Technical Review and Evaluation of *RamDisk Plus* Software

by

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Introduction

In the rapidly changing field of information technology ("IT"), a gap continues to widen between the performance of central processors and random access memory ("RAM"), on the one hand, and the data transfer speeds of rotating storage subsystems, on the other hand. Most recently, with the advent of storage innovations like perpendicular magnetic recording, the data densities of rotating platters have made significant advances. However, there is no disputing the fact that hard disk drives ("HDD") are getting much larger without getting much faster, on average. This trend is already well documented.

Leading manufacturers like Seagate and Western Digital play leap frog by releasing ever larger HDDs, growing most recently from 1 terabytes to 2 terabytes in a single 3.5" form factor. Nevertheless, despite the latest industry standards which have increased interface ceilings from 3 Gigabits per second ("3G") to 6 Gigabits per second ("6G"), the practical limiting factor in all HDDs is the actual rate at which the raw binary digits ("bits") pass directly under their read/write heads. At present, that limit hovers right around 150 Megabytes ("MB") per second for the fastest HDDs rotating at 15,000 rpm.

By comparison, the sheer bandwidth or theoretical maximum transfer speeds of RAM continue to break new records with predictable frequency. By today's standards, DDR2-800 SDRAM is now considered "mainstream," whereas only 4 years ago it was "upper-end." By multiplying that specification by 8 bytes per effective memory cycle, DDR2-800 RAM -- times 8 -- is rated at 6,400 MB/second, also known as PC2-6400. Most recently, within the past 12-18 months Intel has been manufacturing upper-end CPUs and motherboard chipsets that support triple-channel DDR3 RAM with a measured bandwidth of 25,000 MB/second at stock memory settings. And, out there on the "bleeding edge," as

experienced IT professionals like to call it, triple-channel DDR3 memory subsystems have been measured in excess of 30,000 MB/sec. To say that the IT industry now enjoys a robust "over-clocking" community is an obvious understatement.

In the course of trying without very much success to achieve *significant* improvements in the speed at which our office workstations do routine database operations, we decided to look around for reliable ways of moving file systems directly into RAM, in order to harness its obvious speed advantages. Before the Internet, the concept of a "ramdisk" was already well understood by experienced IT professionals. With the help of popular search engines now available on the Internet, our search brought us to the website of SuperSpeed LLC, located in Sudbury, Massachusetts, USA. Their *RamDisk Plus* software had appeared in the list of "hits" produced by Google whenever we asked it to find occurrences of "RAM disks", also known as memory-resident file systems (our "MRFS" *nomme de plume*).

History of SuperSpeed LLC

Located in Sudbury, Massachusetts, USA, SuperSpeed's corporate successes over 24 years are a direct result of their extensive experience in computer performance enhancement solutions. Founded in 1981, the company pioneered disk caching technologies and has continued working closely with its customers to solve their evolving technology and business challenges. SuperSpeed products are deployed at U.S. Federal and State government agencies, Boeing, Morgan Stanley, Merrill Lynch, HP, LexisNexis, Microsoft, Johnson & Johnson, Symantec, Family Dollar Stores and many others. In addition, SuperSpeed is a Microsoft Gold Certified Partner and a member of the Citrix Alliance. SuperSpeed has been awarded 7 U.S. patents.

SuperSpeed's company brochure describes it as the leader in disk caching and RAM disk solutions for Microsoft Windows servers and workstations, including the latest 64-bit Windows technology. Their products maximize return on current hardware and software technology investments by providing cost-effective alternatives to expensive hardware upgrades. SuperSpeed's solutions are able to transform an IT environment. They are designed and certified for Microsoft Windows Server 2003, Windows XP, Windows 2000, and Windows NT. SuperSpeed is an excellent choice to accelerate the PCs and servers that you already own to unprecedented speeds and levels of performance. Major domestic and international Fortune 500 clients employ its solutions to optimize the performance of their internet, intranet, database, OLTP and other I/O-intensive applications.

