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Exploring Digital Publishing: What makes "Fast?"

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What makes a car fast? The obvious answer is "a large engine," but the reality is far more complex. All an engine really provides is potential. Before that potential can be realized, you need a transmission that won't fall out when you step on the gas and tires that won't come apart when the heat is on. You need a fuel delivery system that can keep up with demand and steering that will provide the necessary control. And of course, you need a properly engineered road and a driver with the skill and reflexes to keep all that engineering on the road instead of up a tree.

A Ferrari, Porsche, or Corvette is fast because it is designed, in every aspect, for speed. The entire vehicle, from drive train to suspension to body shape, is balanced to deliver sustained performance. No single component is maximized without first analyzing its effect on, and interaction with, every other component of the system.

Making a Publishing System Fast

Like a car, a digital publishing system is fast only when all elements of the system are in balance. Like the drive train of a car, steps in publishing CDs or DVDs are closely linked and interdependent. Data for the CD or DVD is sent via a local area network to the disc publisher, which compiles the "image" to be recorded and rasterizes graphics for printing. A high-speed local connection carries the information to the autoloader, where discs are robotically "picked," recorded, and printed. Because these steps are sequential, any one that is out of balance with the others becomes a bottleneck. As a chain is limited by its weak link, publishing is limited by its slowest step.

Balancing the System

The first step in balancing the system is to match recorder speed and data throughput. The system must continuously feed data to the recorder at the recorder's maximum speed. If it cannot, the drive stops, waits for data, and then must resynchronize, reducing performance of the entire system. In other words, a recorder that is too fast for its data stream doesn't raise performance; it diminishes it.

Performance can also be slowed by non-continuous data flow. To ensure continuous flow, the CD or DVD image must be cached in a contiguous file on a dedicated hard drive. Caching ensures that the image is waiting for the recorder, rather than the other way around. Storing the image as a contiguous file eliminates time-wasting "seeks" that could interrupt data flow. Using a dedicated hard drive eliminates data requests from other applications that can interrupt the recording process.

Another potential bottleneck is the link between host computer and robotic transporter. USB 2.0 has increasingly replaced the far slower USB 1.1; but in most configurations, USB 2.0 struggles to deliver the sustained performance that the latest high speed recorders require. A more reliable option for multiple drive configurations is Firewire, which delivers better continuous performance and has been used in professional digital video solutions for years.

To maximize total system throughput on a multi-recorder system, a balanced design stages images for recording. While one CD or DVD disc is being recorded, the image for the next disc is being loaded to the cache drive so that recording of the next disc can begin as soon as it is loaded without waiting for data to download. Equally important is handling of the disc itself. The robotics themselves must be fine-tuned to ensure that discs move quickly and smoothly through the system.

Since discs must be imprinted as well as recorded, printing is another potential bottleneck. In a balanced system, artwork is staged and cached for the printer just as data is staged for recording. Another issue is system response when things go wrong. When a disc is rejected or a copy contains errors, system stoppage or manual intervention can be costly and time-consuming. A balanced system responds automatically, resending data without operator intervention to keep the system busy and the job moving.

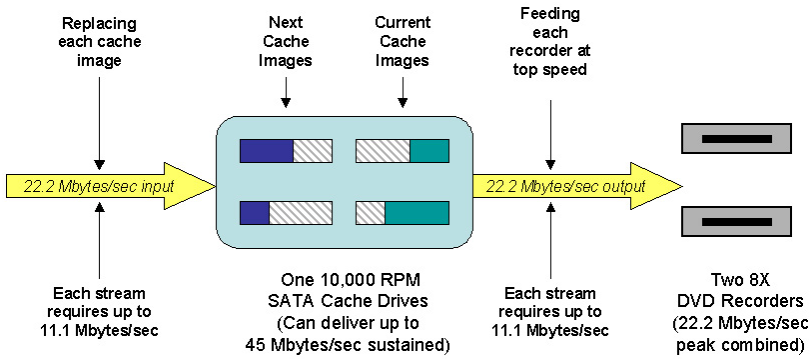
16X: Running the Numbers

As of late 2004, a few digital publishing systems are moving from 8X to 16X DVD recorders. While, this may appear to double recording speed, the actual effect on speed is far less. First, 16X recorders only run at 16X speed for approximately the last 0.5 gigabytes of a full DVD. For the first two gigabytes, they typically run at only 8X, while the next two gigabytes run at 12X. This means that, on a DVD containing 4 gigabytes (out of a possible 4.7 gigabytes) the maximum recording speed will be just 12X and the average will be significantly less.

As previously mentioned, even these speeds may not be reached if there are bottlenecks in the data flow. And, of course, "buffer underrun" failure of data flow to keep up with recording speed will require frequent resynchronization, further reducing throughput.

Assuming a publishing application, in which each disc is unique, here's the math:

Disc Cache/DVD Recorder Data Flow



- The cache drive must deliver up to 11.4 Mbytes/sec of data to an 8X recorder to avoid buffer under-run.
- The cache drive itself must be continuously re-supplied with new data at 11.4 Mbytes/sec so that it can deliver an entire new image to the recorder when it is ready to publish the next disc.
- A fast cache drive can deliver about 45 MBytes/sec., simultaneously supporting two 8X recorders running at top speed while rebuilding the new cache image. However, doubling the recorder speed to 16X completely overwhelms the cache drives, interrupting recording and requiring time-consuming resynchronization.
- Data for the cache drives travels via Gigabit Ethernet (1000 Base-T), which can theoretically deliver over 100 MBytes/sec, but even in ideal switched configurations, delivers far less. In current publishing configurations, this can support up to two 45 megabyte/sec cache drives and four 8X DVD recorders. However, four 16X DVD recorders would require four cache drives, overwhelming the Ethernet link and severely limiting the ability to publish efficiently.

In short, except in single-recorder systems, 8X recorders are pushing current system configurations at or beyond their limits. This is *not* to say that state-of-the-art systems cannot support 16X recorders. They will, once the systems are upgraded to provide balanced throughput at the higher speed. In short, adding a 16X recorder to a maxed-out system can actually reduce throughput, because of the potential buffer under-run situations which can create significant delays.

Matching Media

The final aspect of a balanced system is media. The quality of recorded products depends on media that fully matches the system requirements. The 16X DVD recorders are new enough that universally compatible discs are still being developed. Firmware itself is in flux. As a result, according to recent reviews, there are high-density discs that, once recorded, are readable on fewer than half the DVD players tested. Recorders do not consistently recognize some high-speed media, and many discs do not yet have approved printing surfaces.

As with any new technology, 16X recording has issues to be resolved. Those issues are being addressed. As soon as 16X technology can be configured into balanced systems, it will be a significant step in digital publishing.