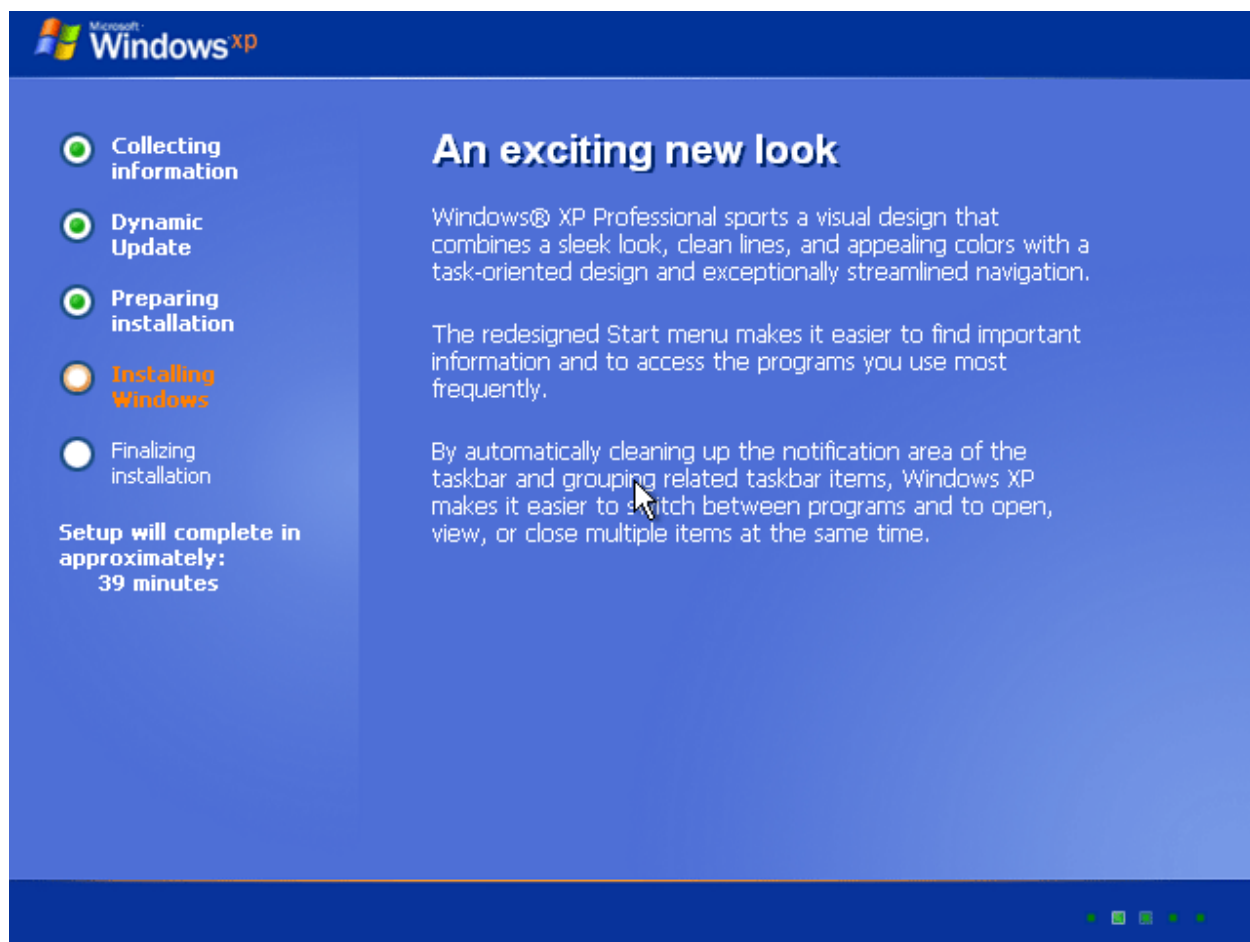


Examining the Accuracy of the Windows XP™ Installation Time Prediction and How to Improve It



Abstract

Objectives/Goals

To test whether the Windows XP™ projected install time of 39 minutes represents an unbiased estimate across a wide range of hardware configurations. If this 39 minute install time is generally biased (as is shown to be the case), is it possible to develop a more accurate prediction of the time it takes Window XP™ to install on a particular hardware configuration?

Materials/Procedures

Twenty-seven computer hardware configurations determined by three different combinations of processors (AMD 3500+, 2800+ and 2200+), RAM memory size (1GB, 512MB and 256MB), and hard drive speeds (7200RPM, 5400RPM and 4500RPM) were assembled. For each hardware configuration, conduct ten runs using an unattended install CD for Windows XP™ and record various times related to the installation process in Excel spreadsheets.

Results

For all hardware configurations tested, it is possible to reject the null hypothesis of a Windows XP™ install time of 39 minutes at $p < .01$ using two-sided t-tests. Alternative approaches were examined to predicting Windows XP™ install times. The most accurate assumes that the exact hardware configuration on which Windows XP™ is being installed has been tested repeatedly so that the mean installation time for that configuration could be looked up in a table. Because variability in install times for the same hardware configure is quite small, a prediction with a quite small forecast error is obtained with this approach. Regression based approaches with different sets of variables can also produce substantially better estimates than 39 minutes.

