

# System Board Considerations

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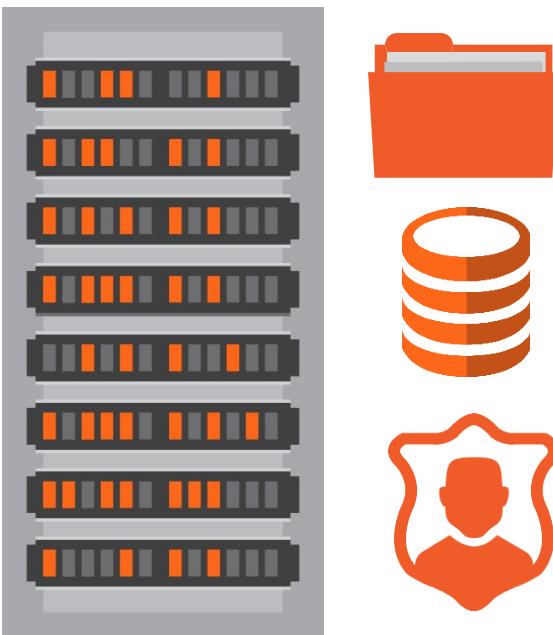


# Storyline

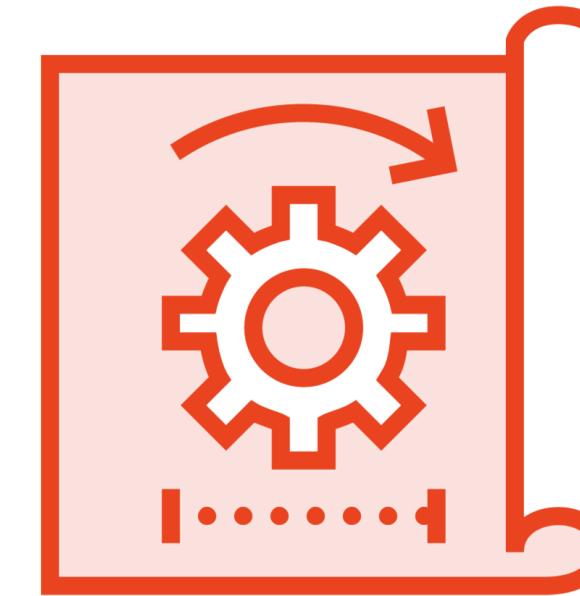


Globomantics are researching the details of their server and are now considering their choices for the system board.

Let's see how their requirements impact their choice of chipset and busses.



# What Do You Need to Know?



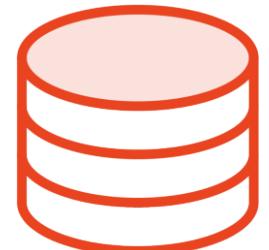
This time we're not looking for a specific component, but rather we are trying to understand the architecture.

We will look at expansion slots, graphics processing units (GPU), the various server interfaces and the busses.

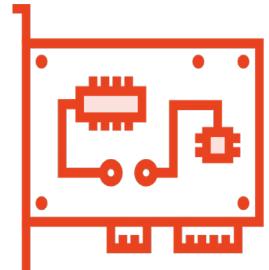
# Server Devices



**Graphics Processing Units (GPUs)**



**Hard disk drives**



**Network cards**



**USB devices**

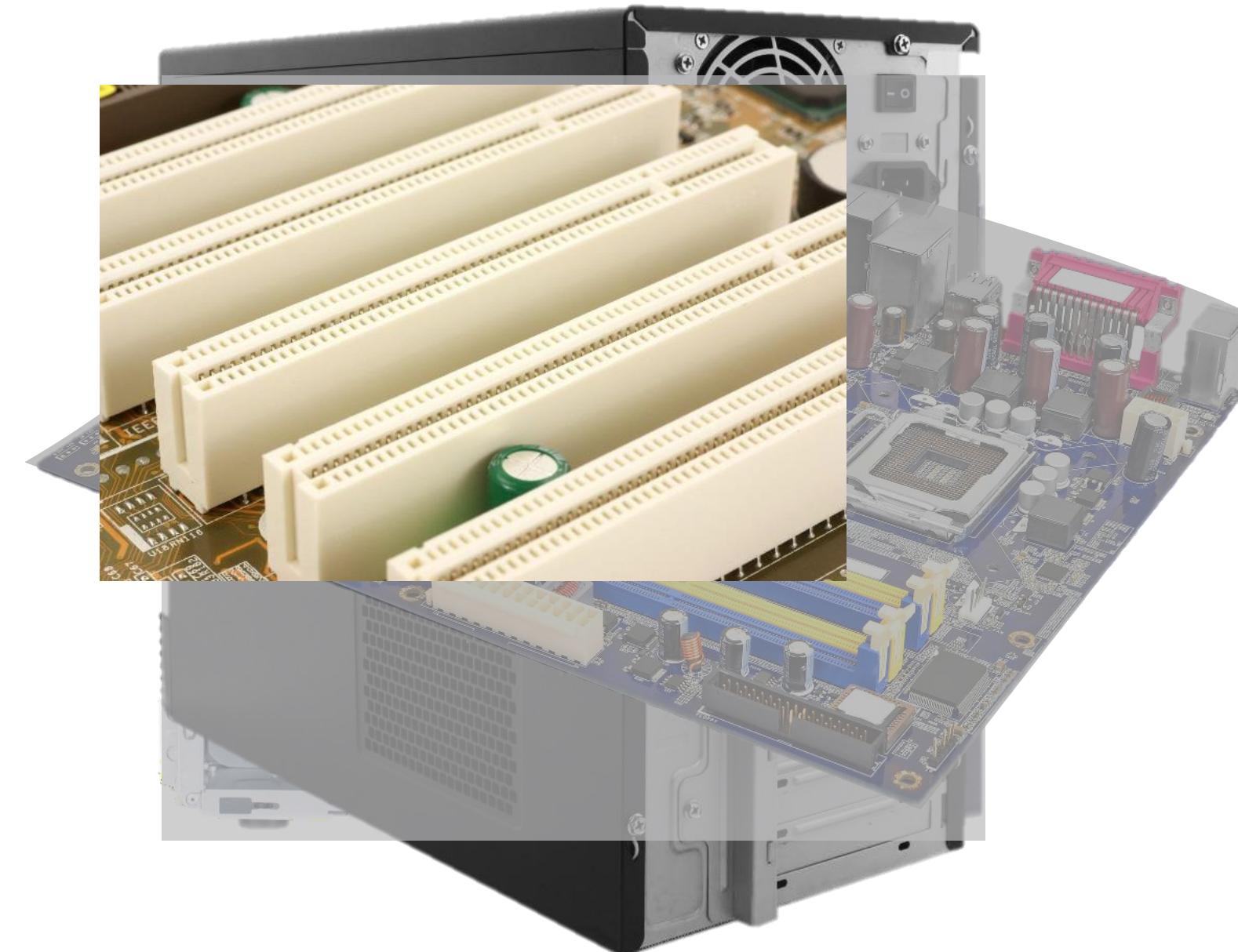


**And more!**

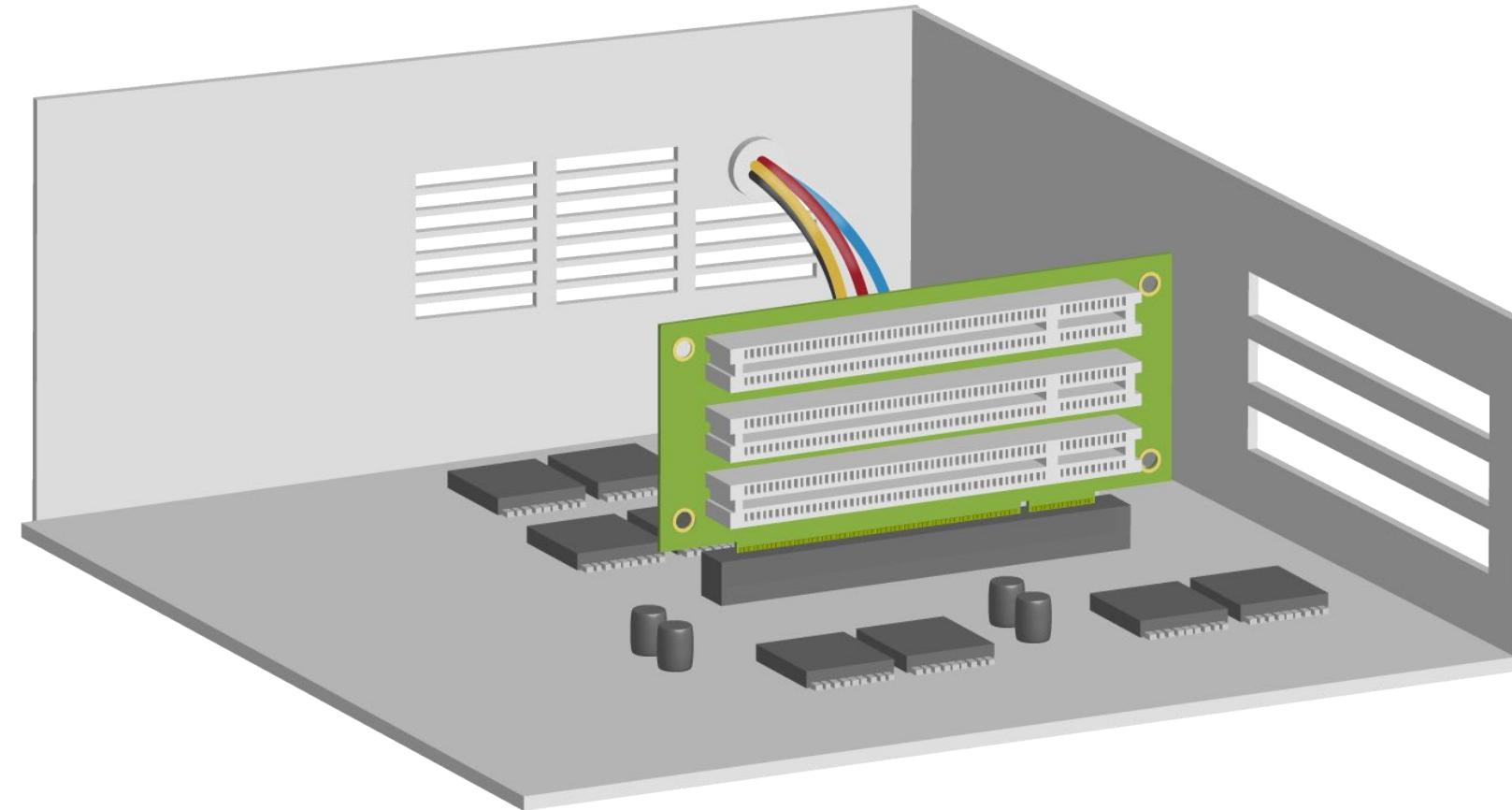
We have discussed CPU and Memory.

But servers can have many other types of devices attached to them.

# Let's Start with the Expansion Slots



# Expansion Slots May Be Horizontal as Well

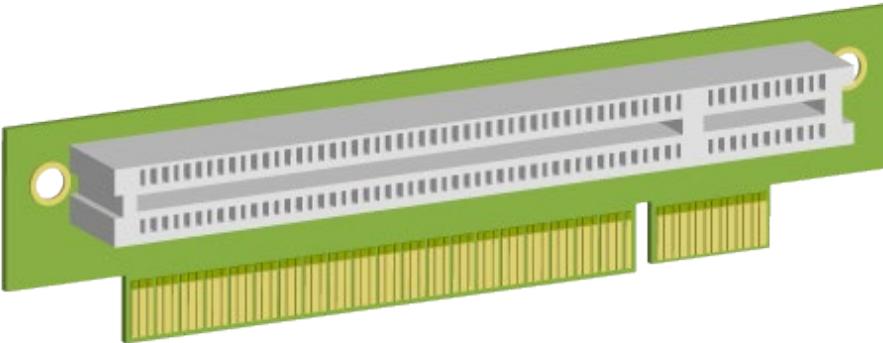


PCI Riser Board and slots

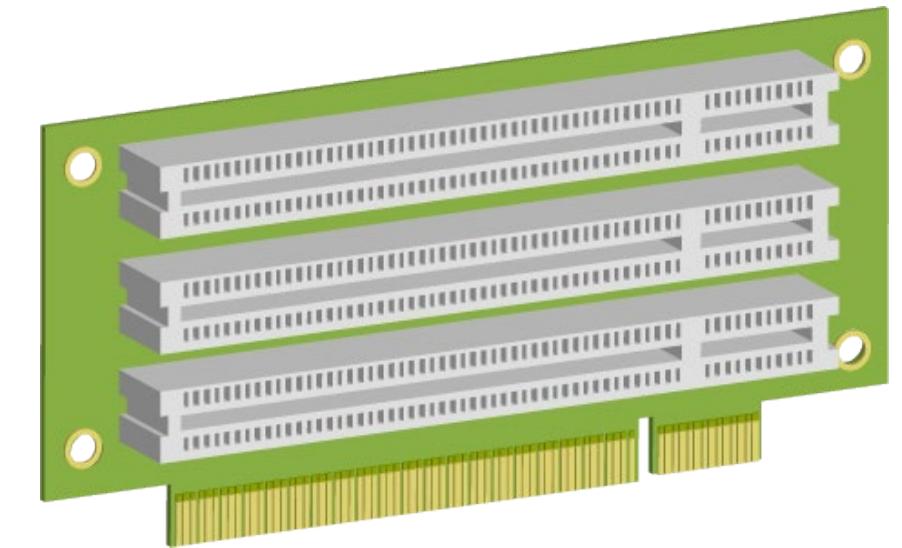
# Riser Cards

Used to give rack and blade servers (usually 1U or 2U) the ability to have expansion cards installed horizontally instead of vertically

