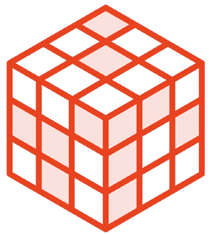
GLOBOMANTICS

DECISIONS

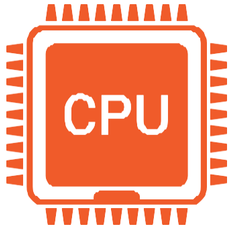
Their OS and software vendors only support CISC processors.



They will use a CISC processor

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

More CPU cores should yield better performance

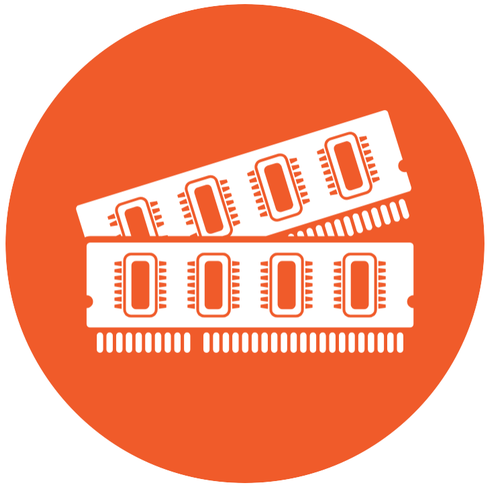


The server will have 2 CPU sockets with 12 CPU cores per socket

RAM

Storyline

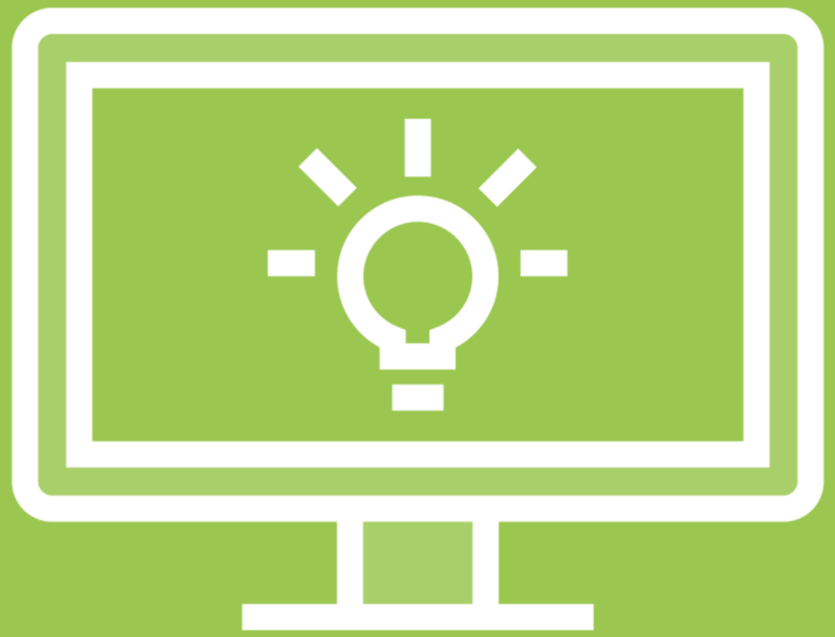
What Do You Need to Know?



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

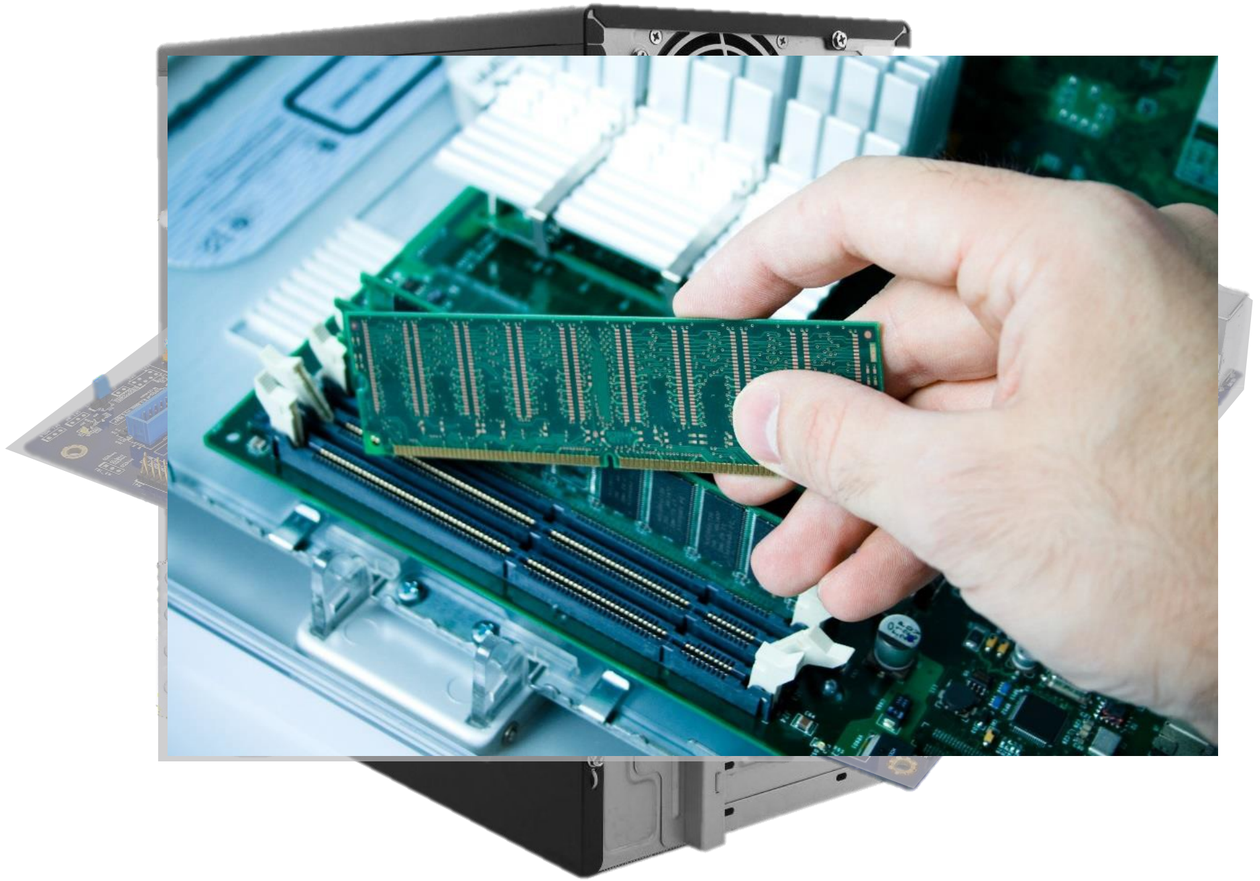
Minimum Hardware	Recommended Hardware
1 CPU Sockets with 6 cores	2 CPU Sockets with 12 cores each
64 GB of RAM	256 GB of RAM
1 Gbps Networking	10 Gbps Networking
512 GB Storage	3 TB Storage



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.

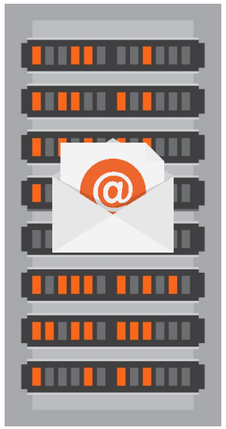
Where you install it

Channel 0, Channel 1

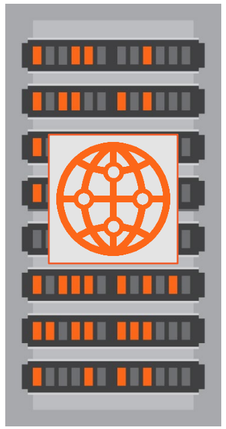
RAM is measured in GB and TB, but it isn’t the same thing as storage space.

What Is RAM Used For?
How Do I Know How Much RAM I Need?

