Intel and SATA 3

Moving forward faster through backward compatibility

Scaling storage with SATA

In 1999, physical storage technology was reaching an impasse. The existing parallel ATA (PATA) interface was no longer keeping pace with new storage products and new silicon process technology. Lack of performance headroom, cabling issues, and voltage tolerance requirements were becoming critical. Without new interface technology, physical storage would become a bottleneck on computing performance, despite advances in other areas.

To address the challenge, Intel joined with other industry leaders to create the standard for **Serial Advanced Technology Attachment** (**SATA**), a storage interface designed for faster, more efficient transfer of data between a computer and storage device. Designed with backward software compatibility and with a clear roadmap for future improvements, SATA technology is now in it's third incarnation – the SATA Release 3.0 specification was released in May 2009. According to IDC analyst John Rydning, "The SATA interface has developed into the de facto hard disk drive interface in computing applications."

Breaking the PATA bottleneck

A decade ago, processor, storage and device manufacturers were all running up against limitations with the existing PATA interface technology. PATA started with a cadence of doubling transfer speed each generation (i.e., 33 to 66 MB/s), but this gradually fell off to only 33% performance improvement in the last iteration (100 to 133 MB/s). The last PATA version was not supported by all manufacturers due to signal integrity concerns, and Intel chose to not support 133 in our chipsets.

At the same time the PATA performance curve was flattening, hard drives were doubling in transfer rates every three years. PATA ribbon cable was also pin-intensive, taking board real estate away from other features, such as USB ports, and its 5V technology was no longer attractive with silicon process technology scaling down to 1.8V and below.

In 1999, Intel and a small group of industry leaders formed the Serial ATA Working Group to develop a new storage interface standard. They established a clear set of objectives for the new SATA standard:
- To precisely emulate the behavior of PATA from the software standpoint, so that no operating system changes would be required to deploy the new storage interface technology. This would allow IT decision-makers and end users to switch their storage technology on their own timeline.
- To use fewer pins, leaving more space available for other device types. PATA used 40 pins (26 were signal and most of the rest were ground pins). The new SATA standard used just 4 signal pins plus ground pins.
- To operate at a lower voltage, compatible with increasingly efficient silicon process technology
- To deliver at least three generations of the standard over 10 years, doubling the speed with each successive generation

The first generation of SATA launched in 2001 at 1.5 Gb/s (150 MB/s), a modest bump from the most recent PATA transfer speed. In 2005, the second-generation of SATA raised the signaling speed to 3.0 Gb/s, and the just-released SATA 3.0 specification doubles the rate again, to 6 Gb/s, completing the original three-generation roadmap. Native Command Queuing (NCQ) is available to increase the performance of SATA storage devices under certain situations by allowing the individual device to internally optimize the order in which received read and write commands are executed. The SATA host controller can still be specified to emulate PATA if needed for backward compatibility, and the SATA protocol for emulating PATA has enabled the proliferation of low-cost PATA to SATA bridge-chips.

The increased transfer rates resulting from these standards have allowed storage devices to scale their performance along with the rest of the platform, avoiding storage bottlenecks that would diminish the benefits that users gain from increasing processor speeds.

Each new standard and speed bump has been timed to allow a smooth transition in the industry. In addition to higher transfer speeds, the standard has delivered lower pin requirements and reduced cabling space requirements, because devices communicate via a high-speed serial cable over two pairs of conductors. It has lowered voltage requirements to a nominal 500mV peak-to peak differential (which means that the actual voltage on a single pin swings by as little as 250mV) and it has added hot-plug capabilities for storage devices. There are now a variety of SATA power enclosures on the market that interface to the PC through USB, Firewire or the increasingly popular eSATA (external SATA). SATA technology benefits include faster speed, simpler upgradeable storage devices and easier configuration at lower cost than other storage interfaces.

