Next Generation Solid State Storage

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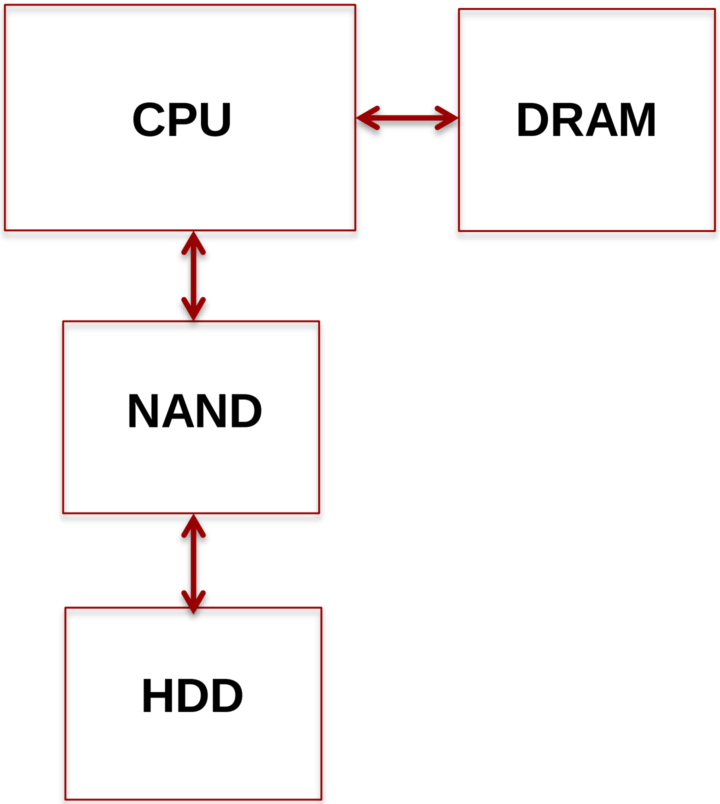
Key Parameters Driving SSD Development

- Endurance
- Longevity
- Density
- Power
- Performance
- Cost

These Parameters Have Priorities

Based on Usage in a Compute Infrastructure

Memory Usage Today



Priorities

DRAM
Performance, endurance, density, power, cost

NAND
Longevity (NVRAM), density, power, endurance, performance, cost

FIXED DISK
Cost, density, endurance, longevity, power, performance

Limitations of Current Structures

- **DRAM**
  - Requires a constant refresh current to retain data.
  - Requires control circuitry to execute a “sleep” state.
  - Requires a high voltage (3V).
  - Read times of 30nS.

- **NAND**
  - Thick film transistor technology with limited stacking capability.
  - The write cycles are limited to 100,000 unless technology is employed to execute a re-heat on a regular basis.
  - Write cycles infer at least 3 operations including a read-modify-write of an entire addressable block using a volatile buffer.
  - Advancing to a 10nm process requires that over 20% of the structure is utilized for ECC.

Potential Replacements

STTRAM (Magnetic Tunnel Junction)

- **Advantages**
  - Faster than DRAM with READ and WRITE times <15nS
  - Energy per bit is 20 times less than DRAM
  - Very high endurance similar to DRAM (>10^15 cycles)
  - Non-volatile with "self refreshing" characteristics
  - Byte addressability similar to DRAM
  - Low voltage requirements
- **Disadvantages**
  - Greater cost than DRAM (+50%)
  - Complicated transistor structure limiting density
  - Long term refresh is required (Weeks)
  - Very low data signal requiring a large sense amplifier
  - BER at 10nm is similar to NAND requiring a large ECC structure

Potential Replacements

PCRAM (“Phase Change” chalcogenide glass)