Along with providing cost-effective performance products, SuperSpeed also provides its clients with essential services. These include resources and training for new users of SuperSpeed's products, assisting with the identification and characterization of performance issues, recommending appropriate solutions to resolve those issues, and helping with installation and tuning of the products.

One of our first impressions of SuperSpeed's resources was the ease with which their trial version of *RamDisk Plus* could be downloaded from their Internet website, and quickly installed on any of our production XP workstations. There was no need to fuss with physical shipments of optical media, or to suffer the delays, and risks, inherent in such delivery methods. With this excellent introduction, we felt that we were definitely off to a good start.

First Experience:

One bright sunny day in San Diego about 4 years ago, I decided to get some exercise by walking from a Circuit City store to a distant bus stop. Along the way, I happened upon the small store front of Micro City, Inc. Once inside, I was greeted with the smiling faces of Roger and Linda Shih, the husband and wife team who run the company there. It didn't take too long before Roger, the CEO, had persuaded me to assemble a new workstation with the i955 chipset, and an Intel 640 CPU for the LGA775 socket in the ASUS P5WD2 Premium motherboard.

We initially configured that computer with a matched pair of 512 MB Corsair XMS2 DDR2-800 memory modules. For a time, a total of 1 Gigabyte ("1 GB") of RAM was quite adequate for most of our production work, such as database management, Internet access and frequent email contact with clients. However, to avoid any memory management conflicts upon enabling a ramdisk, we first upgraded that system to 2 GB. This not only made more RAM available to systems and application software; it also afforded enough additional memory for a single ramdisk of 512 MB in size.

After our memory upgrade was installed and found to be stable, we downloaded what is now an older version of *RamDisk Plus* from SuperSpeed's Internet website, and proceeded to configure and test that 512 MB ramdisk. The ease with which all of this occurred was a welcome surprise: everything appeared to work perfectly the first time. Moreover, Microsoft's Internet Explorer ("IE") also makes it comparatively easy to move the location of its Temporary Internet Files (see Tools | Internet Options | Browsing history | Settings).

Once we had successfully moved IE's cache to our new ramdisk, then the real fun had begun. We noticed immediately how much more responsive IE had become. A good illustration of its higher performance occurred as we accessed a large computer parts catalog, with a large number of product photos accompanied by brief text summaries. After browsing to the details for any given product in that catalog, IE's BACK button suddenly came alive: the entire catalog was almost instantly available again. No doubt, this performance was due to the fact that those catalog photos had been cached in our newly configured ramdisk, and there was no need to read any of those graphics files from relatively slow rotating platters, where IE's Temporary Internet Files are normally stored by default.

One of the most valuable features of *RamDisk Plus* is its ability to do automatic saves and restores of each ramdisk at system shutdown and startup, respectively. Thus, after a full business day of accessing the Internet for 5-6 hours, our ramdisk's contents were not lost when we finally turned that system OFF for the night. By enabling an option which automatically restores ramdisk contents at system startup, we now begin each new business day with the contents of our browser cache *exactly as they were* at the last normal shutdown.

This feature solves the problem of RAM volatility almost completely, with one important exception. As any experienced computer user should know, automatic save and restore does not cover unexpected system crashes. Thus, any ramdisk data changed since the last normal shutdown, or since the last manual save, would be lost. For systems experiencing instability for any reason, browser caches and Windows swap files are good candidates for initial storage of data in ramdisks during systems development *i.e.* lost data is easily restored in situations where systems are less than completely stable.

Expectations for Improved Laptop Performance

Although our office does not use any laptops, as a general rule, the obvious advantages of *RamDisk Plus* for browsing the Internet can be readily exploited in laptop systems as well. Many modern laptops easily accommodate a total of 2 or 4 GB, by populating 2 memory slots with a matched pair of 1 or 2 GB SO-DIMMs (small outline dual in-line memory modules). Such a configuration mimics almost exactly the upgrade we performed on our first LGA775 workstation, designed with the help of Roger Shih, CEO of Micro City, Inc.

