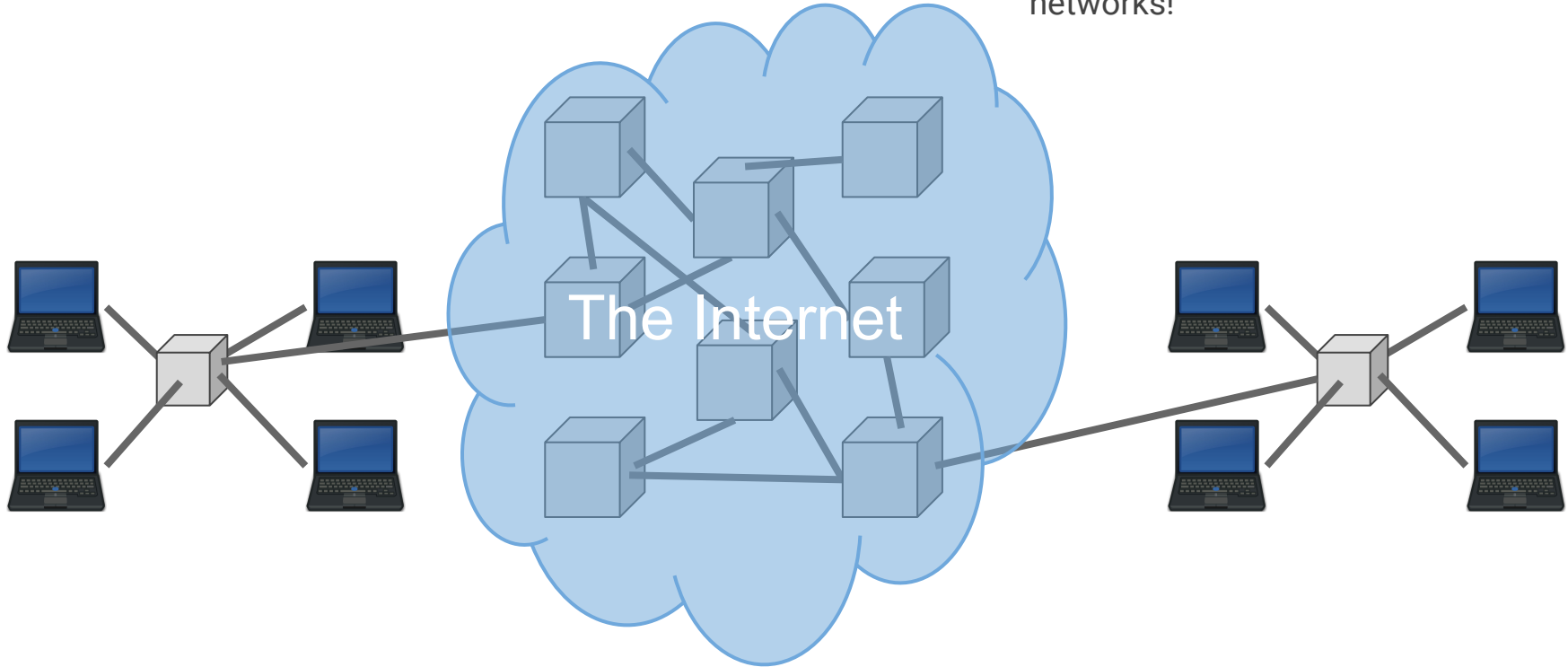
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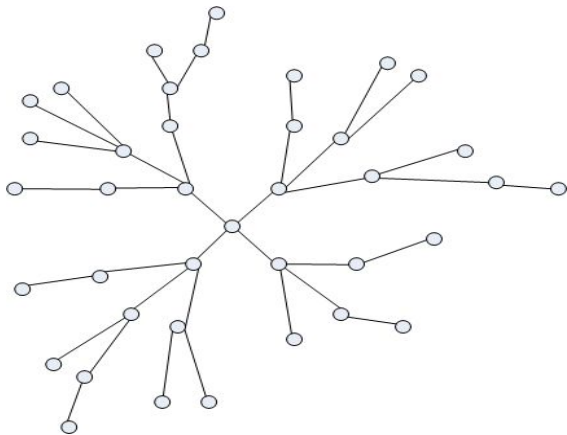
The Internet

This is what we mean when we say that the Internet is a network of networks!



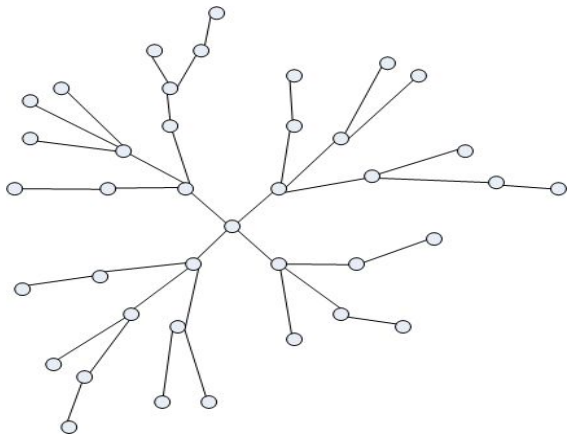
Sending Information

Sending information is the core functionality of the Internet - that's what it's truly designed to do.