Conclusions

Microsoft's 39 minute estimate of Windows XP™'s install time represents a biased estimate for all of the hardware configurations tested. If a computer's basic hardware specification is known, it is possible to predict how long it will take Windows XP™ to install with an average prediction error of less than 1 minute. In contrast, using Microsoft's 39 minute estimate of install time, the average prediction error is approximately 13 minutes. Using information that can be read at the time of start-up from the computer's BIOS, the methods proposed can obtain much better Windows XP™ install time predictions. This can be implemented through a table look-up procedure if prior testing data on hardware configuration is available or from a regression model that predicts install time based on information about the performance of the computer's main components.

Help Received

My father, a University of xxx professor, and Professor xxx, at the University of xxx, helped me in conceptualizing the experimental design and thinking about statistical estimation issues related to this project. My father also answered an endless number of "how to" questions. Xxx, a professor of computer science (xxx), gave me useful advice on some of the hardware and software issues. My mother gave this report a thorough editing and let me use some of the components from her computer in the experiments performed. The data collected in this experiment were also used in my science fair project.

TABLE OF CONTENTS

I.	Introduction and Summary	4
II.	Research Questions	6
III.	Hypotheses	6
IV.	Literature Review	6
	1. Windows XP™ Install Time	7
	2. Understanding the Windows XP™ Install Process	7
	3. Benchmarking Computers and Computer Components	7
	4. Software Installation//Download Predictive Timers	8
	5. Experimental Design/Statistics of Industrial Experiments	8
V.	Materials	8
VI.	Procedures	9
	1. Creating an Unattended Install CD	10
	2. Experimental Design	10
	4. Table 1: Hardware Configurations	12
	5. Figure 1: Experimental Design 3 Factor by 3 Level Full Factorial	13
VII.	Results	14
	1. Figure 2: Actual and Forecasted Windows XP™ Install Times	14
	2. Table 2: Average XP™ Install Times in Minutes by Hardware Configuration	15
	3. Figure 3: Windows XP™ Install Times For AMD 3500+	16
	4. Figure 4: Windows XP™ Install Times For AMD 2800+ Processor	17
	5. Figure 5: Windows XP™ Install Times For AMD 2200+ Processor	18
	6. Table 3: Two Sided t-Tests of Null Hypothesis of 39 Minute Windows XP™ Install Time For 27 Different Hardware Configurations	19
VIII.	Predictive Models	20
	1. Figure 6: Histogram of Absolute Value of Install Time Prediction Errors	20
	2. Figure 7: Box and Whisker Plot—10 Replications for Each Hard Drive Speed	21
	3. Table 4: Regression Model—Main Effects	22
	4. Table 5: Regression Model—Main Effects Plus Interaction Terms	22
	5. Table 6: Regression Model—TimeToName	23
	6. Table 7: Regression Model—Main Effects, Interactions & TimeToName . . .	24
IX.	Threats to Study Validity & Suggestions for Further Study	24
	1. Sources of Variability Not Considered	25
	2. Estimating a More General Predictive Model	25
X.	Conclusion	26
XI.	Bibliography	27
XII.	Appendices	29
	Appendix A: Detailed Hardware Configurations	30
	Appendix B: Excel Spreadsheets Including Raw Data	31
	1. Spreadsheet template and programming notes	32
	2. Spreadsheets for each of the 27 Hardware Configurations (10 Runs Each)	33
	a. AMD 3500+ Computer Runs	34
	b. AMD 2800+ Computer Runs	44
	c. AMD 2200+ Computer Runs	54

I. Introduction and Summary

The research issue this report focuses on is how long it takes for Microsoft Windows XP™ (hereinafter, “Windows XP” or “XP”) to install on a new computer.¹ This issue intrigued me because the Windows XP installation program appeared to check the hardware configuration and then stated that it would take 39 minutes to install on a new computer that I built; and yet, it took less than half of that time. Repeatedly watching XP install itself, two things become evident. First, the indicator of the time remaining until the Windows XP installation is completed jumps erratically during the course of installation. Sometimes it counts off minutes when only a few seconds had gone by while at other times it appeared stuck on the same minute indicator for several minutes. Second, and more surprisingly, on a number of different computers I have built for myself and friends, Windows XP always starts by saying that it will take 39 minutes to complete the installation. Typically, though, the required time was substantially less. The 39 minute predicted install time might be understandable if the installation timer started there but then quickly updated itself to a reasonably accurate estimate of how long the installation would take. This, however, is not the case. The two research questions I wish to address relate to the quality of Microsoft’s 39 minute install time prediction for XP. For a particular hardware configuration, this question has two components. First, is Microsoft’s 39 minute prediction an unbiased estimate? Second, if not, is it possible to come up with a more accurate prediction?

To address these questions, 27 different hardware configurations were assembled that varied using three different processor speeds (AMD 3500+, AMD 2800+ and AMD 2200+), three different RAM memory sizes (1GB, 512GB and 256GB), and three different hard drive speeds (7200 RPM, 5400 RPM and 4500 RPM). This roughly spans a wide range of current and past generation hardware configurations. For each hardware configuration, it was determined that in unattended install mode, Windows XP always indicates that it will take 39 minutes to install, which is taken as the null hypothesis. The alternative hypothesis, which may be true if the particular hardware in the computer matters, is that the installation time is not 39 minutes.

For each of the 27 hardware configurations, Windows XP was installed ten (10) times, for a total of 270 different runs. Average install times across the 27 different hardware configurations varied from just under 12 minutes to just over 44 minutes. For all the hardware configurations, the null hypothesis of a 39 minute installation time is rejected at $p < .01$.²

The research issue that naturally arises after having rejected the hypothesis that Windows XP always takes 39 minutes to install is whether it is possible to come up with a more accurate install time prediction. It may be the case that Windows XP installation times on individual hardware configurations do not take on average 39 minutes, but that divergences from 39 minutes are hard to predict. Better install time forecasts would be useful so that people installing XP can plan how much time they need to devote to setting up their computer so they can be doing other things while XP is installing. Given the millions of computers on which XP gets

¹ Windows XP is a trademarked name of the Microsoft Corporation.