As expected, formal adoption of the SATA standard took about three years to achieve volume crossover. Today SATA is the primary internal storage interconnect for desktop and mobile PCs, connecting the host system to peripherals such as hard drives, solid state drives, optical drives, and removable magnetic media drives. SATA hard disk drives are also gaining a significant presence in enterprise applications, enabling more cost effective and higher capacity storage solutions. External SATA (eSATA) extends SATA technology outside the PC, where fast transfer rates and protocol efficiencies make it the highest-performing storage connection for external devices.

Achieving critical mass

Intel formed the Serial ATA Working Group in partnership with a small group of critical industry players — APT Technologies (a small startup that had some of the core technology), Dell, IBM, Intel, Maxtor, and Seagate — who could represent the needs of processor and storage manufacturers and OEM customers. The original SATA Working Group's charter had a built-in dissolution clause: it was only to see the standard through the first generation of SATA. By the time the first SATA specification was released, that group had grown to 50 or 60 members, and the new Serial ATA II working group was formed to develop the second-generation Serial ATA standard.

Partway through development of the second-generation standard, the group decided to create a sustainable organization to define and support the standard. Officially formed in July 2004 by incorporating the previous Serial ATA Working Group, the Serial ATA International Organization (SATA-IO, for short) is an independent, non-profit organization of more than 200 industry leading member companies dedicated to sustaining the quality, integrity and adoption of SATA technology by maintaining the specifications, promoting interoperability, marketing technology benefits and creating future SATA features to carry storage into the next decade. Dues from SATA-IO member organizations fund numerous activities:

- Ongoing development of new connectors and cables to support adoption in new markets such as the recently announced "micro-SATA" spec for mobile devices and mini-SSD drives
- Certification and compliance testing for members, to maintain the quality of SATA products
- Marketing to create awareness and market acceptance for the standard

Over the past decade, the SATA working group members have learned a number of lessons for creating a successful standard, according to Knut Grimsrud, Intel Fellow and President and Chairman of the Board of SATA-IO. First, be sensitive to the infrastructure changes. Backward compatibility with PATA was a key success factor in the adoption of SATA. The smoother and simpler the transition, the faster companies can adopt a new standard.

Second, partnership is critical. From the beginning, the SATA working groups have had representatives from processor and storage companies and OEMs – all the groups needed to ensure success. Third, if you are asking the industry to transition to a new technology, the value proposition has to be valid from beginning to end. In the beginning, chip sets supported both PATA and SATA, but SATA was faster out of the gate, the cabling was sleeker, and the price difference was very small, so there was real incentive to make the switch. Then, going forward, transfer speeds continued to double, and the work of SATA-IO provided ongoing support and enabling technology such as new connectors that opened new opportunities to use SATA technology.

Whither SATA?

Now that the first ten-year roadmap is complete, what's in SATA's future? Knut Grimsrud says the third-generation SATA standard has just been completed and Intel's initial products for this generation are not released, so it's somewhat premature to pursue yet another generation. The new standard meets the needs of today's hard drives: now it's SSDs, with their much higher transfer capabilities, that are driving the need for higher transfer rates. SATA voltage is now down to 400 millivolts, so the standard is ahead of the power efficiency curve, and the development groups have defined enough connectors with SATA to meet foreseeable cabling and connector needs. External SATA (eSATA) is gaining growing acceptance as the interface standard for external storage devices, and small form-factor connectors are bringing the benefits of SATA to mobile devices and application.

> *"SATA is already the predominant storage interface used in the hard disk drive (HDD) market. The mSATA specification extends the low-cost, high-speed benefits to the rapidly growing SSD market, increasing the options for manufacturers to develop small form factor solutions."*
>
> —Jeff Janukowicz,

Research manager for
Solid State Drives at IDC

The next challenge for SATA-IO members is to work out the future roadmap, whether that is another speed bump (there has been speculation about 12 Gb/s in the trade press) or a new interface to meet new challenges on the horizon. Whatever the direction, the expertise and infrastructure are in place to move the industry to the next level.