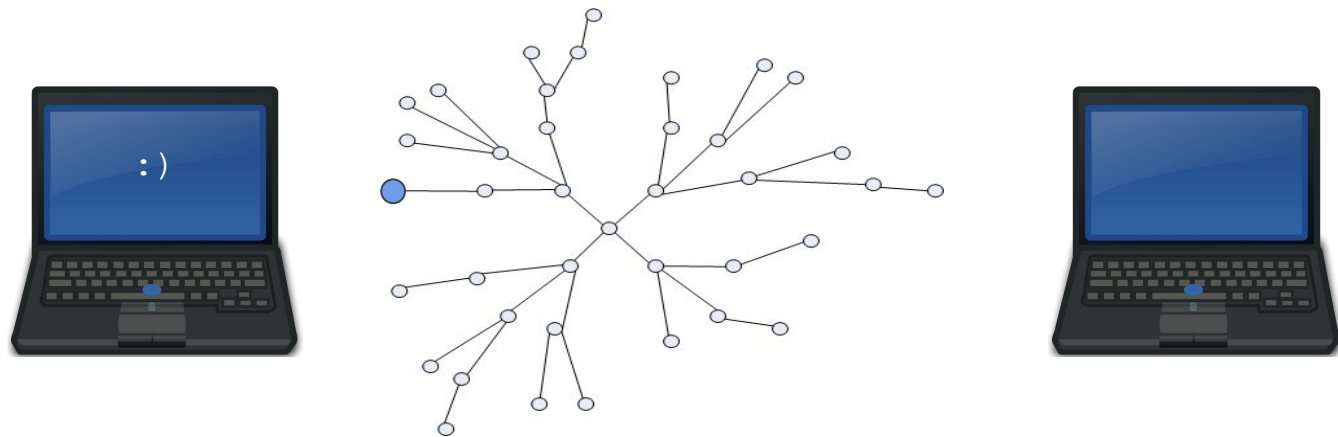
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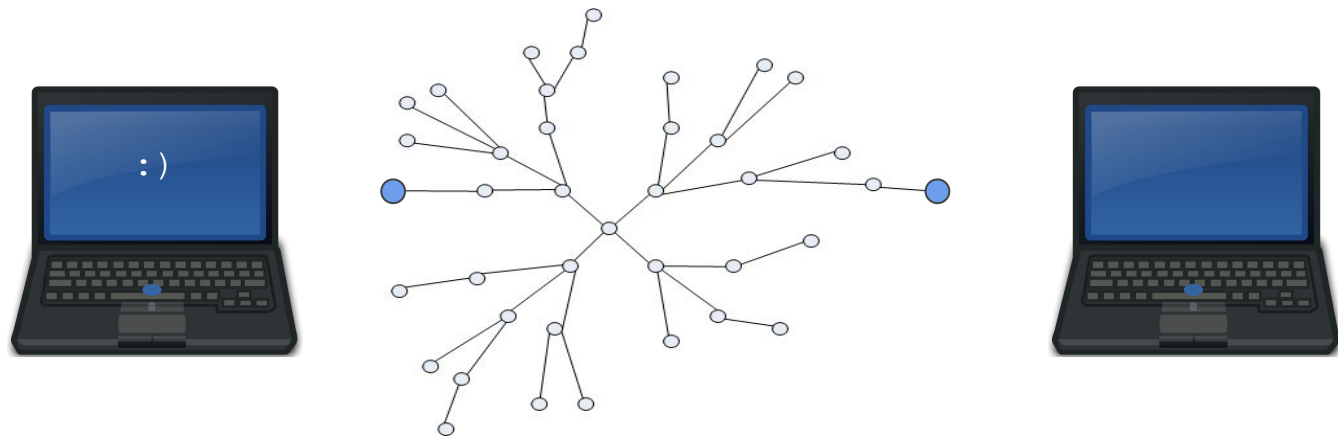
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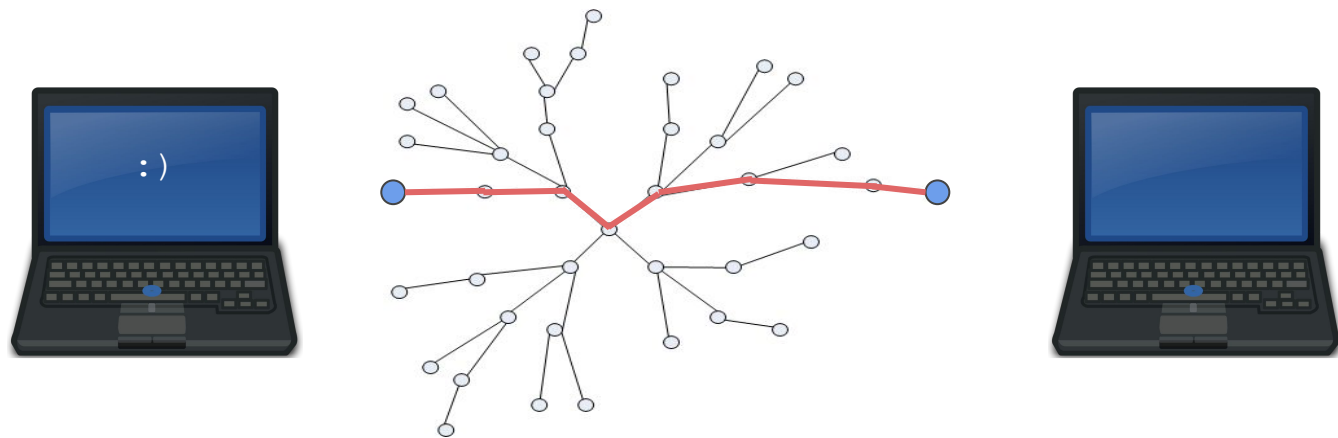
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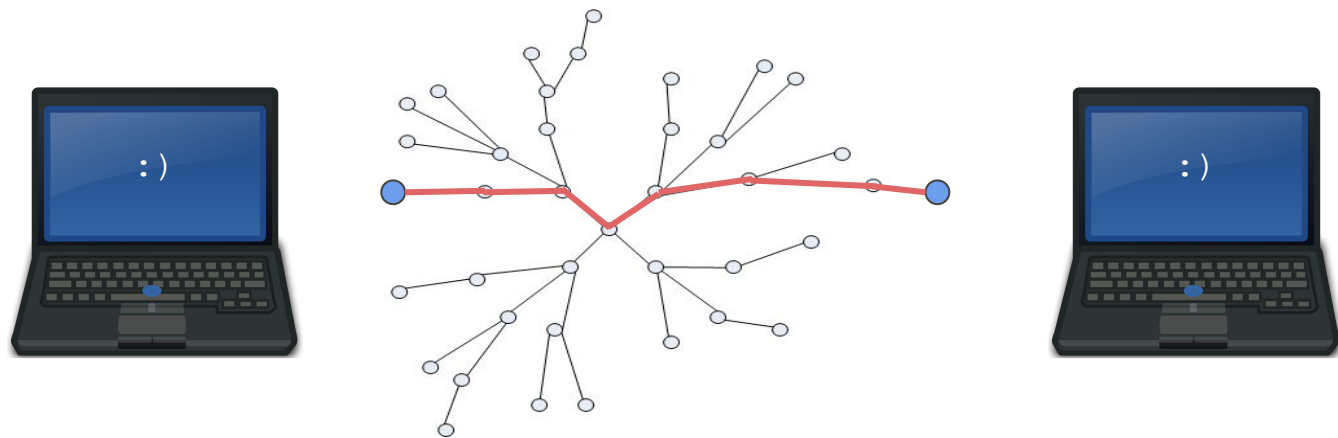
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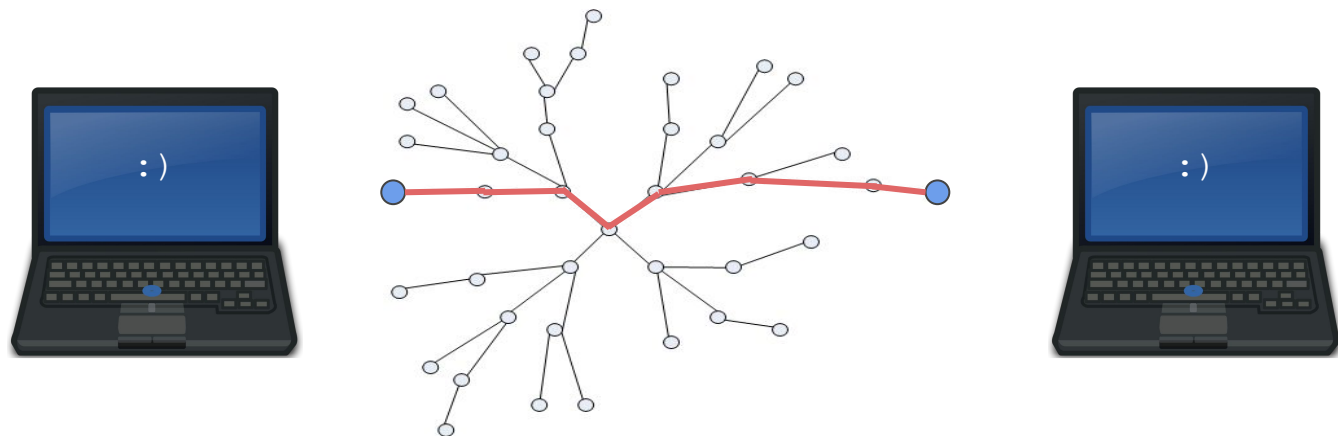
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Sending *Digital* Information