² The fact that some of the hardware configurations tested take on average longer than 39 minutes suggests that it is possible that the 39 minute install time was an unbiased estimate for a particular hardware configuration used for internal testing or when looked at from the perspective of distribution of hardware configurations available when Windows XP was being developed. Even if this was the case, it does not alleviate the problem that XP’s install time prediction is a biased estimate for most hardware configurations. The initial 39 minute prediction time also appears across XP installations with any of the three service packs incorporated into the initial installation disk.

installed, even small improvements in estimating install times over Microsoft's 39 minute estimate may be useful.³

Several approaches to obtain better Windows XP install time predictions were examined. The first simply takes the average install time for the hardware combination (*i.e.*, AMD 3500+ processor/1GB RAM memory/7200 RPM hard drive) from past installations. This approach works quite well because deviations from the average install time are usually less than one minute. Information on a computer's main hardware components are available to the operating system installation program from the computer's BIOS at start up time so it would be possible to quickly look up the average installation time from an internal file table contained in the installation program. The main drawback of this approach is the need to have already obtained install time estimates from that particular hardware configuration.

This problem can be overcome by estimating a statistical model that predicts installation time as a function of the properties of the components. Two types of statistical models were estimated. The first is a simple linear regression with only the main effects terms (processor speed, hard drive speed, and memory size). This model explains 93% of the variability in installation times. It results in a substantial improvement in the average absolute prediction error over Microsoft's 39 minute prediction (8 minutes versus 13 minutes) but this may still be too high for some users. A model with the main effects and the key interaction terms explains 98% of the variability in installation times. It has an average absolute prediction error of about 1.5 minutes, which should be acceptable to most users.

A very different approach is to look at how long it takes the Windows XP install program to get to a particular point in the install process. This is similar to how most software install timers work. This approach does not solve the problem of giving an accurate initial forecast of how long it will take Windows XP to install.⁴ A reasonable "corrected" estimate (slightly inferior to the main effects model) can be obtained about one-third of the way through the process when Windows XP internally assigns a machine name and starts installing the graphical user interface.

It is possible to combine the two approaches by estimating a regression model with the hardware variables and the partial install time variable. Doing this results in some improvement in the Windows XP install time predictions; however, the gain is not large because the prediction time estimate just using the hardware variables is quite accurate. It may be useful though, in cases where it is not possible to test out all possible hardware configurations in advance. A modification of this approach discussed in the "Suggestions for Further Study" section would allow it to work with hardware components whose properties were unknown at the time the operating system was released, as is likely to be the case, since new hardware is constantly being developed. This would be done by including short tests (*e.g.*, hard drive write speed) of the component's key properties. The regression equation for install time would then be based using component test results as the predictor variables. The install time prediction would then be obtained by running these component tests and using them with the estimated model parameters.

³ Windows XP was chosen as the operating system to look at because it is the most popular operating system for gaming and because of its stability and ability to run on a wide range of hardware. It would have been possible to have conducted a similar study with the installation of other operating systems including Microsoft's newer operating system Vista™. Vista™ has higher hardware requirements and has dropped the installation timer feature used in this report, perhaps due to the problems observed in this study. However, the need for an accurate estimate operating system installation time still remains.

⁴ Installation of an operating system with respect to a timer is fundamentally different than installing other software or downloading files from the internet. In those cases, other programs/files being used/downloaded will influence completion times, whereas these factors do not influence installation of an operating system.

II. Research Questions

There are two related research questions addressed in this report.

Research Question 1:

Is Microsoft's 39 minute forecast for how long it takes Windows XP to install correct in the sense of being an unbiased estimate for each PC hardware configuration to be tested?

Research Question 2:

Can a PC's hardware be used to accurately predict Windows XP installation time?

III. Hypotheses

The formal hypotheses to be tested can be stated as:

Null Hypothesis:

The Windows XP prediction of a 39 minute install time is an unbiased estimate for each tested hardware configuration. H0: Install time = 39 minutes for each hardware configuration.

Alternative Hypothesis:

The amount of time it takes to install Windows XP does not equal 39 minutes. H1: Install time \neq 39 minutes for each individual hardware configuration.

The null hypothesis is based on the assumption that Windows XP always reports an initial 39 minute install time. It is possible that for some hardware configurations that the Windows XP installer reports a different initial prediction than 39 minutes. It is not, however, feasible to test all possible hardware configurations. For all 27 hardware configurations used in this experiment, the XP installer always reported an initial install prediction of 39 minutes.⁵

IV. Literature Review

This literature review has several sections. The first relates directly to the question this project sought to address: how accurate are Windows XP install time predictions across a range of hardware configurations? The second relates to understanding how the Windows XP installation process works. The third relates to the issue of benchmarking different hardware components in computers. The fourth relates to the more general issue of software installation/download timers. The fifth, and last, relates to the basic statistical design of experiments to test the impact of changing different factors on Windows XP install times.

