An Evaluation of Windows 7 Release Candidate

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ABSTRACT

This project evaluates Microsoft's latest operating system (OS), ***Windows 7*** and compares its performance to that of ***Windows XP***. Similarities and differences between ***Windows 7*** and ***Windows Vista*** are noted. The performance evaluation of the systems is carried out using freely available benchmarks to characterize the behaviour of the operating systems (OSes). The evaluation is carried out without any performance tuning on any of the OSes. ***Windows 7*** was found to be more secure than ***Windows XP*** due to the benefits that UAC provides. It was also found that if one runs ***Windows 7*** in any mode other than the most secure UAC mode, they work with the same security as that in ***Windows XP.*** Furthermore, ***Windows 7*** also comes with features such as *Bitlocker Drive Encryption* and *Bitlocker To Go* both of which require technologies that are not available on most ordinary PCs thus making them inaccessible to most users. Most of the software that was installed on ***Windows 7*** worked fine but it still has problems with some of the old software for which patches or new versions were required when there were incompatibilities. Some drivers that ***Windows 7*** installed for hardware were either outdated or did not work at all thus needing updates. The performance benchmarking results show that ***Windows XP*** manages to perform better than ***Windows 7*** in most of the tests conducted. However in terms of 3D graphics ***Windows 7*** manages to outperform ***XP*** in all but one test which could not be completed for ***Windows 7***. In general, there is no huge margin between ***Windows XP's*** performance and that of ***Windows 7***. Although ***Windows XP*** slightly outperforms ***Windows 7*** in most tests that were conducted, no one system offers a clearly better overall performance as the differences are not very significant. Furthermore, other factors such as extra features, ease of installation can be convincing reasons for choosing a particular OS. However, ***XP*** still remains a better desktop OS since it has no application compatibility issues, works on ordinary hardware, and has a better performance.

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CHAPTER 1. INTRODUCTION

Windows Vista dubbed by Microsoft as their best OS to date was not received warmly by many customers due to its high demand for computing resources, ceaseless security notifications, lack of compatibility with older applications and many reported crashes especially in its early stages. It has been patched several times in order to counter these bugs. As a result of the ***Vista*** disappointment, Microsoft has been eager to get people to use ***Windows 7*** which they claim to be an improvement. Among the claims that have been made are the following:

- Ease and speed of installation
- Fast start-up and shutdown time
- Enhanced performance (graphics, disk I/O, robustness etc)
- Security
- Software compatibility
- User friendliness

There have also been conflicting views about the timing of the release of the Operating System (OS) with some critics claiming that it is a rushed decision taken to put out the flames started by the Vista saga. Table 1 below shows that there was a 5 year gap between the release of ***Windows XP*** and ***Windows Vista*** compared to 3 year gap between the release of ***Windows Vista*** and ***Windows 7***.

RELEASE DATE	PRODUCT NAME	CURRENT VERSION/BUILD	NOTES	LAST INTERNET EXPLORER
October 2001	Windows XP	NT 5.1.2600	Extended Support until April 8, 2014 for SP3 and July 13, 2010 for SP2. (RTM and SP1 unsupported).	IE 8
November 2006 (volume licensing) January 2007 (retail)	Windows Vista	NT 6.0.6002	Current. Version changed to NT 6.0.6001 with SP1 (February 4, 2008) and to NT 6.0.6002 with SP2 (April 28, 2009).	IE 8
October 2009	Windows 7	NT 6.1.7600	RTM	IE 8

Table 1 - Release of Windows OS since XP [27]

The purpose of this project is to evaluate ***Windows 7 RC*** by investigating the response and implementation of its various attributes as well as to validate some of these claims.

CHAPTER 2. LITERATURE REVIEW AND DESIGN CONSIDERATIONS

2.1. Introduction

Windows Vista did not spread as rapidly as Microsoft expected for many reasons. The corporate sector believed it was a bad idea to spend substantial financial resources on software upgrades during an economic crisis while IT-professionals played their usual game of waiting for the release of the first service pack [30]. As for the home users who have been using ***Windows XP*** for a long time a hostile reception was inevitable. Considering that ***Windows XP*** has been in the market for such a long time and that the transition from ***Windows 98*** to ***Windows XP*** was not a smooth one critics have been questioning the timing of the release of the ***Windows 7*** OS. ***Vista*** has been around for less than 3 years and claims have been made that Microsoft is making a rushed decision by releasing a whole new OS instead of taking their time to fix the bugs in ***Vista***.

Some skeptics claim that ***Windows 7*** is *Vista* with bugs taken out of it with some critics going as far as claiming that ***Windows 7*** is just a Vista patch. John Curran, head of the Windows client group in the United Kingdom, during a ***Windows 7*** briefing was asked by Anderson that, "Since under the covers ***Windows 7*** is so similar to *Windows Vista*, how does Microsoft justify calling it a full new version? [1]" Curran is said to have responded by mentioning new features in ***Windows 7*** such as: *Digital Living Room Network Alliance (DLNA)* compliance in Windows Media Player (WMP) for easier media sharing, *BitLocker to Go* for encrypting USB storage devices, Direct Access for network access without VPN, and new support for sensors and devices that will enable *location-aware* laptops. Anderson then goes on to give a rather half hearted comment that, "…distinguishing between applications and the core operating system is a matter of debate... [1]" Despite this antagonism, ***Windows 7*** has been widely anticipated since developers got the first glimpse of it at Microsoft's Consumer Electronics Show (CES) booth tour held in Las Vegas on the 9th of January 2009 [2]. At the Show, Steve Ballmer, Microsoft's CEO is quoted to have said that they are working hard at putting all the right ingredients such as simplicity, reliability and speed into ***Windows 7*** [2]. He is also reported to have described ***Windows 7*** as a slick, fast, user-friendly successor to *Vista* and that ***Windows 7*** will be "the best version of Windows ever [2]." Microsoft has also promised that the new OS will have faster start up and shutdown times, fewer security alerts, and will provide better power management leading to improved battery life on laptops [26]. They also say that ***Windows 7*** will support *multi-touch interfaces*, simplified home

networking, and easier management of peripheral devices such as cell phones and digital cameras. In addition, Microsoft has also promised that the OS will have an updated Taskbar, new animated desktop effects, *context-sensitive menus* and a smarter desktop search tool [14].

Microsoft has been aiming for an early commercial release of the completed product, a shift from their initial proposed release in 2010. Gregg Keizer said that Microsoft confirmed on the 2nd of June 2009 that it will put ***Windows 7*** on store shelves and computer makers will have systems ready to sell with Vista's successor on the 22nd of October 2009 [8]. A Release Candidate (RC) of the OS has however already been released which has been made available to the public. A critical evaluation of ***Windows 7*** is therefore necessary in order to identify existing bugs, rate the performance of the OS as well as establish its usability.

2.2. Evaluation Strategies

In this project a variety of tests will be carried out on ***Windows 7*** in order to determine ***Windows 7***'s a) performance against its predecessors such as ***Vista*** and ***XP*** b) security capabilities c) usability d) backup and search capabilities e) software compatibility and other operating system functionalities. Details of how the software works cannot be accessed since Windows is proprietary software. What this means is that "black box" or functional testing will be carried out. Hardware compatibility tests may also be conducted if various hardware platforms are provided to try and determine the minimum best hardware platform upon which the ***Windows 7*** gives the best output. Some of the tests to be carried out include:

2.3. Performance Testing

Microsoft claims that ***Windows 7*** will have faster, more responsive performance. They claim that ***Windows 7*** starts up, shuts down, resumes from standby, and responds faster. They also say that ***Windows 7*** provides fewer interruptions and can recover more quickly from problems when they do occur. Furthermore Microsoft claims that ***Windows 7*** will help you fix problems when you want and if the operating system experiences a problem it automatically recovers [15]. However performance improvements are about more than speed. An example is if your laptop battery lasts longer with one operating system than another while running the same applications the longer battery saving OS is said to be more efficient. Microsoft also claims that, "***Windows 7*** comes with power-saving features, such as adaptive display brightness, which dims the display if you have not used your PC for a while thus increasing battery life [8]." In terms of faster performance the OS can be benchmarked and results are compared against other OS benchmarks to verify accuracy of these claims. Traeger

et al (2008) are of the opinion that, “Benchmarking is critical when evaluating performance... [25].” They also argue that complex interactions between I/O devices, caches, kernel daemons, and other OS components result in behaviour that is difficult to analyze. Benchmarks are most often used to provide an idea of how fast some piece of software or hardware runs. The results obtained can significantly add to, or lessen, the value of a product be it monetary or otherwise. As an example the results may be used by potential consumers in making purchasing decisions, or by researchers to help determine a system’s worth [25]. Traeger et al (2008) classify benchmarks into three categories and the categories are as follows:

- Macro-benchmarks: performance is tested against a particular workload that is meant to represent some real-world workload.
- Trace Replay: in this case a program replays operations which were recorded in a real scenario, with the hope that it is representative of real-world workloads.
- Micro-benchmarks: a few (typically one or two) operations are tested to isolate their specific overheads within the system [25].

Traeger et al further argue that useful file benchmarks should highlight the high-level as well as low level performance when they say that,”... we recommend using at least one macro benchmark or trace to show a high-level view of performance, along with several micro benchmarks to highlight more focused views [25].”

The state of the system as benchmark tests are being run can have significant effects on the results obtained. As a result when an appropriate system state is determined, it should always be documented accurately together with the results to allow reproducibility. Some major factors that can affect results are cache state, file system aging, and nonessential processes running during the benchmark. Traeger et al argue that, “the state of the system’s caches can affect the code paths that are tested and thus affect benchmark results. It is not always clear whether benchmarks should be run with “warm” or “cold” caches. On one hand, real systems do not generally run with completely cold caches. On the other hand, a benchmark that accesses too much cached data may be unrealistic as well. Because requests are mainly serviced from memory, the file or storage system will not be adequately exercised [25].” If cold cache results are desired, caches should be cleared before each run. This can be done by allocating and freeing large amounts of memory, remounting the file system, reloading the storage driver, or rebooting [25]. Rebooting can also be an effective method of clearing

caches. Since a dual boot (running ***Windows* XP *SP3*** and ***Windows 7 RC Build 7100)*** will be used in these experiments, caches will automatically be cleared when the machine is restarted to run the other OS. This helps create identical runs, thus ensuring more stable results.

To ensure reproducibility of the results, all nonessential services and processes should be stopped before running the benchmark. These processes can cause anomalous results (outliers) or higher-than-normal standard deviations for a set of runs [25]. It is also essential to ensure that no users log into the test machines during a benchmark run, and to also ensure that no other traffic is consuming network bandwidth while running benchmarks that involve the network. Traeger et al recommend four important guidelines to running benchmarks properly:

- One should ensure that every benchmark run is identical.
- Each test should be run several times to ensure accuracy, and standard deviations or confidence levels should be computed to determine the appropriate number of runs.
- Tests should be run for a period of time sufficient for the system to reach steady state for the majority of the run.
- The benchmarking process should preferably be automated using scripts or available tools to minimize the mistakes associated with manual repetitive tasks [25].

Furthermore Sun Microsystems suggests that, "During competitive system software testing, it is important to ensure the underlying hardware and the benchmarking code is as close to identical as possible so that proper comparisons can be drawn [22]." This means that to ensure comparability:

- The same physical hardware should be used for all tests
- Identical benchmark source code should be compiled on both platforms
- Operating systems that will be installed should be used out of the box, with no special tuning

For comparison purposes, and because no source code is available for the two systems, the benchmarking methodology that will be adopted will be the "black box" approach.

2.3.1. Robustness Benchmarking

"Robustness benchmarking provides important information to both users and designers of off-the-shelf software for dependable systems [21]." It is common for PC software to crash or hang, requiring restarts or even machine reboots. While users may want more dependable software, they have not yet created a marketplace in which developers are under pressure to provide it. The focus of robustness benchmarking is to test the reliability or ability of an OS to handle unforeseen circumstances when application code provides invalid inputs to it [21]. This is because real world software is barely free of bugs. In this method, operating system calls are made with various combinations of valid and invalid parameters. The resultant stress on the OS reveals erroneous system responses, including the ability to crash the entire system from within user code. Examples of such situations are buffer overflow cases where a program uses more memory than the programmer designed it to use resulting in it writing outside its address space.

2.3.2. Security

IT personnel are concerned with system security and they are most comfortable working with systems that they use on a day to day basis. Thilmany, argues that, "If IT personnel have mastered a particular OS, they already know how to make it secure against hackers. That particular know-how does not necessarily extend to a new system [24]."

If employees are used to working with a particular system, a change to a new system can drastically lower productivity for a time. Thilmany further argues that, "…enterprises that do take on a new OS must consider training cost for IT staff and all employees who will use the system when looking at costs [24]." An evaluation of the features available in an OS can help to come up with an estimate of the costs that can be incurred when migrating from one OS to another as well as establishing the benefits of moving over to the new OS. Testing an OS before deployment can also assist in planning for the relevant hardware and software upgrades as well as staff training. Cost of an OS also affects the decision that is made by a user when choosing an OS.

2.3.2.1. Data Encryption

Many accounts have been reported about companies losing control over sensitive information. In some industries, this can have great legal implications, while in other situations the issue is inconvenience. "... Smart compliance policy dictates that sensitive information be safeguarded in the event of a lost or stolen laptop. Furthermore, preventing

sensitive information from being removed from corporate resources is a pillar of effective compliance management [10]."

The ***Enterprise*** and ***Ultimate*** editions of ***Windows 7*** contain a feature called *Bitlocker Drive Encryption* which encrypts all the data on the system volume and another one called *BitLocker To Go* that offers data protection on portable storage, such as USB flash drives. *Bitlocker Drive Encryption* was first implemented in ***Windows Vista***. Compromised systems may contain confidential information which may be more valuable than the hardware itself, if it reaches the right people. *BitLocker* makes it harder to access this confidential information on these systems [3].

With the current generation of OSes it is very simple to break into a laptop. One obvious way is to take the disk drive out of the compromised system and connect it to a second machine as an auxiliary (slave) drive. All data can now be accessed using the administrator (root) privileges of the second machine. "An even easier solution is to use a bootable floppy disk, CD, or USB key that contains a script that resets the Administrator (root) password [3]." It is a sad situation that such scripts and disks are available on-line, and anyone with an Internet connection can download them. Once the Administrator password is reset, the compromised system can be booted and the attacker can log in as the Administrator, giving him complete access to all information on the system.

Ferguson says that, "The classic solution to this problem is to run a low-level disk encryption driver with the key (passphrase) provided by the user, a token (smart card) or a combination of the two. The disadvantage of the classic solution is the additional user actions required each time the computer is used. Most users are unwilling to go through these extra steps, and thus most computers are unprotected [3]." *BitLocker* improves on the classic solution by disallowing the user actions during boot or wake-up from hibernation.

On the downside, hackers can go around this configuration of *BitLocker* by using hardware-based attacks. Hardware based attacks can be stopped but the process requires the use of a token such as a USB key and/or a user-memorized password or PIN [3]. These options are fully supported by *BitLocker*, and they improve the security of the system. *BitLocker* makes use of the Trusted Platform Module (TPM) a tamper-resistant chip mounted on the motherboard. [3]. It is worth noting that this TPM device is not yet available in most of the motherboards available on the market today but will be incorporated in most PCs in the near future. During the boot process the Platform Configuration Registers (PCRs) in the TPM are

used to keep track of the code that runs. The key used to encrypt the disk is sealed against a particular set of PCR values. If an attacker boots into any other machine running the same type of OS, the machine will be fully functional but the PCR values will be different and the TPM will not be able unseal the key. The *BitLocker* disk cipher must be fast otherwise the intended users will not use it [3]. As part of this evaluation a performance analysis will be carried out in order to establish the delay introduced by this added security function.

According to Sams.net, Microsoft's security problems can be summed up in two words: user friendliness [20]. He argues that, "No other platform (not even ***Mac OS***) has been designed so expressly for this purpose. Over the years, the Microsoft team has invested enormous amounts of time and research to deliver ease and enjoyment of use. For example, Microsoft even conducted research to determine from which direction light should fall on an icon. This ease of use comes with a cost." Swap files and disk caches are devices that greatly enhance overall performance (they can compensate for sparse RAM resources). When a large swap is present, certain elements of a program need not be loaded into memory again. This results in increased speed and functionality. Unfortunately, it also results in poor security.

Any type of swapped memory system is insecure because traces of data are left within that swap file or swap area. A good example is the use of encryption like PGP. When done through the Windows environment, the passphrase is written into the swap file and is therefore retrievable [20].

Sams.net further argues that user friendliness has inhibited the development of a truly secure Microsoft operating system. Indeed, this is the greatest challenge facing Microsoft today. Microsoft must find a way to reconcile user friendliness with strong security [20]. An assessment will be made in this regard to find out whether there has been any effort by Microsoft to improve on this loophole in their latest OS (***Windows 7***).

2.3.2.2. Identification and Authentication of Devices

While the number of potential attackers over a network connection is much larger than those within physical proximity of a target system, it is important to consider the threats and security countermeasures available for securing device interfaces [29]. This is particularly relevant for mobile devices such as laptops that are potentially exposed to a large number of individuals. Interfaces present a threat vector for internal users intending to compromise systems or to gain unauthorized privileges without leaving readily identifiable traces. Wolthusen argues that, "While some OS mechanisms may impose certain dynamism such as

temporal restrictions of device access, there are few limitations imposed on communicating through an interface once access has been granted [29].”

What this means is that current common OSes and application programs typically do not identify and authenticate devices and application programs. Wolthusen further argues that, “In many cases the underlying devices do not provide for such mechanisms themselves (e.g. in case of human interface devices attached via radio or infrared interfaces, these commonly employ only limited disambiguation), which can lead to undesirable interactions at both functional and security levels [29].” In other cases, the identification and authentication mechanisms do not establish the identity of the communicating devices. As an example, the Bluetooth pairing mechanism establishes only knowledge of the PIN code, not the identity of a device or even of a subject controlling such a device. This means that devices attached to a host system do not identify individual users but assume that the possession of the device implicitly identifies the user. Furthermore the system assumes that the user identity authenticated on the host system pre-determines the ownership of attached devices. Assessments will be carried out in this regard in order to verify whether there has been a step made towards the improvement of security in terms of devices that access the system via various interfaces.

2.3.2.3. User Account Control (UAC)

One of the main reasons why users detested ***Windows Vista*** were the incessant security notifications that it gave each time an application tried to change the state of the system. Microsoft says that in ***Windows 7***, you get to choose the messages you want to see thus giving one more control over messages [15]. However there have been growing concerns in different parts of the media that ***Windows 7*** may end up being less secure than ***Vista*** as this freedom allowed to the user may allow malicious control of their PCs remotely.

2.3.3. Software compatibility

There is no one perfect operating system (OS). By definition an OS is simply a system that runs a user’s hardware and applications. If a company decides to use a new operating system for their business, they are concerned about the interoperability of the new OS with the already existing hardware and software. Thilmany says that, “It is important to test everything multiple times, including third-party products like backup solutions, before full deployment [24].” As a result establishing the type of applications and the system specifications that an operating system can support is a very important aspect when

evaluating operating systems. This process may involve loading as many applications as possible to determine their compatibility with the new OS.

This attribute will be tested in various ways including installation of software such as *Application Servers* and *IDEs* on a new ***Windows 7*** installation to find out whether the software will install. Microsoft products such as *MS Office 2003* and *2007* will also be tested to find out whether they can run smoothly on the new platform as well as verify whether one of the two is superior. Tests will also be done using highly graphical games such as *Pro Evolution Soccer 2009* and *Need for Speed Underground* in order to find out how well ***Windows 7*** manages its graphics usage. Furthermore, upgrades will be tried on machines already running ***Vista*** or ***XP*** to find out whether this is possible. Software running on these machines will be tested to find out whether they have not crashed. Lower versions of Microsoft OS will be tested to find out whether they can be installed after ***Windows 7*** has been installed. In other words the researcher will be trying to find out whether a dual boot is possible with lower versions of Windows after ***Windows 7*** has been installed.

2.3.4. Hardware compatibility

Testing an operating system with various hardware systems within the organization is also an essential step as this helps to determine which hardware is compatible with the OS [24]. This attribute will not be easy to measure as people from different walks of life have varying uses for computers in their day to day activities. However this attribute will be measured against standard home operation conditions to determine the minimum hardware that can support ***Windows 7*** for an individual to fully exploit the available functionality in the OS. The minimum requirements will also be compared against ***Windows 7***'s predecessors' hardware requirements.

