## Schedule of Course Activities: Session 17

## *[IS 519: Introduction to Cloud Computing Online-Based]*

## *[Instructor: John C. Chan]*

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| **Overview of Session** |  |
| We will answer the following questions: | 1. Data storage hardware system interfaces. 2. Storage speed performance, capacities. 3. Explore storage in finer details. |

**What are the System Interface for the Storages Devices?**

Host Interfaces: The interface is generally one of the interfaces shown below. They include:

* Serial attached SCSI (SAS, > 3.0 Gbit/s) – generally found on servers
* Serial ATA (SATA, > 1.5 Gbit/s) – General found on your Desk-side PC.
* USB (> 1.5 Mbit/s) – Exist in most PC/Laptops.

SATA: **Serial AT Attachment**is a computer bus interface that connects host bus adapters to mass storage devices such as hard disk drives and optical drives.

1. It offers several advantages over the older interface: reduced cable size and cost (seven conductors instead of 40 or 80).
2. Hot Swap capability.
3. Faster data transfer by higher signaling rates (via 2 conductors, instead of 16 in parallel case).
4. Rev.3.2 achieves 16GBit/s.
5. Rev.3.0 achieves 6Gbit/s.

SAS: **Serial Attached SCSI** is a point-to-point serial protocol that moves data to and from computer storage devices such as hard drives and tape drives. SAS replaces the older Parallel SCSI

1. SAS offers backward compatibility with SATA, versions 2 and later. This allows for SATA drives to be connected to SAS backplanes. The reverse, connecting SAS drives to SATA backplanes, is not possible.
2. SAS 3.0 achieves 12GBit/s

USB 3.0: **USB 3.0** adds the new transfer mode SuperSpeed (SS) that can transfer data at up to 5 Gbit/s (625 MB/s), which is more than ten times faster than the **USB** 2.0 standard. Improve bus utilizations, better power management. Electrically, it is more similar to PCI Express 2.0 and SATA.

This video explains well, on the difference between SAS-Drives, and SATA-Drives.

<https://www.youtube.com/watch?v=zriUU5SuKOw>

Key Take-Away:

* Form factors are different.
* SAS has better performance, though lower storage capacity.

Class Assignment: What type of storage is in your Laptop PC?

1. SATA
2. SAS
3. SSD
4. DRAM
5. None of Above.

**Computer System Interfaces in More Detail:**

The interfaces of storage devices, are derived from computer servers’ IO interfaces, which include:

* PCI Express (PCIe, > 2.0 Gbit/s) – Main Peripheral/IO Interface on a Computer Motherboard.
* Fiber Channel (> 200 Mbit/s) – almost exclusively found on servers

PCI-Express:

This is a high-speed serial computer expansion bus standard designed to replace the older PCI, PCI-X.

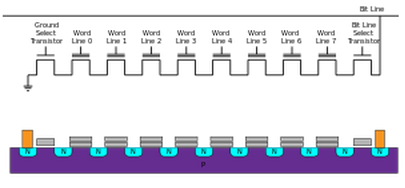
1. Higher maximum system bus throughput, lower I/O pin count and smaller physical footprint,
2. Better performance scaling for bus devices, a more detailed error detection and reporting mechanism (Advanced Error Reporting), and native hot-plug functionality.
3. The PCI Express electrical interface is also used in a variety of other standards, most notably in ExpressCard (e.g. NIC), as a laptop expansion card interface, and in SATA Express as a computer storage interface.
4. Different Form Factors: PCI Expressx1 (e.g. USB2.0), PCI Expressx4, PCI Expressx16.
5. X4 and x8 has max power consumptions of 25W.
6. Voltage domain: 12V, 3.3V.
7. Pin Counts: 82x2
8. Interconnect: (Logical connection), Low-speed peripherals (such as an 802.11 Wi-Fi card) use a single-lane (×1) link, while a graphics adapter typically uses a much wider and faster 16-lane link.
9. 16GB/s per lane.
10. PCI-Express-2 provides USB3.0 connectivity.

