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Group Research Assignment 2

Random Access Memory (RAM) has changed dramatically over the years mutating into different classifications as new ways to process data are found. Perhaps the most common RAM type that people are familiar with and use daily is a combination of Synchronous Dynamic Random-Access Memory (SDRAM) and DDR (Double Data Rate) memory. Today DDR RAM is utilized in most machines because of its fast speeds, ability to communicate with the CPU, and low power consumption. Although it is expensive to produce, its utility typically outweighs the price point.

SDRAM, which was first introduced in 1970, is synchronized with its clock speed as well as the CPU and motherboard. Synchronization allows for better read write speeds because it can communicate with the CPU and know when to process new data; the increased speed was a result of the CPU not having to wait when accessing the memory, which boosted the read and write speeds. This became known as Single Data Rate SDRAM (SDR SDRAM). The speed at which SDR SDRAM operated at was between 100 and 133 MHz, instead of calculating speed in nano seconds it was replaced with MHz.

SDR SDRAM also known as Single Data Rate SDRAM accepts one command with one word data per clock cycle transfer. These chips have typically data bus size of 4, 8, or 16 bits with 168-pin DIMMs. STR SDRAM are slower than DDR variants because of the single data rate but are faster than the predecessors Extended Data Out DRAM (EDO-RAM) and Fast Page Mod DRAM (FPM-RAM) which took 2 to 3 clock cycles to transfer one word of data. SDR SDRAM have three types PC66, PC100 and PC133. PC66 has a clock frequency of 66.66 MHz, a 64-bit bus, a voltage of 3.3 V and 168-pin DIMM and 144-pin SO-DIMM. It was used by intel Pentium and AMD k6-based pcs. Later replaced by the PC100 and PC133. PC100 has a clock frequency of 100 MHz, 64-bit bus and voltage of 3.3 V. Similarly, the PC100 has 168-pin DIMM and 144-pin SO-DIMM and is backward compatible with PC66 and again was replaced by PC133. PC100 was most popular in the 1990s and was in most computers. PC133 operates in a clock frequency of 133 MHz, a 64-bit bus, volage of 3.3 V and is backwards compatible with both PC100 and PC66 with the 168-pin DIMM and 144-pin SO-DIMM. PC133 is the fastest and last iteration of SDR SDRAM with the bandwidth of 1066 MD per second. Again, PC133 will later be replaced by DDR.

Through the 1990s to early 2000s, RDRAM or Rambus DRAM and later Concurrent Rambus DRAM(CRDRAM) and Direct Rambus DRAM (DRDRAM), developed by Rambus, was positioned to replace RAM such as SDRAM. However, RDRAM got embroiled in a format war against DDR SDRAM and quickly lost in price and performance and was discontinued around 2003, no longer supported by personal computers. At the time, RDRAM has increased latency, heat output, manufacturing complexity and cost in comparison to other standards. RDRAM operates at 400MHz and transferred 1600 MBs of bandwidth over a 16-bit bus. It used a 184-pin RIMM (Rambus in-line memory module). The increased cost, heat and minimal performance improvement forced RDRAM to be replaced with DDR DRAM.

SDR SDRAM was a steppingstone for the RAM we use in our everyday systems. Based upon the idea of a Single Data Rate SDRAM, the mighty Double Data Rate SDRAM (DDR SDRAM) was created. It utilizes a double pumping method to transfer data on both edges of the clock signal. This in-turn allows the doubling of data bus bandwidth. So, with the same clock frequency of SDR SDRAM, the DDR SDRAM will have double the bandwidth. DDR SDRAM had a 2 word per cycle limit in its amount of data transferred. As new versions of DDR SDRAM have come out over the years the things that change with each version is the increase in word count per cycle, frequency speeds, decreased power consumption, and increased transfer rates.

When looking at a stick of DDR SDRAM along with the frequency in MHz, addition information is included. Typically, it will have a format of PC (1-4)- number. The numbers after PC represent the DDR number, as in PC2 is equivalent to DDR2. The number that follows the hyphen is the frequency of the RAM but in Bytes-per-second instead of transfers-per-second. This is just a much easier measurement to work with than typical transfers per second.

The discovery and invention of the double data rate interface allowed the reading and writing of data on the rising and falling edges of each clock signal. This resulted in a change in the voltage of the supply from 3.3 V as it was in SDR SDRAM to the now 2.5 V in the DDR SDRAM, which makes DDR SDRAM not backwards compatible with SDR SDRAM. There were four DDR SDRAM standards released in 2000, the DDR-200, DDR-266, DDR-333, and DDR-400. These corresponded to the PC-1600, PC-2100, PC-2700, and PC-3200 modules, respectively. The naming of these modules is to clarify the bandwidth of each module, which is the amount of data that it moves each second. The PC-1600 moves 1.6 GB of data per second, the PC-2100 moves 2.1 GB of data per second, and so on.

The following rates are for the chip in each module. The first module, the PC-1600, started with a clock rate of 100 MHz; each module after had an increase of MHz to its clock rate with the PC-3200 having a clock rate of 200 MHz. The cycle time for the four modules is 10, 7.5, 6, and 5 nanoseconds, respectively. The bus in each module has the same clock rate as its chip and the transfer rate for each bus is double that of the clock rate in MT/s. The bandwidth for the bus’s starts at 1600 MB/s for the PC-1600 and increases by (1/3 of 1600) for each subsequent module, resulting in 2133.33, 2666.66, and 3200 MS/s, respectively. It is also worth noting that the voltage increased from 2.5 V to 2.6 V in the PC-3200. The PC-3200 is unique because it is DDR SDRAM that was designed for use by the DDR-400 in a 200 MHz environment. Since it transfers data on the rising and falling edges of the clocks cycle, its effective clock rate becomes a bolstering 400 MHz. This was just for the first generation of DDR which was released in 2000. DDR SDRAM has evolved into new generations bringing us DDR2 in 2003, DDR3 in 2007, DDR4 in 2014, and now DDR5 just last year in 2015. Interestingly, the jump from DDR3 to DDR4 did not see a jump in words per cycle, it remained at 8, though there were significant increases in clock rate, transfer rate, and bandwidth.

There is another type of random-access memory, the XDR DRAM, which stands for extreme data rate dynamic RAM and was designed to be small and effective in high bandwidth systems, high end GPUs, and high-performance memory applications. It was based on RDRAM which is a type of SDRAM and came out in 2004 shortly after its competitor DDR2. The initial clock rate was 400 MHz, it ran at 3.2 GHz, and the data rate was eight bits per clock cycle per lane with the number of lanes being 8, 16, or 32 depending on the chip. The XDR DRAM was succeeded by the XDR2 in 2005 which saw increases to the clock and data transfer rate.