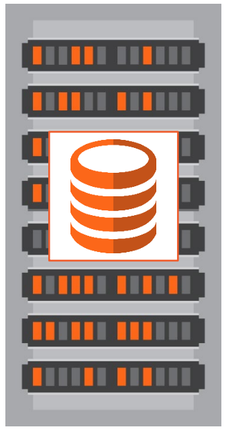
Let’s look at some example server roles and see how they use resources



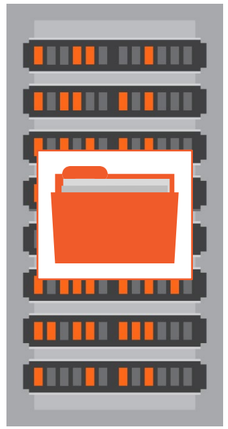
Email Servers



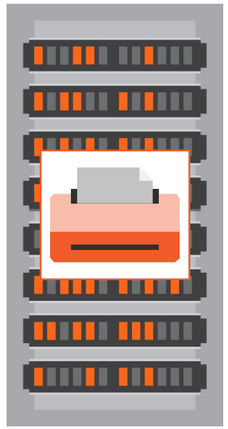
Web Servers



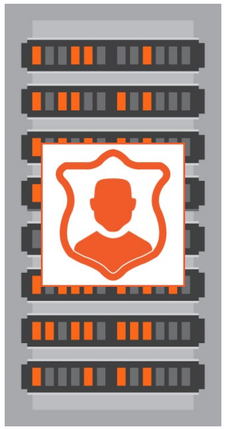
Database Servers



File Servers



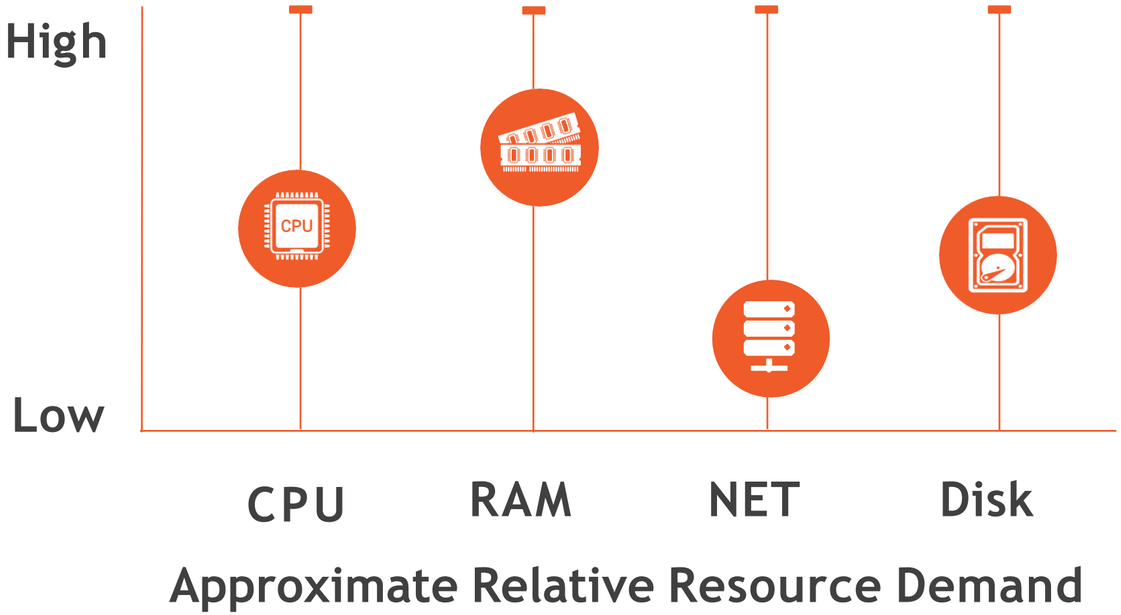
Print Servers



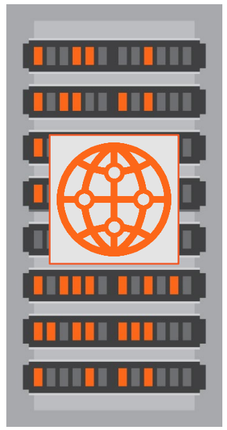
Authentication Servers

Server Role vs. Resource Requirements

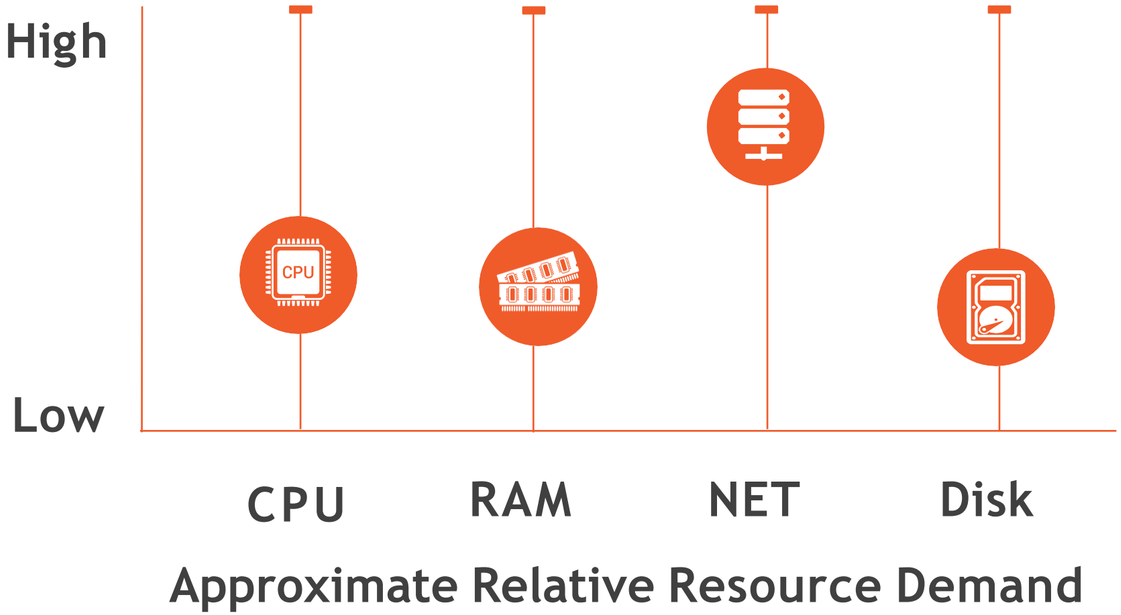
Email Servers