Windows XP Install Time

This inquiry into why the Windows XP install time prediction was so far off started by asking several knowledgeable people about the Windows XP install time forecast. The response

⁵ The assumption that a 39 minute installation prediction is always reported was also checked and verified using a faster processor (3GHz Intel), more memory (4GB), and a faster hard drive (10,000RPM).

was that they did not know why it was so inaccurate but that programmers had laughed about it for years and that the install timer had also worked badly in earlier versions of Windows. A search in the current contents database of journal articles was conducted and nothing was found that discussed the properties of the Windows XP install timer. I also did an extensive search on Google. This search revealed no articles/websites on the timer, either with respect to how it worked or its accuracy. There were a few comments in newsgroups focused on Windows "gripes" that noted the Windows XP install program timer was known to be ridiculously far off with its estimates. It was surprising to see almost nothing written on this topic since Windows XP is installed on millions of computers. Further, nothing I found noted that Windows XP always gives an initial 39 minute estimate of the install time (in unattended mode) even though this was the case. It is possible that there are some hardware configurations for which an estimate of 39 minutes is unbiased but I have not found such a configuration.

Understanding the Windows XP Install Process

Windows XP goes through many steps during its process of installing on the computer's hard drive from a CD. The Windows XP installation setup process is described in detail in Microsoft TechNet (2003). For the purpose of this project, what is important is that Windows XP does not record anything in the system's event log until XP formally assigns the computer a name, which is provided either by the user or contained in a file in the unattended XP install disk. This occurs right before XP starts a stage of the process known as the GUI-mode stage. Windows XP records several more entries into the event log after this and when the setup is complete, it records this event (which is used as the time at which the Windows XP install process is complete). From the perspective of a user, Windows XP still needs to install the user account which takes a few more minutes.

Benchmarking Computers and Computer Components

The major PC magazines all have their own benchmarks for testing the speed of PC's in different hardware configurations (*e.g.*, *PC Magazine's* benchmark programs can be found at: <http://www.pcmag.com/category2/0,1874,1938,00.asp> and PC World's benchmark programs can be found at: <http://www.pcworld.com/resource/article/0,aid,116888,00.asp>). There are also many websites such as Tom's Hardware (<http://www.tomshardware.com/>) and Anand Tech (<http://www.anandtech.com/>) that publish reviews with benchmarks of different PC configurations and types of hardware. There are sites with reviews that compare processors such as Zdnet <http://reviews.zdnet.co.uk/hardware/processors/memory/0,39024015,39164010,00.htm> and <http://www.storagereview.com> that are solely devoted to reviewing the performance characteristics of hard drives. The issue of how much RAM memory Windows XP needs and how its performance varies with the amount of RAM memory has also been examined. See, for instance, the discussions in <http://www.practicalpc.co.uk/computing/windows/ramneeds.htm> and http://reviews.cnet.com/4520-3672_7-5020549-9.html.

What these benchmarks show is that the most important components for Windows XP performance in different situations are processor speed, hard drive speed, the amount of RAM memory; and for games, the speed and memory of the video card. Since there are no visually demanding tasks during the Windows XP install process, only processor speed, hard drive speed, and RAM memory size will be considered.

Software Installation//Download Predictive Timers

When installing software or downloading from the Internet, it is customary that the supplier provides a visible indicator of how long it will take for the task to be completed. For an example, see: Sun's Download Manger: http://www.sun.com/download/sdm/sdm_features.xml, which is a widely used download managing program. It features simple, intuitive controls and indicators, including a graphical progress meter, download time prediction and completion time.

While there is not much information on how these timers work, they appear to work by comparing the fraction of the installation/download already completed to the time taken so far. Download timers appear to take into account current transfer rates, so the predicted time to completion can vary wildly and even increase over time. With software installation, a major source of variability revolves around what other programs are running at the same time.

For the installation of Windows XP, there is neither a variable transfer rate of data over the Internet or other programs running at the same time. This makes predicting the time required to install a new operating system of fundamentally different task.

Experimental Design/Statistics of Industrial Experiments

There is a great deal of information on how to conduct industrial experiments to test hypotheses both against a standard (which Microsoft's prediction of a 39 minute install time is taken to be) and of testing different configurations of components against each other (Box, Hunter and Hunter, 1978; National Institute of Standards and Technology, 2006). While much of this literature deals with complex situations, the main ideas of formal statistical hypothesis testing are easy to grasp. First, there needs to be replication in as carefully controlled environment as possible to determine how much random variation there is in the process being studied. Second, in order to compare different processes, it is best to vary only one component of one of the processes, so that if any differences are observed beyond the random variation, the process can be pinpointed to the component being varied. Third, if one wants look at the impact of varying aspects of multiple components, then a more complex experimental design must be used to be able to isolate the role of different factors. Fourth, an appropriate statistical test should be used to determine whether any difference observed is statistically significant in the sense that differences of roughly comparable magnitude would likely to be observed if the experiment was run repeatedly.

