

# Server Management: Server Hardware Installation and Management

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Server Concepts

# Server Concepts

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# Overview



**Getting Started with Servers**

**Server Form Factors**

**Knowing What to Buy**

**CPUs**

**Memory**

**System Board Considerations**

**Server Maintenance**

**Module Summary**

# Getting Started with Servers

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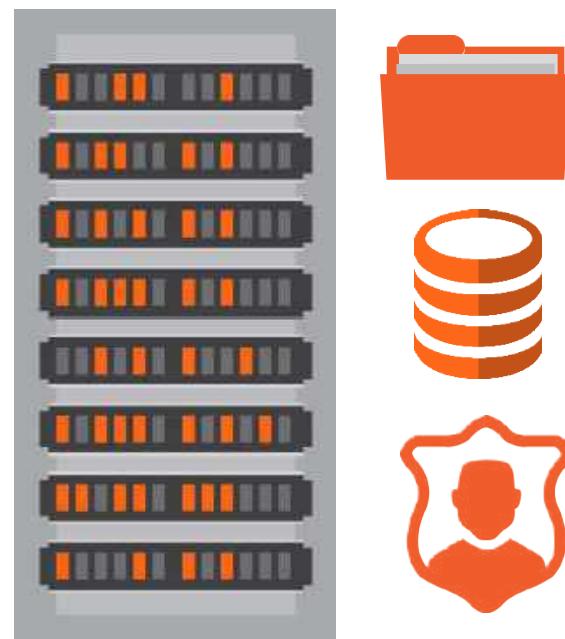


# Storyline

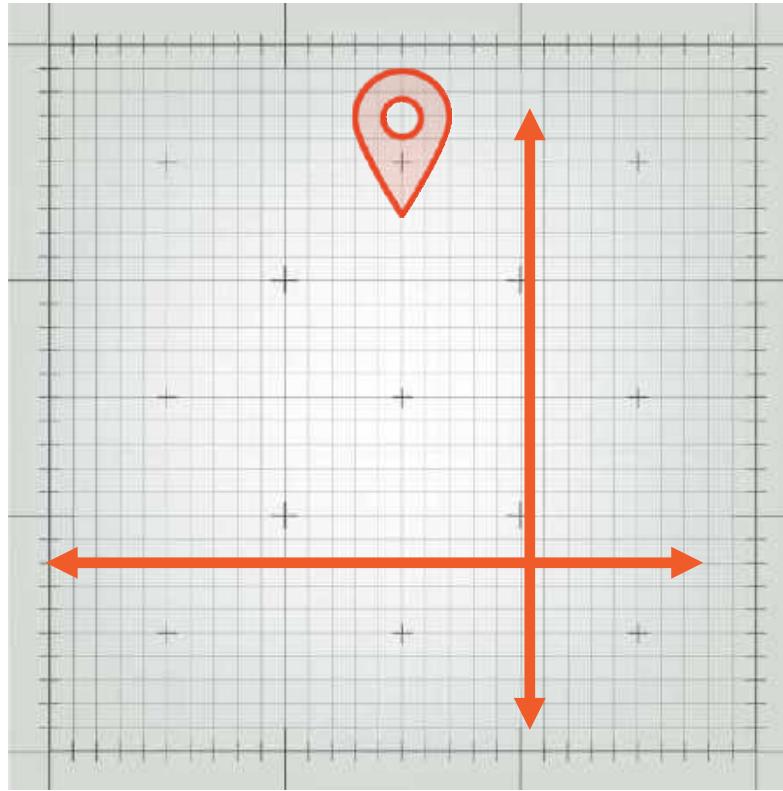
# GLOBOMANTICS

Globomantics is purchasing a new application to help run their business.

They don't have a server for the application today, but they wish to buy one.



# What Do You Need to Know?



Where will it be located?

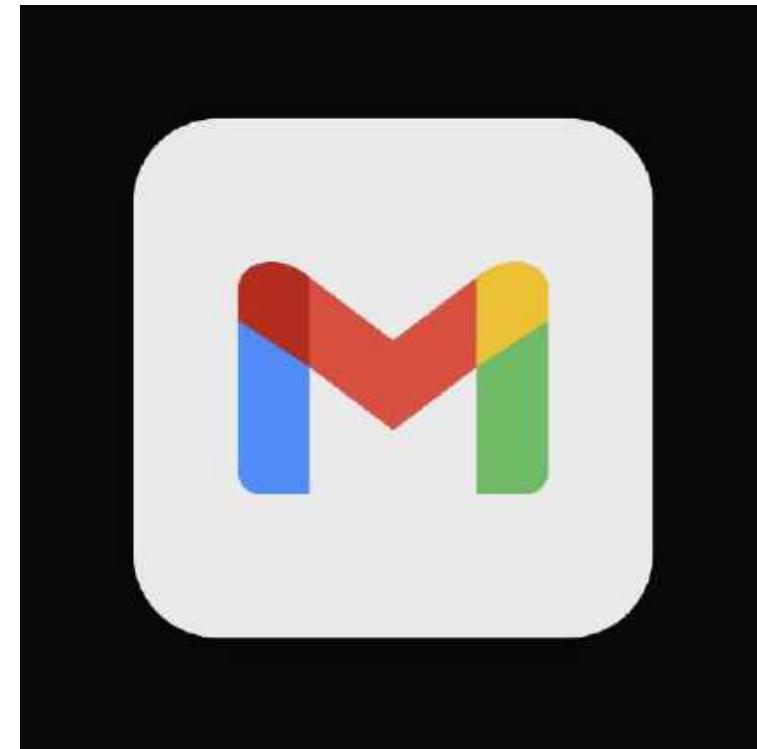


What job will the server perform?



Tech Point  
What is a  
Server?

# Servers – What They Do, and Where We Keep Them?

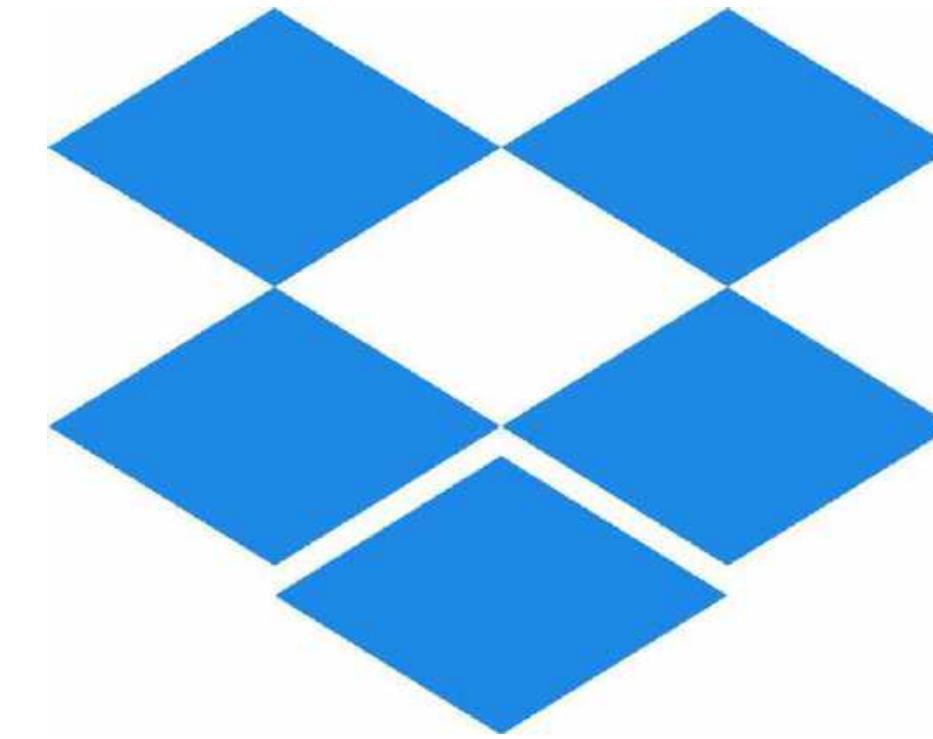


Email



PLURALSIGHT

Web



Data storage

# Public or Private



## Public Servers (Consumers)

Internet-based services

Gmail

Pluralsight

DropBox



## Private Servers (Corporate)

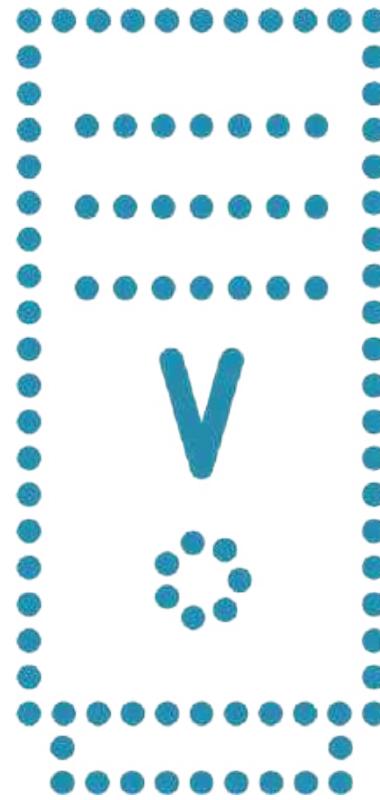
Corporate Services

Email

Intranet / Applications

Home directory

# Virtual or Physical



## Virtual Servers

a.k.a. Virtual Machines (VMs)

Private or Public Cloud Computing  
(See Course ### for more information)



## Physical Servers

a.k.a. bare metal servers

Physical servers may host VMs  
(This course focuses on physical servers)

# Critical Servers

## Myth

The biggest, most powerful server in the data center is the most critical server



## Reality

The server's function, and the importance of that function to the organization, defines the server's criticality



# Server Form Factors

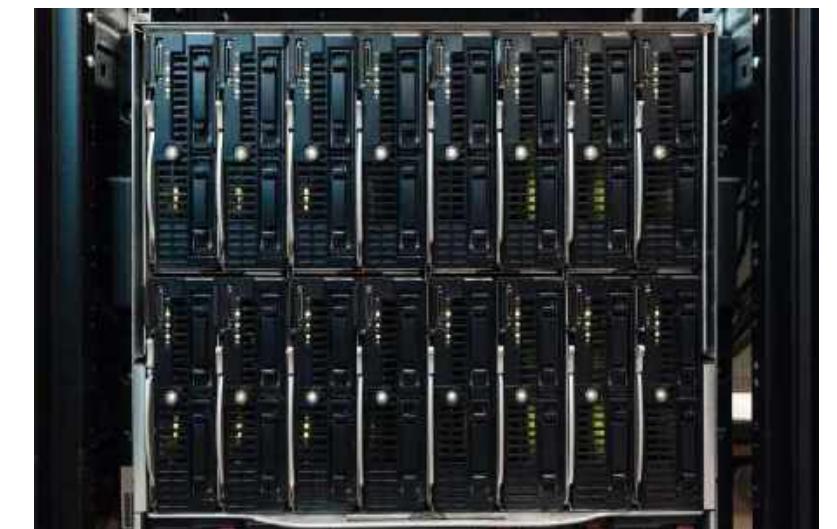
Tower



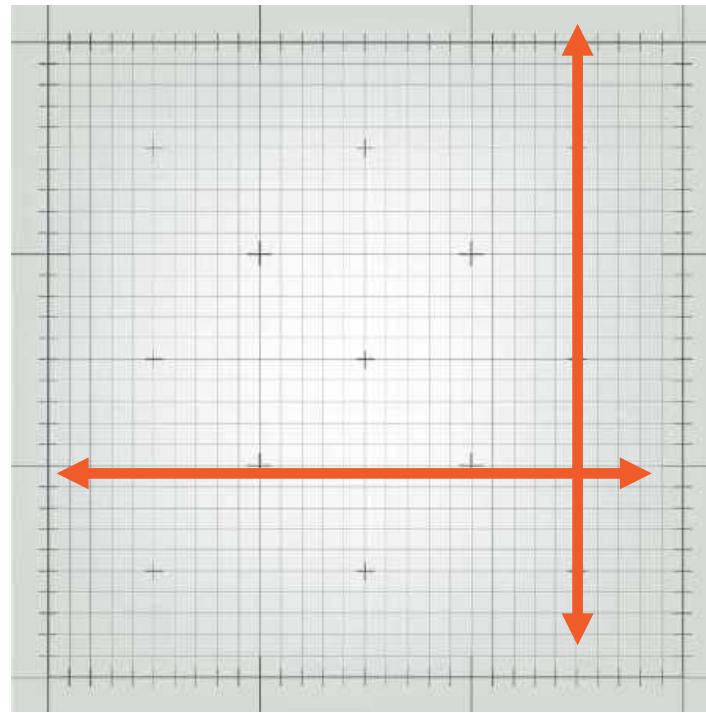
Rack Mount



Blade Technology



# Why Does the Form Factor Matter?

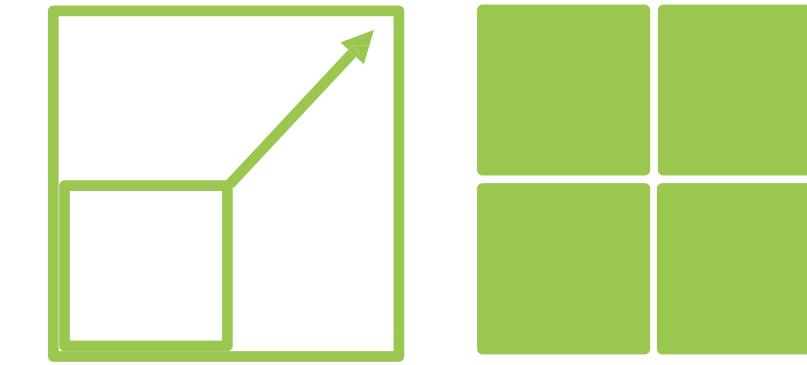


Physical size

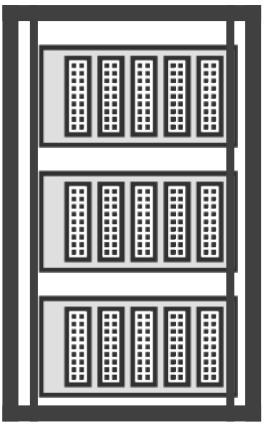


**120V**  
**208V**  
**240V**

Power input  
type



Expansion vs.  
density



Free-standing  
vs. fixed  
mounted

# Server Form Factors

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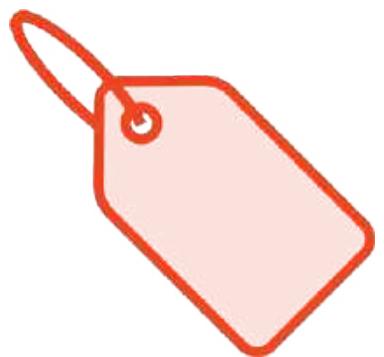


# Storyline

# Globomantics' Needs



The server will be used to host their new line of business software and will serve as file storage for the five office employees



They don't plan to purchase more servers this year



They work in a small office building



**They work in a small office building, and they only intend to purchase one server.**



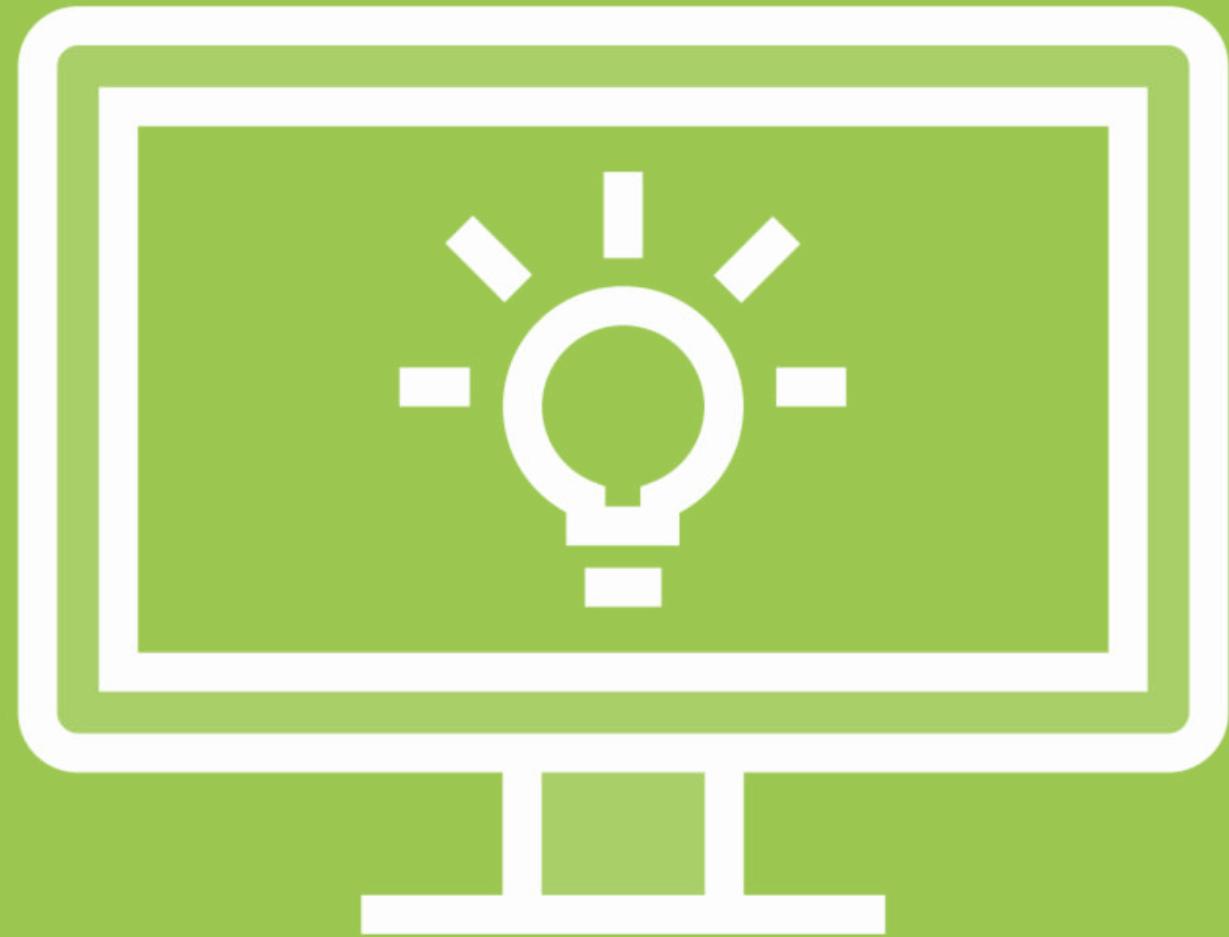
**They don't have a dedicated server room, but want to secure the server**



**The tower form factor suits their needs best.**

**Well-ventilated, locked room**

**Now, let's learn about the choices**



Tech Point  
Tower Form  
Factor



# Tower Form Factor

## Servers That Stand Alone

# Characteristics



- Free-standing vertical computer
- Often rectangular, but shape can vary
- Requires no special mounting hardware
- Removable ‘feet’ keep the server off the ground
- Typically serviced via a removable side panel

# Use Cases



**Small Office / Home Office (SOHO)**

**Small Computer Rooms**

**Specialty, purpose-built servers**

- **Manufacturing Floors**
- **Telecommunications / Voice Mail**

# Tower Form Factor

## Advantages

Portability

Racks are not required

Standard utility power (120V / 240V)

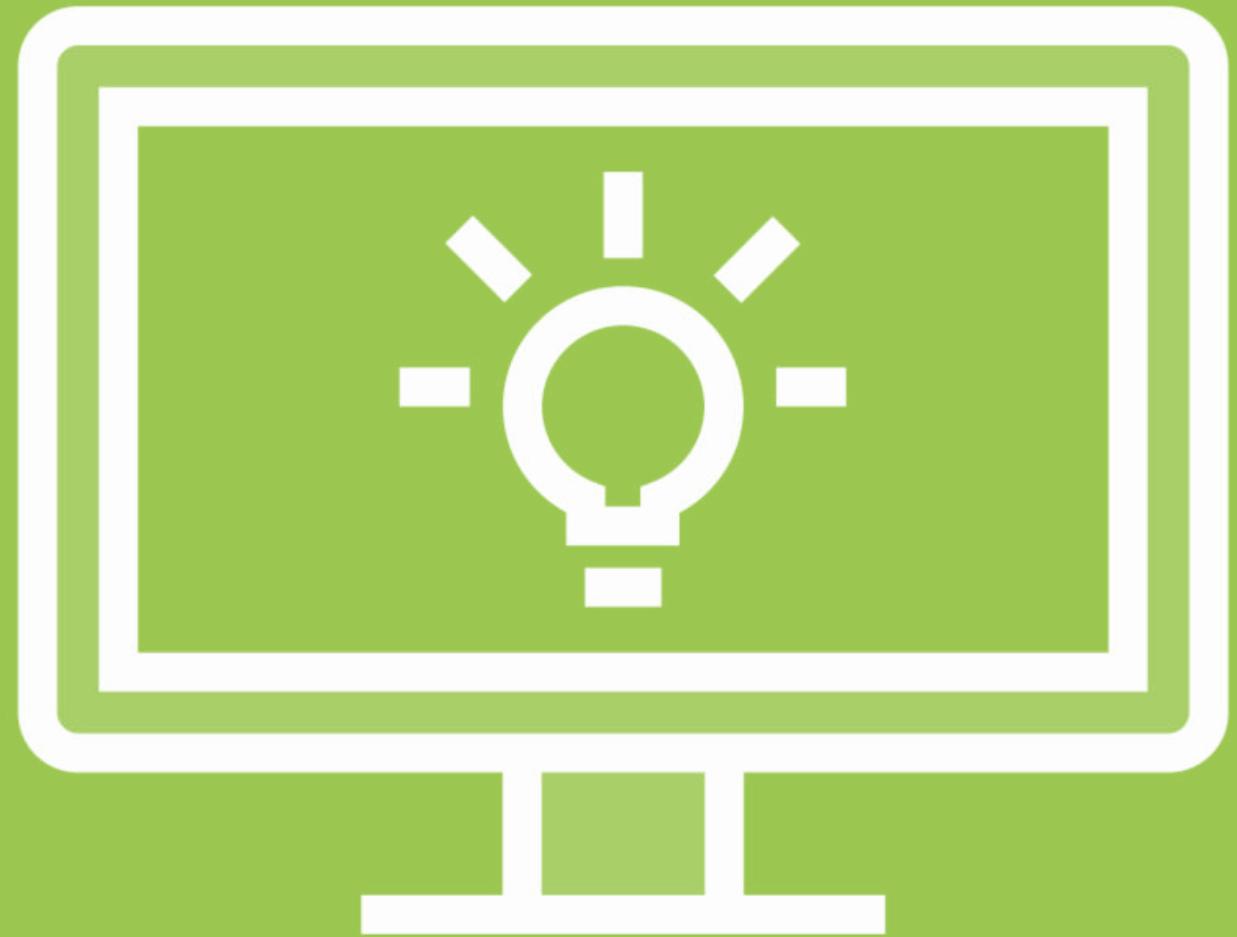
Expansion cards may be easily added

## Disadvantages

Bulky

Hard to stack

Cable mess



Tech Point  
Rack Mount  
Form Factor



## Rack Mount Form Factor

Allows You to Safely Stack  
Multiple Servers

# What Are Rack Mount Servers?



**Mounted in rack enclosures**

**Horizontal server with a special case for mounting hardware**

**NOT a tower on its side**

**Typically includes rails and cable management arms**



# Common Use Cases

**Rack mounted servers are the most common server form factor**



**Wiring Closet**

**Single-tenant Data Center**

**Multi-tenant Data Center**

# Rack Mount Form Factor

## Advantages

- Increased server density
- Optimized floor space
- Built-in cable management
- Lockable enclosures to protect cabling
- Standard utility power (120V / 240V)

## Disadvantages

- Requires a rack enclosure
- Special server mounting procedures
- Requires shelving for monitor and keyboard



Tech Point  
Blade  
Technology



# Blade Technology

A lot of servers in a small  
rack-mountable package

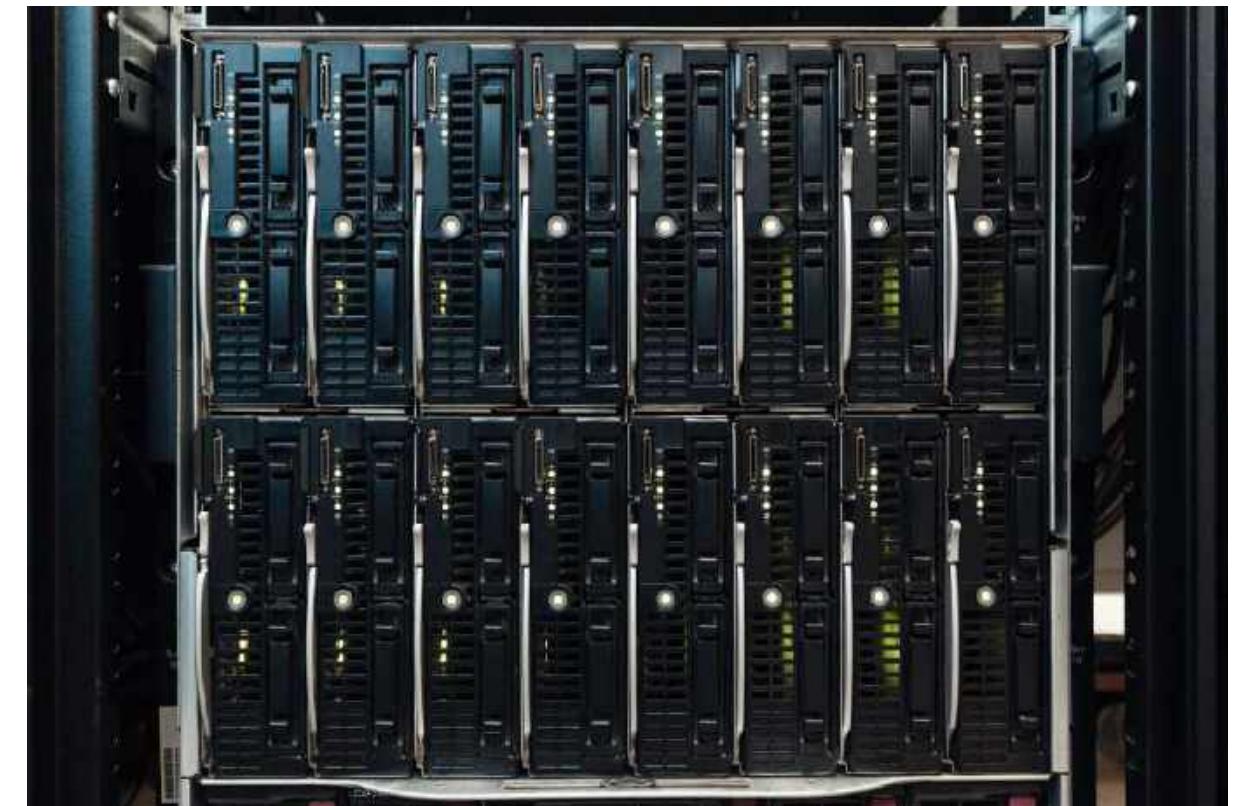
# What Is a Blade Server?

**High density servers**

**Very few (if any) moving parts on the blade**

**Blades plug into an enclosure with:**

- Power and cooling**
- Network switching**
- Storage connectivity**
- Secure management access**



# What Is a Blade Enclosure?

**Highly redundant  
enclosure for the  
blade servers**

**Supplies power and  
connectivity to all  
blades**

**Greatly reduces the  
amount of cables in  
a rack full of servers**

**Most serviceable  
components are  
hot-pluggable**

**Often requires high  
amperage power  
circuits**

# Blade Enclosure Anatomy

## Bays and slots

Back: Management and connectivity modules

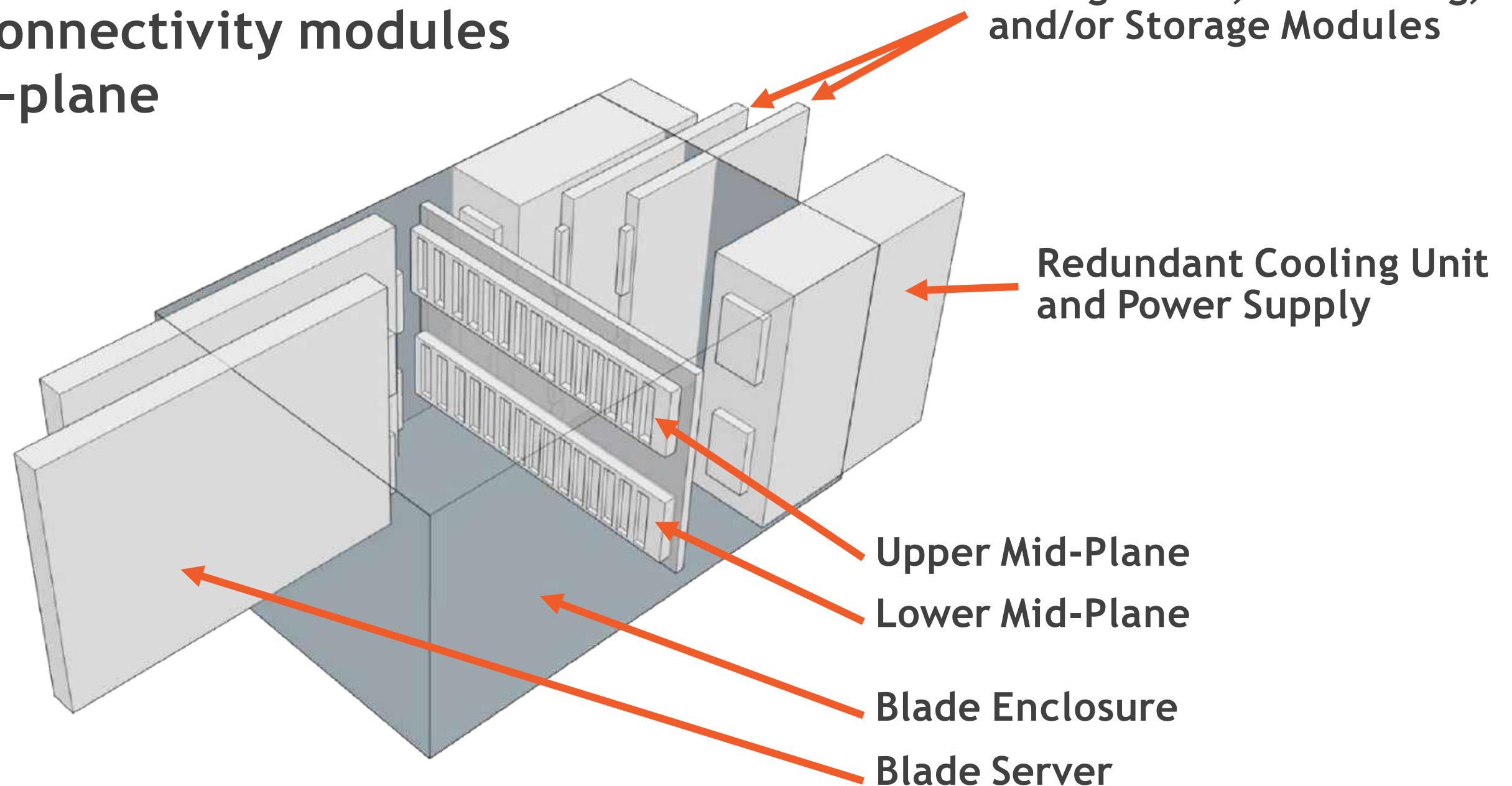
Inside: Mid-plane or Back-plane

Front: Server blade slots

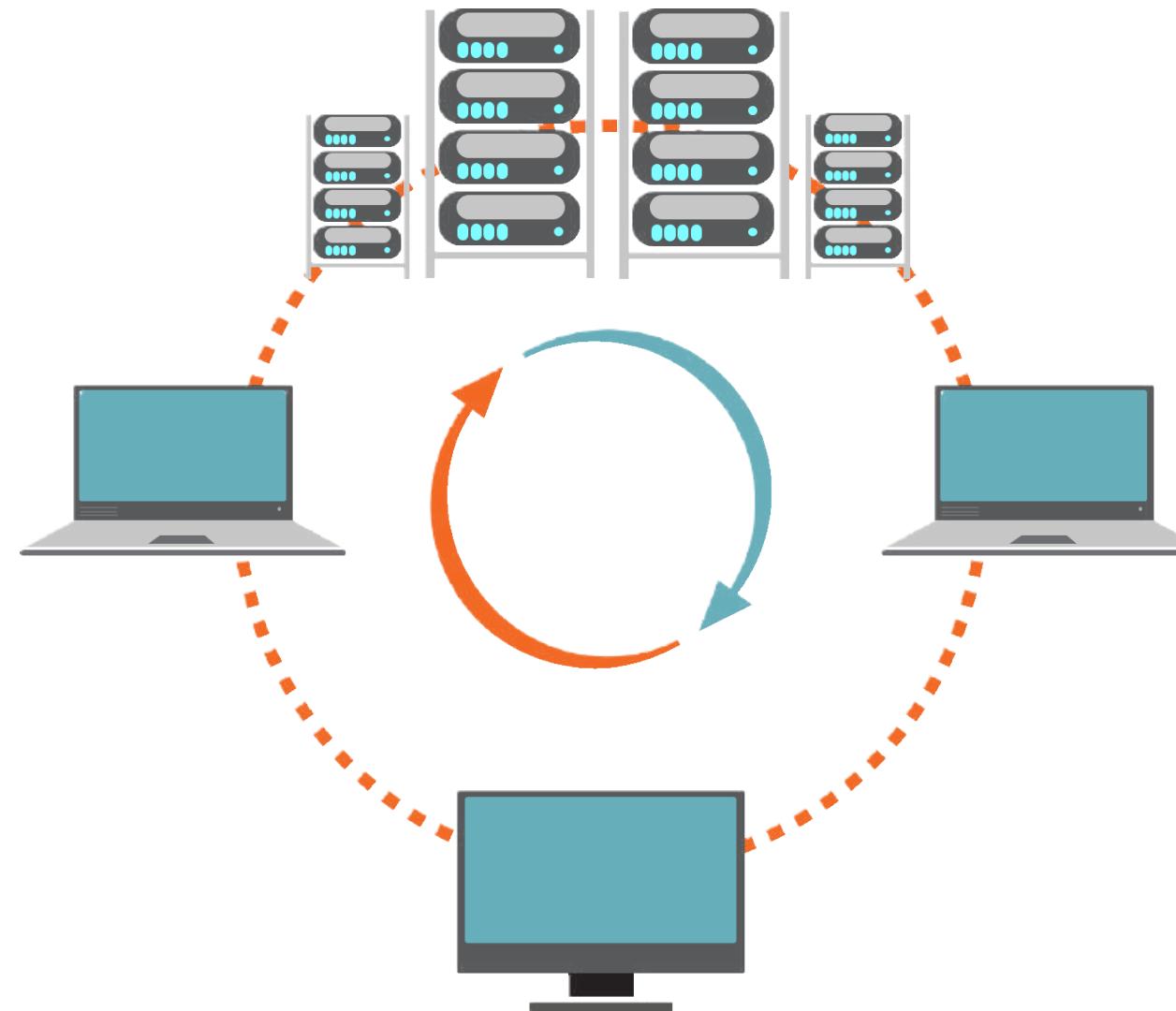
## Service Modules

Network / Storage  
Management

## Power/Cooling



# Managing a Blade



- Designed for 100% remote management
- Web browser to management module
- User security for blades and modules
- IPMI based KVM and power controls
- Remote DVD to install server OS



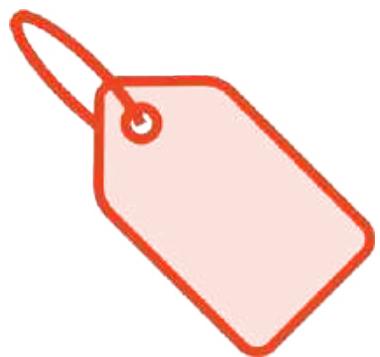
Hindsight



# Reviewing Globomantics' Needs



The server will be used to host their new line of business software and will serve as file storage for the five office employees



They don't plan to purchase more servers this year



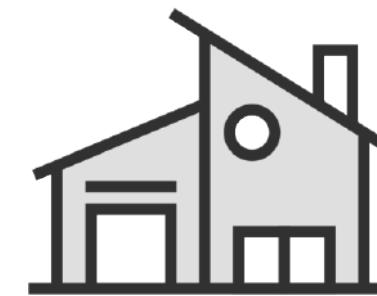
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They work in a small office building, and they only intend to purchase one server.



They don't have a dedicated server room, but want to secure the server



The tower form factor suits their needs best.

Well-ventilated, locked room

Now, let's learn why they made these choices



# Decision Points

# How Many Servers Do You Need?



Tower

Rack  
Mount

Blades

# Planning to Scale up or Out?

**Density**

**Scale Out**

**More servers per cubic foot / meter**



**Expandability**

**Scale Up**

**The ability to add more components to the server**



**Density**

**Expandability**

# Where Will the Server Be Located?



SOHO

- Tower



Wiring Closet



- Tower
- Rack Mount



Data Center



- Rack Mount
- Blade S

# Small Office Home Office (SOHO)



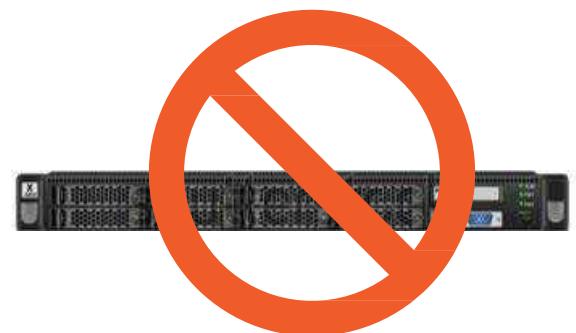
## Tower Servers

- Typically only one server is needed per office



## Not Blades because

- Typical small / home offices do not meet the necessary power / cooling requirements



## Not Racks because

- Typical small / home offices do not have the floor space for a rack of servers

# Wiring Closets



## Rack Mount Servers

- For all servers
- Reduces cable management



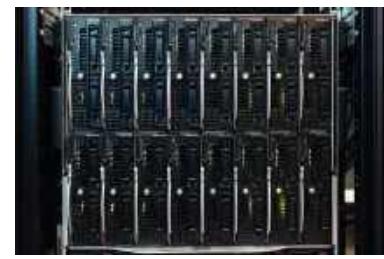
## Tower Servers

- For specialty servers or areas where racks will not fit
- Towers are bulky and present cable management challenges

## Not Blades because

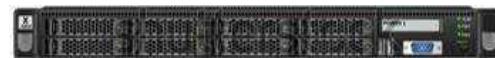
- They only need a few servers, and don't require the high density
- With only a few servers, the ROI of blades may be negative

# Data Center



## Blade Technology

- For hypervisors (hosting virtual machines)
- Greatly simplifies the server cabling requirements



## Rack servers

- For servers that will later need hardware upgrades



**Not Tower because cable management is a major concern**



# Knowing What to Buy

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# Storyline



We know we need a tower form factor server.

How do we determine the rest of the hardware?

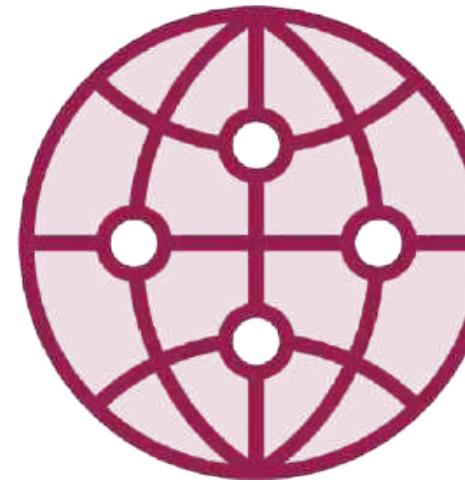


# Reality Check – Business Requirements Lead to Technical Specs

# Business Needs: Buy New Servers



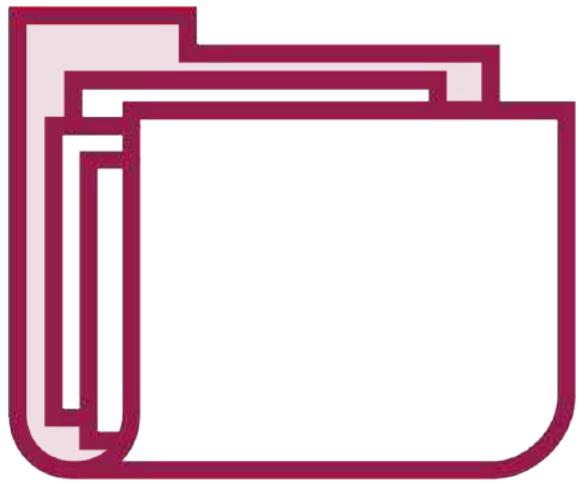
Email



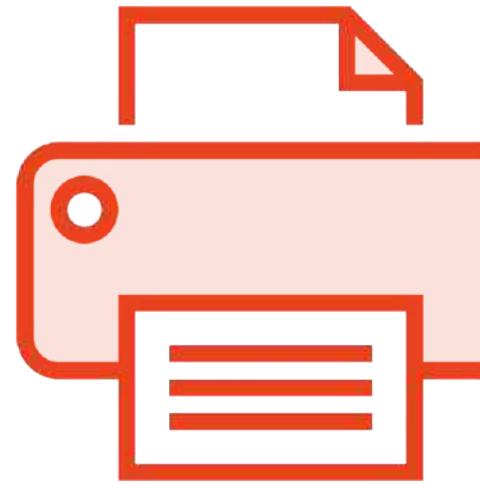
Web



SQL



File

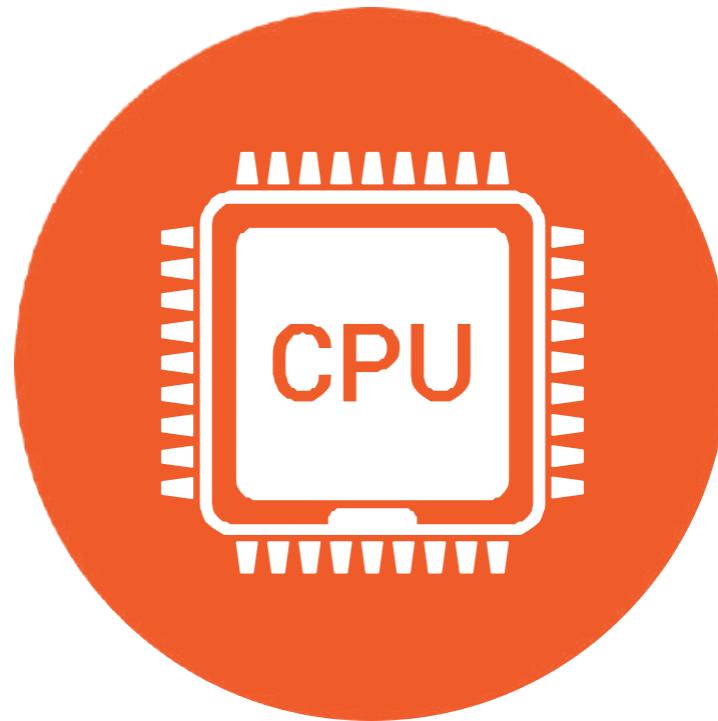


Printing

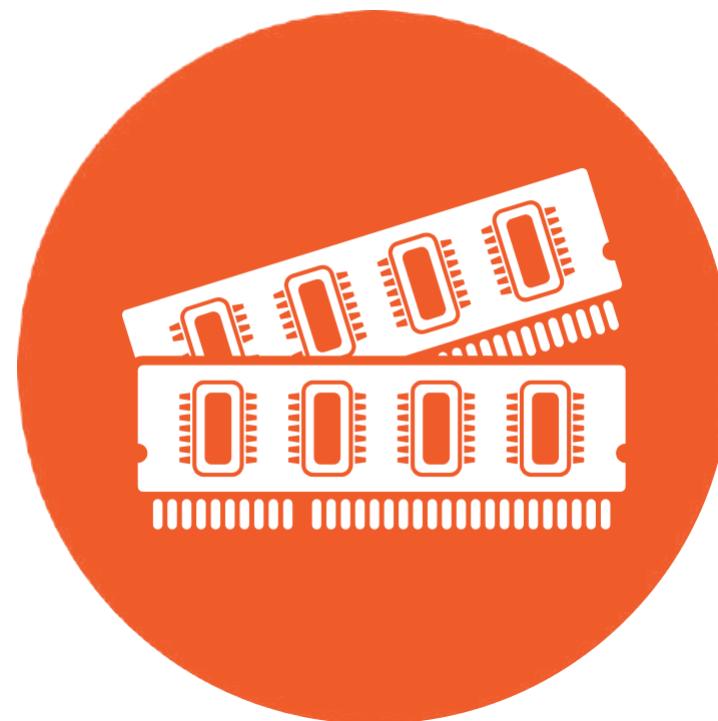


Authentication

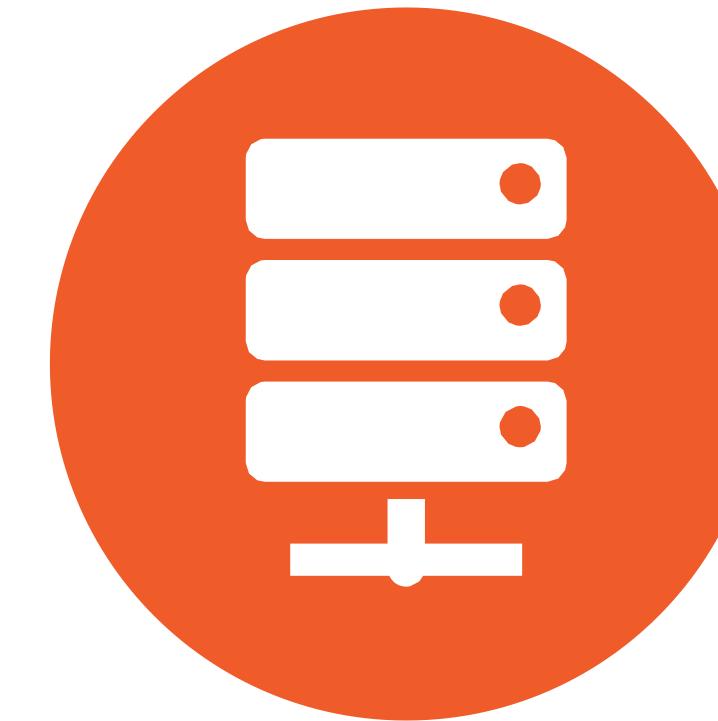
# Resource Food Groups



CPU



Memory



Network

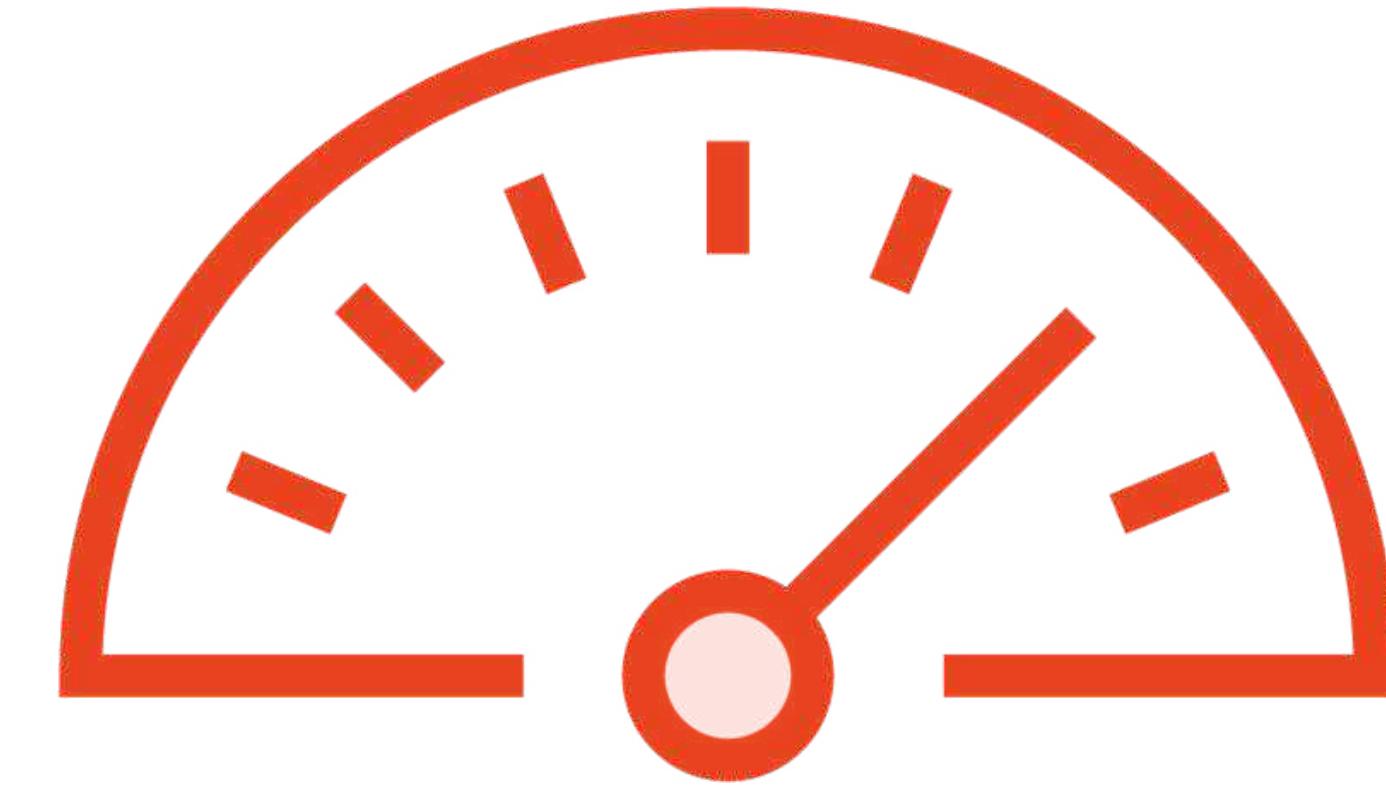


Storage

# Where Do We Start?



**Hardware requirements**  
**Minimum specs**  
**Recommended specs**



**Reliability and performance**  
**How much downtime is acceptable?**  
**How slow is “too slow”?**

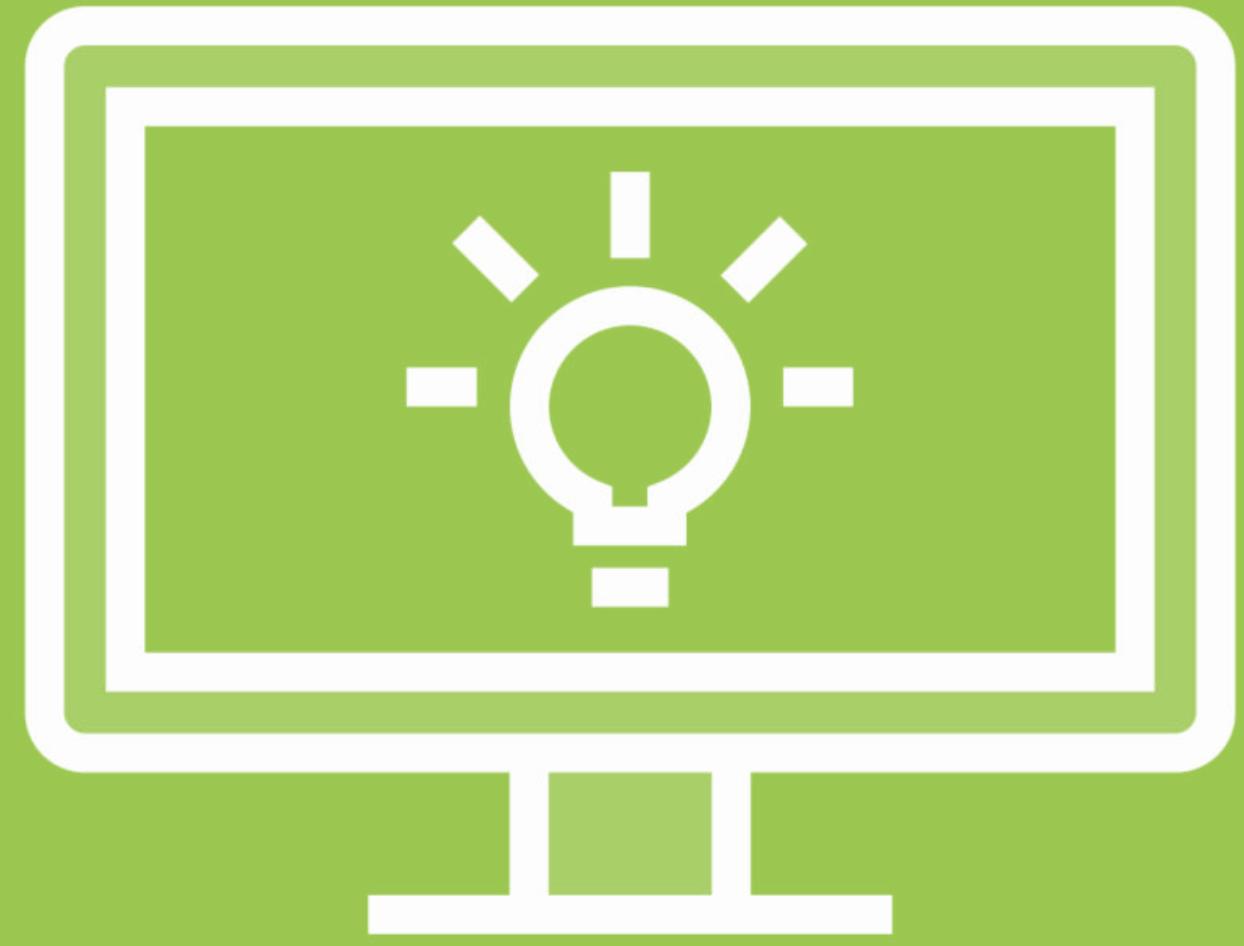
# What Else Do We Need to Know?