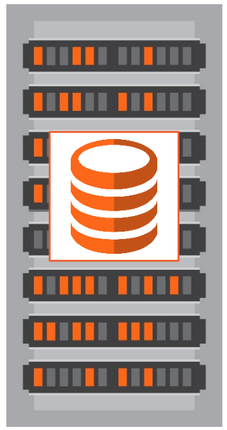
Server Role vs. Resource Requirements



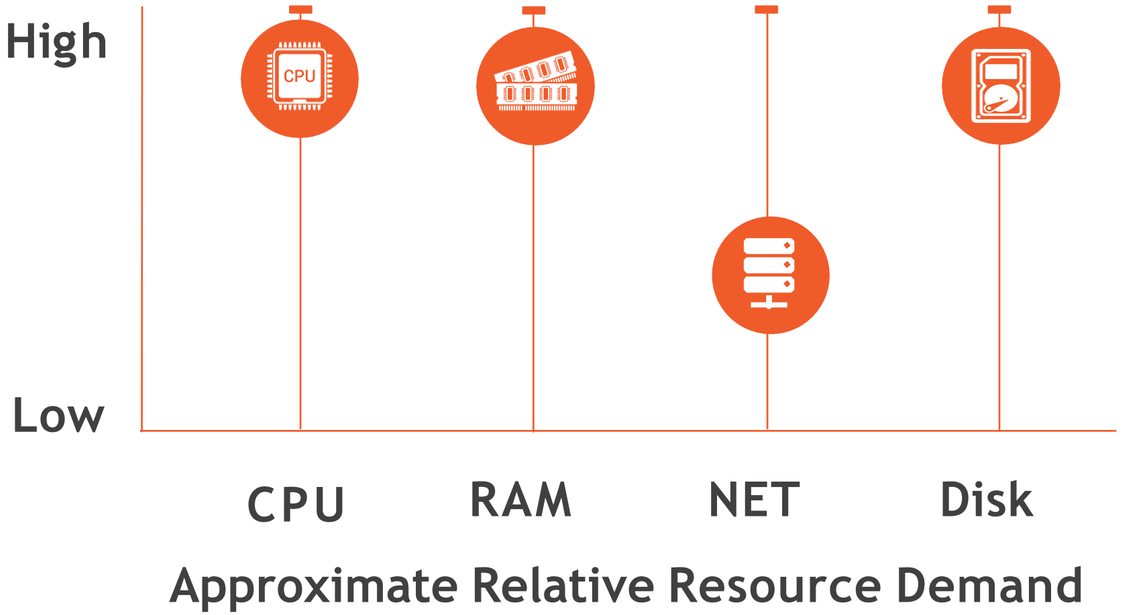
Web Servers



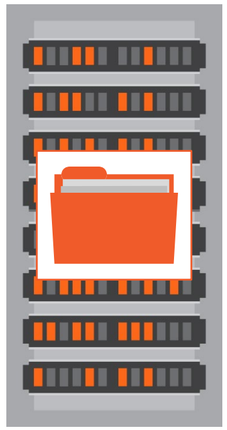
Server Role vs. Resource Requirements



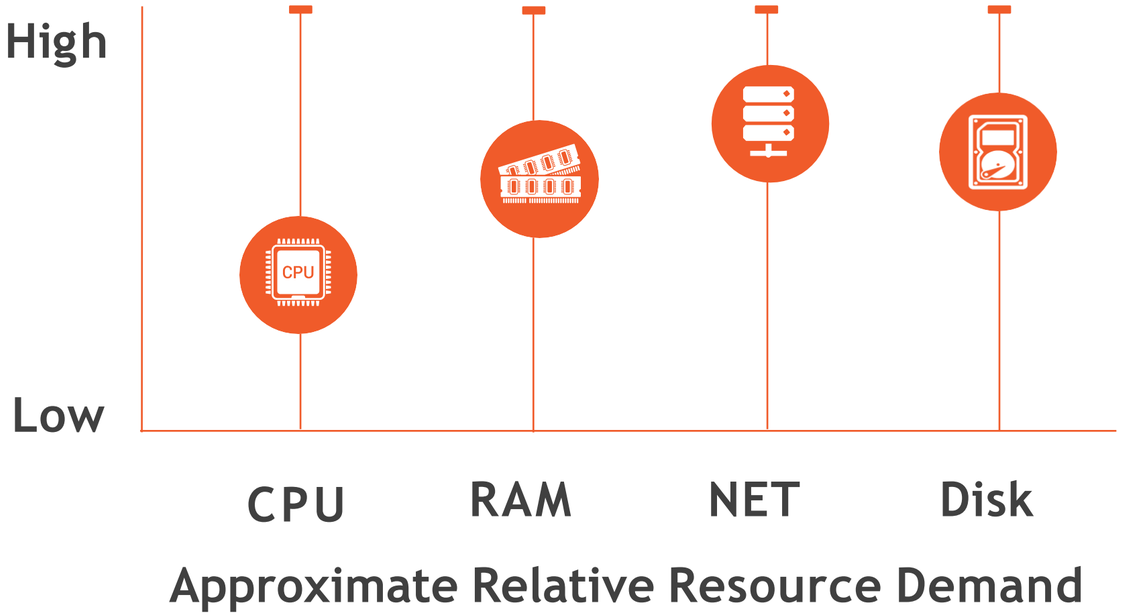
Database Servers



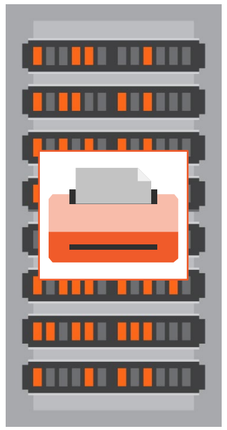
Server Role vs. Resource Requirements



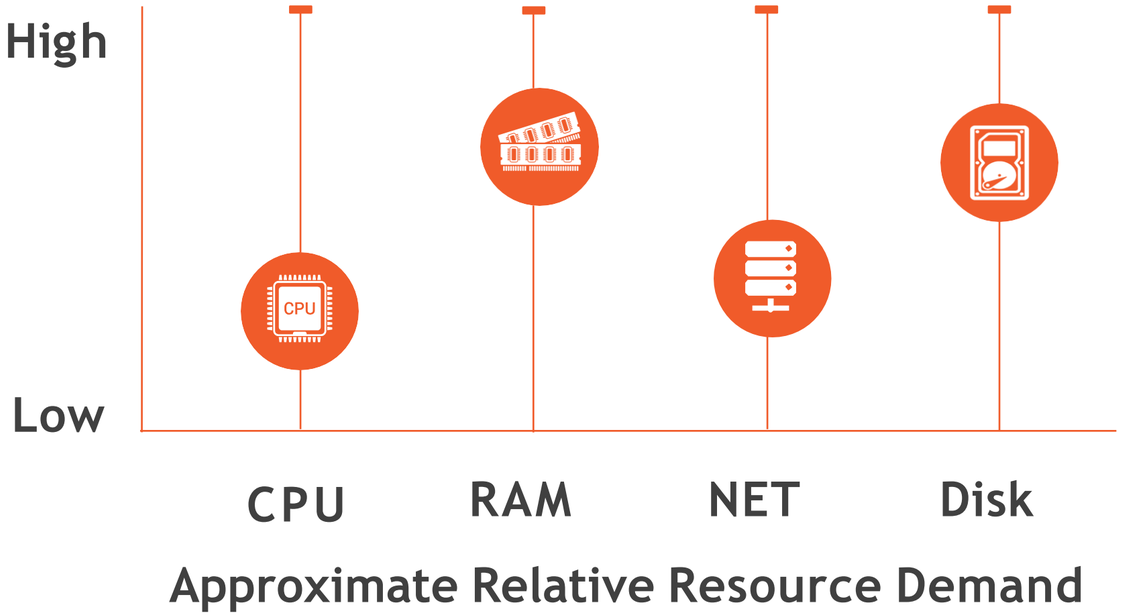
File Servers



Server Role vs. Resource Requirements

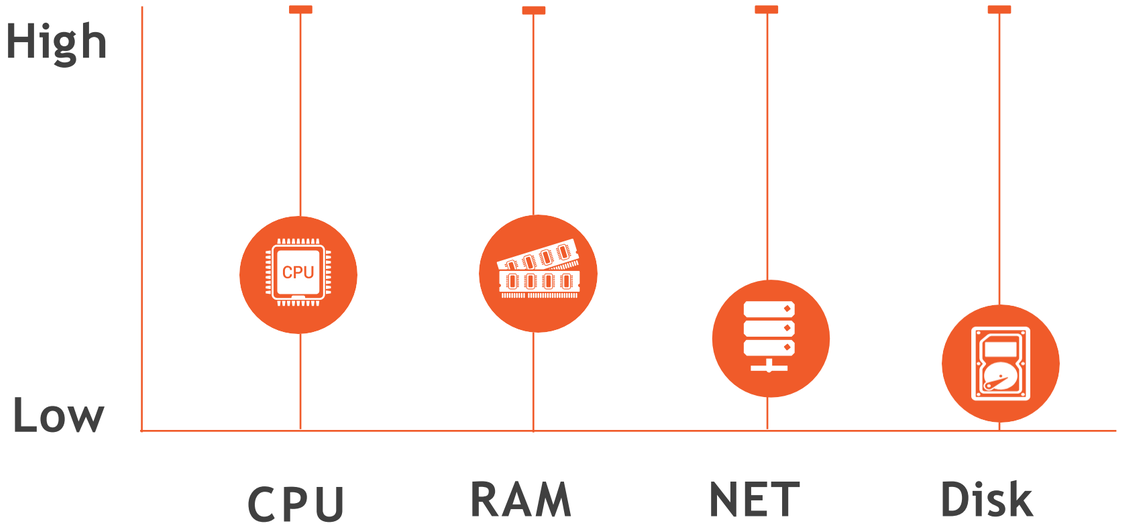