V. Materials

To practically test a fairly large number of different hardware configurations, it was necessary to determine how to assemble them using components from older computers that I had built or could acquire at a reasonably low cost. The first available computer had an AMD 3500+ processor, an ASUS A3N-E motherboard with an NFORCE 4 chipset, two 512MB OCZ PC3200 memory modules, an ATI X700 video card and a 7200 RPM 200GB Western Digital hard drive. The second available computer had an AMD 2800+ processor, an ASUS A7N8-X motherboard with an NFORCE2 chipset, two Corsair 512MB PC3200 memory modules, an ATI X800 video card and a 7200 RPM 200GB Western Digital hard drive. Both computers had the same on-board ethernet and sound chips, as well as a DVD reader and a DVD writer that were comparable. It was possible to under-clock the AMD 2800+ processor in the second computer by setting the GHz speed down from 1.66 to 1.33. When this was done, the motherboard BIOS recognized it as an AMD 2200+ processor. To these components, a Seagate 4.3 GB 4500 RMP hard drive and a

4.3 GB Western Digital 5400 RPM hard drive were purchased on Ebay, and a 256MB Corsair PC3200 Memory module was purchased from Fry's Electronics.⁶

From the literature review, it appears that the components likely to have the largest influence on Windows XP's installation time are the processor's speed, the amount of RAM memory and the hard drive's speed. Three processor speeds (AMD 3500+, AMD 2800+ and AMD 2200+), three RAM memory sizes (256MB, 512MB and 1GB [two 512MB modules]), and three hard drive speeds (7200 RPM, 5400 RPM and 4500 RPM) were used. The slight speed difference in the two ATI video cards between the two computers does not matter from the perspective of installing Windows XP since the installation process is not graphics intensive and the same drivers are loaded. Likewise, the difference between the OCZ and Corsair memory is unlikely to be large given that all of these modules are of the same speed. The difference in the characteristics of the hard drives and the motherboard chipsets may be of more importance in Windows XP install times. The hard drives are of very different sizes, 200 GB and around 4 GB. This seems most important when partitioning the drive, but should not play a large role in the actual installation since Windows XP is designed to install itself on the fastest location on each hard drive. Reviews of hard drives suggest that there sometimes are fairly large performance differences across drives of the same speed, so the results may be difficult to apply to hard drives other than the ones tested. The motherboard chipsets, while both of the same NFORCE 4 family, are different, so that the speed disparity between the AMD 3500+ processor and the AMD 2800+/2200+ processors may be due to the difference in the chipsets rather than the processor speeds. For now, the assumption will be made that the install time variations observed are entirely the result of differences in the processor speed and not the chipsets, with alternatives to this assumption being discussed below in Section IX.⁷

Appendix A contains a detailed description of the computer hardware used in this experiment.

VI. Procedures

The first step in setting up the procedures for the experiment was to determine how to record Windows XP install times at several different points in the install process. This could have been done by either recording the process with a video camera, or the procedure used here of recording the initial installation time and then using information contained in the event log.

The specific procedures used to record times related to the installation process were:

1. Synchronize times on two different computers utilizing the time.windows.com function in Windows XP.
2. Set motherboard BIOS to boot first from the CD, and second, from the hard drive.
3. For each experimental run, record date.
4. Insert unattended install disk.
5. At boot, hit enter to boot from CD.
6. Looking at second computer clock timer, record the time when XP first displays.

⁶ Originally there was an unused 5400 RPM hard drive from an earlier computer which was used for some early runs but its connector pins bent, necessitating a replacement from Ebay with the same model drive.

⁷ In principle, this assumption could always be tested by taking out the processors and installing them in the same motherboard or by getting two identical motherboards. In practice, motherboards only support a limited range of processor speeds.

7. When computer reboots after repartitioning disk and putting on new file system, record the time that the XP screen first appears. This is the official start of the install process.
8. After completion of the XP install process, click on Start Menu → Control Panel → Administrative Tools → Event Viewer → System Log.
9. Using time in [system.log](#), record the first real install event (naming of the machine). This occurs after the devices are installed and is about the time the graphical user interface (GUI) starts.
10. Using the time in [system.log](#), record the time at which XP installation setup completes.

Creating an Unattended Install CD

The next step is to create an “unattended” Windows XP installation CD that fills in requested information during the install process so that it does not stop at places where it would ask for your business information, what you want your computer to be named, etc. (Microsoft Hardware Forum, 2005; <http://tacktech.com/display.cfm?tid=202>). The CD must also reformat the hard drive before each installation run to eliminate the need to do it manually. Slipstreaming Service Pack 2 for Windows XP was used to make sure the most commonly used version of XP was installed. This was accomplished using nLite, a Windows installation customizer (<http://www.nliteos.com>). nLite was also used to install drivers for the chipset, video card, and monitor. However, getting nLite to correctly incorporate the NVIDIA chipset drivers so the video card would correctly install and the monitor resolution did not need to be set manually during the install process was troublesome. After nLite created the installation file, it was burned onto a CD using Nero Burning 6 Ultimate.

The next step was to assemble the particular hardware configuration being tested and synchronize the time. Once this was done, the Windows XP unattended install CD was inserted and the computer was booted from it. The procedures described above for recording times related to the install process were then followed. This was repeated ten times for each of the 27 different configurations described in the Materials Section, for a total of 270 runs.

Start and stop times for each run were recorded in the Excel spreadsheets shown in Appendix B. There is one Excel spreadsheet for each hardware configuration. These spreadsheets are set up to calculate the installation times and related variables and to calculate the t-statistic for the null hypothesis that average installation time is different from Microsoft’s predicted 39 minutes. Programming notes for the base Excel spreadsheet are also provided in Appendix B.