Do they expect vendor support?

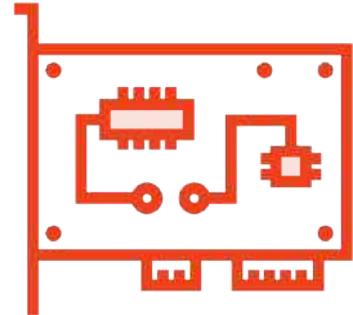


Does the software have a  
Hardware Compatibility List  
(HCL)?

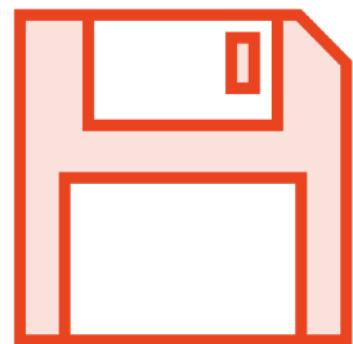


# Tech Point Hardware Compatibility List (HCL)

# What Is a Hardware Compatibility List (HCL)



The list of specific hardware devices the software vendor has tested and approved



May include specific firmware levels of hardware as well



Vendors typically maintain an HCL for each software version they support

## VMware Compatibility Guide

Search Compatibility Guide:  (e.g. compatibility or esxi or 3.0) All Listings Search

What are you looking for: CPU Series Compatibility Guides Help Current Results: 57

Product Release Version: All CPU Series: Enhanced vMotion Capability Modes: Fault Tolerant Compatible Sets:

All	All	All	All
ESXi 7.0 U2	AMD EPYC 7001 Series	AMD Opteron™ Generation 1	AMD Bulldozer Generation
ESXi 7.0 U1	AMD EPYC 7002/7Fx2/7Hx2 Series	AMD Opteron™ Generation 2	AMD Opteron™ Generation 3
ESXi 7.0	AMD Opteron 7003 Series	AMD Opteron™ Generation 3 without 3DN	AMD Piledriver Generation
ESXi 6.7 U3	AMD Opteron 13xx Series	AMD Opteron™ Generation 4	Intel® Haswell Generation
ESXi 6.7 U2	AMD Opteron 23xx Series	AMD Opteron Generation	Intel® Ivy-Bridge Generation
ESXi 6.7 U1	AMD Opteron 24xx Series	AMD Steamroller Generation	Intel® Nehalem Generation
ESXi 6.7	AMD Opteron 3200 Series	AMD Zen™ Generation	Intel® Penryn Generation
ESXi 6.5 U3	AMD Opteron 3300 Series	AMD Zen2™ Generation	Intel® Sandy Bridge Generation
ESXi 6.5 U2	AMD Opteron 41xx Series	AMD Zen3™ Generation	Intel® Westmere Generation
ESXi 6.5 U1	AMD Opteron 4200 Series	Intel® Broadwell Generation	Only With Itself
ESXi 6.5	AMD Opteron 4300 Series	Intel® Cascadelake Generation	
ESXi 6.5 U3	AMD Opteron 61xx Series	Intel® Haswell Generation	
ESXi 6.5 U2	AMD Opteron 6200 Series	Intel® Ivy-Bridge Generation	

Update and View Results CPU/MVM Matrix Reset

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Search Results: Your search for "CPU Series" returned 57 results. Back to Top Turn Off Auto Scroll

CPU Series	Cores/Threads	CPUID Info	CPUIDs	Supported Releases
AMD EPYC 7001 Series	32c/64t	17.01	0x00800F10	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD EPYC 7002/7Fx2/7Hx2 Series	64c/128t	17.31	0x00830F10	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.5 U3
AMD Opteron 3200 Series	4c/8t	15.01	0x00600F10	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD Opteron 3300 Series	6c/12t	15.02	0x00800F20	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD Opteron 4200 Series	4c/8t	15.01	0x00800F10	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD Opteron 4300 Series	6c/12t	15.02	0x00800F20	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD Opteron 6200 Series	8c/16t	15.01	0x00600F10	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
AMD Opteron 6300 Series	8c/16t	15.02	0x00600F20	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
Intel Atom C2700 Series	8c/8t	6.4D 6.37	0x00030670 0x000406D0	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U3 <input checked="" type="checkbox"/> 6.7 U2
Intel Atom C3000 Series	16c/16t	6.5F	0x000506F0	ESXi <input checked="" type="checkbox"/> 7.0 U2 <input checked="" type="checkbox"/> 7.0 U1 <input checked="" type="checkbox"/> 7.0 <input checked="" type="checkbox"/> 6.7 U2 <input checked="" type="checkbox"/> 6.7 U1

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# How Does This Differ from Hardware Requirements?



**Hardware Compatibility List**  
**“The Menu”**

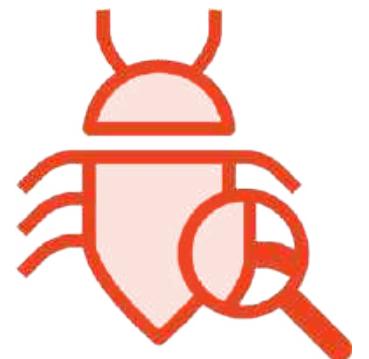


**Hardware Requirements**  
**“A Shopping List”**

# What Is the Purpose of an HCL?



You can feel confident that your hardware has been tested and confirmed to be stable with the vendor's application



The vendor can rule out hardware compatibility issues, making support easier



Some software vendors will not provide support if you do not follow the HCL

# Example: HCL for VMware ESXi v.7.0

## VMware Compatibility Guide

Search Compatibility Guide: ? (e.g. compatibility or esx or 3.0) All Listings Search

What are you looking for: CPU Series

Product Release Version: All ESXi 7.0 U2 ESXi 7.0 U1 ESXi 7.0 ESXi 6.7 U3 ESXi 6.7 U2 ESXi 6.7 U1 ESXi 6.7 ESXi 6.5 U3

CPU Capabilities: Supports SMP-FT Capable of Legacy FT ALL CPUs

CPU Series: All AMD EPYC 7001 Series AMD EPYC 7002/7Fx2/7Hx2 Series AMD EPYC 7003 Series AMD Opteron 13xx Series AMD Opteron 23xx Series AMD Opteron 24xx Series AMD Opteron 3200 Series AMD Opteron 3300 Series AMD Opteron 41xx Series AMD Opteron 4200 Series AMD Opteron 4300 Series AMD Opteron 61xx Series AMD Opteron 6200 Series

Enhanced vMotion Capability Modes: All AMD Opteron® Generation 1 AMD Opteron® Generation 2 AMD Opteron® Generation 3 AMD Opteron® Generation 3 without 3DN AMD Opteron® Generation 4 AMD Piledriver Generation AMD Steamroller Generation AMD Zen™ Generation Intel® Broadwell Generation Intel® CascadeLake Generation Intel® Haswell Generation Intel® Ivy-Bridge Generation

Fault Tolerant Compatible Sets: All AMD Bulldozer Generation AMD Opteron® Generation 3 AMD Piledriver Generation Intel® Haswell Generation Intel® Ivy-Bridge Generation Intel® Nehalem Generation Intel® Penny Lane Generation Intel® Sandy-Bridge Generation Intel® Westmere Generation Only With Itself

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AMD EPYC 7001 Series	32c/64t	17.01	0x00800F10	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD EPYC 7002/7Fx2/7Hx2 Series	64c/128t	17.31	0x00830F10	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.5 U3
AMD Opteron 3200 Series	4c/8t	15.01	0x00600F10	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD Opteron 3300 Series	8c/12t	15.02	0x00600F20	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD Opteron 4200 Series	4c/8t	15.01	0x00600F10	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD Opteron 4300 Series	8c/12t	15.02	0x00600F20	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD Opteron 6200 Series	8c/16t	15.01	0x00600F10	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
AMD Opteron 6300 Series	8c/16t	15.02	0x00600F20	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
Intel Atom C2700 Series	8c/8t	6.4D 6.37	0x00030670 0x000406D0	ESXi 7.0 U2 7.0 U1 7.0 6.7 U3 6.7 U2
Intel Atom C3000 Series	16c/16t	6.5F	0x000506F0	ESXi 7.0 U2 7.0 U1 7.0 6.7 U2 6.7 U1

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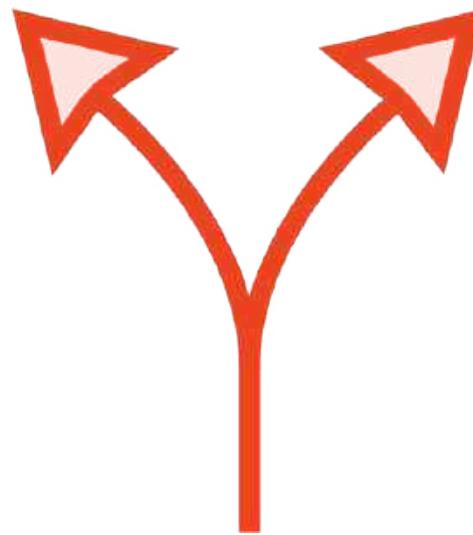
# Do I Have to Follow the HCL?

There are consequences of either choice



## Follow the HCL

The components listed on  
the HCL may be more  
expensive than the off the  
shelf variety.



## Choose your own Adventure

No Support from the  
vendor



Hindsight



# Reviewing Globomantics' Needs



The server will be used to host their new line of business software and will serve as file storage for the five office employees



They do need support from their software vendor



The vendor requires customers to follow their Hardware Compatibility List (HCL) to be eligible for support



**They need support from their  
software vendor**

**The vendor won't support them  
unless they follow the HCL**



**They will verify each of their  
server components is listed  
on the vendor's HCL**

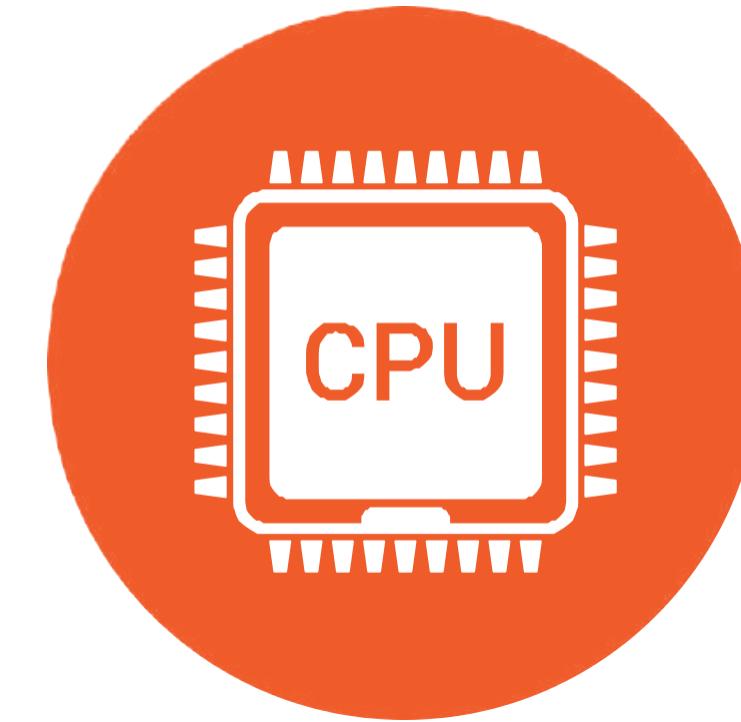
# CPUs

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# Storyline

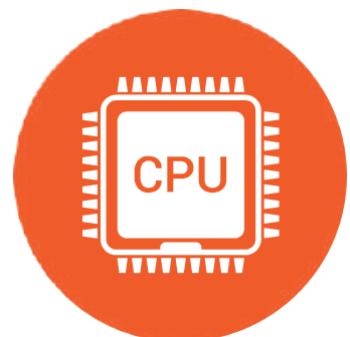
# What Do You Need to Know?



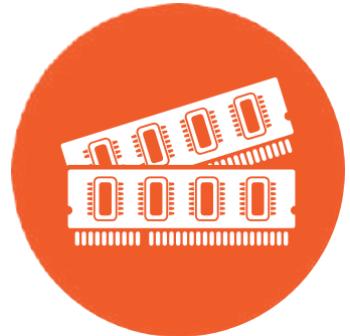
**Globomantics is researching their CPU choices for the new server.**

**Let's learn more about the options and then see if the recommended hardware is suitable for Globomantics**

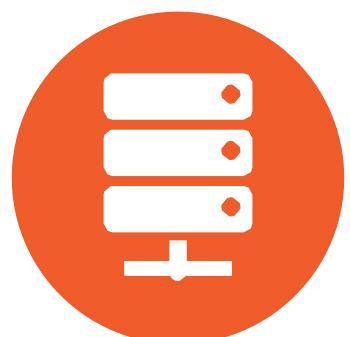
# Minimum Hardware



**1 CPU Sockets with 6 cores**



**64 GB of RAM**



**1 Gbps Networking**



**512 GB Storage**

# Recommended Hardware

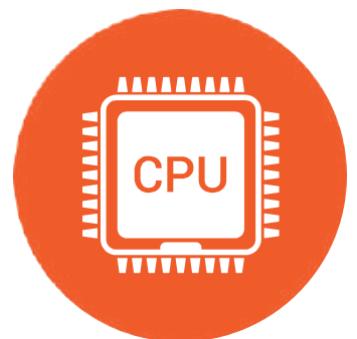
**2 CPU Sockets with 12 cores each**

**256 GB of RAM**

**10 Gbps Networking**

**3 TB Storage**

# Minimum Hardware



**1 CPU Sockets with 6 cores**



**64 GB of RAM**



**1GB Networking**



**512 GB Storage**

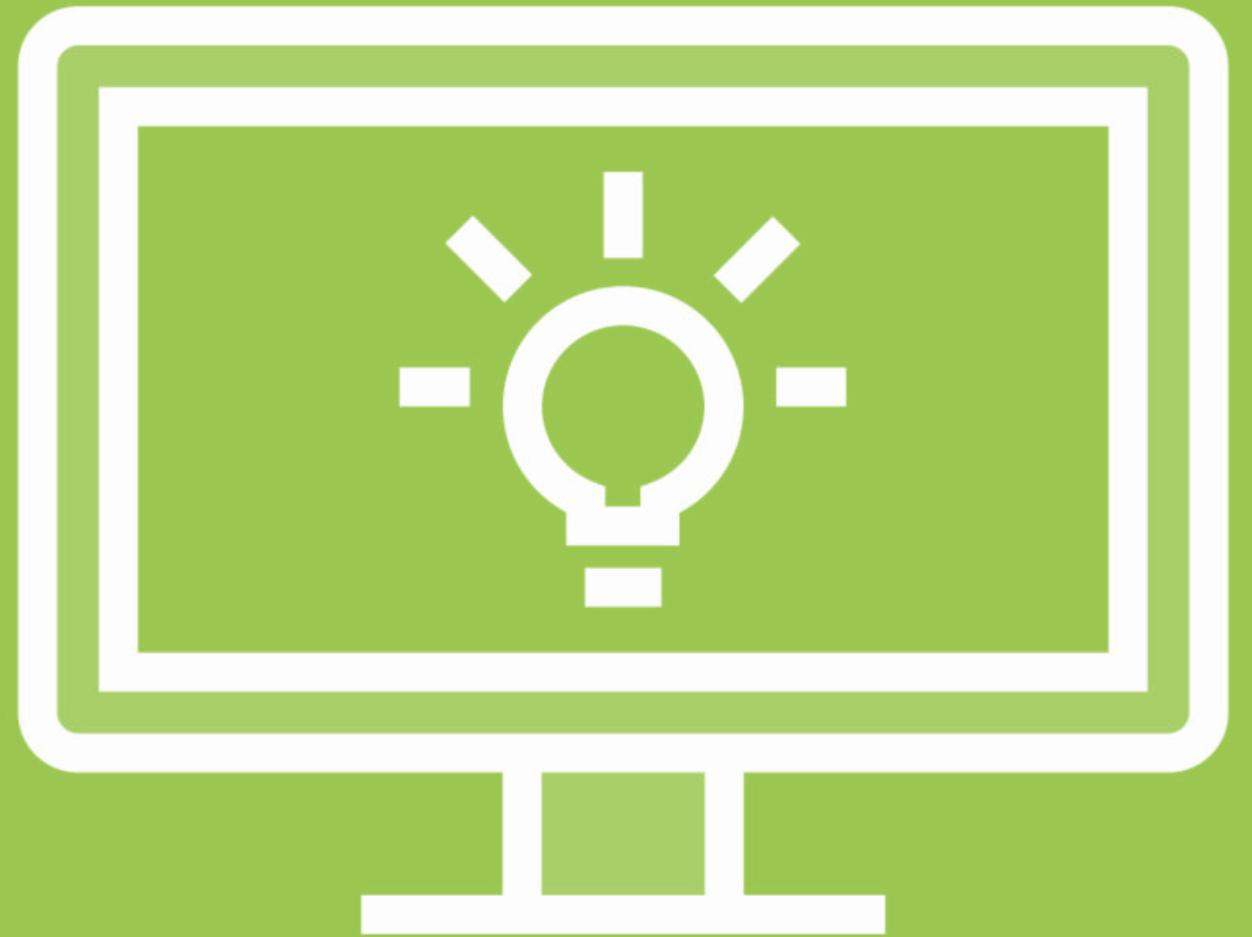
# Recommended Hardware

**2 CPU Sockets with 12 cores each**

**256 GB of RAM**

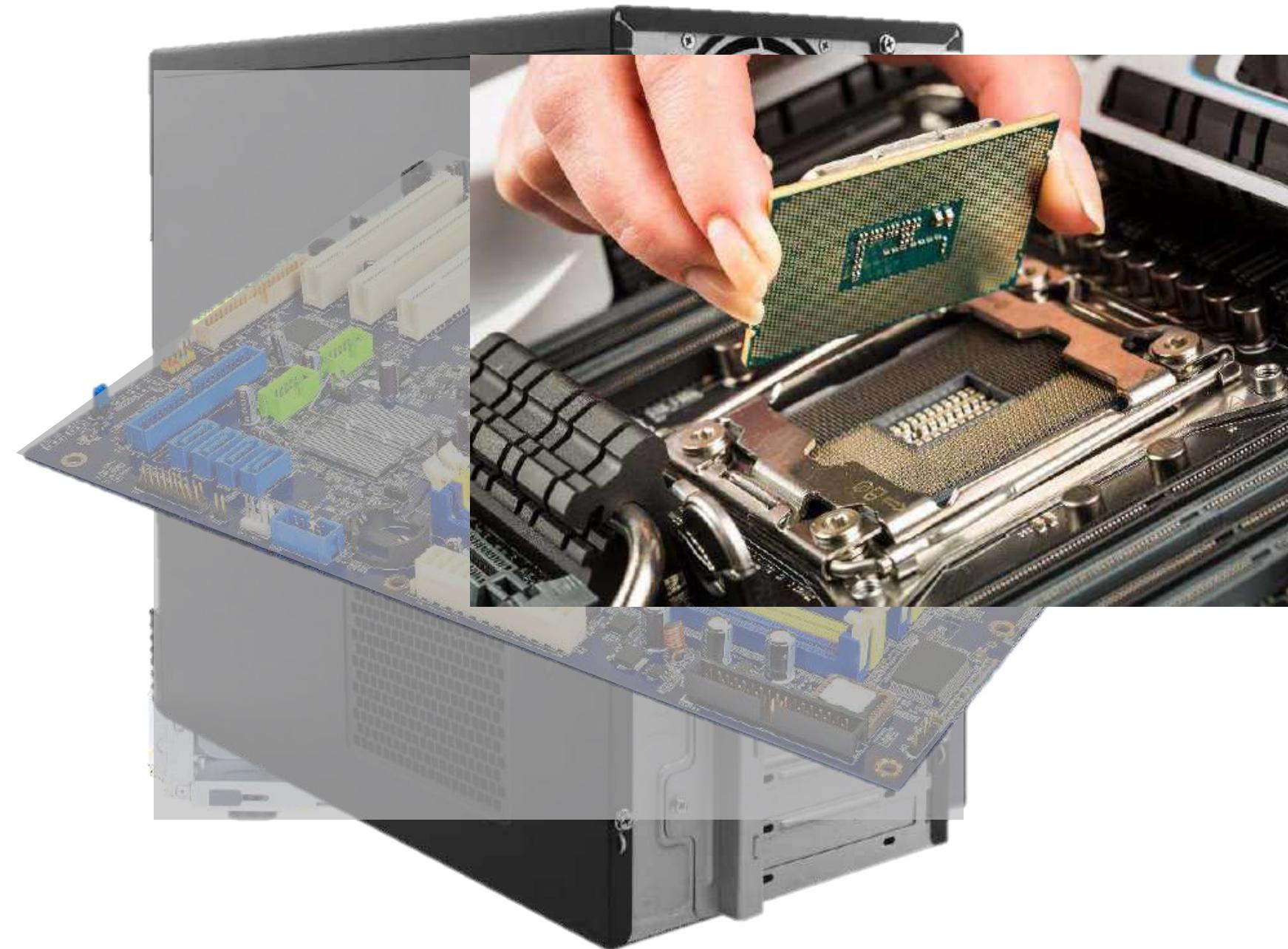
**10 GB Networking**

**3 TB Storage**

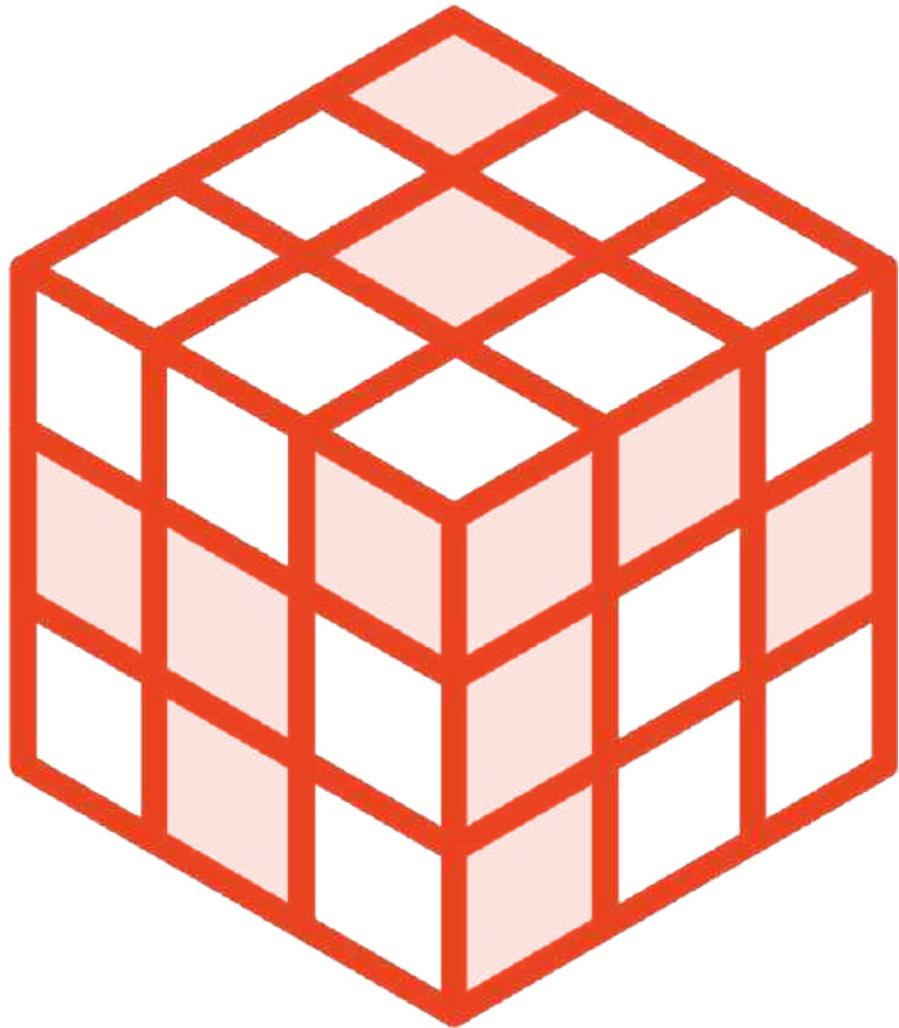


Tech Point  
CPU Cores and  
Sockets

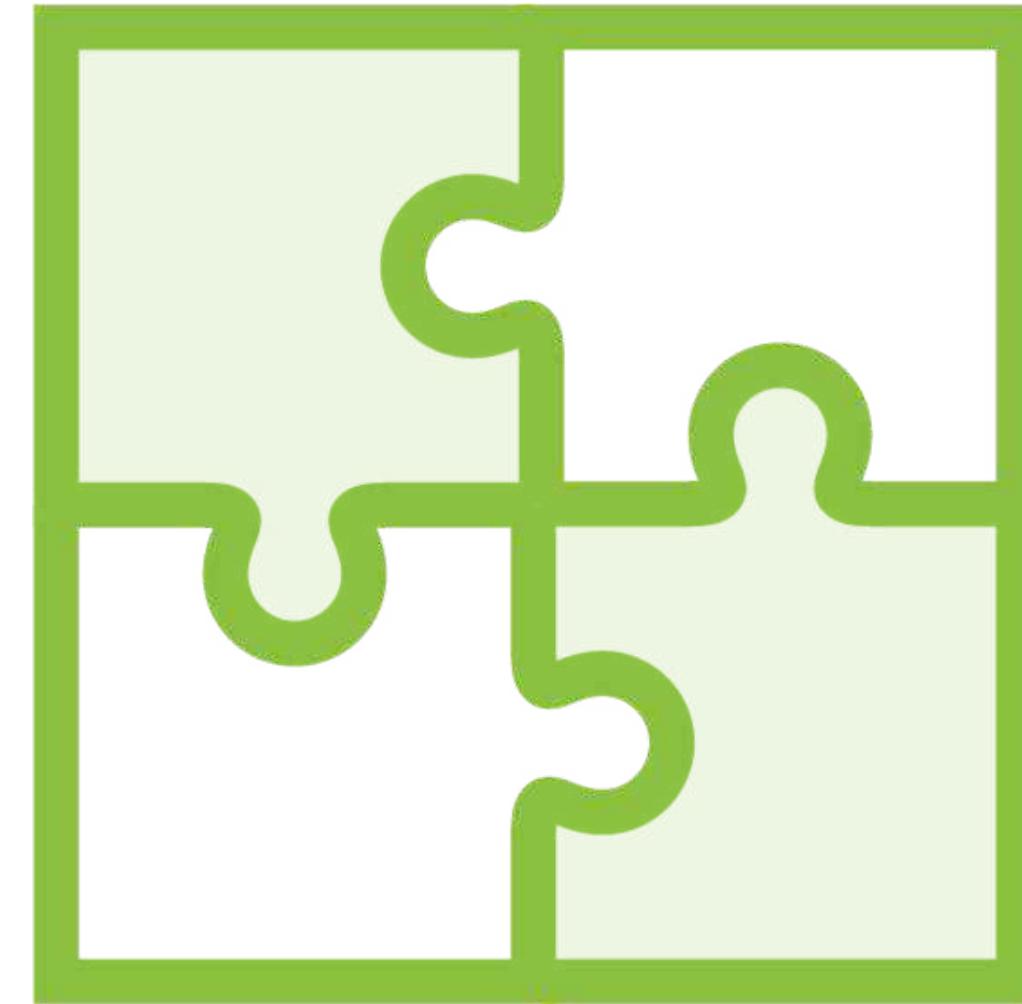
# Visual Anchor



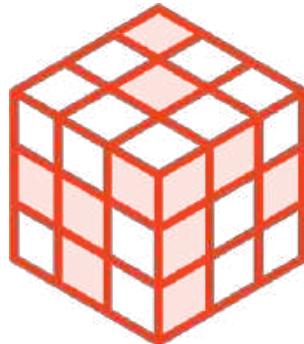
# First, the Type of CPU



**CISC**  
Complex Instruction Set  
Computing



**RISC**  
Reduced Instruction Set  
Computing



# Complex Instruction Set Computing (CISC)

Created and sold by Intel and AMD

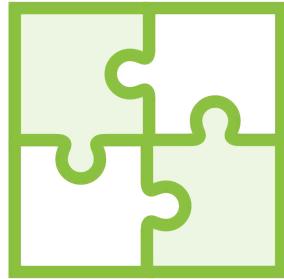


Original Intel standard - 32 bit  
Not used in servers since the  
early 2000s



Standard created by AMD and later  
adopted by Intel  
64 bit architecture

Backwards compatible with x86 CPUs



# Reduced Instruction Set Computing (RISC)

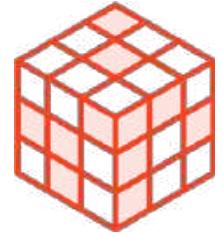
## ARM (Acorn RISC Machine)

Acorn Computers makes the design and licenses them to manufacturers

Not widely used in servers, except low power ones

- Some companies deploy many low power servers for hyper-scale projects, HPC, etc.
- Being tried with Cloud, web servers, etc.

# CPU Instructions Are Collections of Transistors



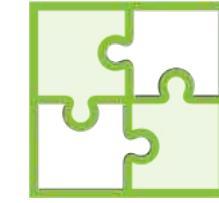
## Complex Instruction Set Computing (CISC)

**More** transistors = **more** power consumption = **more** heat = **more** cooling required

Most PCs and servers contain CISC processors due to the wide operating system support

New versions typically scale up the capabilities of the CPU instruction set

## Reduced Instruction Set Computing (RISC)



**Fewer** transistors = **less** power consumption = **less** heat = **less** cooling required

Great for mobile devices, ultra books, TVs, other embedded solutions, and low-power servers, such as web servers

New versions typically scale out to include more processors / cores

# CPU Processors, Sockets, and Cores



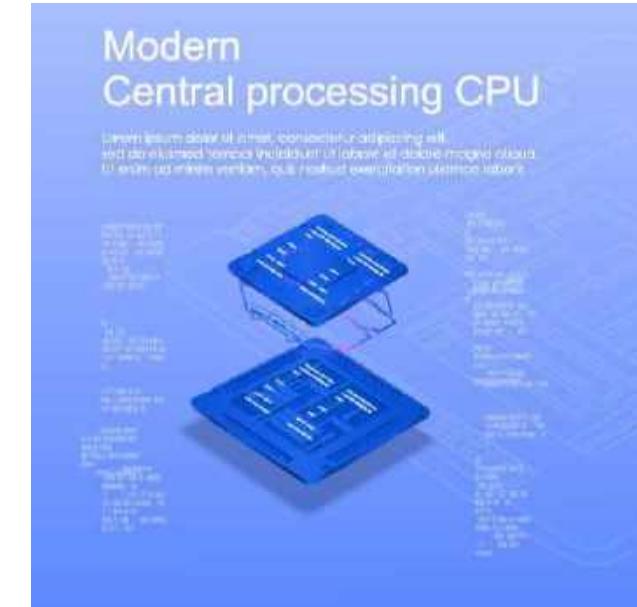
## CPU Processor

A generic term, but usually refers to the physical chip that is inserted into a CPU Socket



## CPU Socket

Contains pins or plugs that electrically connect the CPU Processor to the motherboard



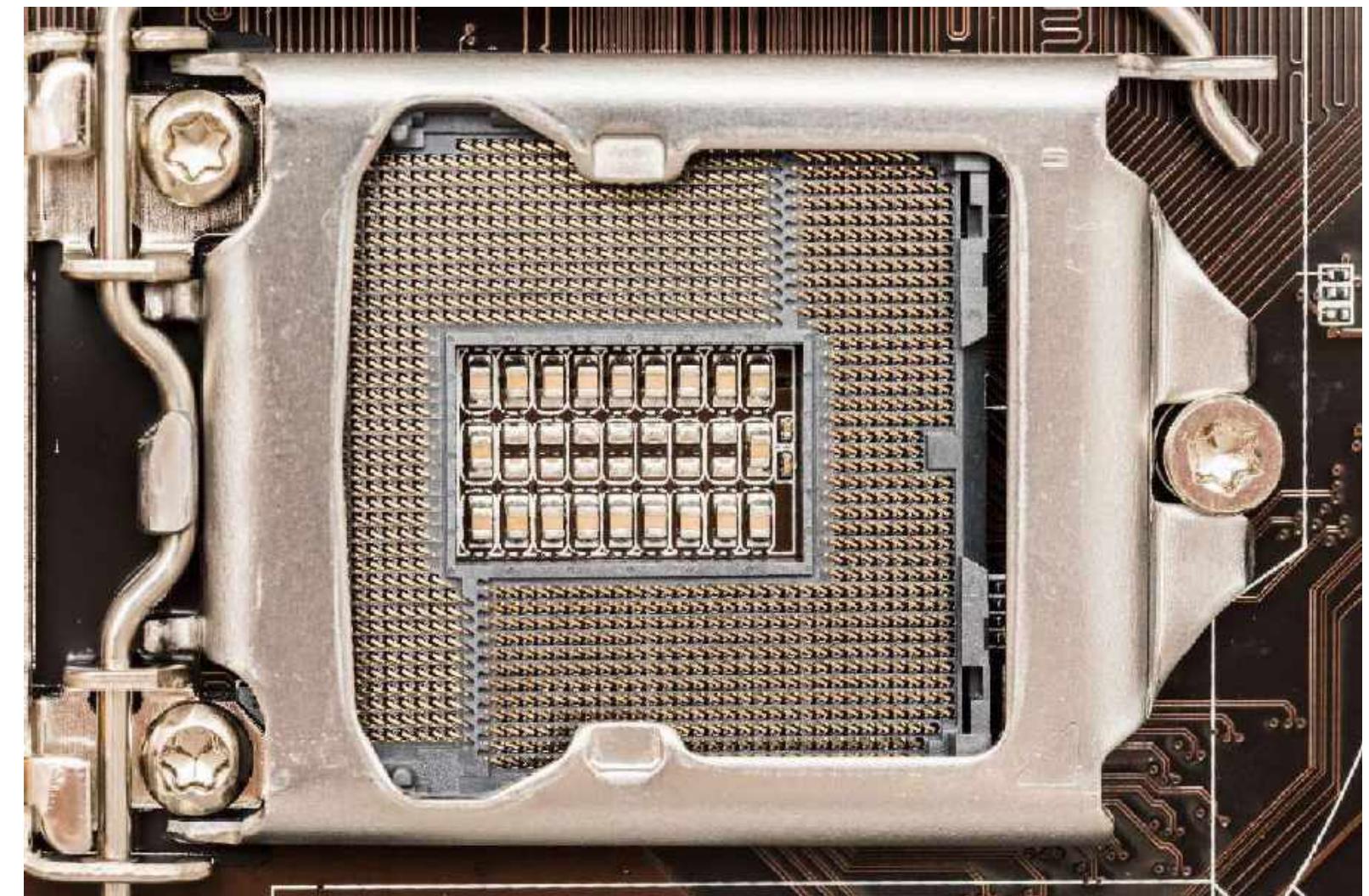
## CPU Core

One or more CPU Cores are contained within a CPU Processor

# Socket Types

**Specific CPUs require a specific socket type**

- Not upgradable
- Built into the motherboard
- Not backwards or forward compatible

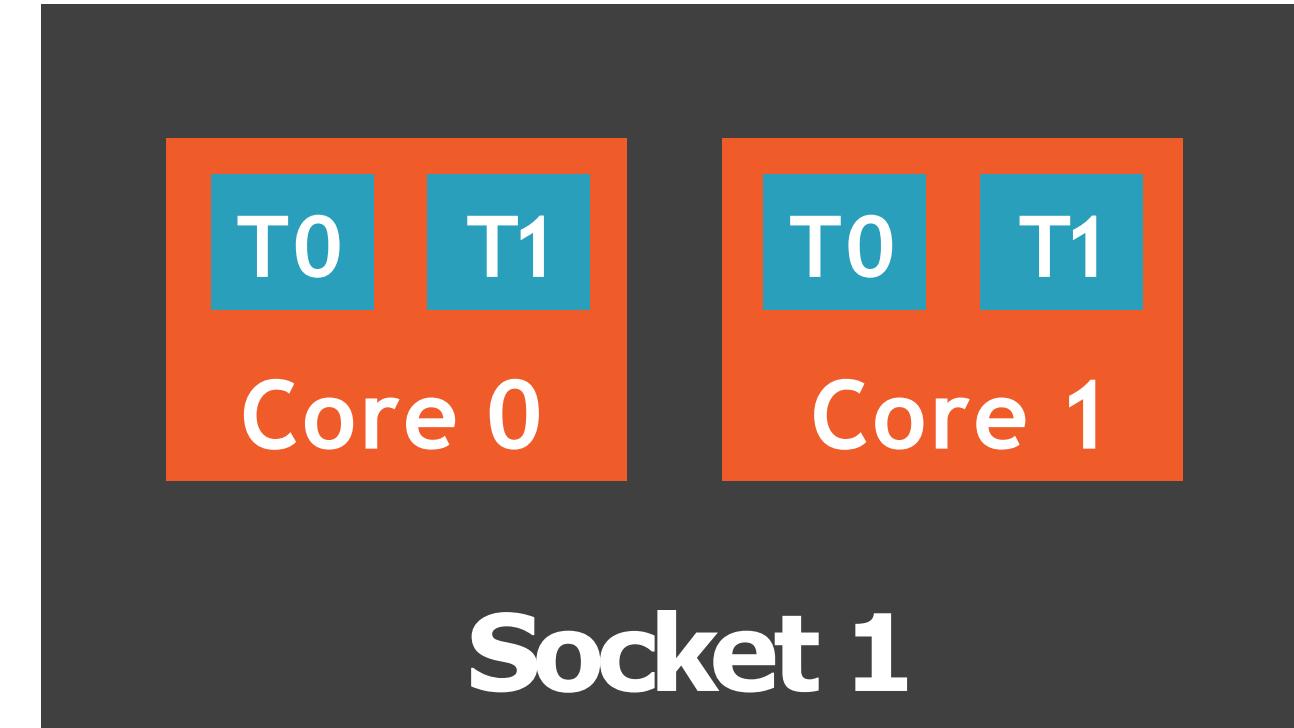


# Multiprocessor vs. Multicore vs. Multithreaded

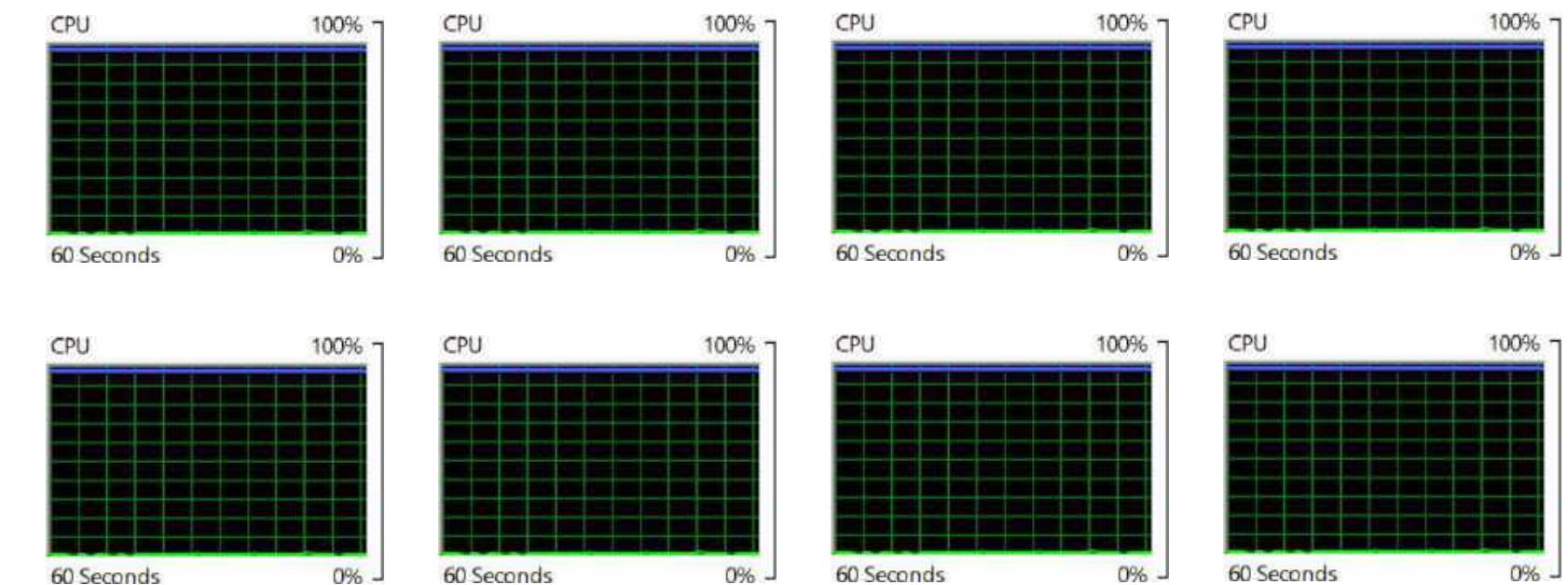
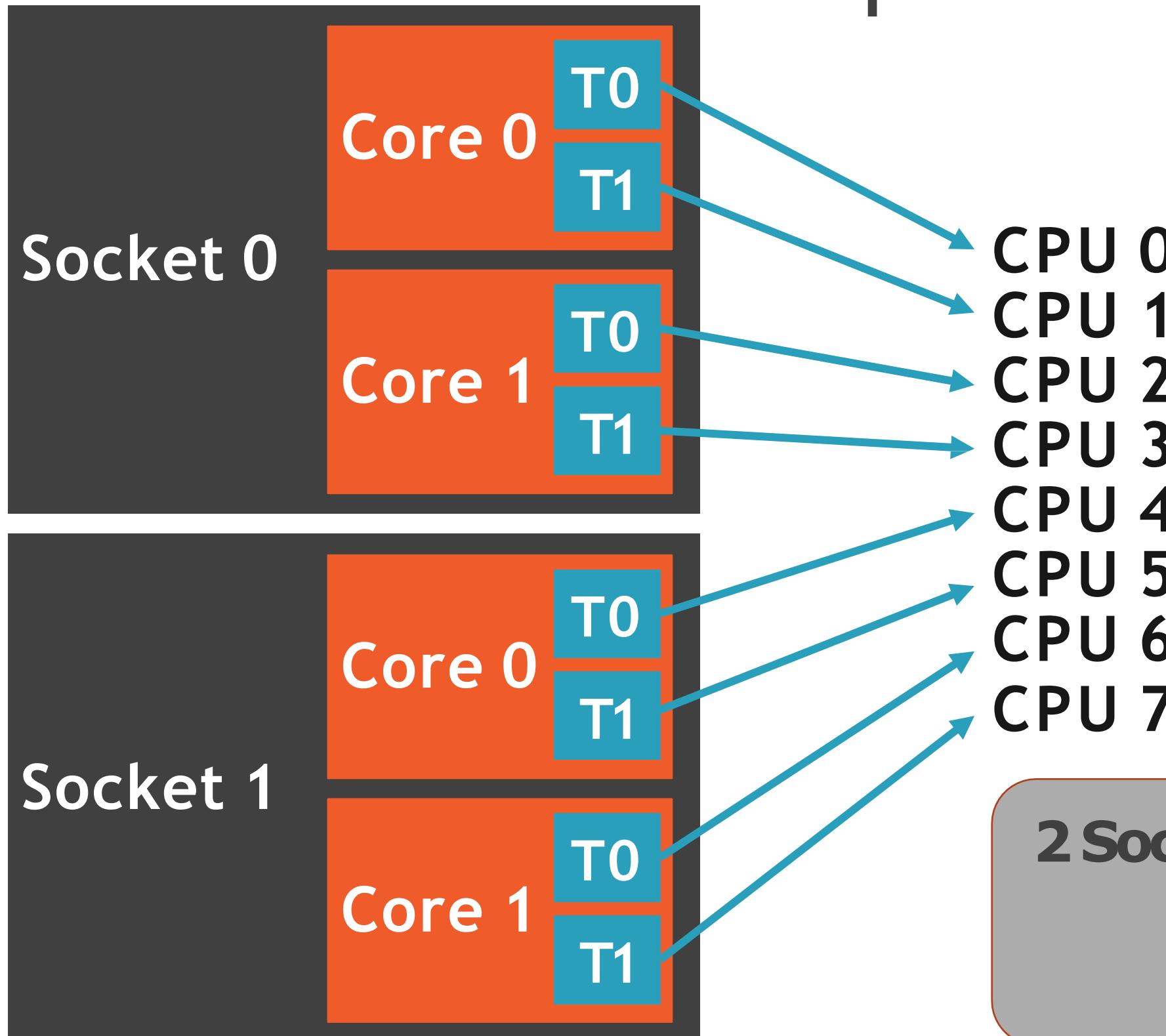
**Multiprocessor** indicates multiple CPU Sockets are used.

**Multicore** indicates multiple CPU cores exist within a processor

Each core can also have two thread execution queues, allowing simultaneous multithreading



# Threads Appear as CPUs in the Operating System



**2 Sockets x 2 cores/socket x 2 threads/core**  
**8 Logical CPUs**

# CPU Speeds

## Base Clock

Speed of one system cycle on the motherboard

## Multiplier

The number of processor cycles that may execute during each system cycle

## Core Speed

Listed speed of the processor

$$\text{Base Clock} \times \text{Multiplier} = \text{Core Speed}$$

Example: If the **base clock** is **100 MHz** and the **multiplier** is **37**, the **core speed** is **3.7 GHz**

# Speed vs. Parallel Processing

Do you require extreme speed for a single process or are you planning to run a highly parallel workload?