- Rotates the installation of the cards 90 degrees



1 slot in a 1U server



3 slots in a 2U server

# Card Sizes



Full-Height; Full-Length



Full-Height; Half-Length



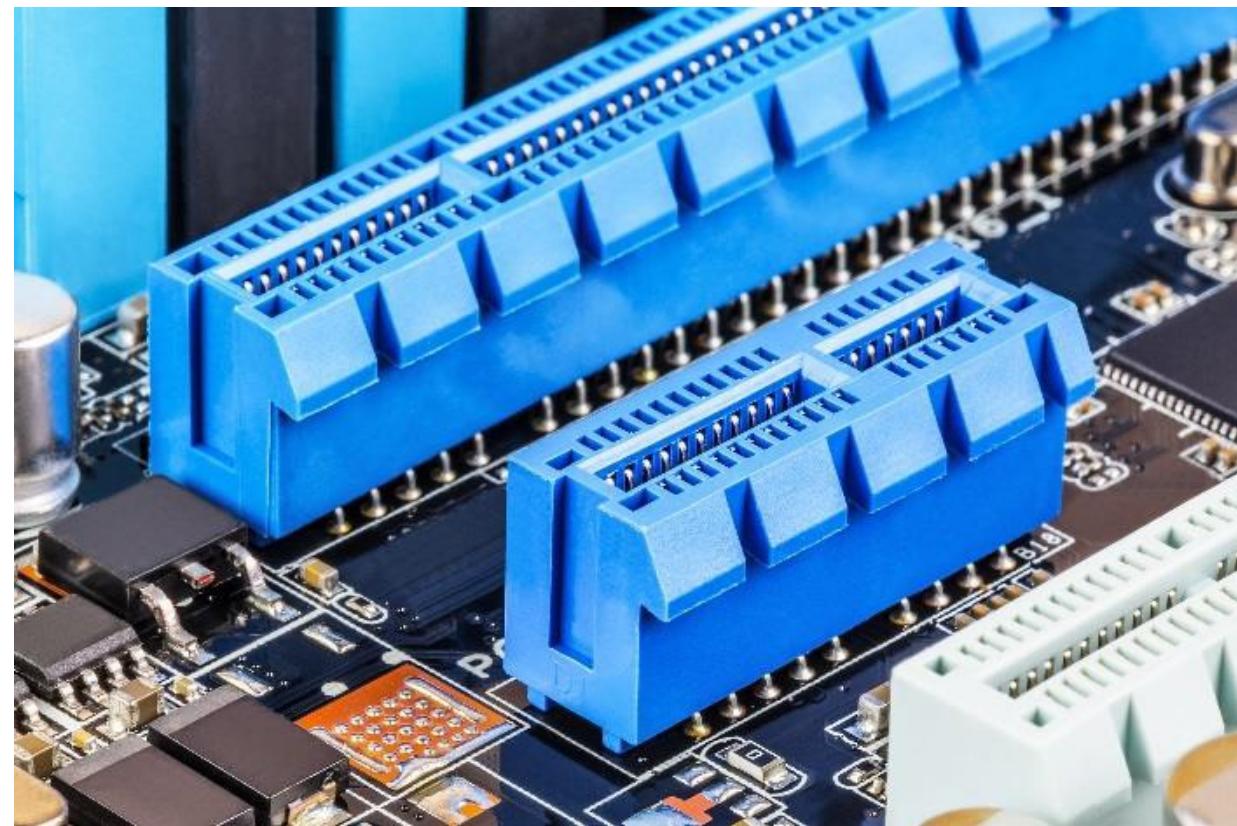
Low-Profile/Slim

PCIe card type	Maximum dimensions (height × length)	
	(mm)	(in)
Full-Height; Full-Length	111.15 × 312.0	4.376 × 12.283
Full-Height; Half-Length	111.15 × 167.65	4.376 × 6.6
Low-Profile/Slim	68.9 × 167.65	2.731 × 6.6



Tech Point  
PCI Express  
(PCIe)

# PCIe Overview



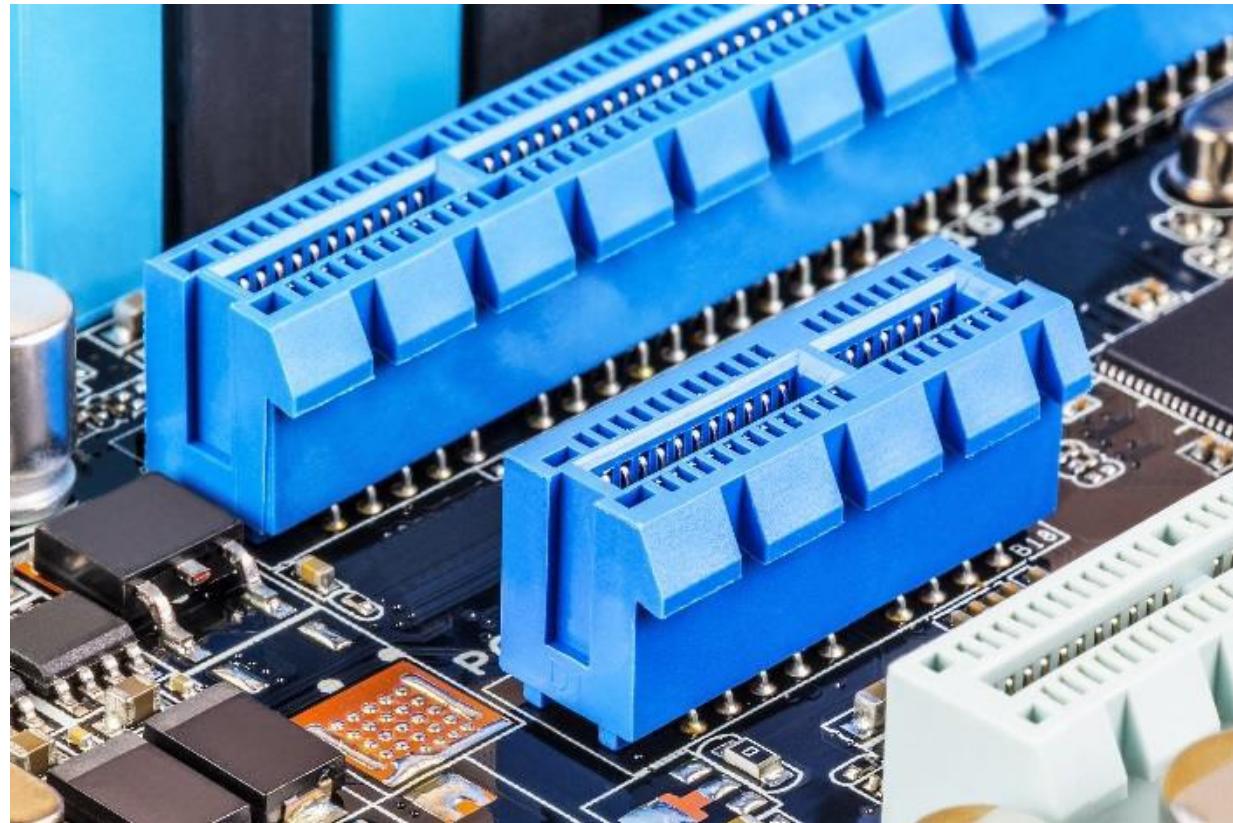
## PCI Express (PCIe)

- Created in 2003
- Most common expansion bus in new servers

PCIe leverages serial communication

Often supports hot-plugging

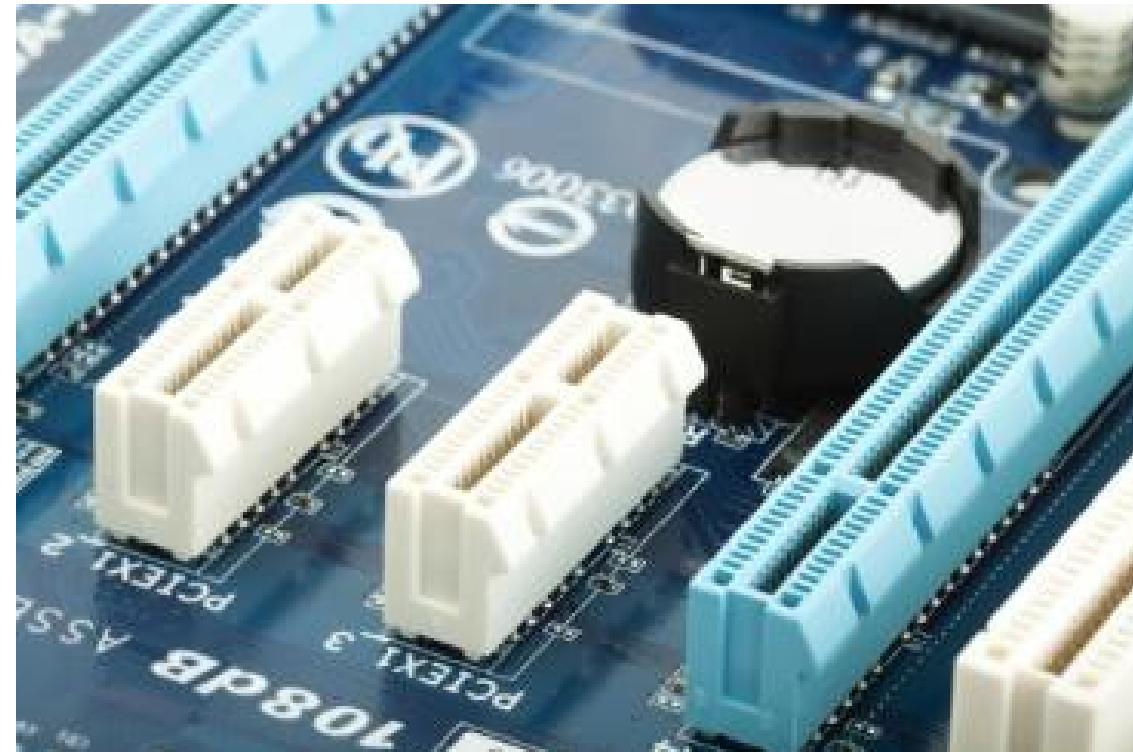
# PCIe Overview



## Dedicated bus per device

- Point-to-point communication
- Full Duplex
- Other installed cards do not impact bus speed
- All cards can communicate at the same time

# PCIe Lanes



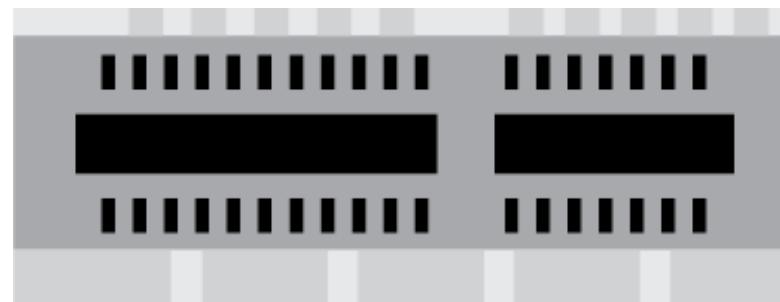
## Lanes (x1, x4, x8, x16)

- Impacts the speed of the slot (and card length)

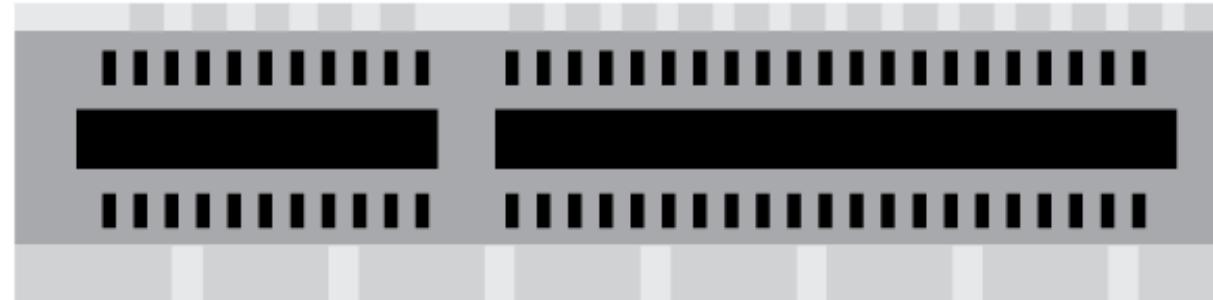
## Communication path in both directions

- 1 bit/lane in each direction per clock cycle
- Linear scaling in speed / performance with number of lanes
  - Example: x4 is 4 times the speed of x1
- Slots are backward compatible
  - A x4 card will function in an x8 slot