Experimental Design

It is straightforward to compare the 10 runs for XP install times for a particular hardware configuration against the 39 minute prediction of Microsoft. This can be done by comparing 39 minutes to the average install time for the hardware configuration and taking account of the variability of the install times (*e.g.*, the standard deviation). The usual statistical procedure for doing this when the sample size is not extremely large is a one sample, two-sided t-statistic (Peck and Devore, 2005). The null hypothesis is that the install time is Microsoft’s 39 minute prediction, with the alternative being that it is not equal. With a sample size of n , the calculation to be made is given by:

$$t = [(\text{mean install time in minutes}) - 39] / [\text{standard deviation of install time} / \sqrt{(n)}].$$

Sample size is the number of times the experimental treatment is replicated where a single replicant will be referred to as an installation run. In thinking about what sample size is needed, a decision must be made to determine how large of a difference the install time between hardware configurations is meaningful. Microsoft's 39 minute prediction will always be wrong if there is any variability in the time it takes Windows XP to install on a particular hardware configuration, and if the installation time is measured precisely enough. I decided that being able to detect a 1 minute difference was reasonable. This was roughly 10% of the install time on the hardware configuration I initially tested. Anything under one minute would either likely not be noticed or bother the person installing the operating system. The initial runs of Windows XP install times on the computer using a 7200RPM hard drive suggested that there was typically less than one minute between the fastest and slowest install times for a particular hardware configuration, with estimates of the standard deviation of the install time being around 0.3. With a standard deviation of this magnitude, a fairly small sample size has good power to detect a one minute difference between average install time for a particular hardware configuration and 39 minutes. Based on this, I decided that ten runs of each hardware configuration should be more than adequate for conducting the main hypothesis tests. In retrospect, using ten runs per hardware configuration turned out to be a good decision since the 5400 RPM and 4500 RPM hard drives had install times with considerably larger standard deviations.

I also wanted to test a fairly wide range of hardware currently in common use.⁸ If only two levels of a factor, such as processor and hard drive speed are used, then only a linear relationship can be estimated. If three or more levels of factors are used, then it is possible to determine whether the relationship is non-linear. Therefore, the three factors (processor speed, RAM memory size, and hard drive speed) were used with each taking on three levels. This yields 27 possible combinations which can be analyzed using a 3^3 (3x3) full factorial experimental design. This experimental design looks at all 27 unique combinations of hardware that can be put together using the variables to be manipulated. This design allows for tests of each of the 27 hardware combinations against Microsoft's estimated 39 minute install time, comparisons of hardware combinations that differ only by one of the factor levels, and for more complex comparisons involving changes in more than one of the factor levels. It also provided data that can be used in later regression models to predict install times as a function of factor levels.

Three factors are used: (a) processor, (b) memory, and (c) hard drive. Each of these factors can take on three levels for each factor. The processors are an AMD 3500+, an AMD 2800+, and an AMD 2200+. The RAM memory sizes used are 1 GB, 512 MB, and 256 MB. The hard drive speeds used are 7200 RPM, 5400 RPM, and 4500 RPM. The hardware configurations tested are shown in Table 1.

⁸ It would have been possible to look at an even broader range of hardware configurations, particularly on the high end. A few limited tests on a machine with a high end (3GZ) dual core Intel processor, 4GB of memory and a 10,000 RPM drive were faster than those reported here but not by as large a margin as might have been expected.

Table 1
Hardware Configurations

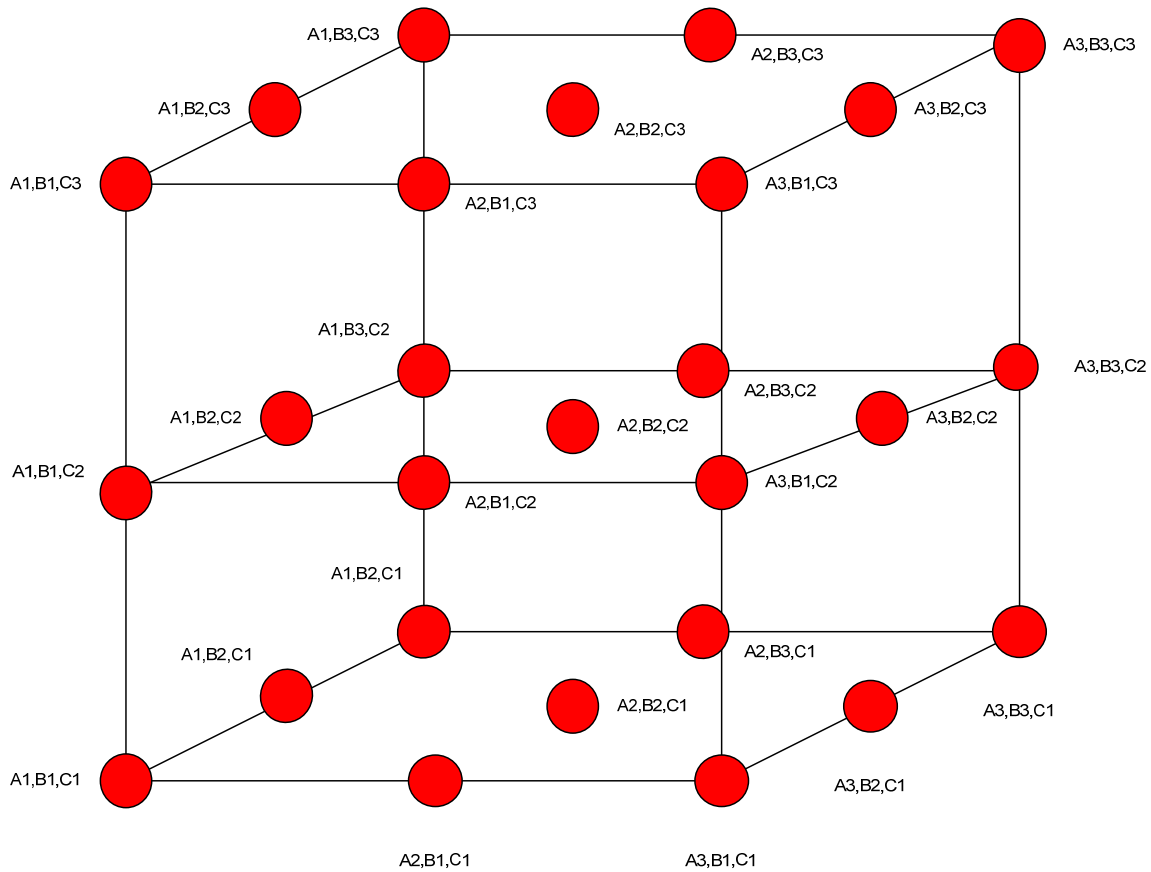
Configuration Number	Processor Speed	RAM Memory Size	Hard Drive Speed
1	AMD 3500+	1 GB	7200 RPM
2	AMD 3500+	1 GB	5400 RPM
3	AMD 3500+	1 GB	4500 RPM
4	AMD 3500+	512 MB	7200 RPM
5	AMD 3500+	512 MB	5400 RPM
6	AMD 3500+	512 MB	4500 RPM
7	AMD 3500+	256 MB	7200 RPM
8	AMD 3500+	256 MB	5400 RPM
9	AMD 3500+	256 MB	4500 RPM
10	AMD 2800+	1 GB	7200 RPM
11	AMD 2800+	1 GB	5400 RPM
12	AMD 2800+	1 GB	4500 RPM
13	AMD 2800+	512 MB	7200 RPM
14	AMD 2800+	512 MB	5400 RPM
15	AMD 2800+	512 MB	4500 RPM
16	AMD 2800+	256 MB	7200 RPM
17	AMD 2800+	256 MB	5400 RPM
18	AMD 2800+	256 MB	4500 RPM
19	AMD 2200+	1 GB	7200 RPM
20	AMD 2200+	1 GB	5400 RPM
21	AMD 2200+	1 GB	4500 RPM
22	AMD 2200+	512 MB	7200 RPM
23	AMD 2200+	512 MB	5400 RPM
24	AMD 2200+	512 MB	4500 RPM
25	AMD 2200+	256 MB	7200 RPM
26	AMD 2200+	256 MB	5400 RPM
27	AMD 2200+	256 MB	4500 RPM