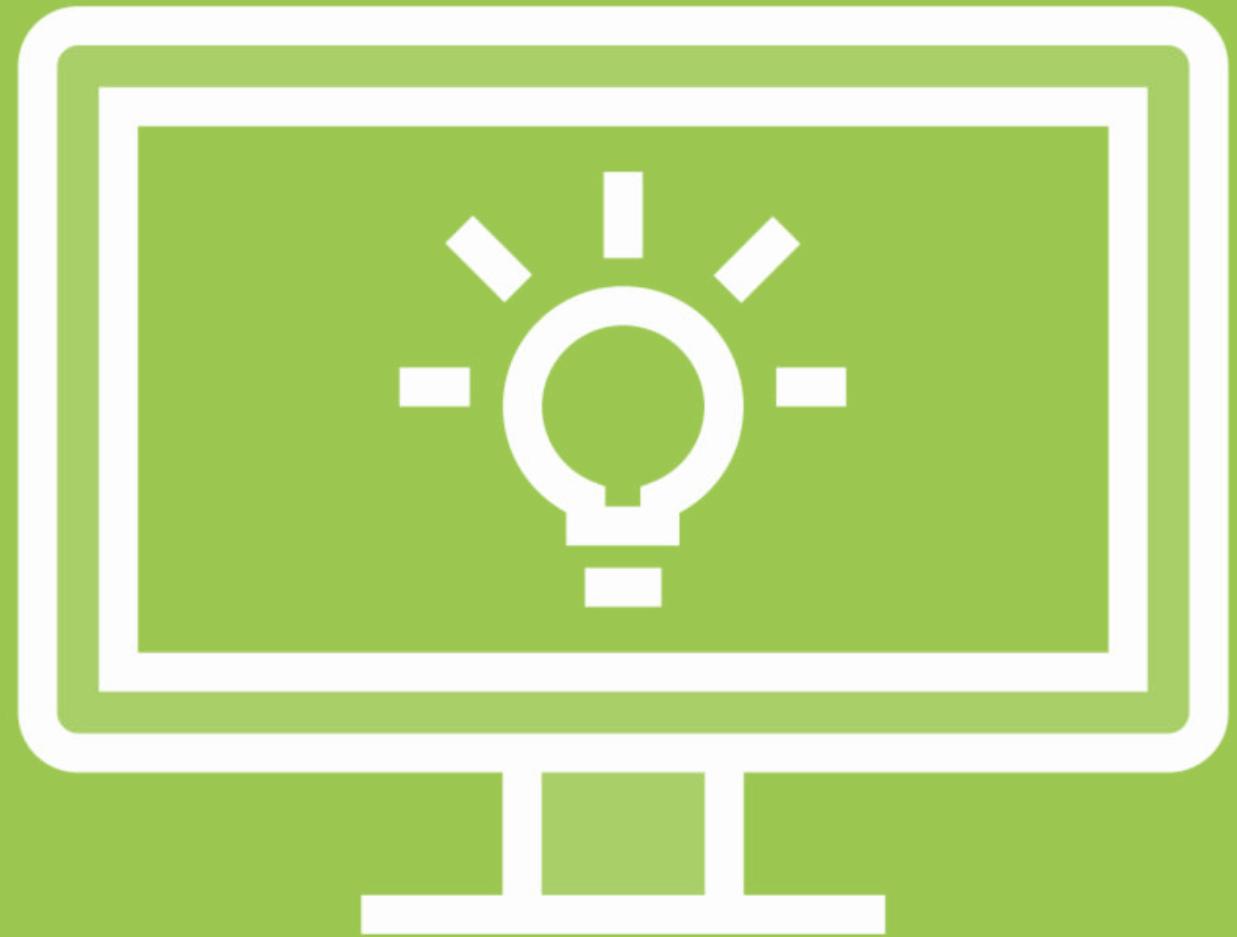
## Single-thread Performance

Choose a system with fewer cores, where each core has a high clock speed

## Highly Parallel Processing

Choose a system with more cores, but each core will have a lower clock speed

It's all about the heat!

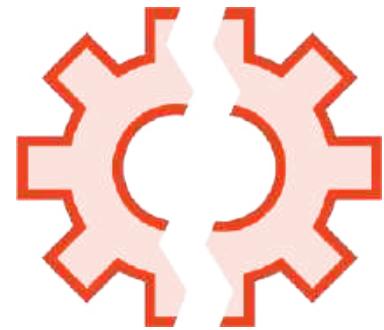


Tech Point  
Heat  
Dissipation

# CPU Thermal Design Power (TDP)



CPU cores turn electricity into heat;  
The faster the clock speed of each core, the more heat the CPU produces



CPUs stop working and may become permanently damaged if they overheat

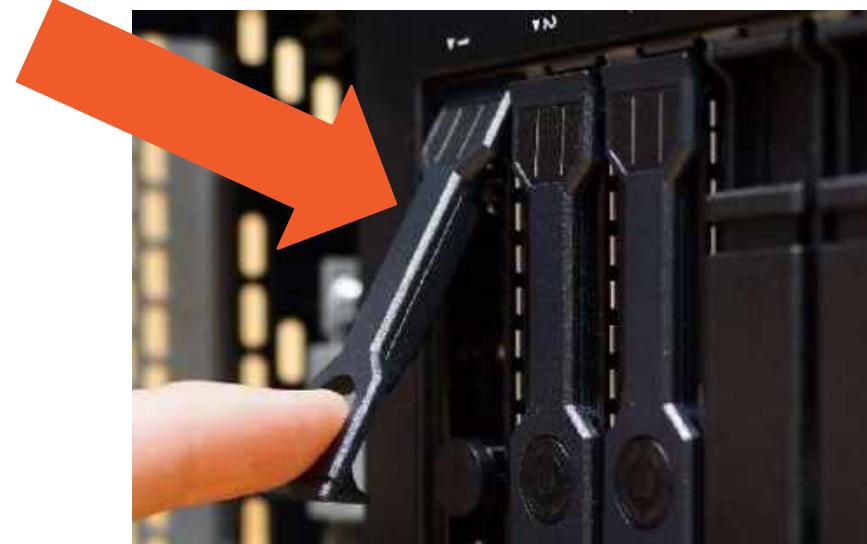


To prevent overheating, the power supplied to a CPU socket is limited;  
This constrains the heat output; but also caps the base clock speed of each core.

# Keeping the Entire System Cool

The CPU is only half of your battle with heat.

The RAM and other components also generate heat and must be kept cool.



**Baffles**

External covers that help channel the intake of cool air



**Shrouds**

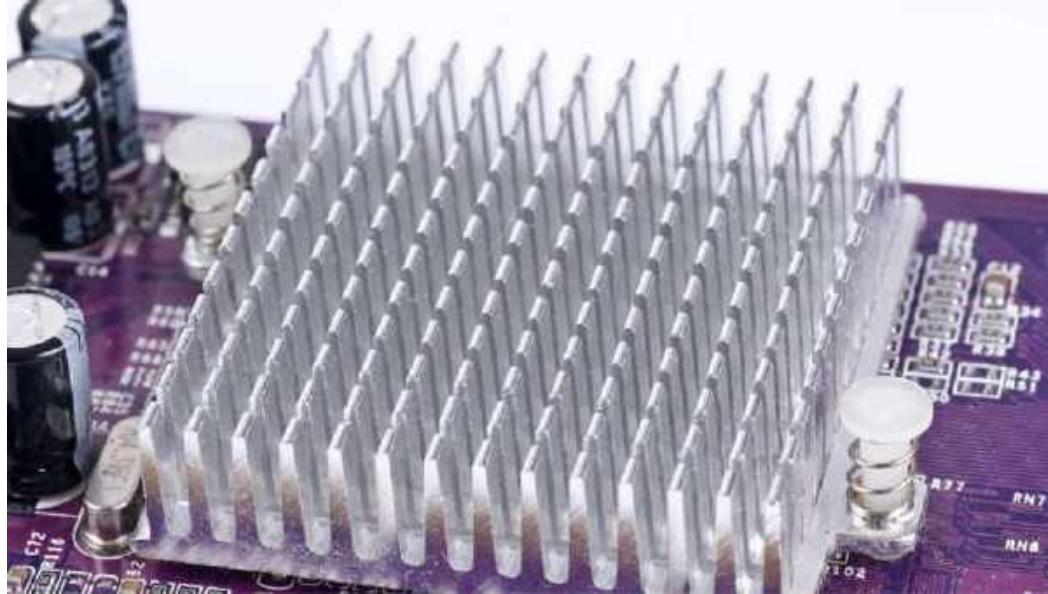
Internal plastic covers that direct the airflow across critical parts



**Fans**

Pulls cool air from the front of the server and exhausts it to the rear

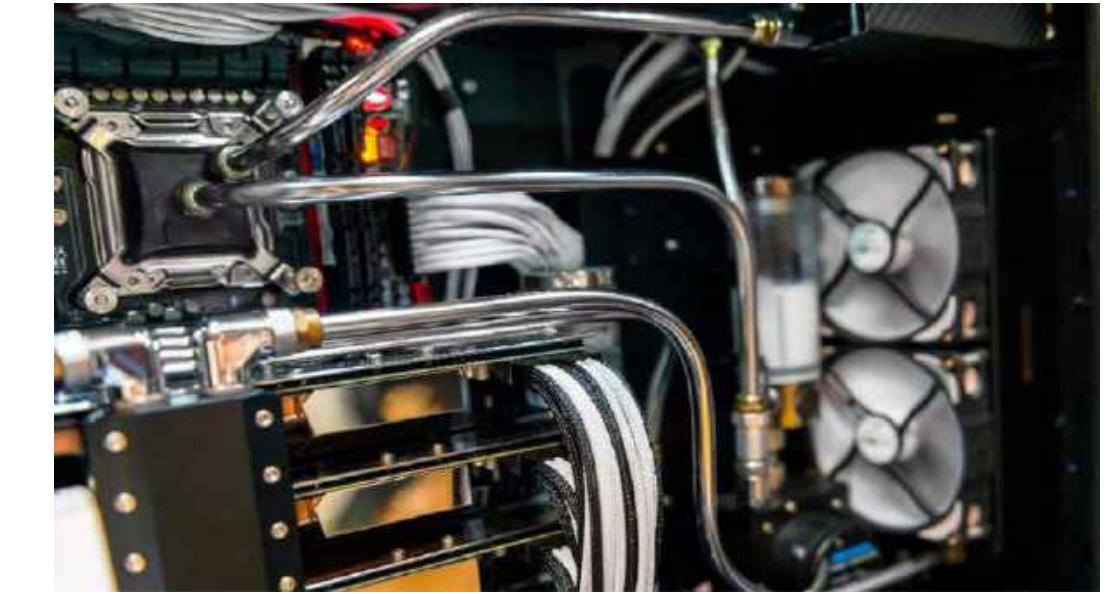
# Beat the Heat



**Passive Heat  
Dissipation**

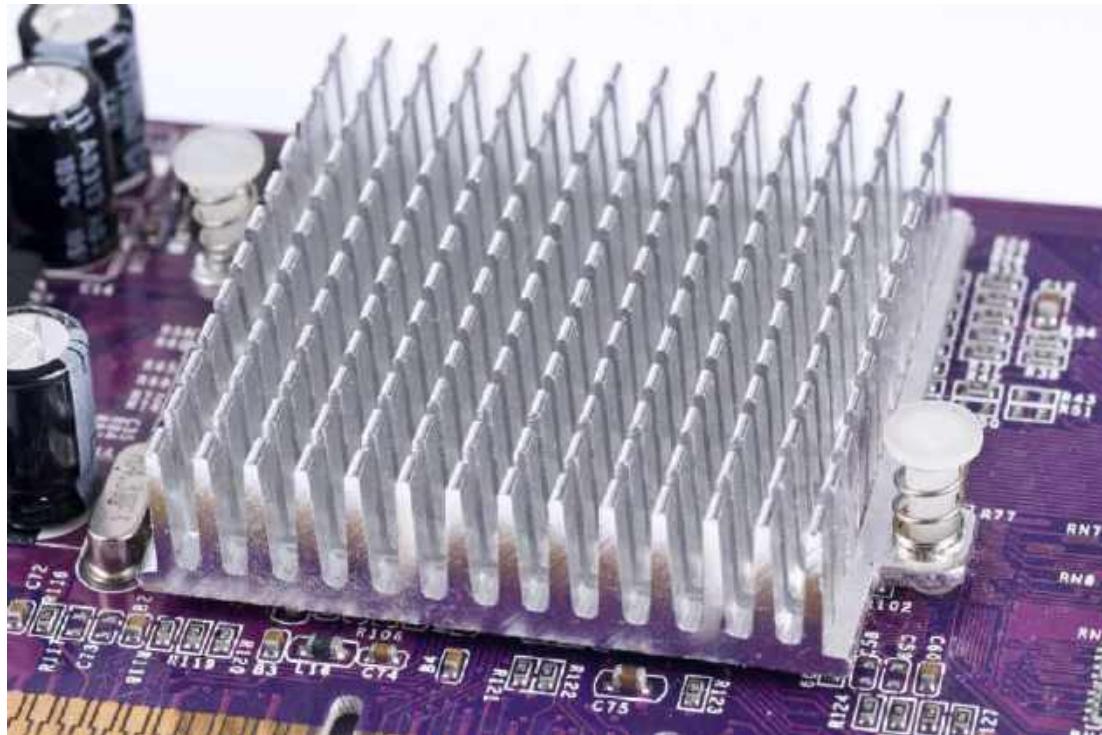


**Active Heat  
Dissipation via forced  
air-cooled heat sinks**



**Active Heat  
Dissipation via liquid  
cooling blocks,  
pumps, and radiators**

# Passive Heat Dissipation



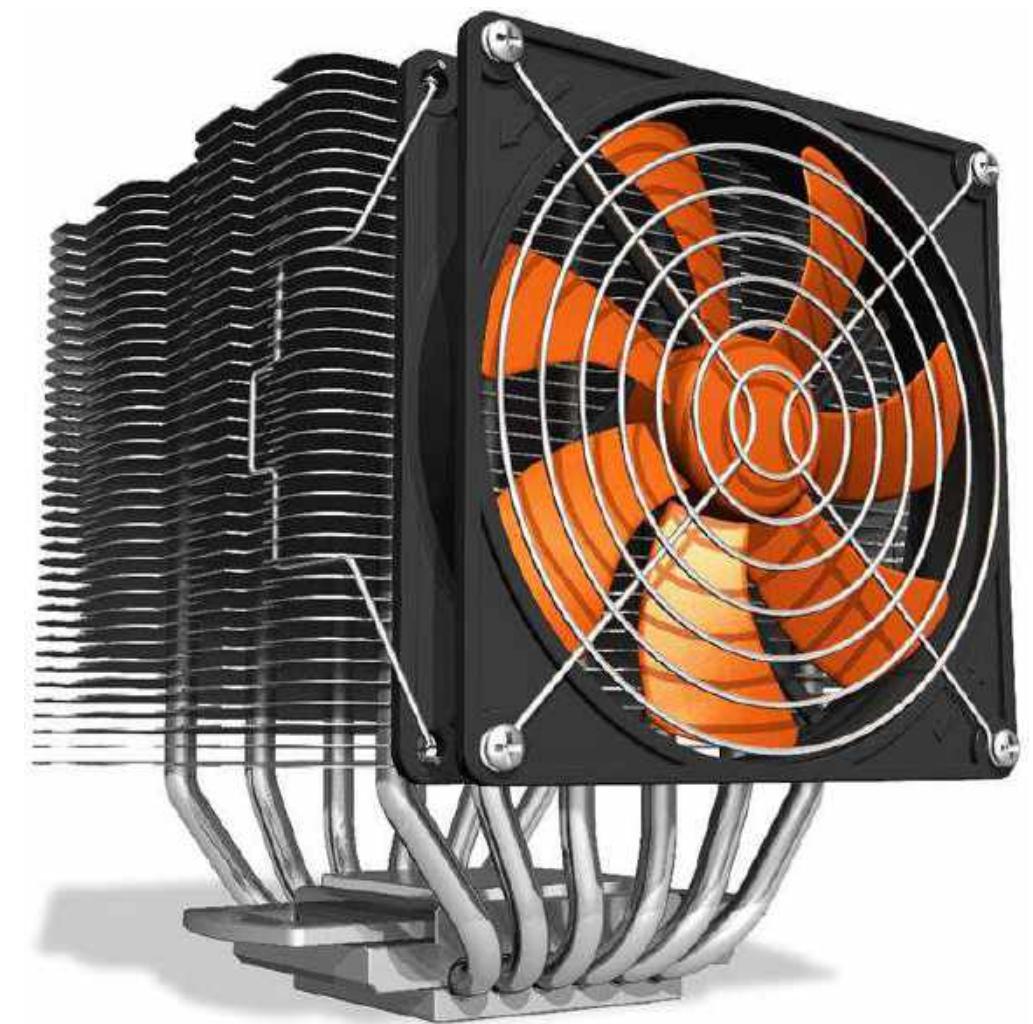
**Many components use passive heat sinks**

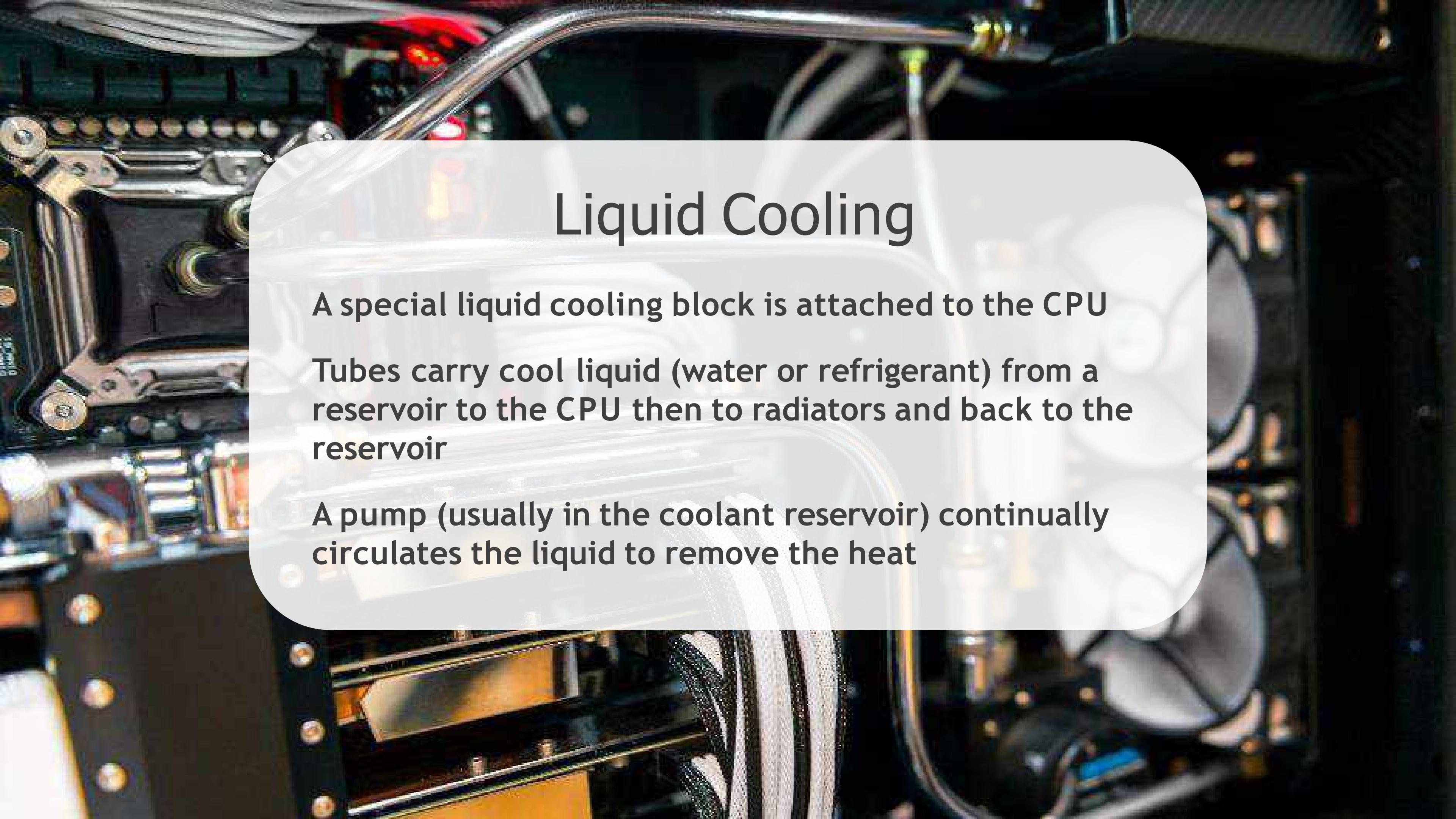
- The metal block conducts heat away from the chip
- Air flows across the fins, removing the heat.
- Usually requires thermal compound to improve heat dissipation
- Requires external fans to circulate air to remove the heat

# Active Thermal Dissipation

Sensitive components like the CPU use active heat sinks

- Active heat sink cooling is similar to passive
- Addition of a fan that blows over/through the heat sink
- They are the primary method of cooling modern processors and graphics cards in servers



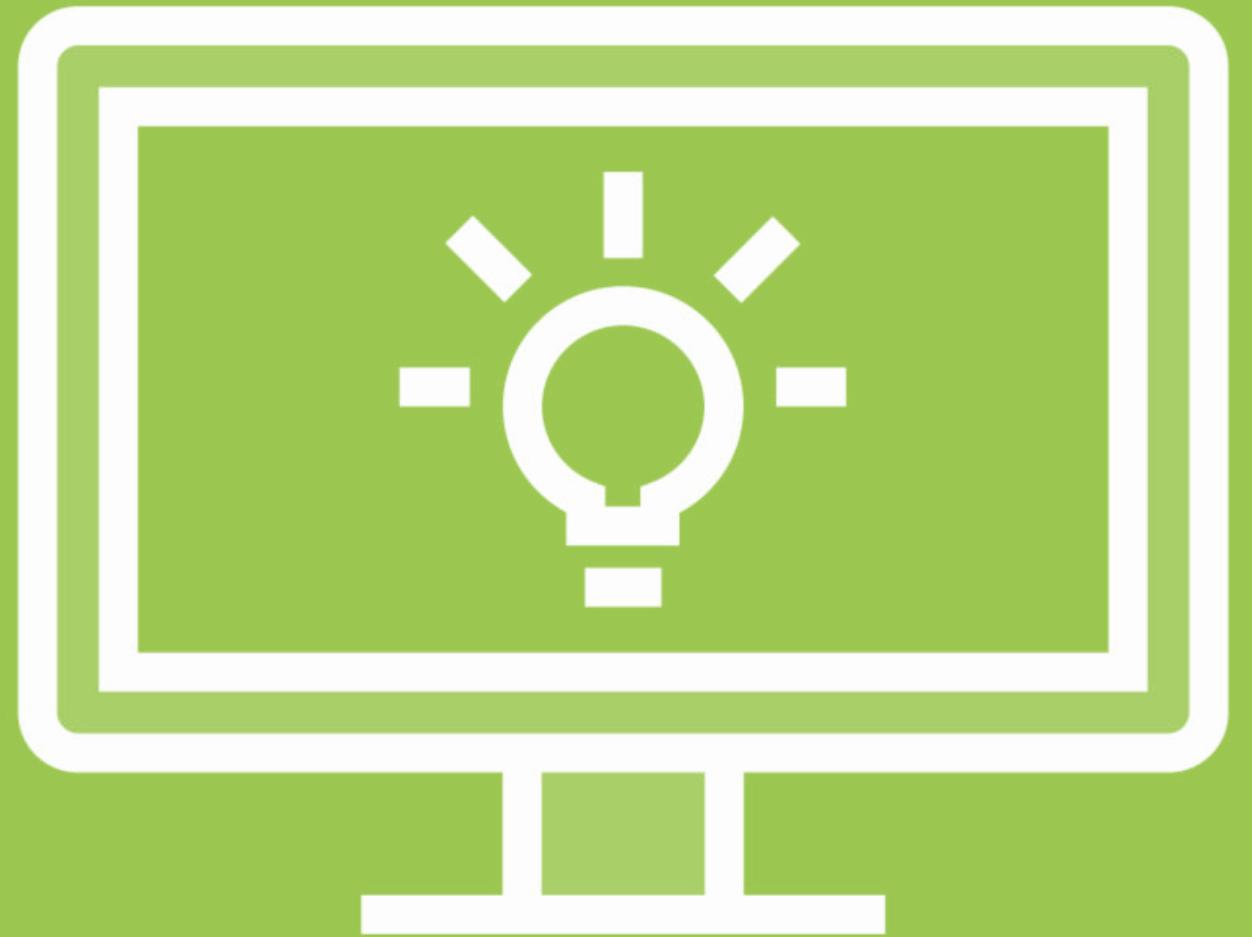


# Liquid Cooling

A special liquid cooling block is attached to the CPU

Tubes carry cool liquid (water or refrigerant) from a reservoir to the CPU then to radiators and back to the reservoir

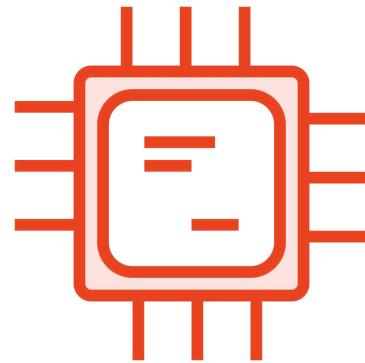
A pump (usually in the coolant reservoir) continually circulates the liquid to remove the heat



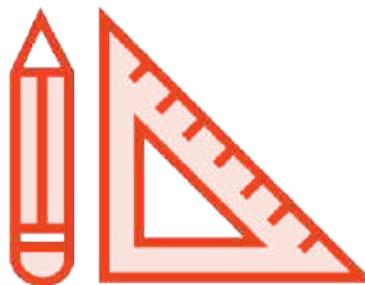
Tech Point  
CPU Cache

Wait, there's memory *inside* of  
the CPU?!

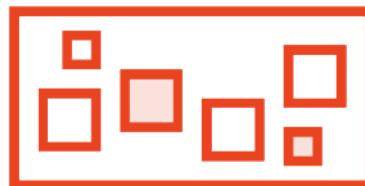
# CPU Cache



**CPUs have small amounts of memory in the chip**

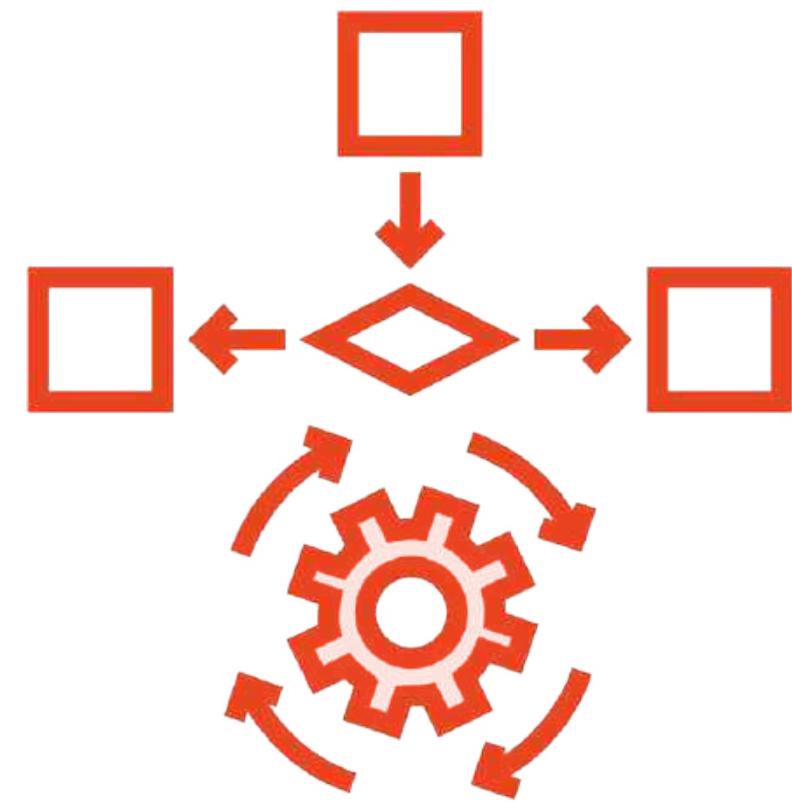


**A cache is a working area, like your desk. You can store things in it that you use very often.**



**Just like your desk, the cache is limited in size**

# Types of Cache



Instructions



Data

# Why Are There Multiple Levels of CPU Cache? (L1, L2, L3)

Larger cache sizes increase the chances of a cache hit, but increase latency

L1 is usually per core and the smallest

The last level (usually 3, possibly 4) is usually shared across all cores in a socket

# Cache Hierarchy

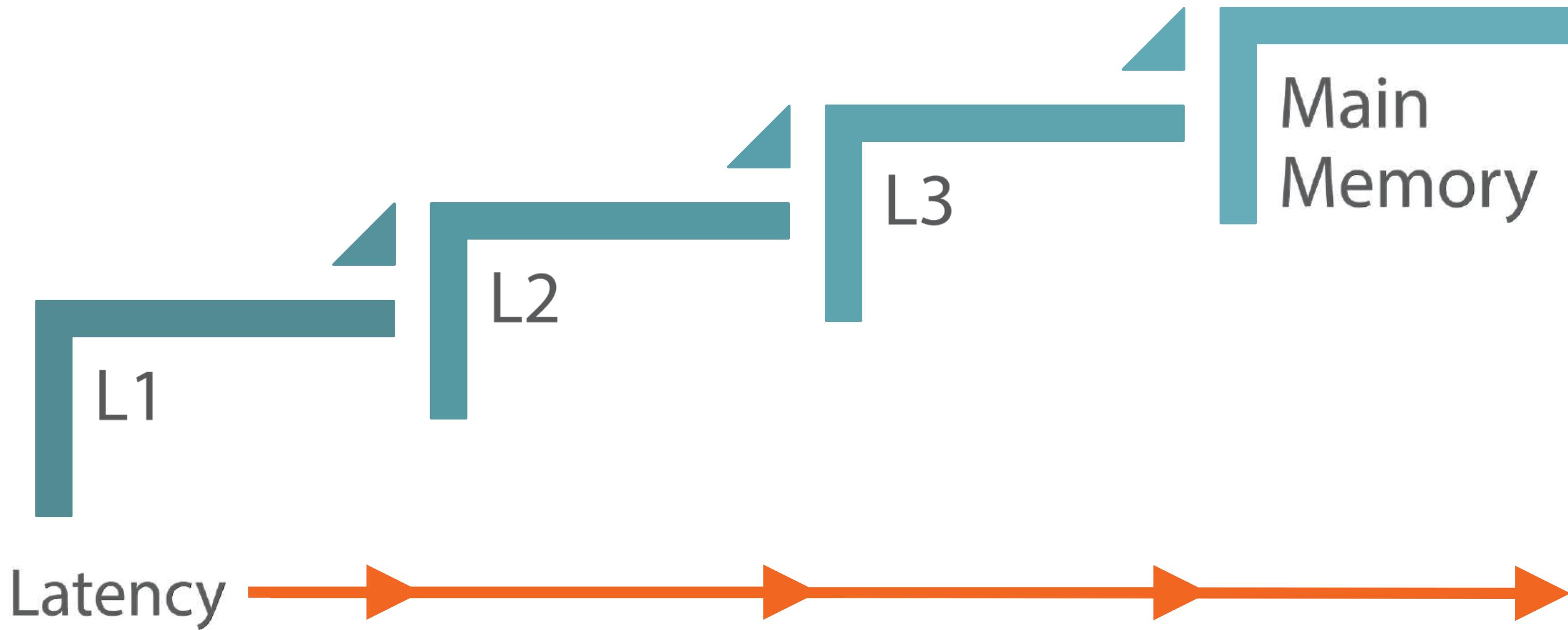
CPU Cache

L3

L2

L1

# Cache Search Process

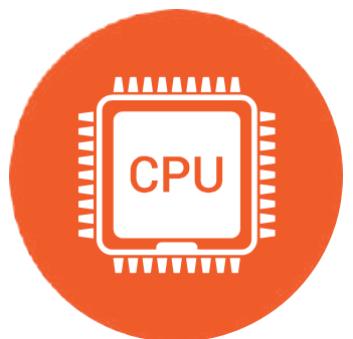




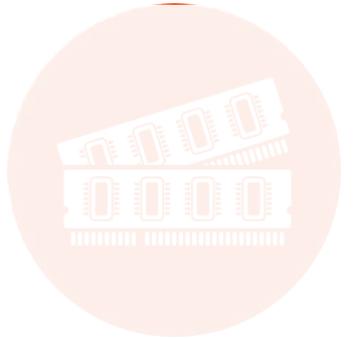
Hindsight



# Minimum Hardware



**1 CPU Sockets with 6 cores**



**64 GB of RAM**



**1 Gbps Networking**



**512 GB Storage**

# Recommended Hardware

**2 CPU Sockets with 12 cores each**

**256 GB of RAM**

**10 Gbps Networking**

**3 TB Storage**

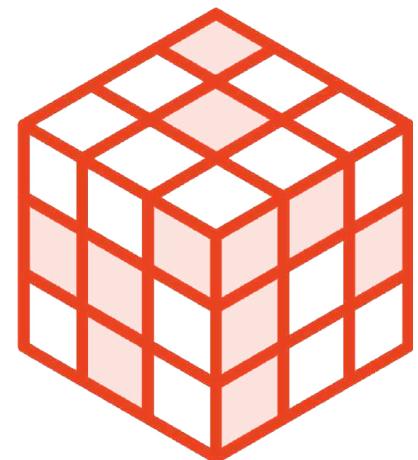


# Decision Points

# CISC or RISC Processor?

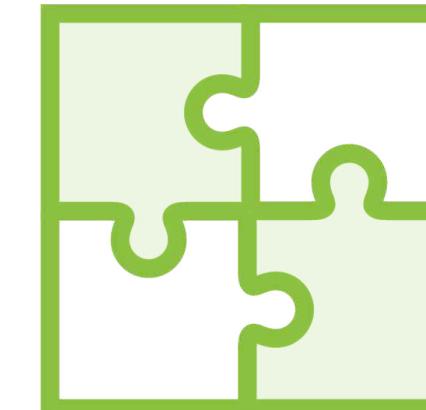
## Complex Instruction Set Computing (CISC)

Most PCs and servers contain CISC processors due to the wide operating system support



## Reduced Instruction Set Computing (RISC)

Great for mobile devices, ultra books, TVs, other embedded solutions, and even low-power web servers



# Higher Clock Speed or More Cores?

The software vendor claims their application is optimized for parallel processing.

Increasing the number of CPU cores may yield better performance.



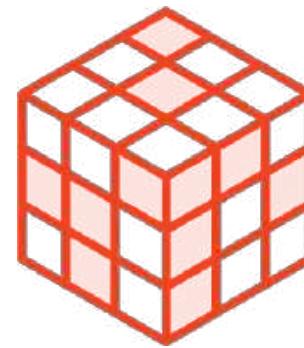
## Single-thread Performance

Choose a system with fewer cores, where each core has a high clock speed

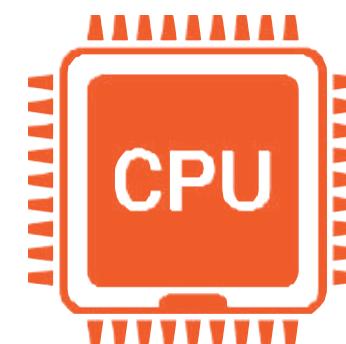
## Highly Parallel Processing

Choose a system with more cores, but each core will have a lower clock speed

Their OS and software vendors only support CISC processors.



The software vendor claims their application is optimized for parallel processing.



They will use a CISC processor

More CPU cores should yield better performance

The server will have 2 CPU sockets with 12 CPU cores per socket

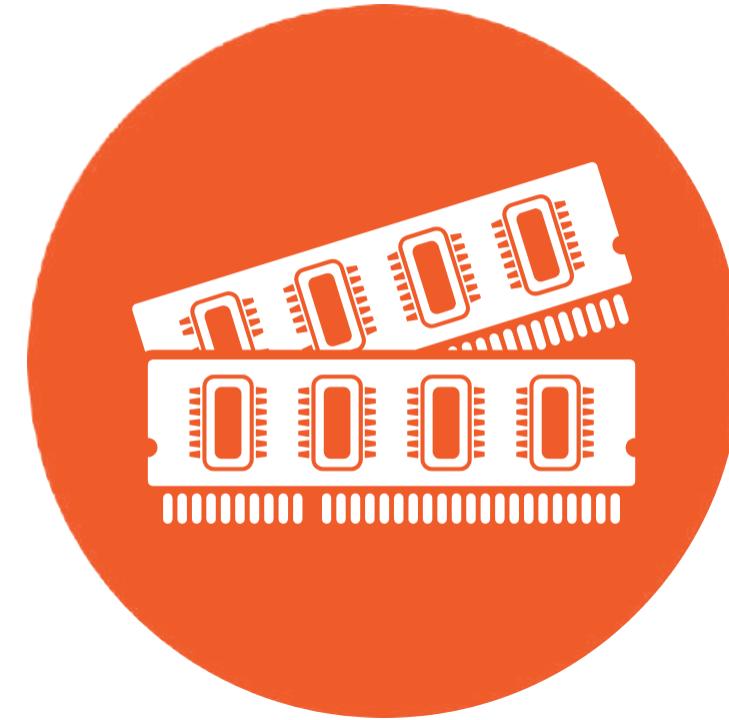
# RAM

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# Storyline

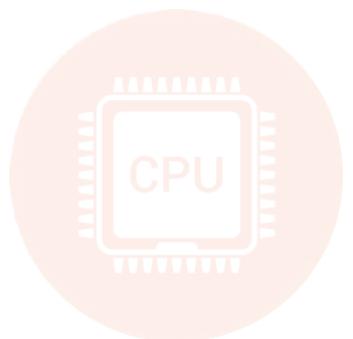
# What Do You Need to Know?



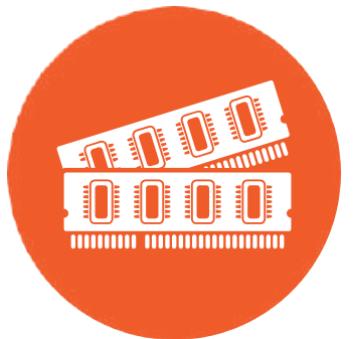
**Globomantics** is researching the kind of memory their server will need

Let's learn more about the options and then see if the recommended hardware is suitable for Globomantics

# Minimum Hardware



1 CPU Sockets with 6 cores



64 GB of RAM



1 Gbps Networking



512 GB Storage

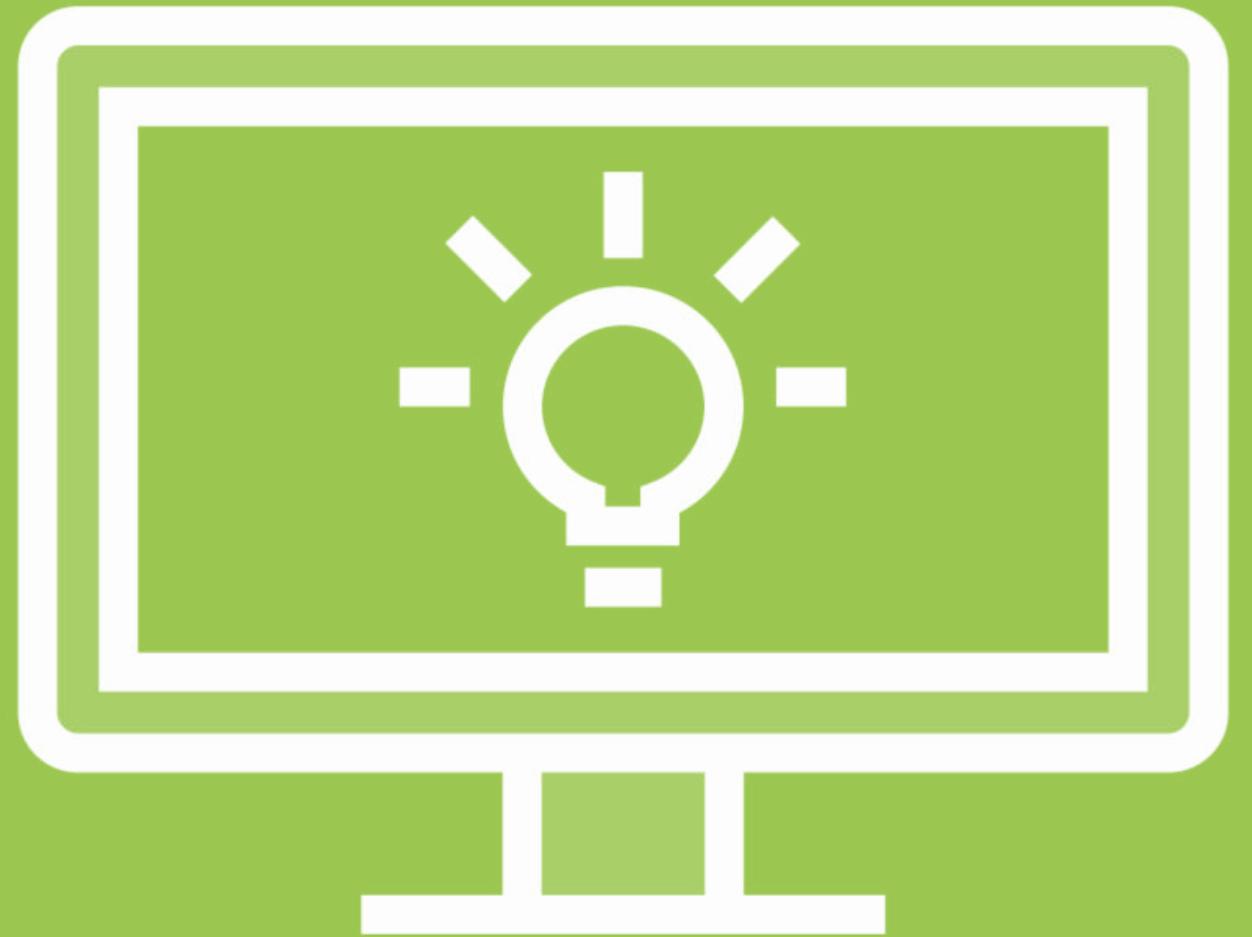
# Recommended Hardware

2 CPU Sockets with 12 cores each

256 GB of RAM

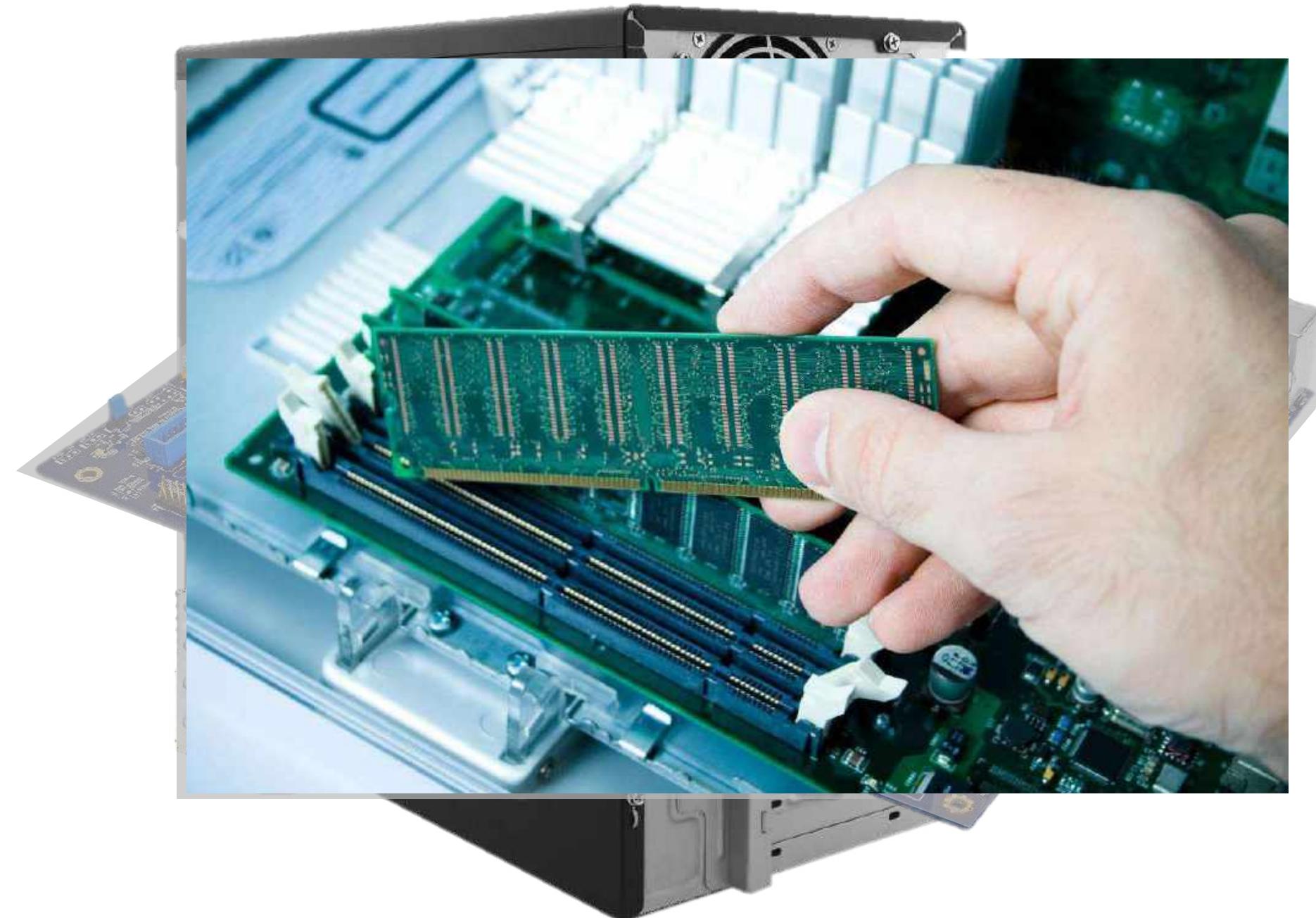
10 Gbps Networking

3 TB Storage

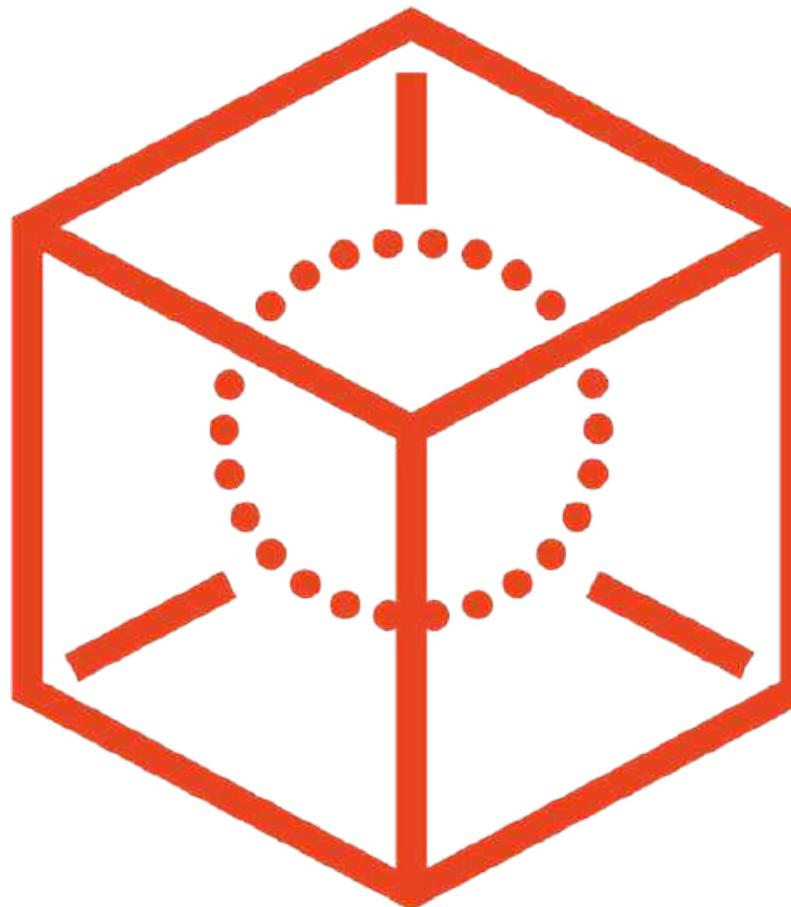


Tech Point  
RAM Capacity

# Visual Anchor

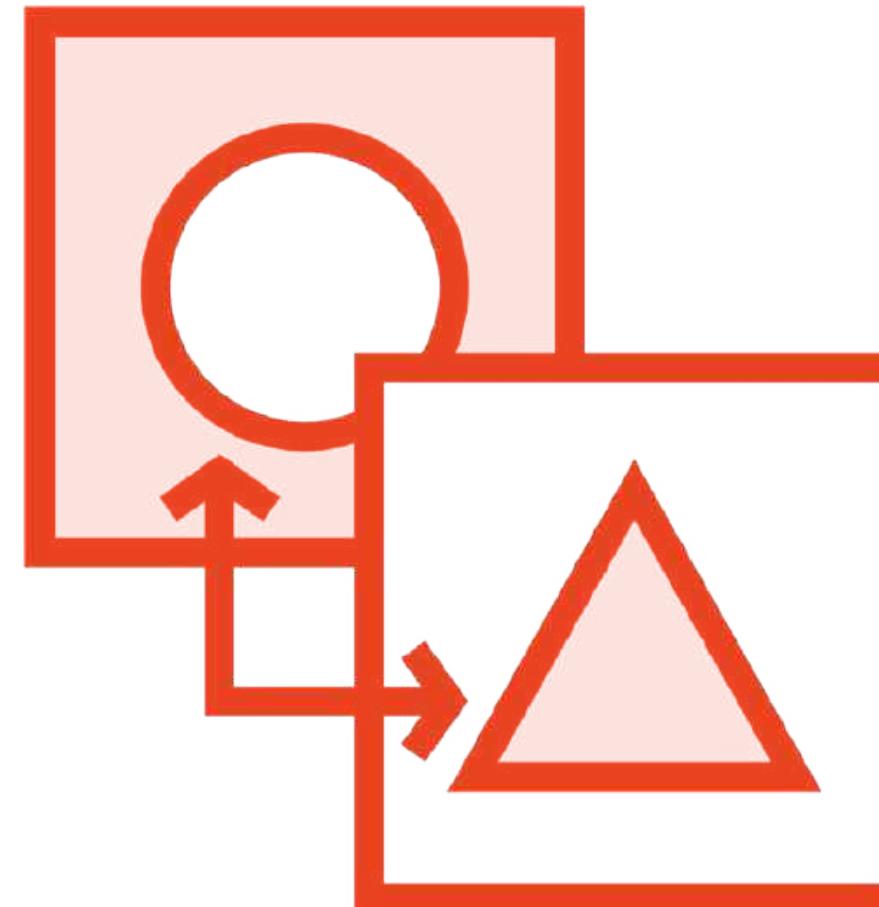


# With RAM, What Matters Most?

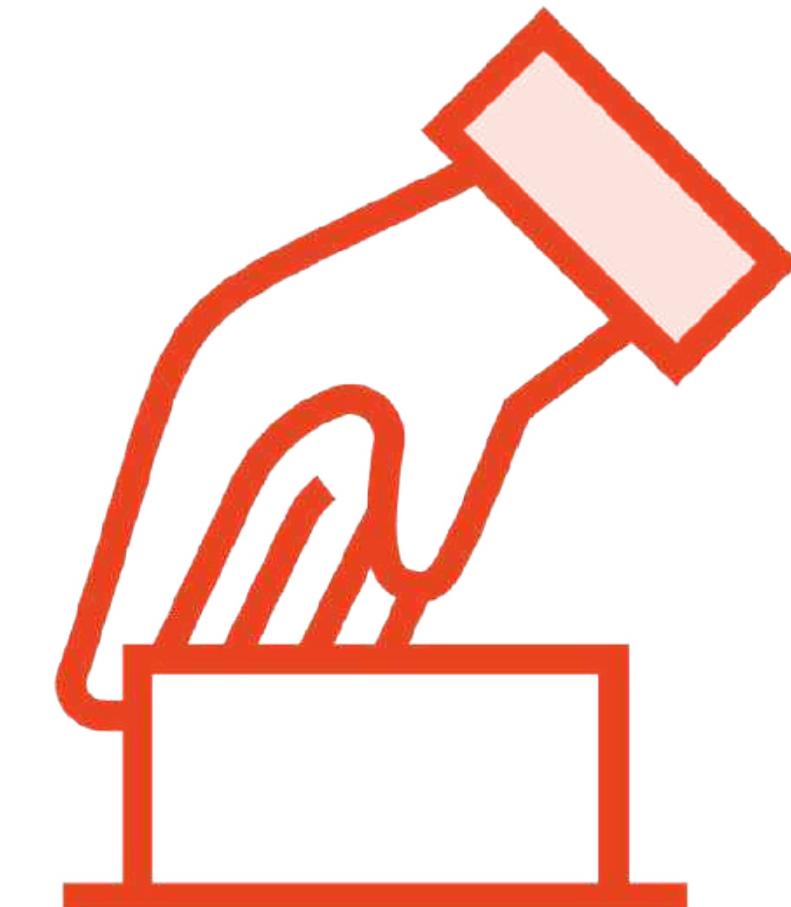


The total RAM  
capacity

64GB, 256GB, 1TB



The type of RAM  
ECC, DDR4, etc.



