Principled Technologies®

TEST REPORT
AUGUST 2006

SysBench performance with varying numbers of virtual machines on Intel- and AMD-processor-based quad-processor servers

Executive summary

Intel Corporation (Intel) commissioned Principled Technologies (PT) to measure the performance of multiple virtualized instances of SysBench in the following quad-processor servers:

- Hewlett-Packard ProLiant DL585 (using the Dual-Core AMD Opteron 885)
- Dual-Core Intel Xeon processor 7140-based server

To create the virtual servers on each system, we used the 32-bit Microsoft Windows Server 2003, Enterprise Edition guest support of VMware's ESX Server, version 3.0 (www.vmware.com/products/vi/esx/). We created 8 virtual machines, each running Windows Server 2003 R2 Enterprise Edition. We tested the servers running 1, 2, 4, and 8 virtual machines, each one using four virtual processors and 2 GB of RAM to simultaneously execute the workload.

KEY FINDINGS

- The Dual-Core Intel Xeon processor 7140-based server outperformed the Dual-Core AMD Opteron 885-based server with 2, 4, and 8 virtual machines (each with 4 virtual processors) simultaneously running SysBench.
- The Dual-Core Intel Xeon processor 7140-based server delivered almost 21 percent higher peak performance than the Dual-Core AMD Opteron 885-based server with 4 virtual machines running the workload (see Figure 1).

The developers at SourceForge.net (www.sourceforge.net) created SysBench to test various aspects of the performance of servers running database systems; its original target was the MySQL database system (www.mysql.com). We ran SysBench 0.4.0 against Microsoft SQL Server 2005 Enterprise Edition (http://www.microsoft.com/sql/editions/enterprise/default.mspx). In our test workload, SysBench created a 100,000-row SQL database and executed a batch of On Line Transaction Processing (OLTP) transactions against that data. We measured the total number of transactions per second (TPS) that all the virtual machines collectively completed during each test.

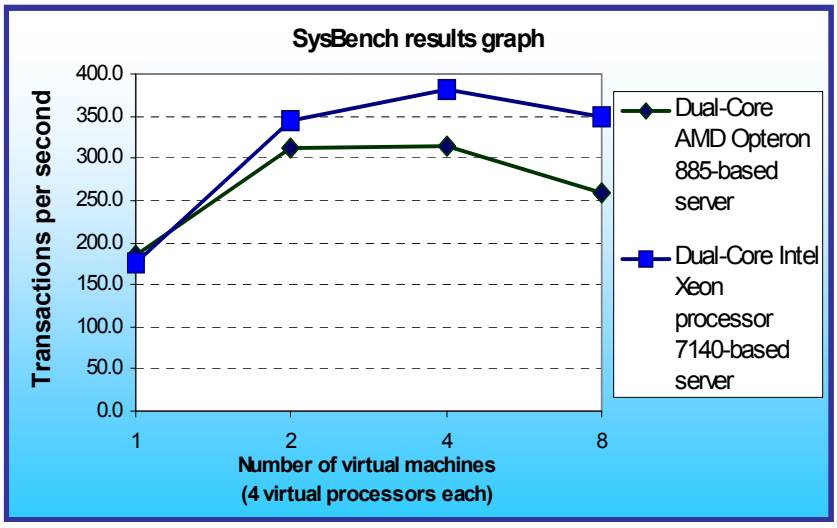

Figure 1: SysBench median results for the two test servers in transactions per second. Bigger is better.

Figure 1 shows the SysBench test results of the two test servers running 1, 2, 4, and 8 virtual machines. Each result is the median peak score of three runs of the benchmark. Both systems achieved their peak performance with 4 virtual machines. The Dual-Core Intel Xeon processor 7140-based server produced higher results than the Dual-Core AMD Opteron 885-based server with 2, 4, and 8 virtual machines. With 8 virtual machines and 4 virtual processors each, the test oversubscribed the processors in both systems. In this situation, the Dual-Core Intel Xeon processor 7140-based server was 34.9 percent faster than the Dual-Core AMD Opteron 885-based server. With 2 virtual machines, the difference was 10.3 percent, while with 4 virtual machines, the Dual-Core Intel Xeon

processor 7140-based server was 20 percent faster. With a single virtual machine, the Dual-Core Intel Xeon MP processor-based server ran about 6 percent slower than the Dual-Core AMD Opteron 885-based server.