Moving a laptop's browser cache(s) into a ramdisk can also reap added benefits for mobile computers, chiefly because many of their hard drives rotate at 5,400 rpm versus the 7,200 and 10,000 rpm standards for desktop HDDs. Even at 7,200 rpm, laptop HDDs generally perform slower than their desktop counterparts. Off-loading those relatively slow HDDs -- by moving their browser cache(s) into RAM -- should also result in prolonging the useful life of those slower laptop hard drives simply because they should wear out more slowly.

And, visible IT trends now foresee a rapidly growing population of laptop users, the arrival of wireless 4G Internet access, and dramatic increases in mobile CPU speeds. As of this writing, the Intel Developer Forum ("IDF") has just announced mobile Nehalem architectures for the first time in that company's history. As the entire world goes wireless, there is every reason why the advantages of ramdisks should be readily available to laptop users too. And, today the IT industry may be mid-stream in another transition from 32-bit to 64-bit systems, but the future will definitely standardize on the latter's immense address space. That trend should also lower prices for matched pairs of 4 GB SO-DIMMs (8 GB total per laptop), even though current prices are prohibitive for most laptop users.

Installation of Additional Browsers

We have a saying in our office: *constant change is here to stay.* With MSIE running much faster, it wasn't too long before we decided to look into competing Internet browsers like Firefox and Opera. Although not as user-friendly as the Internet options in MSIE, both Firefox and Opera do provide mechanisms for moving their temporary file caches to other Windows XP drive letters. We were already experienced moving browser caches to different drive letters, in order to minimize the size of drive image files of C: that we routinely create using Symantec's GHOST software.

Again, not only did Firefox give us the "feel" of superior speed overall; its reliability and responsiveness were particularly noticeable after we moved its browser cache to a ramdisk created by *RamDisk Plus.* At one point, we had to admit that an entire week had passed without using MSIE even once! Firefox had become our preferred Internet browser, hands down, and our ramdisks continued to perform flawlessly.

Although it never became our default, Opera is another browser which allows its temporary file cache to move to different drive letters. Opera had absolutely no problems operating reliably after we moved its temporary file cache to our first 512 MB ramdisk.

Moreover, Opera also comes with a well designed *"Fit to width"* feature which automatically re-sizes scanned documents to fit the available screen area. Although we offered our suggestions that Firefox developers implement a similar feature, that discussion thread appeared to bog down while participants pursued the seemingly endless permutations that accompany graphics display options.

Even though we specifically recommended a movable cache to their programming staff, Google's Chrome does not (presently) permit users to re-locate its temporary file cache.

Second Experience

Armed with the happy results described above, our office invested in quality components to assemble another workstation, with the ASUS P5W64 WS Professional motherboard and Intel D 945 dual-core CPU as basic building blocks. By that time, a matched pair of 2 GB Corsair DDR2-1066 "Dominator" DIMMs (4 GB total), with optional 3-fan memory module cooler, were priced within reach.

This system was chosen with the intent of adding a fast RAID controller to one of the four x16 PCI-Express slots integrated onto that motherboard. Also, it was a simple matter to flash the latest BIOS to accommodate an upgrade to a quad-core Intel Q6600, which we did purchase and install with success after the market prices of that CPU had fallen sufficiently.

We prefer to stay at least 6 months behind the "bleeding edge".

Increasing the RAM in this new workstation from 2 GB to 4 GB made it possible to install *RamDisk Plus* and configure 2 *separate* ramdisks, each sized 512 MB on that new system. One such ramdisk was dedicated to the Firefox cache, while the other was shared by the IE8 and Opera caches. The advantages of this new workstation included higher RAID controller bandwidth, and the migration of all systems and application software to a larger memory subsystem *without* needing to upgrade to the 64-bit version of XP/Pro.