2.3.5. Installation Process

In many OSes, creating disk partitions, logical devices, and new file systems (includes formatting) are detailed processes and this slows operations. Sun Microsystems, Inc argues that, "Because these relatively uncommon tasks are only performed by system administrators, there is little pressure to simplify and speed such administrative tasks [22]." Mistakes are easy to make and can have undesirable consequences. As more users handle system administration tasks, it can no longer be assumed that users have undergone specialized training. Automation of system administration can help to reduce the impact of these mistakes to a great degree. Sun Microsystems argues that manual reconfiguration of disk

space is virtually unnecessary, but it has to be a quick and easy process when it is needed. Administrators can add storage space to, or remove it from, an existing file system without unmounting, locking, or interrupting file system service. Administrators simply state their intent, such as make a new file system, rather than perform the constituent steps [22]. An assessment will be made to find out how much the OS installation has changed and whether users can configure new space into their existing drives without formatting their PCs.

2.3.6. Dual-Boot

Dual-boot systems allow a user to run more than one OS with no virtualization required. A single computer can share multiple operating systems but only one can be executed on the computer but not both at once. This is known as a dual boot system since you must boot up the computer with one OS or another. OSes are fully installed on a machine but on different partitions of a single hard drive or on separate hard drives. When the machine is booted, a user must choose which OS they intend to use. The chosen OS will start up. To change OSes, one would have to reboot the computer and select the other OS. With this solution, both OSes are fully functional, though the machine can only support one at a time.

Microsoft says that ***Windows 7*** can be installed on a computer that is already running ***Windows Vista*** in a dual-boot configuration [12]. However as previously mentioned each operating system must be installed on its own partition. Microsoft gives the following recommendations for setting up a dual boot:

- If a computer does not yet have an OS, one should partition the hard disk so each OS they want to install has a partition and then start by installing the oldest OS.
- Any programs and drivers that one needs to use must then be installed on each operating system that they want to use them in.

It is worth noting that some users prefer to use dual boot systems in order to harness the full power of their systems. Hence this functionality will be tested with ***Windows 7*** to find out how it handles dual boot with other Windows platforms as well as non Windows variants.

2.3.7. Virtualization

The use of dual boot systems comes with some major disadvantages. First, it is high maintenance since both Windows and Linux must be maintained on each machine. Second, it can be time consuming rebooting machines in order to change platforms. Furthermore imaging a number of computers can be a very time consuming task. A solution that can solve

dual boot problems described above is the use of virtual machines [17]. According to Necaise, "A virtual machine is an application program executed on top of one operating system that allows you to run a different OS simultaneously [17]." The virtual machine provides a user with a complete computer running inside a window on their desktop. The user gets complete network support, mouse and keyboard controls and access to disk drives and parallel ports. In effect, the virtual machine is a complete PC running as an application on top of a physical PC.

2.3.7.1. Virtualization in Windows 7

Windows Virtual PC is the latest Microsoft virtualization technology designed for ***Windows 7***. It is the runtime engine for *Windows XP Mode* to provide a virtual Windows environment for ***Windows 7***. With *Windows Virtual PC, Windows XP Mode* applications can be seen and accessed from a ***Windows 7*** desktop. According to Microsoft ***Windows 7*** delivers a richer experience when users are connected to a virtual desktop - much closer to the experience provided by a native Windows desktop. For example, ***Windows 7*** provides multi-monitor support, bi-directional audio to enable Voice over Internet Protocol (VoIP) and speech recognition applications, and access to local devices, such as printers [23].

Microsoft also claims that it is easy to setup a *Windows XP Mode* environment. They say that once the *Windows Virtual PC* and the virtual ***Windows XP*** environment are installed, Windows Virtual PC provides a simple wizard to set up *Windows XP Mode* with just a few clicks. Applications can then be installed in *Windows XP Mode* just as one would normally do on a physical PC. These applications can then be run directly from the ***Windows 7*** desktop, by just going to the Start menu [23].

Above are the claims made by Microsoft about how virtualization of ***Windows XP*** will be implemented to help counter the problem of software incompatibilities. This virtualization technology has been named *Windows Virtual PC*. Microsoft claims that software installed on a ***Windows XP*** virtual machine with ***Windows 7*** OS as the host OS will be directly accessible to the host. Microsoft says, "Users can launch and use their line of business applications installed in the *Windows XP Mode* directly from a ***Windows 7*** desktop, as if these are ***Windows 7*** capable applications [11]." This bold claim will be put to the test in this evaluation to find out whether these claims are true. Furthermore this virtualization extension/tool will be compared to existing tools such as VMware Virtual PC and Microsoft Virtual PC 2007 in order to find out which tool works best with the OS.

2.4. Conclusion

A variety of features exist in OSes that can be evaluated in order to give would be users an idea of how well the OS works in a real working environment. As discussed above the way in which an OS is evaluated depends on the availability of the source code. In the case of this research the “black box” approach will be used since the source code cannot be accessed. This means that a variety of tools (available online and those built into the OS) will be used to assess the functionality of ***Windows 7 Build 7100 RC***. However the internal functioning of the OS cannot be assessed.

CHAPTER 3. EDITIONS

3.1. Introduction

Development of ***Windows 7*** started in 2006, before the completion of its predecessor, ***Windows Vista***. Following the release of ***Windows Vista***, it was confirmed by Microsoft on July 20, 2007 that "the internal name for the next version of the Windows Client OS was ***Windows 7*** [5]. It was then announced on October 13, 2008, that ***Windows 7*** would be the official name of the new OS [4]. ***Windows 7*** will come in a variety of versions. Each version of ***Windows 7*** is specifically designed for particular kinds of users

3.2. Windows 7 Starter

This version is proposed to come without the *AERO* Glass Graphical User Interface (GUI). Microsoft says that ***Windows 7 Starter*** will be designed for users who have only basic computing requirements**.** ***Windows 7 Starter*** will be the only ***Windows 7*** version that will not have a 64-bit option. Microsoft had initially declared that ***Starter*** would limit a user to running three concurrent applications. However they eventually changed their minds due to user pressure as explained on page 17. ***Windows 7 Starter*** will not come with the so-called "easy networking" features that ***Home Premium*** will offer, or the multimedia codecs that ***Home Premium*** will include [6].

3.3. Windows 7 Home Basic

Windows 7 Home Basic, as presented by Microsoft will include: *live thumbnail previews*, an enhanced visual experience, advanced networking support (ad-hoc wireless networks and Internet connection sharing), as well as *Mobility Center* in addition to the features available in the ***Starter*** version [6]. Similar to the ***Starter*** edition ***Home Basic*** will not be privileged with Aero Glass Graphical User Interface and advanced Window navigation.

3.4. Windows Home Premium

In addition to the features available in ***Home Basic, Home Premium*** is proposed to come with support for: *AERO Glass* and *Advanced Windows Navigation*, easy networking sharing across PCs and devices, improved media format support, enhancements to *Windows Media Center* and media streaming as well as multi-touch and improved handwriting recognition. Furthermore ***Home Premium*** will play DVDs without the need to install additional software. However, Microsoft has not officially said anything about Blu-ray support in ***Windows 7***. Microsoft has also added support for a number of media codecs, including WMV, WMA,

MPEG-4 files, AAC and AVC/H.264 codecs. Microsoft has also added support for MPEG-2 Video and Dolby Digital Plus—but not in Windows Home Basic. That's another difference between the two [6]. ***Home Premium*** will have so called "premium" games as well as the capability to create home network groups.

3.5. Windows 7 Professional

Windows 7 Professional builds on ***Windows 7 Home Premium***, and adds the following features: ability to join a managed network with *Domain Join*, Remote Desktop host, better PC management with Group Policy, data protection with advanced network backup and Encrypting File System (EFS). Furthermore ***Professional*** provides access to some of the more advanced networking capabilities such as location-aware printing. ***Windows 7 Professional*** is recommended by Microsoft for small businesses [6].

3.6. Windows 7 Enterprise

Windows 7 Enterprise will only be available though volume licensing. The features that will be in the ***Enterprise*** version will also in be available in ***Windows 7 Ultimate***. Key features include: *BitLocker* data protection on internal and external drives, *DirectAccess* which provides seamless connectivity to your corporate network (this requires ***Windows Server 2008 R2***), *BranchCache* (also requires ***Windows Server 2008 R2***.) which reduces the time branch office workers have to wait to open files across the network as well as *AppLocker* which prevents unauthorized software from running. These features come in addition to those available in the ***Professional*** version [6].

3.7. Windows 7 Ultimate

According to Microsoft, all of the features in the other versions, both for business and consumer, are wrapped up in the ***Ultimate*** edition of ***Windows 7***. It is worth noting that Microsoft also said that ***Windows 7 Ultimate*** will have no extras attached to it as was the case with ***Windows Vista Ultimate*** [6]. This means that ***Windows 7 Ultimate*** will have no additional features that are unique to it as was the case with ***Vista.***

For a more detailed insight into the differences among the various ***Windows 7*** versions please refer to Appendix 1 (page 64).

Microsoft decided to drop the 3 application limitation on ***Windows 7 Starter***, the edition that is expected to ship on most netbooks. This would have blocked users from running more than three applications at the same time. Microsoft spokesman Brandon LeBlanc announced the

change saying that, “Based on the feedback we have received from partners and customers asking us to enable a richer small notebook PC experience with ***Windows 7 Starter*** ... we are going to enable ***Windows 7*** Starter customers the ability to run as many applications simultaneously as they would like, instead of being constricted to the 3 application limit of the previous Starter editions [9].”

This is evidence that Microsoft is trying to avoid the mistakes it made with ***Windows Vista***. They are really doing everything they can to remove any barrier to the windows 7 OS and by removing these barriers, they really are working to make as smooth a transition as possible into ***Windows 7***. Earlier editions of ***Windows XP Starter*** and ***Windows Vista*** Starter, both of which were sold only in a small number of markets outside the U.S., came with the 3 application restriction [7].

3.8. Conclusion

Microsoft expects that a majority of its customers will be best served by two primary versions of ***Windows 7***: ***Windows 7*** *Home Premium* for ordinary consumers and ***Windows 7*** *Professional* for businesses. Mike Ybarra, General Manager for Windows, in an interview said, “With ***Windows 7*** there will be two primary editions: ***Windows 7*** *Home Premium*, and ***Windows 7*** *Professional*. We think those two Stock Keeping Units (SKUs) will meet most customers’ needs. ***Windows 7*** *Home Premium* is the recommended choice for ordinary consumers. It gives them a full-function PC experience and a visually rich environment in everything from the way they experience entertainment to the way they connect their devices. ***Windows 7*** *Professional* is the recommended choice for small businesses and for people who work at home but have to operate in an IT-managed or business environment where security and productivity are critical. For those running *Windows Vista Business*, it will be a very logical move to ***Windows 7*** *Professional* [13].” Furthermore Ybarra said that they will continue to have an Enterprise edition for their enterprise customers. He also pointed out that this edition will not be available at retail or to Original Equipment Manufacturers (OEMs) for pre-installation on new PCs. Furthermore Ybarra is also reported to have pointed out that *Windows 7 Home Basic* will only be offered to emerging markets, to customers looking for an entry-point to the Windows experience on a full-size PC. He also confirmed that they will continue to offer Windows Starter edition, which will only be accessible pre-installed by an OEM.

CHAPTER 4. INSTALLATION ISSUES

4.1. Introduction

In this project most of the experiments that were conducted were done on a machine that was provided for this task (experimental machine). The machine has the following specifications:

- Intel Core 2 Quad processor (Q9400 - 2.66GHz, 6MB L2 cache)
- 4GB RAM
- 500GB SATA hard drive with 32MB cache
- DVD writer with LightScribe
- G45M Digital motherboard with 1GB network port
- DVI and VGA connector
- 256MB graphics with DirectX 10 support

It can be observed that most of the hardware on this machine surpasses the minimum requirements that were set by Microsoft in order to run ***Windows 7***. I did however get the opportunity to install the OS on a personal machine (Lenovo 3000 N200); one I would say has relatively average hardware specifications. The machine has the following specifications:

- Intel Celeron M 550 (2.0GHz)
- 2.5GB RAM
- 120GB SATA hard drive 5400rpm
- DVD±RW
- Intel X3100 motherboard
- 128MB shared graphics with DirectX 10 support

The hardware specifications on this machine also surpass the minimum requirement that were set by Microsoft to run ***Windows 7.*** However, the graphic card meets the exact minimum requirements.

4.2. System Requirements

The hardware requirements of ***Windows Vista*** were probably the most talked about points. Users complained about the system requirements that Microsoft put forward as the recommended system specifications required to run ***Vista***. Microsoft [23] officially announced that the minimum recommended specifications for ***Windows 7 RC*** are as follows:

- 1 GHz 32-bit or 64-bit processor

- 1 GB of system memory (RAM)
- 16 GB of available disk space
- support for DirectX 9 graphics with 128 MB memory (to enable the Authentic, Energetic, Reflective and Open (AERO) theme)
- DVD-R/W Drive
- Internet access (to download updates)

It is of interest to note that the ***Windows 7*** minimum hardware requirements are identical to those that caused a stir in ***Vista***. However, Oiaga Marius pointed out that this high demand for computing resources is no longer a serious issue as the prices of hardware have gone down in the last two years [18]. Furthermore he argues that current ***Vista*** users will not need any hardware upgrade in order to move up to ***Windows 7***.

4.2.1. Graphics

In order to run ***Home Premium, Business*** and ***Ultimate*** at their full potential, Microsoft has recommended a graphics card that has at least 128 MB of dedicated graphics memory and has to be DirectX 10 compatible. ***Home Basic*** and ***Starter*** however do not require this specification since they do not have the *AERO* desktop, and will work fine on any graphics card that is DirectX 10 compatible and has a minimum of 32 MB of memory.

4.3. User Interaction

When installing ***Windows XP***, the user is asked for numerous amounts of information. The user is requested to input the current date, current time, network information, etc at various points during the installation process such that if the user is not around the installation process does not complete. On the contrary ***Windows 7*** presents fewer prompts during installation and most parts of the installation run automatically. All required information is requested at the beginning of the installation and the system does not interact with the user until installation is complete. At installation start-up, there is the usual loading of files in preparation for the installation. The user is then prompted to choose the language of installation, time and currency format as well as the keyboard input method. Since the default language is English and US most users only need to accept and move forward. The next step then involves accepting the license agreement and selecting the partition on which they would like to install the operating system. The rest of the installation is then done without user intervention until the product key is requested.

Windows 7 does not make it compulsory to provide a product key before installation. Instead, you can simply continue to use the OS without supplying the product key. By doing this, one can run the OS until activation is required, 30 days after installation. After this period, ***Windows 7*** simply refuses to boot any user to their desktop until activation takes place.

4.4. System Configuration (Windows System Assessment Tool)

Windows 7 like **Windows *Vista*** boasts of the Windows System Assessment Tool or just WinSAT as it is commonly called. When **Windows *Vista*** is installed on a machine for the first time, a host of system assessments are done of the processor, system memory, graphics, video playback and system disks before the first user login. Similarly when ***Windows 7*** is installed on a machine for the first time, a variety of system assessments are done of the processor, system memory, graphics, gaming graphics and the primary hard disk before the first user login.

Figure 1 obtained from Russell (Windows Client Performance Development Manager) shows the WinSAT application programming interface (API):

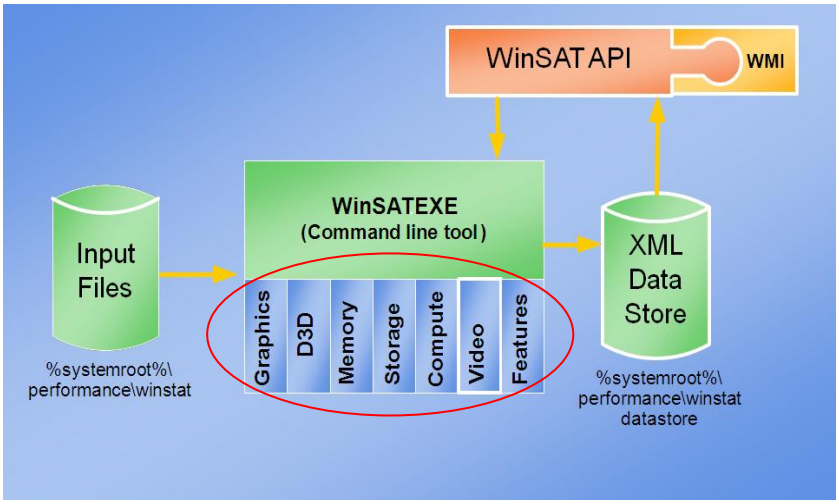

Figure 1 - WinSAT Application Programming Interface [19].

A Component Object Model (COM) is a binary interface standard for software used to enable inter-process communication and dynamic object creation in a variety of programming languages. According to Russell the WinSAT API is meant to provide a simple automated COM interface for languages such as Visual Basic, Javascript, HTML, XML and Powershell [19]. He further argues that it provides easy programmatic access to WinSAT and the data store as well as access to WinSAT via the Windows Management Instrumentation (WMI).

The components of the WinSAT API as presented by Russell are as follows:

- **Data store** – stores formal assessments done by WinSAT. Maintains results of the last 100 assessments and deletes the oldest as new assessments are performed. The initial assessment generated during "Out-of-Box Experience (OOBE)" is kept.
- **Graphics** – assesses a system's ability to run *Aero*. The assessment drives the hardware the same way the Desktop Window Manager (DWM) would. The results are then used by the DWM in making decisions about enabling *AERO*.
- **D3D** – designed to assess a system's ability to render 3D gaming graphics. The assessment concentrates on the shader arithmetic logic unit performance, shader texture load performance and post-pixel blend performance. This assessment is targeted at Pixel Shader 2.0 or better hardware.
- **Memory** – this assessment is focused on memory throughput and not latency, and is designed to assess how well large blocks of memory can be moved.
- **Storage** – this is a "sweep" test of the hard disk in which the physical disk is divided into regions, and evaluated for random read and write performance, and sequential read and write performance. Metrics in mega bytes per second are reported for each region, and an aggregated mean of all the regions is used as that hard disk's rating.
- **Compute (Processor assessment)** – is designed to assess a system's computational ability through the use of data compression and decompression algorithms, data encryption and decryption, as well as windows media encoding.
- **Video** – an assessment designed to assess a system's ability to play high definition Windows Media Video as well as for any other video format for which a codec is available on the system.

WinSAT in ***Vista*** rates each of the above mentioned hardware items on a scale from 1.0 to 5.9, with 1.0 being the lowest and 5.9 being the highest while WinSAT in ***Windows 7*** rates each of the above mentioned hardware on a scale from 1.0 to 7.9, with 1.0 also being the lowest and 7.9 being the highest. A final overall system score known as the windows experience index (WEI) or base score is then determined. This score is not an average of all the scores, but is the lowest score that is scored by any hardware component. This means, if every piece of hardware scores an individual rating of 5.0 except one, e.g. graphics scores 1.5, then the final overall system rating will be a score of 1.5 [16].