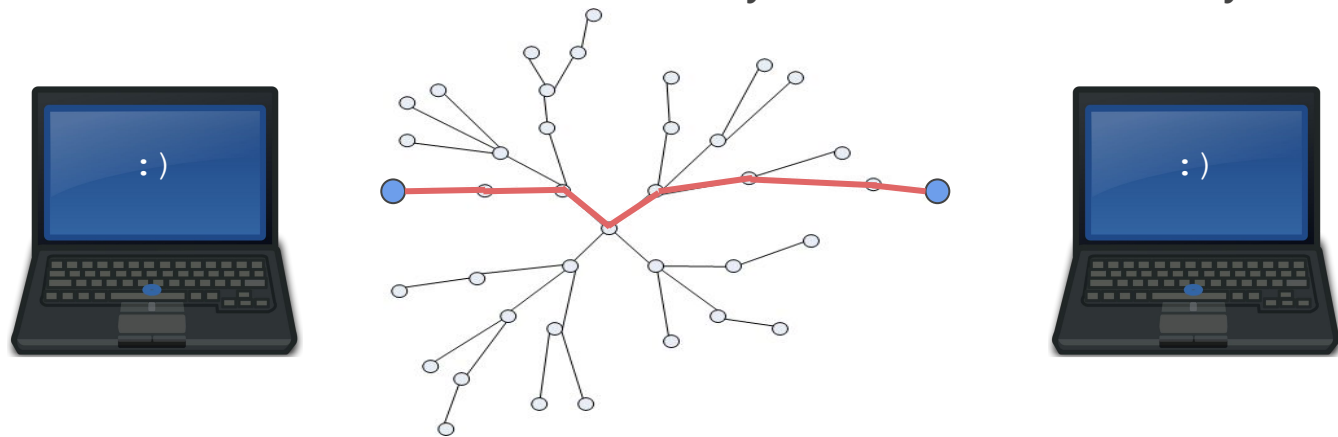
We're not sending a physical smiley face from one computer to another - we're transmitting some binary code that translates to those characters!