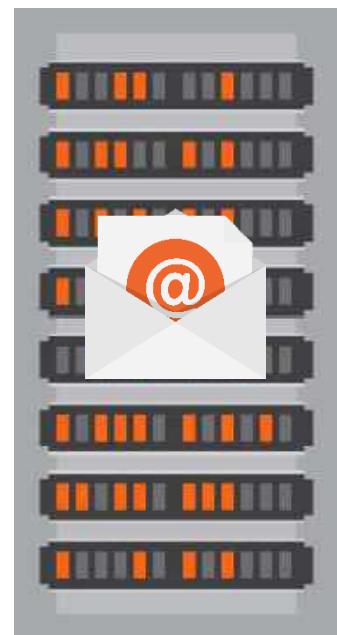
Where you install it  
Channel 0, Channel 1

RAM is measured in GB and TB,  
but it isn't the same thing as  
storage space.

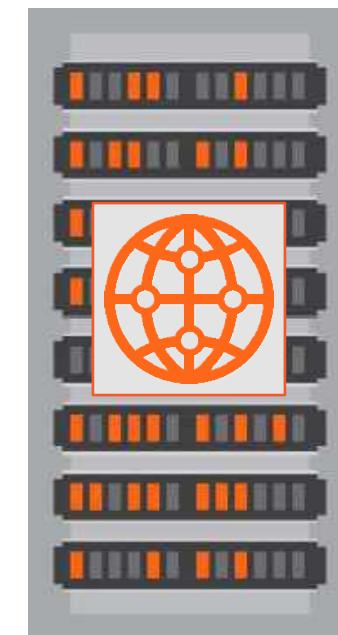
# What Is RAM Used For?

## How Do I Know How Much RAM I Need?

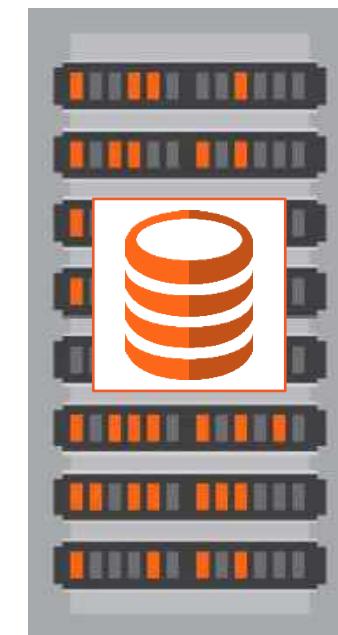
Let's look at some example server roles and see how they use resources



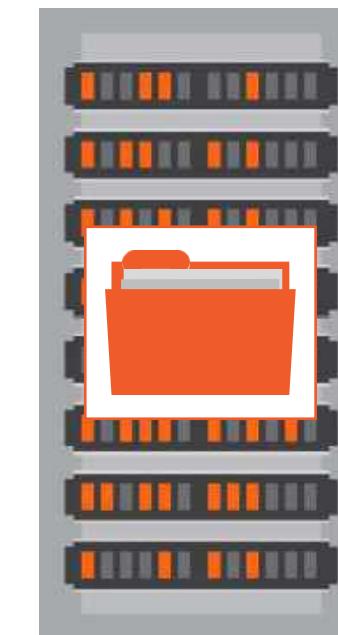
Email Servers



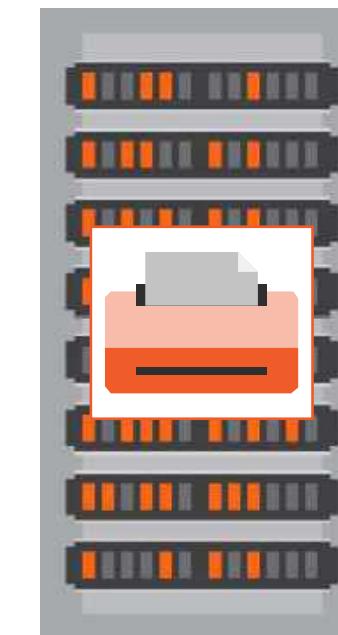
Web Servers



Database  
Servers



File Servers

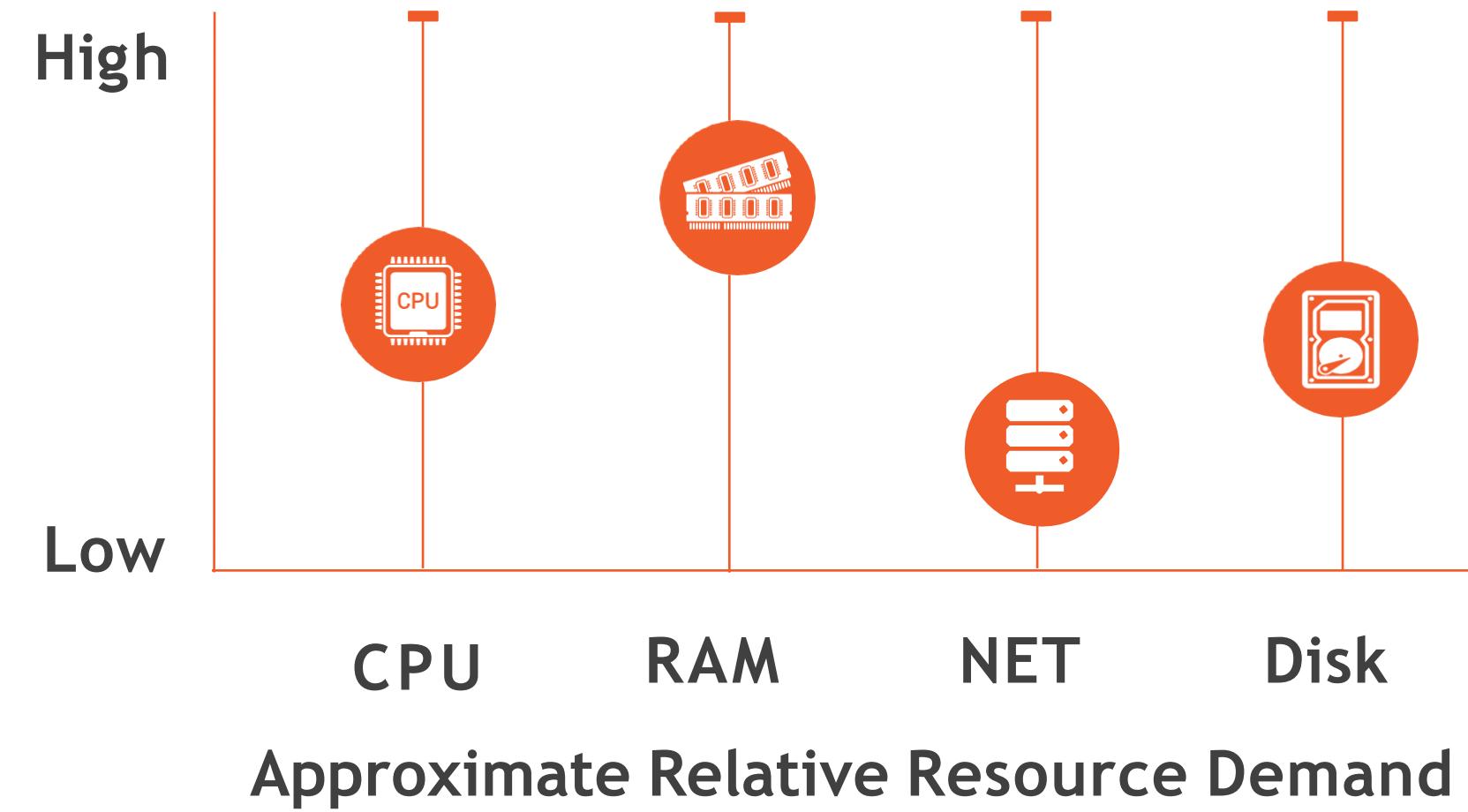
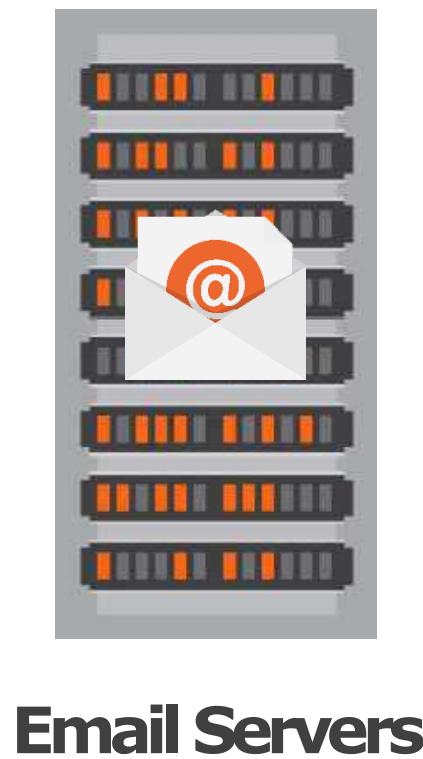


Print Servers

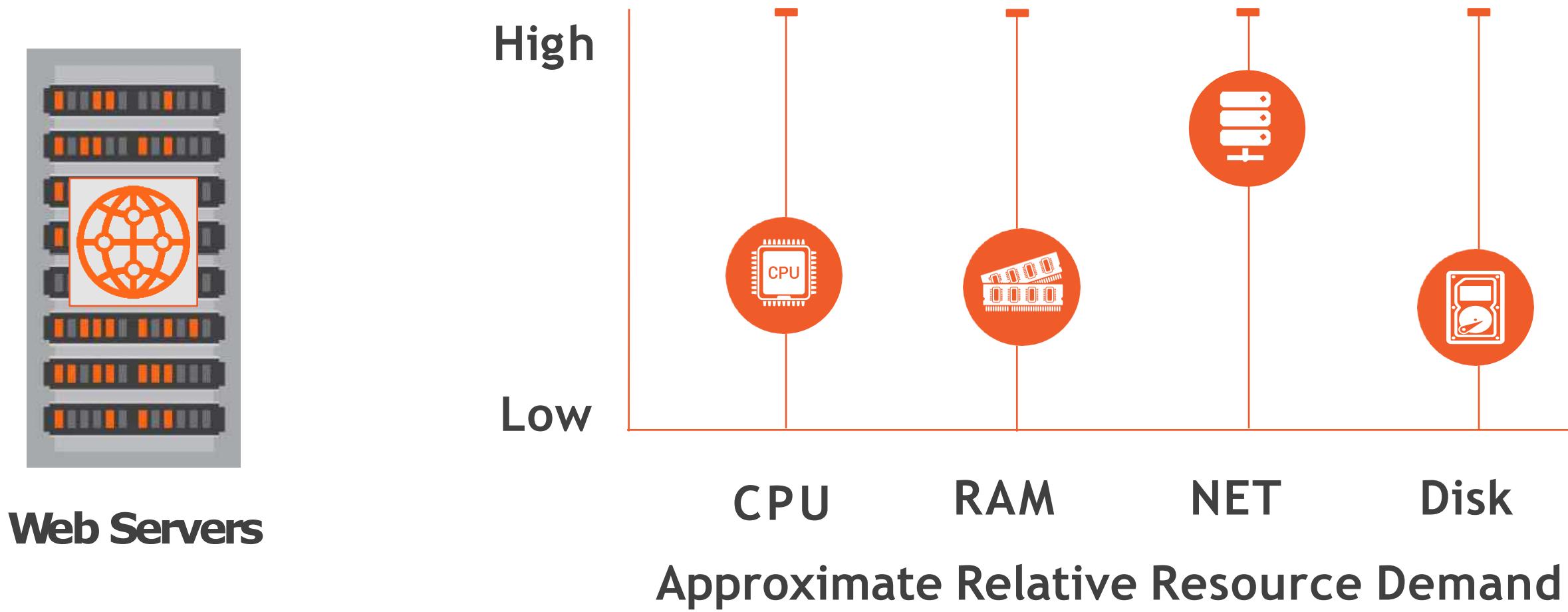


Authenticatio  
n Servers

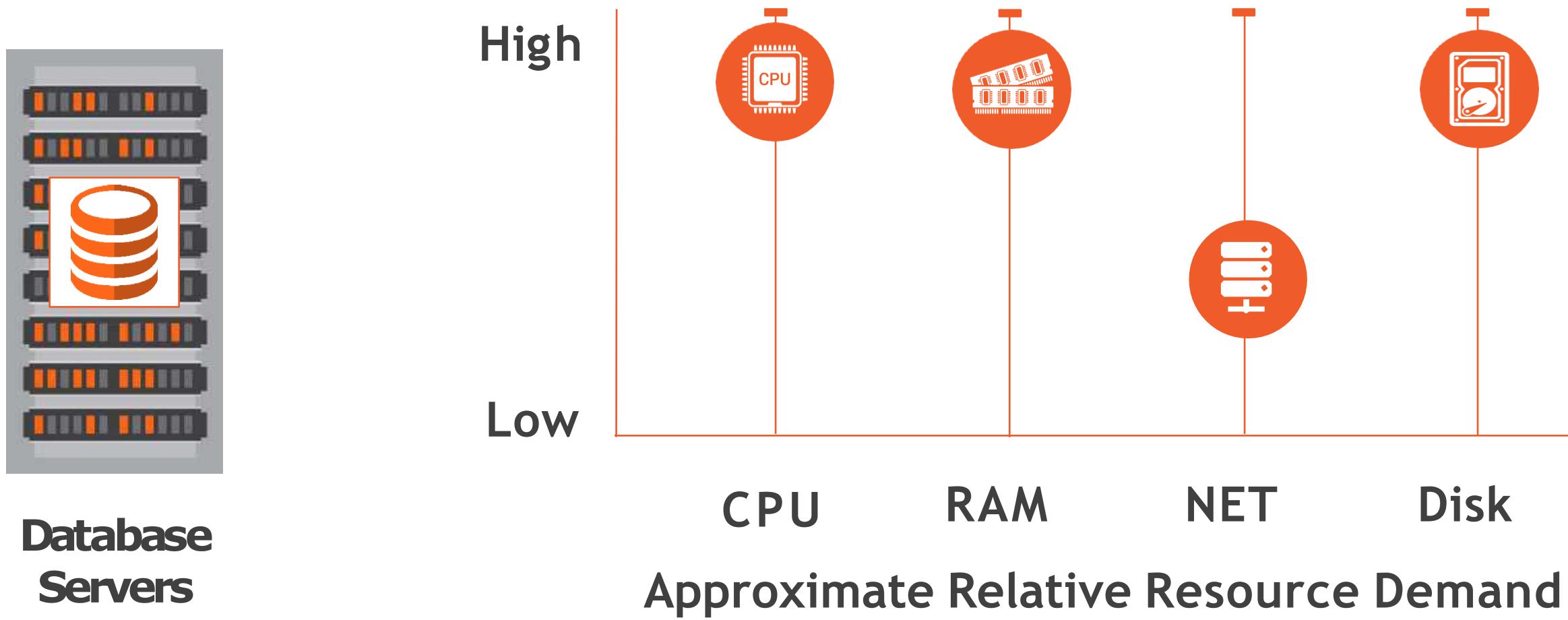
# Server Role vs. Resource Requirements



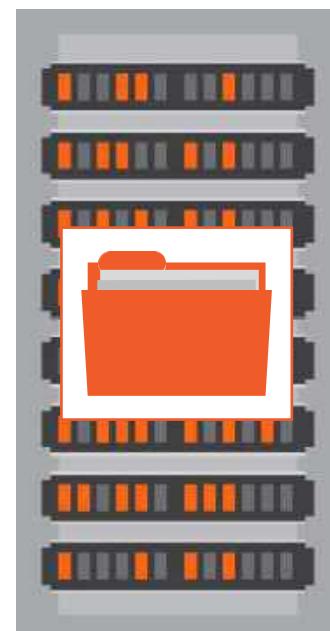
# Server Role vs. Resource Requirements



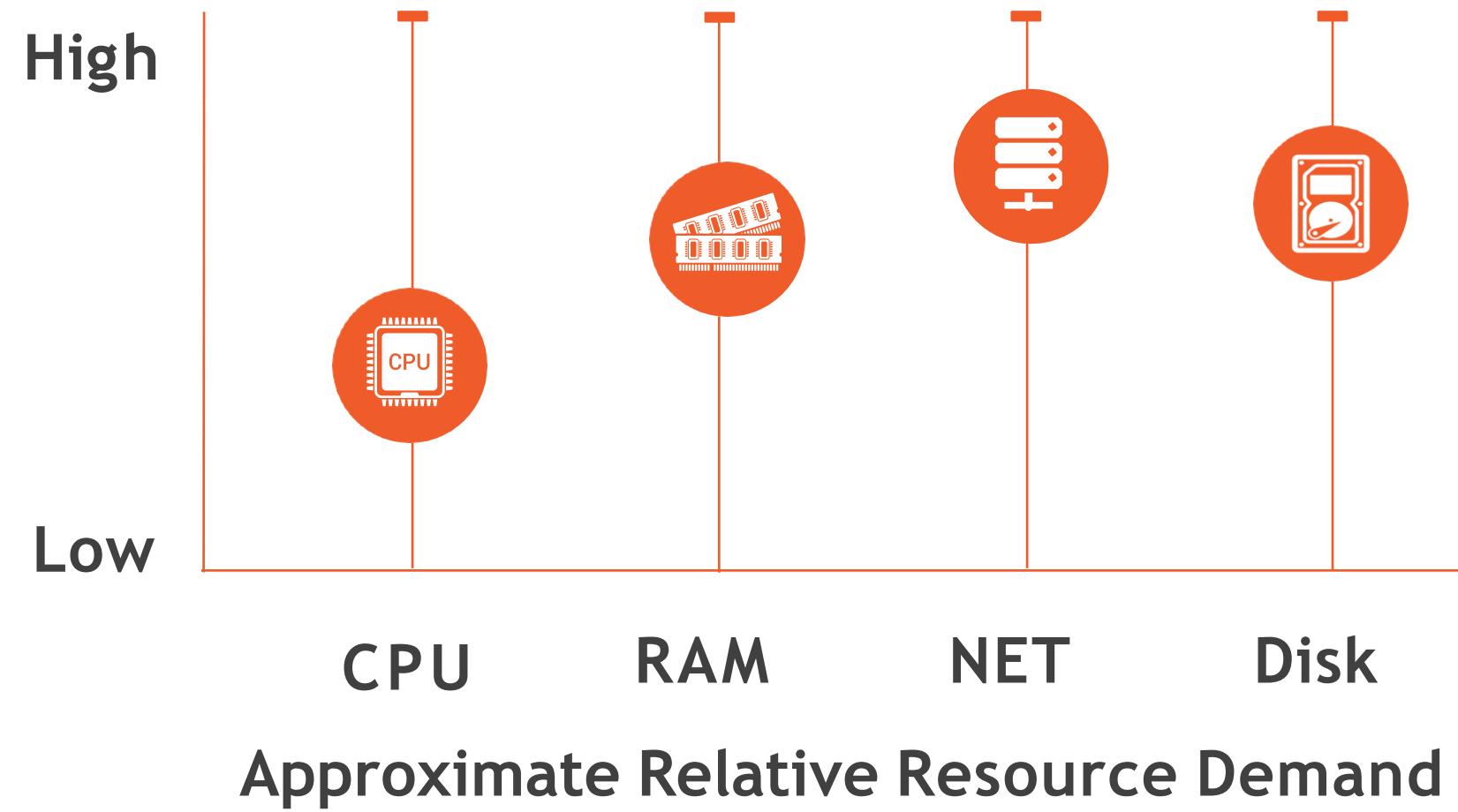
# Server Role vs. Resource Requirements



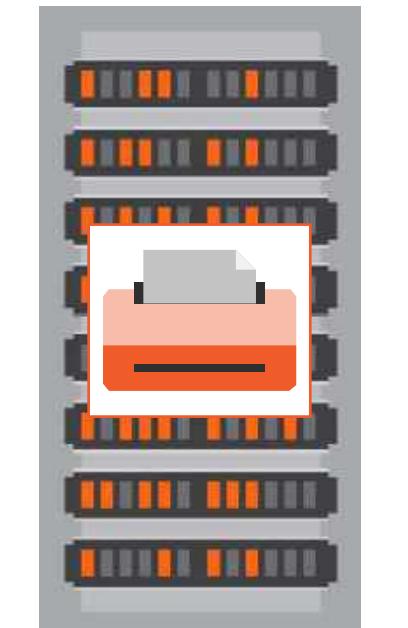
# Server Role vs. Resource Requirements



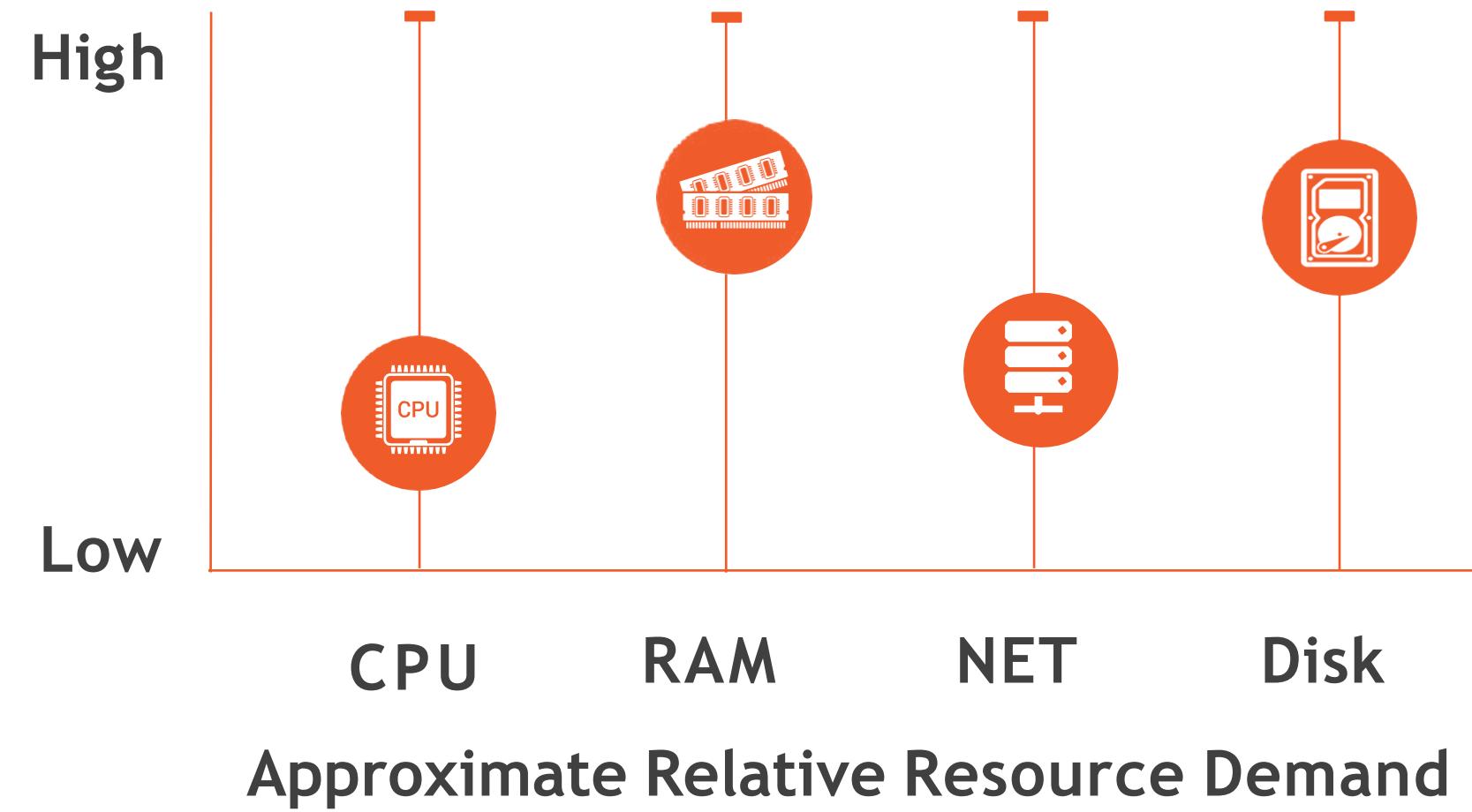
**File Servers**



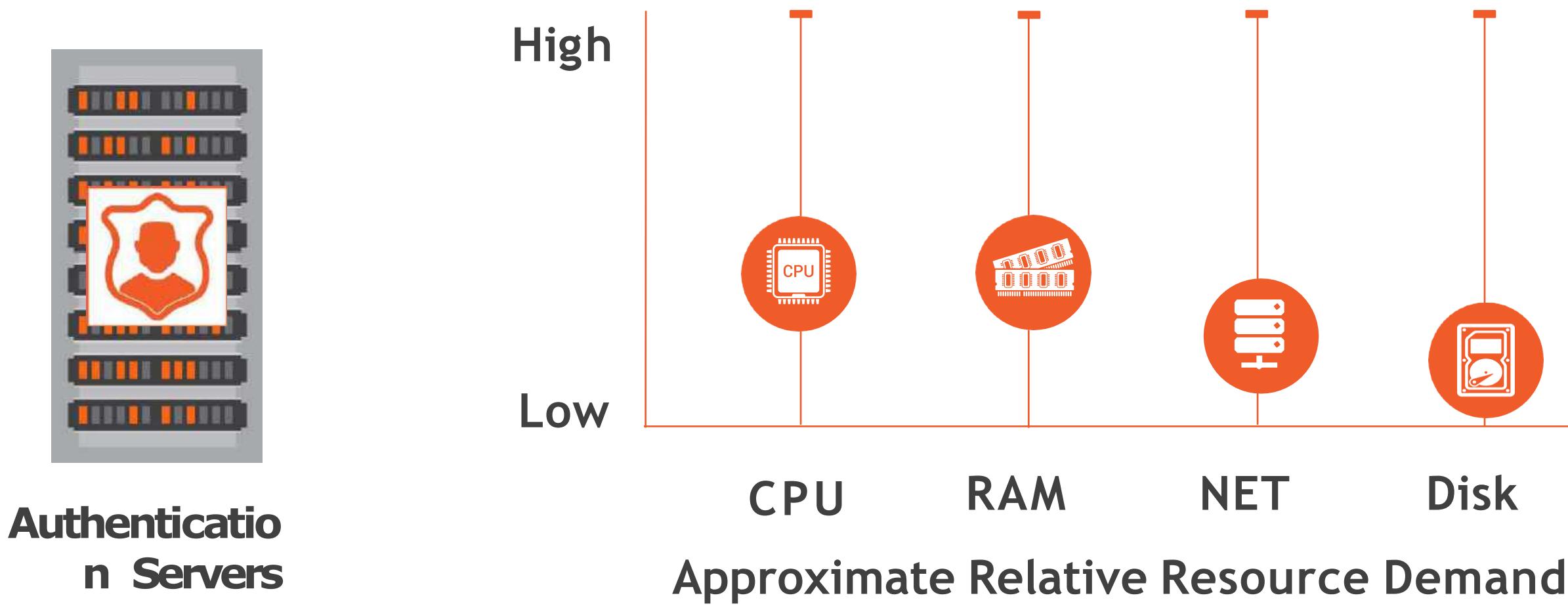
# Server Role vs. Resource Requirements

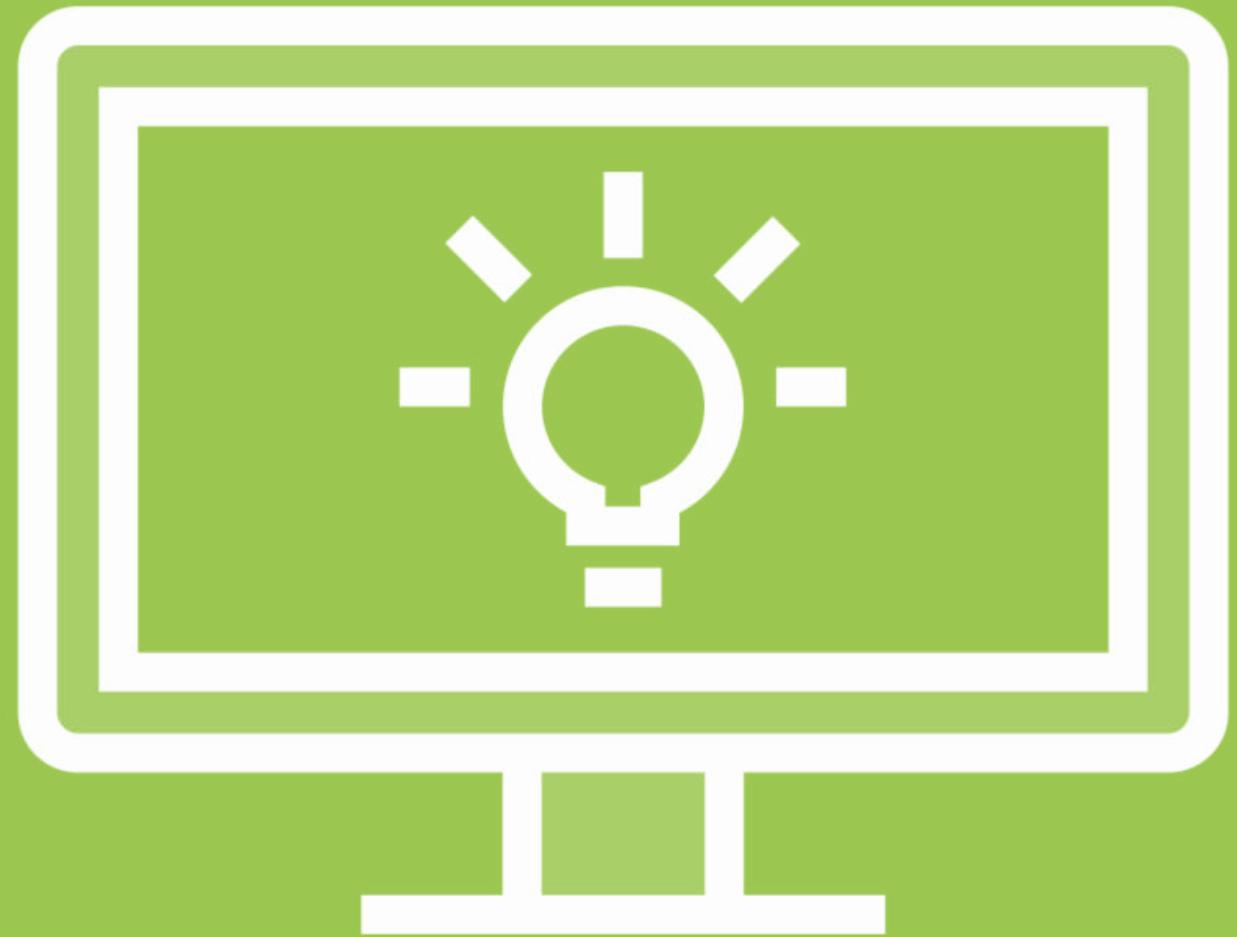


**Print Servers**



# Server Role vs. Resource Requirements





Tech Point  
RAM Types

Always get the fastest RAM you  
can afford, given other  
constraints

# Memory Types

**There are three principal types of Random Access Memory (RAM)**

**Today you will only find SDRAM modules in a server**

## SRAM

### Static RAM

Much faster I/O rates than DRAM at a higher cost per bit stored

Requires 6 transistors per bit of data stored

Commonly used as cache within a CPU, L1 – L3 cache

## DRAM

### Dynamic RAM

Requires only one capacitor and transistor per bit of data stored

Timing is measured in absolute terms using nanoseconds

No longer in wide use

## SDRAM

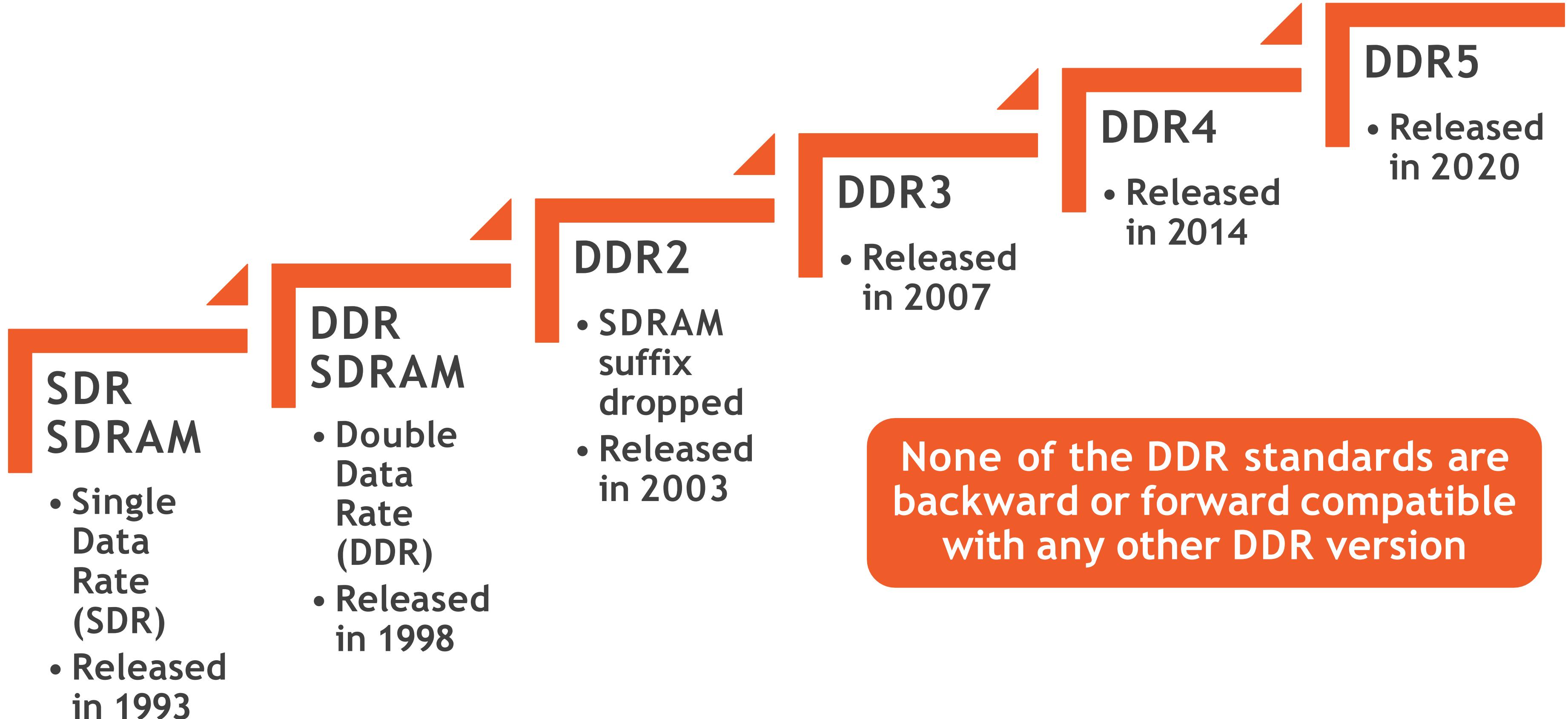
### Synchronous DRAM

Synchronous interface based on clock speed

Memory operations are pipelined (queued) to increase performance

The most common memory type in PCs and servers

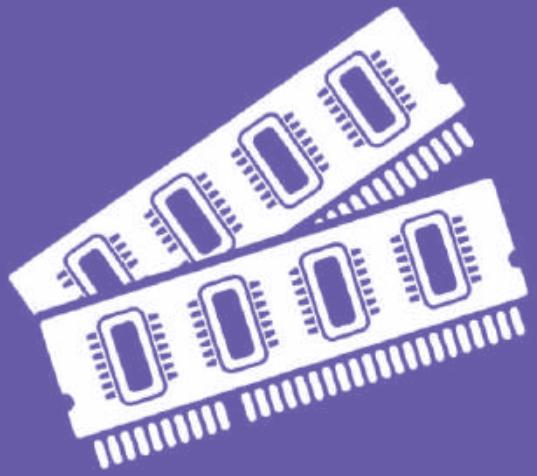
# SDRAM Memory Generations



# Number of Pins

Number of pins per DIMM vary depending on type

- DDR: 184
- DDR 2: 240
- DDR 3: 240
- DDR 4: 288
- DDR 5: 288

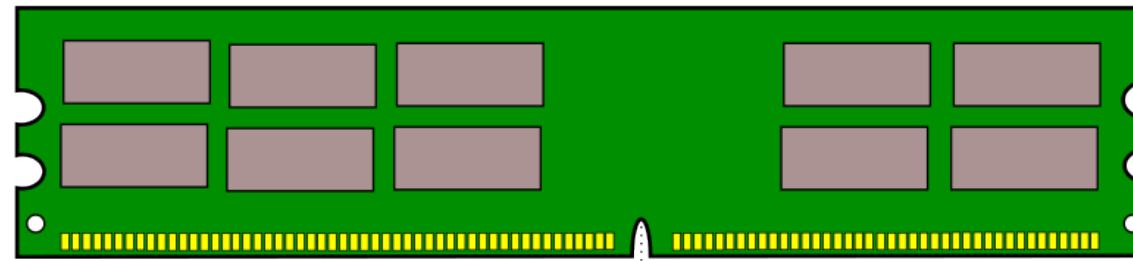


Laptops use a variant called SO-DIMMs that have a different number of pins

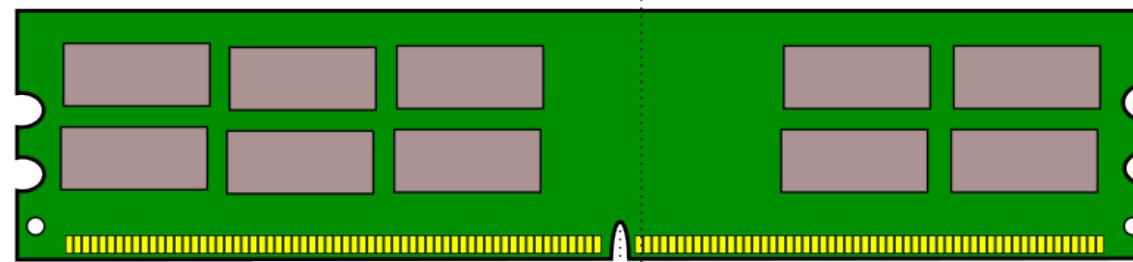


# DDR SDRAM Modules

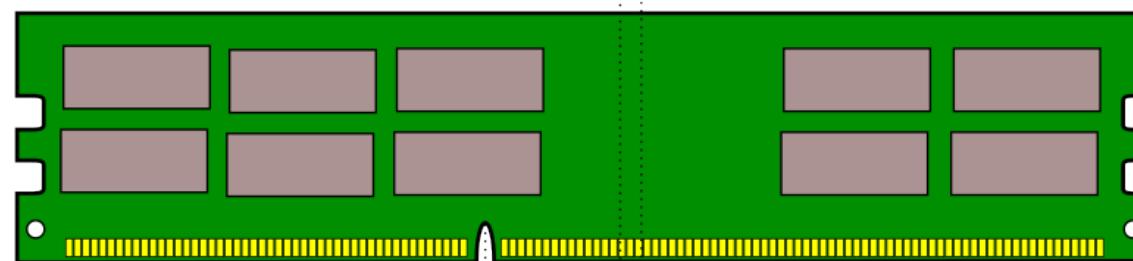
DDR



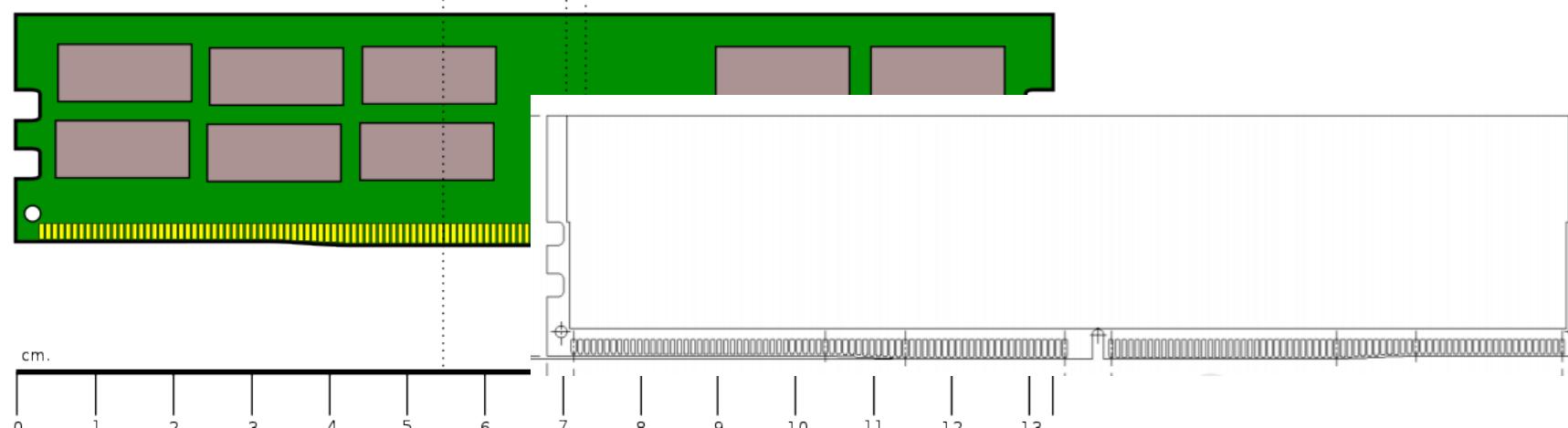
DDR 2



DDR 3



DDR 4



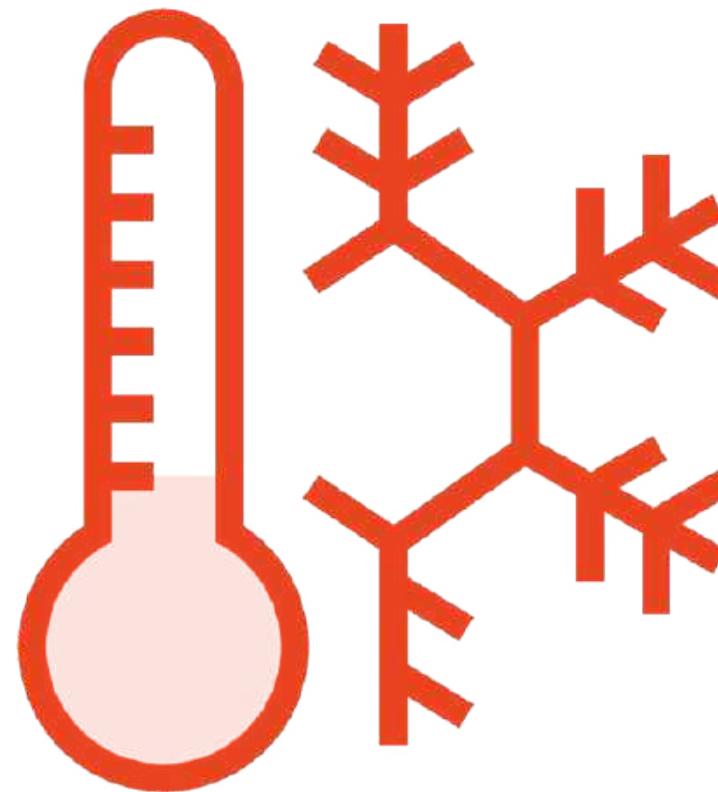
DDR modules are physically incompatible

A notch is placed at different offsets for each DDR family, a process called “keying”

This prevents accidental mixing of modules

# DDR Version Comparison

Each generation is about **20-30%** more power efficient than the previous version



Less heat produced in servers



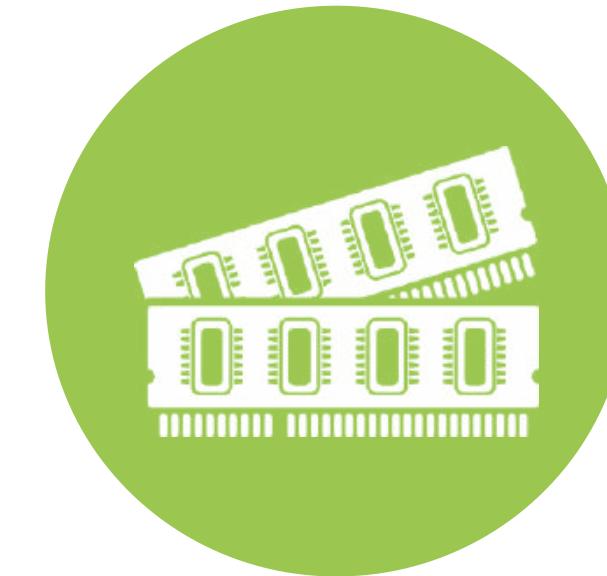
Better battery life for mobile devices

# DDR Version Comparison

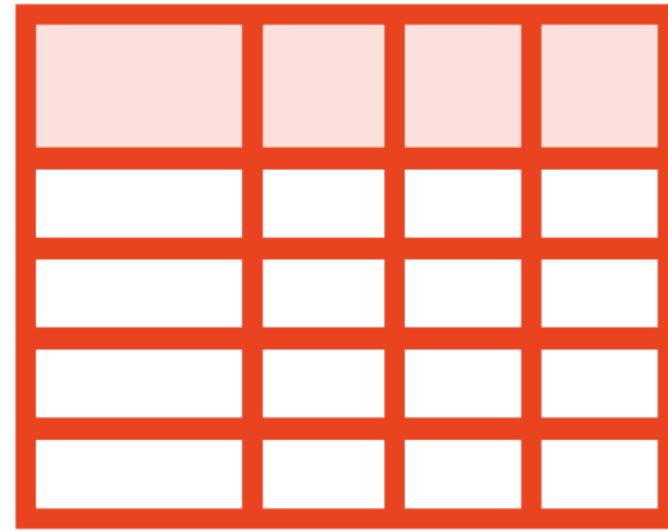
2X

Typically about 2X the maximum data transfer rate of the previous generation

Greater memory density per chip  
- More memory in less space

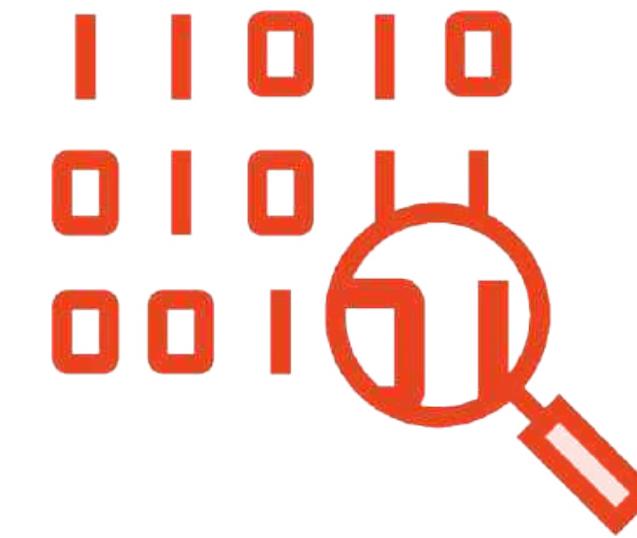


# RAM Characteristics



## Registered/Buffered

Impacts the maximum amount of memory in the system



## Error Correcting

Improves the reliability of the memory by correcting single-bit errors

# Registered/Unregistered Memory

is also known as

Buffered/Unbuffered Memory

# Registered vs. Unregistered Memory

Registered memory allows the memory controller on the motherboard to address more memory than unregistered memory