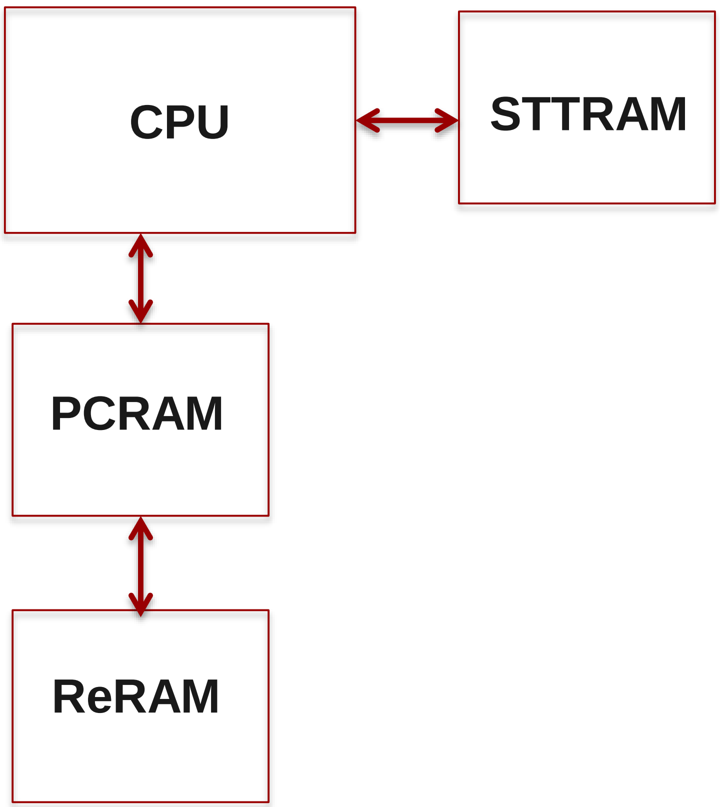
- **Advantages;**
  - Density similar to DRAM
  - Ease of manufacture and low cost (1/2 DRAM cost)
  - DRAM like READ times
  - Byte addressable
  - Long data retention (years)
  - Radiation hard
- **Disadvantages;**
  - Write times >50nS
  - MLC at 2 bits maximum
  - High erase currents
  - Endurance at 10^8 cycles

Potential Replacements

ReRam

- **Advantages**
  - Very dense multiple layer structure utilizing passive junctions
  - Can scale beyond 10nm as a single oxide junction
  - READ times at 10nS (1000 faster than NAND)
  - WRITE times at about 20nS (with process improvements)
  - Endurance is >>10^6 cycles for MLC operation (4 bits)
  - Power requirements are at 1-3 pJ/bit (NAND is at 1000pJ/bit)
  - Retention is in years and is not affected by temperature or radiation
- **Disadvantages;**
  - The current process yields devices that must use a three stage WRITE
  - The use of 4 bit MLC will demand both ECC and a complex sense amp
  - The need for low crystalline defect material is critical

Memory Usage in the Future



Priorities

STTRAM
Performance, endurance, density, power, cost

PCRAM
Longevity (NVRAM), density, power, endurance, performance, cost

ReRAM
Cost, density, endurance, longevity, power, performance

Conclusion

- **Storage must make huge advances in power conservation to keep up with CPU technology**
  - Flash is at 10^4pJ/bit,
  - HDD at 10^8pJ/bit,
  - STTRAM at 0.1pJ/bit
- **Differences in performance layers must be leveled to gain computational efficiency**
  - HDDs access data in mS
  - NAND devices access data in uS
  - DRAM, STTRAM, and PCRAM access data in nS
- **Storage efficiency will increase by orders of magnitude in the future**
- **Processing bottlenecks will be limited by data mobility rather than storage system performance**

Evolution vs. Revolution

- Portable devices are now SSD based (iPhone, tablets, laptops, etc)
- Real development of new technologies like memristor are pushed out to 2020 or beyond
- New NAND technologies such as 3D are a much cheaper product path than STTRAM, PCM, etc.
- PCM is available but will remain expensive because of slow adoption
- Replacing the storage represented by HDD w/ SDD would require at least 5-7 new fabrication facilities at $5B each with the HDD TAM at about $35B

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Questions?

Thank You!

Keep in touch with us

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