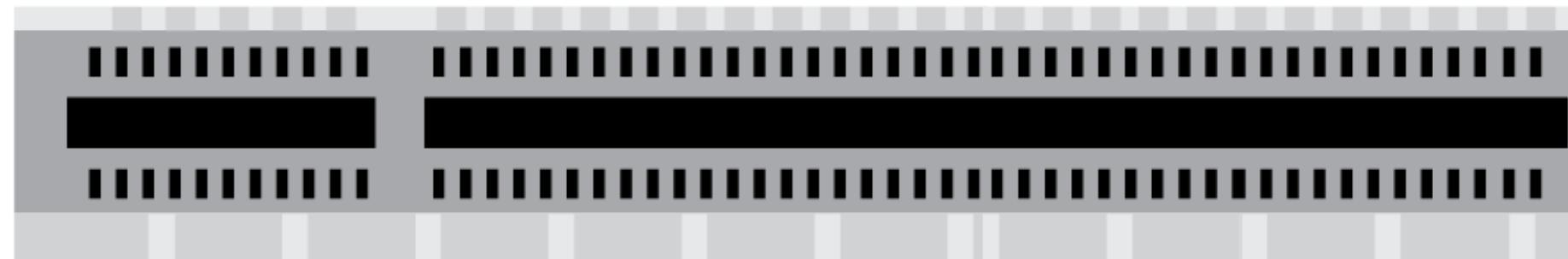
# Examples of PCIe Cards and Slots



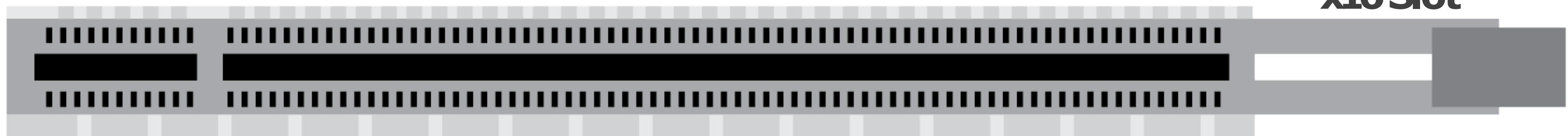
**x1 Slot**



**x4 Slot**



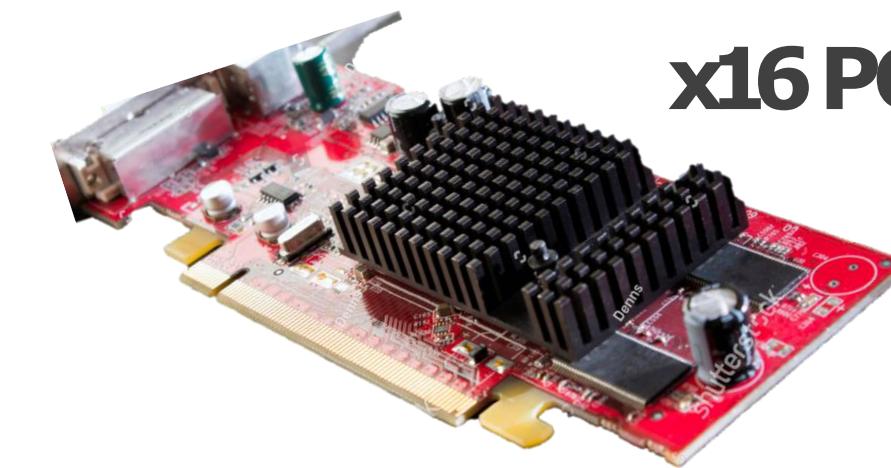
**x8 Slot**



**x16 Slot**



**PCIe x1 card (top)**  
**PCIe x4 card (middle)**  
**PCIe x8 card (bottom)**



**x16 PCIe Card**

# PCIe Versions

Each version defines a number of gigatransfers per second (GT/s)

- Standard is not based on bits/second
- GT/s = number of data transfers per second (per lane)

## Versions

- 1: Created in 2003, 2.5 GT/s
- 2: Created in 2007, 5 GT/s
- 3: Created in 2010, 8 GT/s
- 4: Created in 2017, 16 GT/s
- 5: Created in 2019, 32 GT/s
- 6: Created in 2021, 64 GT/s

# Why Does the Pcie Version and Slot Type Matter?

Suppose you want to add a **40 Gbps network card** to a server.

What do you need to know about the system board?

What is the PCIe bus version?

What type of PCIe slots are available?



This tells you the available bandwidth

For this example, assume the bus (and card) is PCIe 4.0

How many PCIe lanes (the PCIe slot type) would you need to support a **40 Gbps card**?

# PCIe Maximum Bandwidth by Version and Lanes

PCIe Version	Transfer Rate	PCIe Slot type (Number of PCIe Lanes)			
		x1	x4	x8	x16
PCIe 1	2.5 GT/s	2.00 Gbps	8.00 Gbps	16.00 Gbps	32.00 Gbps
PCIe 2	5.0 GT/s	4.00 Gbps	16.00 Gbps	32.00 Gbps	64.00 Gbps
PCIe 3	8.0 GT/s	7.88 Gbps	31.50 Gbps	63.02 Gbps	126.03 Gbps
PCIe 4	16.0 GT/s	15.76 Gbps	63.02 Gbps	126.03 Gbps	252.06 Gbps
PCIe 5	32.0 GT/s	31.50 Gbps	126.03 Gbps	252.06 Gbps	504.12 Gbps
PCIe 6	64.0 GT/s	63.02 Gbps	252.06 Gbps	504.12 Gbps	1.008 Tbps

# Why Does the PCIe Version and Slot Type Matter?

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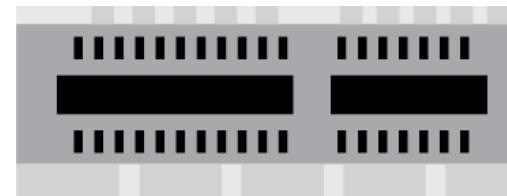
PCIe 4.0

What types of PCIe slots are available?

x1, x4, and x16



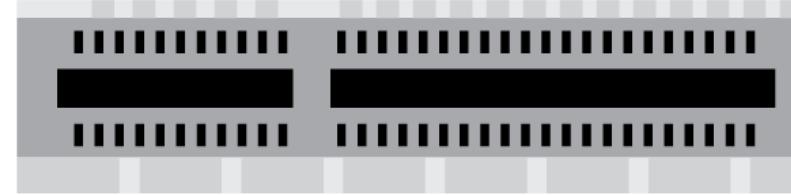
**x1 Slot**



PCIe 4.0 with 1 lane = 15.76 Gbps



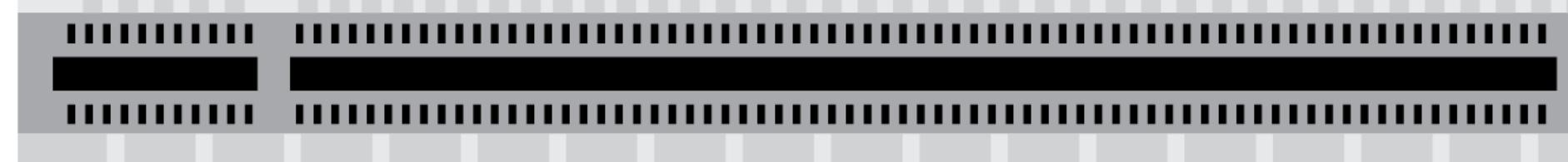
**x4 Slot**



PCIe 4.0 with 4 lanes = 63.02 Gbps



**x16 Slot**



PCIe 4.0 x16 = 252.04 Gbps

# Why Does the PCIe Version and Slot Type Matter?

Suppose you want to add a **40 Gbps** network card to a server.

What do you need to know about the system board?

What is the PCIe bus version?

PCIe 4.0

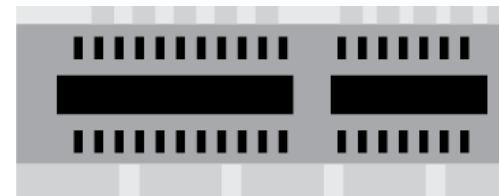
What types of PCIe slots are available?

x1, x4, and x16

Solution:  
PCIe 4.0  
Using one x4 slot



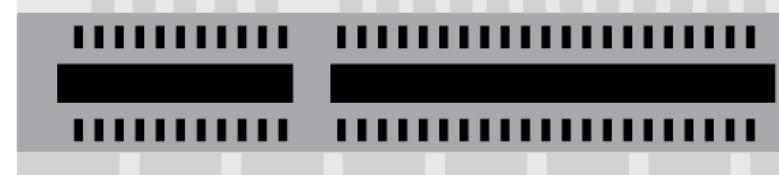
**x1 Slot**



PCIe 4.0 with 1 lane = 15.76 Gbps (insufficient)



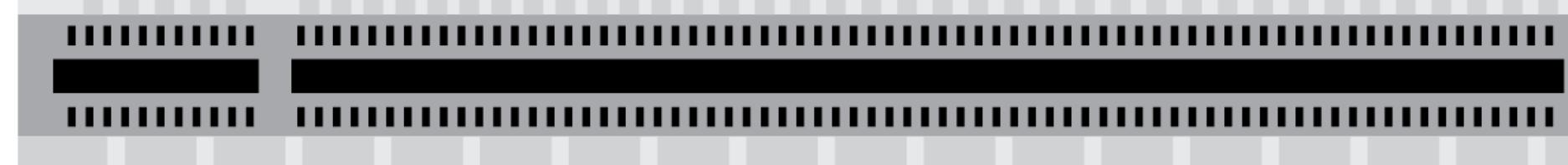
**x4 Slot**



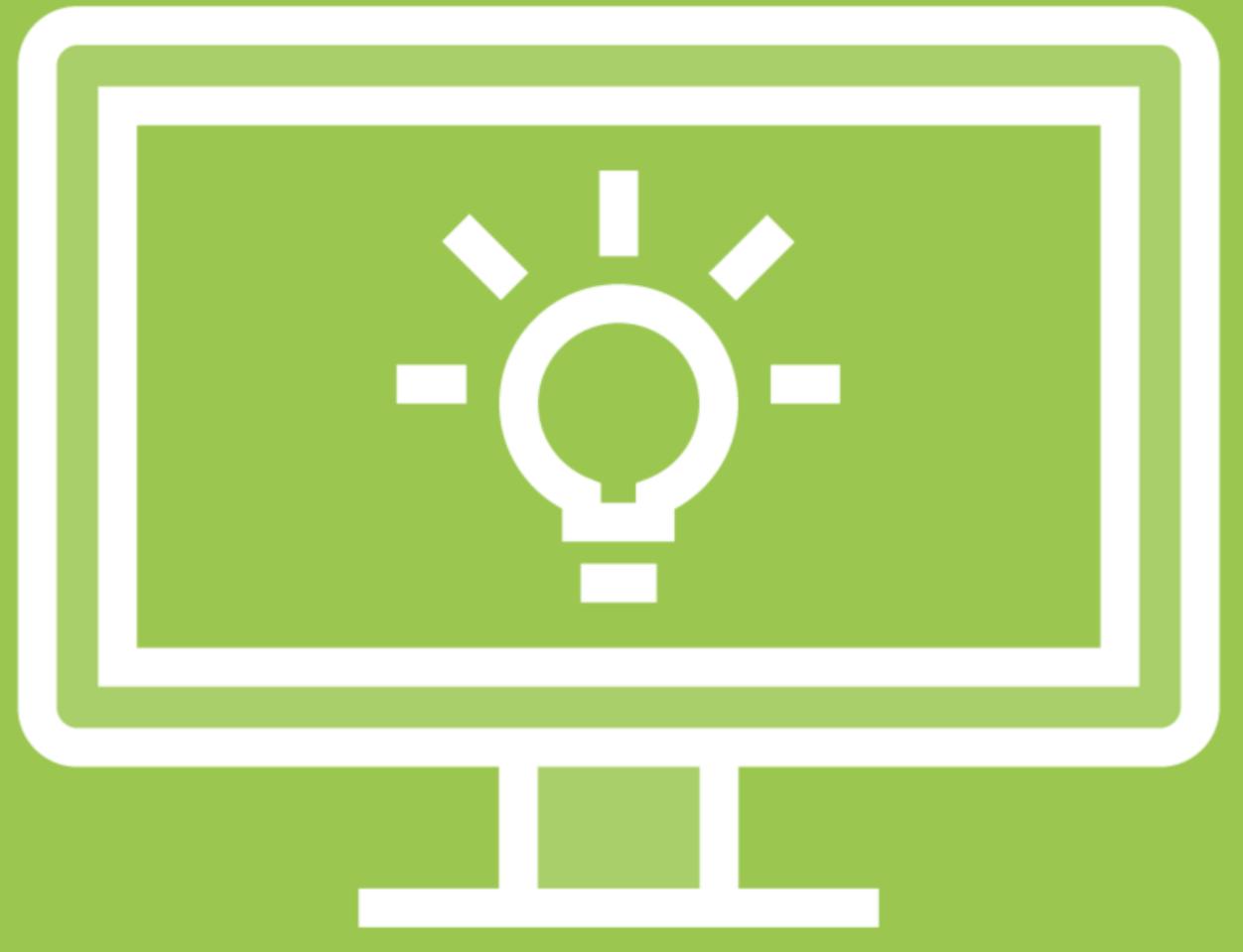
PCIe 4.0 with 4 lanes = 63.02 Gbps (perfect)