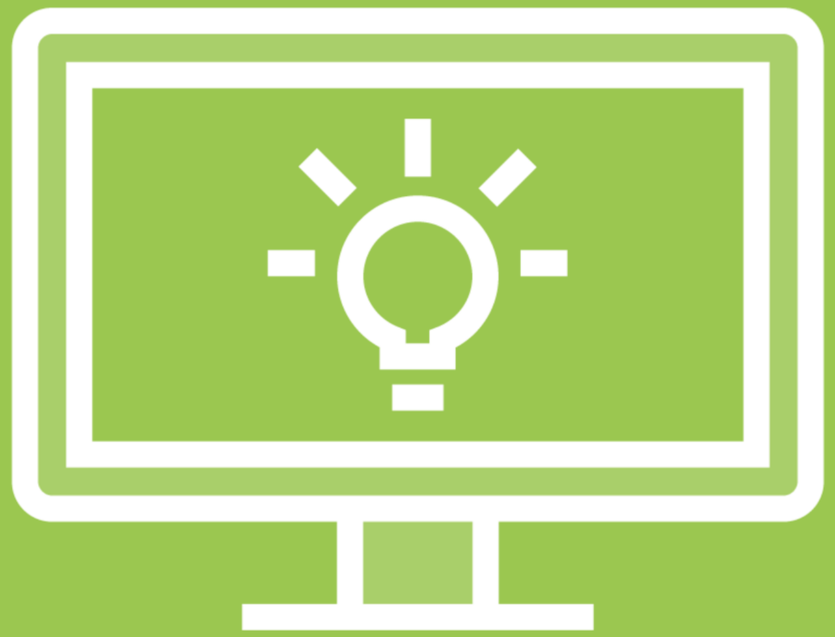
Print Servers



Server Role vs. Resource Requirements

Authentication Servers





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

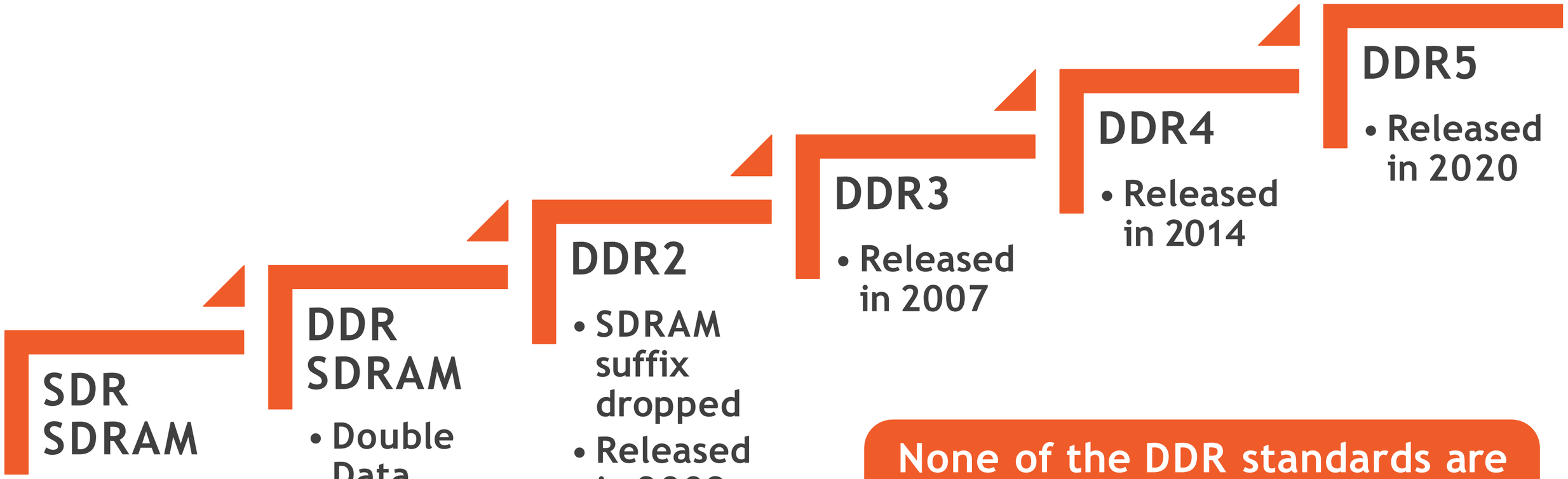
Synchronous DRAM

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

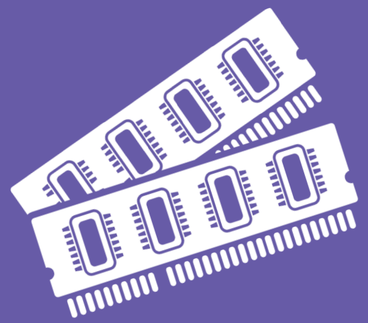


None of the DDR standards are backward or forward compatible with any other DDR version

Number of Pins

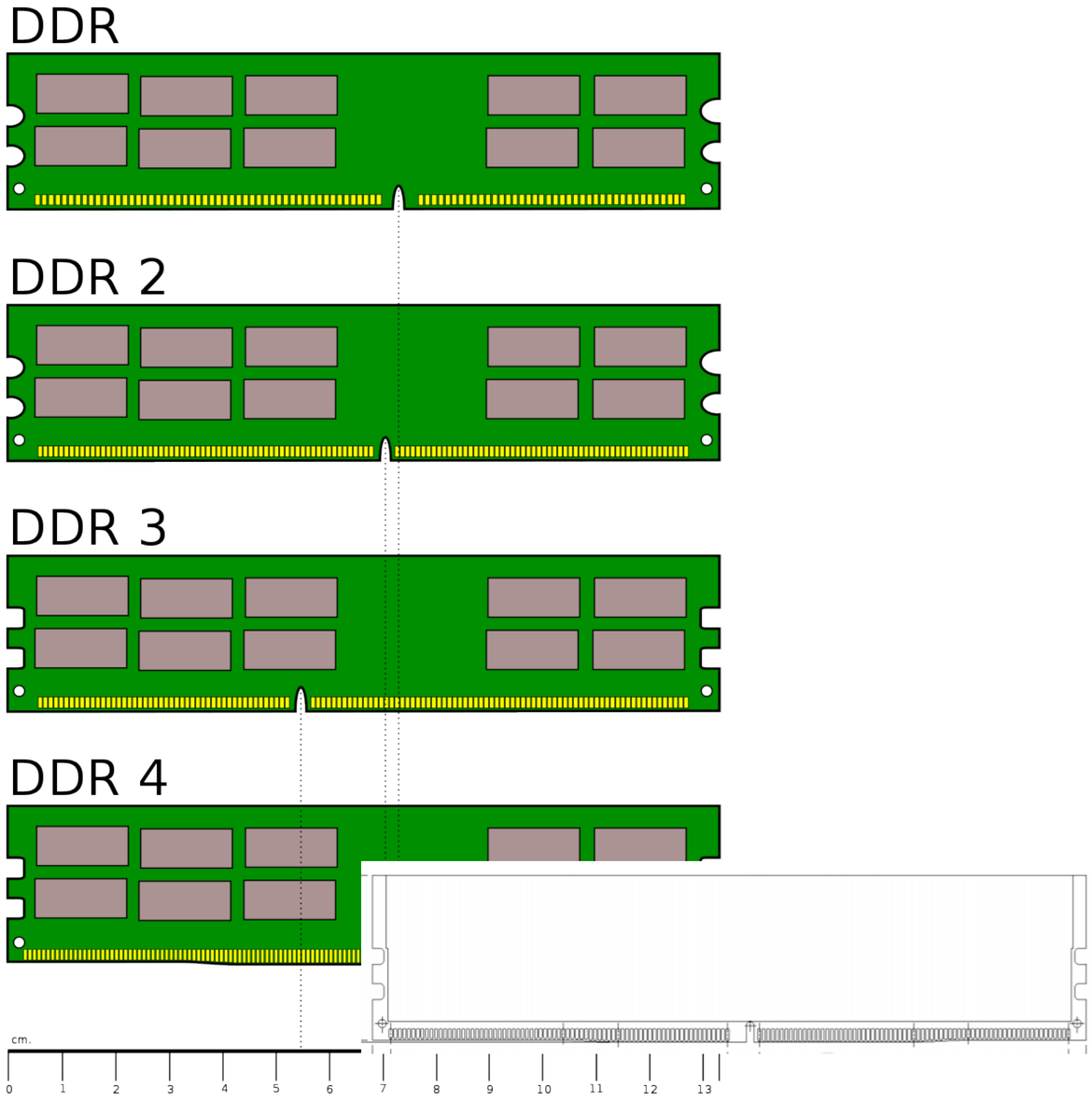
Number of pins per DIMM vary depending on type