See the Test Results section for the median scores from all the SysBench tests on each server.

Test results

Figures 2 through 5 show the median SysBench 0.4.0 results for both servers with 1, 2, 4, and 8 virtual machines running SysBench. We allocated each virtual machine 4 processors and 2000 MB of RAM. (See Installing VMware ESX Server 3.0 for more details on the set-up of the virtual machine environment.) We calculated the completion time, in seconds, by time stamping the log file in each virtual machine when the workload began and when it finished. We calculated the transactions per seconds by dividing the total number of transactions all the virtual machine completed by how long it took them to perform those transactions. For example, with 1 virtual machine and thus only 1 instance of SysBench running, the workload runs 10,000 transactions. With 4 virtual machines, 4 instances of SysBench are running, each performing 10,000 transactions, for a total of 40,000 transactions.

SysBench results with 1 virtual machine		
Server	**Dual-Core AMD Opteron 885-based server**	**Dual-Core Intel Xeon processor 7140-based server**
Completion time (seconds)	54	57
Transactions completed	10,000	10,000
Transactions per second	185.19	175.44

Figure 2: SysBench median results for the two test servers with 1 virtual machine each. Lower numbers are better for completion times. Higher numbers are better for transactions per second.

SysBench results with 2 virtual machines		
Server	**Dual-Core AMD Opteron 885-based server**	**Dual-Core Intel Xeon processor 7140-based server**
Completion time (seconds)	64	58
Transactions completed	20,000	20,000
Transactions per second	312.50	344.83

Figure 3: SysBench median results for the two test servers with 2 virtual machines each. Lower numbers are better for completion times. Higher numbers are better for transactions per second.

SysBench results with 4 virtual machines		
Server	**Dual-Core AMD Opteron 885-based server**	**Dual-Core Intel Xeon processor 7140-based server**
Completion time (seconds)	127	105
Transactions completed	40,000	40,000
Transactions per second	314.96	380.95

Figure 4: SysBench median results for the two test servers with 4 virtual machines each. Lower numbers are better for completion times. Higher numbers are better for transactions per second.

SysBench results with 8 virtual machines		
Server	**Dual-Core AMD Opteron 885-based server**	**Dual-Core Intel Xeon MP processor 7140-based server**
Completion time (seconds)	309	229
Transactions completed	80,000	80,000
Transactions per second	258.90	349.34

Figure 5: SysBench median results for the two test servers with an oversubscribed 8 virtual machines each. Lower numbers are better for completion times. Higher numbers are better for transactions per second.

Test methodology

Figure 6 summarizes some key aspects of the configurations of the two server systems; Appendix A provides detailed configuration information.

Server	**Dual-Core AMD Opteron 885-based server**	**Dual-Core Intel Xeon processor 7140-based server**
Vendor	Hewlett-Packard	Intel
Model	ProLiant DL585	Intel SR4850HW4x Server with Dual-Core Intel Xeon processor 7140
Processor frequency (GHz)	2.6 GHz	3.4 GHz
Single/Dual-Core processors	Dual	Dual
Motherboard	HP ProLiant DL585 G1 P82A4BL9QT90DP	Intel SR4850HW4x Server
Chipset	AMD 8131 chipset	Intel E8500 Chipset
RAM (32GB in each)	16 x 2GB PC-3200	16 x 2GB PC2-3200
Hard Drive	4 x HP BF141468A4B3 15K RPM 146.8 GB drives attached through HP Smart Array 5i SCSI controller	4 x Seagate ST3146854LC 15K RPM 146.8 GB drives attached through LSI Logic PCI-X Ultra320 SCSI controller

Figure 6: Summary of some key aspects of the server configurations.

Intel configured and provided both servers.

The difference in RAM types reflects the capabilities of the two motherboards: the Intel SR4850HW4x motherboard used DDR2 PC2-3200 400-MHz memory components. The HP ProLiant DL585 G1 motherboard supported 184-pin DDR memory, and the highest memory speed available for the Dual-Core AMD Opteron 885-based server was DDR PC3200 400-MHz RAM. (The Intel motherboard supported higher-speed RAM but used DDR2 PC2-3200 400-MHz RAM to make the systems as fairly comparable as reasonably possible.)