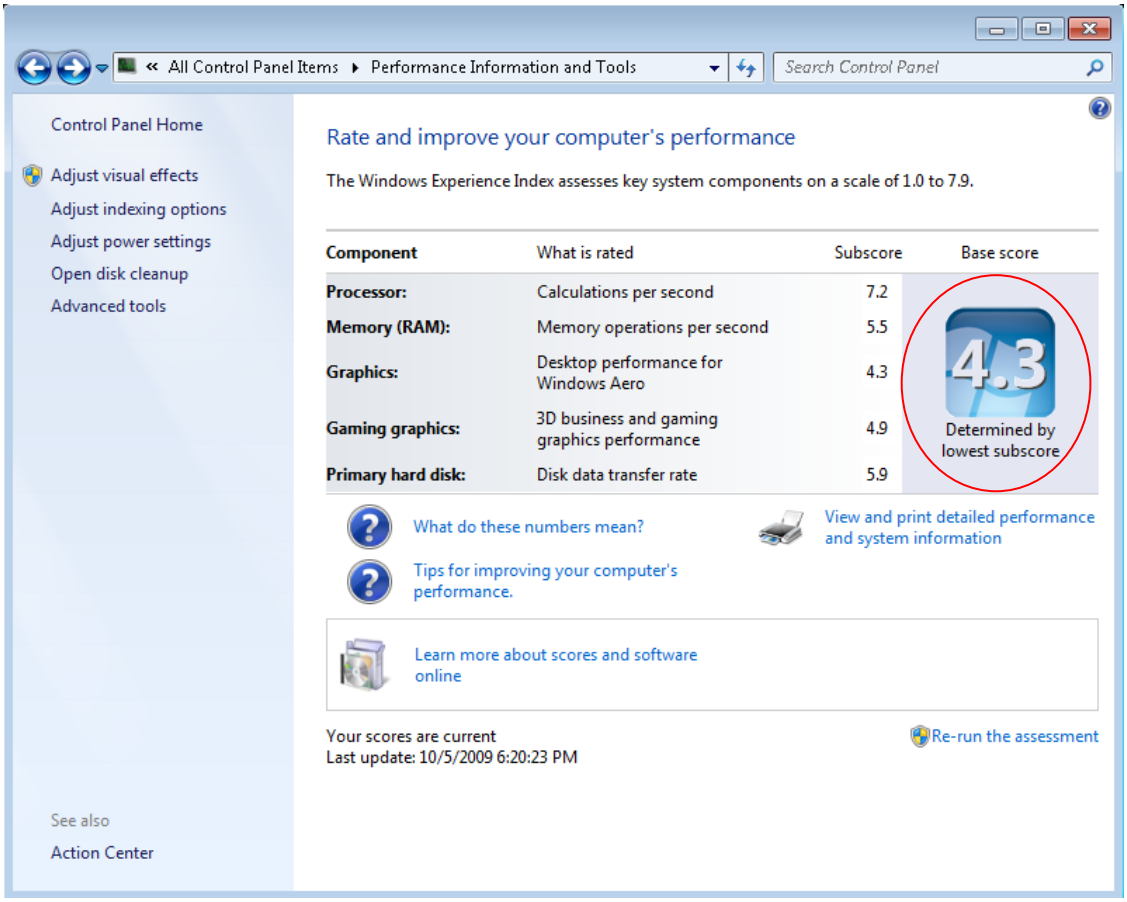

Figure 2 - Windows Experience Index Generated for the Experimental Machine

Figure 2 above shows the rating that was awarded to the experimental machine by the WinSAT. Since the Graphics scored the lowest rating, it serves as the overall system rating as earlier explained.

The results of each WinSAT assessment are saved for later access in the registry, as XML files on the local machine, and in a log file. The XML files are saved in a file called "%systemroot%\performance\winsat\datastore" where %systemroot% refers to the partition on which Windows is installed plus the Windows folder e.g. "C:\Windows". The XML file is more detailed than the log file and contains information about each assessment and the values that were attained from it. The log file contains details about which assessment was run and the end result of that assessment, either a success or a failure. The log file is logged at "%systemroot%\performance\winsat\winsat.log".

According to a presentation by Russell, WinSAT does not run automatically when a hardware or driver is upgraded or changed. In order for this automation to be possible, Russell mentions that the tool would require user account control (UAC) elevation, meaning more prompts for user consent. Russell mentions that since most users refuse the prompt for

elevation, running of the tool is left at the user's discretion. What has also been done is that independent hardware vendors have been asked to run the tool automatically during software installation. Since installation runs under elevation, WinSAT can be started and system assessment can take place after the software has been installed.

4.5. Conclusion

The system requirements of ***Windows 7*** can be said not to be very high. On average, most current PCs will meet the system processor requirements as the cost of hardware has gone down. Although there is a 1 GB RAM recommendation, ***Windows 7*** does run fine on 512 MB of RAM, only the *AERO* effect is lost. The installation process for ***XP*** is completely different from that of ***Windows 7***. There are less prompts in ***Windows 7***, the installation process is easier for novices to get through and most parts of it are done automatically. The graphical installation interface is a definite improvement in ***Windows 7***, and gives a much friendlier and less technical look to it. The WinSAT rating I found was quite harsh, but the log files generated are a great way for a user to monitor differences in hardware upgrades.

CHAPTER 5. FEATURES OF WINDOWS 7

5.1. Introduction

Windows 7 comes with a number of new features intended to make using the new OS simpler to use, faster and more secure. This chapter takes a look at some of these features and how they work.

5.2. Improved Taskbar and Full-Screen Previews

In ***Windows 7*** you can set the order in which the icons appear and they will stay in that order. They are easier to see because of their size. Hovering over these icons produces even bigger icons and clicking once on the new large icons or bigger preview thumbnails makes the window active. You can even see a full screen preview before switching to the window by hovering on the second order thumbnails [15].

5.3. Jump Lists

Jump Lists provide quick access to common tasks. The Jump List feature is a way to quickly reach the files you have recently been working with. To see the files you just right click on the icon on your taskbar or hover over the icon in the start menu. If there are other files you want to keep handy, you can just pin them to the Jump List [15].

5.4. New Ways to Work with Windows

Windows 7 simplifies how you work with the windows on your desktop. You'll have more intuitive ways to open, close, resize, and arrange them. You can drag open windows to screen borders, so you'll no longer have to click on tiny objects in the corner of a window to make it do what you want [15].

Maximize a window by dragging its border to the top of the screen, and return the window to its original size by dragging it away from the top of the screen. Drag the bottom border of a window to expand it vertically [15].

The contents of two windows can be compared by dragging the windows to opposite sides of the screen. As the cursor touches the edge, the window will resize to fill that half of the screen. The user just needs to drag their mouse to the lower right corner of their desktop in order to see all your desktop gadgets. This action will make all the open Windows transparent thus making the desktop and the gadgets on it, immediately visible.

5.5. Windows Live

With ***Windows 7***, some features previously included in the OS have been removed but are available for download through Windows Live Essentials which is a set of free applications available for your PC and supported by ***Windows 7***. Applications that can be downloaded include Windows Live Messenger, Photo Gallery, Mail, Writer, Movie Maker, and more [15].

With ***Windows 7***, you start with a clean desktop and get to decide how it looks. Microsoft provides templates, or themes from which one can choose a colour or format. This includes the option of using a slideshow as a desktop background. New theme packages include rich backgrounds, 16 glass colours, sound schemes, and screensavers. One can download new themes and create their own to share with friends and family [5].

5.6. Windows Touch

While great for a lot of tasks, using a keyboard and mouse is not always the easiest way to do things. With a touch screen or a touch-screen monitor, you can just touch your computer screen for a more direct and natural way to work. Use your fingers to scroll, resize windows, play media, and pan and zoom. Large touch-sensitive areas on the Start menu and the taskbar make it easy to use [15].

5.7. Handwriting Recognition Additions

Handwriting recognition has been improved in ***Windows 7***. Beginning with greater accuracy and speed, ***Windows 7*** improves pen input in several ways. You can write math expressions, create personalized custom dictionaries for handwriting recognition, and use the new languages supported in ***Windows 7***. You can also use the pen to just make a quick list [15].

5.8. Task Automation with Scripting

To help IT administrators better maintain a consistent environment and improve personal productivity, ***Windows 7*** includes an updated graphical scripting editor, Windows PowerShell 2.0 - a powerful, complete scripting language that supports branching, looping, functions, debugging, exception handling, and internationalization.

- PowerShell 2.0 has an intuitive, graphical user interface that helps make script generation easier, especially for administrators who are not comfortable in command-line environments.
- PowerShell 2.0 supports two types of remoting:

- Fan-out delivers management scripts on a one-to-many basis, and one-to-one interactive remoting to support troubleshooting of a specific machine
- One can also use the PowerShell Restricted Shell to limit commands and command parameters to system administrators, and to restrict scripts to those who have been granted rights.

- PowerShell 2.0, with the Group Policy Management Console (available as a separate download), allows IT professionals to use scripting to manage Group Policy Objects and to create or edit registry-based group policy settings in ***Windows 7***. Similarly, you can use PowerShell to configure PCs more efficiently, using richer logon, logoff, startup, and shutdown scripts that are executed through Group Policy [23].

5.9. Enhanced Troubleshooting Tools

Windows 7 provides rich tools to identify and resolve technical issues, often by the end users themselves. If a help desk call is unavoidable, ***Windows 7*** includes several features and troubleshooting tools to help speed resolution.

- The Problem Steps Recorder allows end users to reproduce and record their experience with an application failure, with each step recorded as a screen shot along with accompanying logs and software configuration data. A compressed file is then created that can be forwarded to support staff to help troubleshoot the problem.
- ***Windows 7*** includes a suite of troubleshooting packs, collections of PowerShell scripts, and related information that can be executed remotely by IT professionals from the command line, and controlled on the enterprise basis through Group Policy Settings.
- ***Windows 7*** also includes Unified Tracing to help identify and resolve network connectivity issues in a single tool. Unified Tracing collects event logs and captures packets across all layers of the networking stack, providing an integrated view into what's happening in the ***Windows 7*** networking stack and aiding analysis and problem resolution [23]

5.10. Conclusion

Windows 7 comes with a host of new features, most of which improve the general usability of the OS. Features such as Jump lists and Scripting can help to improve the speed of accessing programs, backing up documents and simplify routine tasks. Enhanced

troubleshooting tools such as the problem steps recorder allow users to easily explain their problems to technical staff thus improving the chances of getting back helpful feedback.

CHAPTER 6. SECURITY

6.1. Introduction

Many accounts have been reported about companies losing control over sensitive information be it when a computer is stolen or through hacking over the internet. To counter such problems Windows 7 comes with security features build into the OS. This chapter analyses the implementation of these features and evaluates their ease of use.

6.2. Bitlocker Drive Encryption

Bitlocker comes with an option that allows a user to encrypt the partition upon which the OS is installed. This feature requires that a Trusted Platform Module (TPM) 1.2 chip be present on the motherboard of the computer as explained in the section 2.3.2.1. Once a user chooses to encrypt their OS partition the computer boots off a 100MB partition that is created at installation and stores core OS files used solely for this purpose. This function was tested on my experimental machine and it failed to work highlighting the fact that a TPM could not be found on my machine. This led to further investigation upon which the following was discovered. ***Windows 7*** comes with hardware drivers packaged with it. As a result it was expected that the driver for the TPM chip would be installed automatically. When this was checked in the device manager it was observed that a driver for the TPM had been installed with details shown in the Figure 3 below:

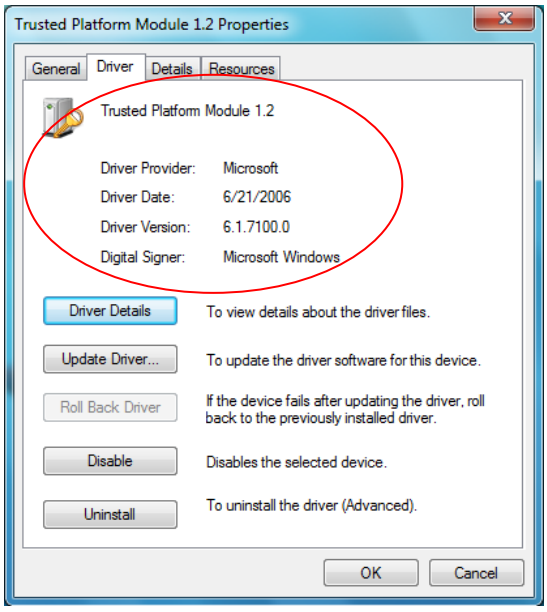

Figure 3 - TPM Driver Installed on Windows 7

However the device manager showed that the installed driver was not compatible with the hardware since it showed a yellow triangle with an exclamation mark as shown in the Figure 4 below. From Figure 3 the Driver date section shows that the TPM driver installed automatically by ***Windows 7*** was made in 2006. This coincides with the time that ***Windows Vista*** was being produced suggesting that the driver could have been made for ***Vista.*** It can therefore be inferred that the driver failed to work because it was designed for ***Vista***. An attempt to update the driver over the internet resulted in a message that said that the driver already installed on the computer was up to date.

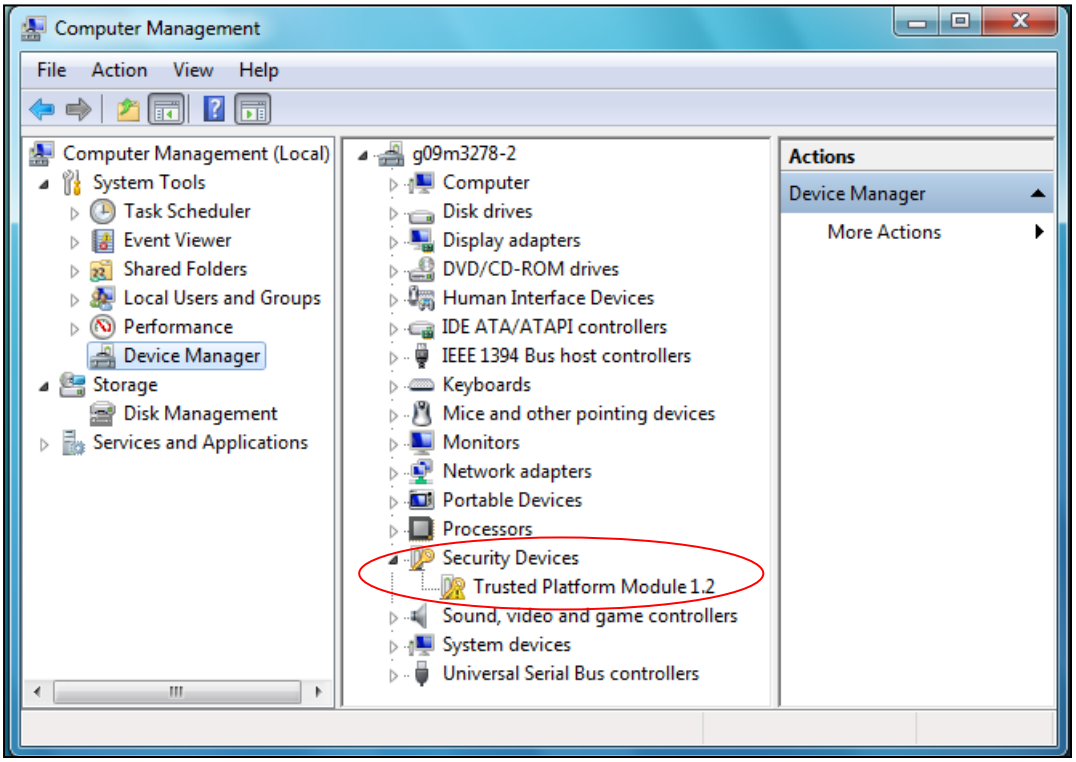

Figure 4 - Device Manager Showing that the TPM Driver is not Installed

As a result of these problems, a driver had to be sourced directly from the manufacturers of the chip, Intel. The driver that was made available on the Intel website did not install successfully and an error message showed that the software had failed to find a compatible TPM as shown in the Figure 5 below:

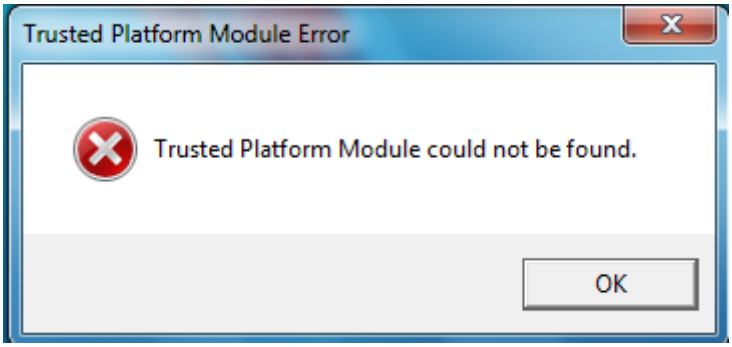

Figure 5 - Error Message Generated when Installing TPM Driver from Intel

It can be established from Figure 3 and Figure 4 that the computer that this technology was tested upon had a TPM 1.2 chip which meets the hardware requirement set by Microsoft. However, for some reason that could not be established the drivers could not identify with the hardware. This may mean that some users with this hardware available on their machines may not have access to some functions of *Bitlocker Drive Encryption*. Of concern is the fact that this TPM device is not yet available in most of the motherboards available on the market today but will be incorporated in most PCs in the near future. This means that most if not all users upgrading from ***Vista*** to ***Windows 7*** may not be able to utilise this security function. This issue was a real disappointment as Microsoft has used this technology as a selling point since the ***Vista*** era.

However, the *Bitlocker Drive Encryption* feature managed to work in all cases where the TPM chip was not required, for example, the rest of the partitions on the computer could be encrypted. Furthermore *Bitlocker To Go* which allows a user to encrypt external storage devices was tested on flash drives and was found to be very useful. The encrypted flash drives could also be used on ***XP*** based machines making it a portable feature.

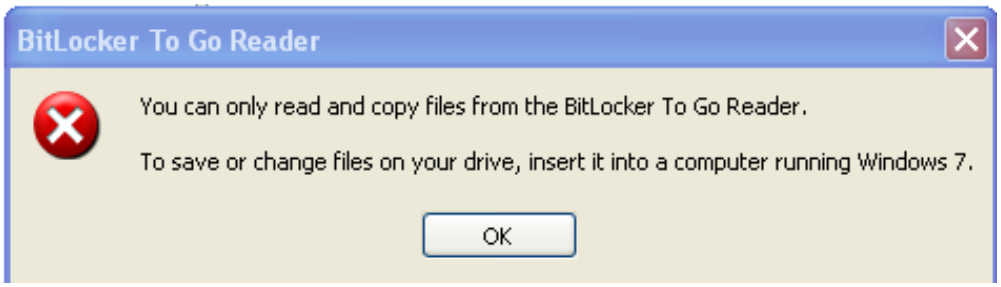

Figure 6 - Message to inform user that files on drive cannot be edited or changed

Like *Bitlocker Drive Encryption*, *Bitlocker To Go* did not live up to my expectations. One of the problems noticed was that one cannot copy files from a PC that is not running ***Windows 7*** to a device that was encrypted with *Bitlocker To Go* as shown in Figure 6 above. A user

cannot edit/change files stored in a device that was encrypted with *Bitlocker To Go* from a PC that is not running ***Windows 7***. Furthermore, if a user attempts to open any file by double clicking on it the *BitLocker To Go* Reader window, the user will be prompted to copy the file to the PC, as explained in Figure 7 below

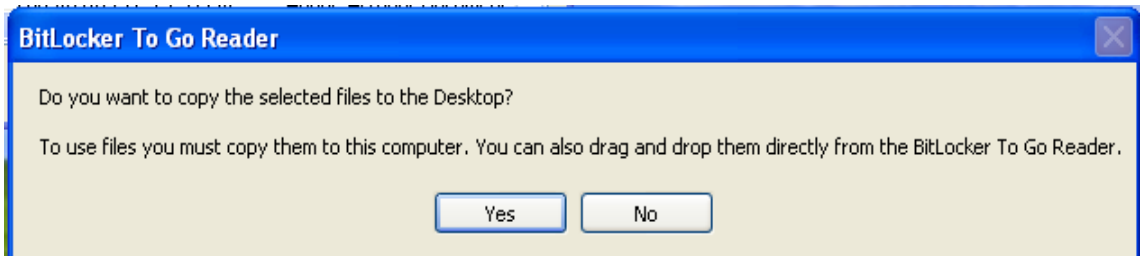

Figure 7 - Instruction to the user to copy files to computer before use

This means that one will not be able to open a file on any external drive encrypted using Bitlocker To Go without copying it to their PC.

6.3. User Account Control (UAC)

As earlier mentioned UAC has been one of the most debated, talked about and controversial technologies since it was first introduced in ***Windows Vista.*** It is one of the primary reasons why ***Windows Vista*** is not being used by administrators and companies as a desktop OS. In the case of end users, UAC has just been a source of annoyance. Despite this issue Microsoft has been using UAC as one of its selling points of ***Windows 7*** claiming that it provides increased security by limiting the potential damage that malware can do.

6.3.1. UAC Options with Windows 7

Windows 7 UAC implementation was evaluated and a discussion is given on how the user experienced the new UAC technology in ***Windows 7***. Microsoft introduced 4 levels to UAC which one moves through using a slider called the UAC slider. This was done in an effort to reduce the number of UAC security queries in ***Windows 7*** compared to ***Vista***.

The slider control allows a user or an administrator of the PC to control which level of UAC prompts and security will be implemented. The slider also serves to control which application types will cause a prompt and which ones will be allowed to elevate without a prompt. This can be established in the descriptions of the four different slider settings below.

The different levels are defined as follows:

1. Always notify me when:

- Programs try to install software or make changes to my computer
- I make changes to windows settings

A UAC prompt will result when any system-level change is made (Windows settings, software installation, etc.). This is the default setting for any standard user account that is created.

This setting is recommended if you routinely install new software and visit unfamiliar websites.

2. Notify me only when:
   - Programs try to make changes to my computer.
   - Do not notify me when I make changes to windows settings.

   This is the default setting when you do a fresh installation as shown in Figure 8 below. This setting does not prompt when you change Windows settings, such as control panel and administration tasks. This setting is recommended if you use familiar programs and visit familiar websites.