- 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



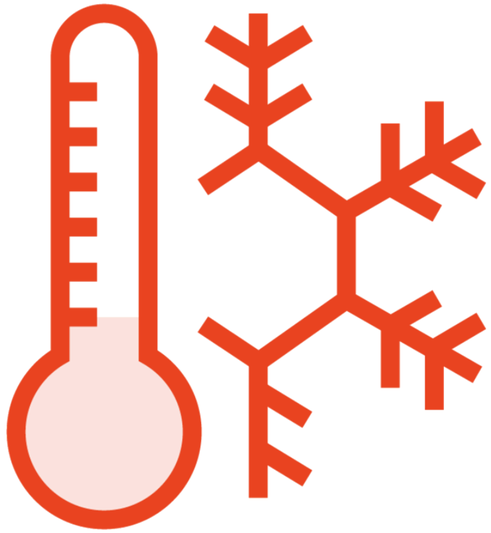
DDR modules are physically incompatible

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

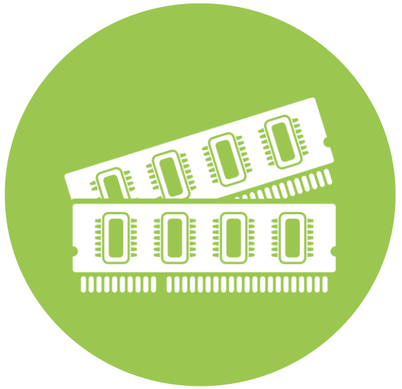


Less heat produced in servers

Better battery life for mobile devices

DDR Version Comparison

2X

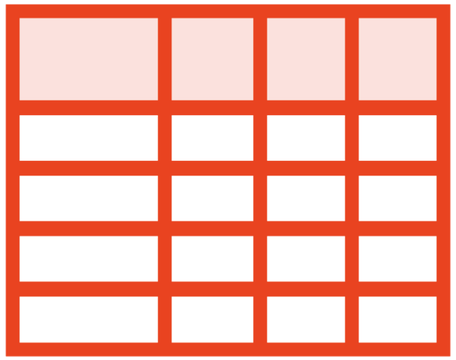


Typically about 2X the maximum data transfer rate of the previous generation

Greater memory density per chip

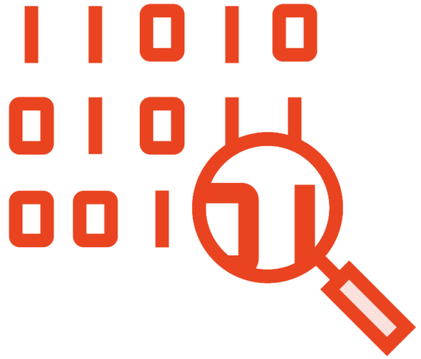
- **More memory in less space**

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

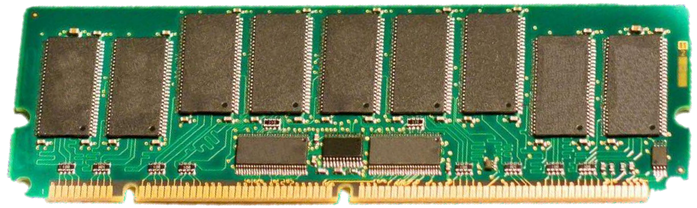
Registered memory allows the memory controller on the motherboard to address more memory than unregistered memory

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)