**x16 Slot**

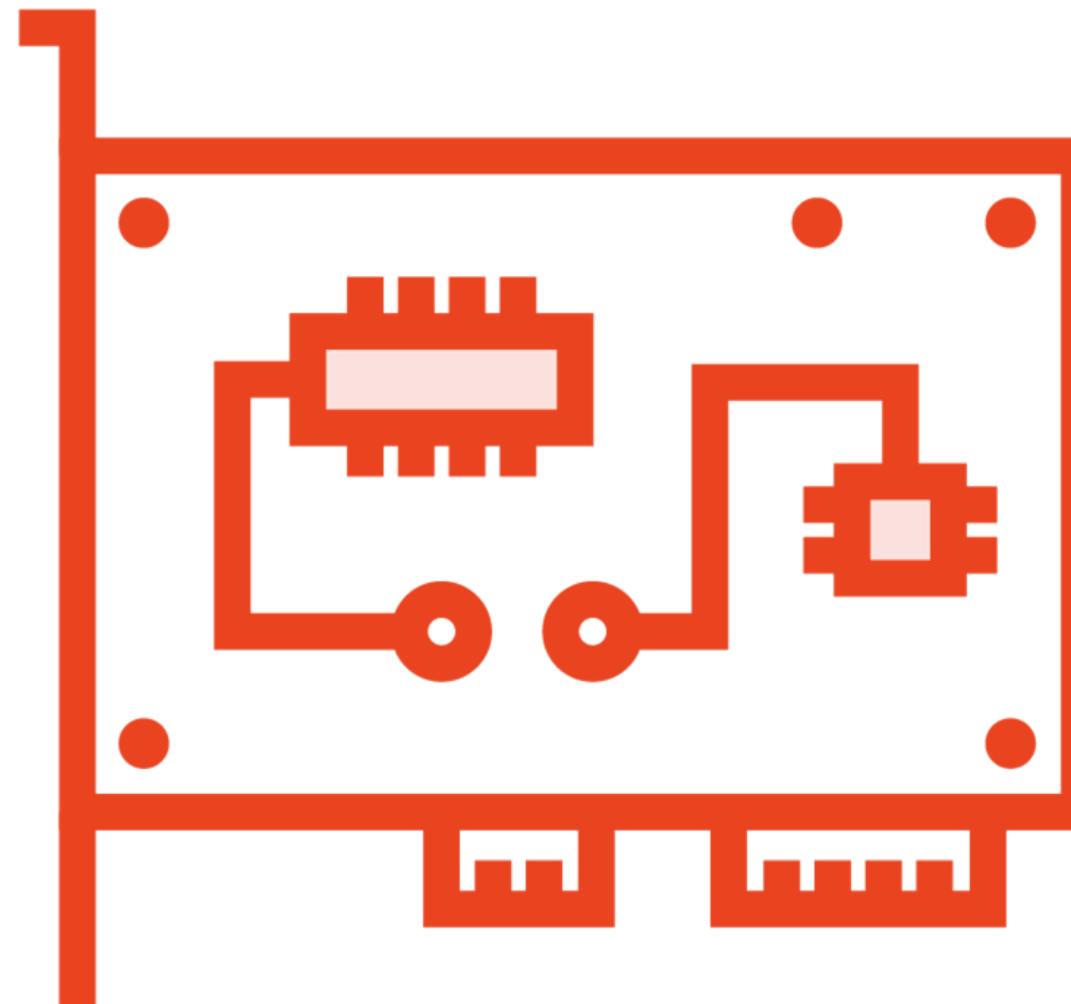


(overkill)



Tech Point  
Graphics  
Processing Unit  
(GPU)

# What Is a Graphics Processing Unit (GPU)



A GPU is a video card, but in a server it also has other uses

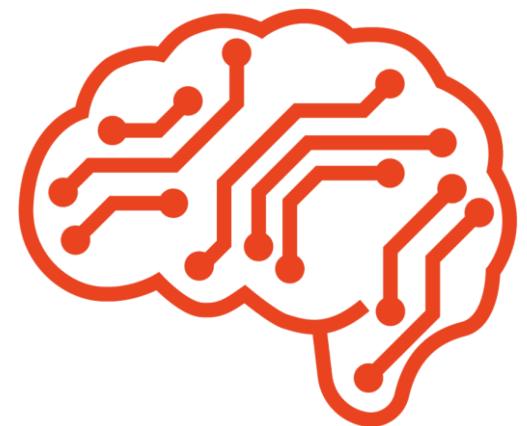
The GPU contains an extremely powerful processor typically used to render video

They typically require auxiliary power and due to their heat output, always require cooling

Do You Play  
Games on Your  
Server?



# GPU Use Cases in Servers



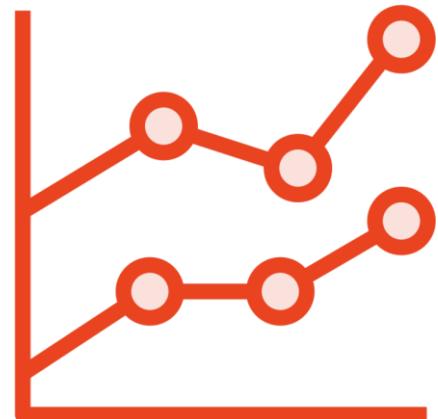
Machine Learning



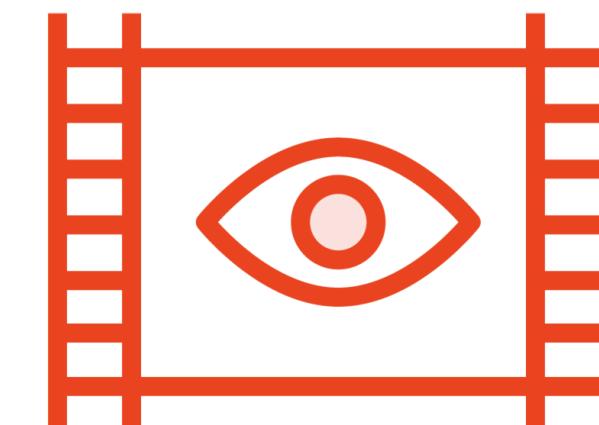
Geospatial Engineering



Weather Modeling



Analytics

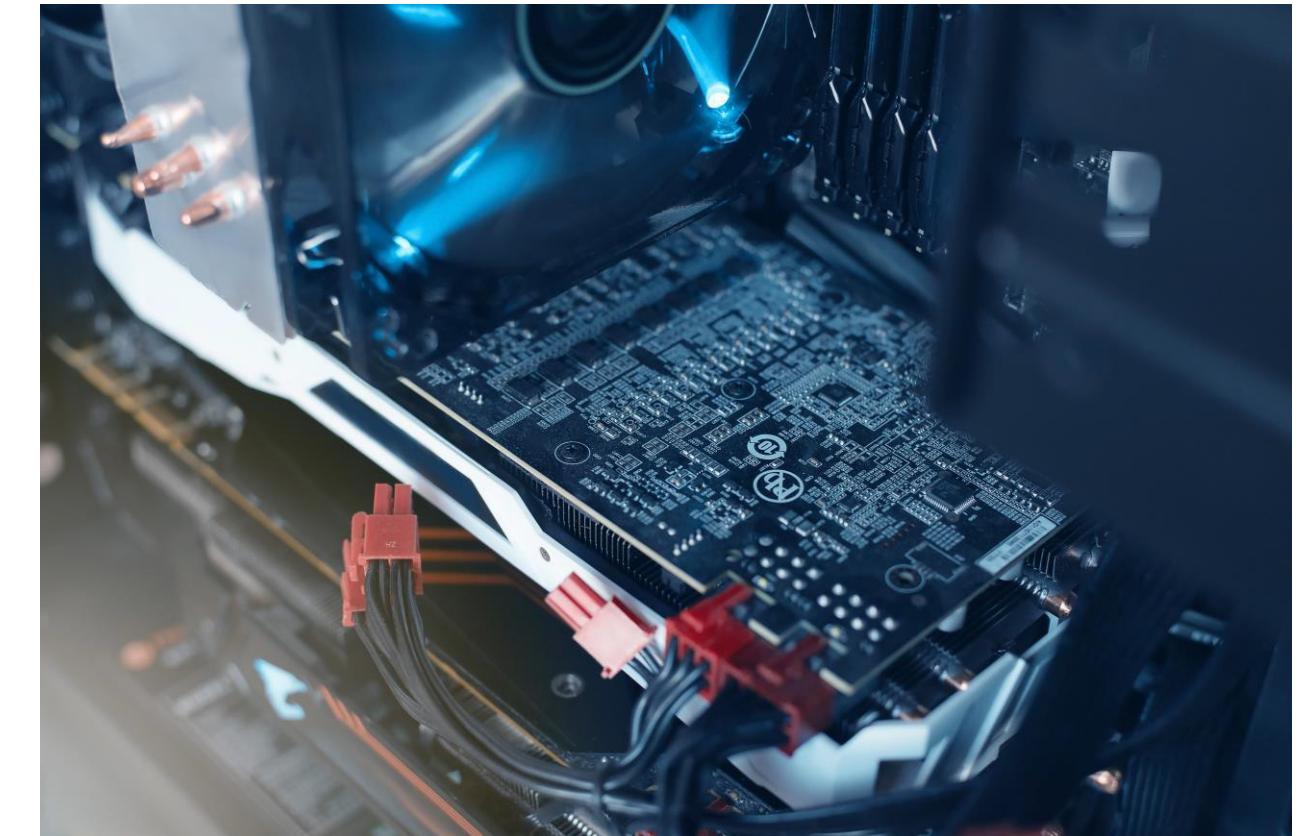


Video Rendering

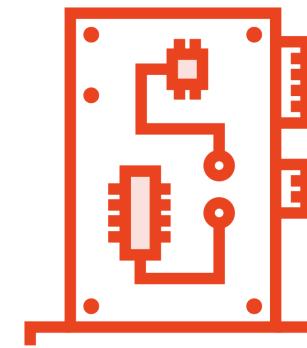
# You Can Use Multiple GPUs in a Server

**Just be careful about how much power your GPUs are drawing**

**Ensure your server's power supply can handle the load, and that it has sufficient power connectors for the cards**



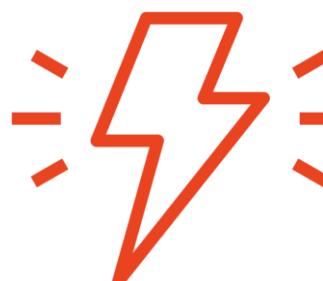
# What Do You Need to Consider About GPUs?



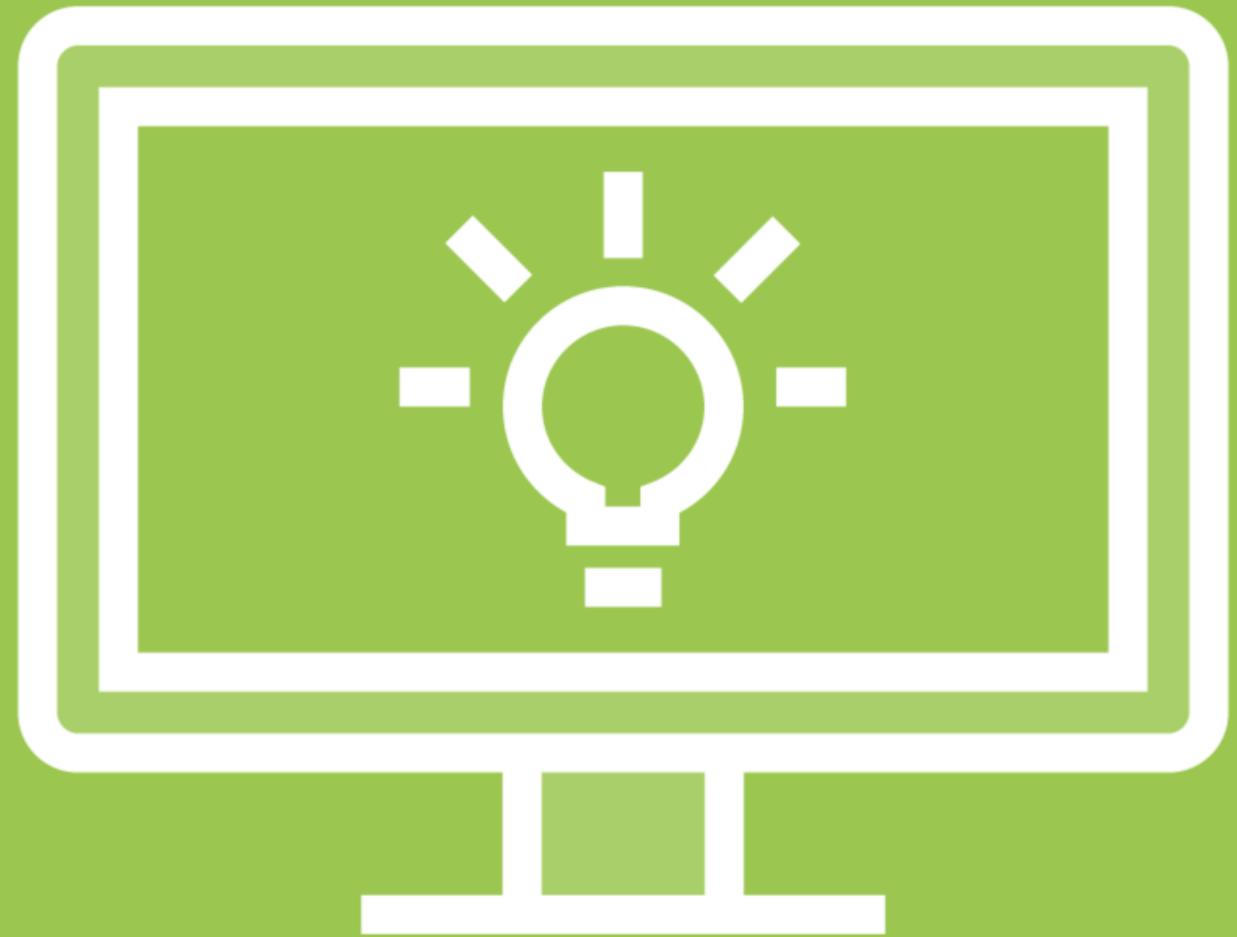
How many cards do you need?