Re-visiting the 4 GB Barrier in Windows XP 32-bit

About the time we had finished assembling and testing that 4 GB workstation, lots of discussions were appearing in Internet User Forums, like the one at Tom's Hardware, concerning the 4 GB software barrier that exists in all instances of XP 32-bit. Using the hindsight that comes with almost 38 years of IT experience, we could see that Microsoft at one point had made a key architectural decision to use 32-bit words to address 8-bit bytes. This decision resulted in a maximum logical address space of 4 GB (four gigabytes), which we get by computing 2^32. One can do this computation quickly and easily with CALCULATOR by changing to "Scientific" View.

Contrast that architectural decision and its far-reaching consequences, with a commitment instead to use 32-bit words to address 32-bit words, each of which contains four 8-bit bytes. Within each 32-bit word, individual bytes could be addressed, or accessed, via specialized instructions and/or dedicated firmware. After all, for some time now Intel CPUs have been able to address RAM using 36-bit hardware registers. Therefore, a 36-bit register can easily access the individual bytes stored within any of 4 billion 32-bit addresses: 2^36 = 64 GB! Moreover, only 2 more bits are needed mathematically to access each byte: thus, only 34 bits are needed to enlarge XP's 4 GB barrier by a factor of four: 2^34 = 16 GB!

Unfortunately, when our office acquired and tested the 64-bit version of XP/Pro, we quickly confirmed that many of our third-party software packages did not come with 64-bit device drivers compatible with that version of XP. Moreover, their vendors had dropped plans to develop such drivers after Microsoft released its VISTA operating system. And, unfortunately for Microsoft, VISTA immediately ran afoul of poorly written and/or incompatible device drivers, particularly for graphics display subsystems.

The Positive Benefits of XP's 4 GB Barrier

Because Windows XP has been one of *the* most successful operating systems in 50 years of IT history, a huge installed base of 32-bit software now runs on literally millions of 32-bit versions of Windows XP worldwide. In a very positive sense, that 4 GB limitation has resulted in creating a "virtual barrier" to all 32-bit software which simply cannot compute or "reach" beyond that limit. What has resulted, then, is a kind of *security mechanism*, if you will, for all application software running in RAM addresses below 4 GB, particularly on machines with more than 4 GB of RAM actually installed.

Insofar as superior programmers can develop ways to exploit the 36-bit and now 64-bit hardware registers that have been available in modern CPUs for quite some time, the memory regions above 4 GB can be effectively *isolated* from all systems and application software running in addresses below 4 GB. We believe that this key technological insight was one of *the* main factors which motivated SuperSpeed's expert designers to develop, and then patent, a method for addressing what they now call "unmanaged Windows memory" *i.e.* not managed by the 32-bit versions of Windows XP. (Time will tell if this theory of ours morphs into fact.)

That additional feature was first released in *RamDisk Plus* version 9, and it has now been refined and improved with the release of version 10.0.1. Specifically, the latest version can also create ramdisks in "stubbornly inaccessible memory" between ~3.2 GB and 4 GB, due to the requirement that 32-bit versions of XP must pre-assign memory addresses below 4 GB to specific device drivers after POST (power-on self-test at system startup). This of course explains why many XP systems only display ~3.2 GB of RAM under Task Manager's "Performance" tab *even though* 4 GB total (2 x 2 GB or 4 x 1 GB DIMMs) are installed and running fine in single- or dual-channel mode.

Third Experience (most recent)

Armed with the knowledge that recent versions of *RamDisk Plus* now support creation of *multiple* ramdisks in unmanaged Windows memory *e.g.* RAM addresses above 4 GB, we went about selecting components for a new 16 GB workstation. We chose Intel's Q9550 "Yorkfield" quad-core CPU and the ASUS P5Q Premium motherboard with Intel's P45 chipset, because the latter is designed specifically to address a maximum RAM of 16 GB (4 DIMMs @ 4 GB each).

The key feature of this newest workstation is a memory subsystem using 4 x 4 GB DIMMs of Corsair's excellent DDR2-800 "matched quad" model QUAD2X16G-6400. Although this memory worked perfectly the first time it was installed, on the advice of Corsair's brilliant "RamGuy" we decided to increase the memory controller voltage to the top of its "safe" range for the "NB Voltage" setting in the P5Q Premium's BIOS.

