RAM

Introduction

Watch the following video about RAM evolution.

Watch the following video called How to choose RAM for Begginers.

Questions

- How much RAM do I need?
  - 8 GB minimum
  - 16 GB for normal use
  - 32 GB for video editing and gaming
- RAM Compatibility
  - DDR Generation
  - Avaliable DIMM slots on motherboard
  - Maximum RAM capacity supported size
  - Clearance underneath CPU Cooler
  - RAM Form-Factor
    - DIMM vs. SO-DIMM
- Performance
  - Frequency
  - Latency

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Clearance underneath CPU Cooler

| RAM with Tall Heat Spreaders Corsair Vengeance RGB Pro	Low-profile RAM modules Corsair Vengeance LPX
Height: 51 mm	Height: 34 mm

Cooler Dark Rock PRO 4

Corsair Vengeance RGB Pro stiks wouldn't fit with this cooler.

DDR Meaning

DDR stands for Double Data Rate. It's a type of SDRAM (Synchronous Dynamic Random-Access Memory) that **transfers data on both the rising and falling edges of the clock signal**—which is how it achieves double the data rate of earlier SDRAM. **This doubles the effective data rate without increasing the clock frequency.**
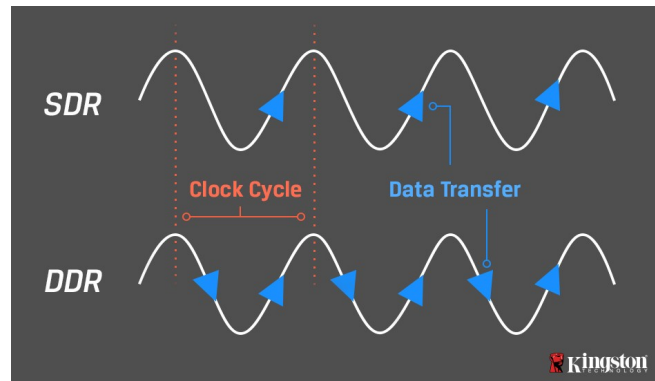
DDR uses a **prefetch buffer** to temporarily store data from the memory array. The size of this buffer increases with each generation:

Generation	Prefetch Size	Internal Clock (Example)	I/O Bus Frequency	Effective Data Rate (MT/s)	Bandwidth (64-bit bus)
DDR	2 bits	100 MHz	100 MHz	200 MT/s	1.6 GB/s
DDR2	4 bits	100 MHz	200 MHz	400 MT/s	3.2 GB/s
DDR3	8 bits	100 MHz	400 MHz	800 MT/s	6.4 GB/s
DDR4	8 bits	100 MHz	800 MHz	1600 MT/s	12.8 GB/s
DDR5	16 bits	100 MHz	1600 MHz	3200 MT/s	25.6 GB/s

Frequency (MHz) and data rate (MT/s) are therefore both good parameters for measuring RAM speed. MHz measures RAM speed in terms of the number of times it can change voltage per second, while MT/s measures RAM speed in terms of the amount of data it can transfer per second.

- **Example for DDR3-1600:**
  - Bandwidth = Data Rate (MT/s) × Bus Width (in bytes)
  - 1600 MT/s × 8 bytes = 12.8 GB/s

Effective vs Real Frequency

- The I/O Bus Frequency is the frequency at which data is sent between the memory chip and the memory controller.

- Because DDR is double data rate, you multiply this frequency by 2 to get the effective data rate (MT/s).

Performance

Memory Frequency (or Clock Speed)

- Memory frequency (or RAM frequency) is how many cycles per second the memory can perform. It's measured in megahertz (MHz). A higher frequency means the memory can do more operations in a given amount of time, leading to faster data transfer rates between RAM and the CPU.

- How it works:

  Think of memory frequency like the speed of a train: the faster it moves, the more stations (data) it can visit in a given time. So, a higher frequency means more data can be transferred in the same time frame.

- Example:

  - 2400 MHz means the memory completes 2.4 billion cycles per second.

  - 3200 MHz means 3.2 billion cycles per second.

A higher frequency, in general, leads to faster data transfer.

Memory Latency (or Timings)

- What it is:

  Latency refers to the delay or time it takes for the RAM to respond to a request from the CPU. It's measured in timings (e.g., 16-18-18-36), where each number refers to a specific timing of the memory's operations.

- How it works:

  Latency is like the response time of a service. If you ask for information from the memory, latency is how long it takes before the memory delivers that data. Lower latency means the memory responds faster.

- Example:

  - A latency of CL16 (CAS Latency 16) means that it takes 16 cycles for the memory to access a particular piece of data.

  - Lower latency (like CL14) is better, because it means fewer cycles to access the data, resulting in faster response times.