Most motherboards only allow one type (Registered or Unregistered), but some allow both

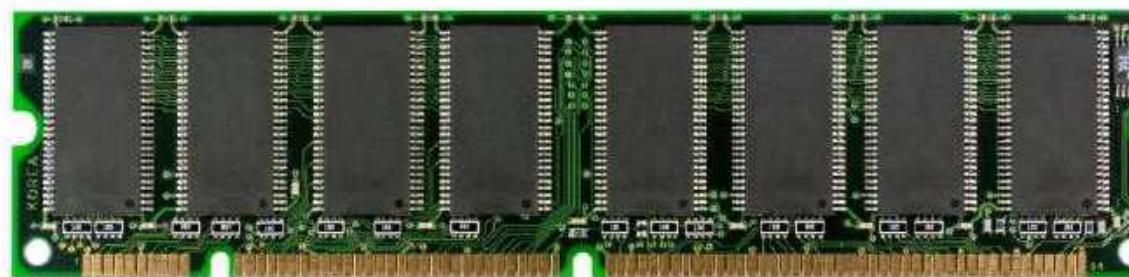
Example: A server may support 128 GB of unregistered RAM, but 512 GB of registered

Registered memory is more expensive and usually only used in servers

# ECC vs. Non-ECC



ECC Memory DIMM  
(Note the 9 chips)



Non-ECC Memory DIMM  
(Note the 8 chips)

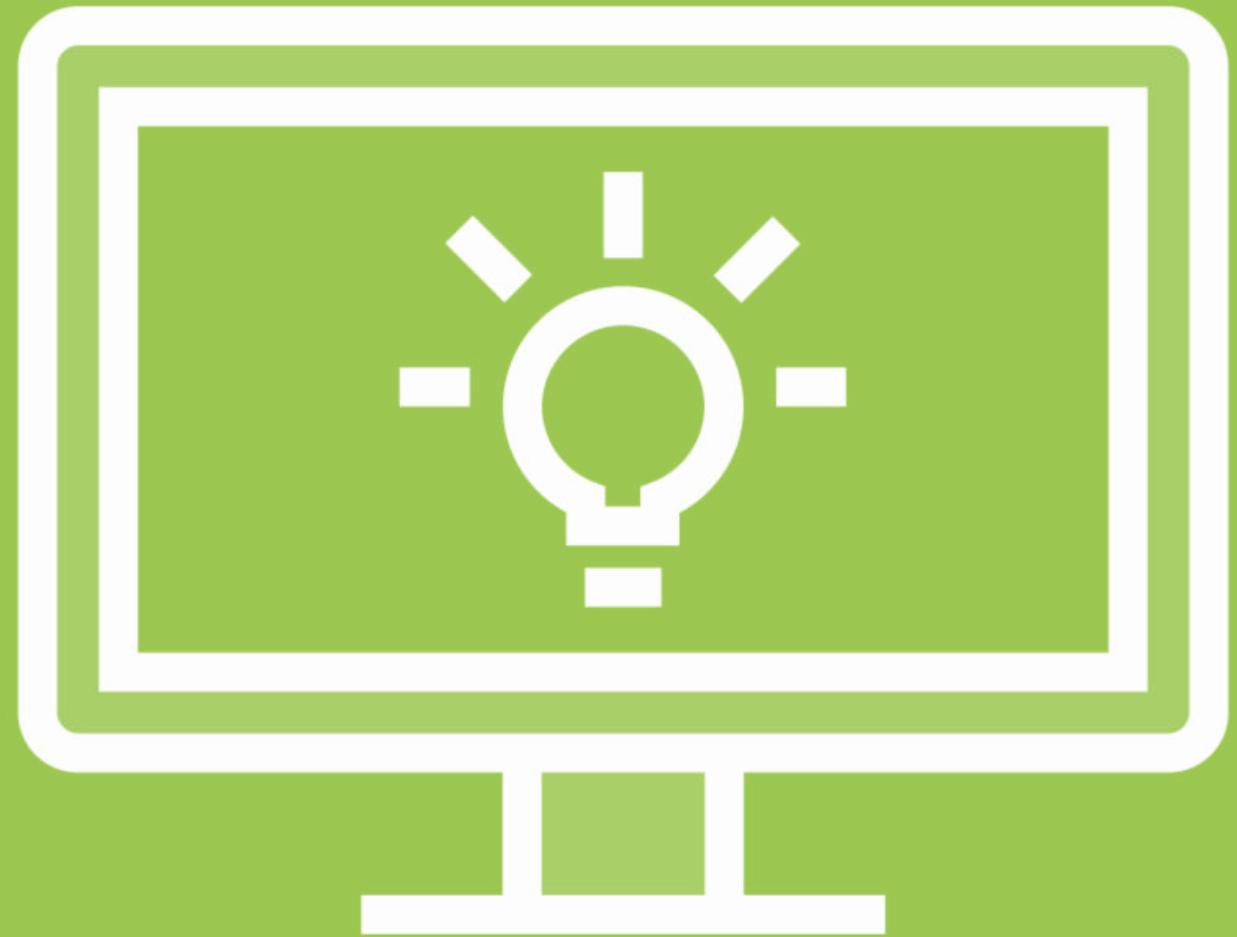
**ECC = Error Correcting Code**

**Physically ECC usually has 9 chips per DIMM  
vs. Non-ECC has 8**

**Can correct single bit errors (per 64 bit  
“word”) and detect (but not correct) double  
bit errors**

**Errors are usually reported in system logs**

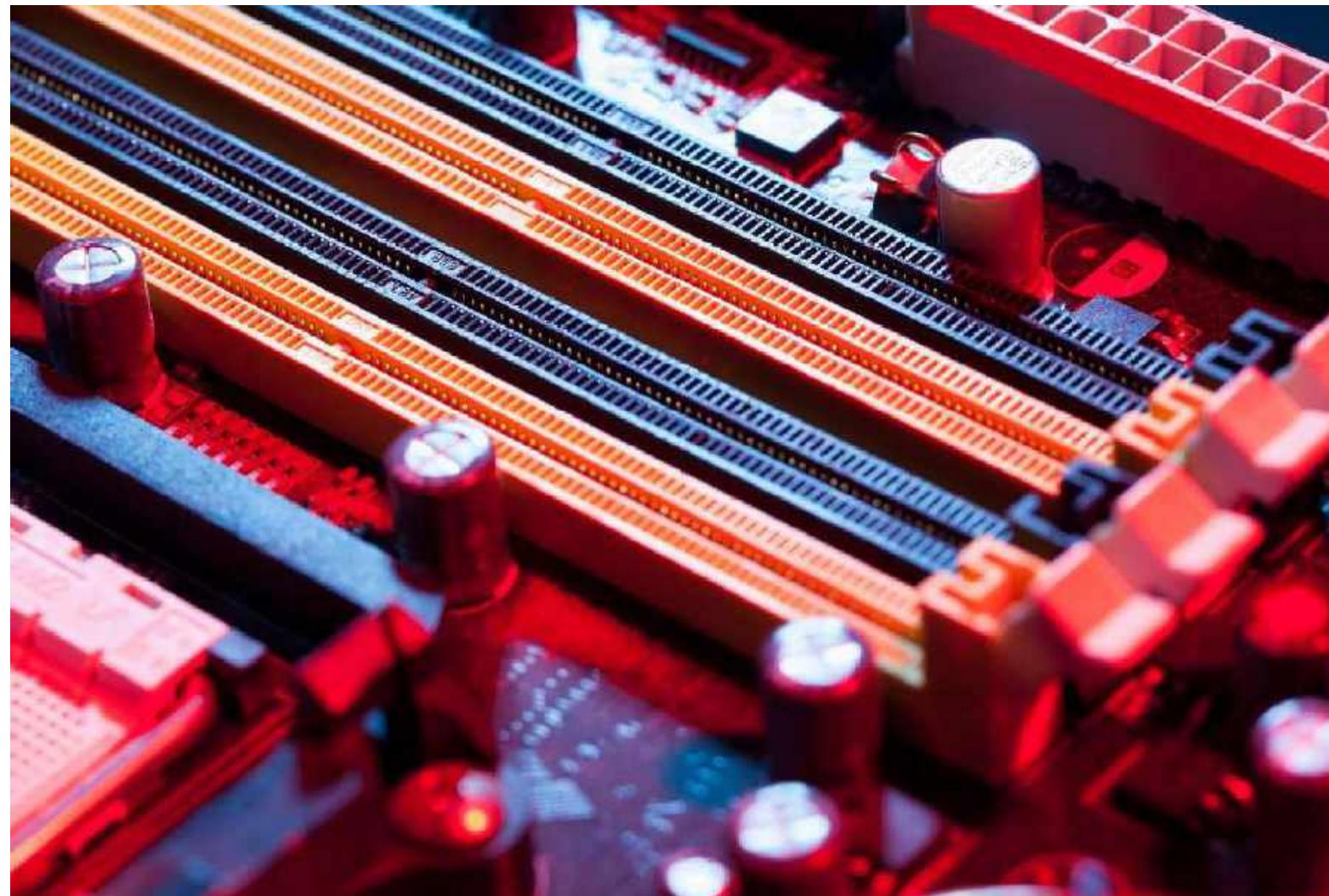
**ECC memory is more expensive and therefore  
usually only used in servers**



Tech Point  
Memory  
Placement

Location, Location, Location...

# Module Placement



Memory modules are typically installed in pairs into banks (slots)

The banks represent different memory channels, each associated with a particular CPU socket

You must be very careful into which channels you place your RAM

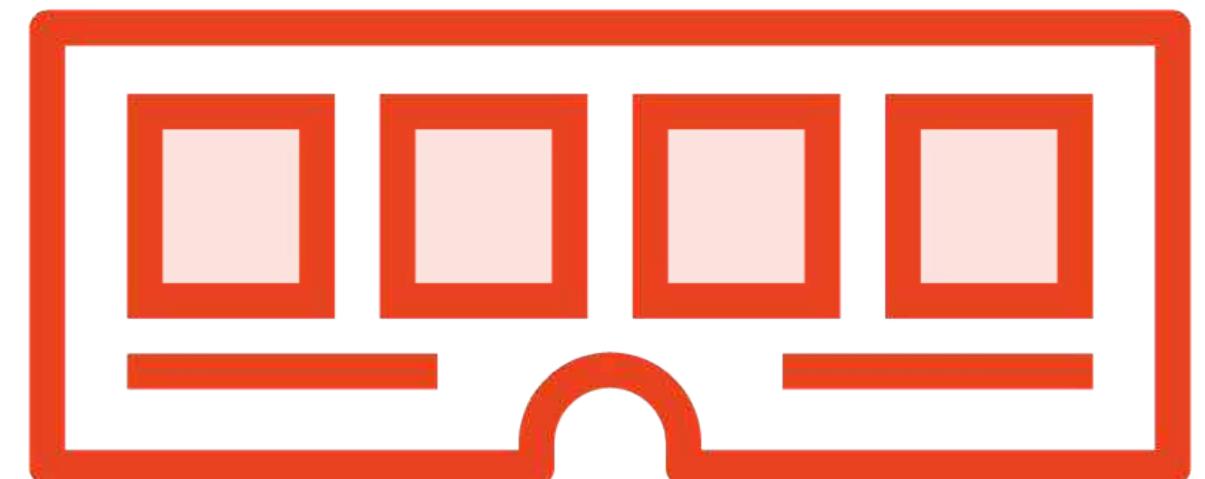
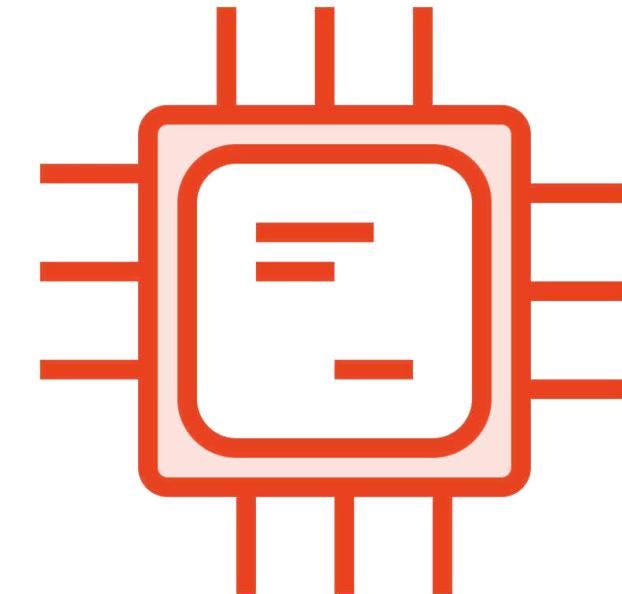
# NUMA Considerations

**NUMA = Non-Uniform Memory Access**

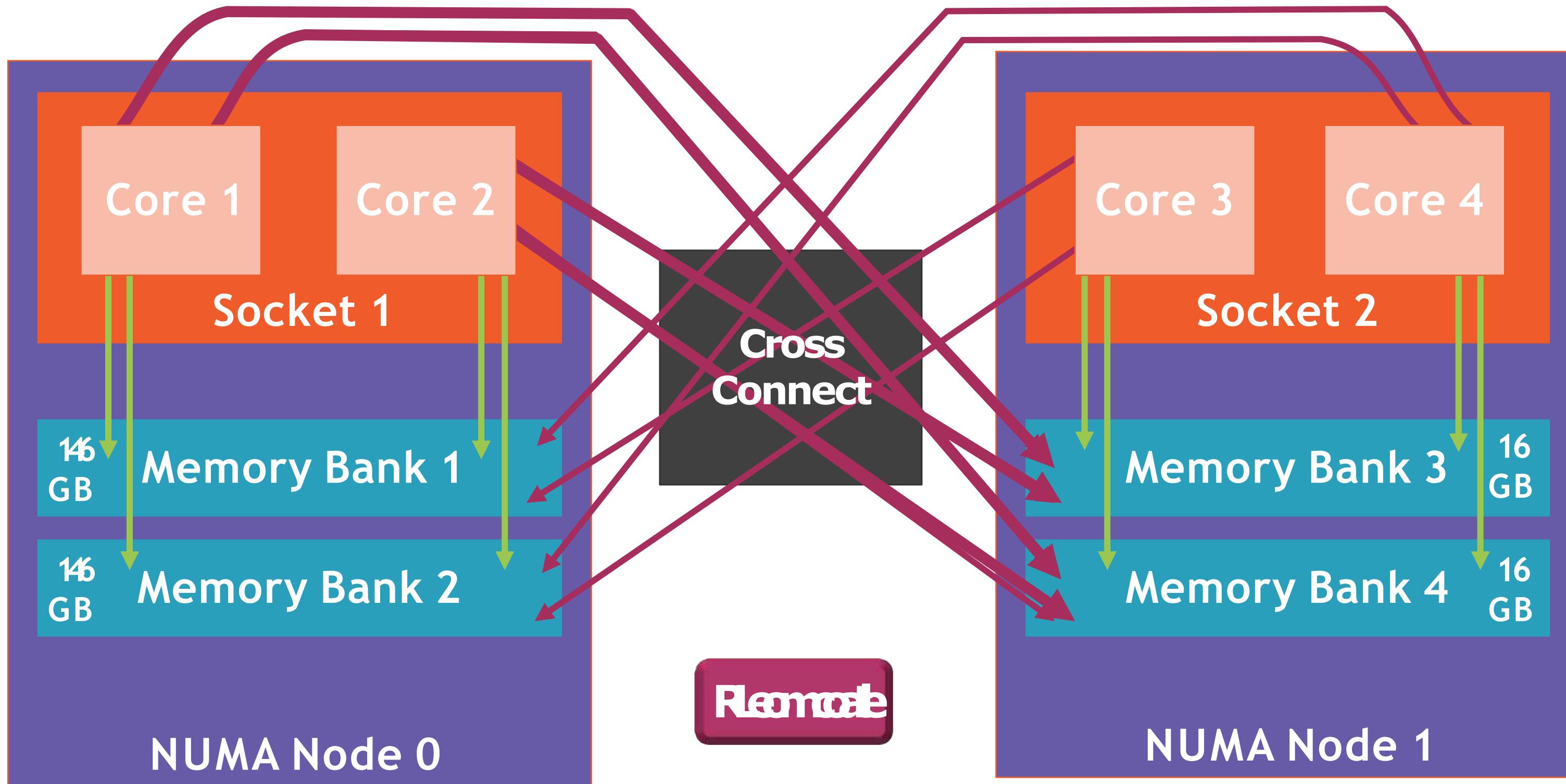
Modern operating systems allocate memory to take advantage of NUMA

NUMA systems have one or more NUMA nodes

Each NUMA node should have the same amount of memory



# NUMA Nodes





Tech Point  
RAM Speeds

# Data in Memory Is Stored in a Matrix

	A	B	C
1			
2			
3			



Select the row



Then select the column



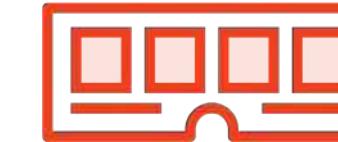
Finally, retrieve/store the  
contents at the intersection

# RAM Speeds

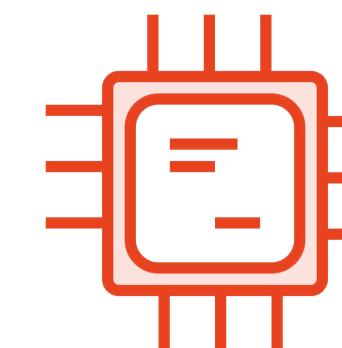
The speed of RAM is based on a number of factors



Clock speed



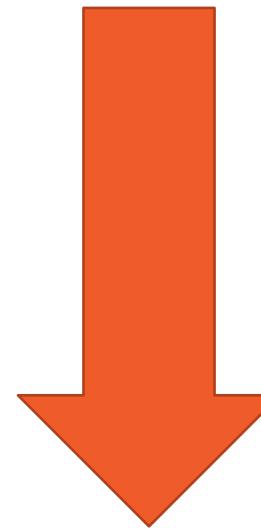
Memory chip latency



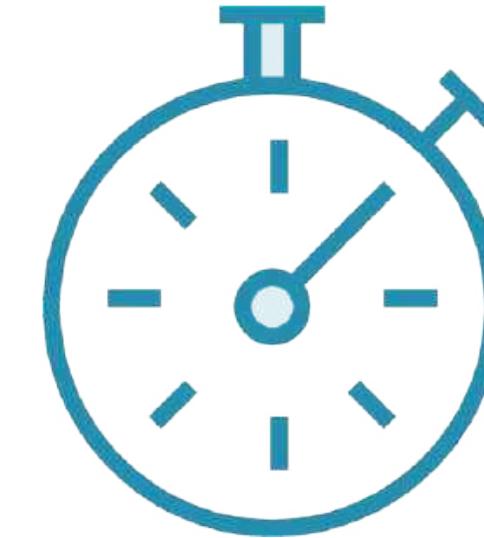
Contention from access by multiple CPUs

# Timing Overview

Memory timings are typically 4 numbers in a row, separated by dashes,  
(ex. 16-18-18-36 or 24-21-21-47)



Lower is generally better



In modern memory technologies (like DDR4) these numbers represent **clock cycles** rather than nanoseconds.

The latency in nanoseconds will be lower.

# Timing Numbers



Example: 16-18-18-36

16

$t_{CAS}$  Column Access Strobe (CAS): Column selection latency (CL)

18

$t_{RCD}$  Row Column Delay: Time between opening a row and selecting the column

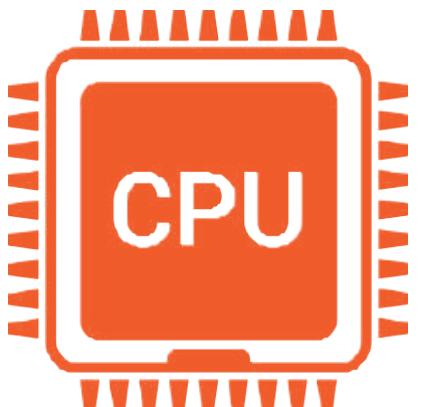
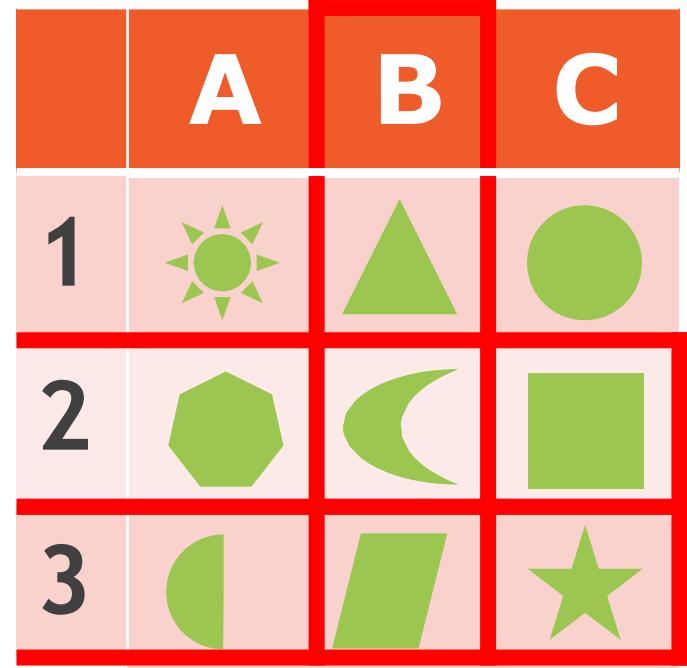
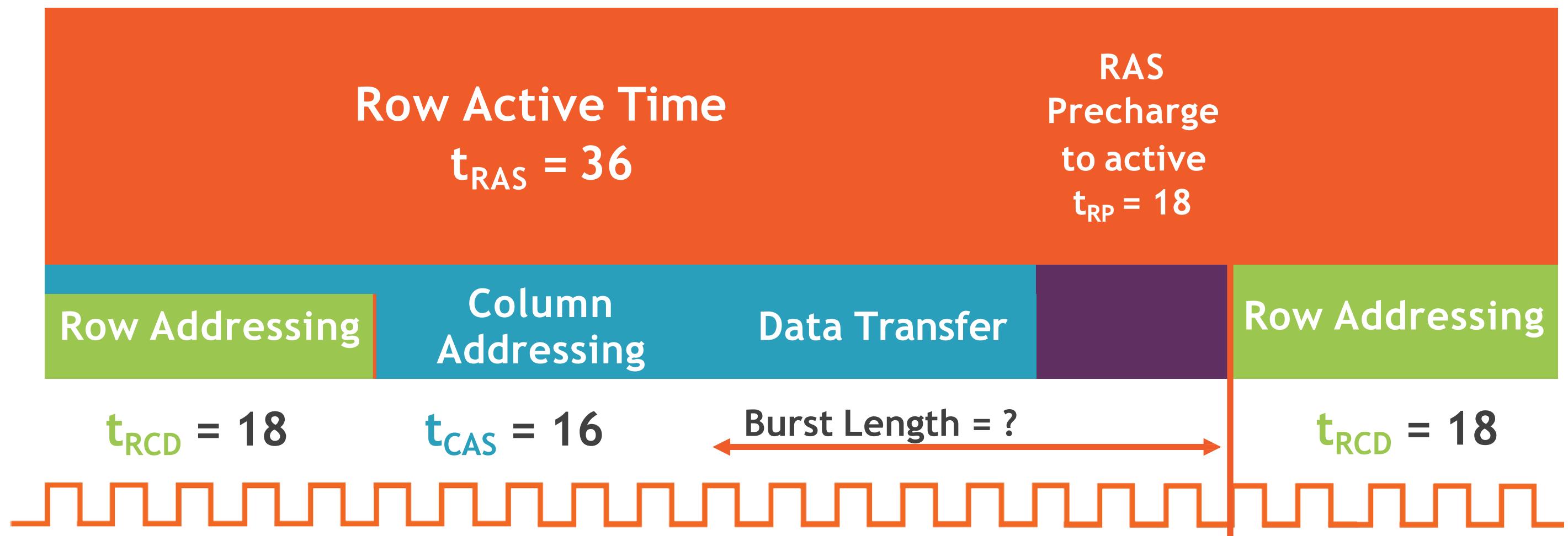
18

$t_{RP}$  Row Precharge: Time required before moving to a new row

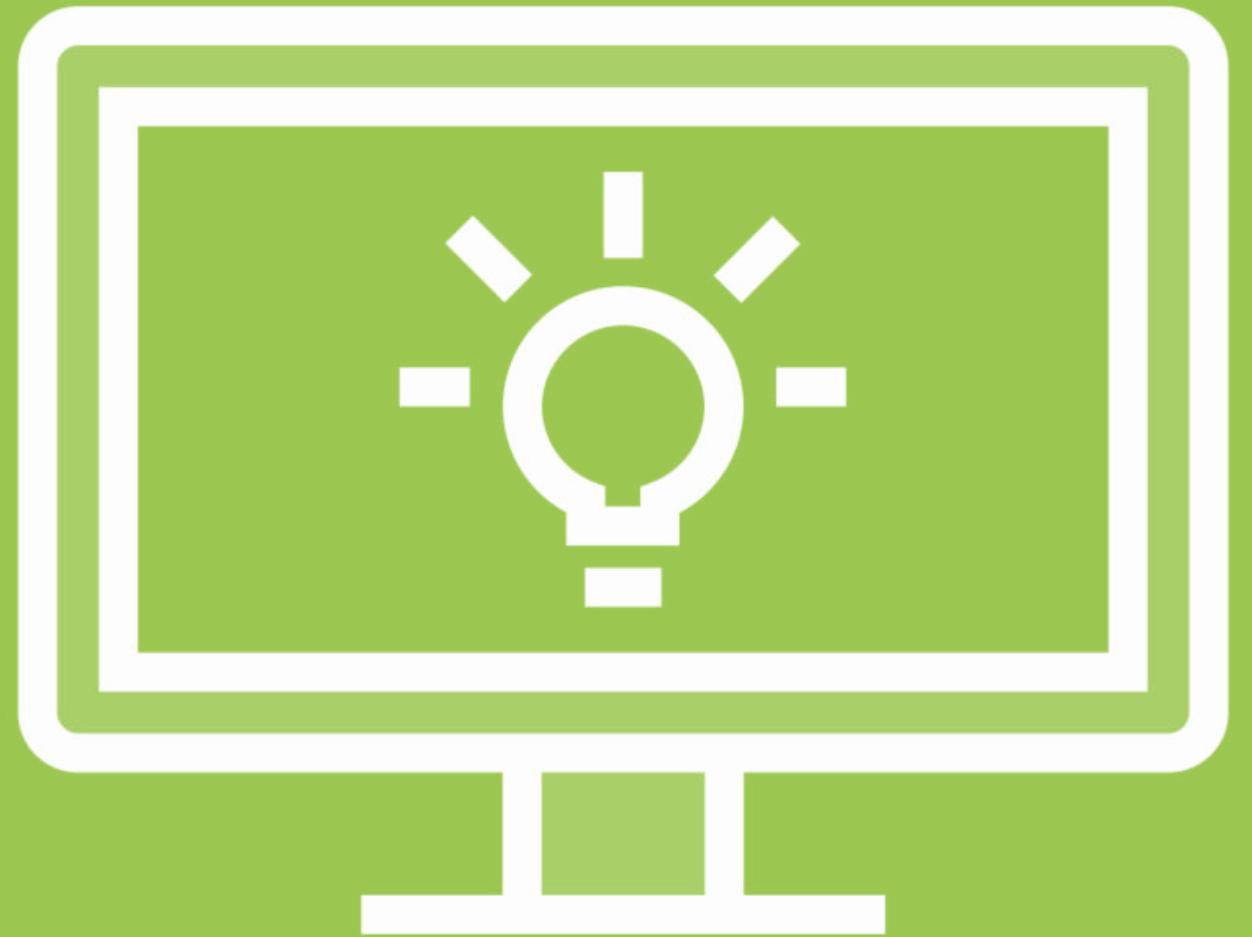
36

$t_{RAS}$  Row Active Time (RAS): Not a typo. Minimum time a row must be active to allow enough time to access desired data

# Timing Illustration

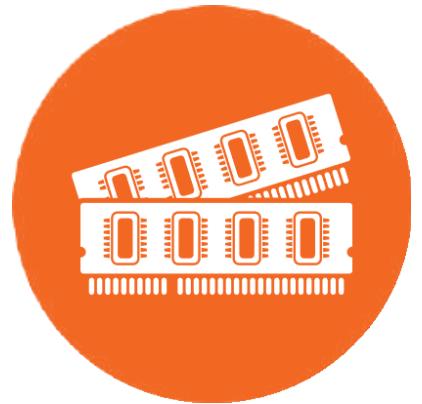


Example: 16-18-18-36



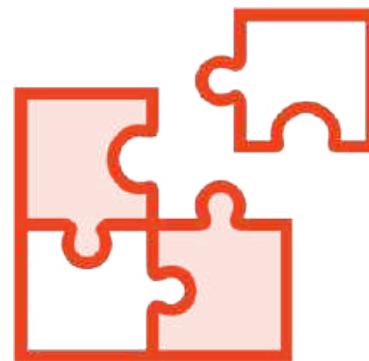
Tech Point  
Fault Tolerant  
Memory

# Memory Pairing Requires Group Installation to Achieve Full Capabilities



**Usually 2, but 3, 4, or even more are possible**

- Groups are usually color coded, but no standard on colors or how they are grouped



**If less than the full group is used (ex. 2 of 4), will operate in dual channel mode instead**



**Memory must be the same speed and capacity (ideally they are identical)**

- If slower, runs at slowest module in the group
- In some cases, if smaller, uses dual channel mode for size in common and single channel for the rest

# Fault Tolerance Techniques

ECC vs. non-ECC

Memory mirroring

Memory sparing

# Memory Mirroring

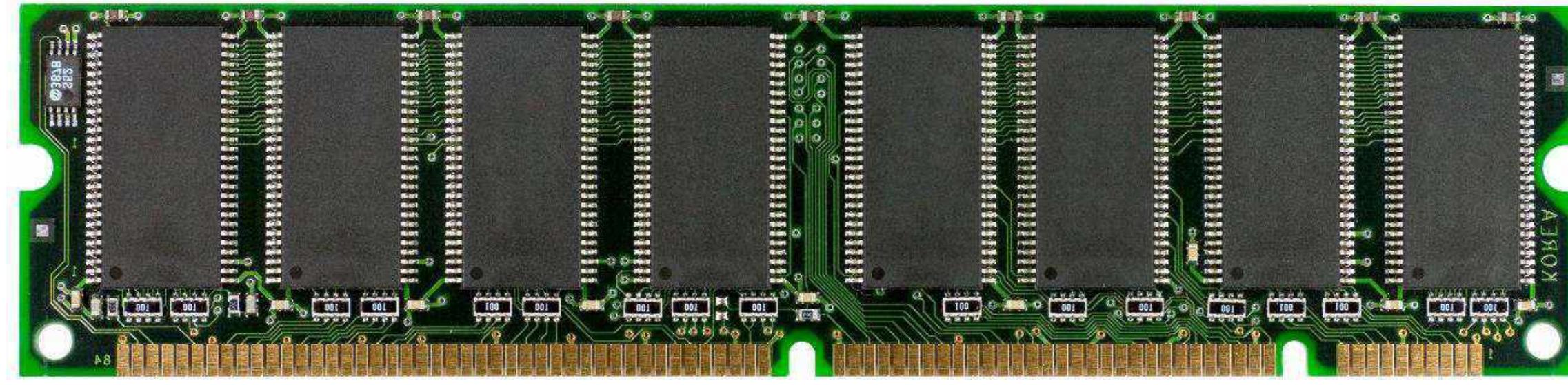
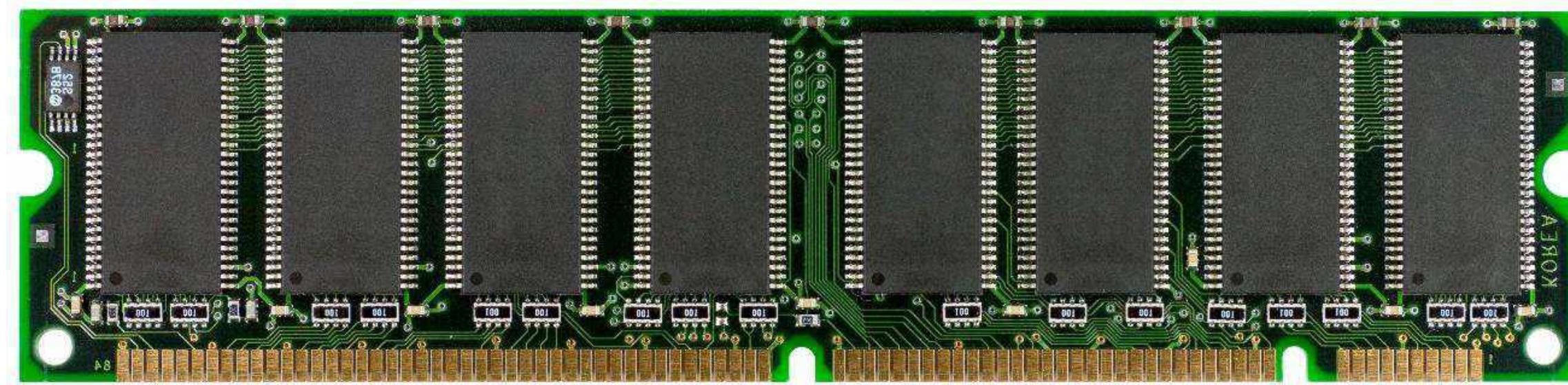
Similar to RAID 1  
for RAM

Two copies of data  
written to separate  
memory channels

- Only half of purchased RAM is usable
- Writes are mirrored to both DIMMs
- Reads are alternated between the copies

Not often used  
except for the  
most sensitive of  
data that cannot  
under any  
circumstances get  
corrupted or lost

# Memory Mirroring Example



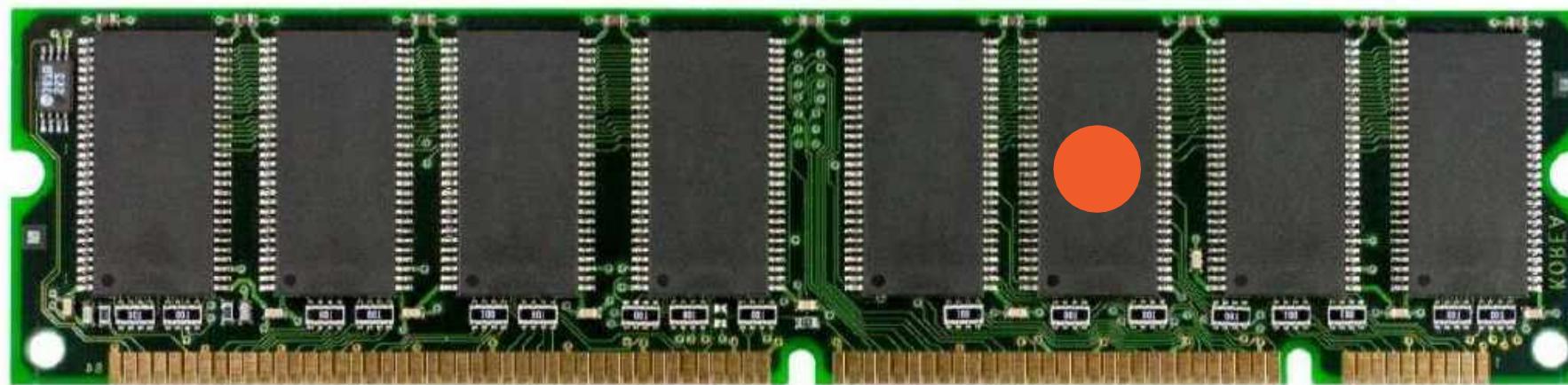
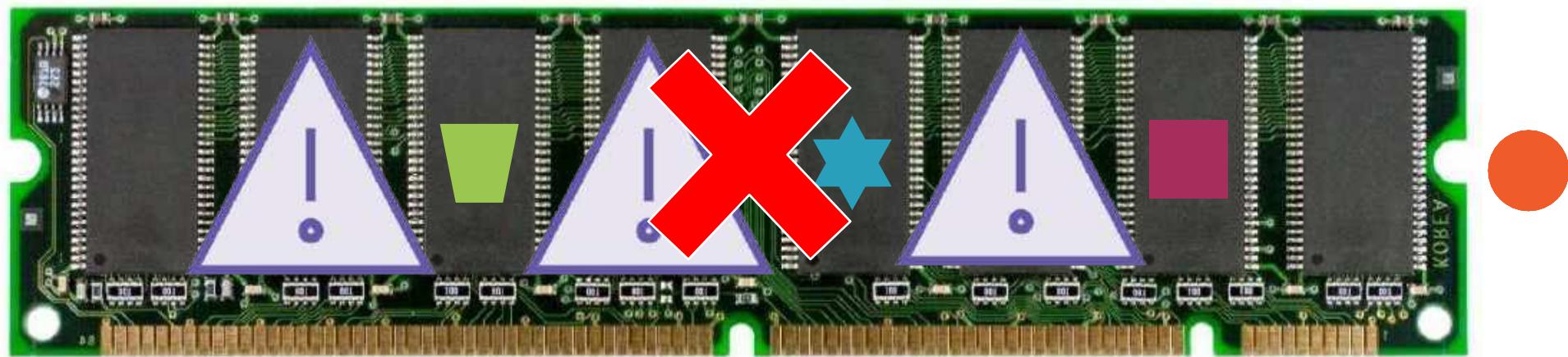
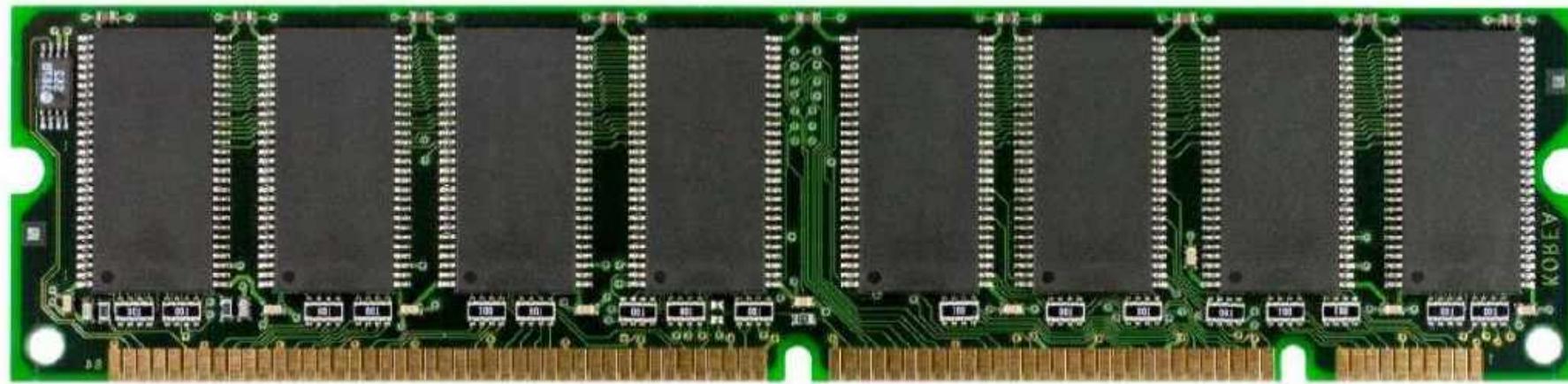
# Memory Sparing

Similar to a hot spare in storage

DIMM is not used until a preset number of errors occurs (the threshold), then contents are copied from failing DIMM to the spare

Can be used with ECC memory and / or Memory Mirroring

# Memory Sparing Example

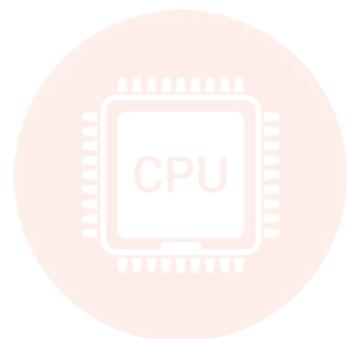




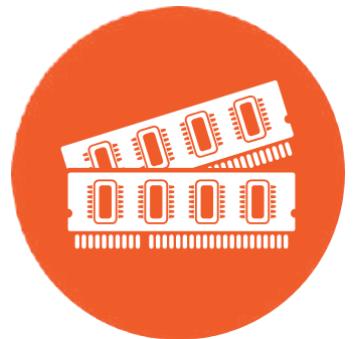
Hindsight



# Minimum Hardware



1 CPU Sockets with 6 cores



64 GB of RAM



1 Gbps Networking



512 GB Storage

# Recommended Hardware

2 CPU Sockets with 12 cores each

256 GB of RAM

10 Gbps Networking

3 TB Storage



# Decision Points

# How Critical Is the Server?

If server downtime will cause lost business or opportunities the server may be Mission Critical to the company, even if the company is small.

When lives are on the line, redundancy is imperative.



**Standard Server**

Non-ECC Memory



**Mission Critical**

ECC memory required

Memory spares if available



**Lives depend upon it**

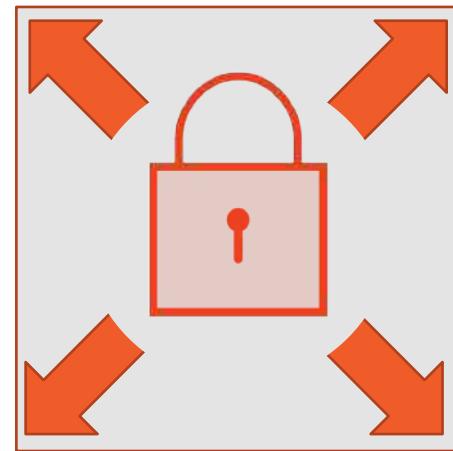
Memory Mirroring  
Required

Memory Spares Required

# Is Memory Scalability Important?

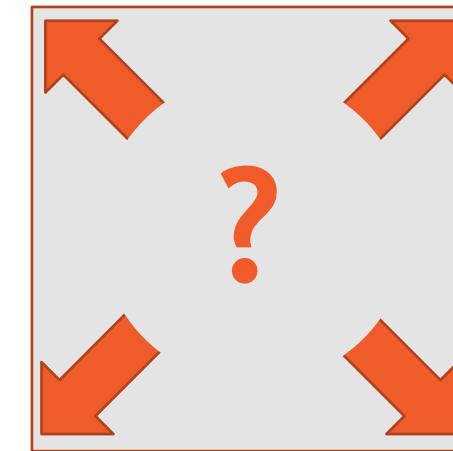
In terms of memory, scalability refers to increasing the RAM capacity of the server later in its lifecycle.

Scalability is important if you intend to add additional roles or applications to the server.



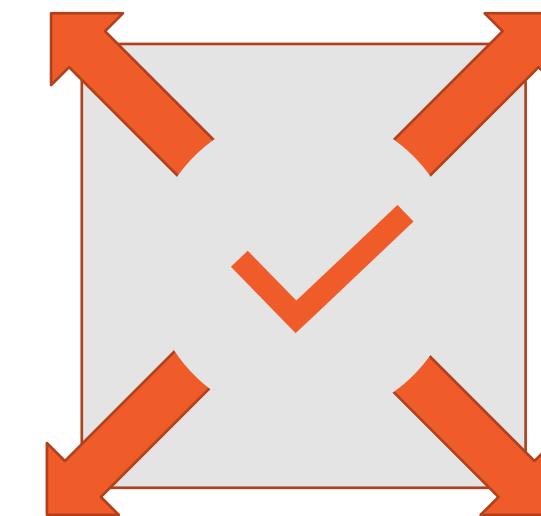
## Will not be scaled up

Unregistered (unbuffered) memory is sufficient and less expensive.



## May be scaled up

Consider Registered (buffered) memory if supported by the server



## Will be scaled up

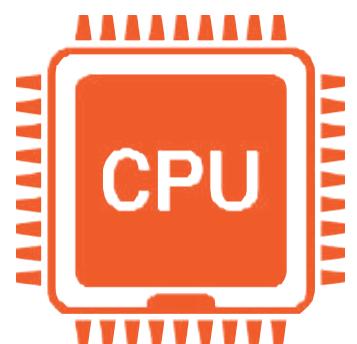
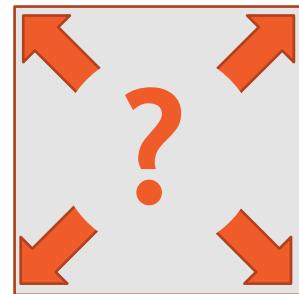
Use Registered (buffered) memory



Globomantics is a small company, but this server is mission critical to them.

They do not intend to scale up the server, but it may be necessary.

The server will be multi-processor, meaning that NUMA must be considered.



ECC Memory will be required,  
No need for memory mirroring,  
Hot spare memory if available.

Registered (buffered) memory if possible, but not required

Ensure that the memory is evenly divided between the CPU sockets



# System Board Considerations

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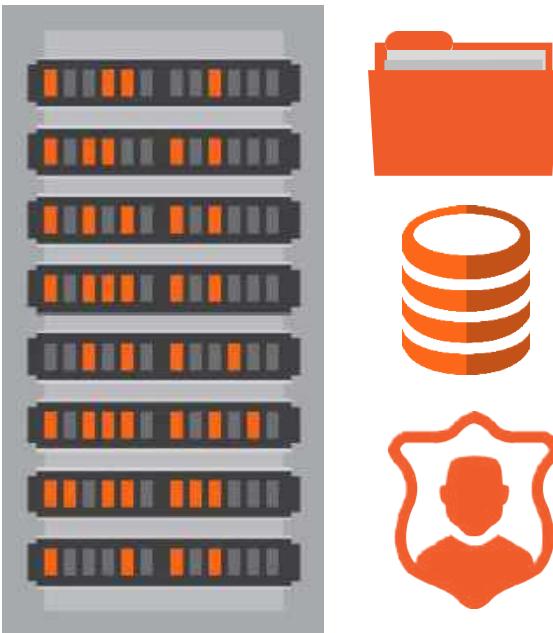


# Storyline

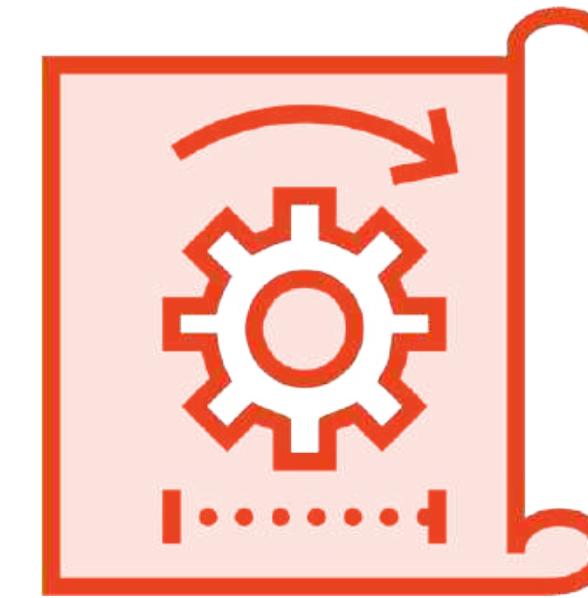


Globomantics are researching the details of their server and are now considering their choices for the system board.

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



# What Do You Need to Know?



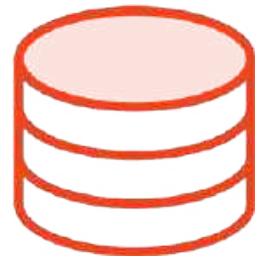
This time we're not looking for a specific component, but rather we are trying to understand the architecture.