Sending *Digital* Information

At a basic level, all we need to do is get digital information from one computer to the other.

Let's discuss different methods by which we can actually transmit those bits!



Internet Hardware



There are 3 primary ways that we transmit digital informations from one computer to another:

1. Electricity
2. Light
3. Radio



Sending Bits with Electricity



The most common cable used by modern computers for transmitting digital data via electricity is the **Ethernet** cable.

Pros:

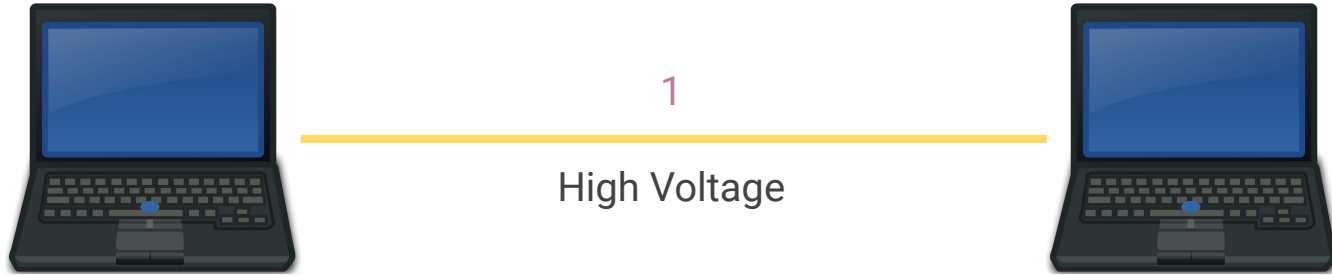
- Cheap

Cons:

- Only covers medium distances



Sending Bits with Electricity

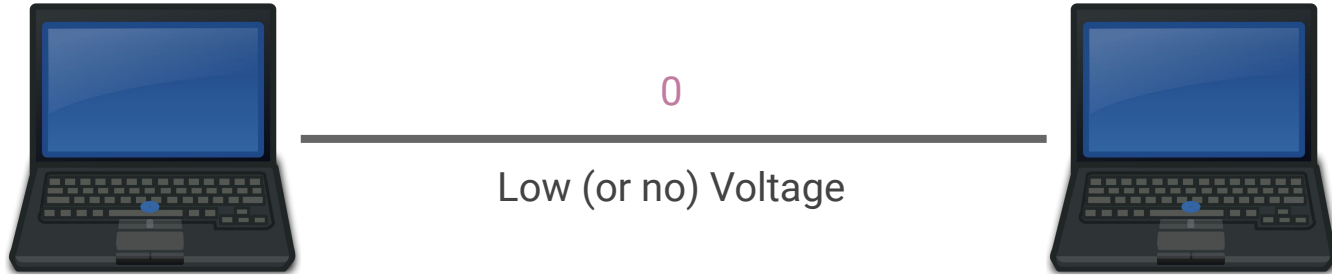


The most common cable used by modern computers for transmitting digital data via electricity is the **Ethernet** cable.

To send a 1 via electricity, we simply send a signal with a high voltage!



Sending Bits with Electricity



The most common cable used by modern computers for transmitting digital data via electricity is the **Ethernet** cable.

To send a 0 via electricity, we simply send a signal with a low voltage (or no voltage at all)!

Sending Bits with Light



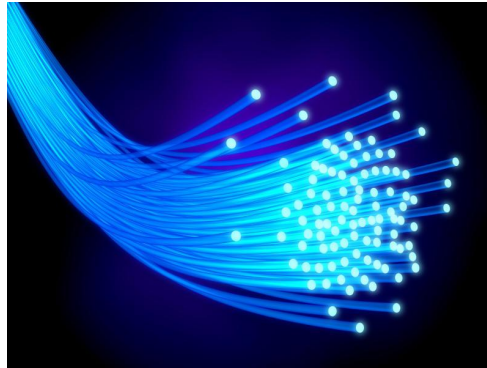
When we want to send digital information via Light, we need to use Fiber Optic cables.