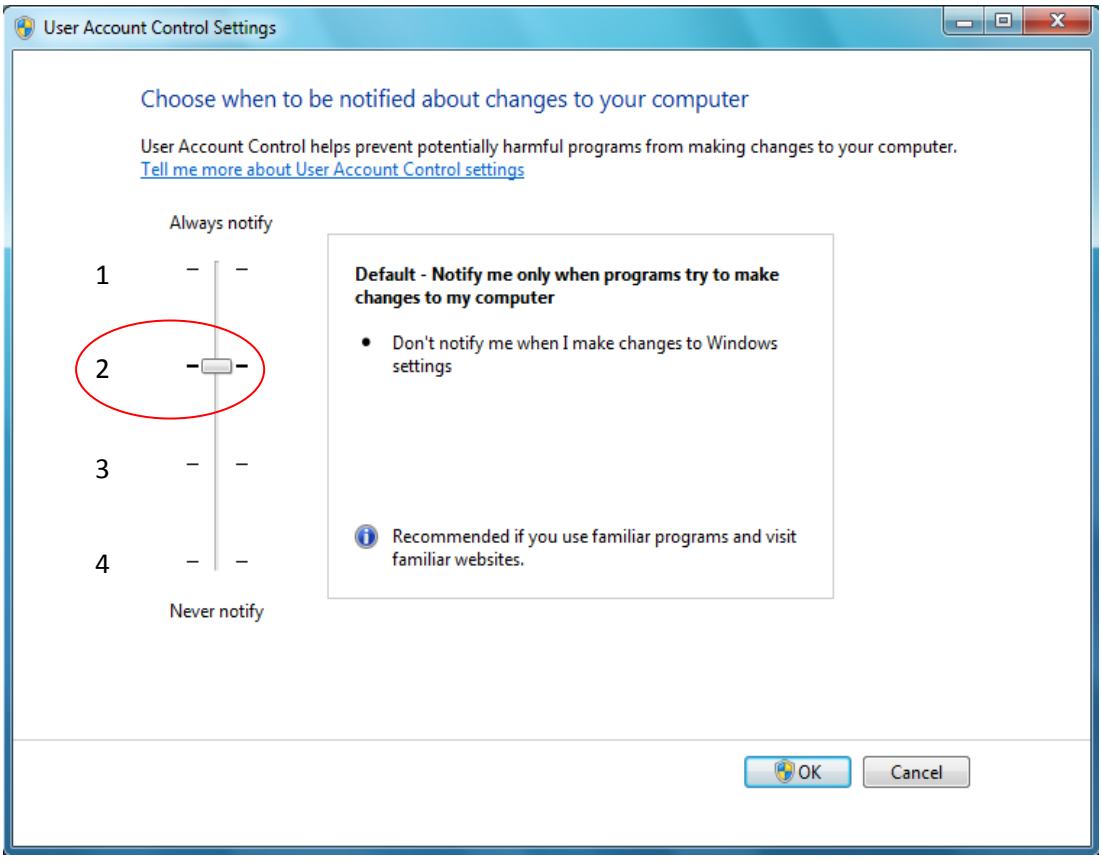

Figure 8 - Default UAC Setting for an Administrative Account

3. Notify me only when:
   - Programs try to make changes to my computer (do not dim my desktop).

This is the same as setting 2, but the UAC prompt appears on the normal desktop instead of the *Secure Desktop*. While this is useful for certain video drivers which make the desktop switch slowly (graphics respond slowly when moving from one GUI to another), the *Secure Desktop* is a barrier to software that might try to spoof your response.

This setting is not recommended and should only be chosen only if it takes a long time to dim the desktop on your computer.

4. Never notify me when:
    - Programs try to install software or make changes to my computer
    - I make changes to windows settings

    This turns off UAC altogether.

    This setting is not recommended and should only be chosen if you need to use programs that are not certified for ***Windows 7*** because they do not support UAC.

6.3.2. Evaluative Comment

Assessing the slider settings it is evident that the most secure setting is level 1 as it notifies the user of any changes made to the system by the user or software. With ***Windows 7*** you will have a slider to control whether you have a ***Windows Vista*** type UAC prompt environment or non-prompting environment. The most secure setting (level 1) may be annoying, but it is very secure. Users who get frustrated with UAC prompts should not have administrative rights on any machine running ***Windows Vista*** or ***Windows 7***. Turning down the slider to a lower security level basically reduces the protection in a ***Windows 7*** PC to the level of that available in a PC running ***Windows XP***, which is less secure.

UAC in ***Windows 7 RC*** is a wonderful technology for people who understand what the prompts mean, such as administrators. A problem that UAC faces and one that does not seem to have a good solution is that most Windows users do a lot of administration duties that they do not understand. Users are faced with all sorts of dialogs they do not understand but then just accept them because they want to get on with what they are doing. Since users are the ones with the administrative rights they use them without understanding what the consequence is. As a result the usefulness of UAC comes under fire. The question becomes whether UAC is really serving its purpose or it is just a source of annoyance for the ordinary user.

Furthermore many users do not understand trust. There are so many professional looking sites that appear to give you good software and more often than not they look better than genuine sites. Most users would therefore be better off if they only downloaded from safe, verified sources of software and plugins. The repository model like the one used for Linux operating systems would be much better for users.

The default setting for a standard user account is level 1. It was interesting to note that a user can only move the slider to level 2 and not lower than that level. If one tries to lower the UAC slider below level 2 a notification pops up notifying the user that they should be logged in as administrator in order to select the setting. Generally in a standard account one can move up or down between level 1 and level 2 but not lower than level 2. This setting ensures that if any system changes are to be made from within a user account administrative permission will have to be sought before these changes are effected.

6.4. Conclusion

Windows 7 is more secure than ***Windows XP*** due to the benefits that UAC provides. If one decides to disable UAC, the PC is not much better off than one running ***Windows XP***. This means that if one runs ***Windows 7*** in any mode other than the most secure UAC mode, they are working with the same security as that in ***Windows XP***. ***Windows 7*** also comes with features such as *Bitlocker Drive Encryption* and *Bitlocker To Go* both of which require technologies that are not available on ordinary PCs thus making them inaccessible to most users.

CHAPTER 7. VIRTUALISATION

7.1. Introduction

Windows Virtual PC is the latest Microsoft virtualization technology designed for *Windows 7*. With *Windows Virtual PC, Windows XP Mode* applications can be seen and accessed from a *Windows 7* desktop. These are some of the claims made by Microsoft about how virtualization of *Windows XP* will be implemented to help counter the problem of software incompatibilities. This chapter aims to evaluate this feature in order to validate to find out whether the claims put forward are true.

7.2. Windows 7 XP Mode

Despite its age, ***Windows XP*** is still widely used for several reasons the leading ones being speed and compatibility [31]. ***Windows 7*** will include a special *XP Mode* as a feature or as an application that can be installed. This feature will allow users to run ***XP*** in a virtual environment inside ***Windows 7*** to ensure maximum application compatibility. Users of ***Windows 7 Professional, Ultimate and Enterprise*** will be able to download and install the *XP Mode* feature that will allow them to run a virtualized copy of ***XP SP3***. Microsoft will include a full license of ***Windows XP SP3*** with every copy of ***Windows 7 Professional, Enterprise*** and ***Ultimate*** to be used with *XP Mode*.

However, to run *XP Mode* one will need a PC that has the following minimum hardware specifications:

- 1 GHz 32bit or 64bit processor or better
- CPU with AMD-VTM or Intel® VT features turned on (supports for chip level virtualization)
- 2 GB of memory recommended
- Additional 15GB of hard disk space per virtual Windows environment is also recommended

These are additional requirements above and beyond the requirements of the ***Windows 7*** OS itself. From the above stated minimum requirements it can be established that a PC is required to support chip level/hardware based virtualization in order to support *XP Mode*. Chip level/hardware based virtualization is a technology that is found in recent processors. Some processors have it and some do not and it is not easy to tell if your CPU supports chip-level virtualization or not. One also needs to have the chip level virtualisation switched on in

the BIOS. Most of the users are not familiar with the system BIOS which means they may need to refer to the manufacturer's manual for guidance on how to carry out this process. This can be very frustrating for most users. However, both Intel and AMD have tools that can help one to figure out what their CPU is capable of. The software is listed below respectively.

- Intel Processor Identification Utility
- AMD Virtualization Compatibility Check Utility

The Intel Processor Identification Utility was tried out in order to verify that my CPU supports chip-level virtualization and here is Intel's utility in action:

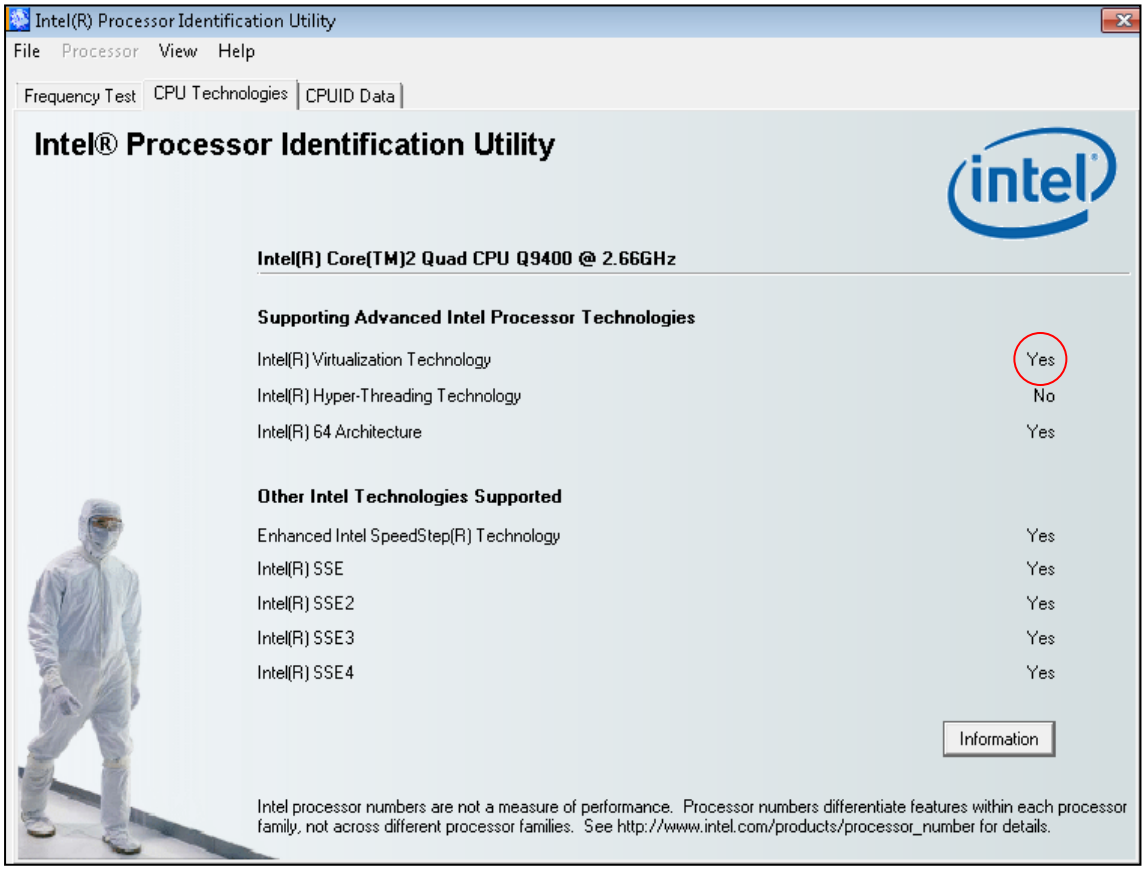

Figure 9 - The Intel Processor Identification Utility in Action

As can be observed from the Figure 9 above that my CPU does support chip-level virtualization. This implies that it has the capability to run *Windows XP Mode*. *XP Mode* is handy technology, as long as you have a PC that can run it.

XP Mode consists of two things, the Windows Virtual PC engine and a licensed copy of ***Windows XP Service Pack 3***. One of the observed benefits of *XP Mode* over existing virtualization products such as Microsoft Virtual PC 2007 is the fact that, after a setup process, the ***Windows XP*** virtual machine runs in the background so users do not have to

manage multiple desktops. Furthermore *XP Mode* automatically installs shortcuts for ***XP*** programs in the ***Windows 7*** start menu for software that is installed inside the virtual machine. When you run software from the ***Windows 7*** start menu that has been installed in the *XP Mode* virtual machine the virtual machine is started automatically.

It should be understood that like any virtual machine, *XP Mode* is not a security solution and users are recommended to protect their systems. This means that users will need to install antivirus software on their ***Windows 7*** desktop as well as on their ***Windows XP*** virtual machine. This also includes other operating system maintenance practices such as downloading updates. The ***Windows XP*** OS running inside the virtual environment notifies the user when updates become available if it is connected to the internet and if the automatic updates option is set. Warnings also pop up if antivirus software is not installed and if there are any other security issues. This means that the user is expected to maintain two operating systems, something that users may find appalling.

Note: When ***Windows 7*** installs updates automatically in the absence of the user it restarts and does not maintain the state of affairs that were there before it restarted. As a result if you leave any windows open with unsaved information in them the information will be lost.

7.3. Conclusion

Like *Bitlocker* drive encryption *Windows XP Mode* requires special hardware support to be available in the processor in order to run. This makes the feature unusable to users who have PCs that do not meet this condition. Furthermore XP Mode will only be able to function in the three highest editions of Windows 7 further depriving users of its convenience. XP Mode also increases the hardware requirements that are needed in order to run Windows 7 a situation that may make some users uncomfortable.

CHAPTER 8. APPLICATION COMPATIBILITY TESTS

8.1. Introduction

The compatibility tests take a look at some applications used and what problems were encountered whilst using these applications, if any. This attribute was tested in various ways including installation of software such as *Application servers* and *Integrated Development Environments (IDEs)* on a new ***Windows 7*** installation to find out whether the software would install. Microsoft products such as *MS Office 2003* and *2007* were also tested to find out whether they would run smoothly on the new platform as well as verify whether one of the two is superior. Tests were also done using highly graphical games such as *Pro Evolution Soccer 2008* and *Need for Speed Underground* in order to find out how well ***Windows 7*** manages its graphics usage.

8.2. Successfully Installed Software

A variety of classes of software were installed on the experimental machine and run for 4 months to test their stability on the new platform. A full list of the software that installed successfully and managed to run for the full 4 months without any problems is given in Appendix 4 (page 76).

8.3. Failed Installations and Malfunctioning Software

Some software failed to install at all while some installed but failed to run correctly. Among these software is:

- Need For Speed Hot Pursuit II which had problems with graphics on both OSes. Since both OSes could not run the game display effects efficiently this problem could be a result of the graphics card. This can be inferred from the fact that this game could work efficiently on the personal machine (Lenovo laptop) which had less graphics memory available to it.
- JBoss Application Server also installed successfully but failed to run when started giving a long string of errors.
- ProEvolution Soccer 2009 installed successfully but experienced a graphics problem on ***Windows 7*** machine. An error was displayed when the game started that indicated that the computer only had 64MB of graphic memory available on the graphic card which was less than the minimum requirement of 128MB. However the game could

be started and played but had a poor image quality as compared to that on the XP machine.

- All versions of Daemon Tools tried (4.0.3, 4.0.6 and 4.8.0.0) failed at installation and caused the computer to crash and perform repair at start-up.

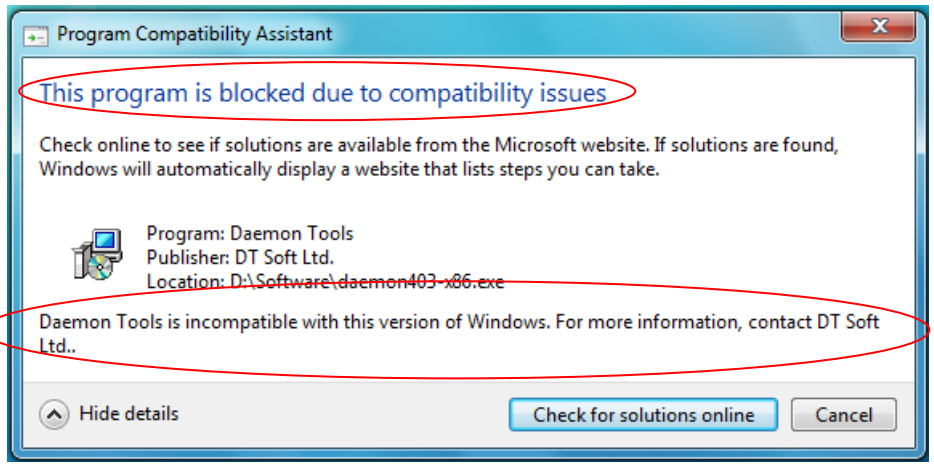

Figure 10 - Daemon Tools failed to install with due to a compatibility error

Figure 10 above shows the error message that is generated when one tries to install a version of Daemon tools on ***Windows 7***. It is interesting to note that Windows notifies the user that the program is blocked due to compatibility issues. This may imply that the program will not install because it is not allowed to do so by the OS. Further down in Figure 10 the OS further emphasizes the fact that Daemon Tools is incompatible with it and that the user needs to contact the developers of the software. This may mean that the developers of the software did not make their software compatible with ***Windows 7*** thus the software is untrusted or there is a later version of the software being produced that is compatible with ***Windows 7***.

- Nero 7 also failed during installation and Figure 11 below shows the error message that was generated. The error message generated when Nero fails to install draws the attention of the assessor in that it highlights that the program has known compatibility issues. This may imply that the developer is aware of the fact that the software does not work with a particular OS and that a fix is available or a compatible version is available.

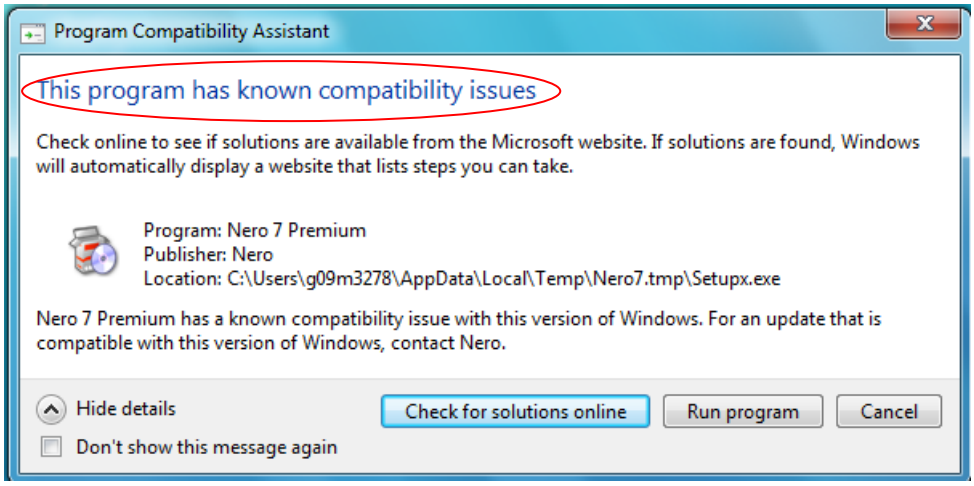

Figure 11 - Nero 7.00.2421 failed to install with a known compatibility issue error

8.4. Conclusion

Windows 7 does have problems with some of the old software and requires patches or new versions when there are incompatibilities. Some drivers that it installs for hardware are either outdated or do not work at all thus needing updates. Most of the software installed worked fine and some of the compatibility issues may be blamed on the developers of the software who fail to follow the standards laid down by Microsoft. This may mean that software may request privileges that the OS is designed not to grant which results in the software failing to run or install.

CHAPTER 9. PERFORMANCE TESTS

9.1. Introduction

Many claims have been made about improvements that have been made on ***Windows 7*** since the ***XP*** era and the ill fated ***Vista*** era. ***Windows 7*** is said to install easier and faster than its predecessors as well as perform better. A number of questions remain unanswered on how well ***Windows 7*** performs in real world tests. This assessment sought to validate some of these claims and answer some of the questions that have been raised about ***Windows 7*** by running some tests on the OSes and comparing the results.

Some of the tests that were carried out on ***XP*** and ***Windows 7*** were:

- How long does each operating system take to install?

  The amount of time saved during installation can be valuable in cases where installations are done on various models of computers. In this case a single install image cannot be used since the hardware settings of the computers will be different.
- How long does boot up and shutdown take?

  Users have always found it frustrating to wait for a computer to boot when they want to carry out a task. As a result reducing the amount of time it takes to get to a working desktop helps to reduce the amount of frustration that users experience when they need to perform a task urgently. This therefore makes comparing the amount of time it takes for a computer to get to a working desktop an important aspect of evaluating an OS.