With the following exceptions, we used the default BIOS settings on each server: on the Dual-Core Intel Xeon processor 7140-based server, we disabled the HW Prefetcher and Enhanced Intel SpeedStep, and we enabled VT (though VMware's ESX Server does not take advantage of the hardware VT support). These options were not available on the Dual-Core AMD Opteron 885-based server.

We began by installing a fresh copy of Microsoft Windows Server 2003 R2 Enterprise Edition on each server on one of the SCSI drives. We followed this process for each installation:

1. Assign a computer name of “AMD32VM-1” or “INTEL32VM-1”, as appropriate.

2. For the licensing mode, use the default setting of five concurrent connections.
3. Enter the password “password” for the administrator account.
4. Select Eastern Time Zone.
5. Use a specific IP address for the Network installation.
6. Use the default name “WORKGROUP” for the workgroup.

We applied the following updates from the Microsoft Windows Update site:

- Security Update for Windows Server 2003 (KB921883)
- Windows Malicious Software Removal Tool - August 2006 (KB890830)
- Cumulative Security Update for Internet Explorer for Windows Server 2003 (KB918899)
- Security Update for Windows Server 2003 (KB920670)
- Security Update for Windows Server 2003 (KB920683)
- Security Update for Windows Server 2003 (KB922616)
- Security Update for Windows Server 2003 (KB917422)
- Security Update for Outlook Express for Windows Server 2003 (KB920214)
- Security Update for Windows Server 2003 (KB921398)
- Security Update for Windows Server 2003 (KB917537)
- Security Update for Windows Server 2003 (KB914388)
- Security Update for Windows Server 2003 (KB917159)
- Security Update for Windows Server 2003 (KB911280)
- Security Update for Windows Server 2003 (KB917734)
- Security Update for Windows Server 2003 (KB914389)
- Security Update for Windows Server 2003 (KB917344)
- Security Update for Windows Server 2003 (KB918439)
- Security Update for Windows Server 2003 (KB917953)
- Security Update for Windows Server 2003 (KB908531)
- Cumulative Security Update for Outlook Express for Windows Server 2003 (KB911567)
- Security Update for Windows Server 2003 (KB911562)
- Security Update for Windows Server 2003 (KB911927)
- Security Update for Windows Server 2003 (KB908519)
- Security Update for Windows Server 2003 (KB912919)
- Update for Windows Server 2003 (KB910437)
- Security Update for Windows Server 2003 (KB904706)
- Security Update for Windows Server 2003 (KB896424)
- Security Update for Windows Server 2003 (KB900725)
- Security Update for Windows Server 2003 (KB902400)
- Security Update for Windows Server 2003 (KB899589)
- Security Update for Windows Server 2003 (KB901017)
- Security Update for Windows Server 2003 (KB905414)
- Security Update for Windows Server 2003 (KB893756)
- Security Update for Windows Server 2003 (KB896428)
- Security Update for Windows Server 2003 (KB896358)
- Security Update for Windows Server 2003 (KB899587)
- Security Update for Windows Server 2003 (KB890046)
- Security Update for Windows Server 2003 (KB899591)
- Security Update for Windows Server 2003 (KB899588)
- Security Update for Windows Server 2003 (KB901214)
- Update for Windows Server 2003 (KB898715)

Installing the server and configuring the SCSI drives

We set up the servers so we could run 1, 2, 4, or 8 virtual machines under the VMware ESX 3.0 server. We first created a partition on one disk drive and installed Windows Server 2003. We then installed VMware ESX 3.0 and

edited the Grub loader (on the Dual-Core AMD Opteron 885-based server) or the NTLDR (on the Dual-Core Intel Xeon processor 7140-based server) so we could dual-boot the operating systems. Figure 7 illustrates the disk layout we used to accommodate both operating systems and 8 virtual machines.

SCSI drives	Partition type	Partition size (MB)
sd0		
Windows Boot Partition	NTFS	102
Windows Server 2003 R2 Enterprise Edition	NTFS	14650
Windows Pagefile	NTFS	39070
Spare Storage	NTFS	82910
sd1		
/boot	EXT3	102
/	EXT3	4800
Spare Virtual Machine Storage	VMFS	129180
Swap	Swap	541
/var/log	EXT3	1950
VmKore	vmkcore	102
sd2		
Virtual Machine Storage (X4)	VMFS	136730
sd3		
Virtual Machine Storage (X4)	VMFS	136730

Figure 7: SCSI drive configurations for both operating systems and all the virtual machines.