Pros:

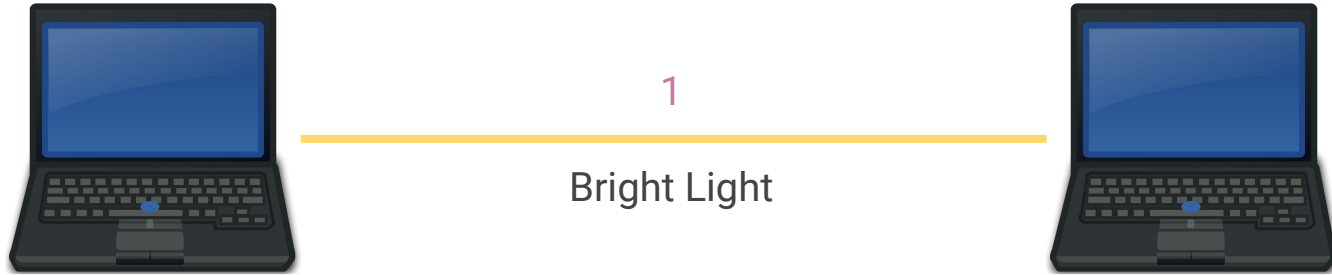
- Can cover VERY long distance

Cons:

- Expensive



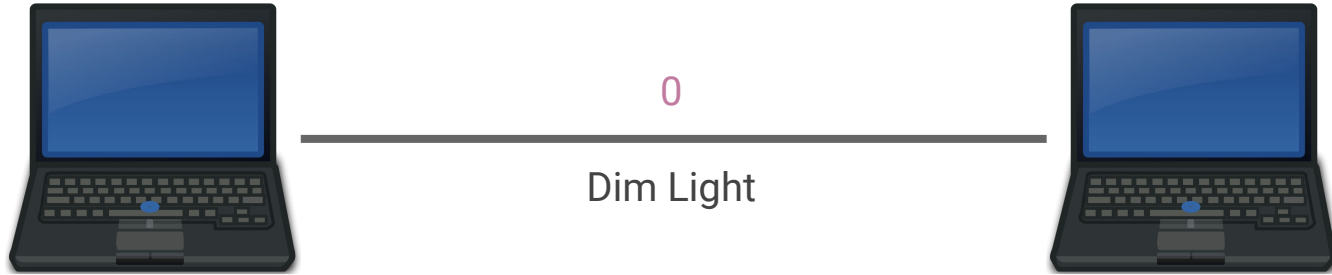
Sending Bits with Light



When we want to send digital information via Light, we need to use Fiber Optic cables.

Similarly to when we sent a 1 via electricity, we send a bright light through the cable to transmit a 1 with light!

Sending Bits with Light



When we want to send digital information via Light, we need to use Fiber Optic cables.

To send a 0 with light, we shine a dim light, or turn the light off altogether!



Sending Bits with Radio Waves



When we want to send digital information via Radio waves, we don't need cables at all - we need a Wifi Router or Cell Tower!

Pros:

- Wireless!

Cons:

- Short Range



Sending Bits with Radio Waves

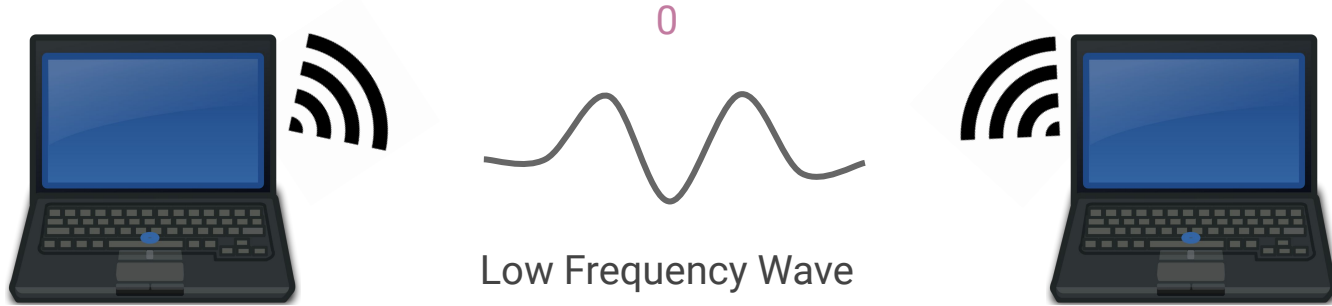


When we want to send digital information via Radio waves, we don't need cables at all - we need a Wifi Router or Cell Tower!

To send a signal of **1** via Radio Waves, we need to transmit a wave with High Frequency.



Sending Bits with Radio Waves



When we want to send digital information via Radio waves, we don't need cables at all - we need a Wifi Router or Cell Tower!

To send a signal of 0 via Radio Waves, we need to transmit a wave with Low Frequency.