  Shutdown time is a very important aspect of any OS in terms of delivering protection/security. If a user or an administrator discovers that their machine is being compromised shutting it down in the shortest period of time can help to reduce the amount of damage that malware can cause or can help to reduce the amount of information that a hacker can retrieve. This fact among others makes measuring the amount of time an OS takes to shutdown a crucial aspect.
- How well does each OS score in the PerformanceTest benchmark?

9.2. Testing Conditions

- The same computer hardware was used for all tests
- Both OSes were installed fresh

- These results reflect what you get when you install a plain OS without any tweaks or configuration changes (standard install) like most users do.
- Install time was measured from the moment the option to boot from CD/DVD was chosen until the point where the desktop was reached.
- The ***Windows 7*** version used is the open RC version that Microsoft issued in May 2009.
- Each OS was updated with all available patches before any tests were performed.
- ***Windows 7*** has technology to increase the speed of the system over time as it learns to cache programs intelligently. It also allows users to use flash drives to act as temporary storage to boost speed further. None of the tests that were carried out are likely to show these technologies in action, so please take this into account when reading the results.
- The file system, boot, shutdown and performance benchmarking were performed 5 times on each OS then the results were averaged.

9.3. Installation Time

9.3.1. Setup

Three measurements were taken for each OS and the average time that it took to install each OS was calculated. Install time was measured from the moment the option to boot from CD/DVD was chosen until the point where the desktop reached.

9.3.2. Results

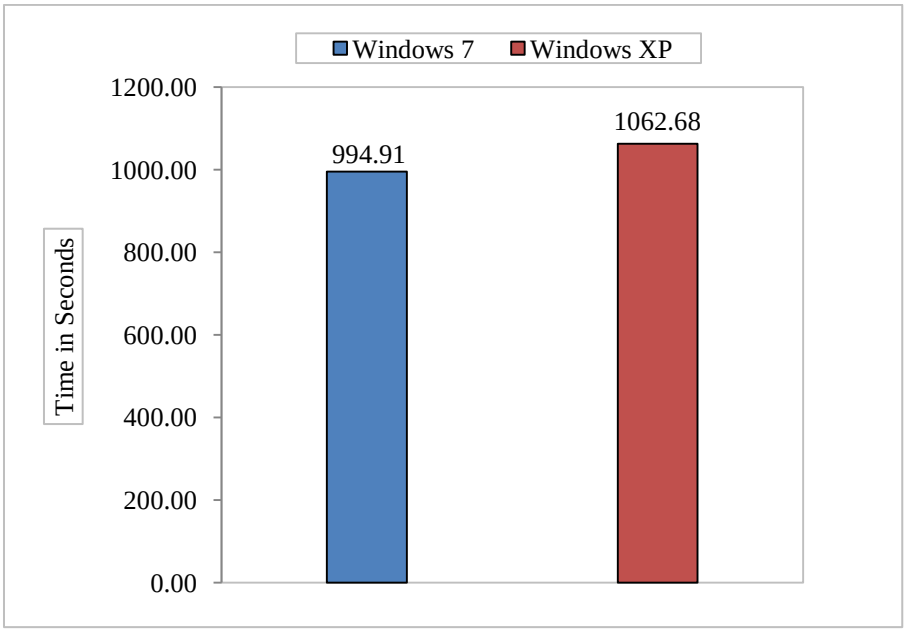

Figure 12 - Average Installation Time for Windows XP and Windows 7

9.3.2. Evaluative Comment

Table 2 below shows the measured installation times for each OS for each of the 3 installations done.

	Windows 7 Installation Time (seconds)	Windows XP Installation Time (seconds)
First Installation	1008.46	1069.57
Second Installation	992.78	1049.86
Third Installation	983.49	1068.62

Table 2 - Installation Times for Windows XP and Windows 7

The average installation times for each OS are shown in Figure 12 above. At first glance, Figure 12 above shows that ***Windows 7*** installs faster than ***Windows XP***. The difference between the installation times is about 67.77 seconds. While this is true there is also an important factor that needs to be considered, that is, ***Windows 7*** runs system benchmarks part way through the installation process to determine the computer's capabilities. This fact may imply that ***Windows 7*** could have scored an even faster installation time than ***XP*** had it not been for this benchmark. Furthermore ***Windows 7*** installs drivers during the installation process, another factor that makes ***Windows 7*** installation slower. However the fact that drivers are installed automatically makes ***Windows 7*** installation easier for novice users.

9.4. Boot Time and Shutdown Time

9.4.1. Setup

Firstly the times to get to the logon screen, times to get to a working desktop and the shutdown times were measured in seconds for each OS without any applications installed. The times to get to the logon screen and times to get to a working desktop were measured using software called BootRacer and the shutdown times were measured using a stopwatch. The same experiments were repeated with each OS running 16 applications. For each experimental setting, 5 tests were conducted.

9.4.2. Results

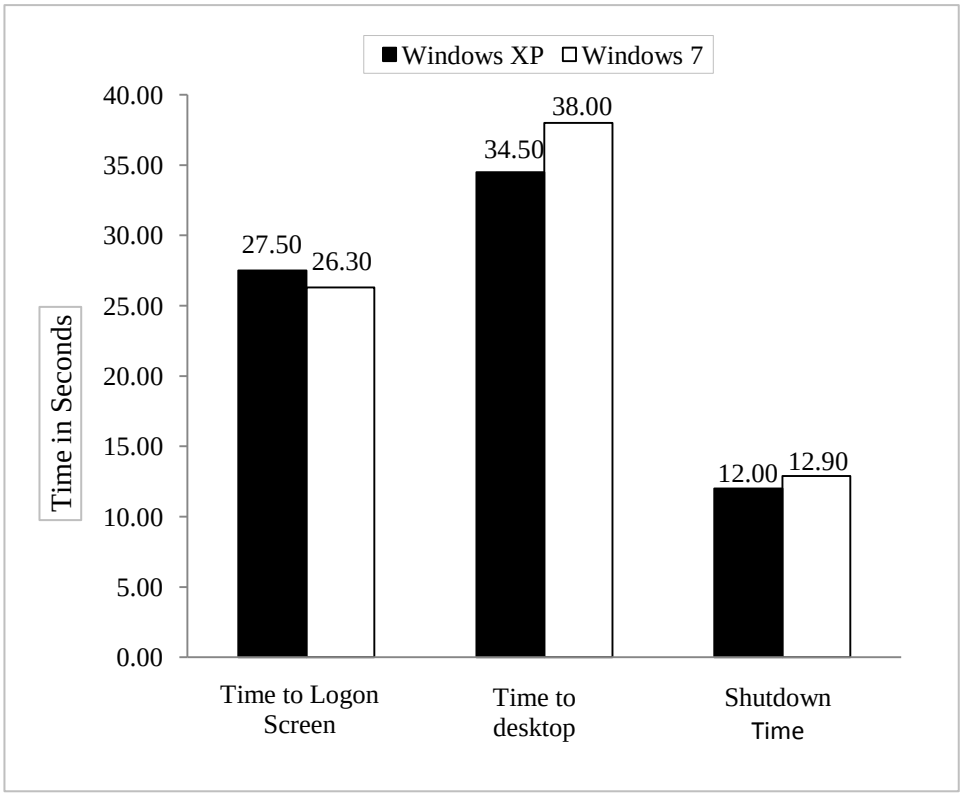

Figure 13 - Average Start-up and Shutdown times for Windows XP and Windows 7

9.4.3. Evaluative Comment

The detailed start up and shutdown times that ***Windows XP*** and ***Windows 7*** scored during testing are shown in Appendix 2 (page 67). Both OSes took the same amount of time to get to the logon screen without any applications installed while ***Windows 7*** took longer to get to the logon screen than ***XP*** with 16 applications installed. In the time to desktop and shutdown time tests ***XP*** outplays ***Windows 7*** in all tests conducted both with and without applications. However the difference between the times is not that significant for the average shutdown times with no applications installed (the difference is only 0.37 seconds).

The overall averages (average of the 10 results with applications installed and without any applications installed) for the times to get to the logon screen, times to get to a working desktop and the shutdown times were then calculated. The results obtained are summarized in Figure 13 above and it is evident that overall ***Windows 7*** takes a shorter time than ***Windows XP*** to get to the logon screen but ***XP*** takes less time to get to a working desktop. Users do not like to wait too long for a computer to become useable. The 3.5 seconds difference between the ***Windows 7*** times to working desktop and ***XP's*** times may not easily be noticed by users since ***Windows 7*** has a 1.2 seconds advantage in the time to logon screen. Figure 13 also shows that ***XP*** shuts down slightly faster than ***Windows 7*** by about 0.9 seconds**.**

9.5. Performance Benchmarking

Passmark PerformanceTest version 7.0 was used to benchmark ***Windows XP*** and ***Windows 7 RC***. Passmark PerformanceTest version 7.0 was chosen because it is recommended by reputable companies such as VMware. Furthermore it hosts a number of test suites each of which contains a number of different tests designed to measure specific aspects of a computer system. The **CPU test suite** is designed to measure CPU operations, **2D Graphics test suite** tests the standard of 2D graphical functions, **3D Graphics test suite** tests the *DirectX 3D* graphics system, **Disk test suite** is designed to measure the rate at which files are read from and written to disk, and lastly the **CD/DVD test suite** measures CD read speed. These tests were performed on ***Windows 7*** as well as on ***Windows XP*** and the results of each test are presented comparatively in the graphs below using particular units of measurement. The y axes of these graphs have no units because the units of measurement for each test within each suite differ. The following graphs show the average value that each operating system scored for the 5 runs of the performance test. The detailed figures of what each OS scored in each run can be viewed in the Appendix 3 (pages 68 – 75).

9.5.1. CPU Tests

The CPU test suite of Passmark PerformanceTest hosts a variety of CPU tests that are designed to exercise the processor subsystem of the computer. From within the CPU Test suite the following tests were carried out on the two OSes being compared:

- **Integer** – performs 32bit and 64bit addition, subtraction, multiplication and division (Millions of operations per second).

- **Floating Point** – carries out single precision floating point 32bit and 64bit addition, subtraction, multiplication and division (Millions of operations per second).
- **Find Prime numbers** (Thousands of Primes per second).
- **Compression** (Kilobytes Processed per second).
- **Physics** - uses the Tokamak Physics Engine (Frames per second).
- **Random String Sorting** (Thousand Strings per second).

9.5.1.1. Setup

Windows XP and ***Windows 7*** were installed in a dual boot setup with each OS allocated a 100GB partition. The dual boot setup ensured that both OSes had access to exactly the same hardware setup in exactly the same way. The above tests were run 5 times for each OS and a reboot was done after each test to make sure that the results were not affected by any caching. The average of what each OS scored in each test was then calculated and the results were plotted into a bar graph.

9.5.1.2. Results

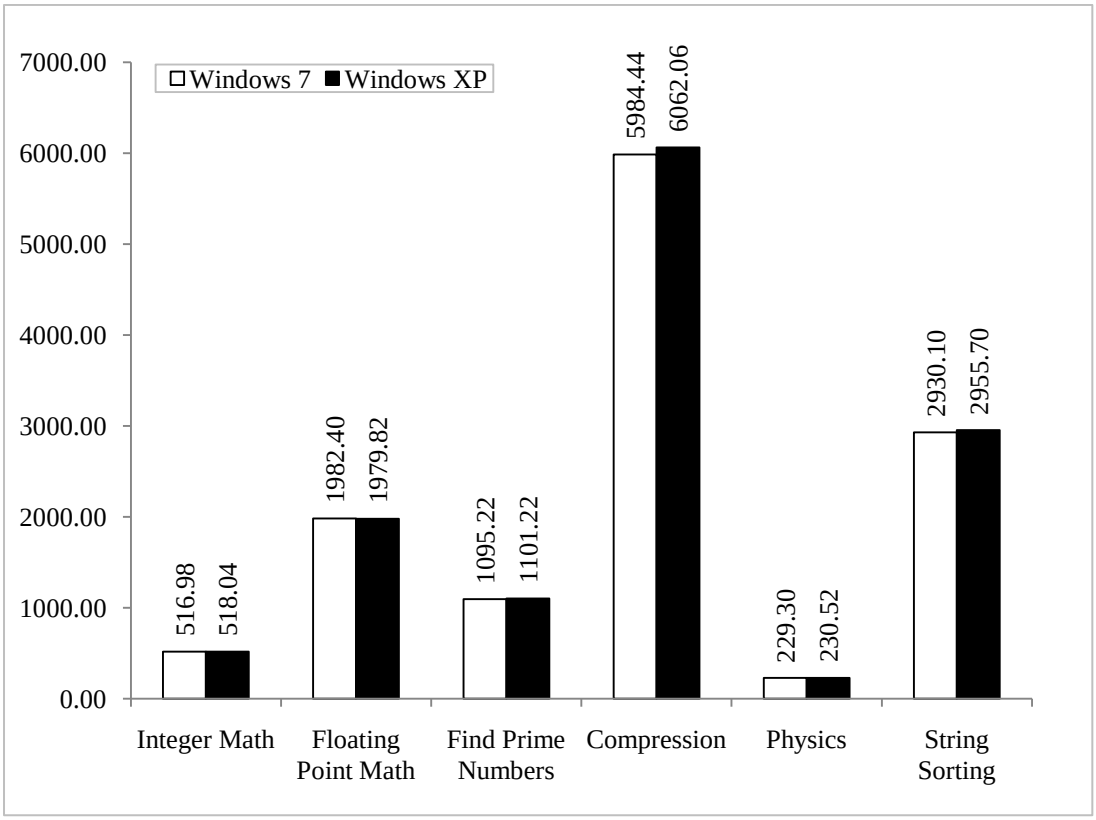

Figure 14 - CPU Tests Conducted on Windows 7 and Windows XP

9.5.1.3. Evaluative Comment

The averages calculated from results obtained for the 5 runs that were done on ***XP*** and ***Windows 7*** are summarized in Figure 14 above. It is evident that ***XP*** did perform better than ***Windows 7*** in all the CPU tests that were carried out. The most significant difference can be seen in the compression test where ***XP*** manages to compress 77.62KB of information more than ***Windows 7***. However the differences in the other CPU tests are not very significant, for example, there is a 1.22 frames per second difference in the physics tests which one would barely notice and 0.2% difference between the integer math figures. These differences may imply that given the same hardware ***XP*** will outperform ***Windows 7*** in terms of speed of carrying out instructions if we consider that these differences are calculated per second. However these marginal differences in instruction cycles may not be noticed by an end user.

9.5.2. Memory Tests

The memory test suite of Passmark PerformanceTest version 7.0 was used to perform memory tests on ***XP*** and ***Windows 7***. This suite contains a number of tests that exercise the memory subsystem of the computer. All tests use a combination of 32bit and 64bit data when reading or writing from or to RAM. The suite performs the following five tests on system memory:

- **Cached –** measures the time taken to read a small chunk of memory small enough to be held in cache (Megabytes transferred per second).
- **Uncached –** measures the time taken to read a large block of memory too big to store in cache (Megabytes transferred per second).
- **Write –** measures the time taken to write information to memory (Megabytes transferred per second).
- **Allocate small block** – this measures the time taken to allocate and free small zeroed memory blocks around 100KB in size (Megabytes transferred per second).
- **Large RAM –** measures the time taken to allocate large amounts of RAM and the time taken to read this RAM (Operations per second)

9.5.2.1. Setup

Five runs were also carried out for each OS in the memory tests and the computer was rebooted after each run as in the CPU tests. The results for each test were also averaged and presented in a bar graph - see Figure 13 below.

9.5.2.2. Results

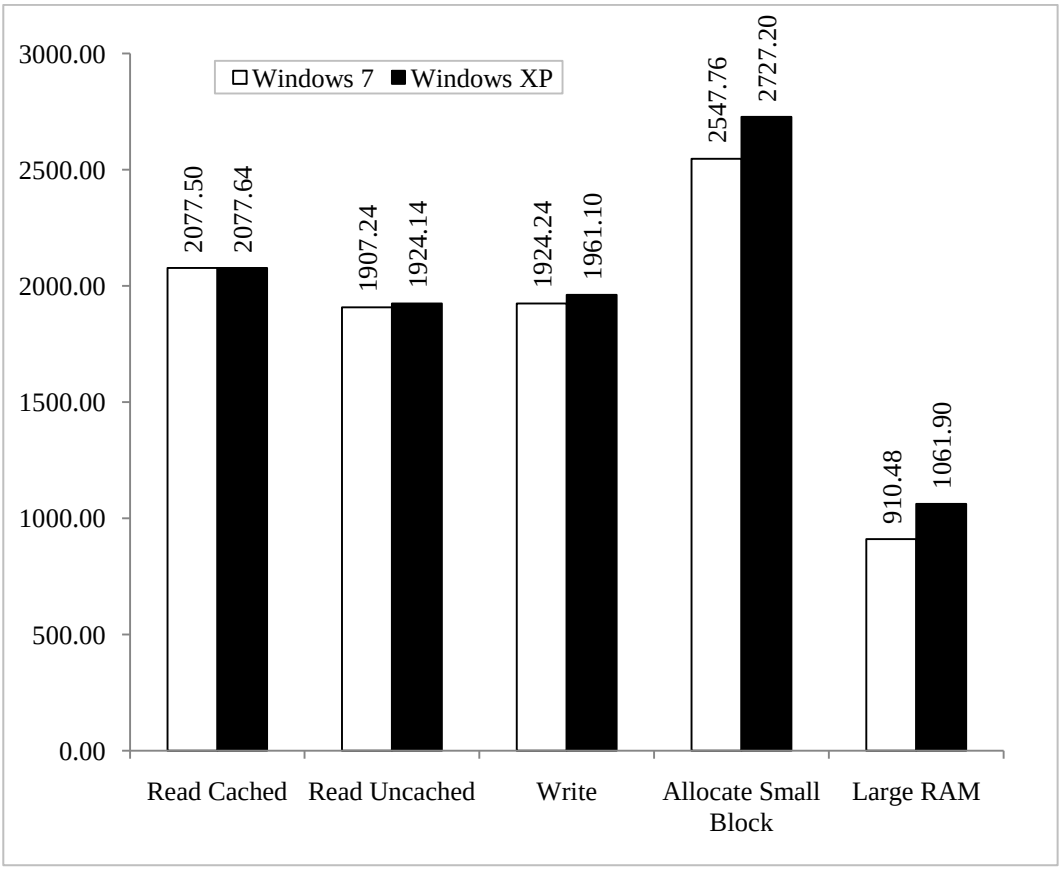

Figure 15 - Memory Tests Conducted on Windows 7 and Windows XP

9.5.2.3. Evaluative Comment

From Figure 15 above ***XP*** outperforms ***Windows 7*** in all the memory tests conducted. This may mean that memory management in ***XP*** is better than ***Windows 7*** since the test program is able to read and write to and from memory faster on ***XP*** than on ***Windows 7***. It is interesting to note that there is a very slight difference between the amounts of data transferred per second by both OSes when they read small chunks of memory held in the cache but there is a significant difference when they read large blocks of memory that are too big to be held in the cache. This pattern should be expected since the OSes use the same amount of cache when executing memory reads from cache. However, in the case of uncached reads it should be taken into account that ***Windows 7*** assigns a larger amount of its memory to graphics as compared to the amount that ***XP*** assigns to graphics as will be discussed in the 3D graphics tests section. This may result in slower memory reads as less memory is available to read. Another possible cause could be the *SuperFetch* memory system in ***Windows 7***. Since programs are now constantly kept in memory, it would mean that less memory would be

available to other requesting programs, such as the test program. In this case, it will probably not be able to get as much memory on ***Windows 7*** as it can on ***XP***.

9.5.3. Disk Tests

This suite contains a number of tests that exercise the mass storage units connected to the computer. These mass storage units could be hard disks or even flash drives. The disk test suite evaluates the following activities:

- **Disk Sequential Read** - a large test file is created on the disk under test and the file is read sequentially from start to end (Megabytes transferred per second).
- **Disk Sequential Write** - a large file is written to the disk under test and the file is written sequentially from start to end (Megabytes transferred per second).
- **Disk Random Seek + RW** - a large test file is created on the disk under test. The file is read randomly, that is, a seek is performed to move the file pointer to a random position in the file, a 16KB block is read or written then another seek is performed (Megabytes transferred per second).