Installing VMware ESX Server 3.0

We installed VMware ESX Server 3.0 by following this process:

1. Reboot the server with the VMware ESX Server CD in the CD-ROM drive. The installation wizard will start and guide the installation process.
2. Assign a host name (“amd.localhost” or “intel.localhost”, as appropriate).
3. Enter the password “password” for the administrator account.
4. Select Eastern/New York Time Zone.
5. Use specific IP addresses for each server.
6. Once the installation is complete, reboot the server.
7. Log into the VMware ESX 3.0 Server.
8. Edit the Grub configuration file (grub.conf) in the boot/grub directory and add the following lines:

```
title Windows Server 2003 R2 Enterprise Edition
    rootnoverify (hd0,0)
    chainloader +1
```

10. For the Dual-Core Intel Xeon processor 7140-based server, use bootpart.exe to create an ESX boot file, and then change the NTLDR file to point to that same file (i.e. c:\bootpart\bootsec.lnx). This file redirects the boot to the ESX grub loader.
11. Attach one management desktop system directly to each server using a crossover Cat 5 network cable.
12. Apply IP addresses in the same subnet as the above IP address.
13. On each management desktop system, use a Web browser to work with the Web interface available in VMware ESX 3.0 server.
14. Download and install the VMware Virtual Infrastructure Client 2.0.0 from the VMware ESX 3.0 Server. This software serves as a management console to the VMware ESX Server and lets you build and set the resources for each of the virtual machines.
15. Mount the vmfs partitions in Figure 7.
    - In the Configuration tab of the Virtual Infrastructure Client, click the Storage (SCSI, SAN, and NFS) item under Hardware.

- Use the Add Storage… wizard to mount each directory.
- Accept all default settings with one exception: mount only the partition you designated for virtual machine storage, not the entire SCSI drive.
- Repeat this and name the two storage partitions storage2 and storage3.

16. Use the New Virtual Machine Wizard to create the first virtual machine with the following parameters:
    - Storage area: storage3
    - Guest operating system: Microsoft Windows Server 2003 R2 Enterprise Edition
    - Memory: 2000MB
    - Number of NICs: 1
    - Hard disk space: 30GB
    - CPUs: 4 virtual processors
    - SCSI controller type: LSI Logic
    - Virtual machine name: Intel32VM-1 or AMD32VM-1, as appropriate.
20. After creating the first virtual machine with the VMware Infrastructure Client, place the Windows Server 2003 CD in the management desktop system
21. Power on the virtual machine.
22. Mount the virtual CD-ROM drive connecting the virtual machine to the CD-ROM drive on the management desktop system.
23. The virtual machine will boot and detect the bootable installation disk.
24. Install Microsoft Windows Server 2003 R2 Enterprise Edition with the same configuration and updates we showed previously.
25. Install VMware tools by clicking Inventory->Virtual Machine->Install VMware Tools.
26. Follow the installation wizard accepting all of the default settings.
27. Shut down Windows and make sure that you have completely powered down the virtual machines.

Cloning the virtual machines

To create the other virtual machines, we did the following:

1. On the VMware ESX Server, push Alt-F1 to switch to a console.
2. Log in as root.
3. Maneuver to the storage area where the newly created virtual machine resides: /vmfs/volumes.
4. VMware has already created a directory in storage3 named Intel32VM-1 (or AMD32VM-1) for the first virtual machine you previously built.
5. Use the mkdir command to create the directories for the other 7 virtual machines. Spread the directories so that storage2 and storage3 each contain 4 virtual machines. For example, you might enter the following:
    - mkdir ./storage2/Intel32VM-2
    - mkdir ./storage2/Intel32VM-3
    - mkdir ./storage3/Intel32VM-4
6. When you finish this process, the storage partitions should have one directory for each virtual machine.
7. Maneuver to the directory that holds the first virtual machine (/vmfs/volumes/storage3/Intel32VM-1).
8. Copy the two core files, Intel32VM-1.vmdk and Intel32VM-1-flat.vmdk, to one of the directories you just created.
9. On the management desktop system running VMware Virtual Infrastructure Client, click the Virtual Machines tab.
10. Click File->New->Virtual Machine…
11. Use the Custom selection for Wizard Type and configure each virtual machine with the same parameters as above.
12. At the Select a Disk screen, choose Use an existing virtual disk.
13. Click Next.
14. Maneuver to the directory of the next virtual machine.
15. Repeat Steps 9 through 14 for the remaining virtual machines.
16. Boot each virtual machine, one at a time, starting with virtual machine number 2.
17. Change the IP address to the next address in numerical order.