Sending Bits



1010



Sending Bits



1010



1



Sending Bits



1010



10



Sending Bits



1010



101



Sending Bits



1010



1010



Sending Bits



1010



1010

That worked perfectly!



Sending Bits



10001



Sending Bits



10001



1



Sending Bits



10001



10



Sending Bits



10001



10



Sending Bits



10001



10



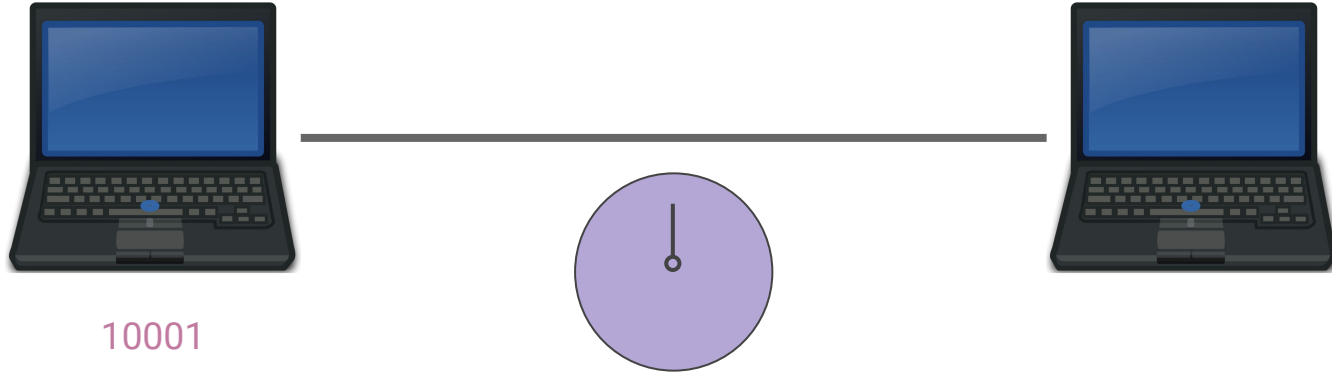
Sending Bits



Now we have a disconnect - that's not what we want!

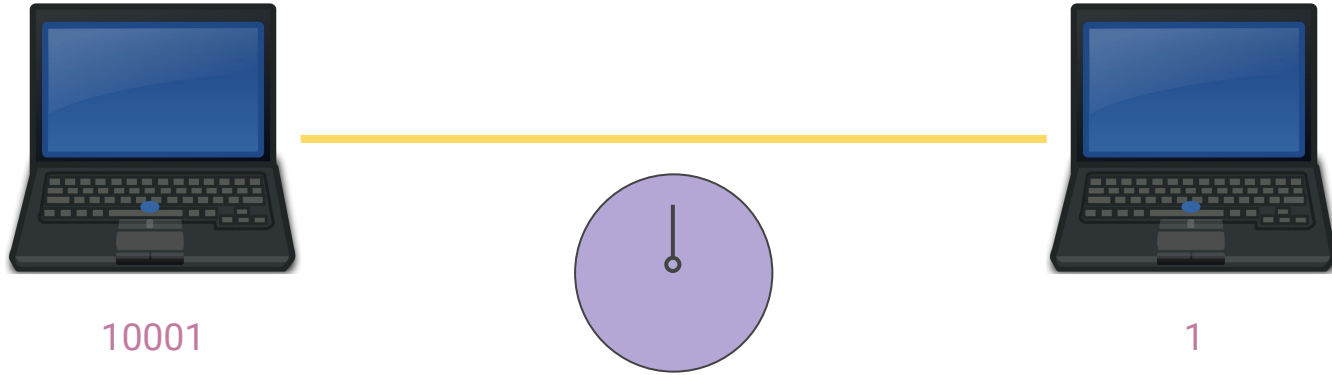


Sending Bits



To solve this issue, we can use a **clock**, which will allow the computers to agree on how often to send/receive a bit.