9.5.3.1. Setup

The above tests were all carried on the same file system (NTFS) since the two OSes that were being evaluated were both Windows OSes. The partition on which the OS was installed, that is, the C: drive was used for this test for both ***XP*** and ***Windows 7***. For each test a file was created in the root directory of the selected disk. The size of the test file used was 200MB and the read or write block sizes used were 16KB. Each test uses uncached asynchronous file operations with an IO queue length of 20 and runs for at least 20 seconds.

9.5.3.2. Results

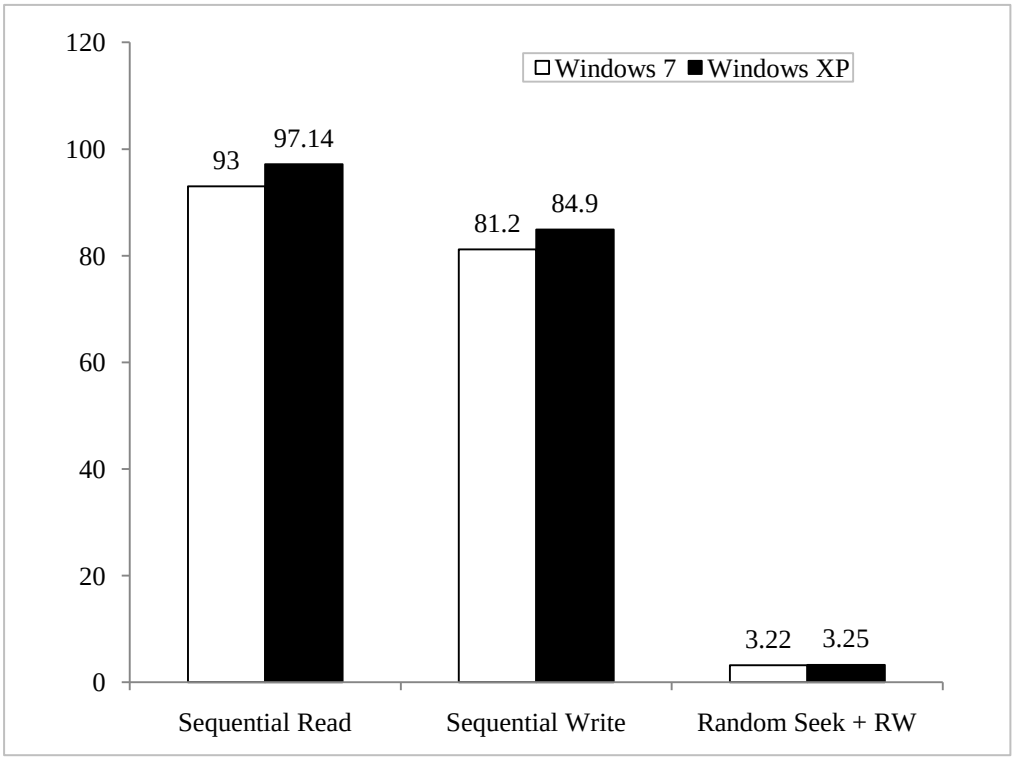

Figure 16 - Disk tests conducted on Windows 7 and Windows XP

9.5.3.3. Evaluative Comment

What can immediately be established from the Figure 16 above is that ***XP*** reads and writes to disk faster than ***Windows 7***. ***XP*** manages to transfer 4.14MB of data per second more than ***Windows 7*** when it reads sequentially from disk and further manages to transfer 3.7MB of data per second more than ***Windows 7*** when it writes sequentially to disk. This therefore shows that ***Windows 7*** has significantly higher overheads than ***XP*** when it comes to disk operations. There is however a very slight difference in the random seeks and random Read Write (RW) operations between the 2 OSes with ***XP*** transferring 0.92% more operations per second than ***Windows 7***. It is worth pointing out that ***Windows 7*** assigns more memory to graphics than ***XP*** and this could have contributed to slowing down the rate at which the system reads and writes to disk. Some data can be cached before it is written and can be accessed quicker if it is still cached so a larger available RAM would be an advantage.

9.5.4. Graphics Tests

The objectives of running the 2D and 3D graphics tests were to compare the two systems with respect to specific graphics operations. Although a comprehensive study of graphics performance was not the main goal of this work the results obtained can help to show the key

differences between the two systems. This can then give an insight into other aspects of graphics performance.

9.5.4.1. Two Dimensional Graphics Tests

The Passmark PerformanceTest 2D graphics suite was used to exercise the standard Windows graphics functions. The 2D graphics test suite evaluates the following:

- **Solid Vectors** - draws a rectangle filled with a gradient, a solid filled ellipse, a line, a Bezier curve (used to model smooth curves that can be scaled indefinitely) and a solid filled star as many times as possible. After 32 cycles the colours are randomized (Thousands of vectors drawn per second).
- **Transparent Vectors** - same as solid vectors test but with all colour fills partially transparent (Thousands of vectors drawn per second).
- **Complex Vectors** - draws a jungle scene using a number of complex vector images of trees and animals as many times as possible within the time limit and always finishes on a complete drawing of the scene (Complex vectors drawn per second).
- **Fonts and Text** - tests the performance of the graphics card with the typical rendering of Fonts and Text (Operations per second).
- **Windows Interface** - tests the performance of the graphics card and the Windows Display settings for interacting with the Graphical User Interface. The test includes the performance measurement of Common GUI controls: treeview, listview, sliders and edit boxes, as well as window movement and resizing (Operations per second).
- **Image Filters** - applies rotation, brightness and greyscale filters to an image and counts the number of filters applied per second (Filters per second).
- **Image Rendering** - measures the rate at which a bitmap image can be rendered to the screen at various sizes. The test always finishes on a complete cycle of rendering smallest to largest (Images per second).

9.5.4.1.1. Setup

The display resolution was set to 1280X1024 arrays of pixels before running the tests. The tests were executed 5 times for each OS and then the average for each test was calculated. It is worth noting that the results from this suite depend on the speed at which the video card can carry out 2D graphics operations and the colour depth being used. Since the OSes were

set up in a dual boot manner the graphics card speed needed no adjustment but the display resolution had to be adjusted before the tests were conducted.

9.5.4.1.2. Results

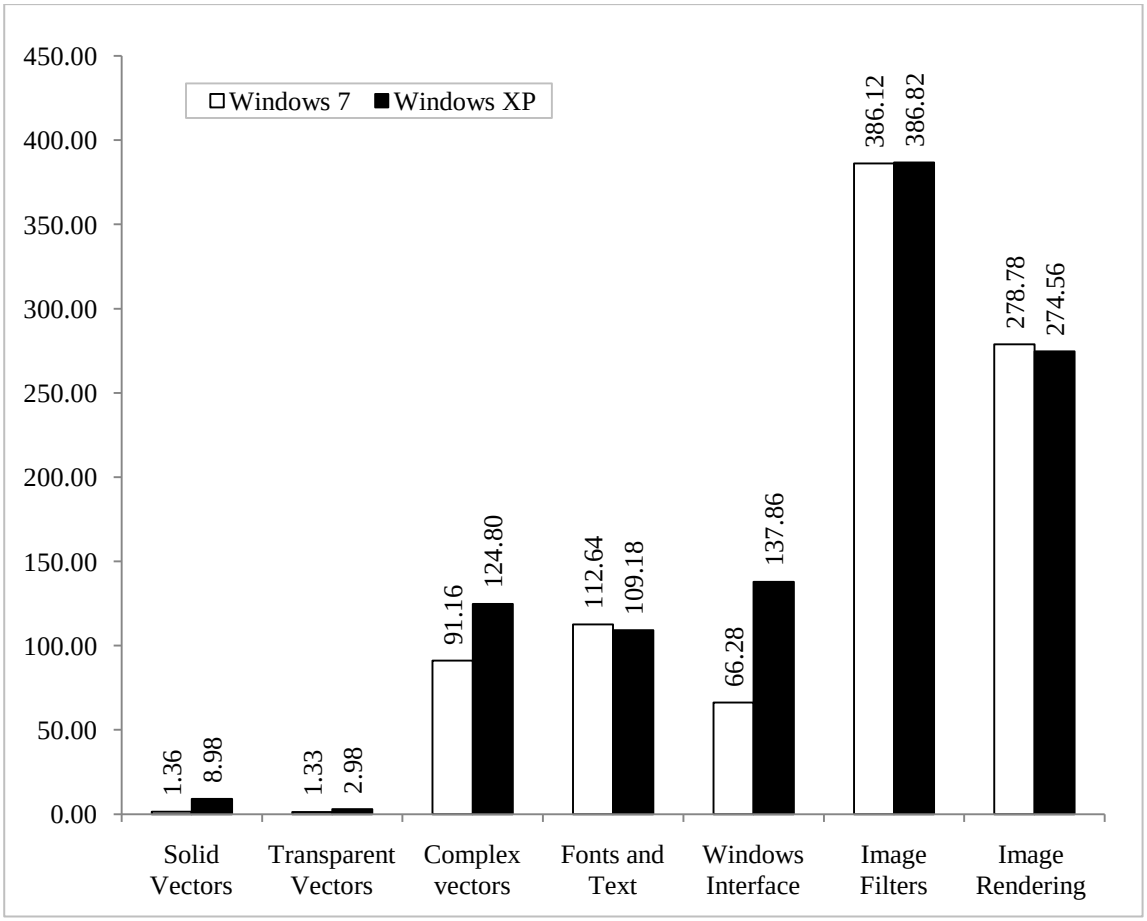

Figure 17 - 2D Graphics Tests Conducted on Windows 7 and Windows XP

9.5.4.1.3. Evaluative Comment

Figure 17 above shows the comparative results for the 2D graphics tests carried out on ***XP*** and ***Windows 7***. In all 2D graphics tests performed ***Windows 7*** lags way behind ***Windows XP*** except in the Fonts and Text test in which ***Windows 7*** performs better than XP. It was expected that ***Windows 7*** would perform better than ***XP*** in these 2D graphics tests since it dedicates more memory to graphics. Furthermore ***Windows 7*** was expected to perform better than ***XP*** in at least the transparent vectors test because it is highly likely that the former's 2D performance is optimized to deal with the *AERO* interface. However it still performs below the ***XP*** standard.

9.5.4.2. Three Dimensional Graphics Tests

This test suite attempts to measure the performance of the 3D graphics hardware installed on the machine. The test makes full use of version 9 of the Microsoft DirectX 3D graphics library meaning without DirectX 9.0 or above it will not be possible to run these tests. Of the four standard tests that have been defined for this suite only 3 were run on the two OSes under test: Simple (Frames per second), Medium (Frames per second), and Complex (Frames per second).

9.5.4.2.1. Setup

The test was run five times on both the ***Windows 7*** *OS* and the ***XP*** OS and the results of the tests were taken to be concrete since they showed some consistency. Windows 7 was running DirectX 11 which it installs by default while XP was running DirectX 9 which it also installs by default. However Passmark PerformanceTest attempts to alter the DirectX installed on the machine to DirectX 10 before it runs the 3D graphics test suite. This means that it was able to upgrade the DirectX in XP but not downgrade the DirectX in Windows 7. The display resolution was also set to 1280X1024 arrays of pixels before running the tests as in the 2D graphics tests.

Before looking at the results it is worth noting that an error was encountered while evaluating the complex 3D graphics on ***Windows 7*** which highlighted that the video card had to support 4x Anti-Aliasing to run the test as shown in Figure 18 below.

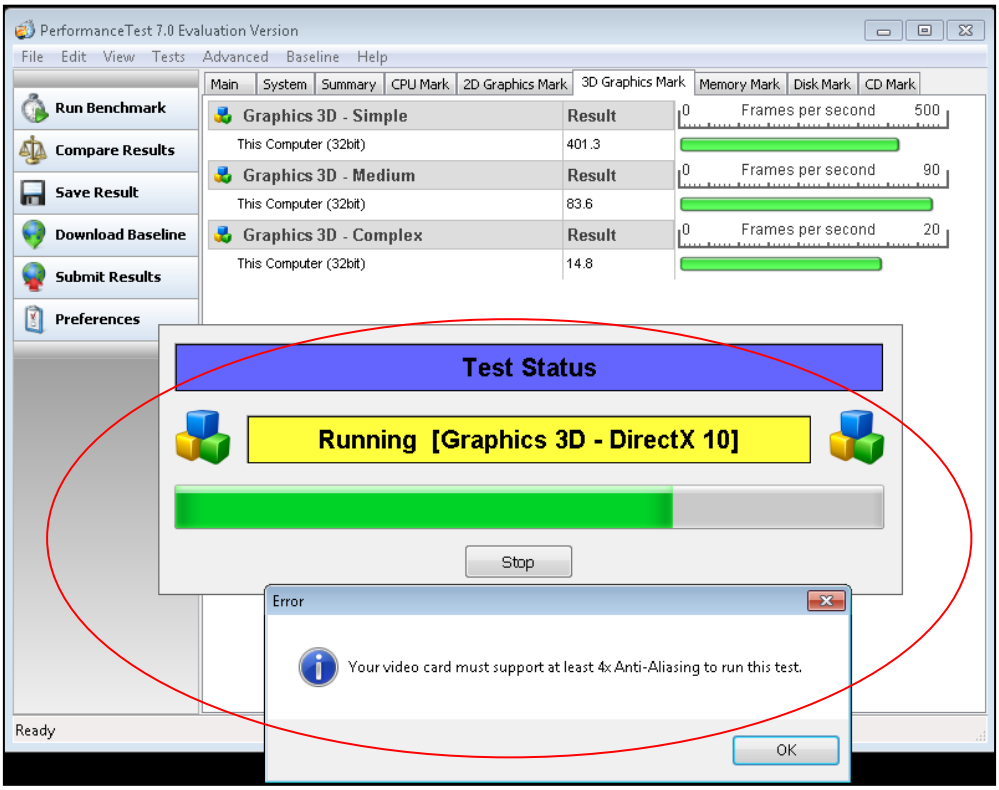

Figure 18 - Error Encountered while Evaluating 3D Graphic Capabilities of Windows 7 RC

As a result the 3D graphics test could not be completed for ***Windows 7***. A factor that could have caused the complex 3D graphics test to fail on ***Windows 7*** could be the fact that ***Windows 7*** installs DirectX 11 by default and the graphic card on the PC that was used for experimentation does not support DirectX 11. This was inferred from the fact that the same test managed to run on the same hardware with less graphics memory and using ***Windows XP***. Figure 18 also shows that the graphics 3D test was run using DirectX 10 a factor that could also have contributed to the failure of 3D graphics test. Furthermore the graphic driver installed on ***XP*** is different from that installed which ***Windows 7*** installs by default as shown in the Figure 19 below.

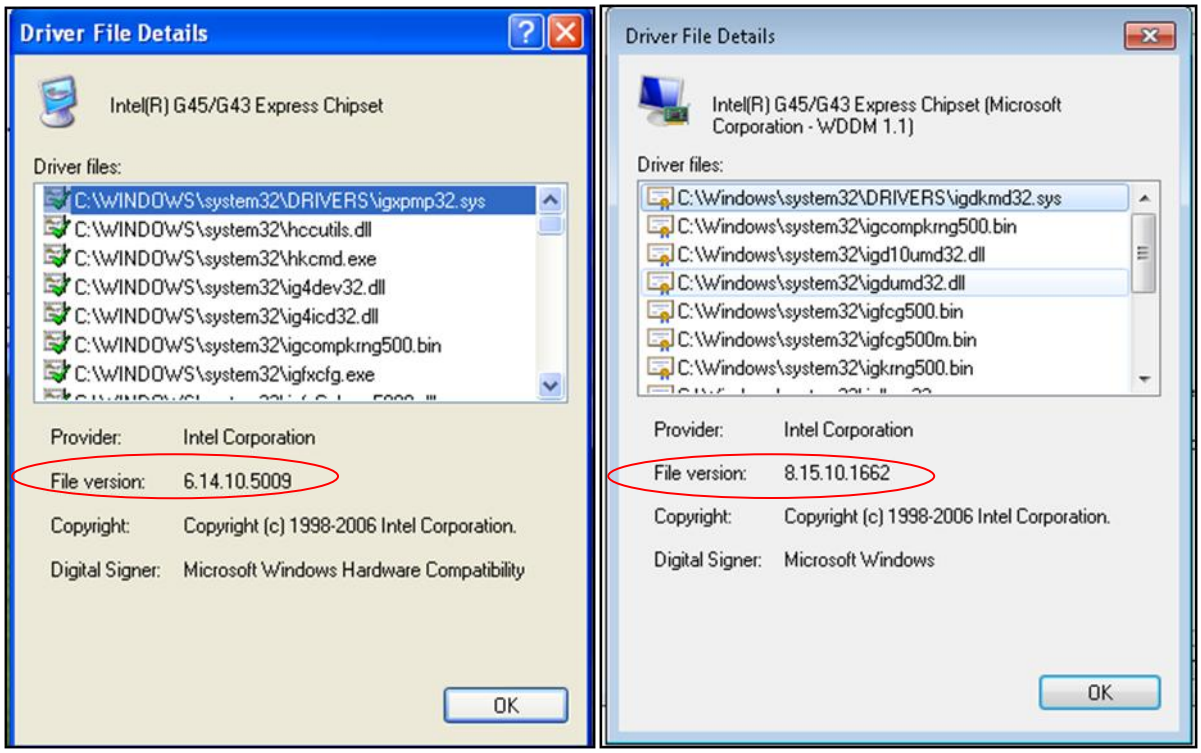

Figure 19 - Graphic Drivers Installed on Windows XP (left) and Windows 7 (right)

9.5.4.2.2. Results

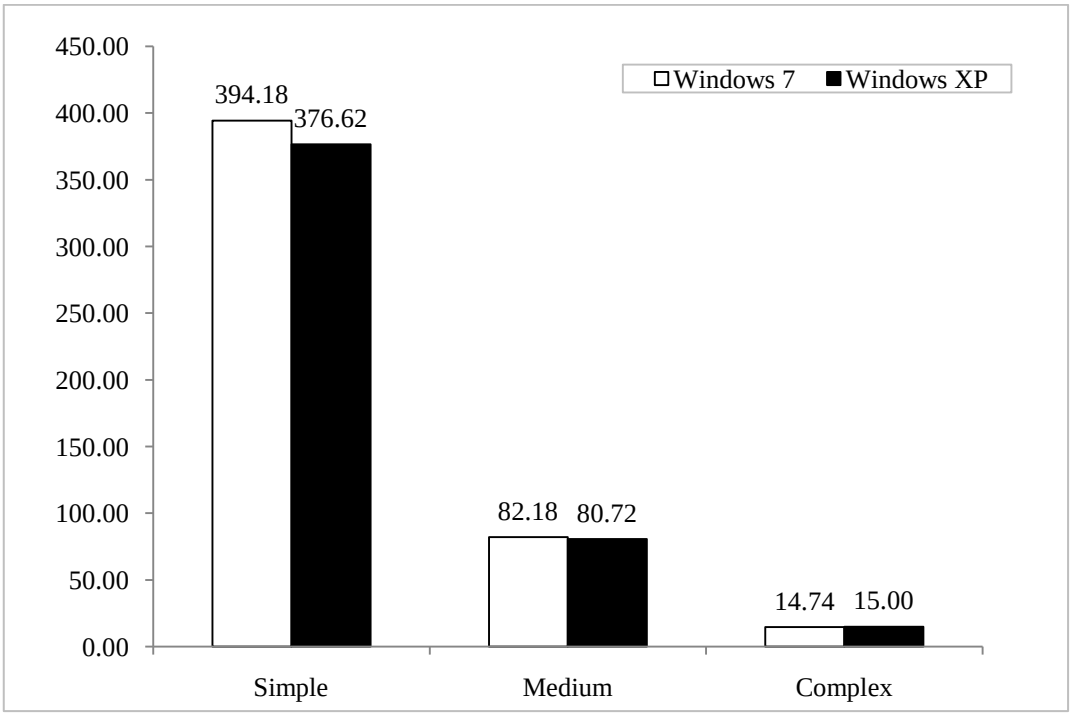

Figure 20 - 3D Graphics Tests Conducted on Windows 7 and Windows XP

9.5.4.2.3. Evaluative Comment

Despite this problem Figure 20 above shows that ***Windows 7*** managed to outperform ***Windows XP*** in the Simple and Medium 3D graphics tests. This can be attributed to the fact that ***Windows 7*** assigns more memory to graphics. In the case of the experimental machine ***Windows 7*** assigned 1294MB of memory to graphics while ***XP*** assigned a mere 256MB. However, ***XP*** managed to edge ***Windows 7*** in the complex 3D graphics test and this may be a result of the fact that the complex 3D graphics assessment could not be completed for ***Windows 7***.