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

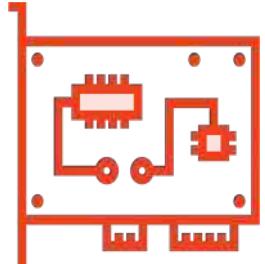
# Server Devices



**Graphics Processing Units (GPUs)**



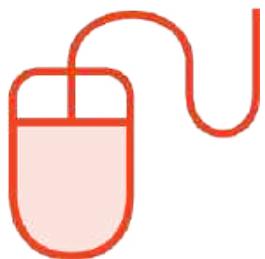
**Hard disk drives**



**Network cards**



**USB devices**

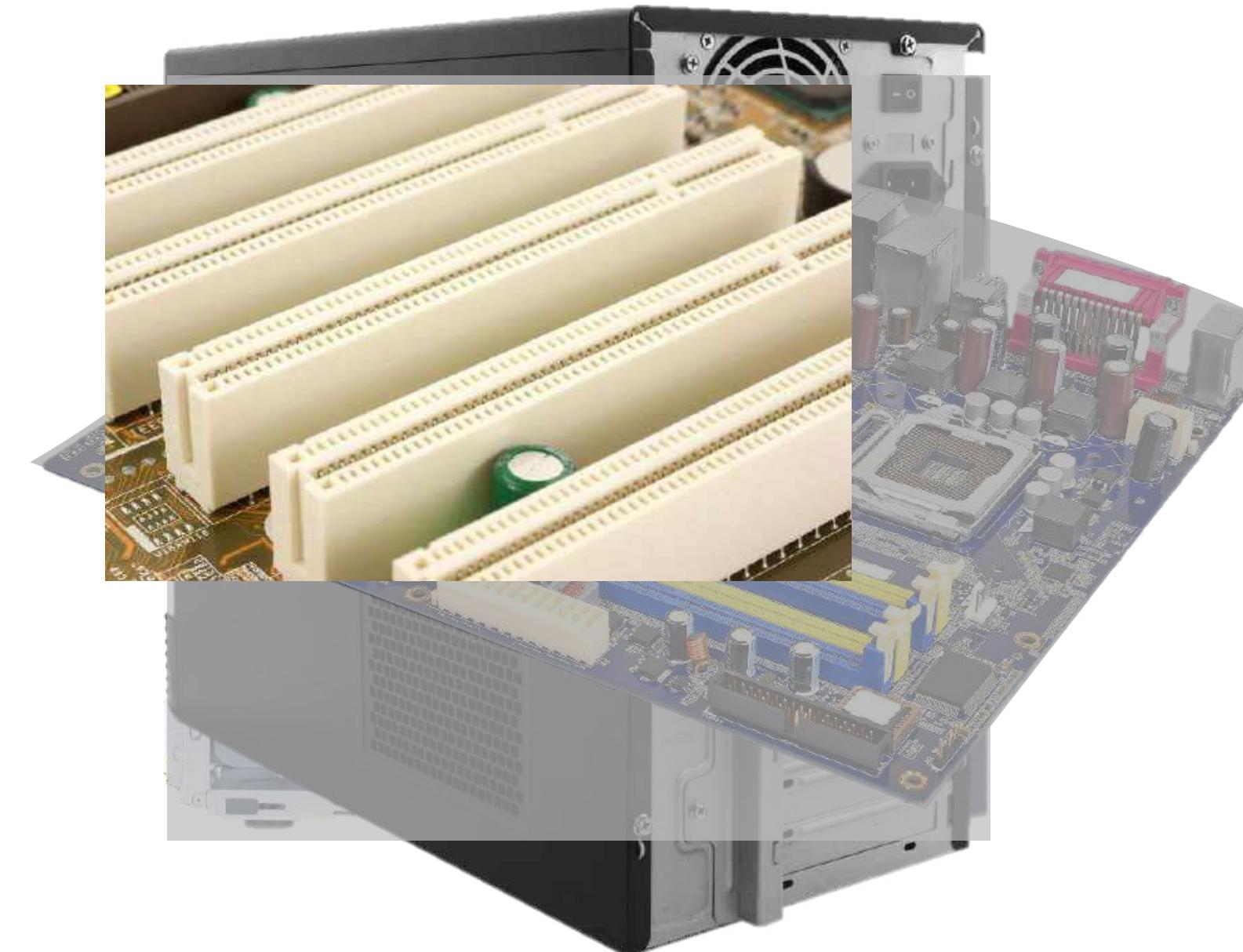


**And more!**

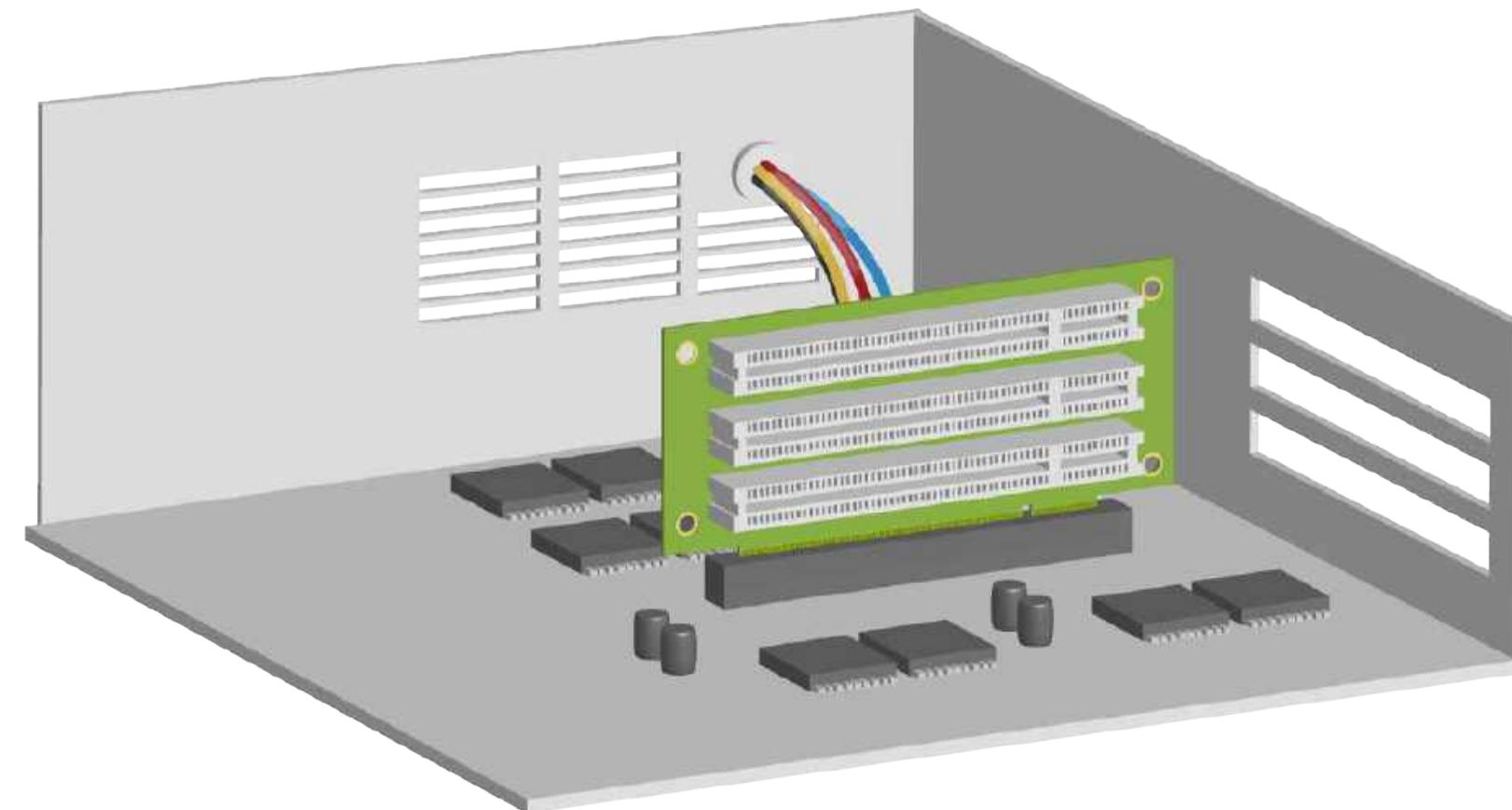
We have discussed CPU and Memory.

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

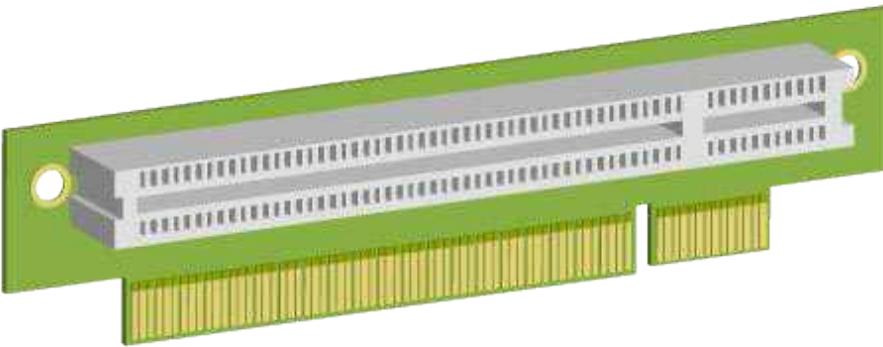


PCI Riser Board and slots

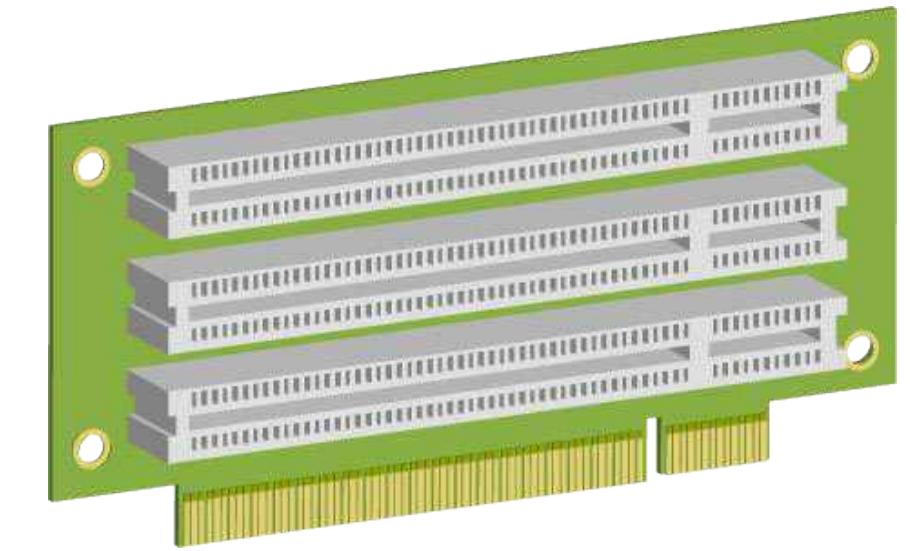
# Riser Cards

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



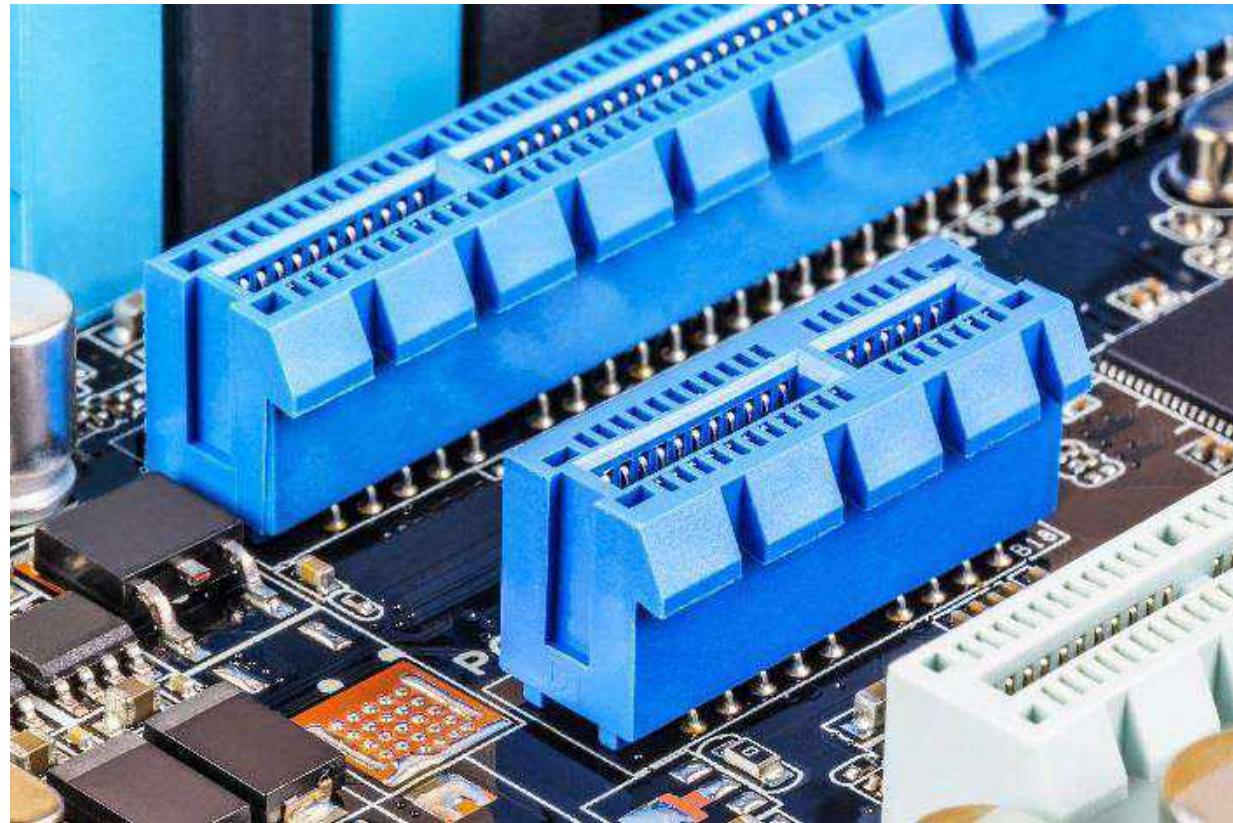
## PCI Express (PCIe)

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

PCIe leverages serial communication

Often supports hot-plugging

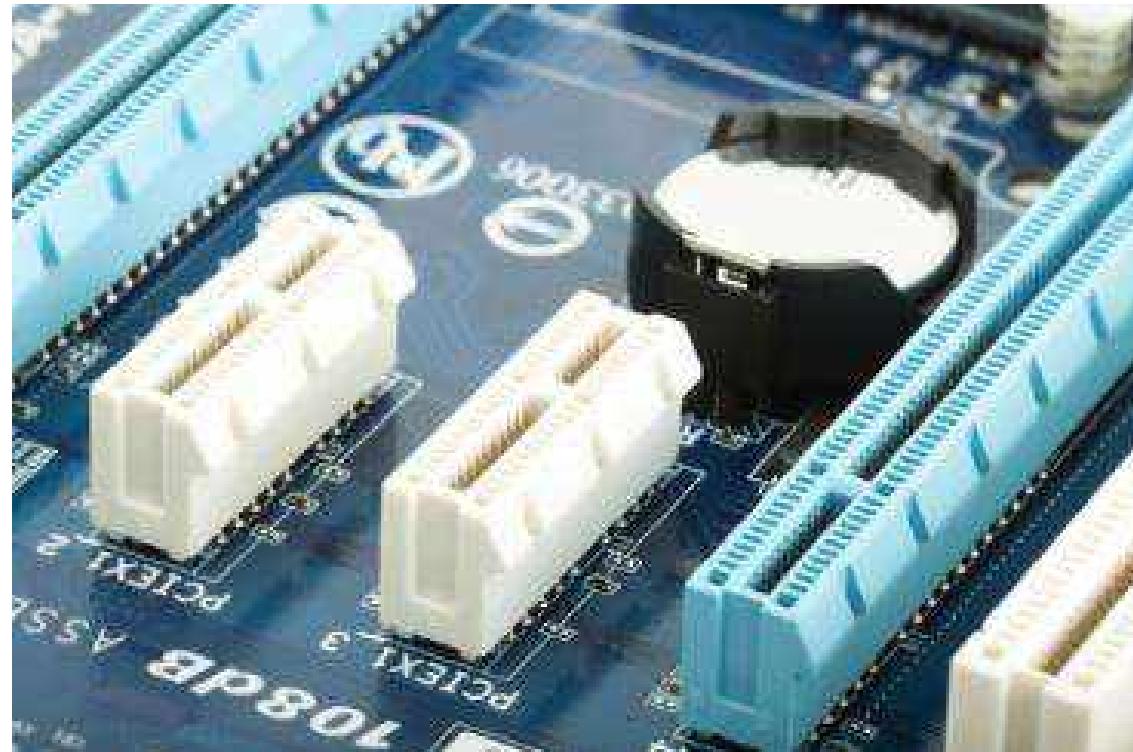
# PCIe Overview



## 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



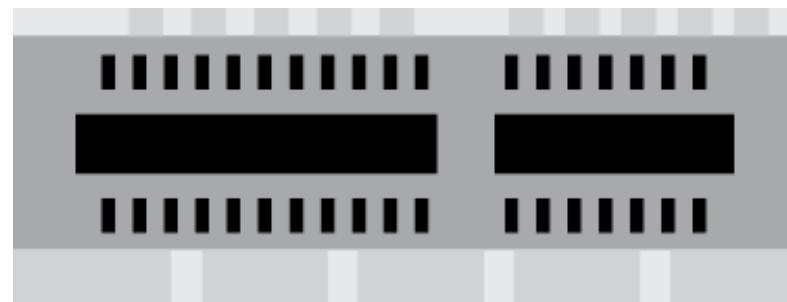
## Lanes (x1, x4, x8, x16)

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

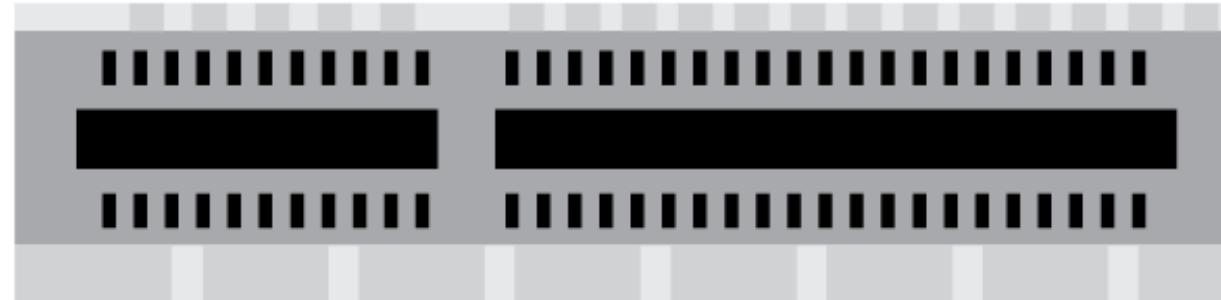
## Communication path in both directions

- 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

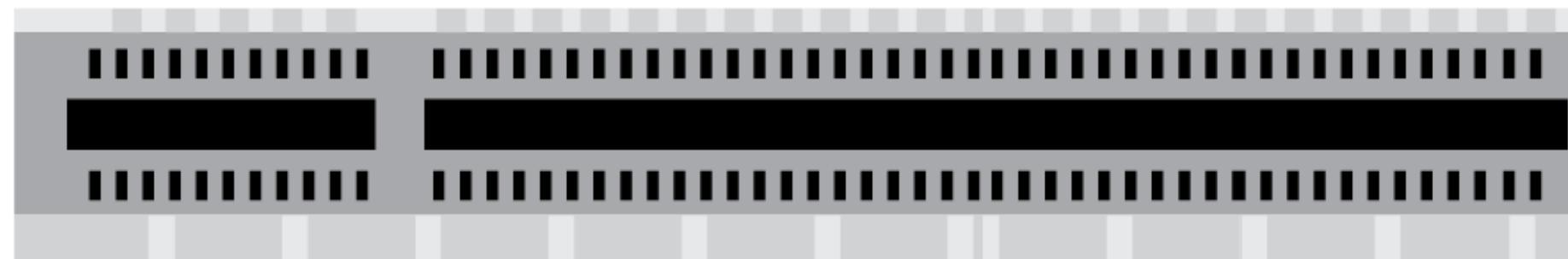
# Examples of PCIe Cards and Slots



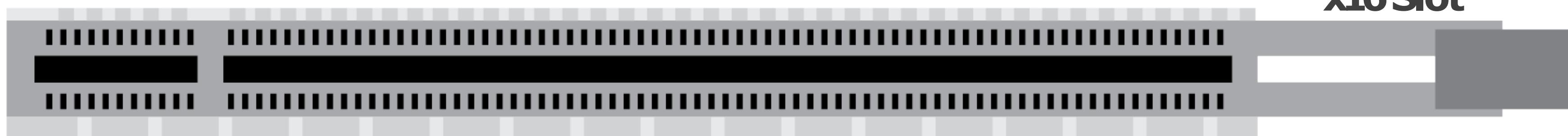
**x1 Slot**



**x4 Slot**



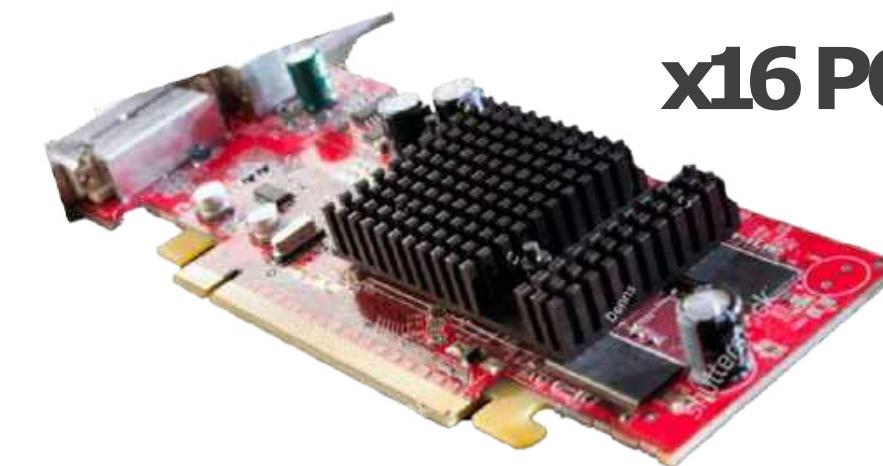
**x8 Slot**



**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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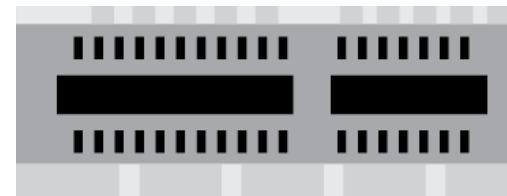
PCIe 4.0

What types of PCIe slots are available?

x1, x4, and x16



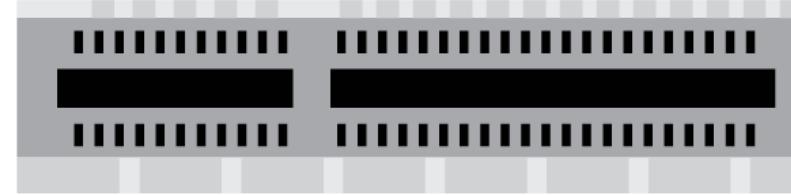
**x1 Slot**



PCIe 4.0 with 1 lane = 15.76 Gbps



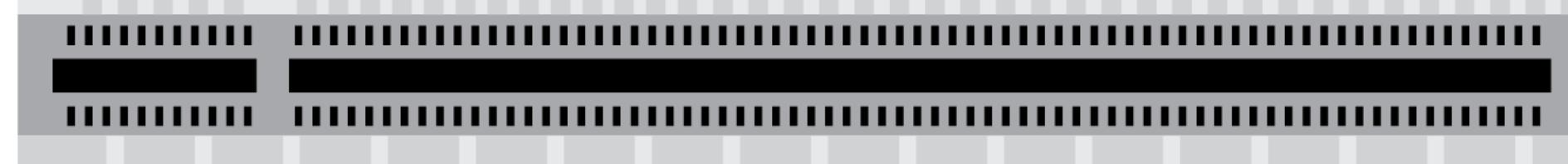
**x4 Slot**



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

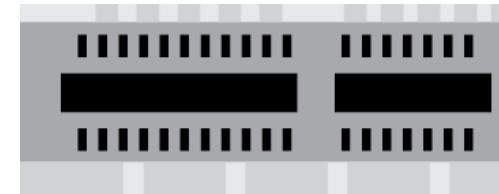
What types of PCIe slots are available?

x1, x4, and x16

Solution:  
PCIe 4.0  
Using one x4 slot



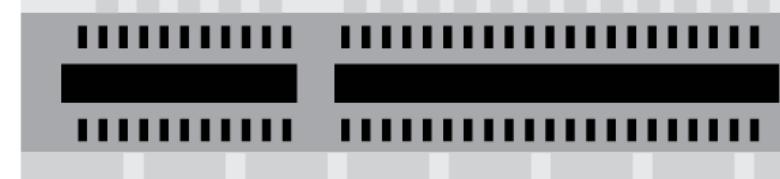
**x1 Slot**



PCIe 4.0 with 1 lane = 15.76 Gbps (insufficient)



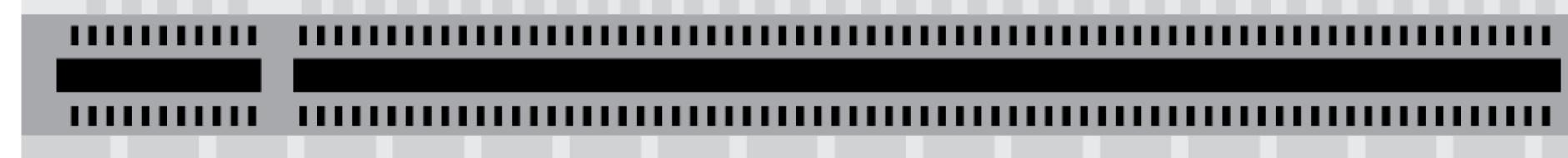
**x4 Slot**



PCIe 4.0 with 4 lanes = 63.02 Gbps (perfect)



**x16 Slot**

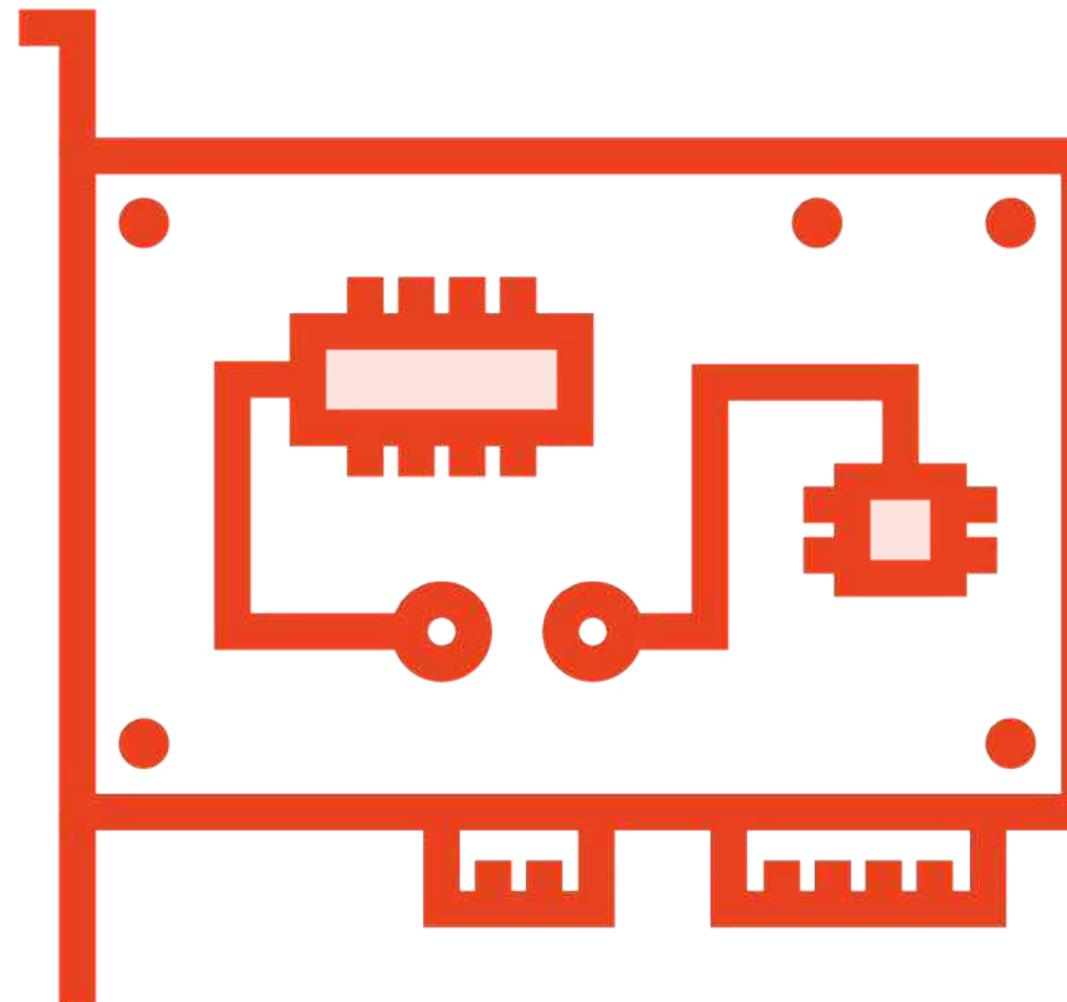


(overkill)



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

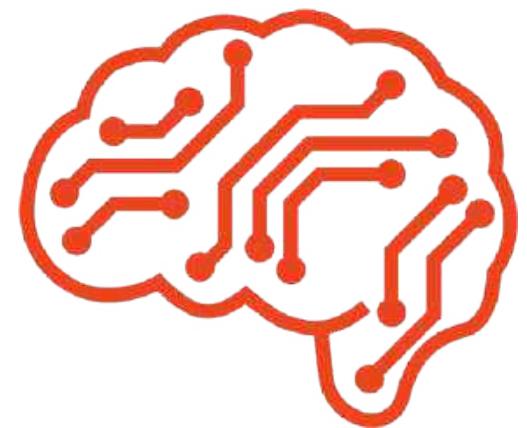
The GPU contains an extremely powerful processor typically used to render video

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



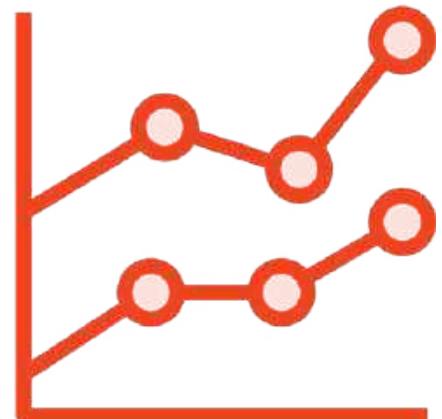
Machine Learning



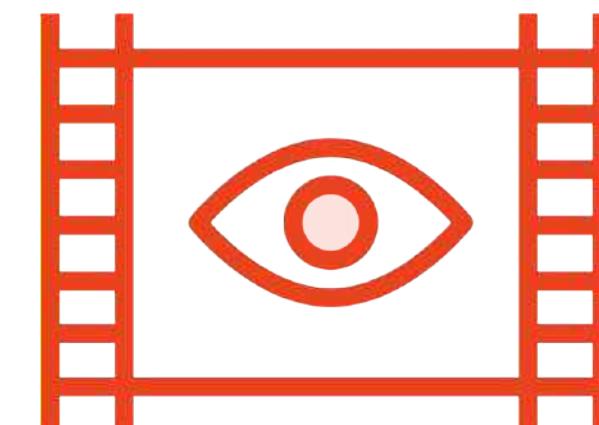
Geospatial Engineering



Weather Modeling



Analytics

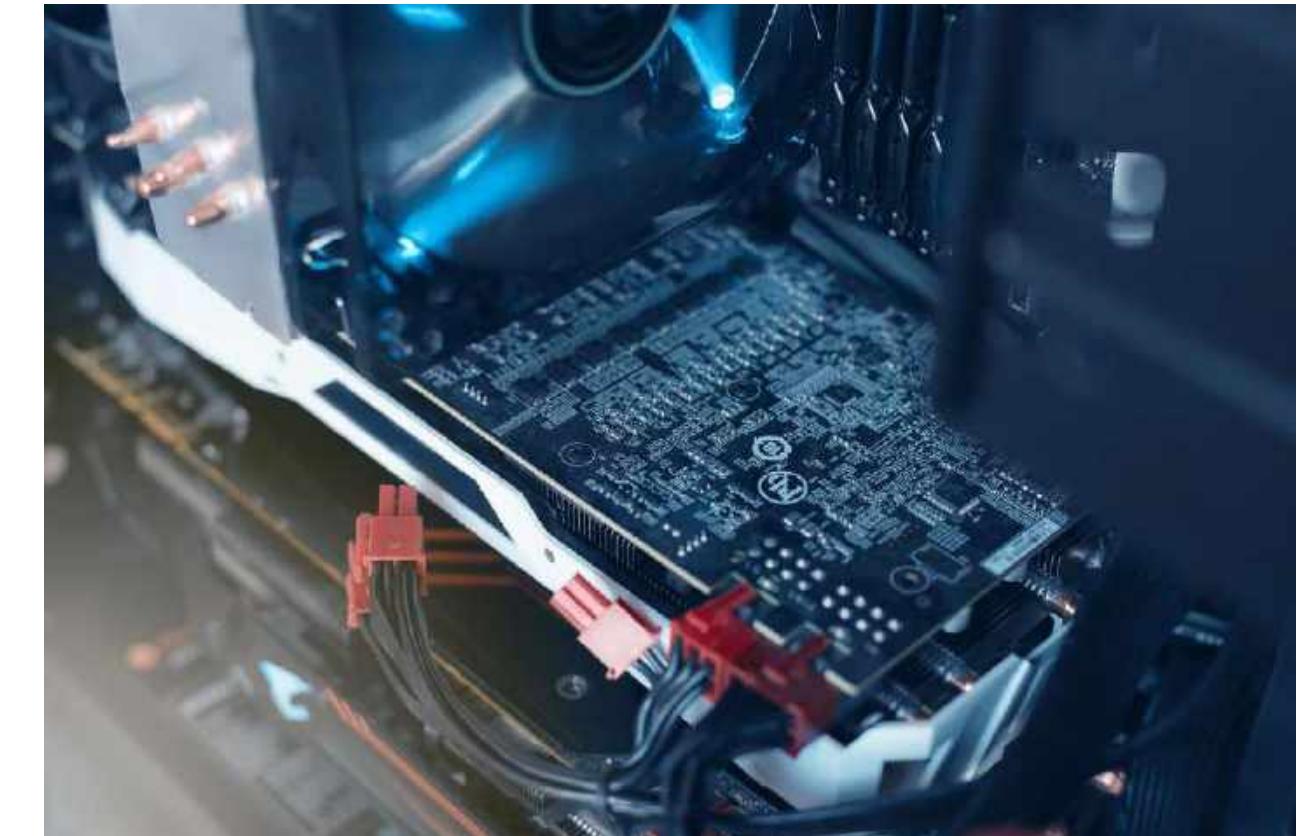


Video Rendering

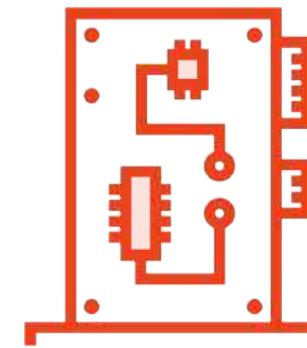
# You Can Use Multiple GPUs in a Server

**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?



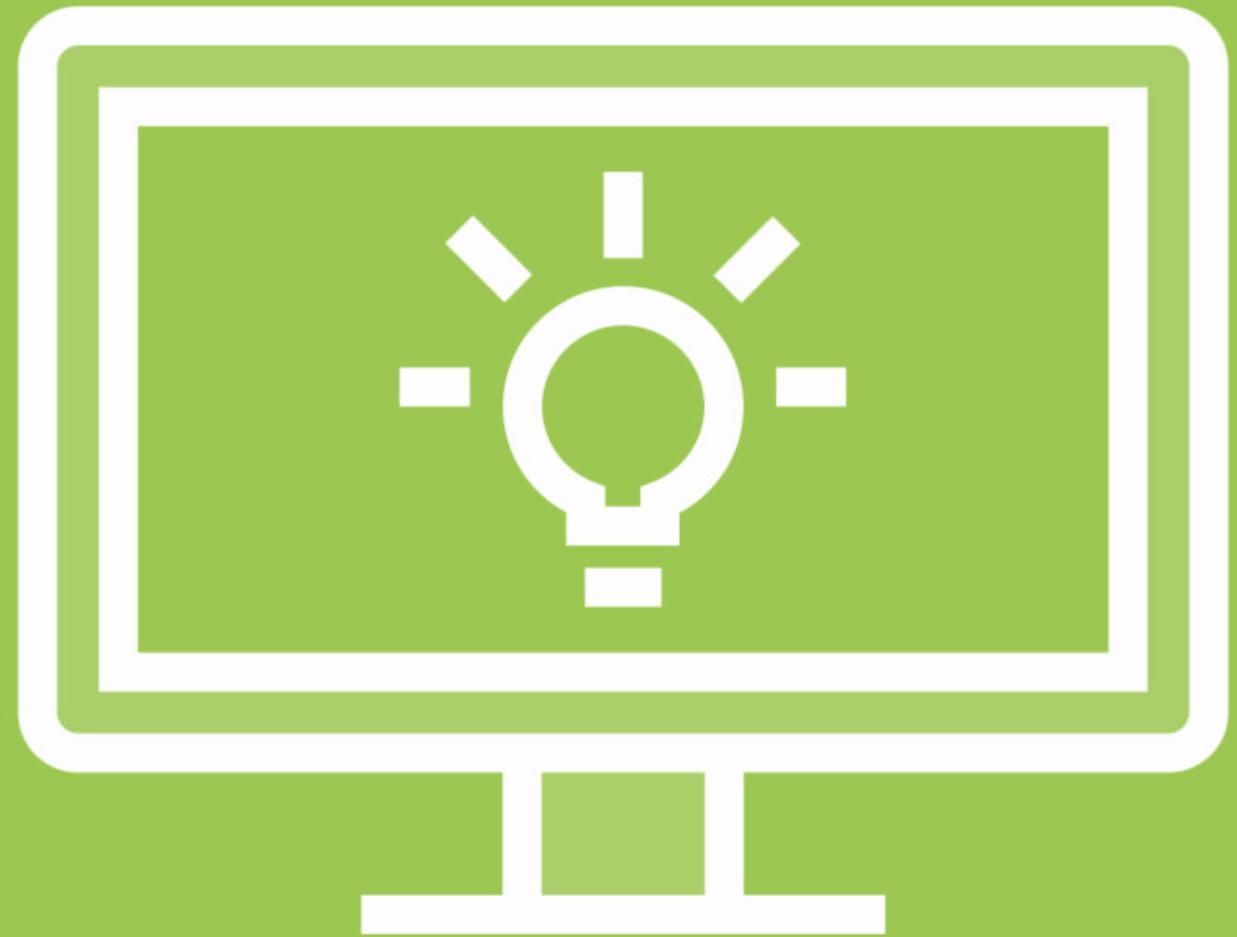
How many cards do you need?



Bus type of the card



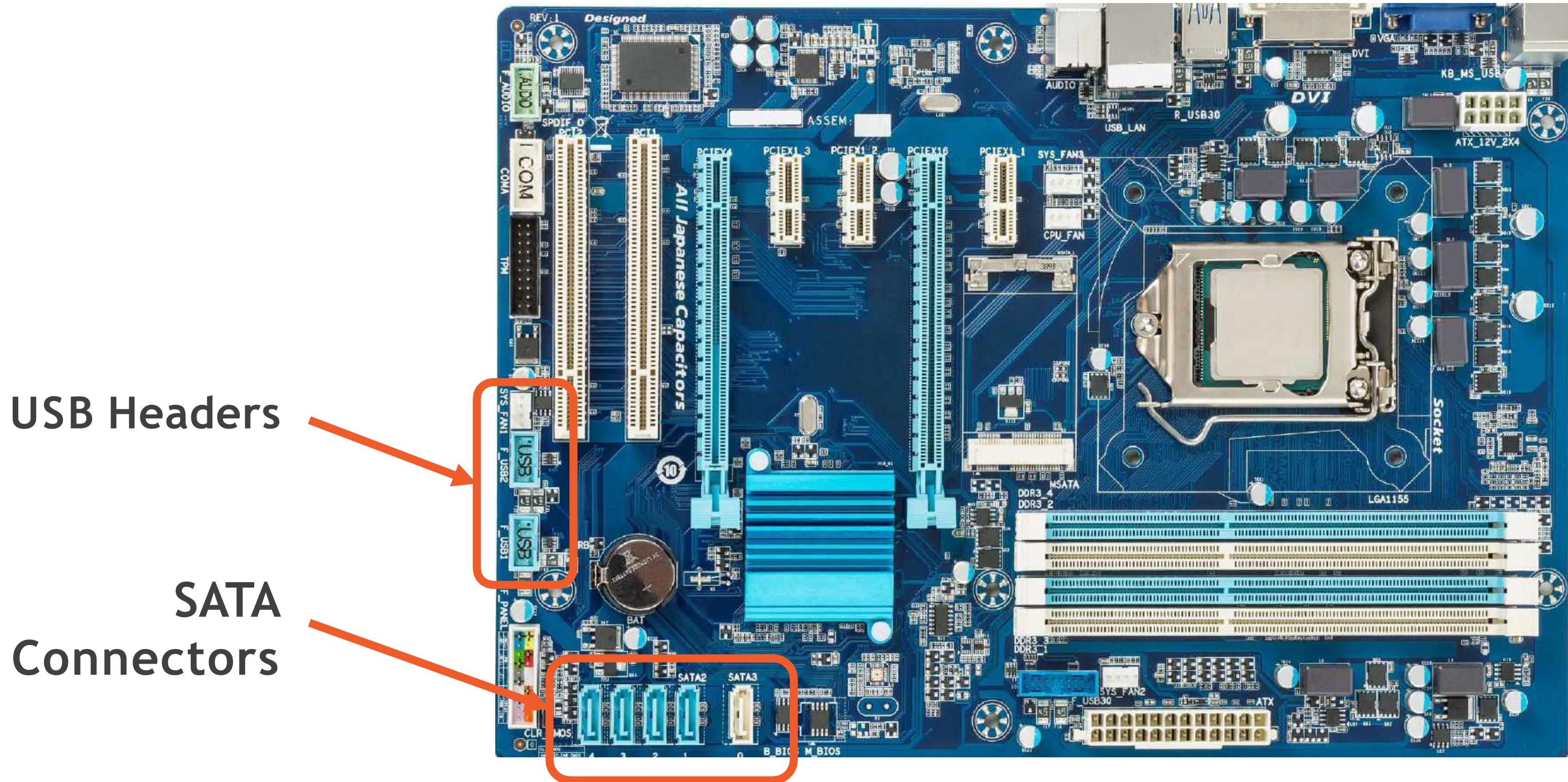
Power draw of the cards



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.

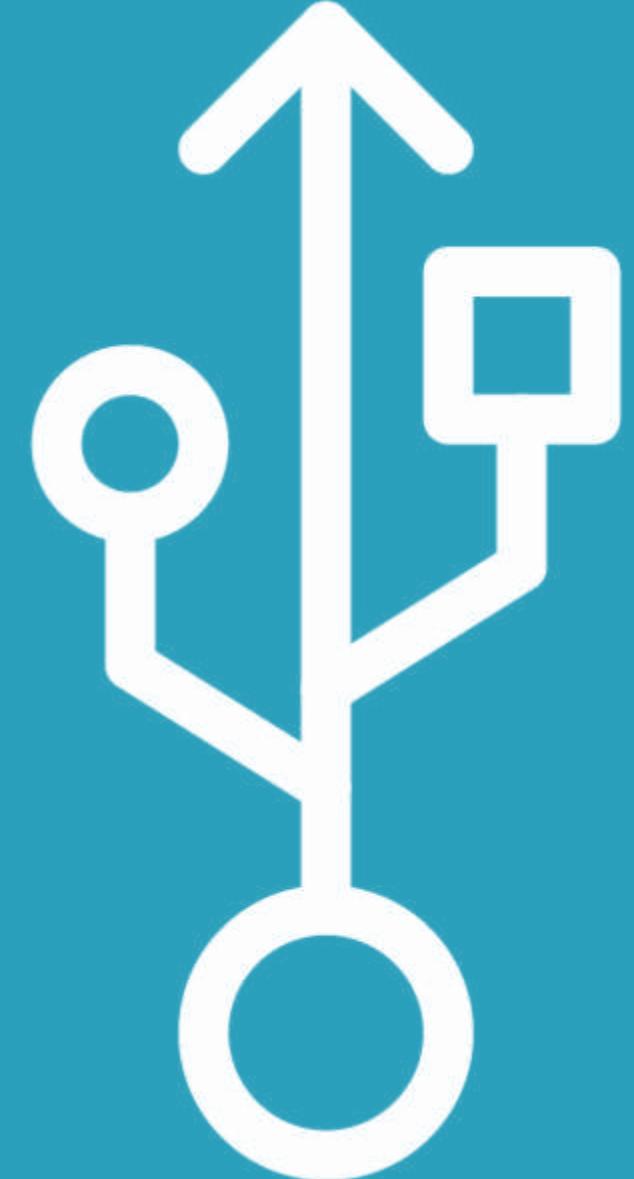
Each port connects to a single internal drive.