Bus type of the card



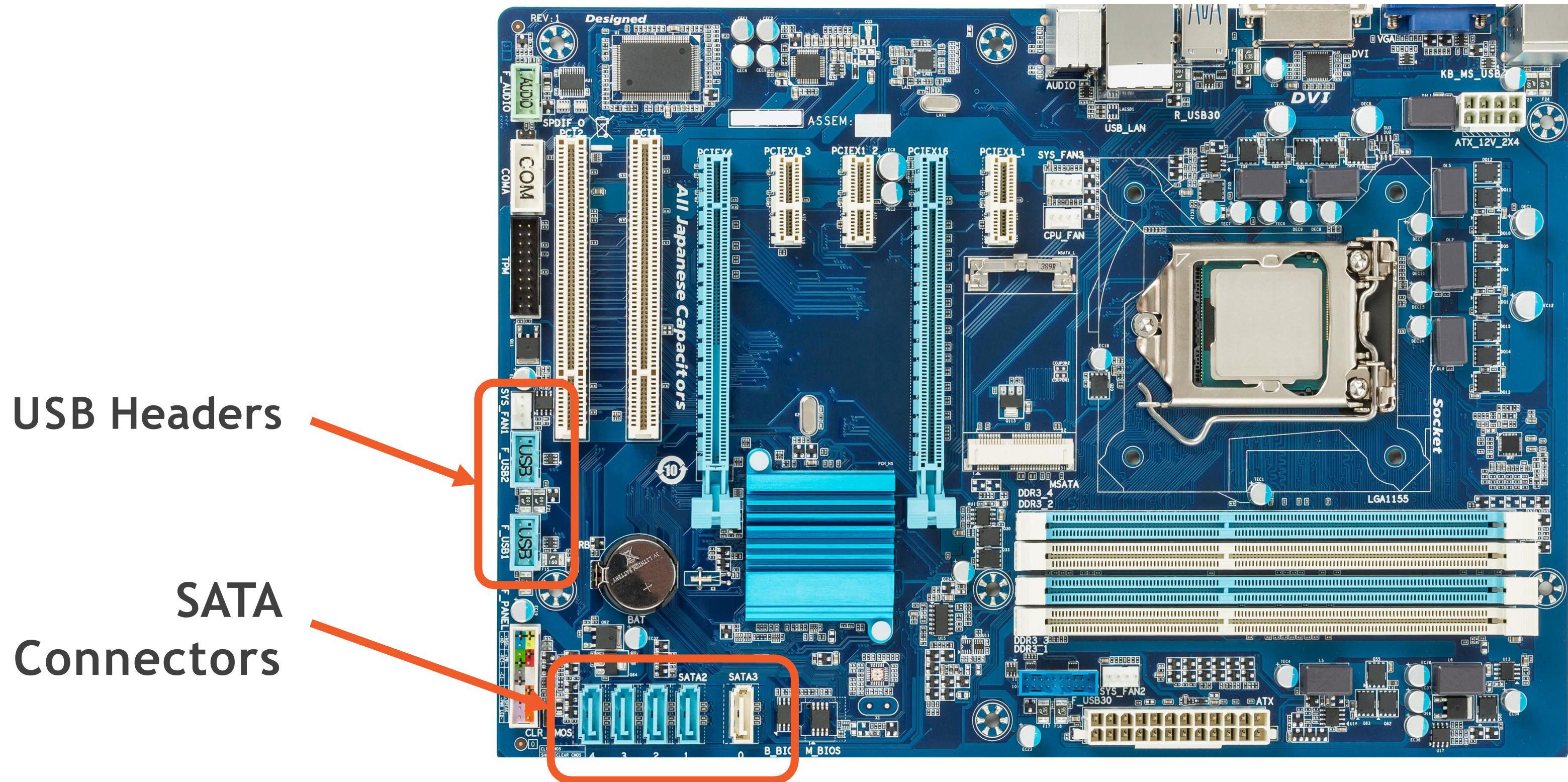
Power draw of the cards



Tech Point  
SATA and USB

SATA  
Serial ATA

# Internal and External Interface Types



# What Is SATA?

A server may have Serial ATA (SATA) ports on the system board for internal hard drives.

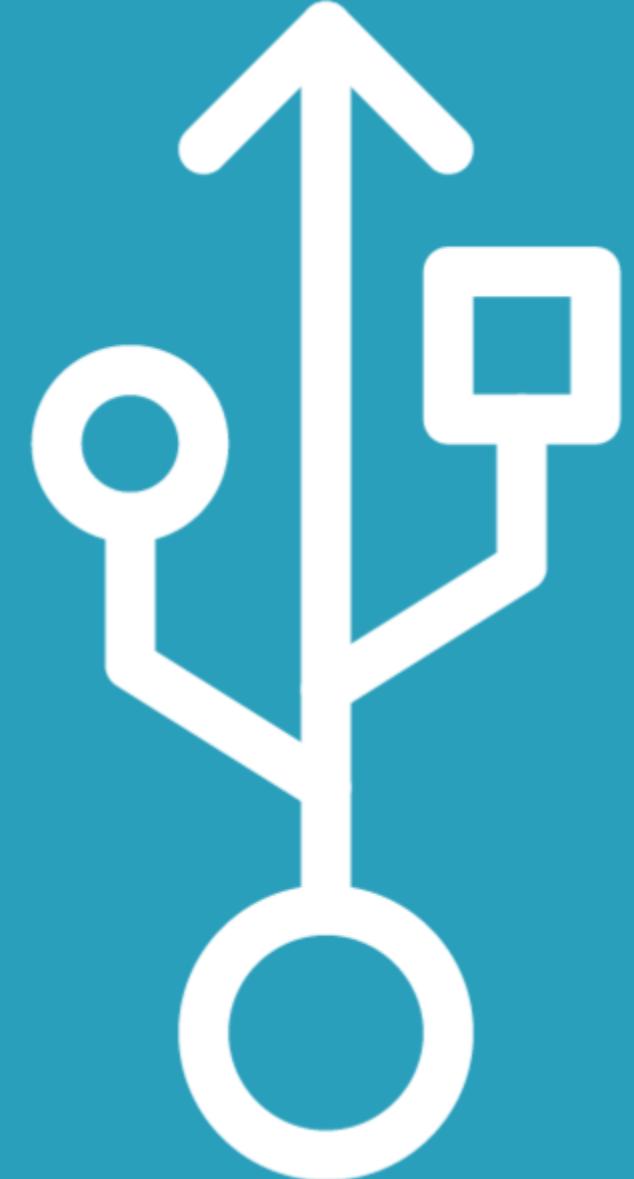
Each port connects to a single internal drive.

Alternatively you may purchase a PCIe storage adapter for added functionality or performance.



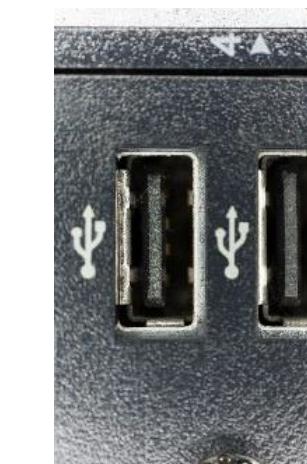
**SATA will be  
discussed in the  
next module**

**This course**  
Storage module

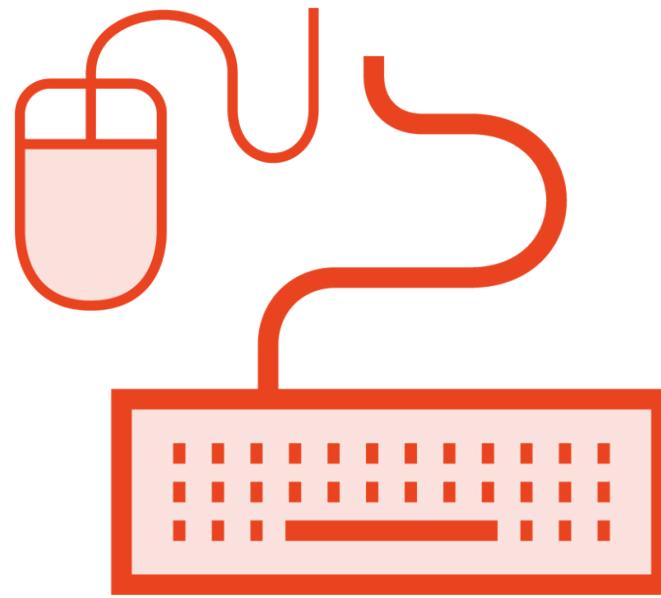


USB  
Universal Serial Bus

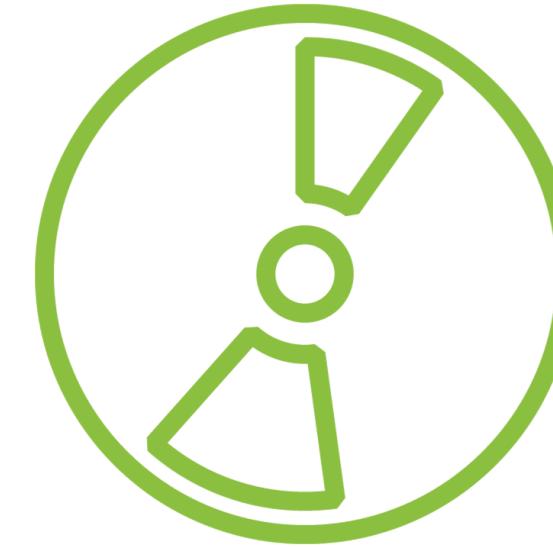
# Visual Anchor



# Common Uses for USB on Servers



**Keyboard / Mouse**



**External CD-ROM /  
DVD drives**

- Especially in blade servers



**External hard drives**

- For loading of data, for example:
  - Restoring archived data
  - Loading a new customer's initial data

# USB Standards (1.0 to 4.0)

Version	Speed	Alternate Names	USB Type A Port Color	Notes
1.x	12 Mb/s	--	Black	1.1 was first widely used version
2.0	480 Mb/s	--	Black	<p>Other features added:</p> <ul style="list-style-type: none"><li>• USB On-The-Go: allows 2 USB devices to talk without a host</li><li>• Battery charging</li></ul>
3.0	5.0 Gb/s	USB 3.2 Gen 1 SuperSpeed 5 Gbps	Blue	First full duplex USB standard
3.1	10 Gb/s	USB 3.2 Gen 2 SuperSpeed 10 Gbps	Teal	Same speed as 1 <sup>st</sup> generation Thunderbolt
3.2	20 Gb/s	USB 3.2 Gen 2x2 SuperSpeed 20 Gbps	Red	New naming scheme introduced Available only for USB-C connectors
4.0	40 Gb/s	USB4 (no space)	N/A	Based on and compatible with Thunderbolt 3 Available only for USB-C connectors