Factor labels used are processor (a1=AMD 3500+, a2=AMD 2800+, a3=AMD 2200+), memory (b1=1 G, b2=512 MB, b3=256 MB), and hard drive (c1=7200, c2=5400, c3=4500).

The 3 x 3 experimental design used can be seen visually in Figure 1 to span the 3 levels of the 3 factors in a cube (National Institute of Standards and Technology, 2006).

Figure 1

Experimental Design 3 Factor by 3 Level Full Factorial



Processors

A1=AMD 3500+
A2=AMD 2800+
A3=AMD 2200+

RAM Memory

B1=1 GB
B2=512 MB
B3=256 MB

Hard Drive Speeds

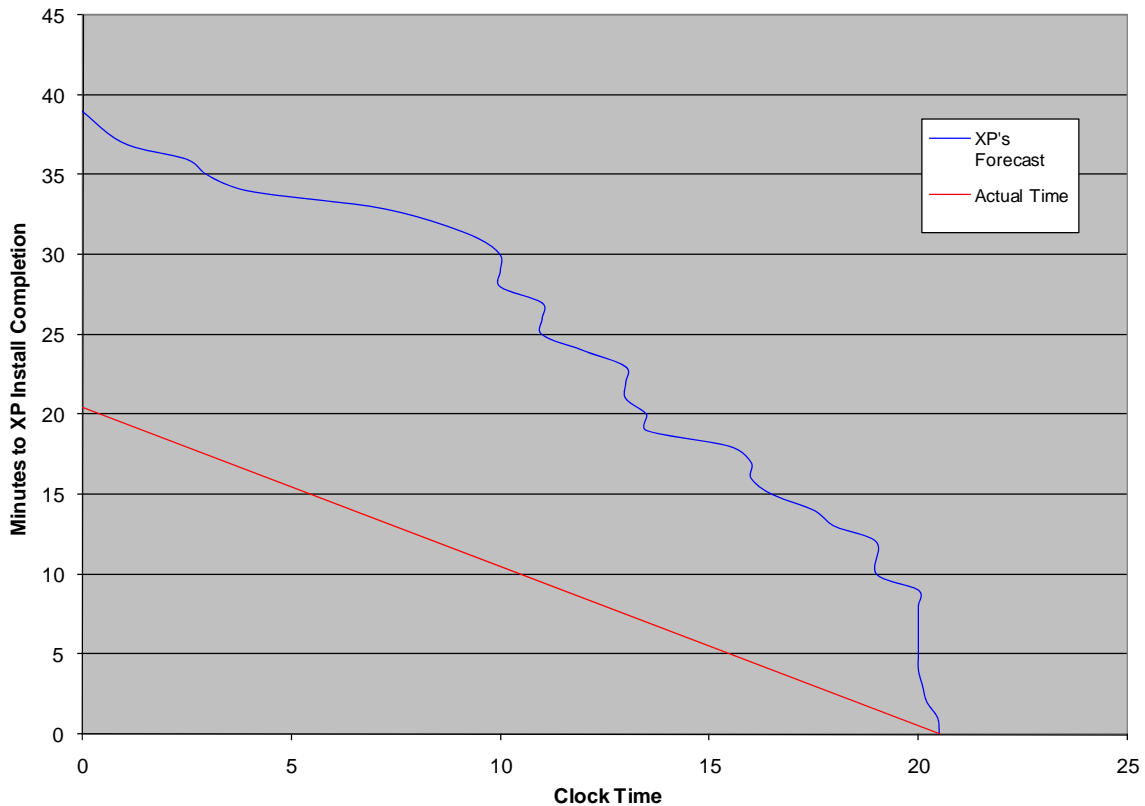
C1=7200 RPM
C2=5400 RPM
C3=4500 RPM

VII. Results

The first thing to note is that in addition to always starting out at 39 minutes, the Windows XP forecast of time remaining until the installation is completed is inaccurate throughout the install process, as this example run with one of the hardware configurations shows in Figure 2. More extreme versions (*e.g.*, with 7200RMP hard drives) and less extreme versions (*e.g.*, with 4500RPM hard drives) of this figure starting out at 39 minutes can also be plotted.

Figure 2

Actual and Forecasted Windows XP™ Install Times
[Hardware: AMD 3500+ Processor, 1GB RAM, 5400RPM Hard Drive]



The average install times from each of the 27 hardware configurations is given below in Table 2.⁹

Table 2
Average XP Install Times in Minutes by Hardware Configuration

Processor	RAM Memory	Hard Drive Speed		
		7200RPM	5400RPM	4500RPM
AMD3500+	1GB	12.49	21.69	28.63
AMD3500+	512MB	12.04	23.83	35.12
AMD3500+	256MB	11.19	30.31	37.06
AMD2800+	1GB	16.50	21.21	34.33
AMD2800+	512MB	16.24	30.21	42.28
AMD2800+	256MB	16.11	35.61	43.89
AMD2200+	1GB	15.17	23.71	31.56