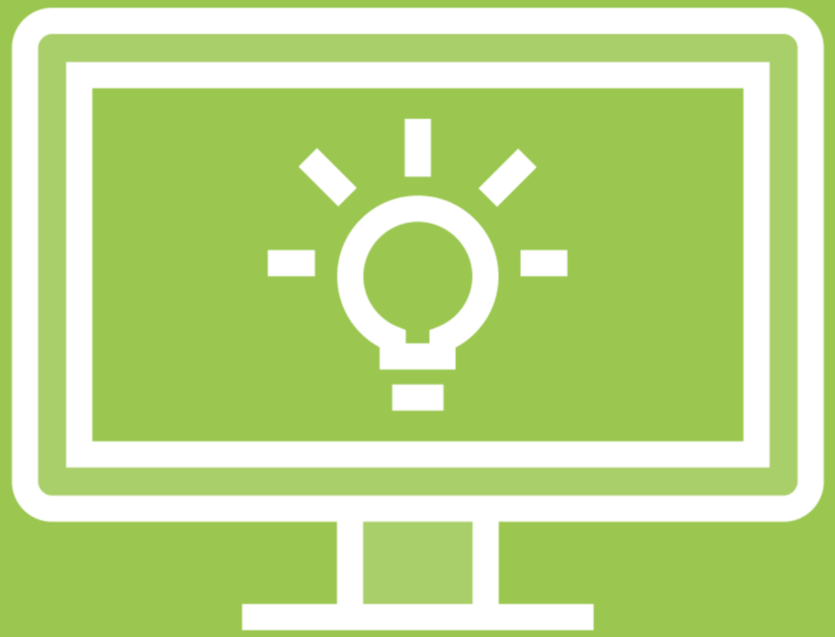
ECC = Error Correcting Code

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

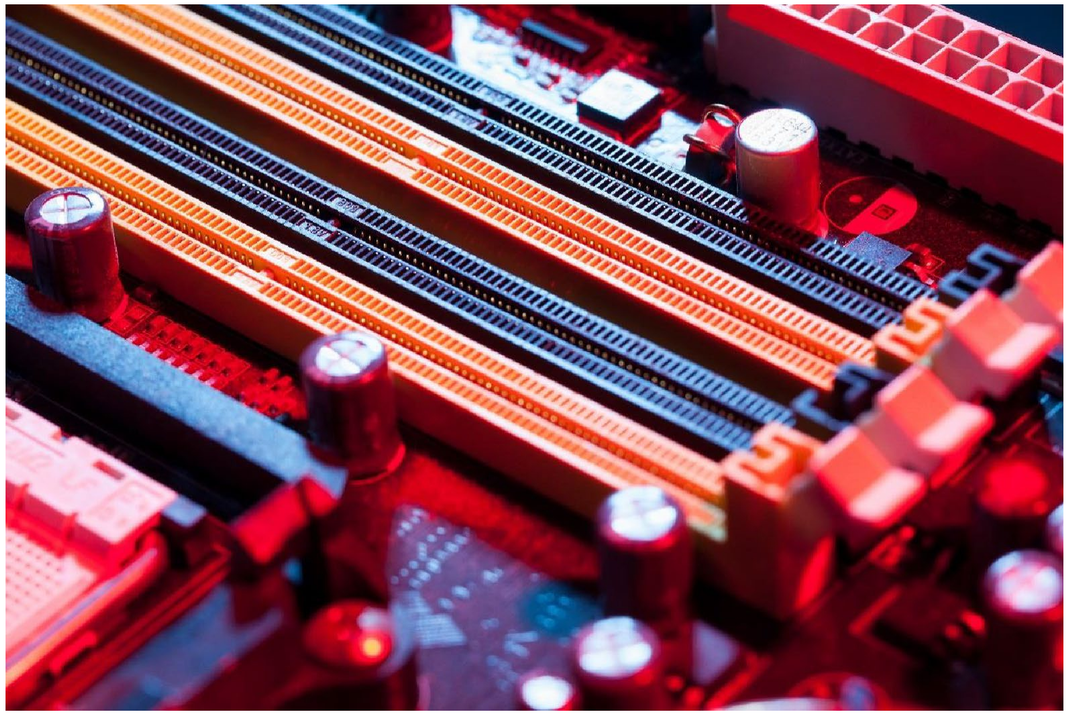


Tech Point

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

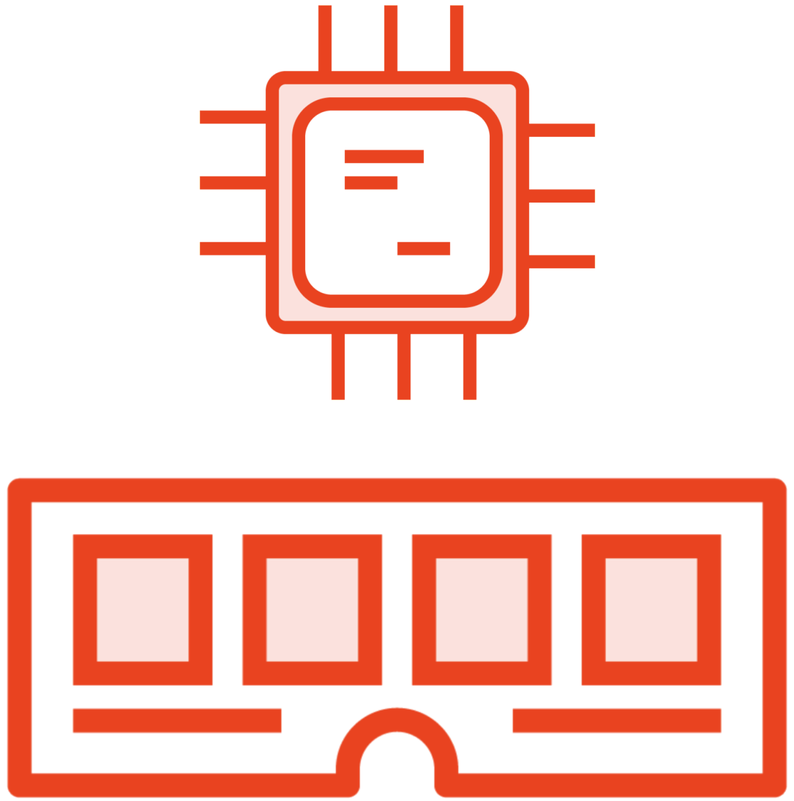
NUMA Considerations

NUMA = Non-Uniform Memory Access

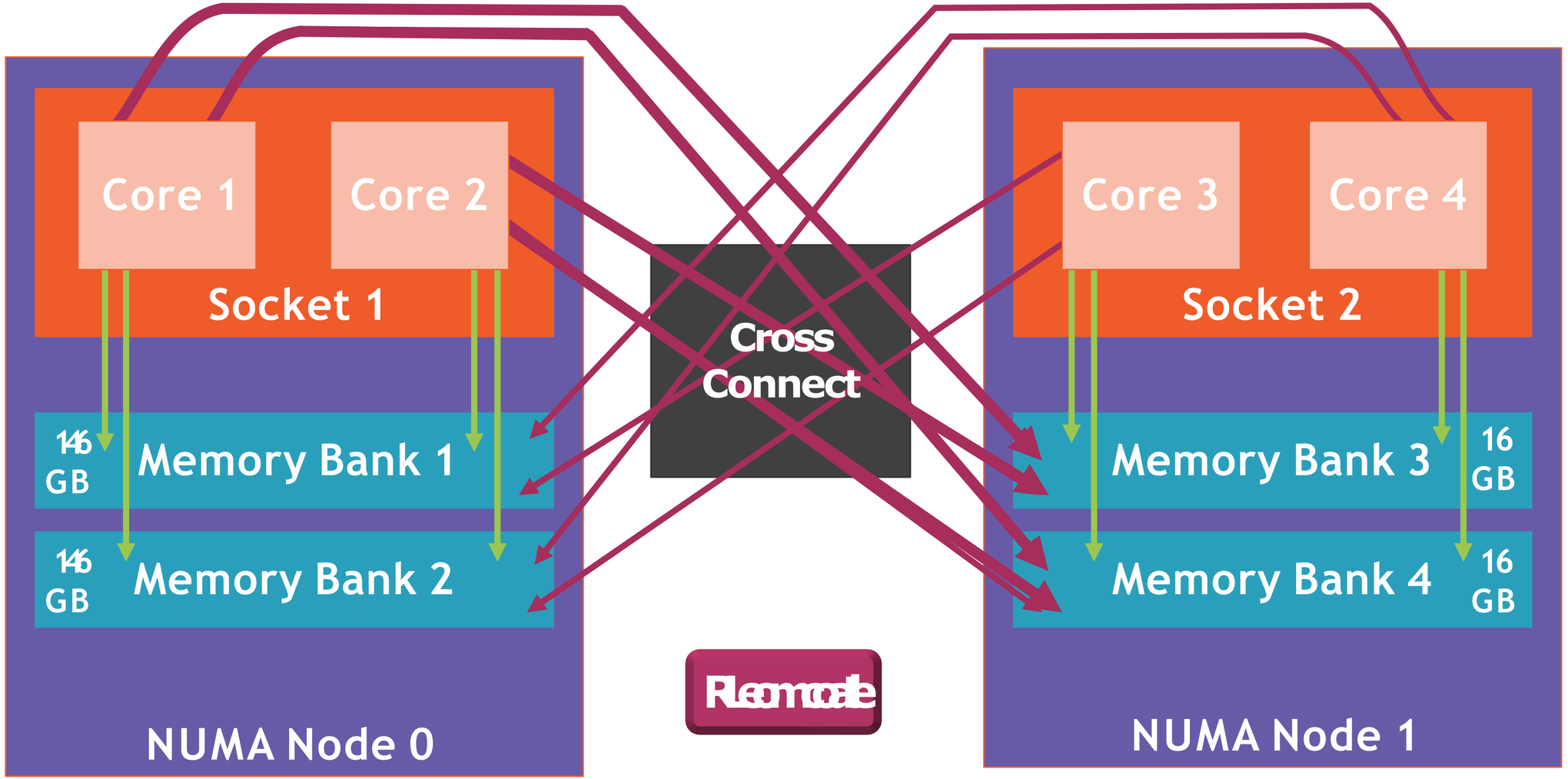
Modern operating systems allocate memory to take advantage of NUMA

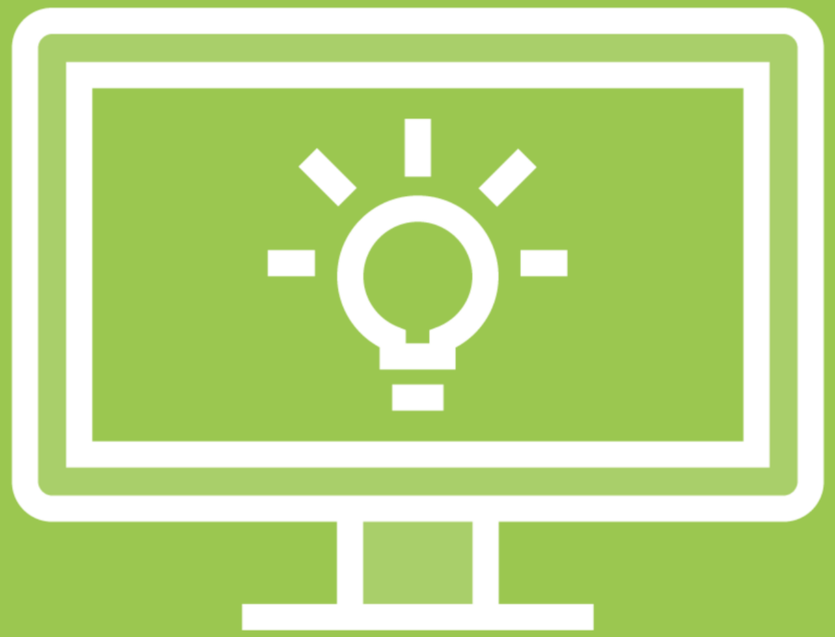
NUMA systems have one or more NUMA nodes