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



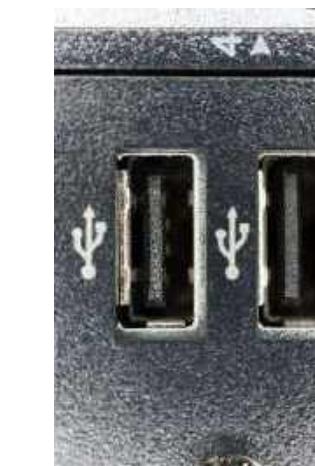
SATA will be  
discussed in the  
next module

This course  
Storage module

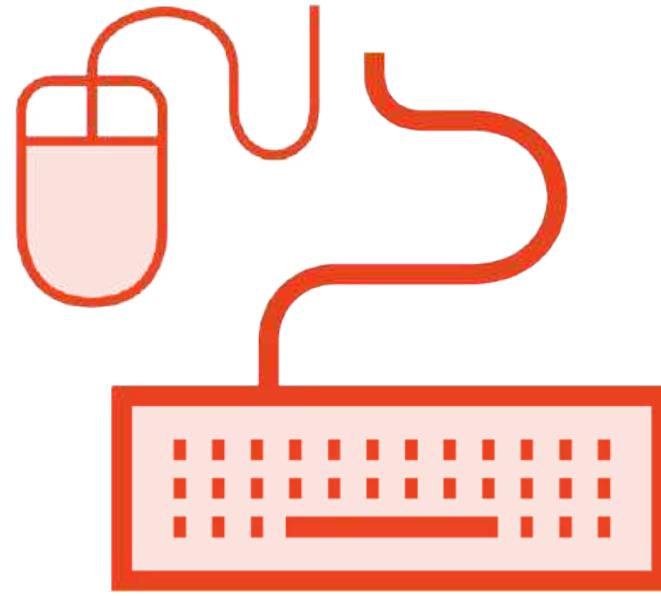


USB  
Universal Serial Bus

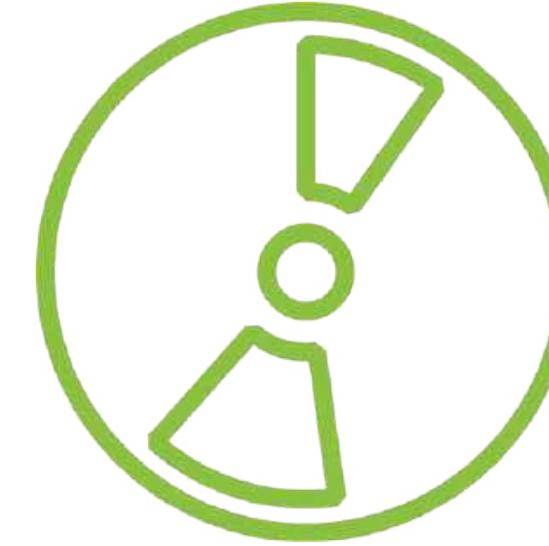
# Visual Anchor



# 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

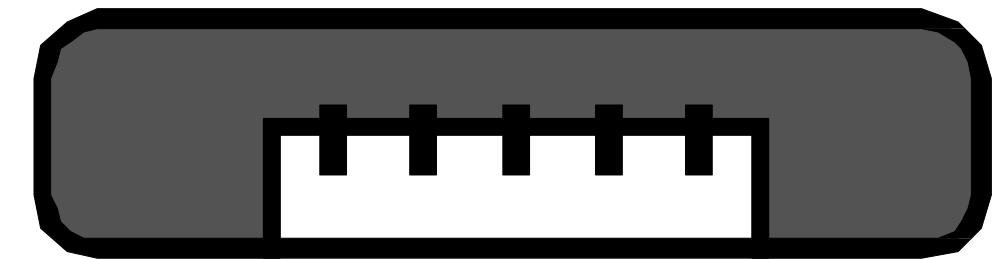
# USB Connector Types



Standard A



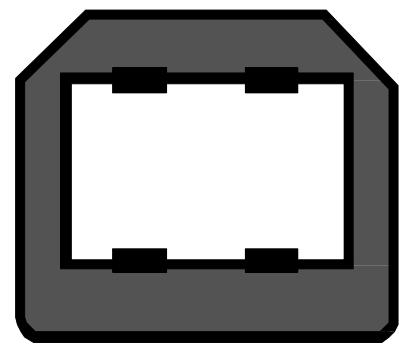
Mini-A



Micro-A

Not drawn to scale

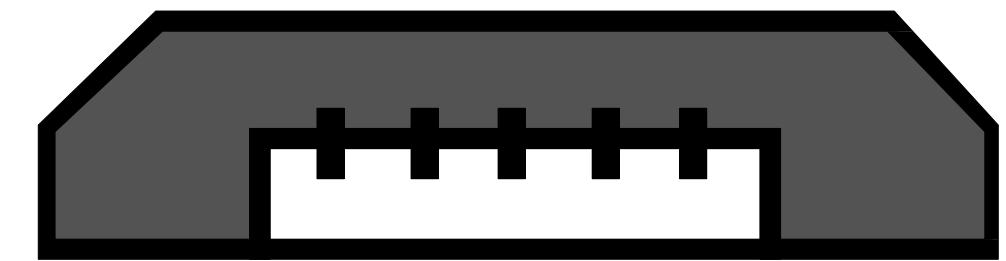
# USB Connector Types



**Standard B**



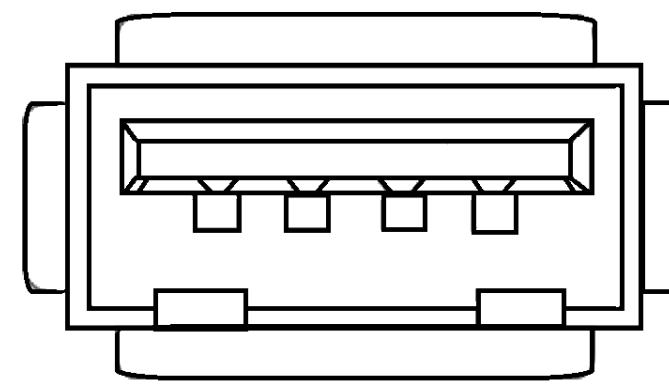
**Mini-B**



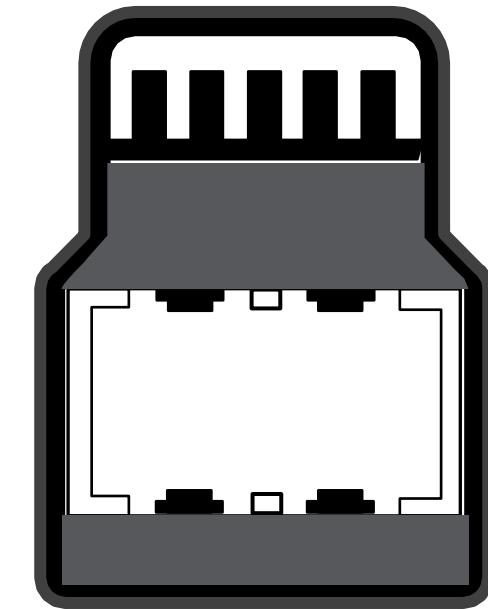
**Micro-B**

Not drawn to scale

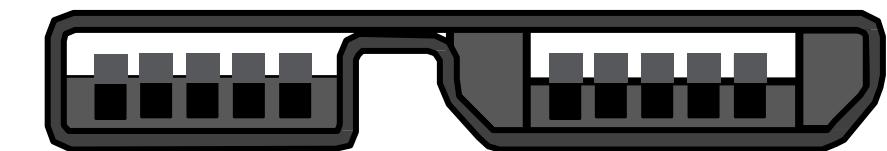
# USB Connector Types



**USB 3.0 Type A**



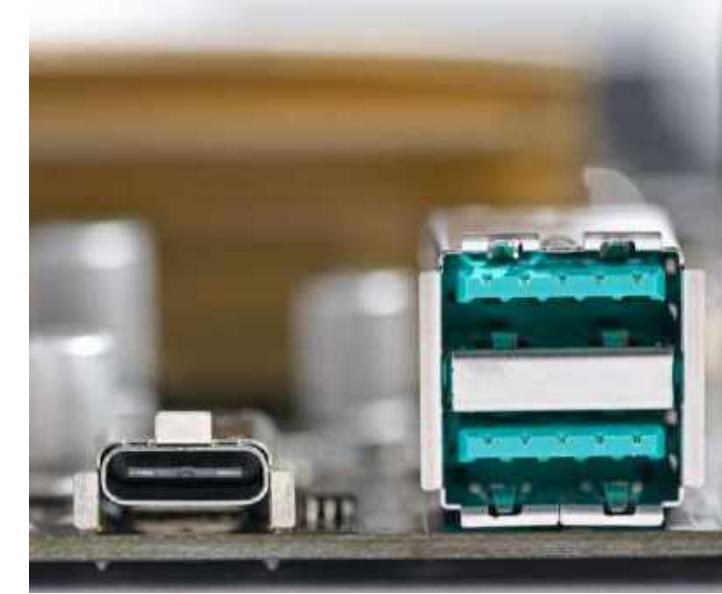
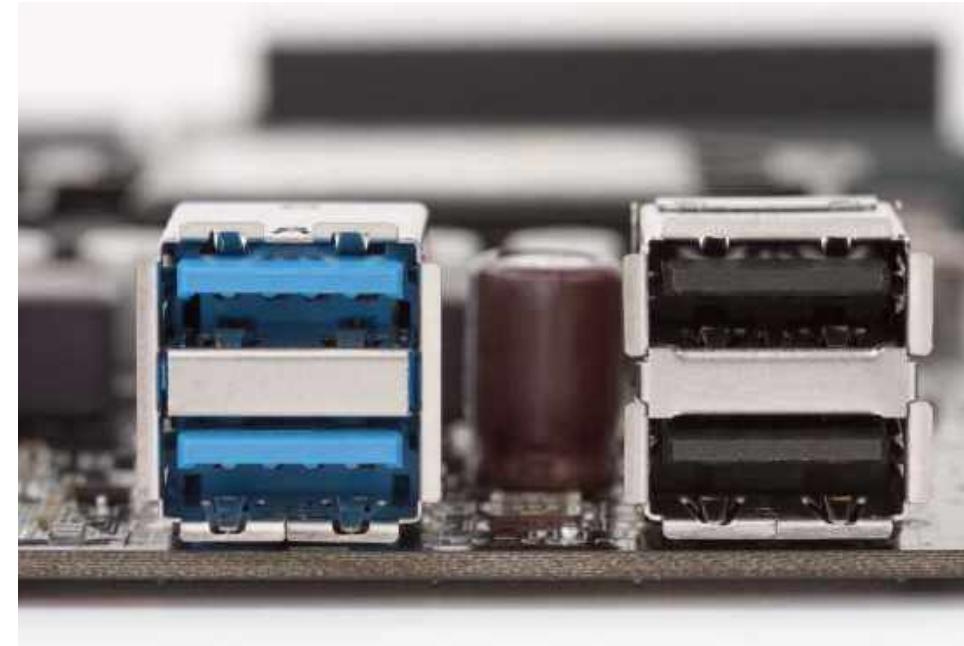
**USB 3.0 Type B**



**USB 3.0 Micro-B**

Not drawn to scale

# USB Color Coding



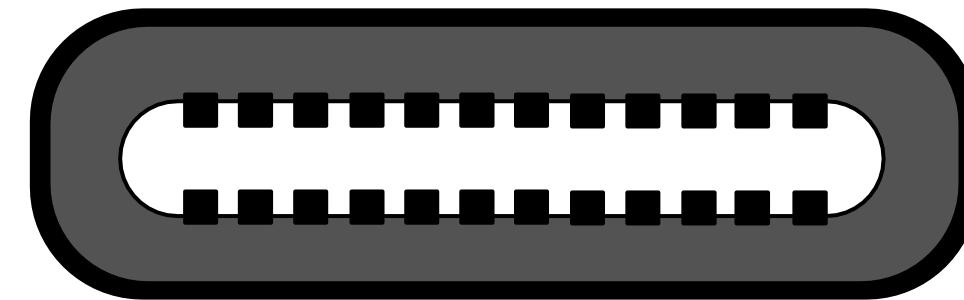
Typically, USB 3.x ports and cables use colored connectors

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

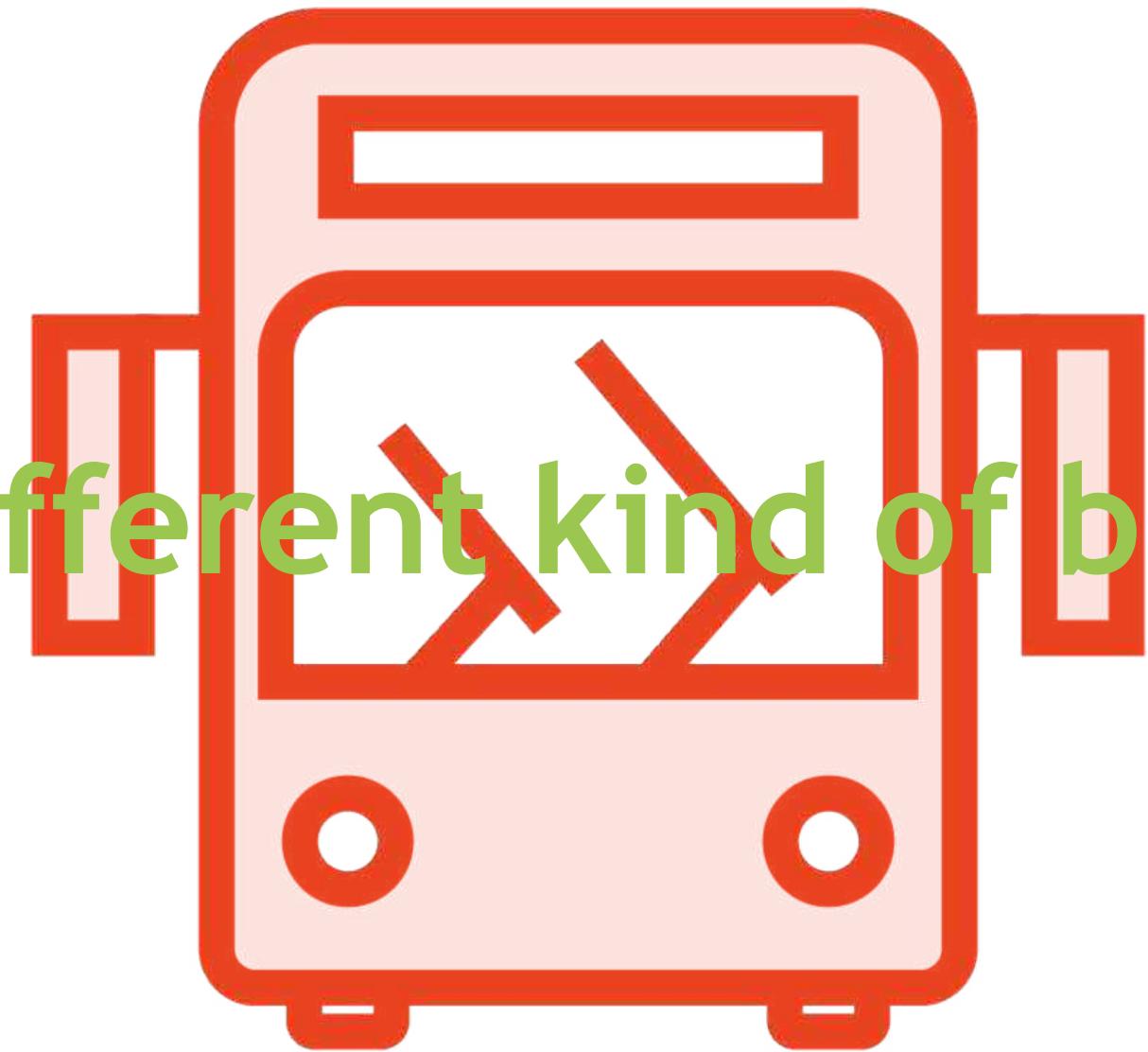
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Tech Point  
The Bus

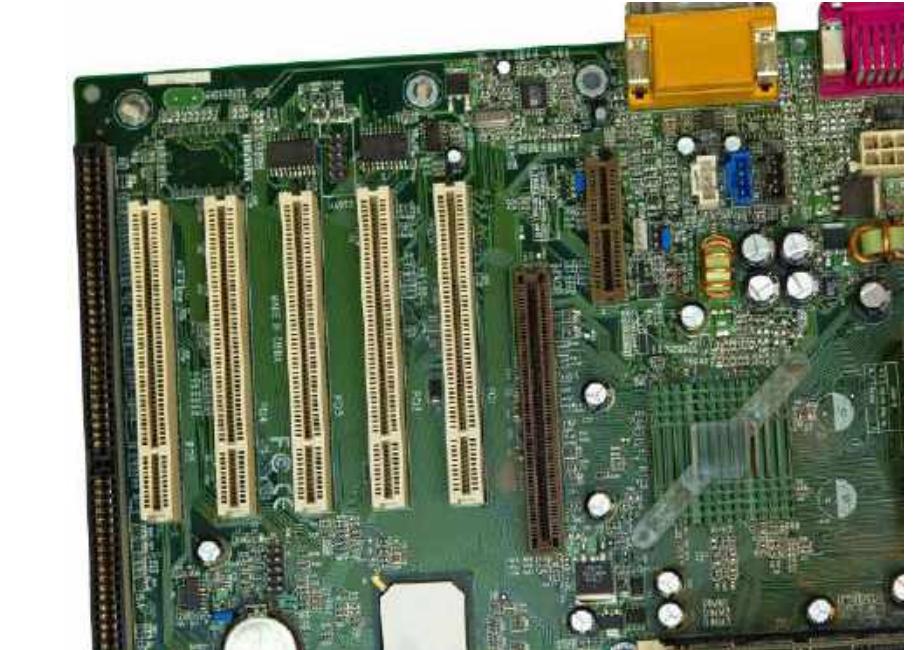
# Take the Bus!!

A different kind of bus...

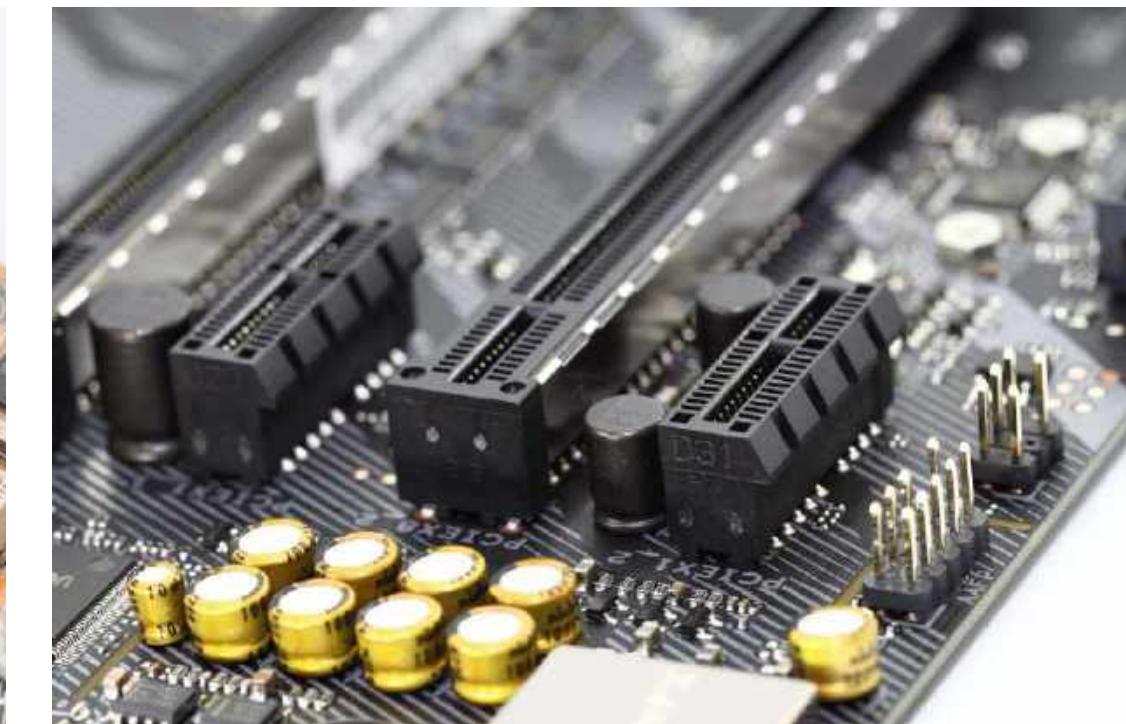
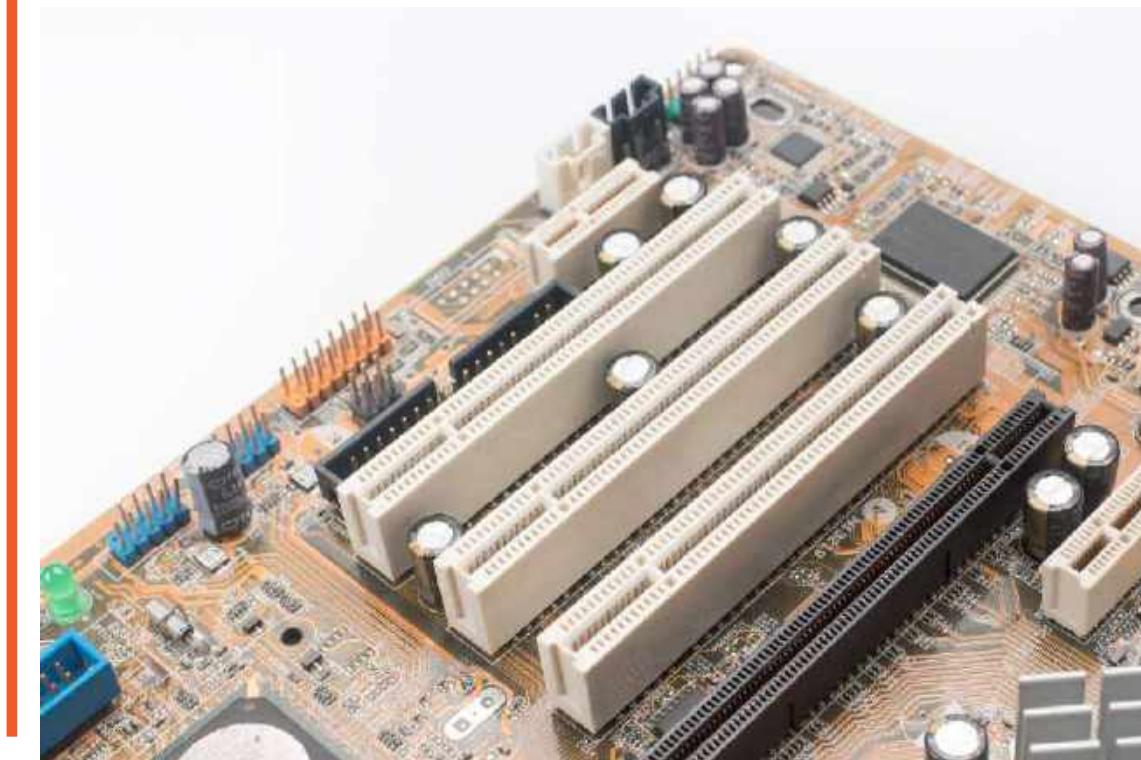


# Everything in a Server Talks on a Bus

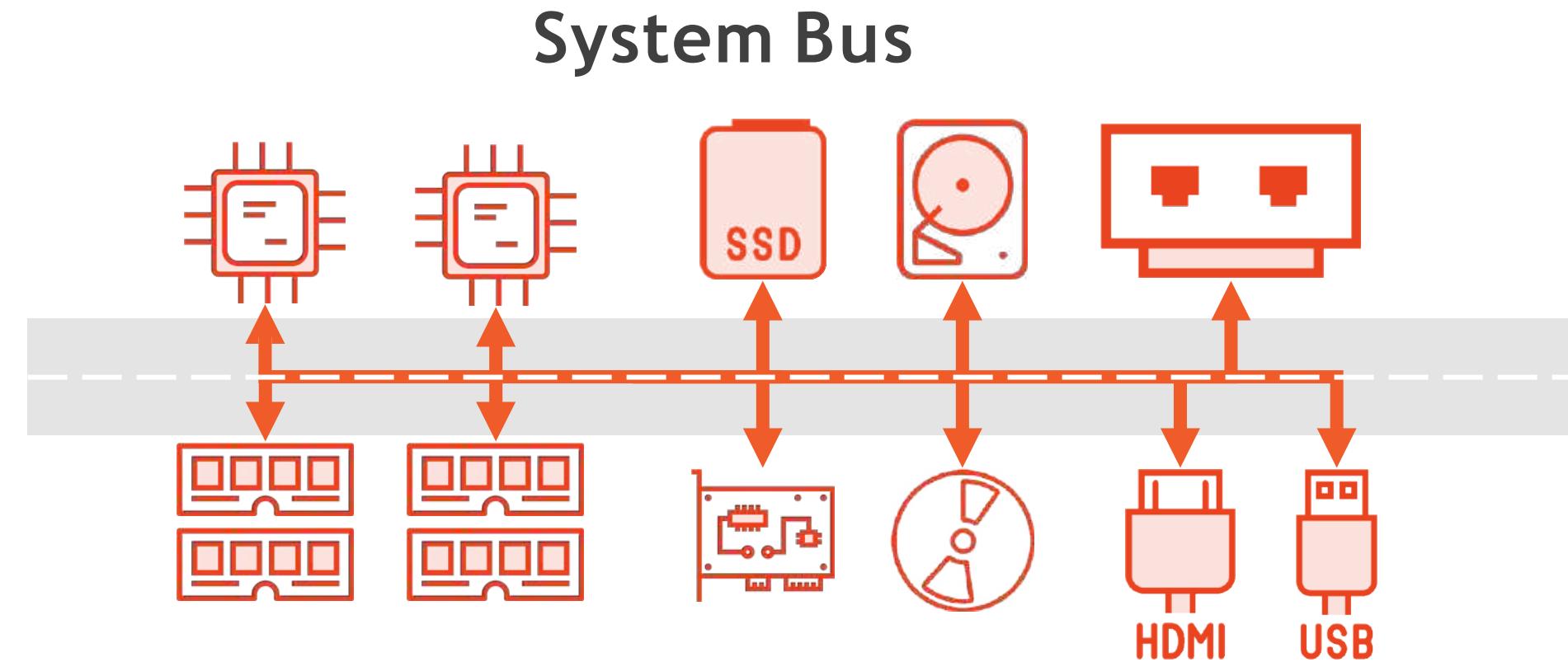
Think of a bus as the wiring that ties all the components together



As components evolved, so did the bus architectures



# The Original System Bus



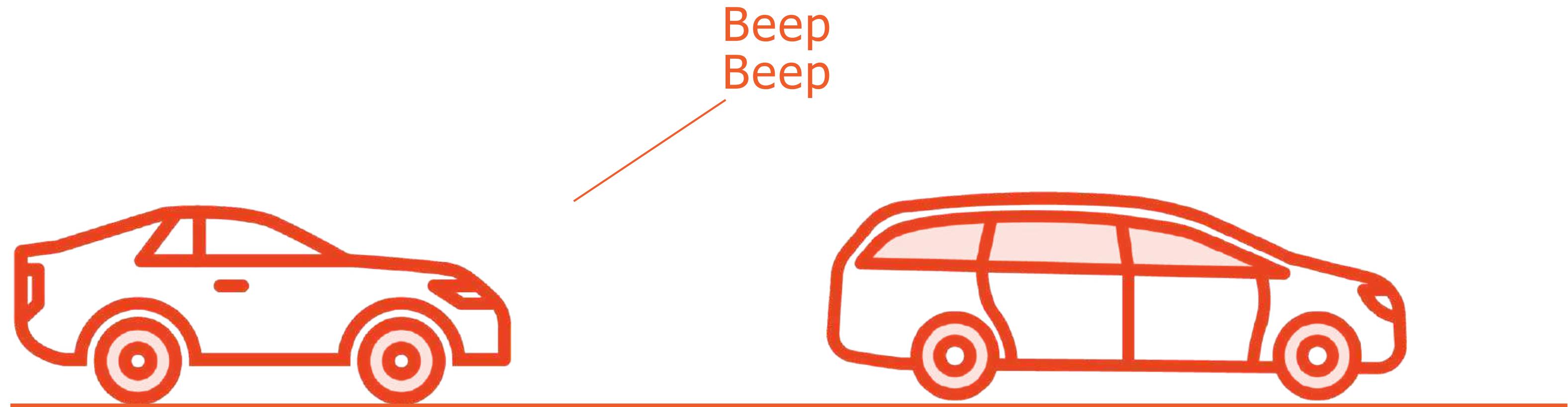
A bus is like a single lane street.

Traffic jams could happen.

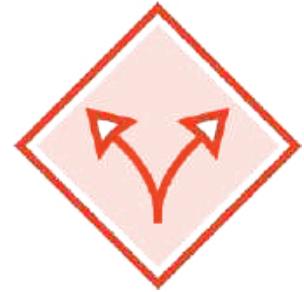
# Lane Contention

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

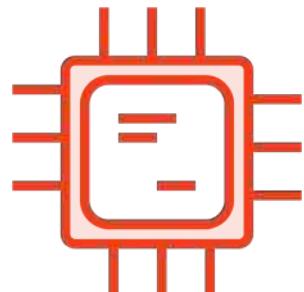
**The slowest vehicle (device) sets the speed for everyone**



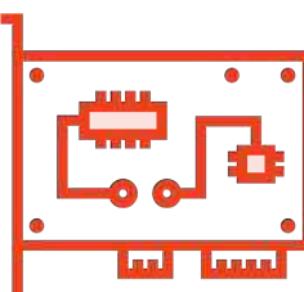
# Solution: Split the Bus!



**Vendors split the bus into two parts: Internal and External**



**The Internal bus was dedicated to the CPU and RAM**



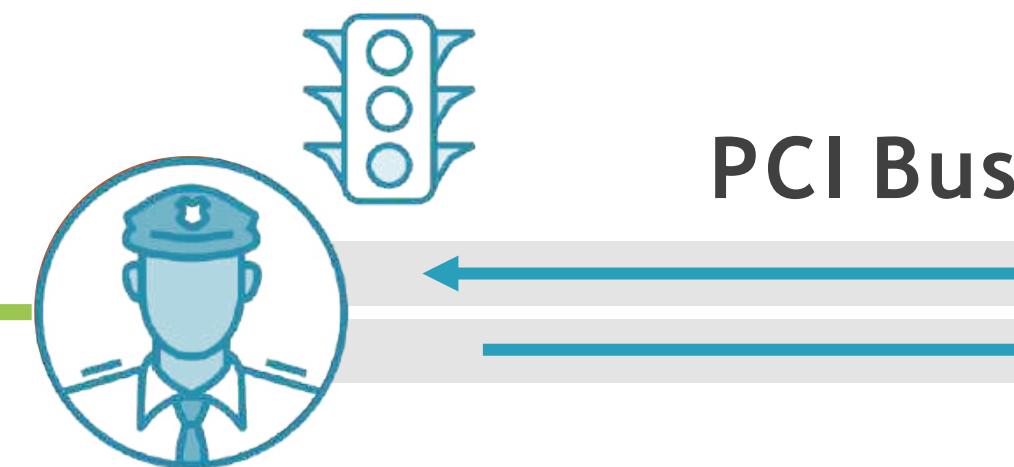
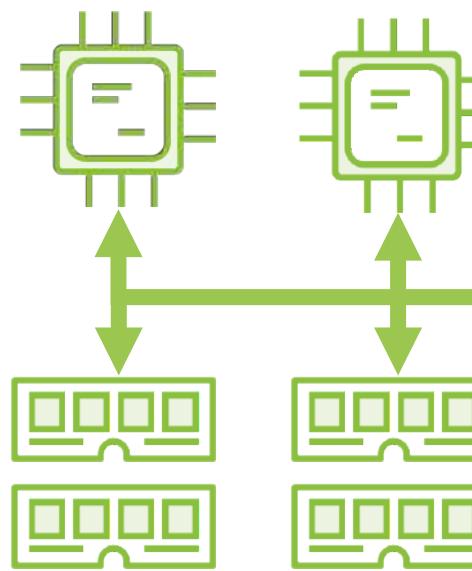
**The external bus supported all other devices**



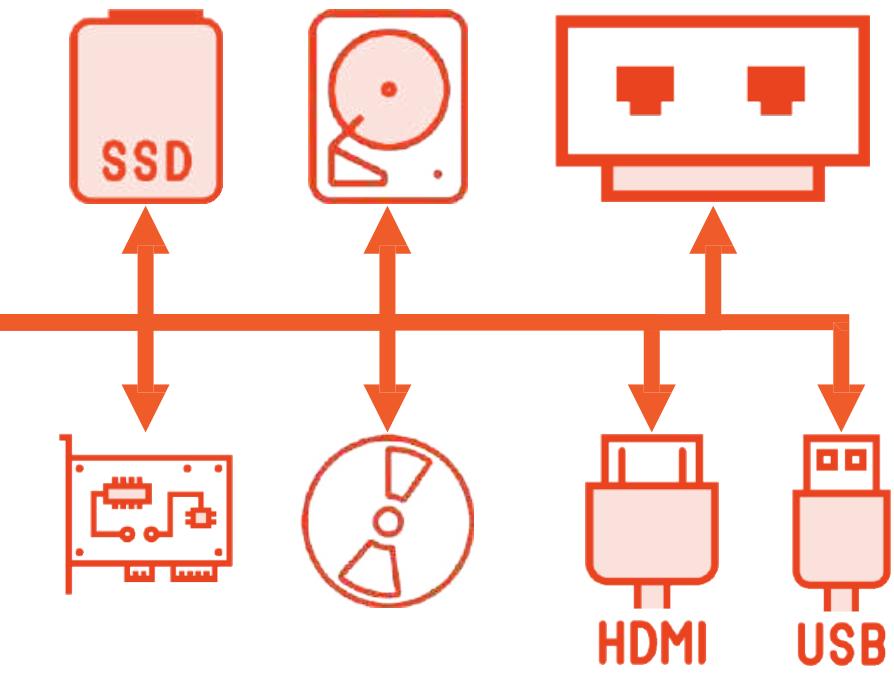
**This separation allowed the CPU and RAM to operate at their own speeds, unimpacted by the slower peripherals on the external bus**

# Introducing the Traffic Cops: The Chipsets!

**Internal Bus**  
“Northbridge”



**External Bus**  
“Southbridge”



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

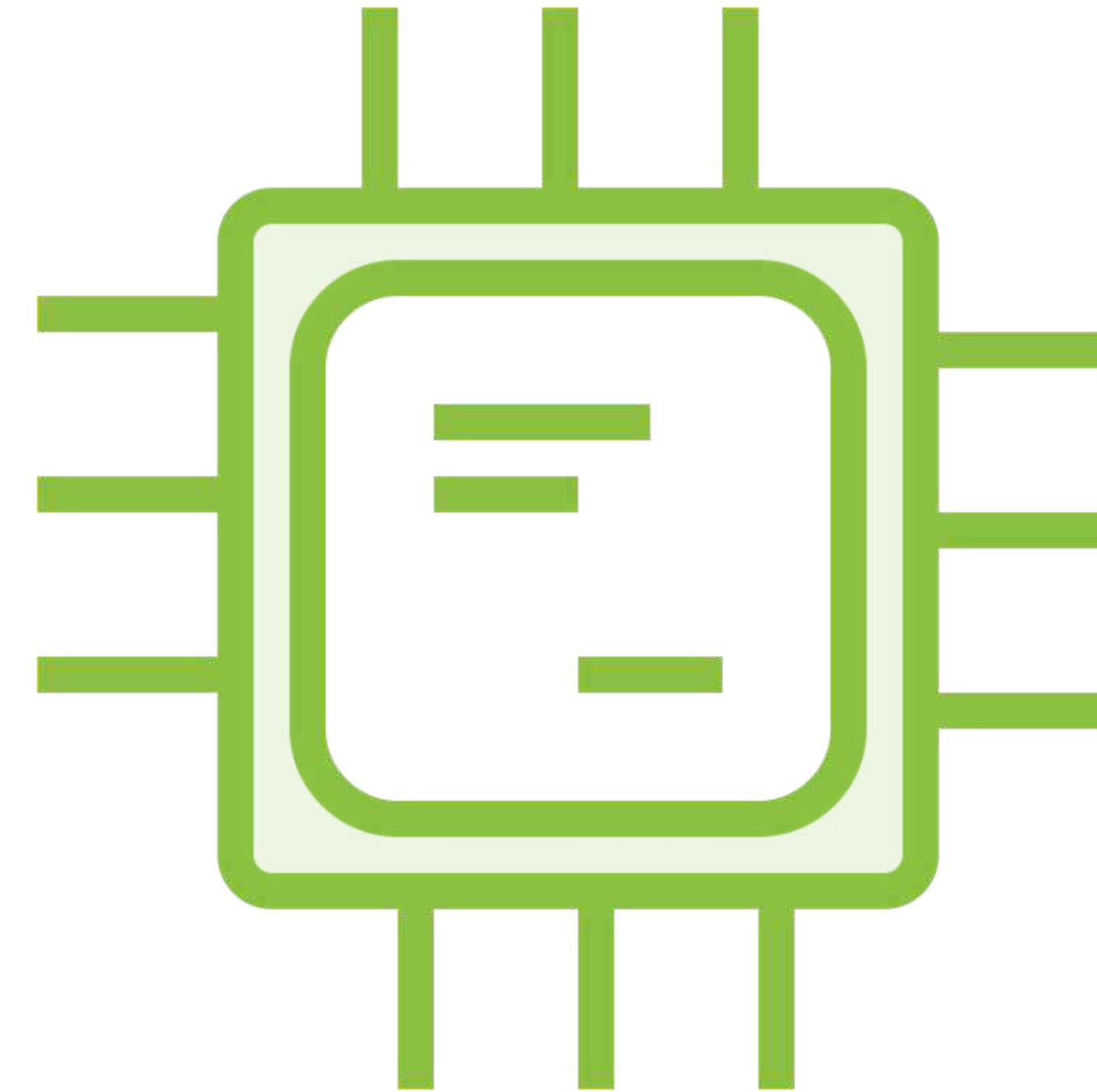
# External Busses

Connect all  
external  
components to the  
system

Examples include  
USB, SATA, and  
cards in expansion  
slots

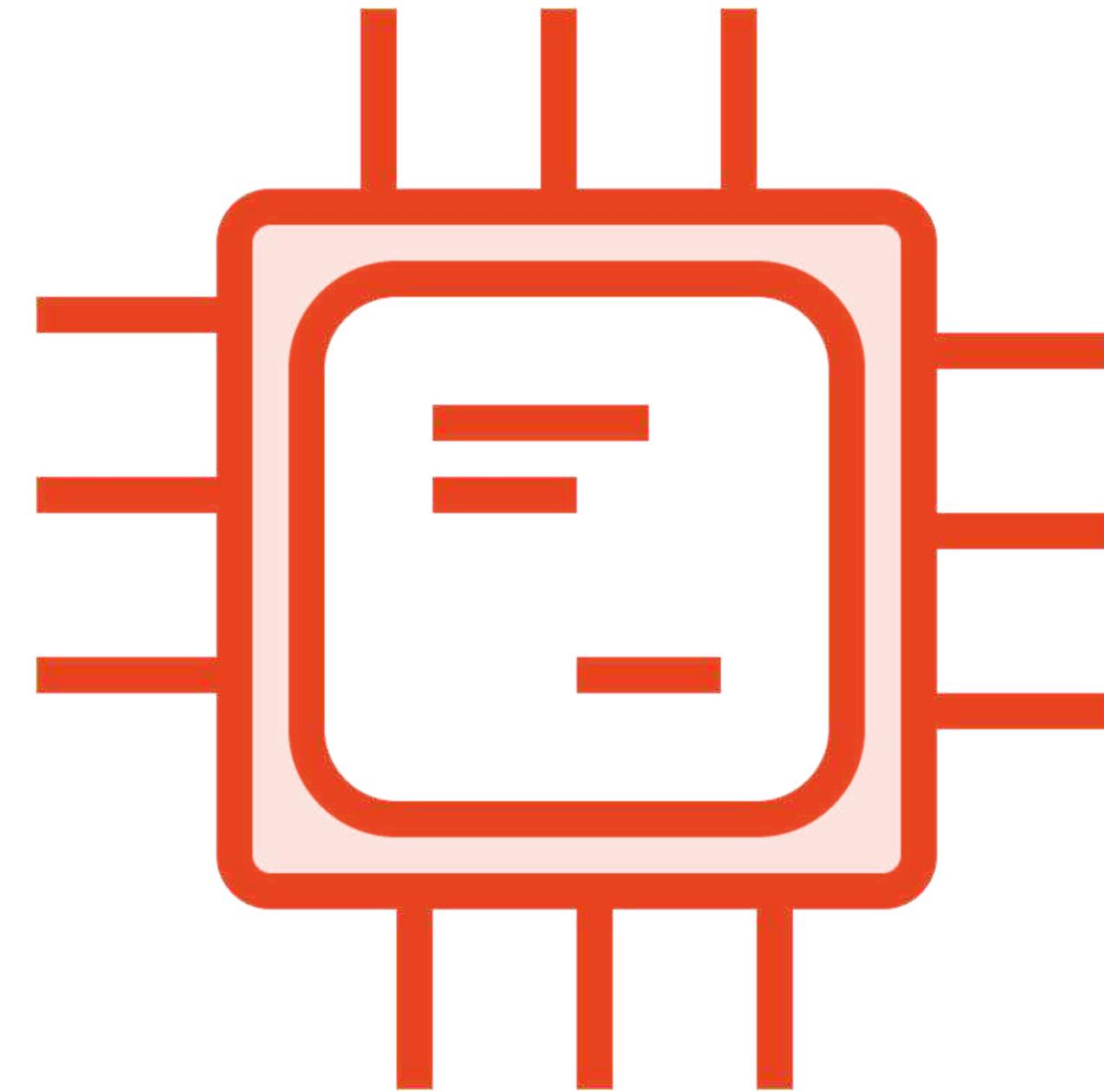
Also called the  
expansion bus

# Internal Bus Today



Now the Internal Bus is incorporated in the CPU

# External Bus Today



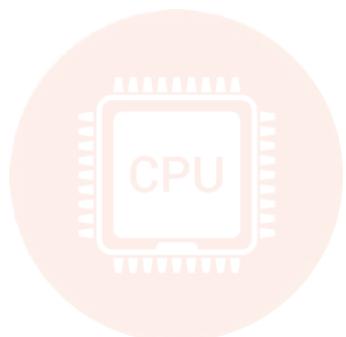
The External Bus remains separate and has different names depending on the manufacturer.



Hindsight



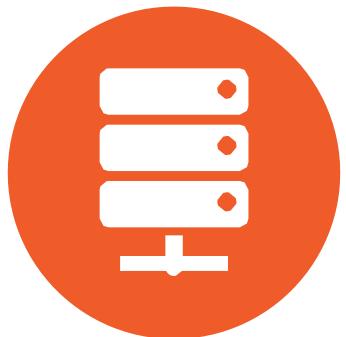
# Minimum Hardware



1 CPU Sockets with 6 cores



64 GB of RAM



1 Gbps Networking



512 GB Storage

# Recommended Hardware

2 CPU Sockets with 12 cores each

256 GB of RAM

10 Gbps Networking

3 TB Storage

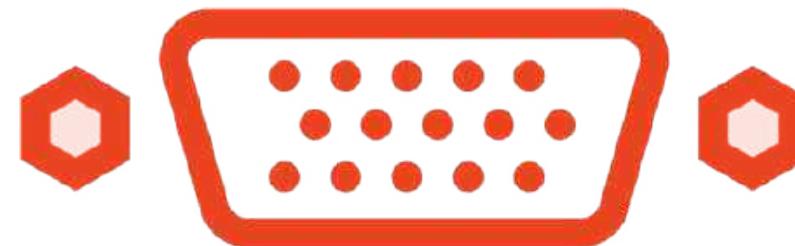


# Decision Points

# Are the Built-in Components Sufficient?

Most system boards have integrated display, storage, and network adapters

These devices may not be powerful enough for your needs

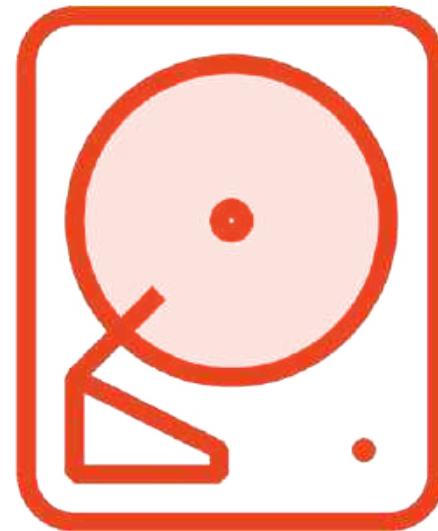


**VGA**

## Graphics Card

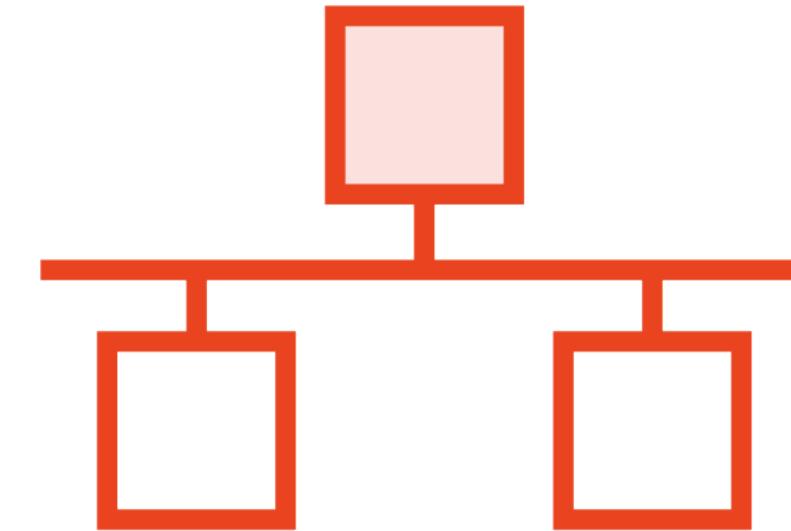
Is VGA acceptable or do you require HDMI?

Do you need GPUs?



## Storage Adapter

Is SATA sufficient, or do you need another storage type?



## Network Adapter

Is the 1Gbps or 10 Gbps adapter sufficient, or do you require higher speeds?

# What Type of PCIe Slots Do You Need?

Do you intend to add PCIe cards now or in the future?

How much bandwidth will the cards require?

PCI  
Version

Lanes

Slots

PCIe v4.0 or 5.0?

This is represented as x1, x4, x8, and x16

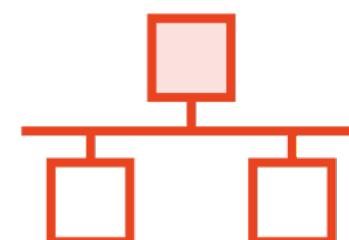
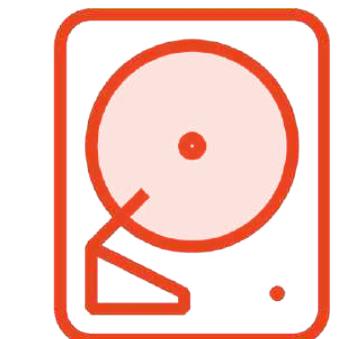
How many cards will you add now and in the future?



Globomantics does not need any GPUs or an HDMI display.

They have not decided upon their storage needs yet.

The built-in 10 Gbps network adapter is sufficient today.



Use the built-in VGA port

Plan for a PCIe storage adapter

Plan for future upgrade to a 40 Gbps network adapter

# Server Maintenance

---



# Storyline

# LOBOMANTICS

Globomantics is finalizing the hardware plans for their new server

Just a few more questions remain unanswered



How much downtime can they experience?



How difficult will it be to replace failed hardware components?



Should they have spare parts on hand?



Globomantics only plan to purchase a single server, therefore it must be redundant



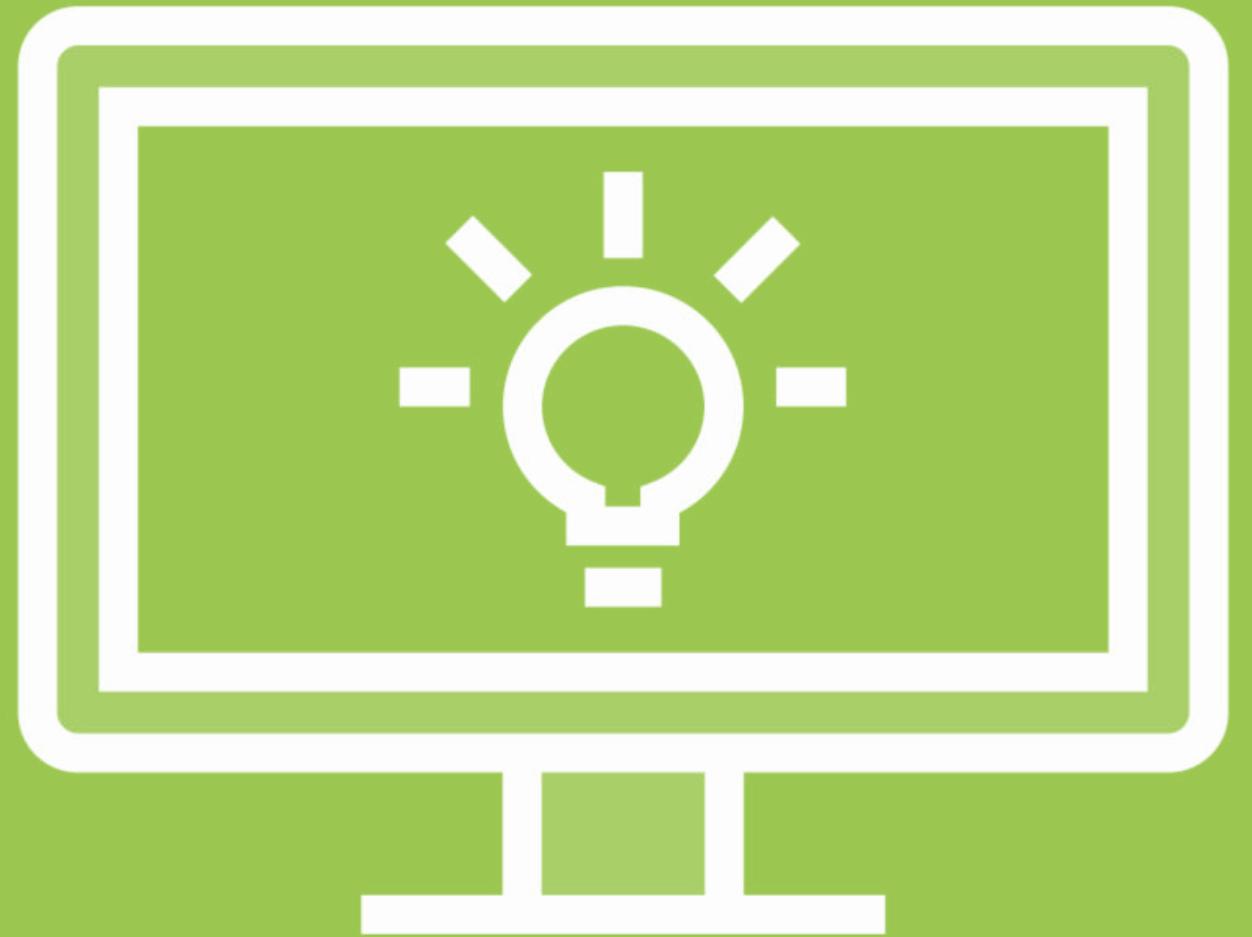
The server will run Microsoft Server 2019 or later, which is a 64-bit operating system



The server will boot UEFI



Now, let's learn about the choices



Tech Point  
Hot Swap  
Components

# Hot Swap



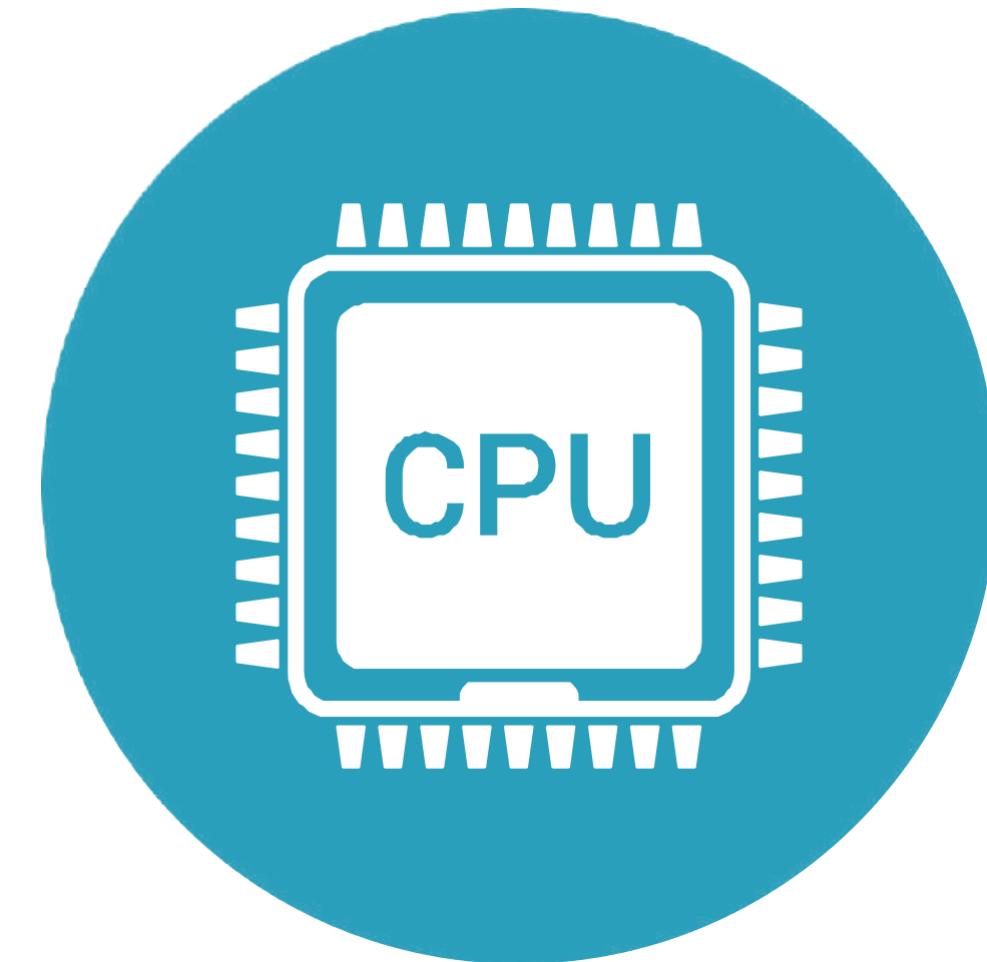
Hot Swap (aka Hot Plug) devices can be added/removed while the device is running

- Hot Swap usually denotes replacing devices (ex. when it fails)
- Hot Plug usually denotes adding functionality (ex. plugging in a USB device)

# Non-hot Swap

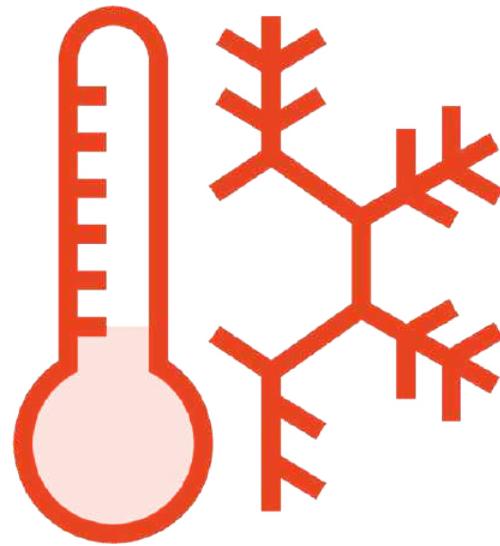
## Cold Plug / Swap

- Also known as non-hot swappable
- The computer is powered off

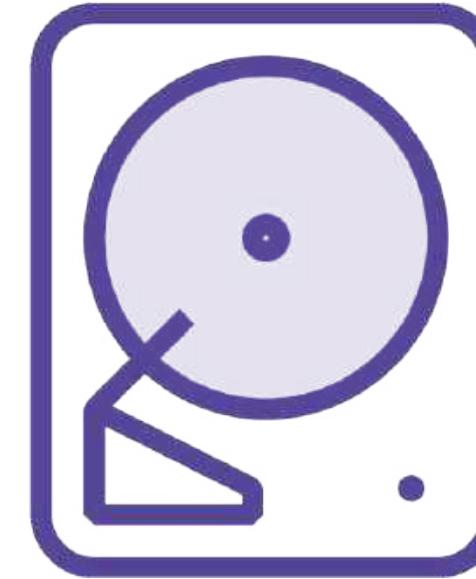


# Common Hot Swappable Components

Components that can often be hot swapped in servers:



Fans

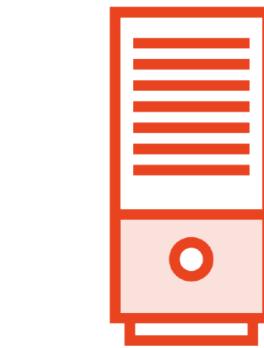


Hard drives

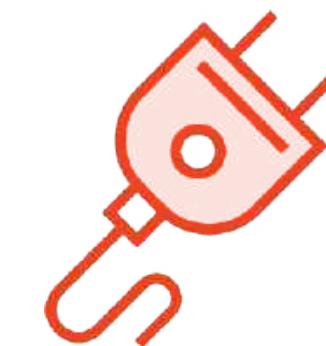


Power supplies

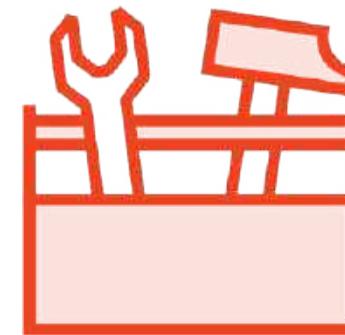
# Hot Swap Fans



Located inside the server chassis

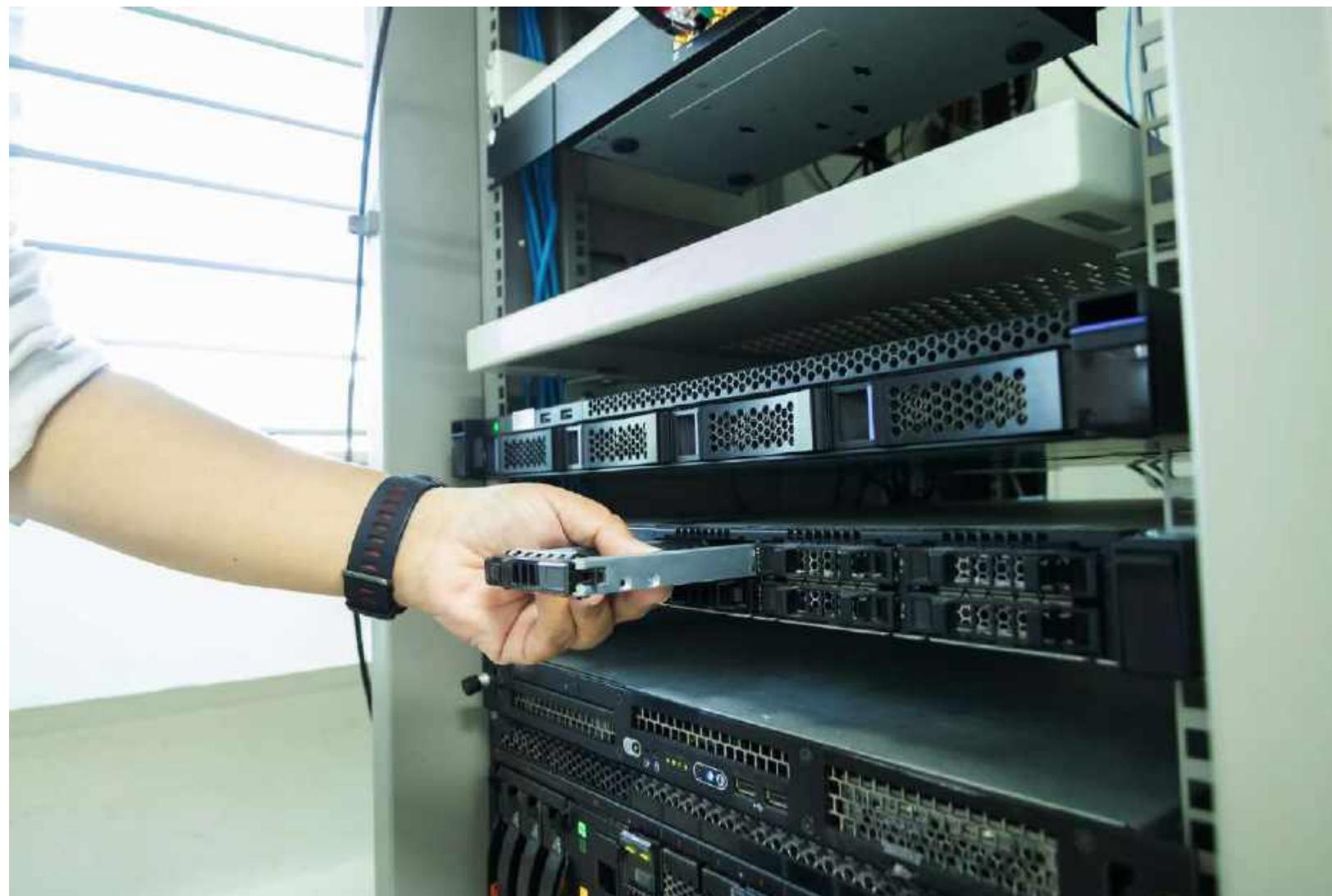


Typically encased in a plastic assembly with a plug (as shown)



Often you can install additional fans for redundancy

# Hot Swap Hard Drives



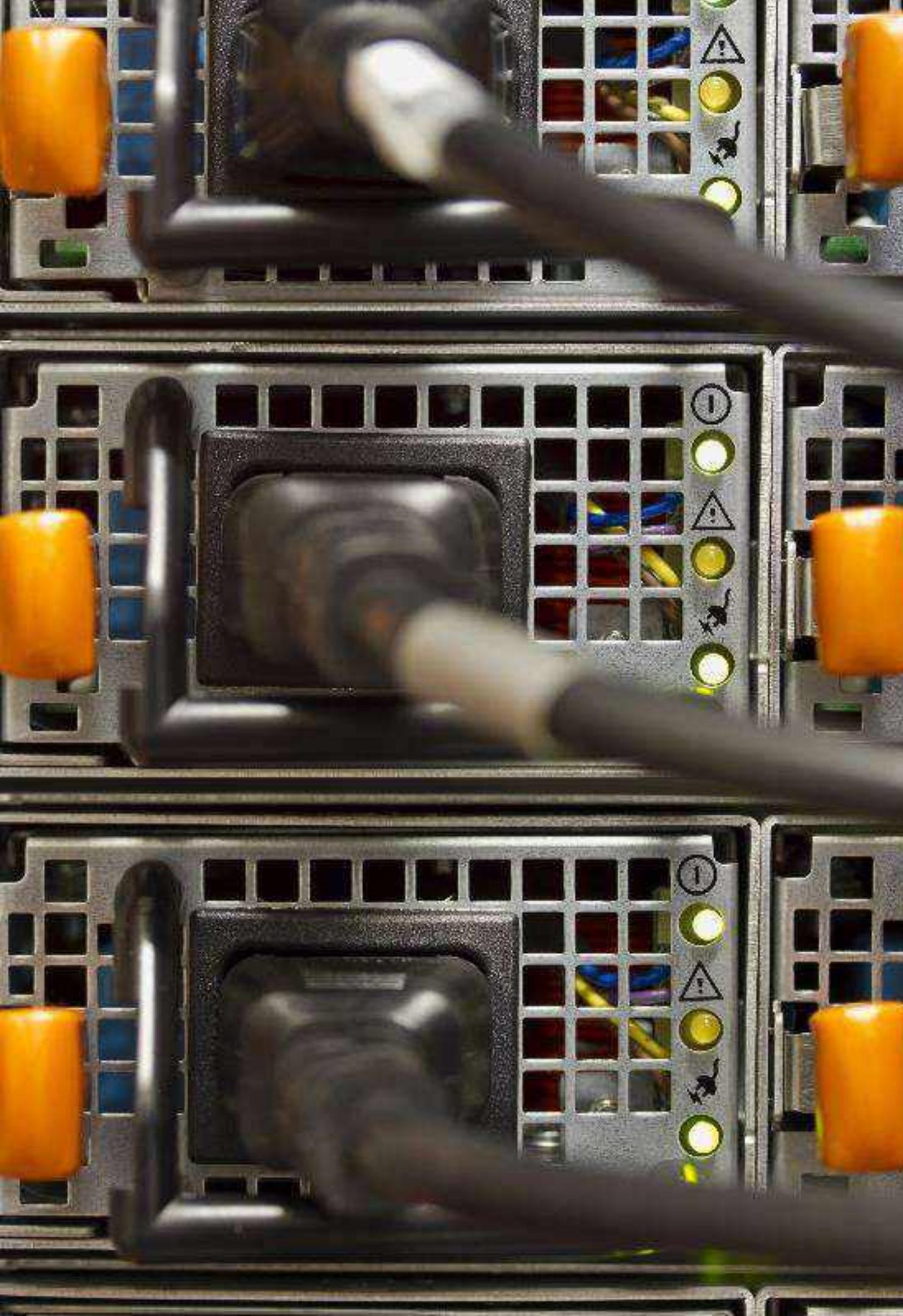
May be located inside or outside the server chassis



Be sure to insert the drive fully and lock it in place



Fill all empty spaces with the provided baffles



# Power Supplies

Tower, vs. rack, vs. blade

Same function, different power draw

We need to understand:

- Power draw per server, per rack, per row, for the entire data center
- Redundancy needs

# Other Hot Swappable Components

**High-end servers  
may also support  
hot-add of CPU  
and RAM**

- Often these systems do not support hot-remove

In most servers,  
CPU/Memory are  
NOT hot pluggable

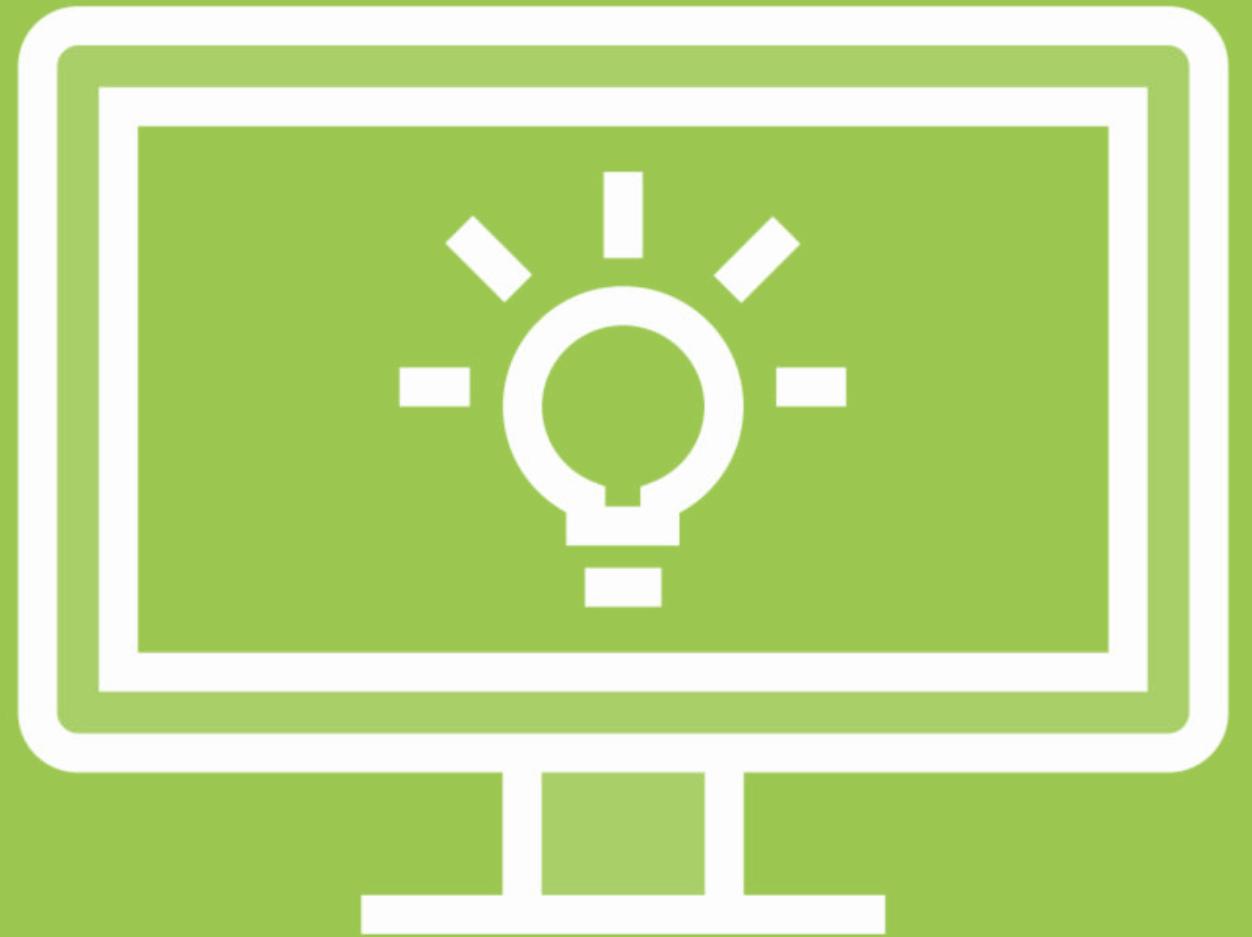
**Hot swap requires  
hardware and OS  
support**

# Hot Swappable Components Color Coding / Icons

No industry standard

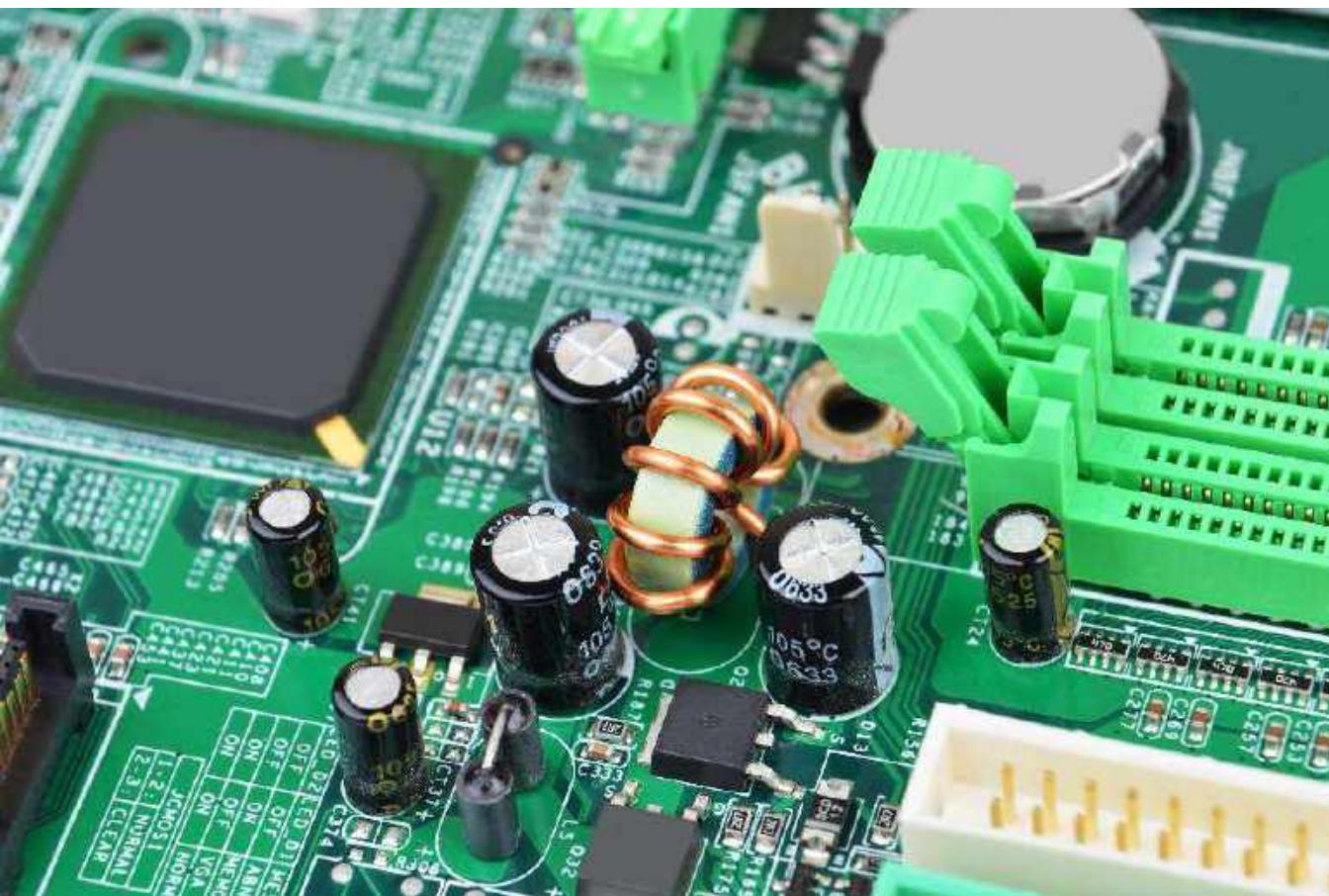
Defined by the manufacturer

Usually documented on the system cover



Tech Point  
UEFI and BIOS

# Visual Anchor



# BIOS

**Basic Input/Output System (BIOS) has been used since the dawn of PCs**

**Very first code loaded and run when a computer is powered on**

**Purposes:**

- Set and use configuration of options (for example date & time or boot device)
- Initialize and test components (for example memory)
- Load bootloader code from boot device (which loads OS)

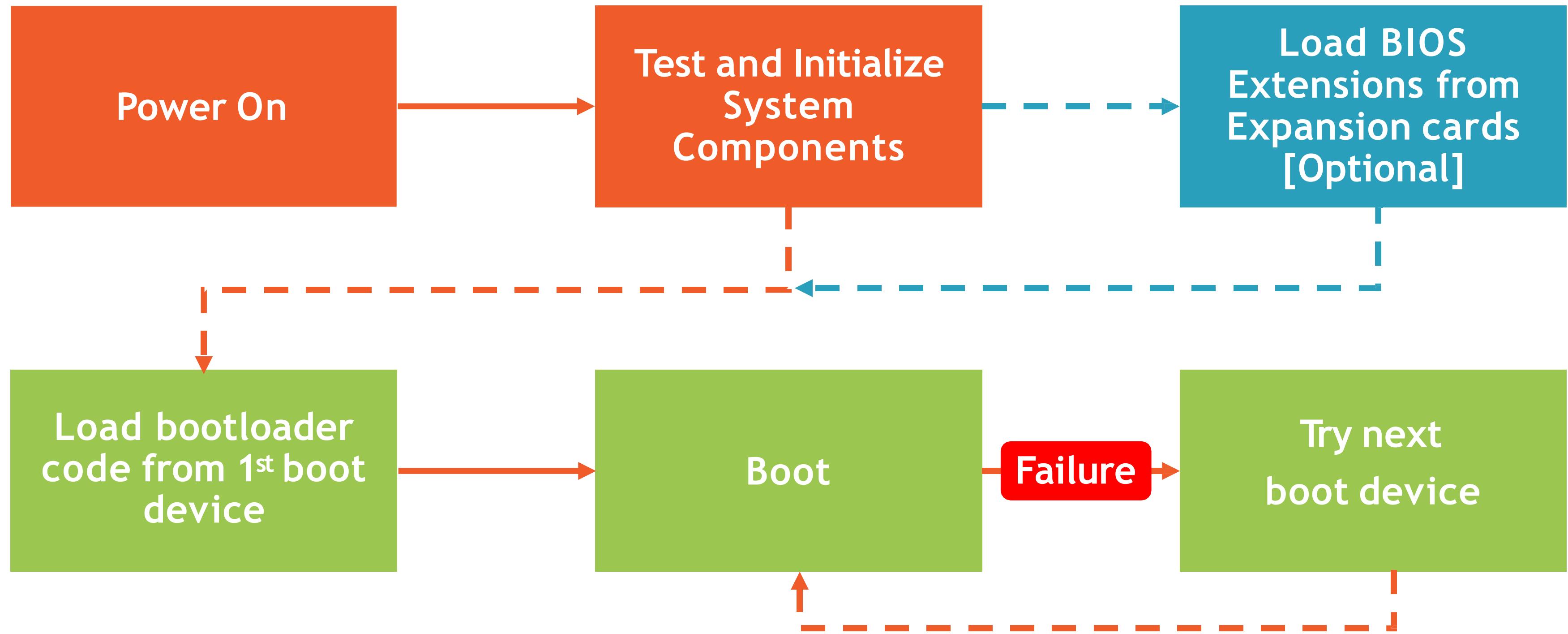
# BIOS

Stored in semi-permanent flash memory

- Retains content without power indefinitely
- Can be upgraded via software as bug fixes and improvements are made by the computer manufacturer

Can be extended by cards installed in the system with their own BIOS extensions

# BIOS Boot Process



# UEFI

UEFI (Unified Extensible Firmware Interface) is successor to BIOS

- Provides BIOS services to OS for backwards compatibility

Can be securely booted

- Cryptography
- Linked to TPM (Trusted Platform Module) in servers

Used in all recent computers

Can be virtualized by VMware, Hyper-V, etc. like BIOS

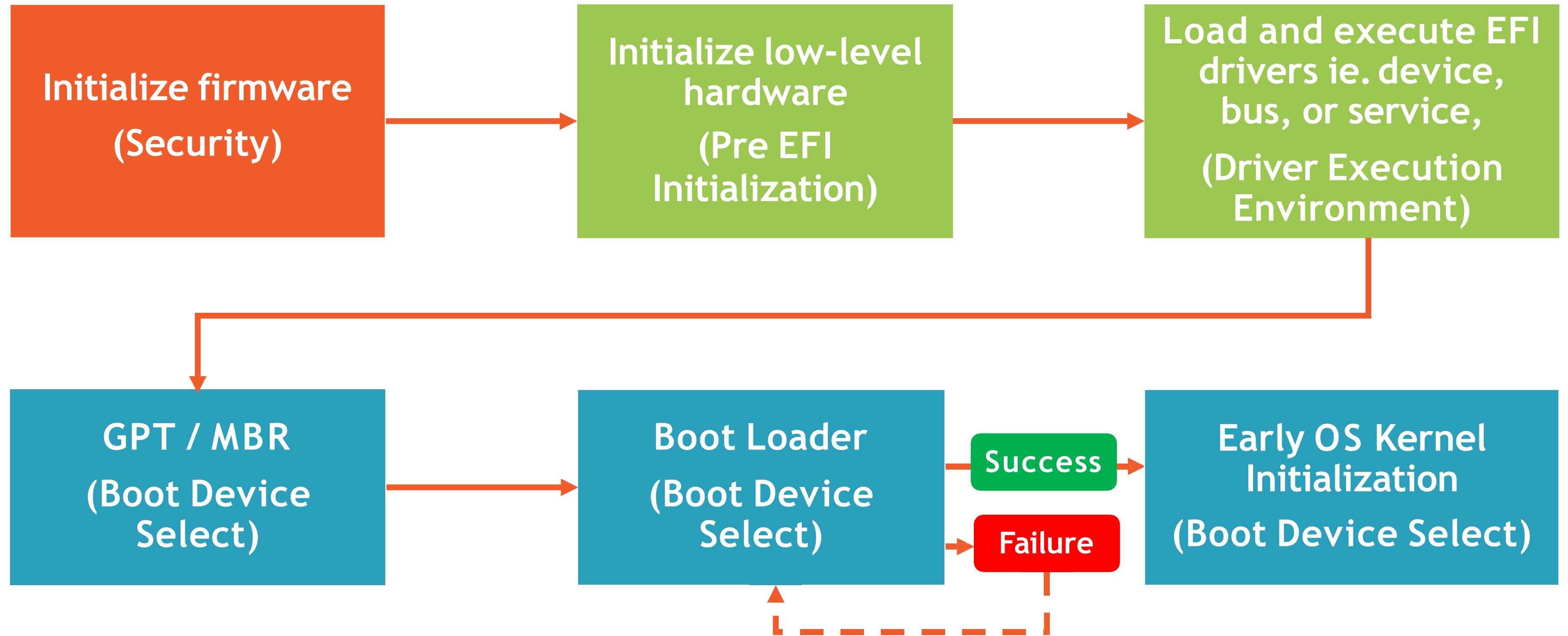
- Can have a VM with BIOS or UEFI boot on a system with either

# UEFI OS Support

The operating system must support UEFI, or the system board must support BIOS compatibility mode

All major operating systems have supported UEFI since 2010, many were earlier than this

# UEFI Boot Process



# Differences between BIOS and UEFI

Characteristic	BIOS	UEFI
# bits	16 (1 MB addressable space)	32 or 64
Max disk size	2 TB (MBR)	> 2 TB (MBR or GPT)
CPU-independent architecture and drivers	x86 (x64) only	x86 (x64), ARM, Itanium
Modular design	No	Yes
Support for time zones & daylight savings time	No	Yes
Support for boot from SAN & network	via BIOS extensions on adapter cards	Native

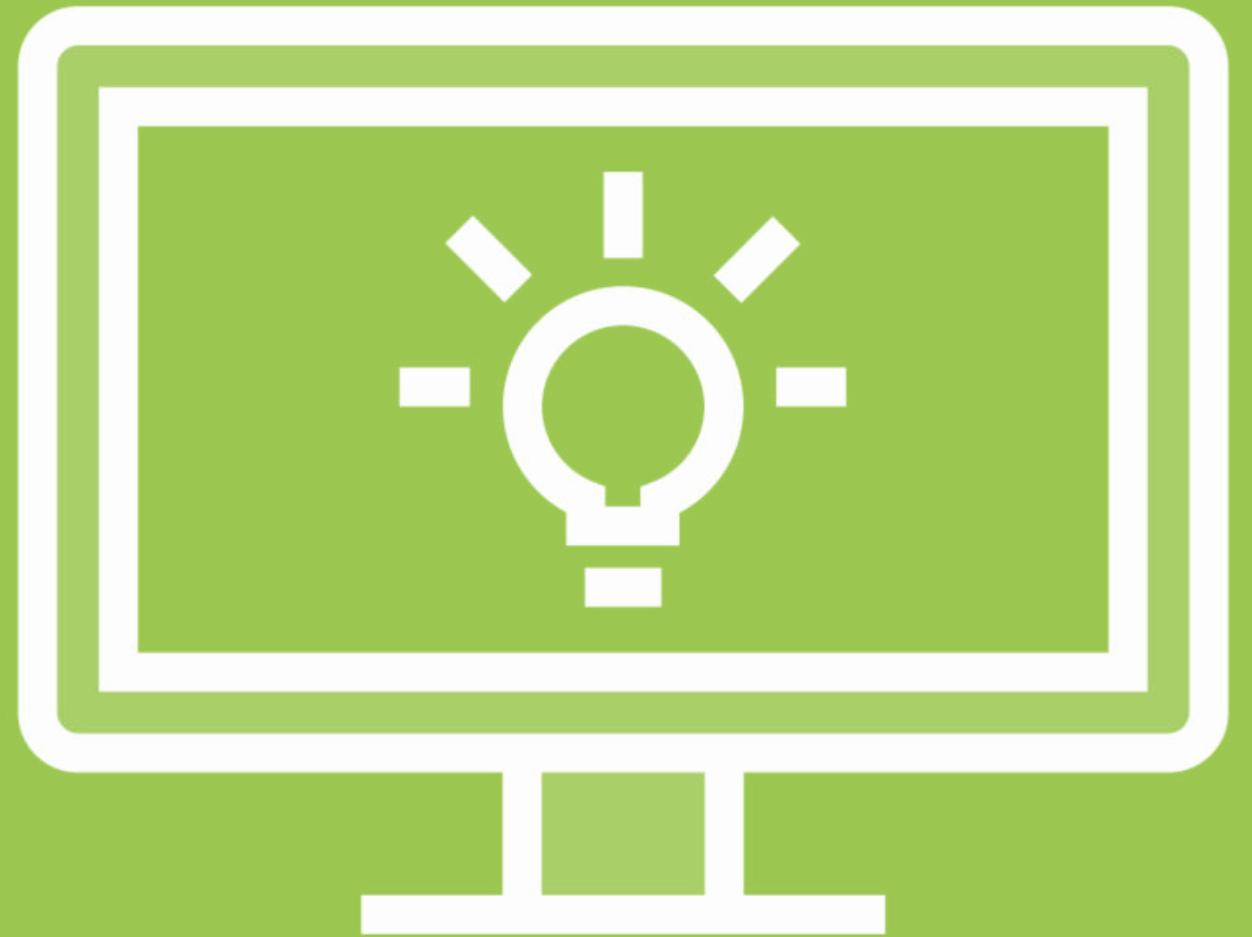
# CMOS Batteries

Keeps the clock accurate (relatively speaking) when the server is off



Battery typically lasts 2 - 10 years

- Usually on the longer side with servers as power is typically off infrequently
- Usually a coin cell battery



Tech Point  
Firmware

# Firmware

Low-level code to run basic functions of a device

Examples:

BIOS for booting  
(then OS does  
most of the work)

Code on an  
expansion card  
(like a storage  
controller)

External devices  
such as scanners  
and printers use it  
for all functionality  
it offers

# Firmware

**Stored in non-volatile memory  
(like the BIOS, which is a type  
of firmware)**

**Updateable in computers and  
associated devices**

- Used to add features, fix bugs, etc.
- Original code is stored in addition to the update in case the update fails

# Firmware vs. BIOS/UEFI

## Firmware

Generic term

Used by many devices

Updated less frequently than  
BIOS/UEFI

## Example:

Firmware on a hard drive is rarely, if ever, updated

## BIOS / UEFI

BIOS/UEFI is specialized firmware

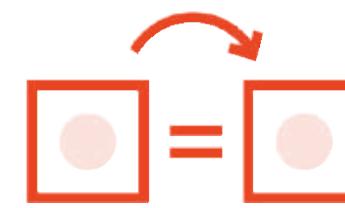
Handles the pre-boot processes

Updated several times during the lifespan of the server

May be hacked

# Updating Firmware

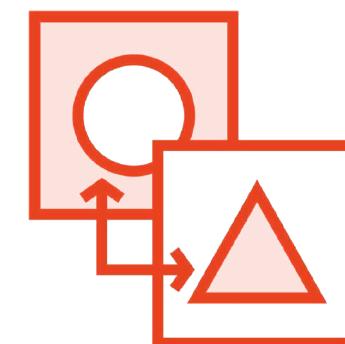
Risks and considerations for updating component firmware



Backup the current firmware



Do not power off the device during the update process



Know how to restore the old firmware before beginning the upgrade



Hindsight



# LOBOMANTICS

Globomantics is finalizing the hardware plans for their new server

Just a few more questions remain unanswered



How much downtime can they experience?



How difficult will it be to replace failed hardware components?



Should they have spare parts on hand?



# Decision Points

# How Critical Is the Server?

If server downtime will cause lost business or opportunities the server may be Mission Critical to the company, even if the company is small.

When lives are on the line, redundancy is imperative.



## Standard Server

Standard Non-Hot Plug Components



## Mission Critical

Hot-Plug Components



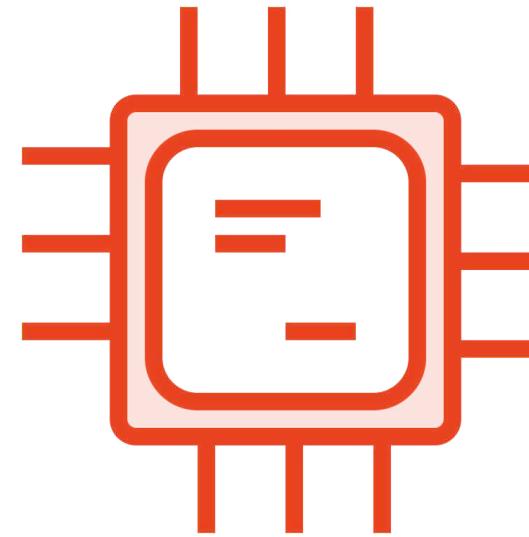
## Lives depend upon it

Hot-Plug Components

Have spare components  
on hand

# Will the Server Run a 64-bit Operating System?

**32-bit operating systems typically do not support UEFI**



**BIOS**

Stored in a chip located on the system board

Primarily used in older systems



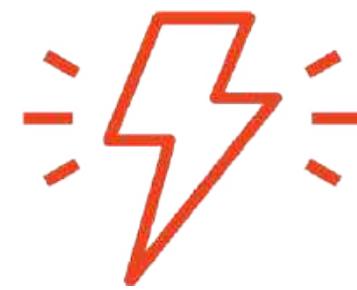
**UEFI**

Stored in NVRAM or in files on the hard drive

Much more extensible than BIOS



**Globomantics only plan to purchase a single server, therefore it must be redundant**



**The server will run Microsoft Server 2019 or later, which is a 64-bit operating system**



**The server will boot UEFI**



**They will use hot swap power supplies, PCIe cards, fans, and hard drives**

# Module Summary

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# Review



**Server Form Factors**

**The Hardware Compatibility List (HCL)**

**CPU Cores vs. Clock Speed**

**Memory Type and Placement**

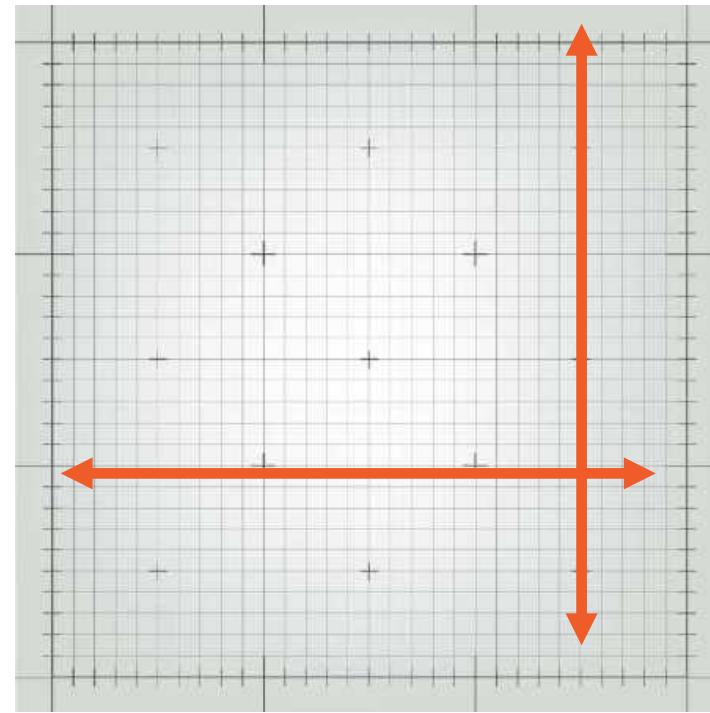
**PCIe Version and Slot Type**

**GPU Considerations**

**Hot Swappable Hardware**

**Firmware vs. UEFI/BIOS**

# Why Does the Form Factor Matter?

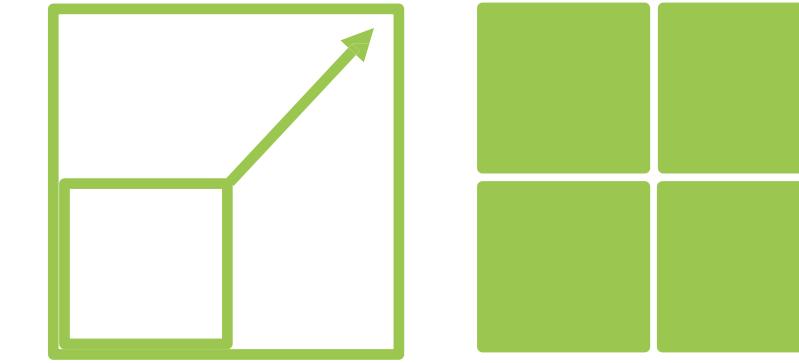


Physical size

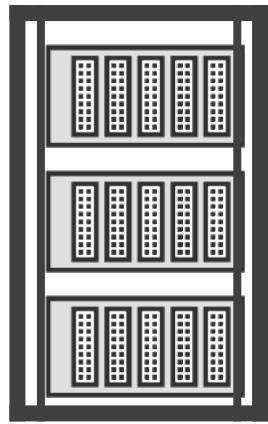


**120V**  
**208V**  
**240V**

Power input  
type



Expansion vs.  
density

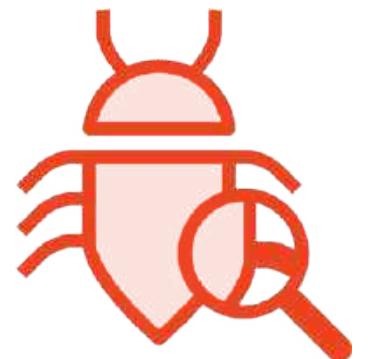


Free-standing  
vs. fixed  
mounted

# What Is the Purpose of an HCL?



You can feel confident that your hardware has been tested and confirmed to be stable with the vendor's application



The vendor can rule out hardware compatibility issues, making support easier



Some software vendors will not provide support if you do not follow the HCL

# Speed vs. Parallel Processing

Do you require extreme speed for a single process or are you planning to run a highly parallel workload?



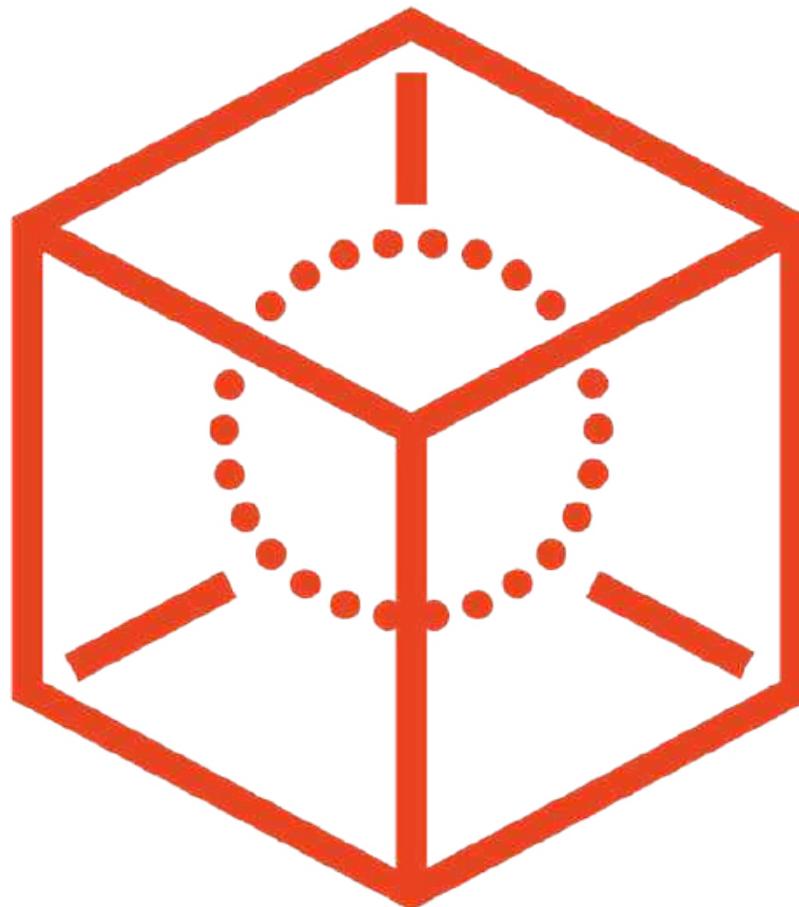
## Single-thread Performance

Choose a system with fewer cores, where each core has a high clock speed

## Highly Parallel Processing

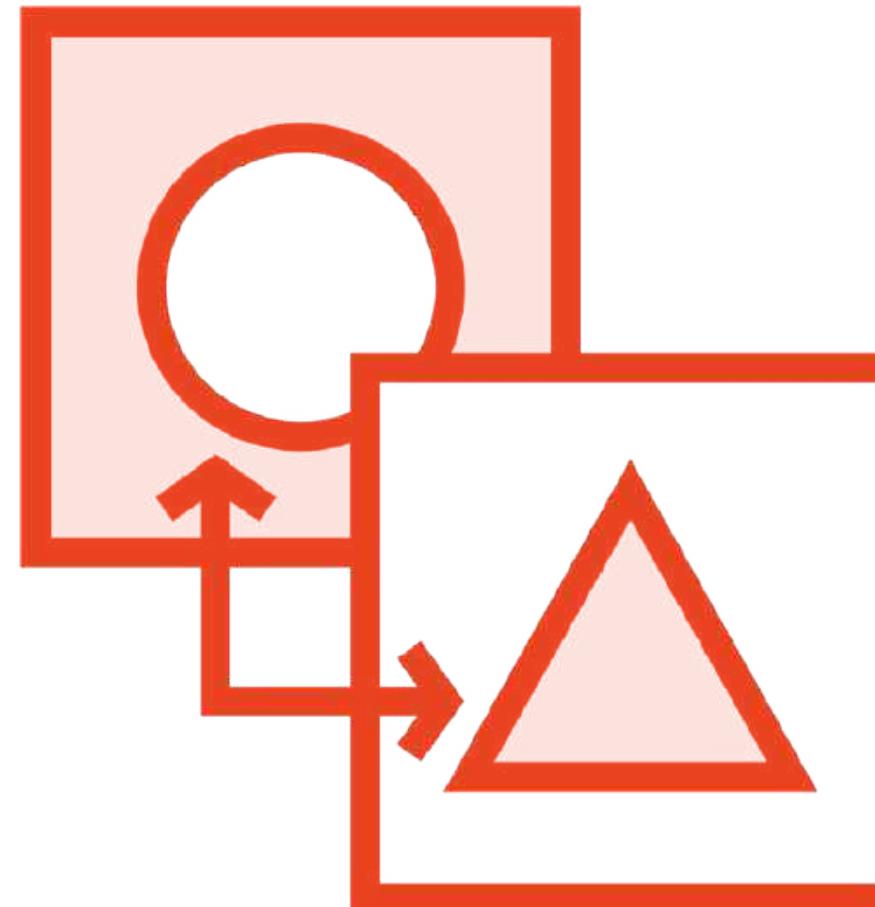
Choose a system with more cores, but each core will have a lower clock speed

# With RAM, What Matters Most?

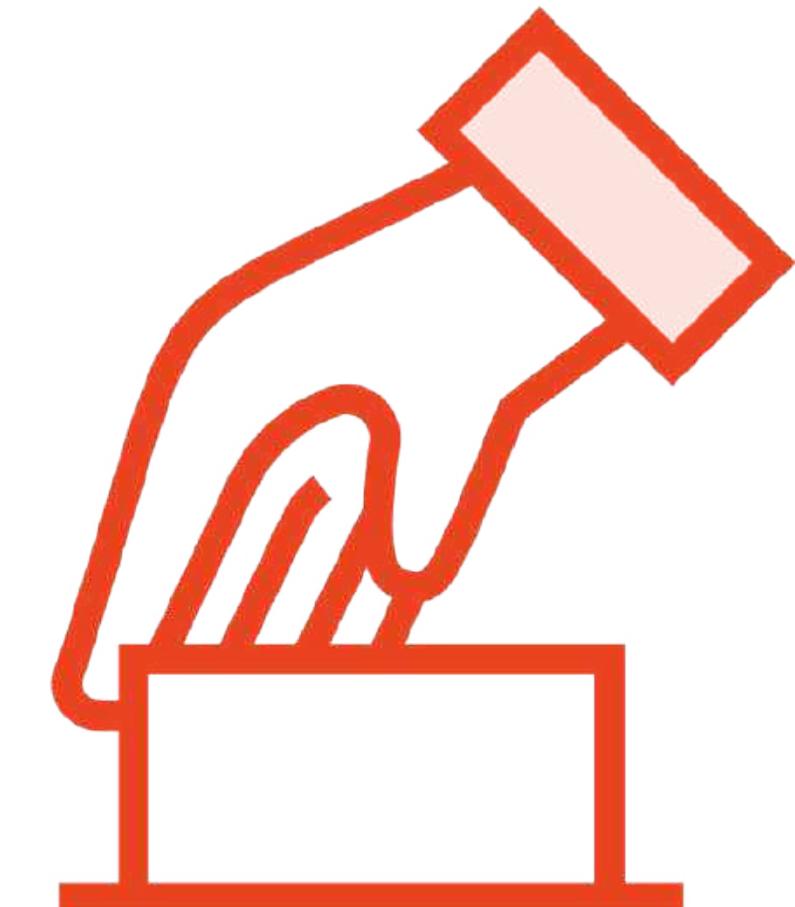


The total RAM  
capacity

64GB, 256GB, 1TB



The type of RAM  
ECC, DDR4, etc.



Where you install it  
Bank 0, Bank 1

# How Critical Is the Server?

If server downtime will cause lost business or opportunities the server may be Mission Critical to the company, even if the company is small.

When lives are on the line, redundancy is imperative.



**Standard Server**

Non-ECC Memory



**Mission Critical**

ECC memory required

Memory spares if available



**Lives depend upon it**

Memory Mirroring  
Required

Memory Spares Required

# 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**?

# Why Does the PCIe Version and Slot Type Matter?

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PCIe 4.0

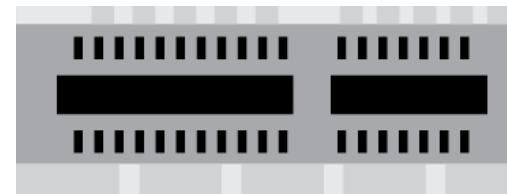
What types of PCIe slots are available?

x1, x4, and x16

Solution:  
PCIe 4.0  
Using one x4 slot



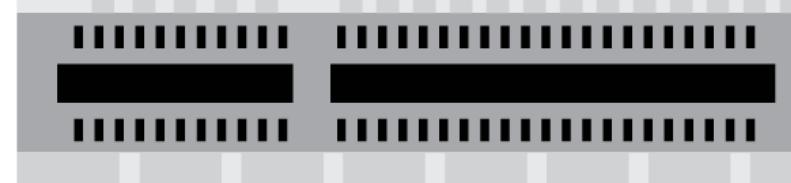
**x1 Slot**



PCIe 4.0 with 1 lane = 15.76 Gbps (insufficient)



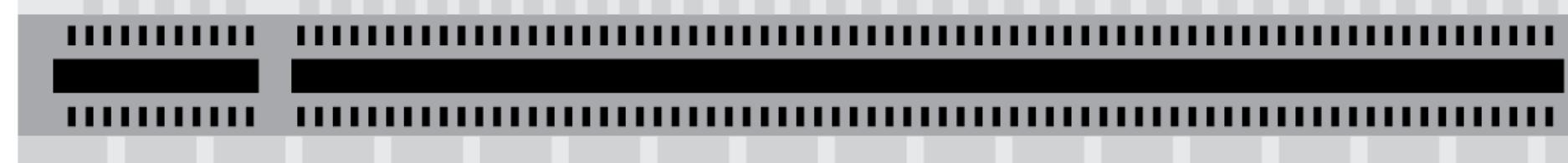
**x4 Slot**



PCIe 4.0 with 4 lanes = 63.02 Gbps (perfect)

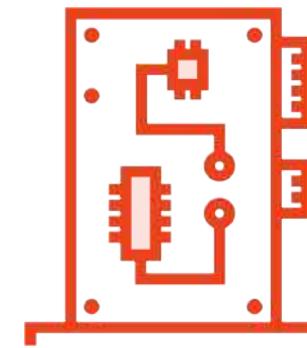


**x16 Slot**



(overkill)

# What Do You Need to Consider About GPUs?



How many cards do you need?



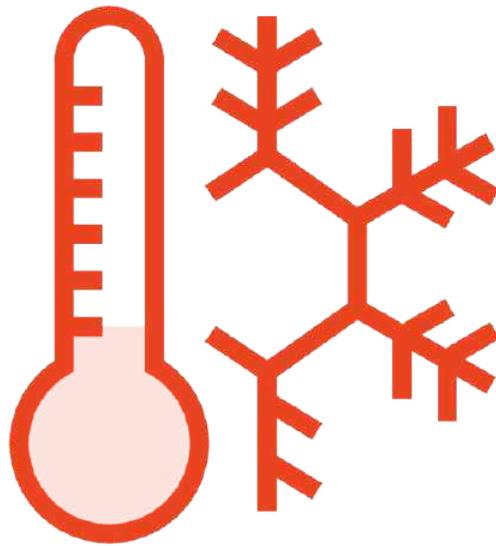
Bus type of the card



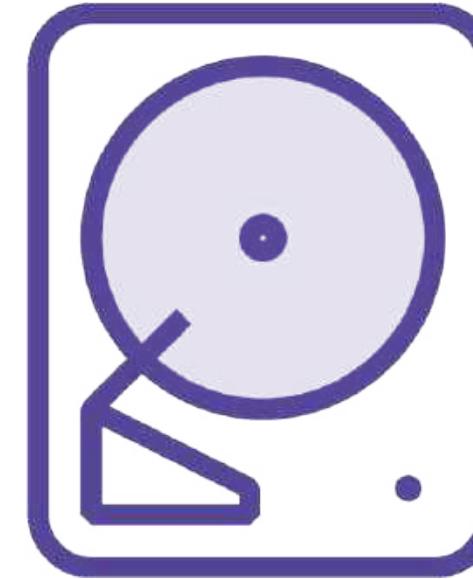
Power draw of the cards

# Common Hot Swappable Components

Components that can often be hot swapped in servers:



Fans



Hard drives



Power supplies

# Firmware vs. BIOS/UEFI

## Firmware

Generic term

Used by many devices

Updated less frequently than  
BIOS/UEFI

## Example:

Firmware on a hard drive is rarely, if ever, updated

## BIOS / UEFI

BIOS/UEFI is specialized firmware

Handles the pre-boot processes

Updated several times during the lifespan of the server

May be hacked

Up

Next:

~~Storage~~

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