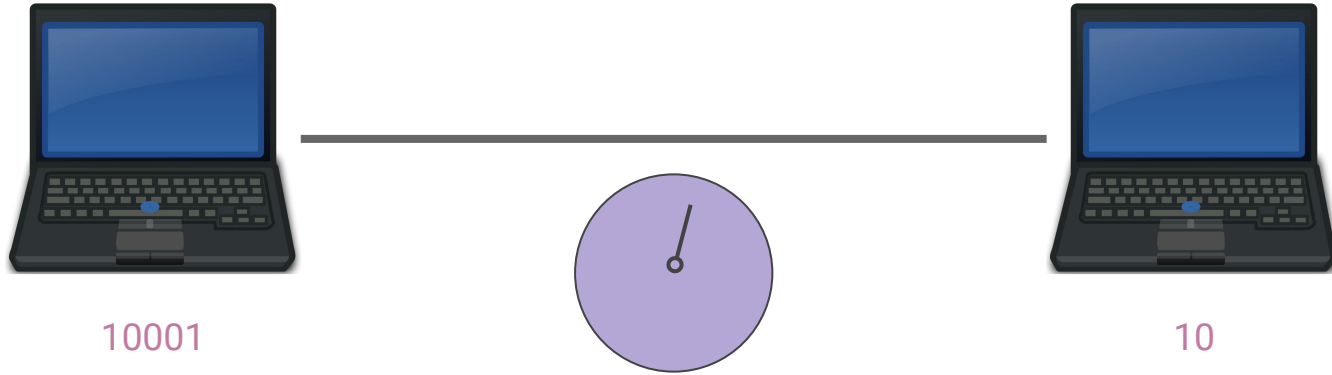
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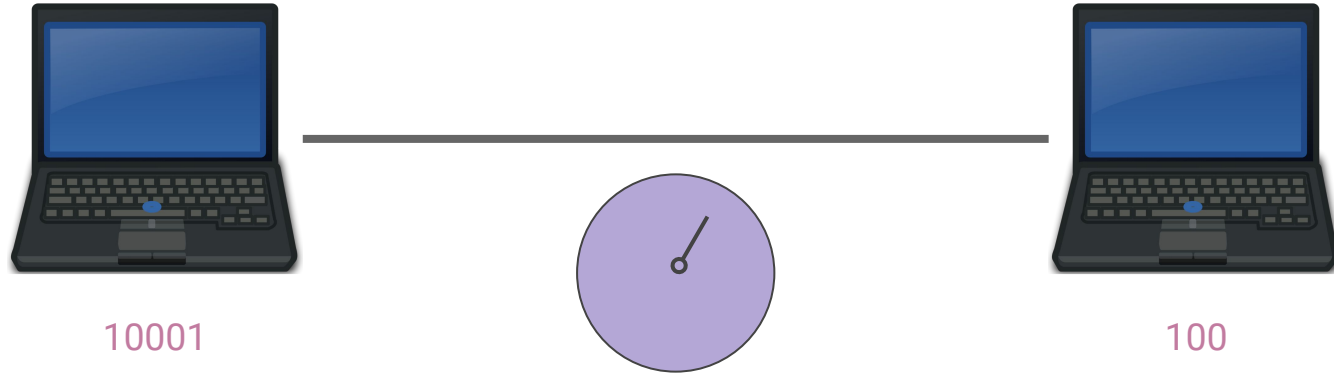


Sending Bits



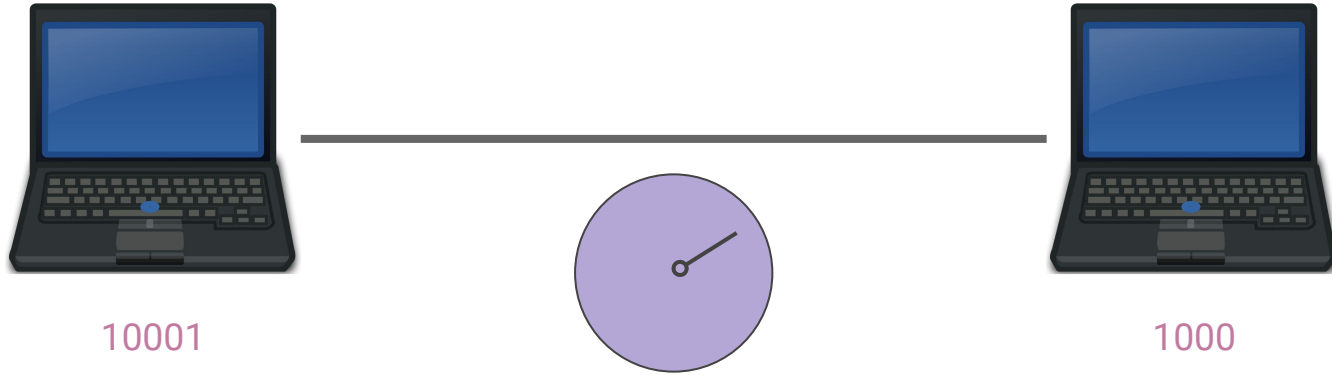
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Sending Bits



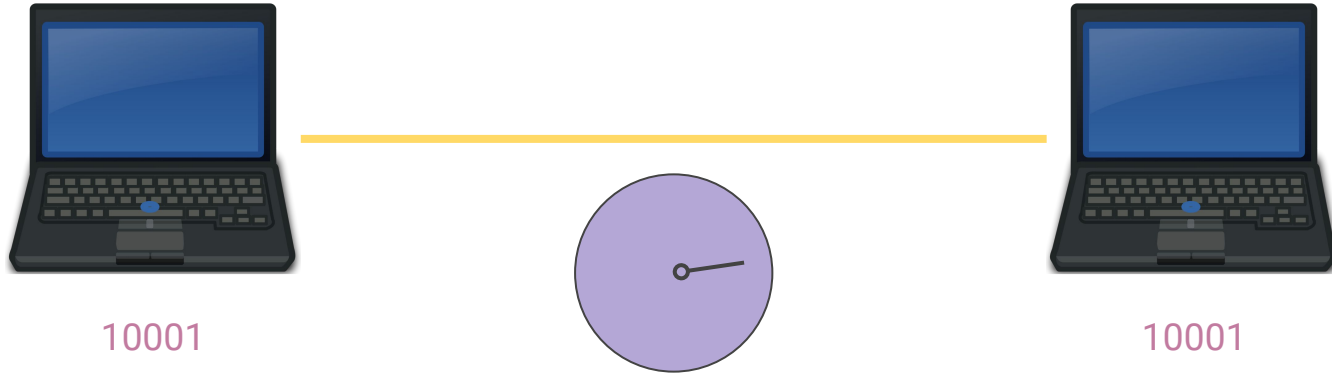
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Sending Bits