18. Change the computer name to the next name in logical succession (for example, intel32vm-2 and intel32vm-3).
19. Reboot the virtual machine.

Installing and configuring SysBench

Before using SysBench, we installed Microsoft SQL Server 2005 Edition, which also required us to install Microsoft IIS Services available in Windows Server 2003. We installed this service using the Manage Your Server wizard.

After we placed the Microsoft SQL Server CD in the CD-ROM drive, the installation wizard automatically appeared. We used the following steps to install and configure Microsoft SQL Server so we could run the SysBench benchmark with it.

1. At the Feature Selection Setup Screen, select:
   - Database Services
   - Integration Services
   - Client Components
2. For Instance Name, select the Default, and click Next.
3. At Service Account, select Use the built-in System account, chose Local system, and click Next.
4. At the Authentication Mode, select Windows Authentication Mode, and click Next.
5. For the Collation Settings screen, keep all the default settings, and click Next.
6. For Error and Usage Report Settings screen, keep both check boxes unchecked, and click Next.
7. At the Ready to Install screen, click Install.
8. When the Installation Complete screen appears, click Finish.
9. Reboot the server.

We used the following steps to create the database “sbtest” (the default database name for SysBench):

1. Click Start->All Programs->SQL Server 2005->SQL Management Console.
2. When the console opens, right-click Databases in the left pane.
3. Select Create Database.
4. When the Create Database dialog box opens, enter sbtest in the Database Name prompt, and click OK.
5. Close the SQL Server management console.

The SysBench benchmark is a self-contained executable with a list of options for the type of workload to run and the parameters under which to run it. It does not require a special installation process. Instead, we simply copied the SysBench executable to the root C: drive.

We used the following batch file to launch the SysBench benchmark with the database throughput performance settings:

```
c:\sysbench.exe --test=oltp --oltp-table-size=100000 --num-threads=4 --max-requests=10000 run
1>>sysbench.log 2>>sysbench.err
```

Launching the benchmarks simultaneously in multi-virtual machine environments

To run copies of SysBench in multiple virtual machines simultaneously, we ran a batch file (run.bat) on each virtual machine that used the presence of a file (run1.txt) as a flag to determine when to start the benchmark.

From our management desktop , we ran a batch file (startrun.bat) that launched run.bat on each virtual machine. run.bat started by cleaning up and preparing the test table in the sbtest database. Once the database was ready, the next step in the batch file launched a loop that searched for run1.txt. Again, from the management desktop system, we launched a batch file (beginrun.bat) that copied our master copy of run1.txt to each virtual machine. When the virtual machine detected the presence of the run1.txt file, run.bat launched runsysbench.bat, which then started SysBench.exe with the command line options and parameters we noted previously. SysBench.exe then

called start_timer.bat, which created a time stamp in a log file in the hh:mm:ss.ss format. Once the SysBench workload completed, it created a final time stamp using stop_timer.bat. We used these two time stamps to calculate the duration of the run.

After each test, we powered off the virtual machines and restarted VMware ESX Server before running the test again.

Appendix A – Test server configuration information

This appendix provides detailed configuration information about each of the test server systems, which we list in alphabetical order.