9.8. Conclusion

In general, ***Windows XP*** dominated most of the benchmarks run. ***XP*** performed well on CPU operations, memory operations, disk operations and 2D graphics operations tests. The superior performance of ***XP*** in the disk tests shows that it incurs less overhead in terms of reading and writing to disk. However, the better performance of ***Windows 7*** in the 3D graphics tests may be a suggestion that ***Windows 7*** has an efficient graphics implementation as compared to ***XP***.

CHAPTER 10. CONCLUSIONS AND RECOMMENDATIONS

10.1. CONCLUSIONS AND RECOMMENDATIONS

The experiments carried out in testing the performance of ***Windows XP*** and ***Windows 7*** revealed a number of differences. The differences that were encountered may be of interest to those choosing which OS to run. Although some of these differences may change in the final release of ***Windows 7***, some may not change. These differences include the installation process, and system bugs found while running the benchmarks. Most of the benchmarks were run successfully on the two systems except for the 3D graphics test which could not be completed on ***Windows 7***.

Image processing firms, gamers and anyone who requires a high amount of graphics may be more interested in ***Windows 7*** due to its better performance in the 3D graphics tests. DirectX 11 which is backward compatible with DirectX 10 may also turn out to be a major selling point for ***Windows 7*** as it improves graphics performance. However this could be realised in the future as DirectX 11 graphics cards only started shipping round about August 2009 and most people still have to upgrade their hardware. It will take a while for game development companies to start taking advantage of the new DirectX11 capabilities.

There are also quite a number of new features introduced in ***Windows 7*** that make it a pleasure to work with. Features such as Jump lists, *AERO* and a variety of shortcuts (both mouse driven and keyboard) make using ***Windows 7*** a memorable activity. Installation experiences with the two systems were very different, with ***Windows 7*** being the easier to install than ***XP***. Some of the good installation features in ***Windows 7*** include:

- Intuitive partitioning of the hard drive with a simple interface.
- User enters all the required information at the beginning of the installation and the rest of the process happens automatically.
- The ***Windows 7*** installation process includes the installation of drivers automatically and is still faster than that for ***XP***.

Some of the important security features introduced to ***Windows 7*** are *BitLocker Drive Encryption* and *Bitlocker To Go*. These features have only been made available in the ***Ultimate*** and ***Enterprise*** editions of ***Windows 7***. In this day and age, such security is necessary for any computer user regardless of whether they are business people or not. The fact that Microsoft left it out of most of the ***Windows 7*** editions is rather unfortunate.

Furthermore some functions of *BitLocker Drive Encryption* require a special hardware device called TPM 1.2 which is not available in most previous generation motherboards and is available only in few current generation motherboards.

The highly advertised *Windows XP Mode* will only work on the 3 higher versions of ***Windows 7***. As if this is not enough, *XP Mode* requires special hardware in the processor in order to run. However, as it stands, I do not see a good reason why ordinary users should move from ***XP*** since it outperforms ***Windows 7*** in most of the tests conducted. It is my opinion that ***Windows XP*** still works exceptionally well and is relatively simple to use. ***XP*** still remains a better desktop OS since it has no application compatibility issues, works on ordinary hardware, and has a better performance.

As a final word the disadvantage of "black box" benchmarking approach is that it cannot conclusively explain all of the performance differences in these systems. In many cases, it merely exposes the differences. In addition, using microbenchmarks isolates the areas of both good and bad performance, but microbenchmarks cannot predict overall performance of the OS. Despite the differences on the microbenchmarks, the systems' overall performance on the macrobenchmark tests may be much closer.

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CHAPTER 11. FUTURE WORK

11.1. Future Work

Deployment tests could not be conducted to determine ***Windows 7***'s ability to be deployed on a large scale from a single source. It would be of interest to find out how ***Windows7*** works with some of the most popular ways of large scale deployment such as GHOST. Furthermore, ***Windows 7*** includes several tools to streamline the creation and servicing of the deployment image, and to get users up and running as quickly as possible. These would also be of interest to test in order to find out how well they work and to see if they are better than the commercial tools available.

If the source code for the OS is made available an assessment of the inner workings of the OS can be carried out in order to explain the causes of the differences in the results of the benchmarks that were established in this research.

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APPENDICES

Appendix 1 – Features of the Various Windows 7 Versions

Key Features	Starter	Home Basic	Home Premium	Professional	Ultimate	Enterprise
Improved Windows Taskbar and Jumplists	✓	✓	✓	✓	✓	✓
Windows Search	✓	✓	✓	✓	✓	✓
Join a Homegroup	✓	✓	✓	✓	✓	✓
Windows Media Player	✓	✓	✓	✓	✓	✓
Back-up and Restore	✓	✓	✓	✓	✓	✓
Action Center	✓	✓	✓	✓	✓	✓
Device Stage	✓	✓	✓	✓	✓	✓
Enhanced home media streaming, including Play To	✓	✓	✓	✓	✓	✓
Application Capabilities	Up to 3 concurrent programs	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Live Thumbnail Previews from Taskbar		✓	✓	✓	✓	✓
Fast User Switching		✓	✓	✓	✓	✓
Create ad-hoc wireless networks		✓	✓	✓	✓	✓
Internet Connection Sharing		✓	✓	✓	✓	✓
Aero Glass and advanced Window navigation			✓	✓	✓	✓
Windows Touch (Multi-touch and handwriting support)			✓	✓	✓	✓
Create a Homegroup			✓	✓	✓	✓

Windows Media Center			✓	✓	✓	✓
DVD Video Playback and authoring			✓	✓	✓	✓
Location aware printing				✓	✓	✓
Domain Join & Group Policy Controls				✓	✓	✓
Remote Desktop Host				✓	✓	✓
Advanced Back-up (Network and Group Policy)				✓	✓	✓
Encrypting File System				✓	✓	✓
BitLocker and Bitlocker To Go					✓	✓
AppLocker					✓	✓
DirectAccess					✓	✓
BranchCache					✓	✓
MUI Language Packs					✓	✓
Estimated Cost		FPP $200	FPP $260 Upgrade $120	FPP $300 Upgrade $200	FPP $320 Upgrade $220	
Availability	Worldwide to OEMs on new PCs	Only to emerging markets	Worldwide to OEMs on new PCs and retail	Worldwide to OEMs on new PCs and retail	Limited OEM and retail	Volume licensing

Table 3 - Major features expected with each Windows 7 version [10]

Fully Packaged Product (FPP)

Multilingual User Interface (MUI) is the name of a Microsoft technology for Microsoft Windows, Microsoft Office and other applications that allows for the installation of multiple interface languages on a single system. On a system with MUI, each user would be able to select his or her own preferred display language. MUI technology was introduced with Windows 2000 [28].

Appendix 2 – Full Results for Time to Logon, Time to Desktop and Shut-down time for XP and Windows 7

	Time to Logon Screen in Seconds	Time to Desktop in Seconds	Time to ShutDown in Seconds
No Application s Installed	18	25	10.15
	30	33	9.82
	21	29	10.40
	19	24	10.29
	24	30	10.11
Average	**22.4**	**28.2**	**10.15**
16 Application s Installed	34	42	13.43
	31	36	14.09
	30	37	13.40
	36	44	14.5
	32	45	13.8
Average	**32.6**	**40.8**	**13.84**

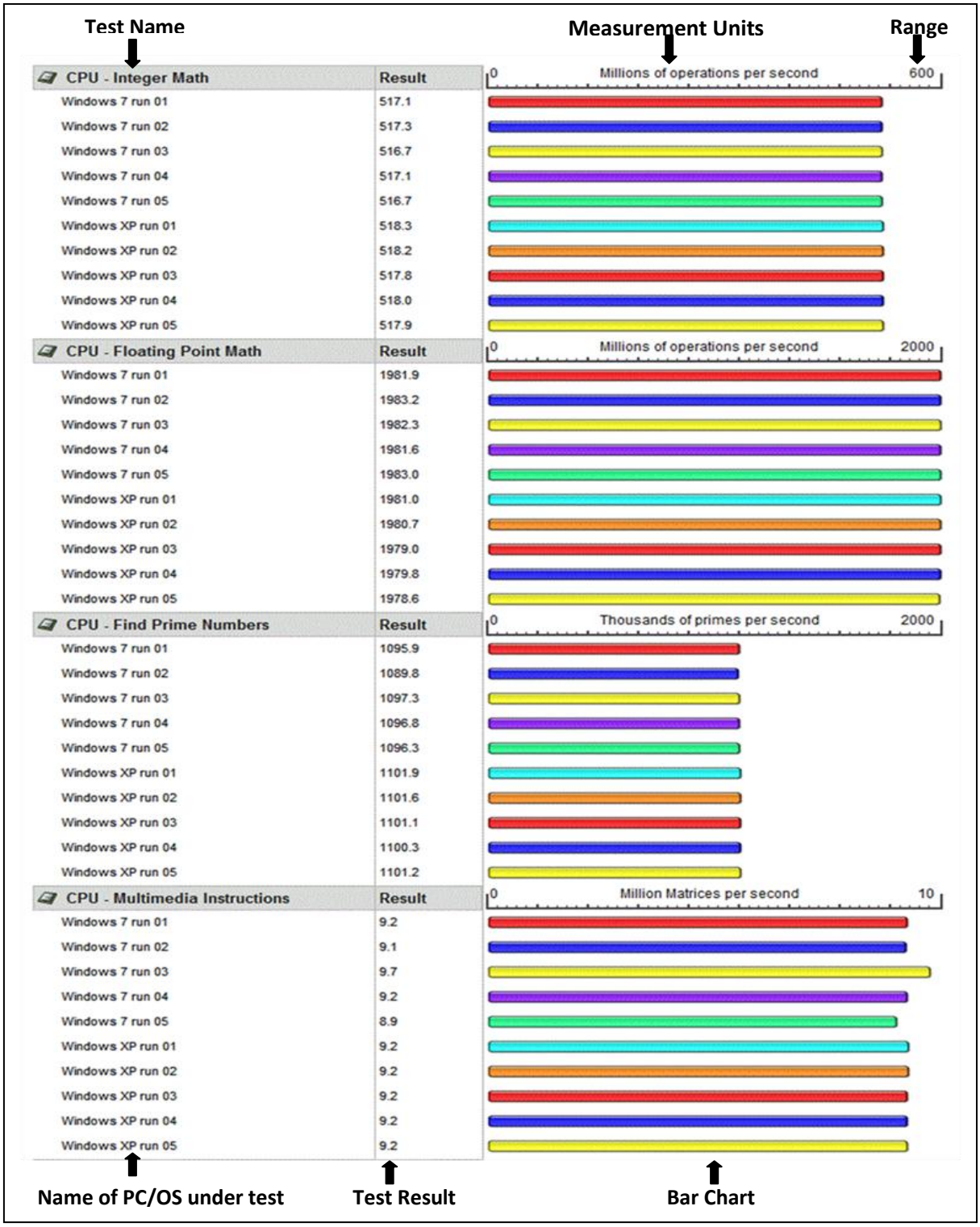
Table 4 - Windows XP Start-up and Shutdown Time

	Time to Logon Screen in Seconds	Time to Desktop in Seconds	Time to ShutDown in Seconds
No Application s Installed	22	31	11.44
	22	32	9.69
	23	32	10.28
	21	29	11.11
	24	35	10.08
Average	**22.4**	**31.8**	**10.52**
16 Application s Installed	30	38	14.30
	32	41	15.91
	24	39	15.31
	33	51	14.84
	32	52	16.01
Average	**30.2**	**44.2**	**15.274**

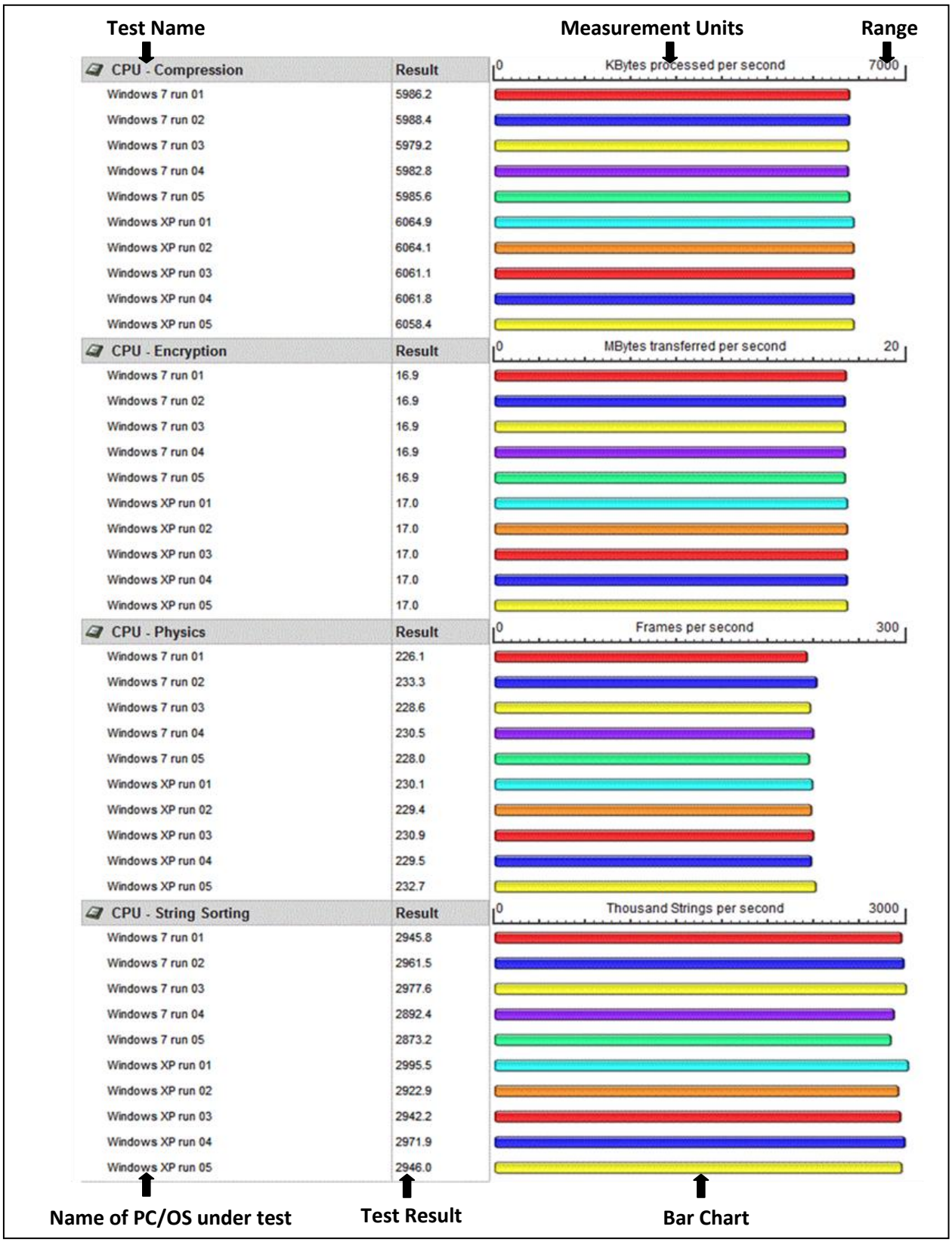
Table 5 - Windows 7 RC Start-up and Shutdown Time