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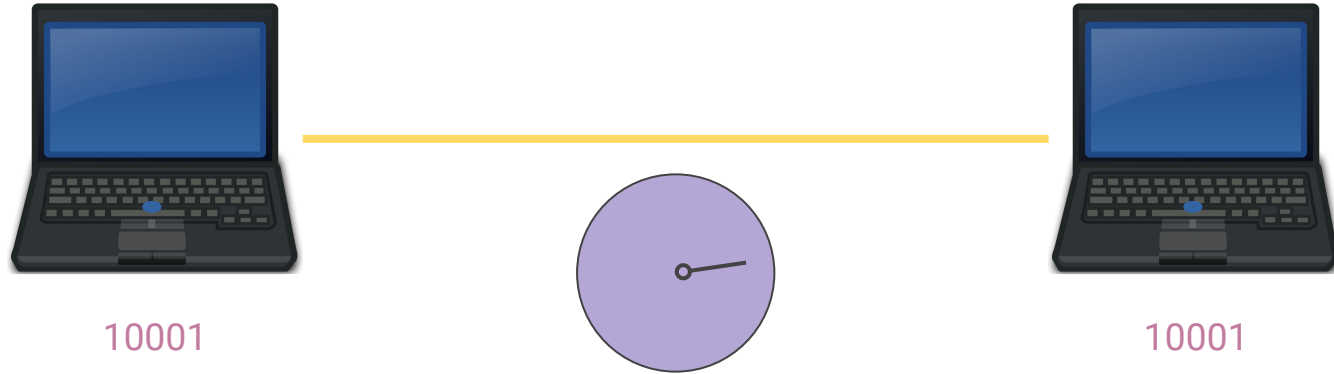
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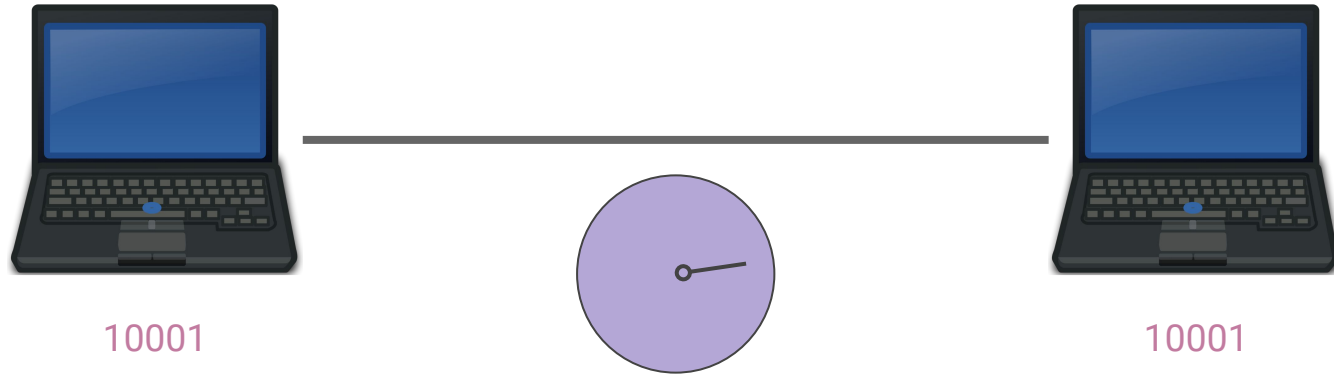
Sending Bits



To solve this issue, we can use a **clock**, which will allow the computers to agree on how often to send/receive a bit.

Because of the clock, we have a matching message on both ends now!

Sending Bits



This example where we transferred **1** bit every second is **incredibly** slow - fortunately, computers are much faster than that.

The amount of data that can be transferred by a single system is referred to as that system's **Bandwidth**. It is measured by **Bitrate**, which is the number of bits that can be sent or received by a system in **1** second.

Bandwidth

Bandwidth	Bitrate
excruciatingly Low	1 bps
High	5 Mbps



Latency

One last thing to take into account is the idea of **Latency**, which is the time that it takes for a bit to get from the sender to the receiver.

If you have Low Latency, then that means that you have a fast connection.

Fiber Optic cable has the best latency - it can transmit data at the speed that light moves through glass (~5 microseconds / kilometer)

Ethernet cables have a latency of ~300 microseconds / kilometer, though Ethernet connections are typically shorter than a kilometer.



Recap

- The Internet
 - A **Network** connecting **Networks**
- **Network**
 - A group of 2 or more connected computers
 - Typically connected via Routers
- Ways to send digital information
 - Electricity (ethernet)
 - Light (fiber optic)
 - Radio Waves (WiFi, Cell)
- No matter what type of connection is being used, we're just sending bits - no more and no less!