Each NUMA node should have the same amount of memory



NUMA Nodes

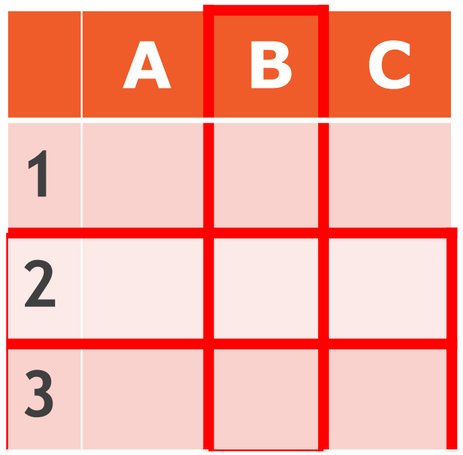

Core 1
Core 2
Socket 1
Core 3
Core 4
Socket 2
Cross Connect
16 GB
Memory Bank 1
16 GB
Memory Bank 2
Memory Bank 3
16 GB
Memory Bank 4
16 GB
Remote
NUMA Node 0
NUMA Node 1



Tech Point

RAM Speeds

Data in Memory Is Stored in a Matrix



y Select the row

x Then select the column

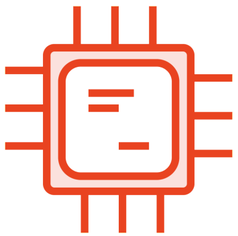
$\{y,x\}$ Finally, retrieve/store the contents at the intersection

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

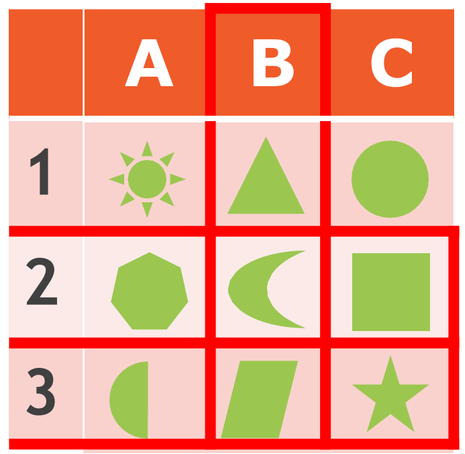
16 — t_{CAS} Column Access Strobe (CAS): Column selection latency (CL)

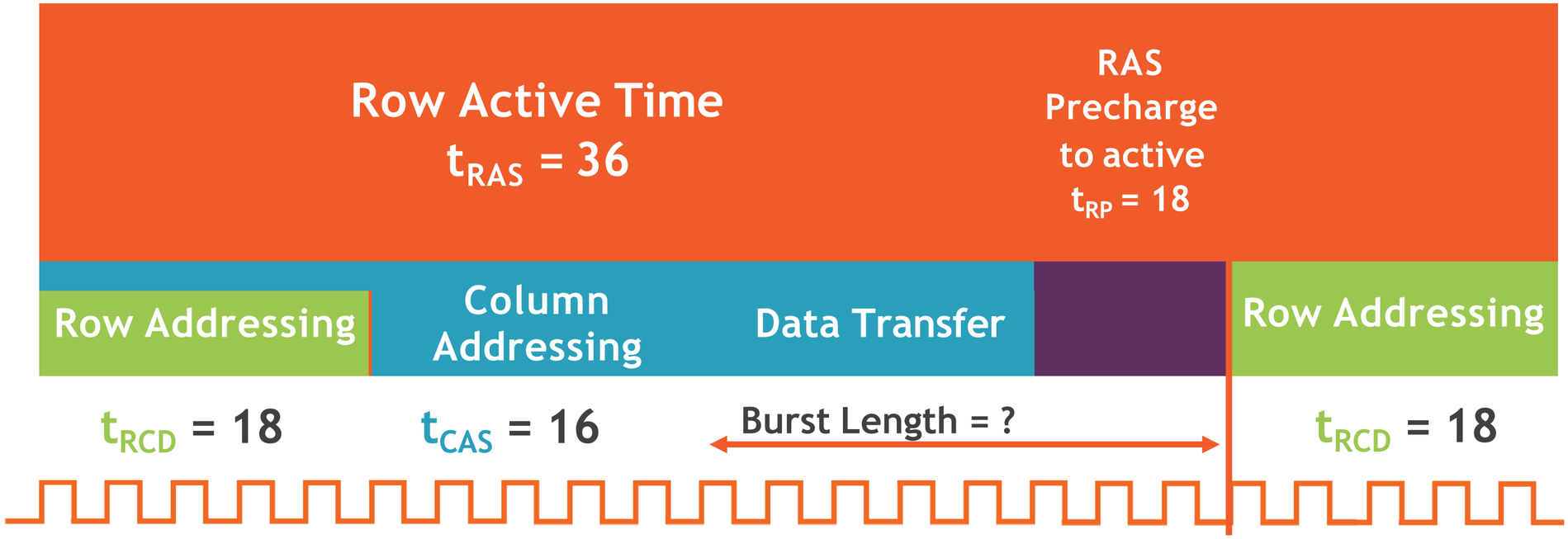
18 — t_{RCD} Row Column Delay: Time between opening a row and selecting the column

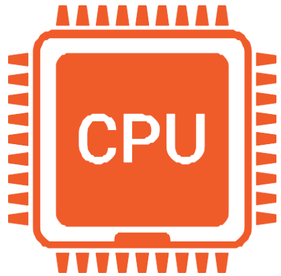
18 — t_{RP} Row Precharge: Time required before moving to a new row