Appendix 3 – Full Results for Performance Tests done on XP and Windows 7

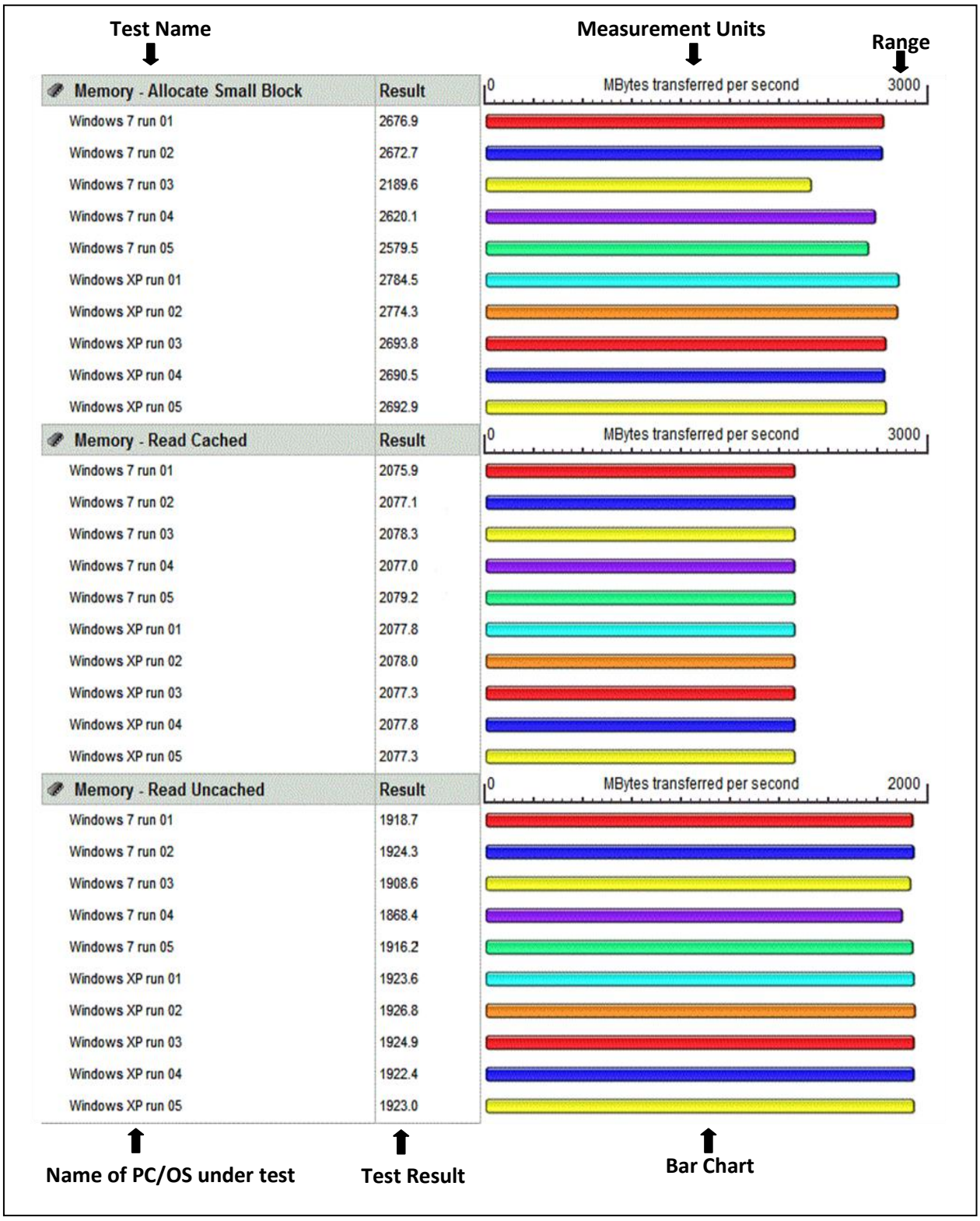
CPU Tests



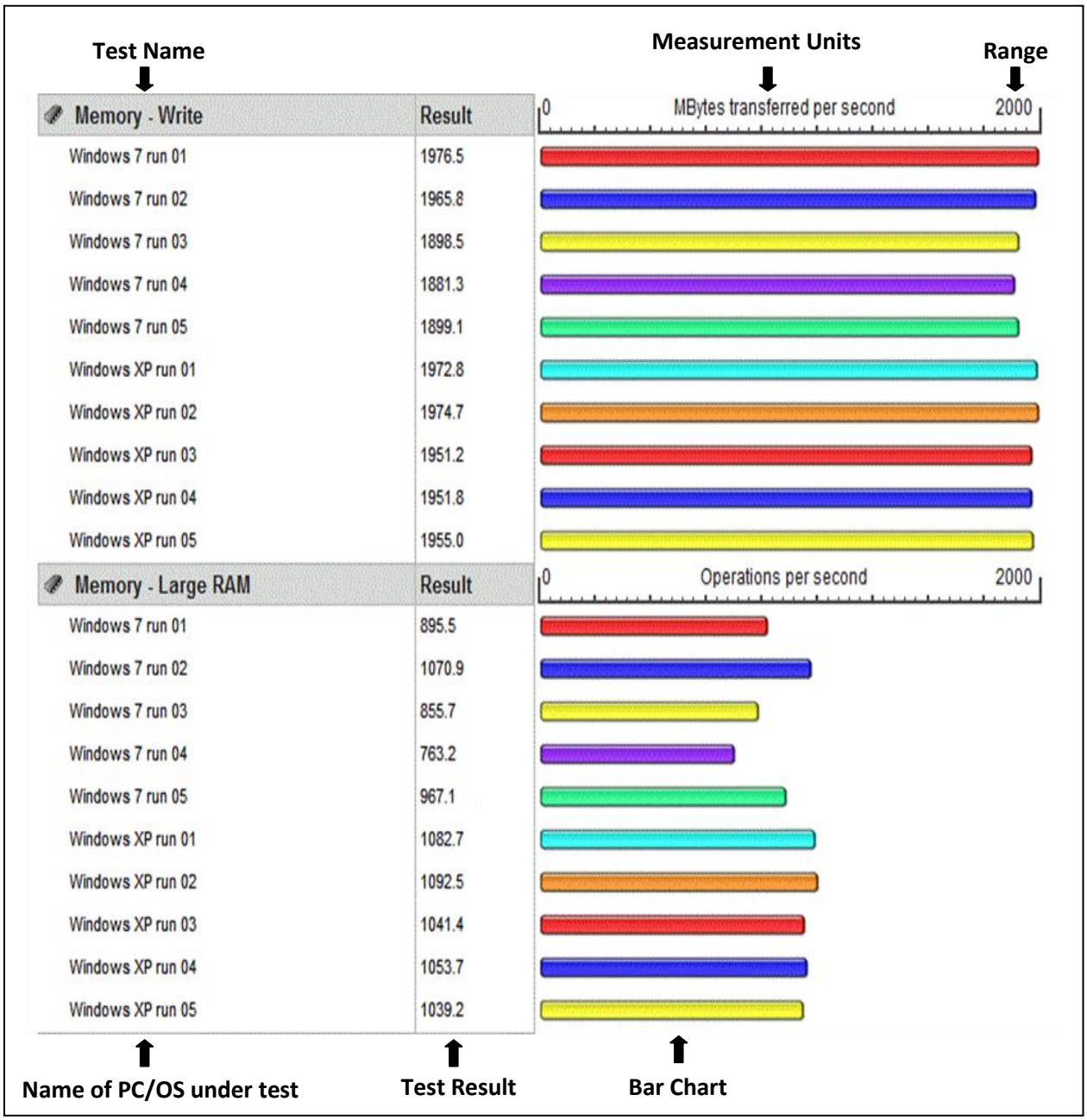
CPU Tests Continued



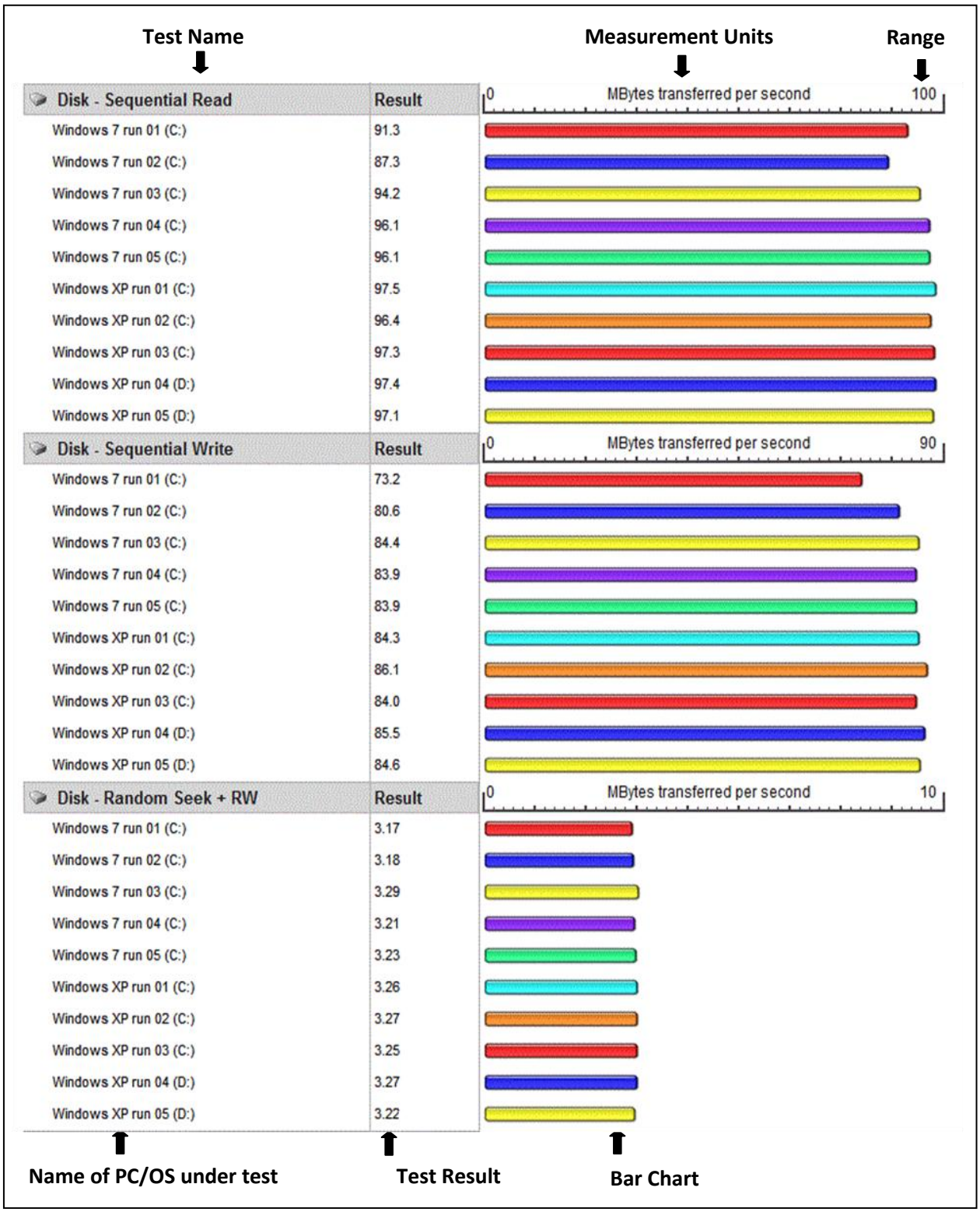
Memory Tests



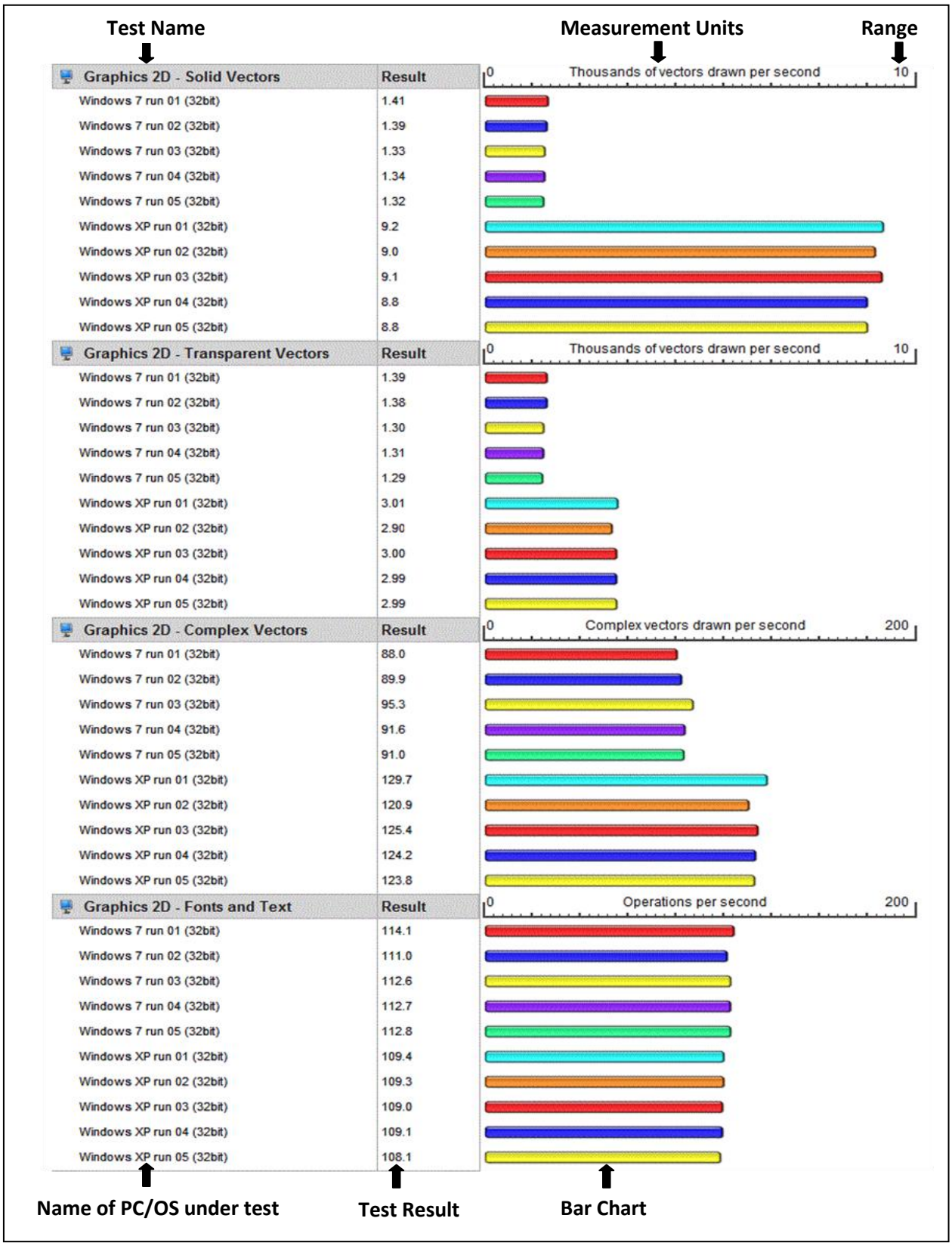
Memory Tests Continued



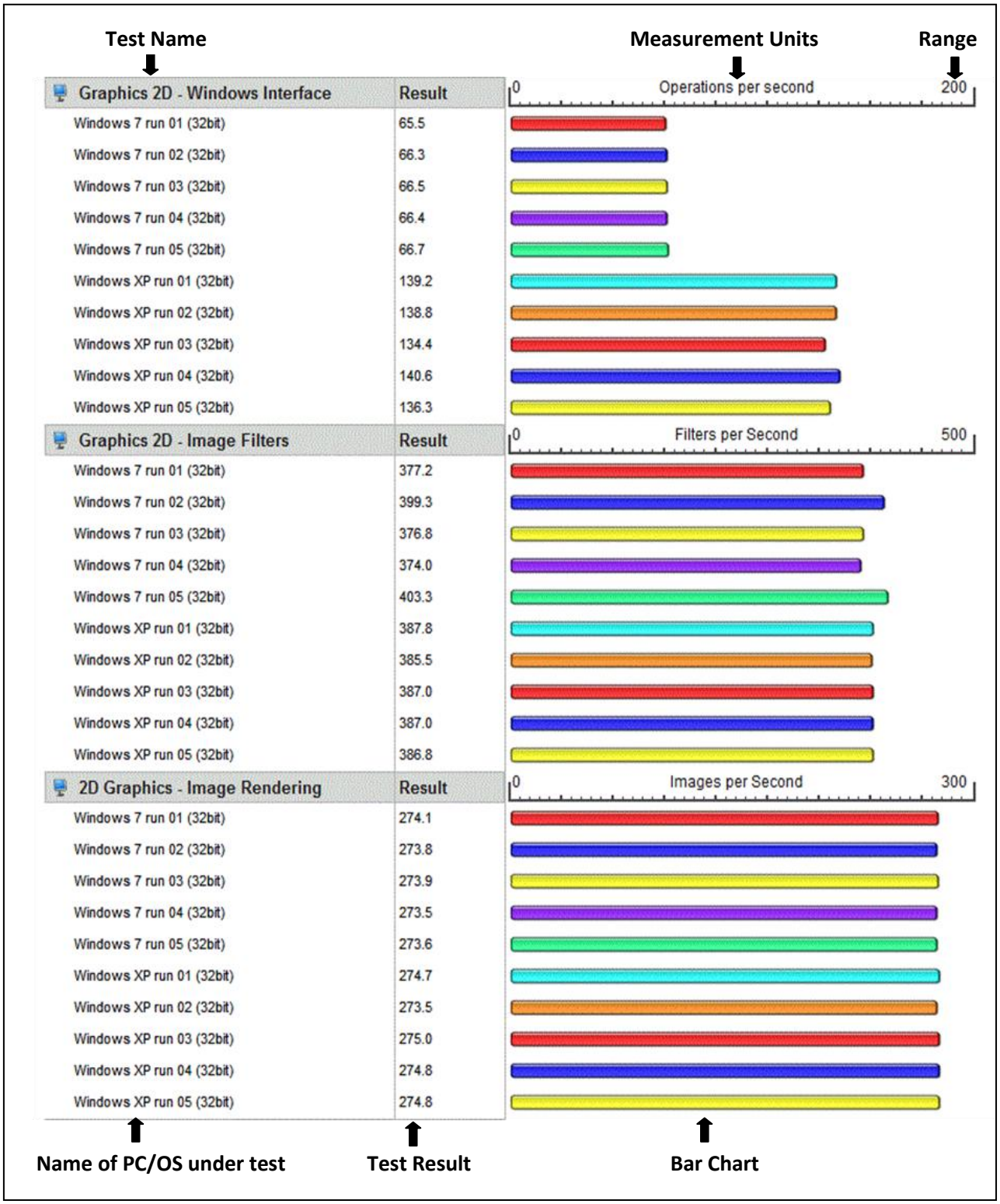
Disk Tests


Test Name
Measurement Units
Range
Disk - Sequential Read
Result
0
MBytes transferred per second
100
Windows 7 run 01 (C:) 91.3
Windows 7 run 02 (C:) 87.3
Windows 7 run 03 (C:) 94.2
Windows 7 run 04 (C:) 96.1
Windows 7 run 05 (C:) 96.1
Windows XP run 01 (C:) 97.5
Windows XP run 02 (C:) 96.4
Windows XP run 03 (C:) 97.3
Windows XP run 04 (D:) 97.4
Windows XP run 05 (D:) 97.1
Disk - Sequential Write
Result
0
MBytes transferred per second
90
Windows 7 run 01 (C:) 73.2
Windows 7 run 02 (C:) 80.6
Windows 7 run 03 (C:) 84.4
Windows 7 run 04 (C:) 83.9
Windows 7 run 05 (C:) 83.9
Windows XP run 01 (C:) 84.3
Windows XP run 02 (C:) 86.1
Windows XP run 03 (C:) 84.0
Windows XP run 04 (D:) 85.5
Windows XP run 05 (D:) 84.6
Disk - Random Seek + RW
Result
0
MBytes transferred per second
10
Windows 7 run 01 (C:) 3.17
Windows 7 run 02 (C:) 3.18
Windows 7 run 03 (C:) 3.29
Windows 7 run 04 (C:) 3.21
Windows 7 run 05 (C:) 3.23
Windows XP run 01 (C:) 3.26
Windows XP run 02 (C:) 3.27
Windows XP run 03 (C:) 3.25
Windows XP run 04 (D:) 3.27
Windows XP run 05 (D:) 3.22
Name of PC/OS under test
Test Result
Bar Chart

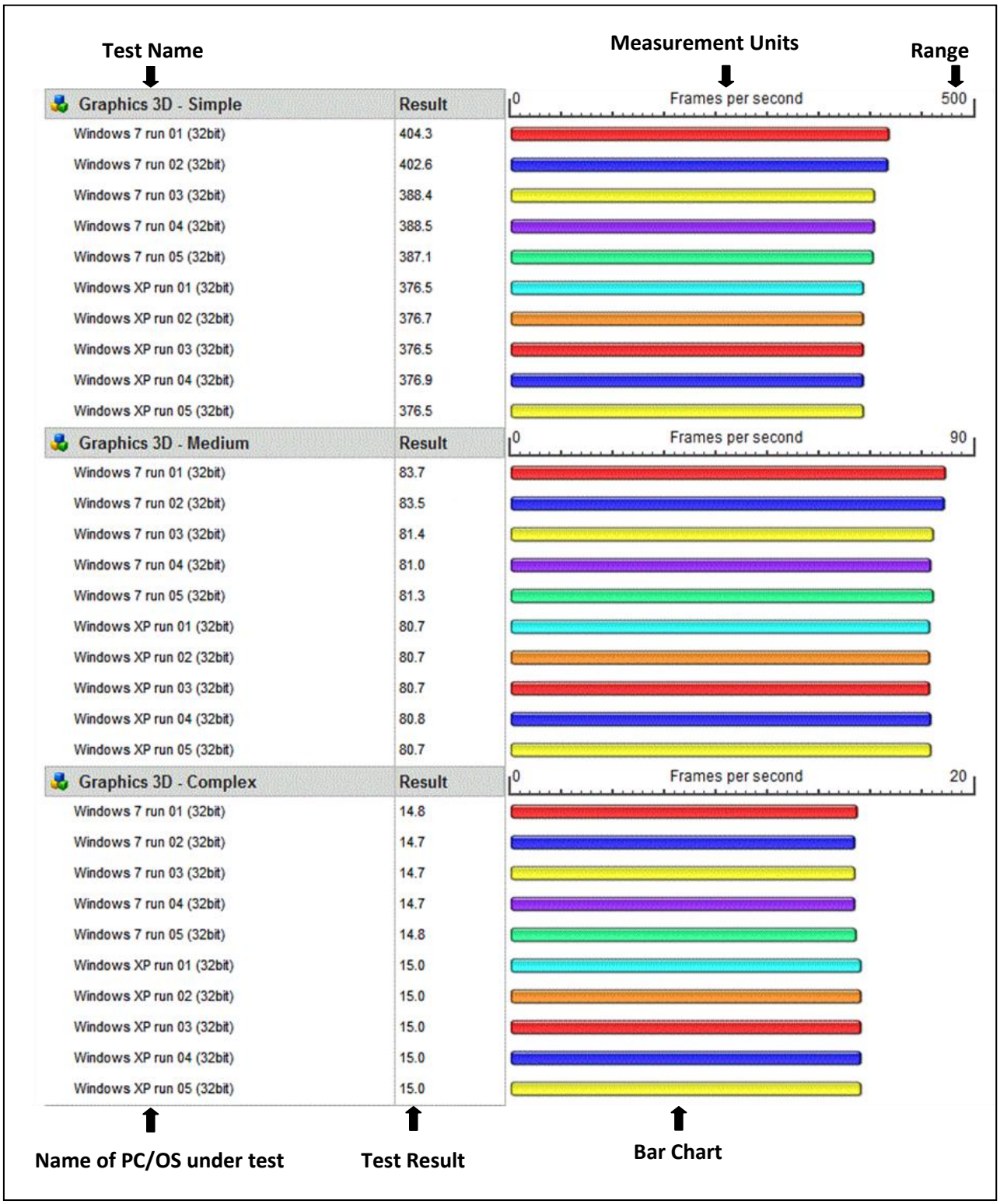
2D Graphics Tests



2D Graphics Tests Continued



3D Graphics Tests



Appendix 4 - Successfully Installed Software

Games	**Editors**	**Application Servers**
Need For Speed Carbon PacMania II	conText version 0.98.5 Notepad++	Glassfish v2 UR2 Apache Tomcat 6.0.18
IDEs	**Virtualisation Software**	**Web Browsers**
JCreator LE version 4.50 NetBeans 6.5	Microsoft Virtual PC 2007 VMWare Workstation 6.5.1 Windows Virtual PC Release Candidate	Mozilla Firefox version 3.0.1 Opera
Media Players	**Other**	**Other**
VLC Media player RealPlayer 10 KMPlayer Quicktime Player version 7.0.4	Adobe Reader 8 version 8.0.0 Adobe Reader 9 version 9.0.0 Altova XMLSpy 2009 Microsoft Office	PrimoPDF (PDF Creator) PowerIso Protege 4.0 version 1.0.0.0 Eyepatch Logitech Quickcam version 11.70.1200
Other	**Other**	**Other**
Virtual Earth 3D (Beta) version 4.0.903.16005 F-Secure Antivirus for Workstations 5.0 Adobe Flash Player 10 ActiveX version 10.0.22.87 DCPlusPlus version 0.705	GoogleTalk Wireshark 1.0.6 WinPcap 4.0.2 Wamp 5 version 1.7.0 Concise Oxford Dictionary 10th Edition version 1.0.0	WinRar WinZip 8.1 PassMark PerformanceTest 7.0 BootRacer JDK 6 update 11
Other		
MATLAB 2009a Dreamweaver 8 Firework 8 Flash 8		