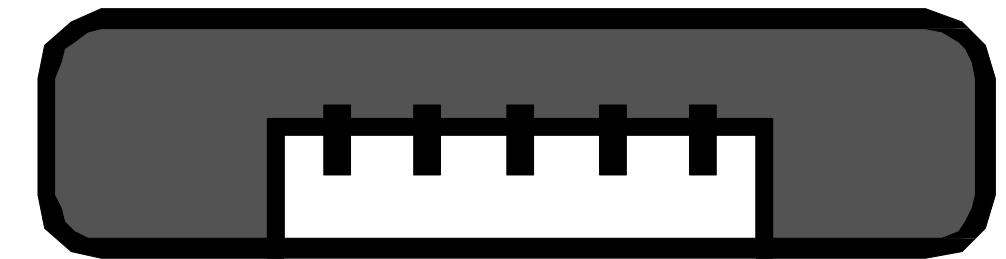
# USB Connector Types



Standard A



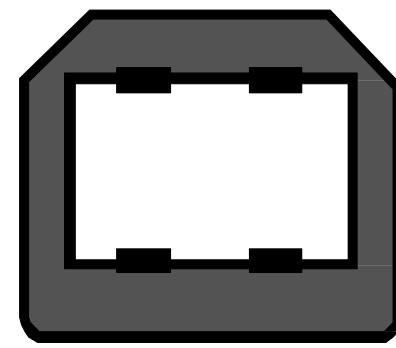
Mini-A



Micro-A

Not drawn to scale

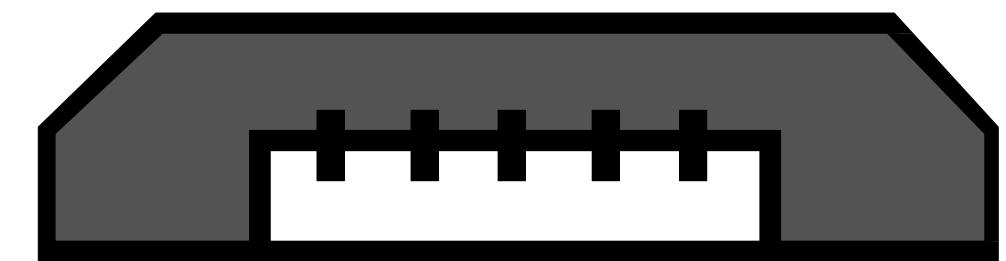
# USB Connector Types



**Standard B**



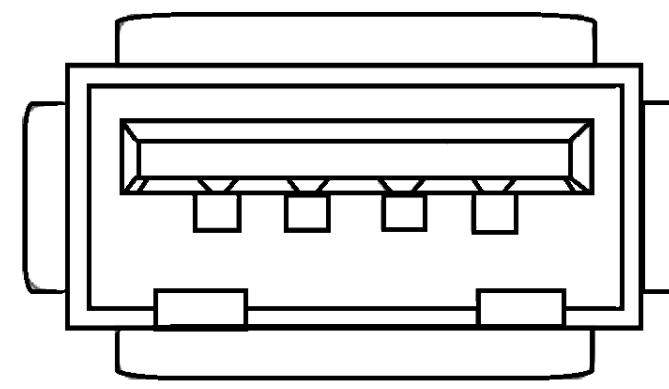
**Mini-B**



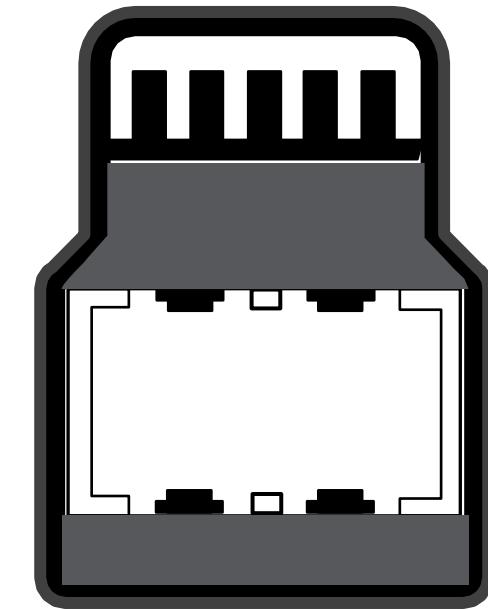
**Micro-B**

Not drawn to scale

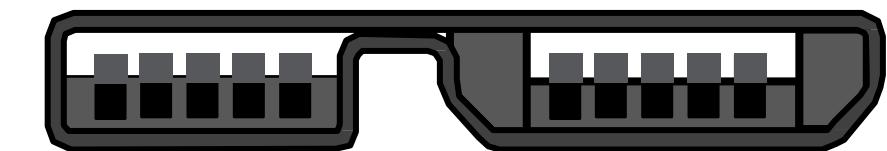
# USB Connector Types



**USB 3.0 Type A**



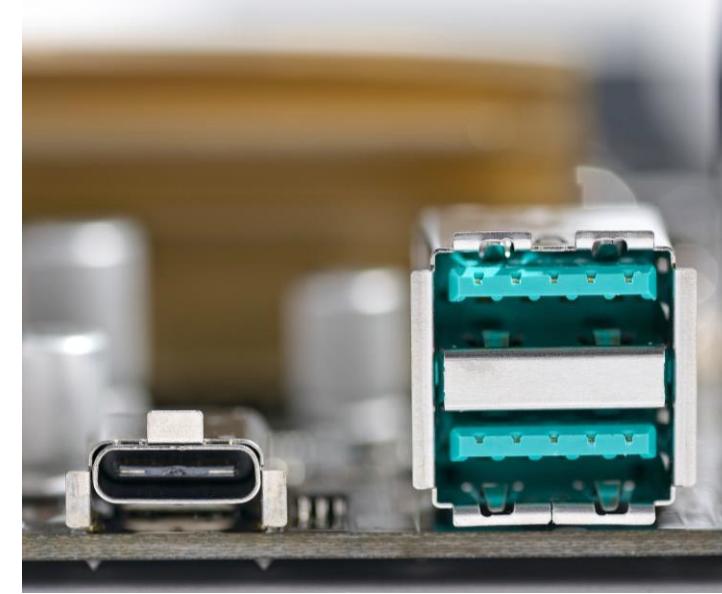
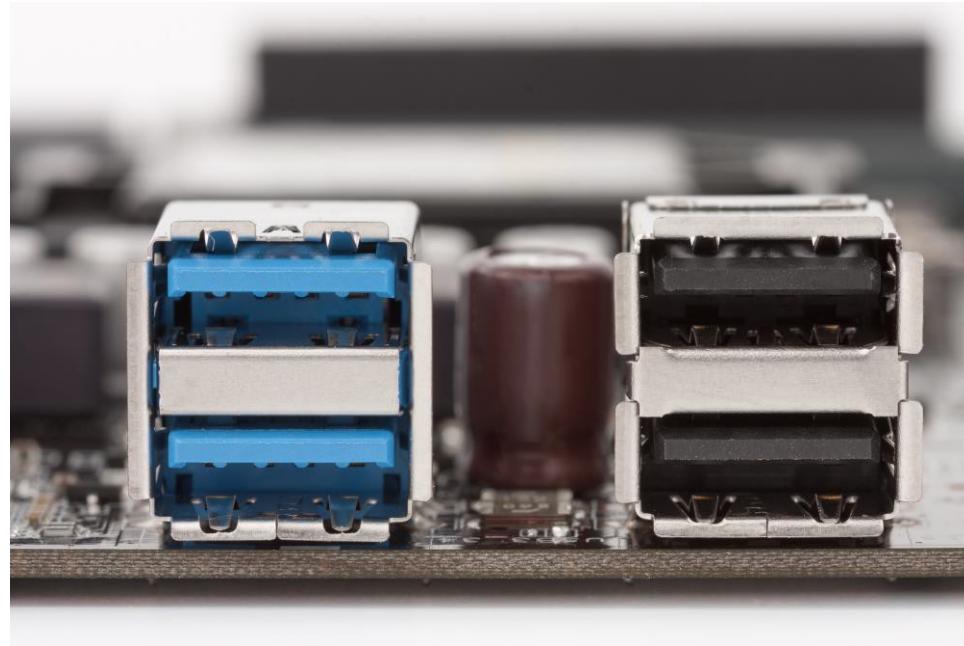
**USB 3.0 Type B**



**USB 3.0 Micro-B**

Not drawn to scale

# USB Color Coding



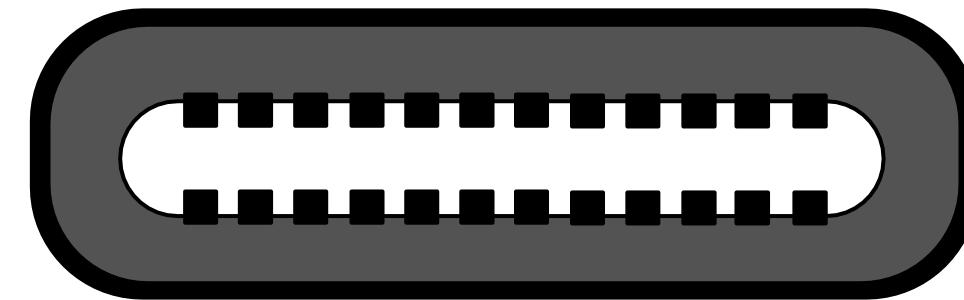
Typically, USB 3.x ports and cables use colored connectors

USB 3 is **BLUE**

USB 3.1 is **TEAL**

USB 3.2 is **RED**

# USB Connector Types

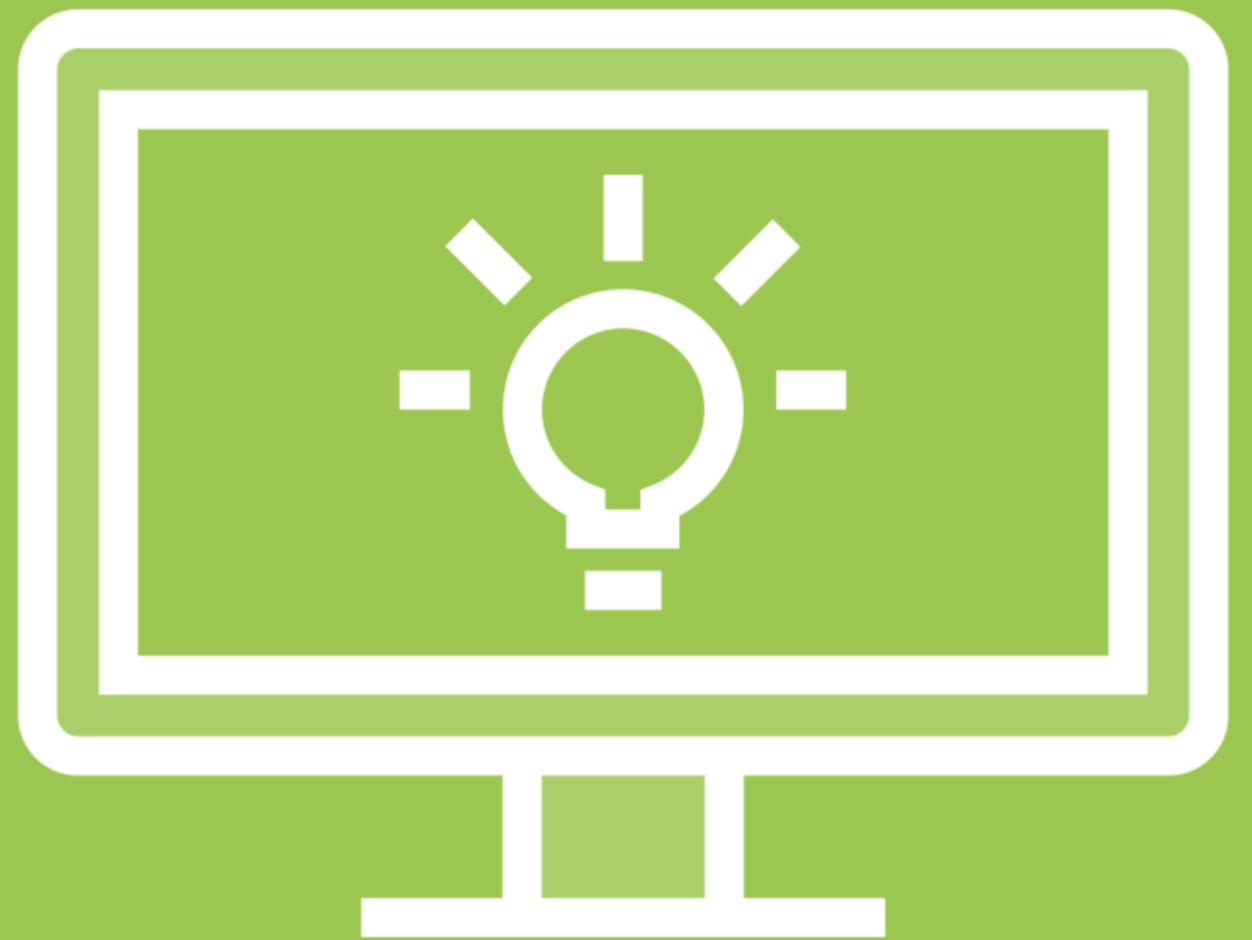


Type C

**Important!**

A USB-C connector doesn't automatically mean the port is capable of 10, 20, or 40 Gbps