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

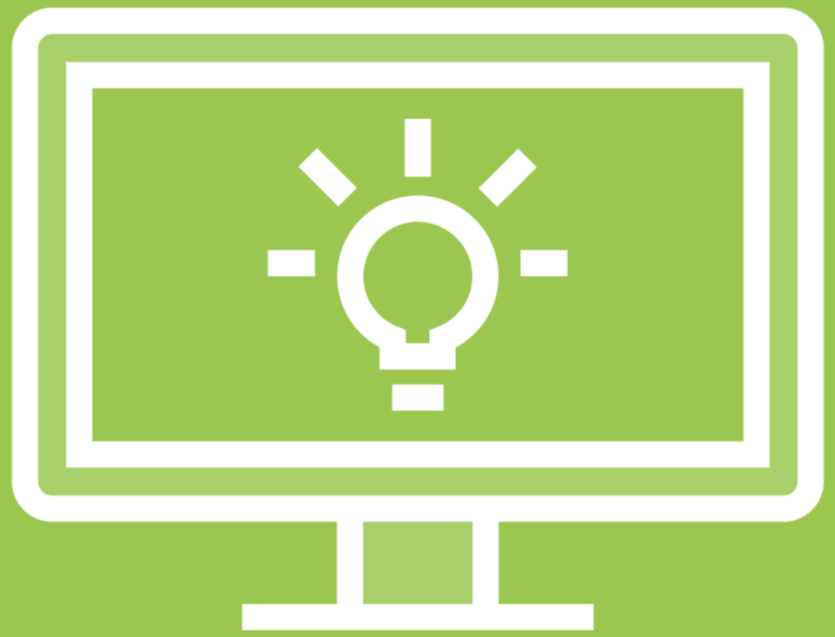
Timing Illustration







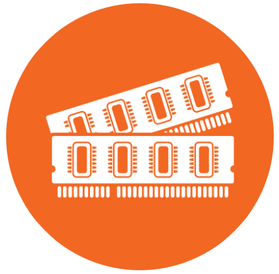
Example: 16-18-18-36



Tech Point

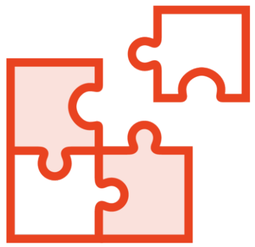
Fault Tolerant Memory

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

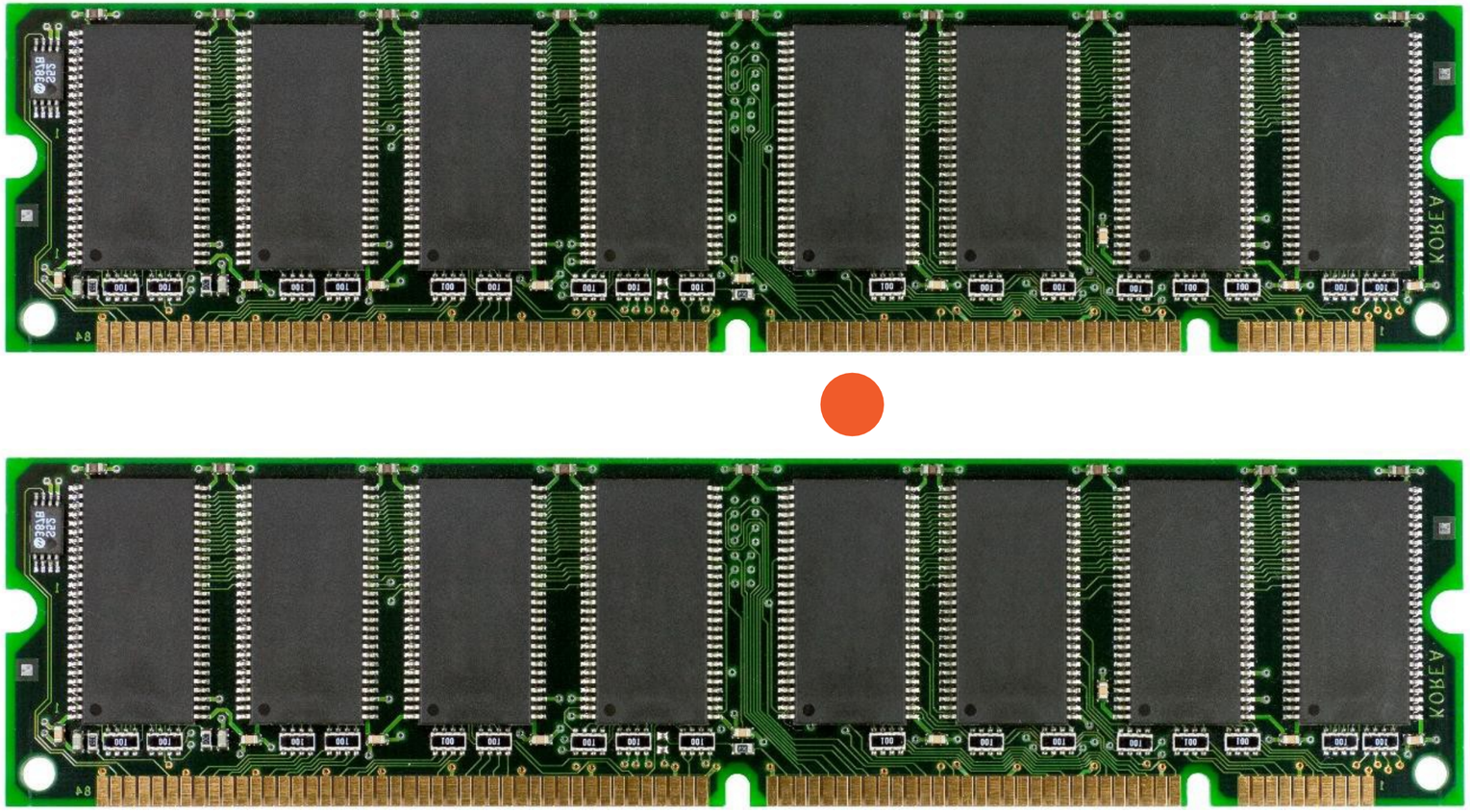
Similar to RAID 1 for RAM

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



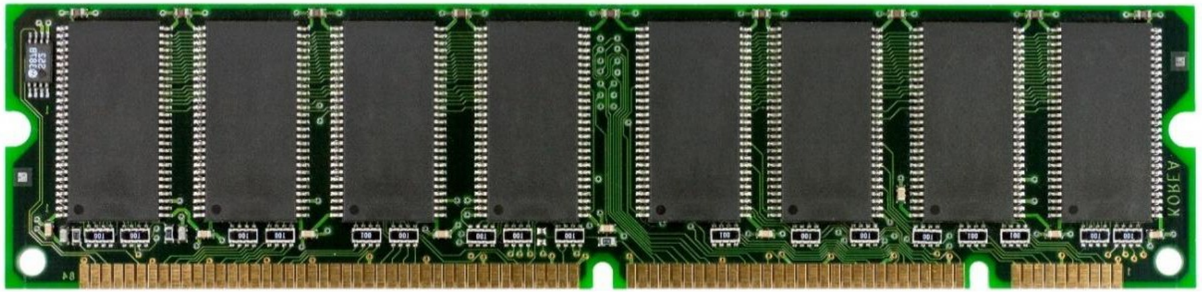
Memory Sparing

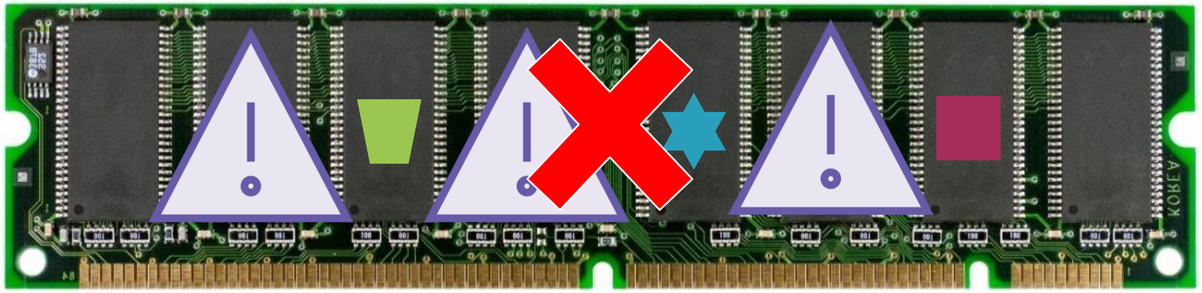
Similar to a hot spare in storage

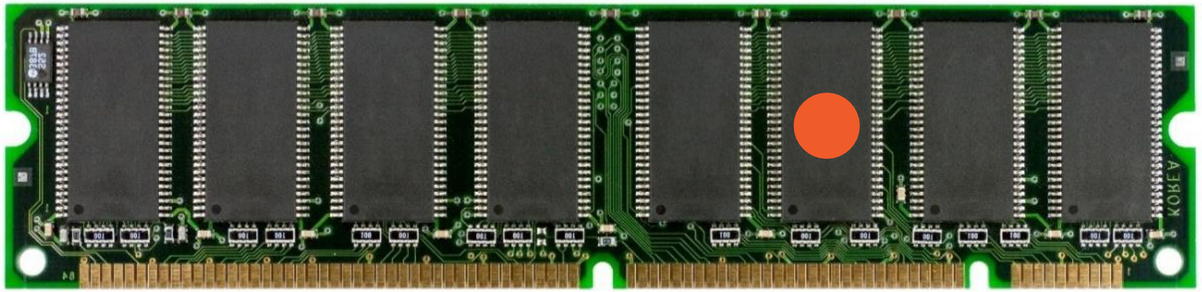
DIMM is not used until a preset number of errors occurs (the threshold), then contents are copied from failing DIMM to the spare

Can be used with ECC memory and / or Memory Mirroring

Memory Sparing Example







Hindsight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Minimum Hardware	Recommended Hardware
1 CPU Sockets with 6 cores	2 CPU Sockets with 12 cores each
64 GB of RAM	256 GB of RAM
1 Gbps Networking	10 Gbps Networking
512 GB Storage	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.

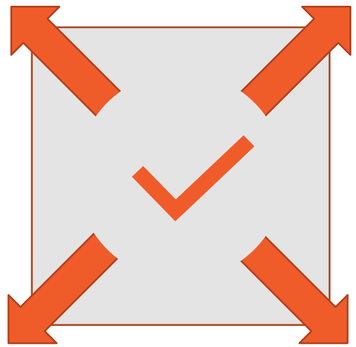
Scalability is important if you intend to add additional roles or applications to the server.

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

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DECISIONS

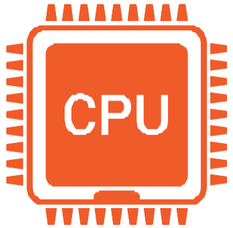
Globomantics is a small company, but this server is mission critical to them.

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

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

Registered (buffered) memory if possible, but not required

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



Ensure that the memory is evenly divided between the CPU sockets