Processors	Dual-Core AMD Opteron 885-based server	Dual-Core Intel Xeon processor 7140-based server
System configuration information		
General		
Processor and OS kernel: (physical, core, logical) / (UP, MP)	4P8C8L / MP	4P8C16L / MP
Number of physical processors	4	4
Single/Dual-core processors	Dual	Dual
System Power Management Policy	Always On	Always On
CPU		
Vendor	AMD	Intel
Name	Dual-Core AMD Opteron 885	Dual-Core Intel Xeon processor 7140
Stepping	2	8
Socket type	940	LGA 771
Core frequency (GHz)	2.60 GHz	3.4 GHz
Front-side bus frequency (MHz)	1000-MHz HyperTransport	800 MHz
L1 Cache	64 KB + 64 KB	12 KB + 16 KB
L2 Cache	2 MB (1 MB per core)	1 MB
L3 Cache	N/A	16 MB
Platform		
Vendor	Dual-Core AMD 885 Opteron server	Dual-Core Intel Xeon processor 7140-based server
Motherboard model number	HP ProLiant DL585 G1, P82A4BL9QT90DP	Intel SR4850HW4x Server
Motherboard chipset	AMD 8131 chipset	Intel E8500 Chipset
Motherboard revision number	BL	11
Motherboard serial number	011977-502	QSHM61700171
BIOS name and version	Hewlett Packard, version A01, 03/22/2006	Intel Corporation SHW40.86B.P.09.00.0060, 08/23/2006
BIOS settings	Default	HW Prefetcher, Adjacent cache line prefetcher, and Enhanced Intel Speedstep Technology disabled; VT enabled
Chipset INF driver	Microsoft Version 5.2.3790.1830	Microsoft Version 5.2.3790.1830
Memory module(s)		
Vendor and model number	AVANT Technology AVM7256R53C34007SAC	Kingston KVR400D2D4R3
Type	PC-3200 Registered DIMM	PC2-3200 Registered DIMM
Speed (MHz)	400	400
Speed in the system currently running @ (MHz)	400	400
Timing/Latency (tCL-tRCD-iRP-tRASmin)	3-3-3-8	3-3-3-8
Size	32768 MB	32768 MB
Number of RAM modules	16	16

Chip organization	Double-sided	Double-sided
Channel	Dual	Dual
Hard disk		
Vendor and model number	HP BF1468A4B3	Seagate ST3146854LC
Number of disks in system	4	4
Size	146.8 GB	146.8 GB
Buffer Size	8 MB	8 MB
RPM	15,000	15,000
Type	SCSI	SCSI
Controller	HP Smart Array 5i SCSI	LSI Logic PCI-X Ultra320 SCSI
Controller driver	VMware 5.2.3790.1830 (LSI Logic)	VMware 5.2.3790.1830 (LSI Logic)
Operating system (Windows)		
Name	Microsoft Windows Server 2003 R2 Enterprise Edition	Microsoft Windows Server 2003 R2 Enterprise Edition
Build number	3790	3790
Service Pack	SP1	SP1
Microsoft Windows update date	08/23/2006	08/23/2006
File system	NTFS	NTFS
Kernel	ACPI Multiprocessor x32-based PC	ACPI Multiprocessor x32-based PC
Language	English	English
Microsoft DirectX version	DirectX 9.0c	DirectX 9.0c
Operating system (VMware)		
Name	VMware ESX Server 3.0.0 build-27701	VMware ESX Server 3.0.0 build-27701
File system	ext3 (server) vmfs (virtual machines)	ext3 (server) vmfs (virtual machines)
Kernel	Version 2.4.21-37.0.2.EL	Version 2.4.21-37.0.2.EL
Language	English	English
Graphics		
Vendor and model number	ATI Rage XL	ATI Radeon 7000
Chipset	ATI Rage XL PCI (B41)	ATI Radeon 7000 PCI
BIOS version	GR-xlcpq-5.882-4.333	BK-ATI VER008.004.037.001
Type	Integrated	Integrated
Memory size	8 MB	16 MB
Resolution	800 x 600	800 x 600
Driver	VMware SVGA II 11.2.0.0	VMware SVGA II 11.2.0.0
Network card/subsystem		
Vendor and model number	Broadcom dual NetXtreme Gigabit	Broadcom dual NetXtreme Gigabit
Type	Integrated	Integrated
Driver	VMWare 2.0.0.8	VMWare 2.0.0.8
Optical drive		
Vendor and model number	HL-DT-ST GDR8084N	Philips SDR089
Type	DVD-ROM	DVD-ROM
Interface	Internal	Internal
USB ports		
# of ports	2 (2 back)	5 (3 front, 2 back)
Type of ports (USB 1.1, USB 2.0)	USB 1.1	USB 2.0

Figure 8: Detailed configuration information for the two test servers.

Principled Technologies, Inc.
4813 Emperor Blvd., Suite 100
Durham, NC 27703
www.principledtechnologies.com
info@principledtechnologies.com