Not drawn to scale



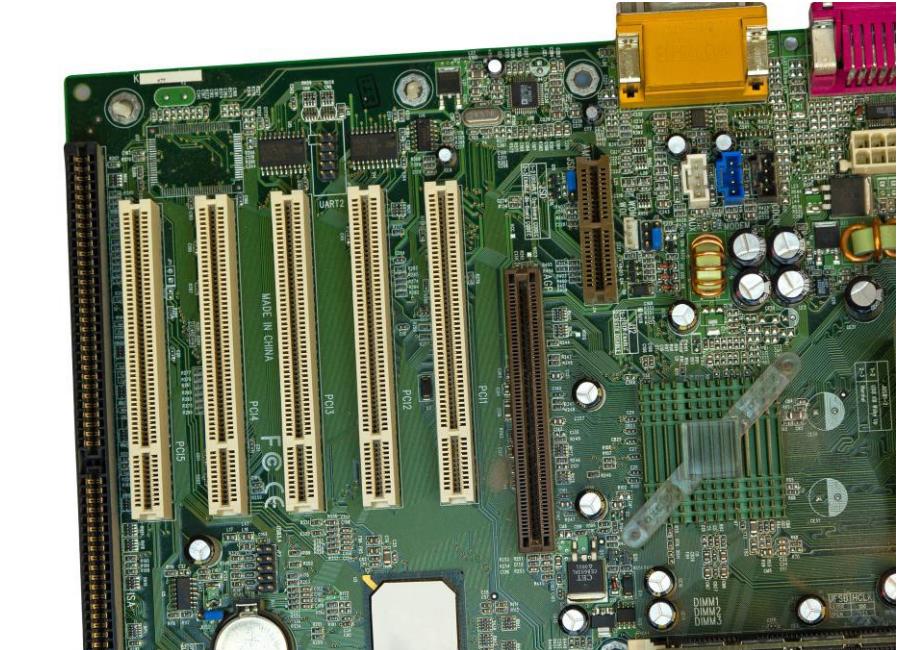
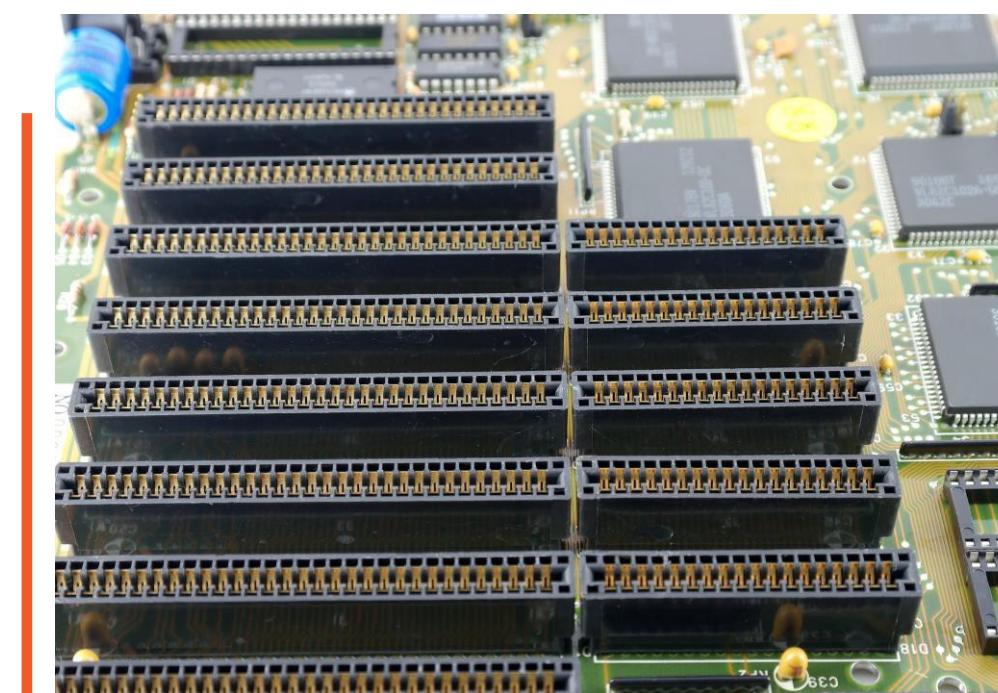
Tech Point  
The Bus

# Take the Bus!!

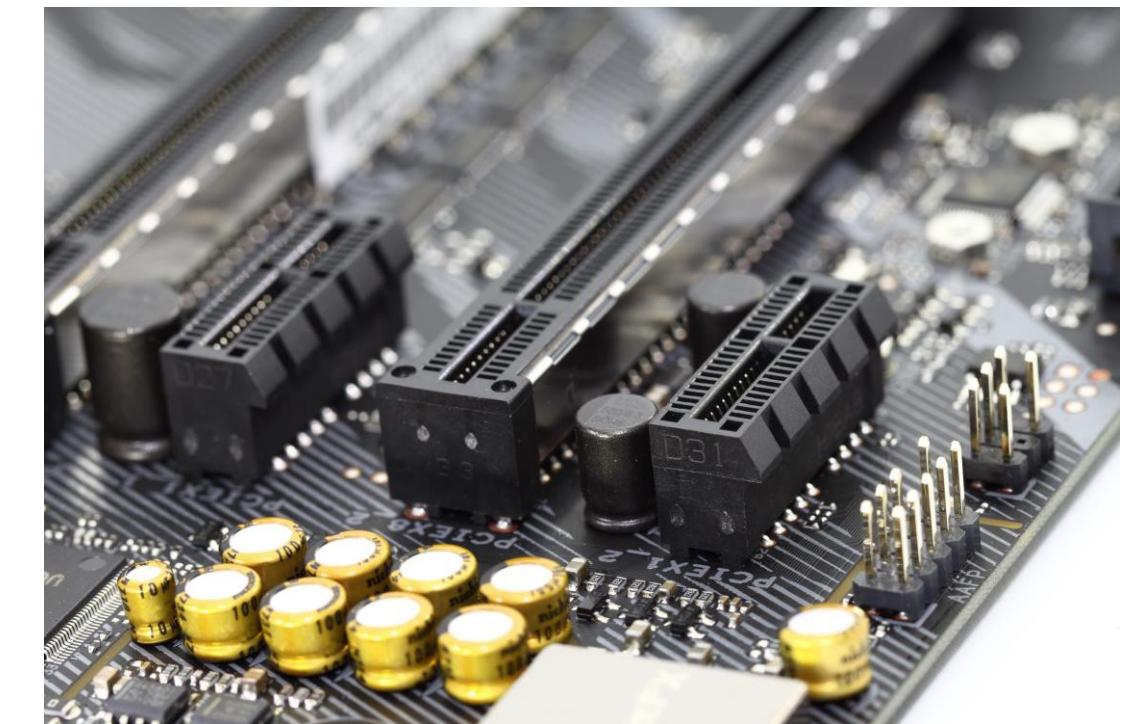
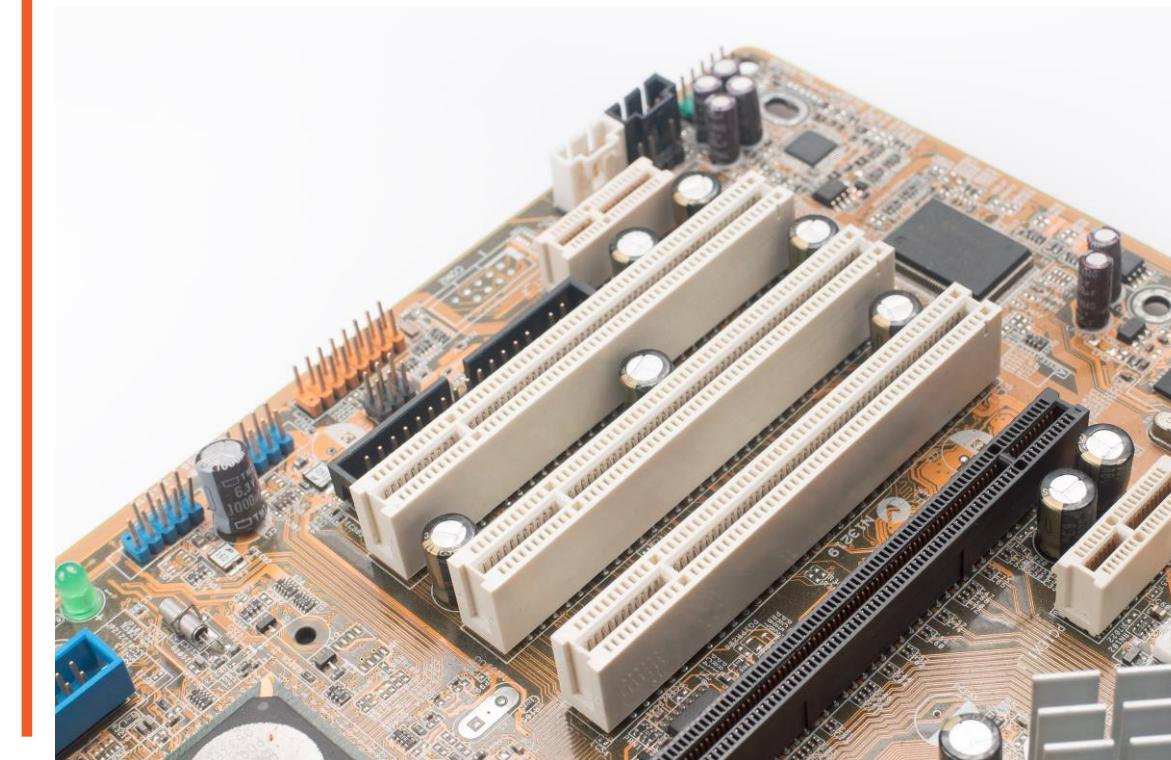


# Everything in a Server Talks on a Bus

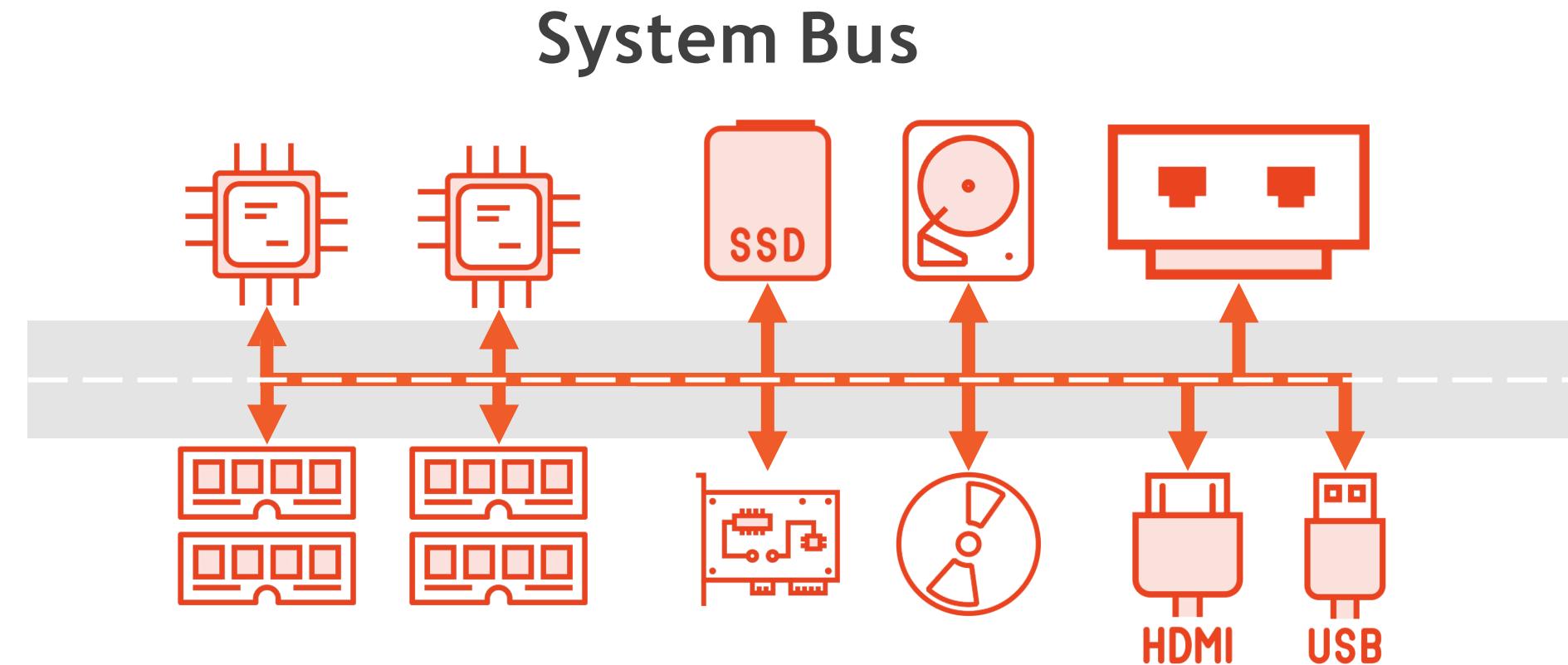
Think of a bus as the wiring that ties all the components together



As components evolved, so did the bus architectures



# The Original System Bus



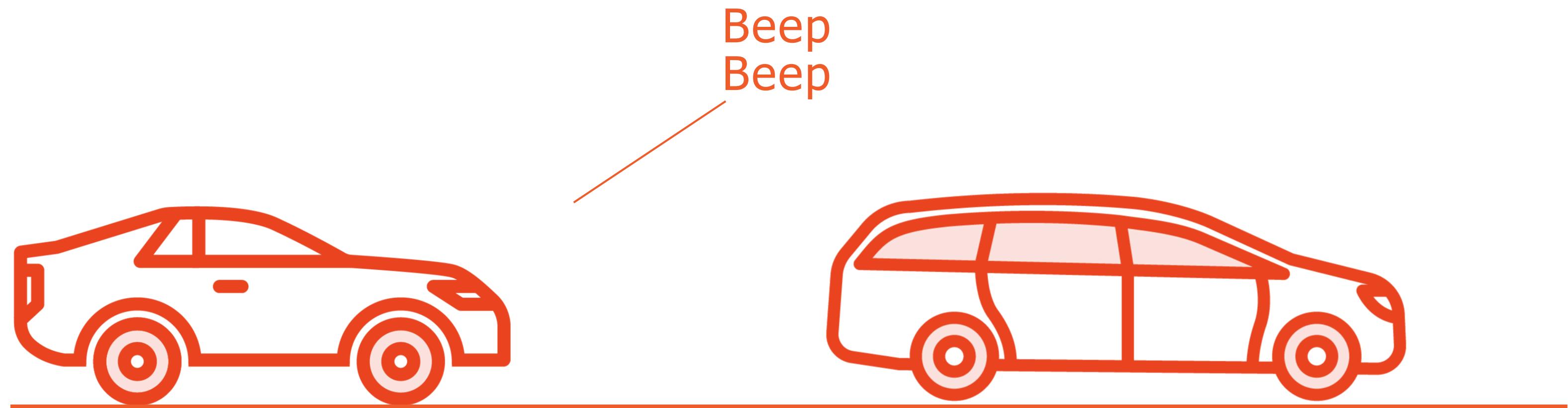
A bus is like a single lane street.