**A Deeper Look into SSD:**

(The figures shown in this section, are beyond the scope of the class. It is at the transistor-level! But then, it conveys the most fundamental concept. This is how SSD is designed by electrical engineer. These are the building blocks of the SSD! This section is tailored for the hardware geeks, the game players. You can skip reading the rest of the presentations).

NAND vs NOR Flash, EEPROM:

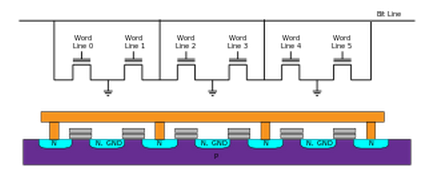
* EPROM had to be completely erased before being re-written.
* NAND flash memory, may be written/read in blocks (pages). Series Connections resembles NAND gate.

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NAND: While reading and programming is performed on a page basis e.g.4kB, erasure can only be performed on a block basis, e.g. 128kB.

Most NAND devices are shipped from the factory with some bad blocks. These are typically marked according to a specified bad block marking strategy. By allowing some bad blocks, the manufacturers achieve far higher yields than would be possible if all blocks had to be verified good. This significantly reduces NAND flash costs and only slightly decreases the storage capacity of the parts.

NOR flash allows single byte to be written: Parallel connection (by Bit\_Line). Drain (Bit\_line));Gate(Word-line);Source(Ground)



Flash memory Limitations:

* Block Erasures: Starting with a freshly erased block, any location within that block can be programmed. However, once a bit has been set to 0, only by erasing the entire block can it be changed back to 1. In other words, flash memory (specifically NOR flash) offers random-access read and programming operations, but does not offer arbitrary random-access rewrite or erase operations.
* Memory Wear: Most flash products are guaranteed to withstand 100,000 P/E cycles before wear begins to deteriorate.
* Read Disturb: The method used to read NAND flash memory can cause nearby cells in the same memory block to change over time (become programmed).
* X-Ray Effects.

SSD Controller Functions:

 Some of the functions performed by the controller include:

* Error-correcting code (ECC)
* Wear leveling : to distribute writes as evenly as possible across all the flash blocks in the SSD
* Bad block mapping
* Read scrubbing and read disturb management
* Read and write caching
* Garbage collection
* Encryption

SSD Performance:

* The performance of an SSD can scale with the number of parallel NAND flash chips used in the device. A single NAND chip is relatively slow, due to the narrow (8/16 bit) [asynchronous I/O](https://en.wikipedia.org/wiki/Asynchronous_I/O) interface.
* 4kB Page: ~25 [μs](https://en.wikipedia.org/wiki/Microsecond" \o "Microsecond) to fetch a 4 [KB](https://en.wikipedia.org/wiki/KiB) page from the array to the I/O buffer on a read, ~250 μs to commit a 4 KB page from the IO buffer to the array on a write (~2 ms to erase a 256 KB block).
* When multiple NAND devices operate in parallel inside an SSD, the bandwidth scales, and the high latencies can be hidden, as long as enough outstanding operations are pending and the load is evenly distributed between devices.
* In consumer products the maximum SSD transfer rate typically ranges from about 100 MB/s to 600 MB/s, depending on the disk.
* Write Ops is slower than READ Ops.
* Memory Wear. Finite number of program-erase cycles (~100,000).
* …

**SSD vs HDD, another look:**

* SSDs do not need to spin or seek to locate data.
* SSDs have challenges with mixed reads and writes, and their performance may degrade over time.
* SSDs are significantly more reliable than HDDs.
* SSDs are uniquely sensitive to sudden power interruption, resulting in aborted writes or even cases of the complete loss of the drive.
* SSD takes ½, or 1/3 the power of HDD.
* No sensitivity to vibrations etc.

End-of-Class Module.

Questions? Please email to me, or post it on Blackboard.

Thank you.