The 32-bit XP operating system was installed on a 50 GB C: partition, using a RAID-0 array assembled with two 750 GB Western Digital RAID Edition 3 ("RE3") HDDs, controlled by Intel's excellent ICH10R I/O controller hub. This effectively enabled "short-strokes" on the 2 read/write armatures inside those 2 HDDs. The remainder was formatted as a single data partition approximately 1.3 TB in size (1,300 GB).

This hardware is now stable with these "core" components.

Installing and Testing an 8 GB Ramdisk

The biggest and the most exciting milestone came for us after we downloaded and installed a trial version of *RamDisk Plus* version 10.0.1, and configured a single ramdisk sized at 8 GB (8,192 MB), using unmanaged Windows memory. After debugging an unexpected glitch with our PS/2-to-USB adapter, which connects to our keyboard via a KVM switch, we succeeded in activating a perpetual license with clear directions from SuperSpeed's support staff (plus a few extra cups of coffee, and one headache complete with tunnel vision).

Then, we copied our 6 GB database, containing about 110,000 discrete files, from our RAID-0 data partition to that ramdisk partition: the sheer speed of that one operation was rather dramatic, to say the least. The progress of that COPY task was actually limited by the throughput of the RAID-0 subsystem where the source files were stored, not by the far superior speed of the 8 GB ramdisk.

Current ramdisk image files are automatically saved and restored to and from that RAID-0 data partition. System startups and shutdowns are now requiring ~1 extra minute to complete, chiefly because that RAID-0 partition has shown a sustained throughput of about 200 MB/second (8 GB / ~200 MB/second = ~40 seconds) when measured with PerformanceTest version 4.0. We still use the latter software in order to maintain comparability of our numerous measurements over time.

In a word, performance has been FANTASTIC. Using the "raw read" option in PerformanceTest, measured READs are averaging ~2.6 GB/second (2,606.3 MB/second). A routine virus check of our 6 GB database executes I/O about 14 TIMES faster than the rate at which the same I/O executes on our RAID-0 partition (2,606 / 192 MB/sec).

All utility I/O *e.g.* XP's CHKDSK, SystemSuite 9, likewise runs ~14 TIMES faster. The biggest bonus is the sheer speed we observe when updating our Copernic DesktopSearch index, which is our most frequent, and quite time-consuming, production task.

There is one performance "dip" which we have observed in the various tests we have performed to date. PerformanceTest's graphs reflect a measurable overhead accessing RAM above 4 GB. We were able to detect this "dip" by comparing the performance of a 512 MB ramdisk enabled on the same workstation with only 4 GB of dual-channel DDR2-1066 installed initially (before our "matched quad" arrived). This kind of behavior is to be expected, given the computational overhead that must be necessary whenever SuperSpeed's proprietary device driver in *RamDisk Plus* addresses unmanaged Windows memory *i.e.* above 4 GB.

If anything, our systemwide "bottleneck" has now shifted to the storage subsystem during routine shutdowns and startups (requiring ramdisk saves and restores, respectively). We do not anticipate needing to do regular manual saves or restores of that ramdisk partition.

On a subjective level, our assessment of browser effects remains the same, if not better than what we experienced with our older workstations. For example, Opera's *"Fit to width"* feature produces almost *instantaneous* results on-screen when displaying scanned document images. These graphics files seem to appear even *before* my finger has finished lifting off the mouse button!

Accessing the Internet, particularly via popular email servers like Gmail, Yahoo! and MSN's Hotmail, is likewise accelerated for the same reasons: without any problems, we also moved our 3 browser caches to that 8 GB ramdisk, with predictable performance effects and no observable malfunctions. Sweet!

The overall experience is one of silky smooth performance -- what one would expect from their "dream" system.

Future Plans

Our current plans anticipate upgrading our RAID controller by adding Intel's RS2BL080 with SAS/6G ports, then adding 2-4 Seagate Savvio 15K.2 SAS/6G HDDs, then 2-4 SATA/6G SSDs when the latter become available, more mature, and hopefully less expensive.