Traffic jams could happen.

# Lane Contention

**Everyone moves along the same one-lane road**

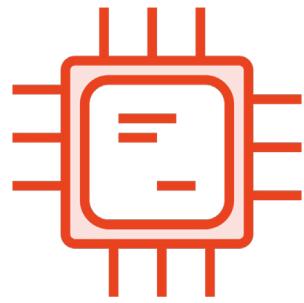
**The slowest vehicle (device) sets the speed for everyone**



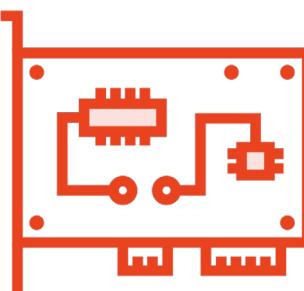
# Solution: Split the Bus!



Vendors split the bus into two parts: Internal and External



The Internal bus was dedicated to the CPU and RAM

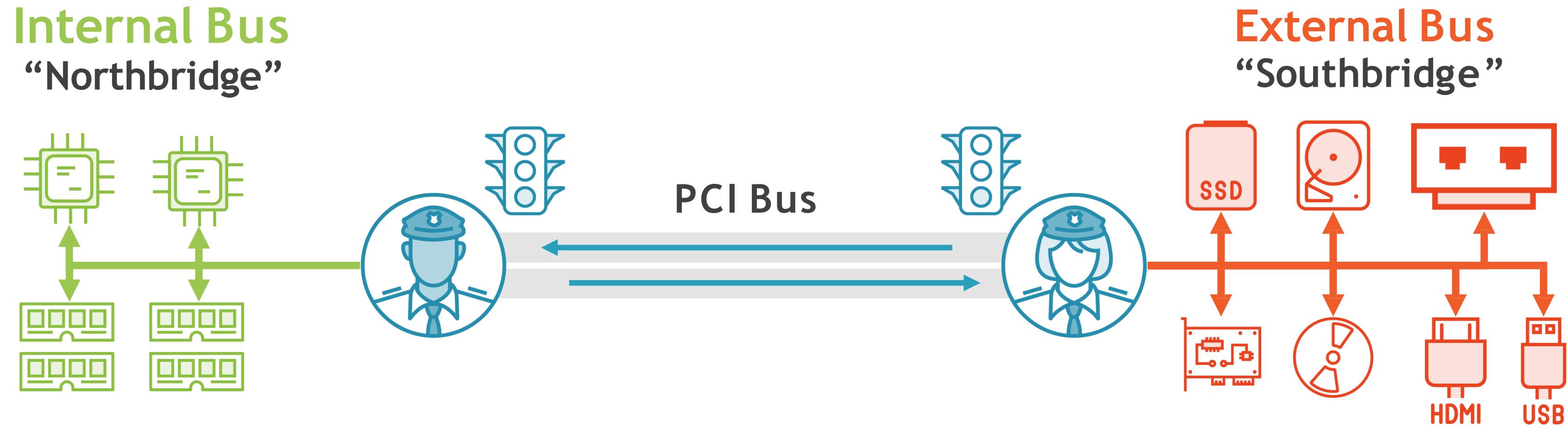


The external bus supported all other devices



This separation allowed the CPU and RAM to operate at their own speeds, unimpacted by the slower peripherals on the external bus

# Introducing the Traffic Cops: The Chipsets!



The chipsets control the data flow on the PCI bus

Chipsets have evolved significantly over time,  
allowing for different types of system buses.

# Splitting the Bus

The Northbridge side handles the data on the bus connecting the CPU and RAM.



The Southbridge side handles all the peripherals.



# Internal Busses

Connect CPU to memory

Connect other internal components

Separate and distinct from external bus or busses

Also called Front-Side-Bus (FSB) or system bus

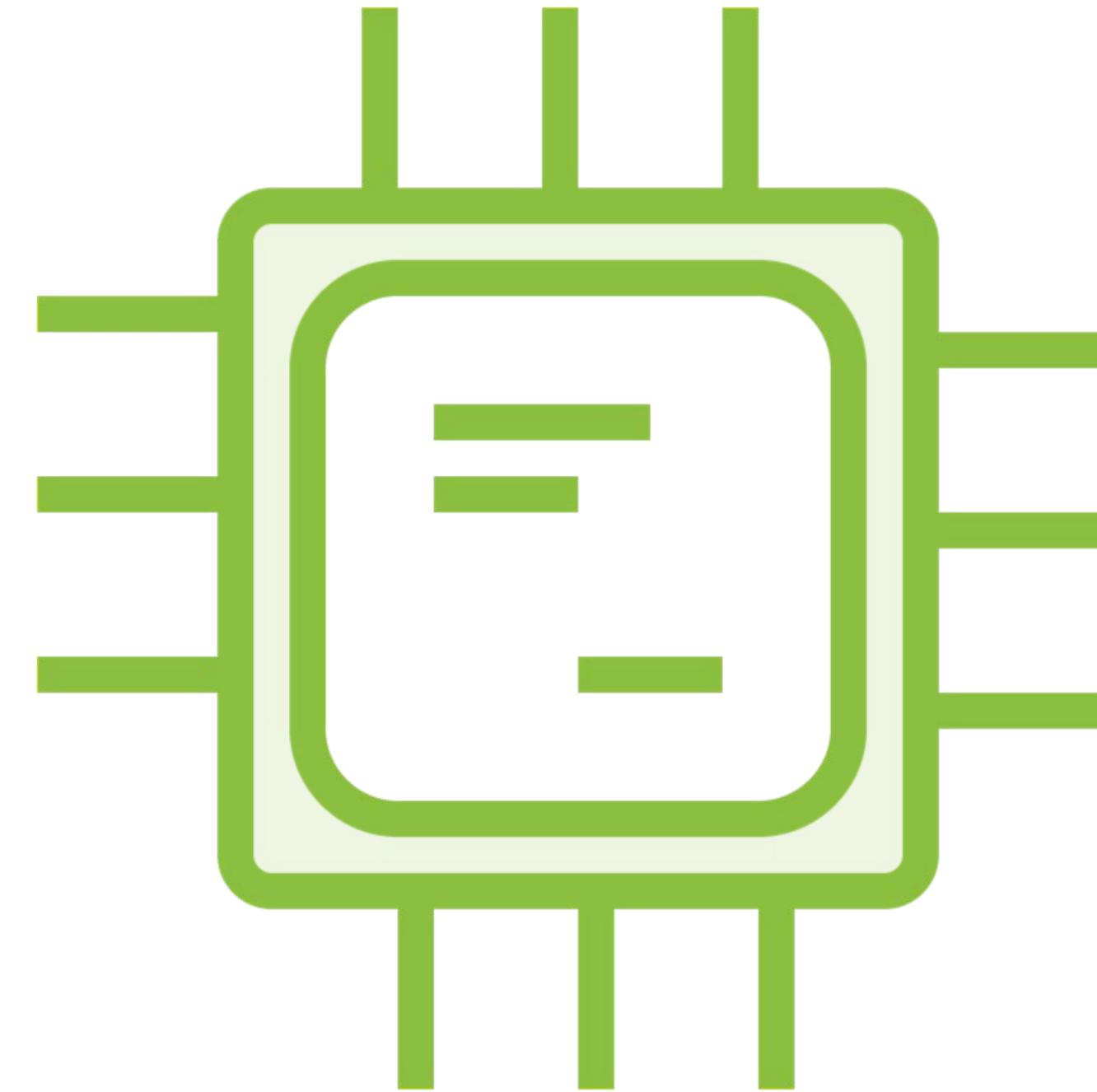
# External Busses

Connect all  
external  
components to the  
system

Examples include  
USB, SATA, and  
cards in expansion  
slots

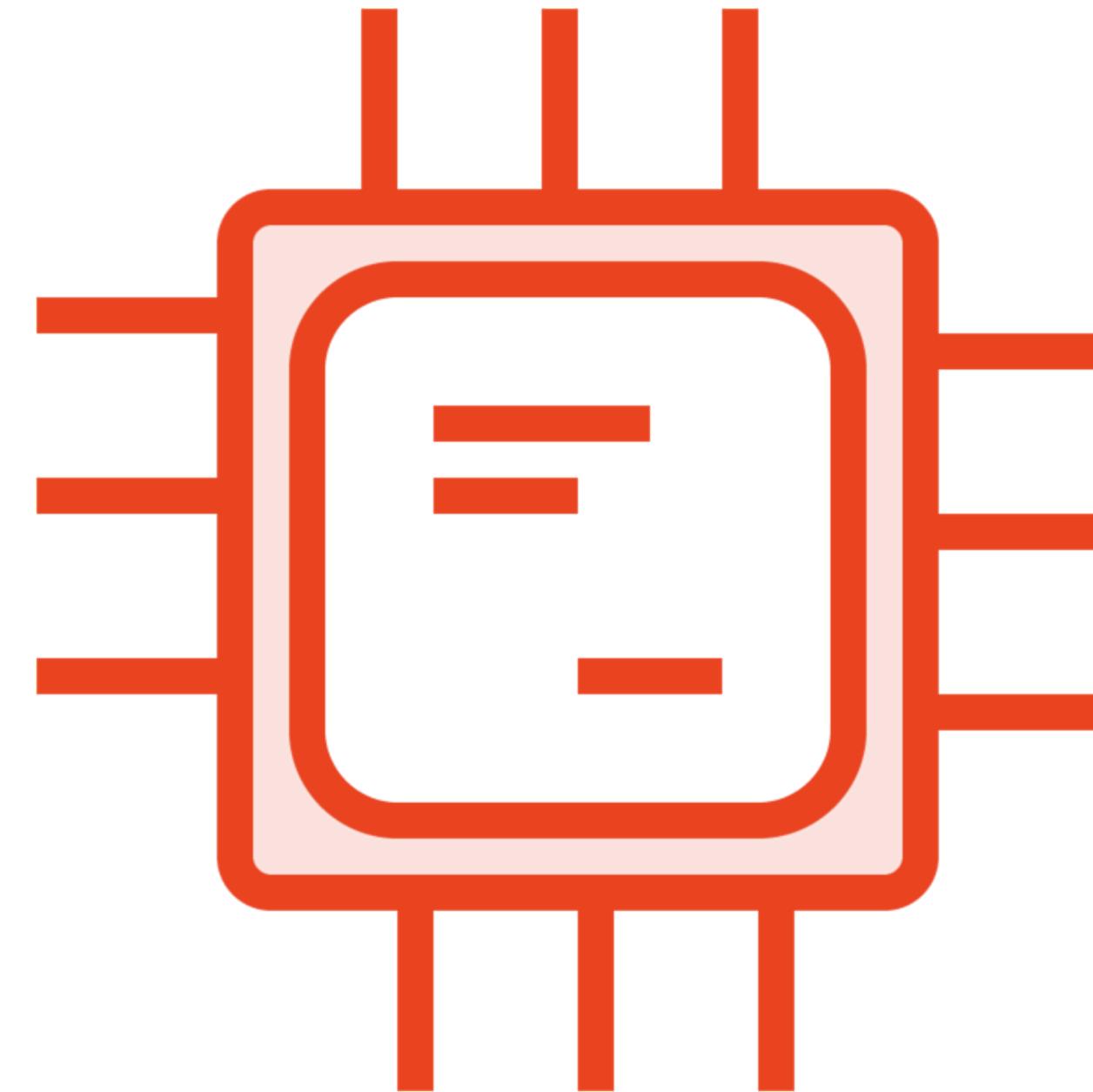
Also called the  
expansion bus

# Internal Bus Today



Now the Internal Bus is incorporated in the CPU

# External Bus Today



The External Bus remains separate and has different names depending on the manufacturer.



Hindsight