Higher frequency gives you faster data throughput (tasa de transferencia)**, but higher frequency doesn't always mean lower latency.**

For instance, a 3600 MHz CL18 RAM might have better performance than a 2666 MHz CL16 RAM because the faster frequency will likely offset the slight increase in latency

Problem: Latency Increases With Newer RAM Generations

Memory Kit VENGEANCE® LPX 16GB (2x8GB) DRAM DDR4	DDR5 DRAM VENGEANCE de 16 GB (1x16 GB)

Frequency: 3200 MHz
Latency: C16

Frequency: 5600 MHz
Latency: C40

Does this mean that DDR4 has less latency than DDR5? Not Always

Explanation:

- Latency Is Measured in Clock Cycles (Not Time Alone)

  - CAS Latency (CL) is the number of clock cycles it takes to access data.

  - But each generation of RAM runs at a much higher frequency, meaning each cycle is much shorter in time.

- Higher Frequency = Shorter Cycles

  - Latency (ns) = (CL ÷ Frequency) × 2000

  - DDR4-3200 CL16 → (16 ÷ 3200) × 2000 = 10 ns

  - DDR5-5600 CL40 → (40 ÷ 5600) × 2000 = ~14.3 ns

- **The actual delay in time is often similar or slightly higher, but bandwidth and efficiency improve overall.**

# How does Computer Memory Work

Watch the following video.

Related Vocabulary:
- Memory Stick
- DIMM (Dual Inline Memory Module): Each DIMM has several DRAM Chips in each side.

Dynamic RAM (DRAM)	Static RAM (SRAM)
• Capacitors are used to store data in DRAM. • To store information for a longer time, **the contents of the capacitor need to be refreshed periodically**. • Provides slow access speeds. • These are cheaper. • Used in main memories	• Transistors are used to store information in SRAM. • Capacitors are not used hence no refreshing is required. • SRAM is faster compared to DRAM. • These are expensive. • Used in cache memories and registers

- DRAM Slots
- DDR5 Channels vs. DDR4 Channels

DDR 4 Channels	DDR 5 Channels
• DDR4 modules have a single 64-bit channel • **In DDR4, a single 64-bit channel may be busy handling one request.**	• Each DDR5 DIMM (memory module) is split into two independent 32-bit channels • Although the total data width per module remains 64 bits (same as DDR4), having two smaller independent channels improves efficiency and parallelism. • This means the memory can handle two smaller requests at the same time, instead of one large request, which speeds up performance in real-world multitasking and high-load scenarios. • **In DDR5, the module is split into two 32-bit channels, allowing two separate requests to be handled in parallel.**
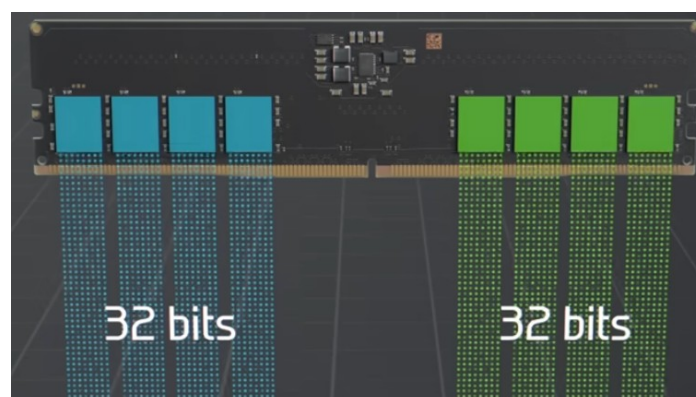
Exercises

1) Translate the following sentences to Spanish
   a) If you are working with an extremely **tight budget** and just looking to build an **entry-level gaming** PC to save money, you can start with 8 GB of RAM.
   b) If you have empty **DIMM slots** on your motherboard, **upgrading** to more memory is as simple as adding another **stick** to your system. You'll just need to make sure that you **match** the new memory stick or kit to the original one you installed in order to get dual-channel.
   c) Big, **bulky air CPU coolers** can often **hang over** DIMM slots, and in some instances, they can prevent memory kits with tall **heat spreaders** from being installed.
   d) As a general **rule of thumb** Intel CPUs typically don't benefit as much when paired with faster memory but on the other hand AMD CPUs have been known to benefit by using faster Ram
   e) For most gamers using a Ryzen 5000 CPU, 3600 MHz CL16 memory is considered the **sweet spot** for balancing performance and price.
   f) **Latency** and **bandwidth** are critical performance metrics for RAM, affecting the speed and volume of data transfer between the CPU and memory.
   g) DDR5 RAM introduces dual 32-bit independent channels per DIMM, enhancing parallelism