We expect such a faster disk storage subsystem to reduce startup and shutdown times from 60 extra seconds to ~20 extra seconds (maybe less).

We can *still* increase the total size of our current ramdisk(s) from 8 GB to 12 GB *without* using any RAM addresses below the 4 GB barrier (16 – 4 = 12): with 16,384 MB total, only 4,096 MB are actually "managed" by Windows XP x32, leaving 12,288 MB "unmanaged" and available for recent versions of *RamDisk Plus* to use.

Given the proven reliability of all hardware components plus the 32-bit version of XP/Pro, frequent system re-starts are a thing of the past; all of our systems typically run all day now without halting. This is indeed an enormous blessing, because we spend so much time accessing the Internet on a daily basis.

Ultimately, all or almost all core system components will be solid-state, except for necessary cooling fans: this should extend the useful life of a system's core. For example, Corsair RAM routinely comes with a limited lifetime warranty.

Backups can be done only as needed by writing to SSDs, or to rotating platters that exploit "green" energy-saving technologies. Alternatively, HDDs can be switched ON only as needed for such backup purposes and then switched OFF, further saving energy (and enabling superb virus and malware protection: computers simply cannot be infected when they are switched OFF completely).

The Visible Future

When we were choosing Intel's Q9550 and the ASUS P5Q Premium motherboard for our latest workstation success, we realized that this hardware is not the very latest and greatest. Intel's Core i7 CPUs are available now with triple-channel memory architecture, supporting a larger maximum up to 24 GB of very high-speed DDR3 (6 DIMMs x 4 GB), even more in large server systems *e.g.* sporting 32 ECC DIMM slots.

The measured bandwidth of this triple-channel architecture is 25,000 MB/second at stock speed and stock latency settings. Thus, compare 25,000 MB/second from DDR3 in triple-channel mode, with 6,400 MB/second from DDR2-800 in dual-channel mode (cf. discussion above). By doing this comparison, we feel it is reasonable to expect that the speed of routine I/O -- using *RamDisk Plus* on a 12-to-24 GB Core i7 machine -- should scale up in the same proportion *i.e.* ~3.9-to-1 (25,000 / 6,400). Call it 4-to-1, adjusting for the varying speeds of CPUs with integrated memory controllers *e.g.* Intel Core i7 and now i5.

Nevertheless, there was a "method in our madness" so to speak: we wanted to demonstrate a fully functional 16 GB workstation that did NOT require the very latest and greatest Core i7 hardware, and thus did NOT impose the premium costs of that architecture in order to achieve demonstrable advances in the measured speed of input-output with most frequently used files stored on our workstations.

Also, the cost of a Core i7 machine with 12 GB of triple-channel DDR3 worked out to be almost the same as the cost of our 16 GB workstation as described above. Comparing only those two, the extra RAM capacity tipped the scales in favor of the P45 chipset, *despite* the obvious premium we had to pay in order to purchase Corsair's 16 GB "matched quad" at current market prices. (See Newegg for details.)

A 24 GB Core i7 machine was way beyond our budget, due to the *prohibitive* price premium that now exists for 6 x 4 GB DDR3 DIMMs.

Recall above where we explained our desire to stay about 6 months behind the "bleeding edge". There is a lot to recommend this policy, particularly for work environments where computer stability is a paramount concern. And, today's hottest IT hardware inevitably falls in price, as soon as it is superseded by tomorrow's hotter hardware.

Conclusions

Coupled with the current low costs of extra RAM, particularly DDR2 SDRAM, *RamDisk Plus* version 10.0.1 is a highly cost-effective way to accelerate I/O with a Windows system's most frequently used files. This expanded speed also occurs *without* disturbing existing 32-bit systems and application software, and *without* requiring expensive and technically challenging upgrades to 64-bit architectures. The speed differences expected from premium memory subsystems -- like those that come with the Core i7's triple-channel architecture -- should scale up in direct proportion to their measured memory bandwidths.