AMD2200+	512MB	15.88	33.08	44.29
AMD2200+	256MB	17.31	35.95	44.11

Figures 3, 4 and 5 show the information contained in Table 2 in a graphical form which clearly shows that the hard drive speed has the largest influence on install times. Hard drive speed is increasing from left to right and the RAM size is decreasing from front to back. Install time is on the vertical axis and can be read following the line around on the grey background. Looking at Figure 3, it is easy to see that the drive speed has a significant impact. Larger RAM sizes seem to improve install speeds with a slow hard drive but have little impact on install speeds with a 7200 RPM hard drive. Similarly, comparing Figure 3 (for the AMD 3500+ processor) to the other processor speeds in Figures 4 and 5 suggest that using this processor results in faster install times while the comparison between the other two processor speeds is less clear. Overall, Table 2 and the related figures suggest that some combination of bottlenecks and/or substitution effects make the install time not a linearly additive function of the factor levels used.

⁹ The mean install time over all of the 270 trials was 27.27 minutes with a standard deviation of 10.92 minutes. Median install time was less than a minute longer at 28.08 minutes with a minimum install time of 11.02 minutes and a maximum install time of 49.95 minutes.

Figure 3

**Windows XP™ Install Times For AMD 3500+ Processor
As A Function of Hard Drive Speed and RAM Memory Size**

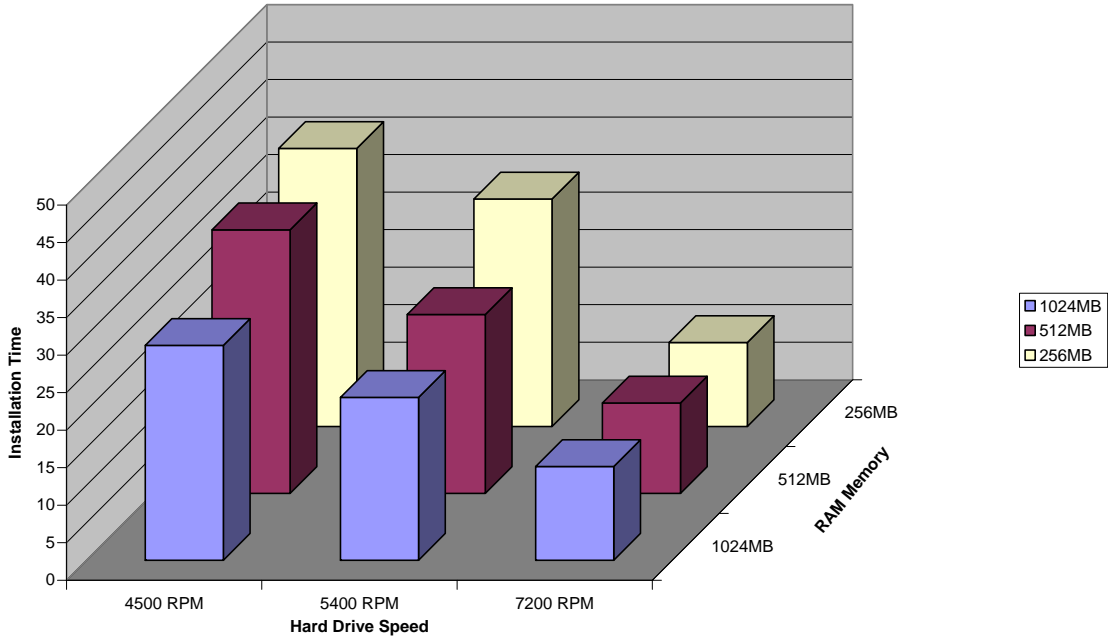


Figure 4

**Windows XP™ Install Times For AMD 2800+ Processor
As A Function of Hard Drive Speed and RAM Memory Size**

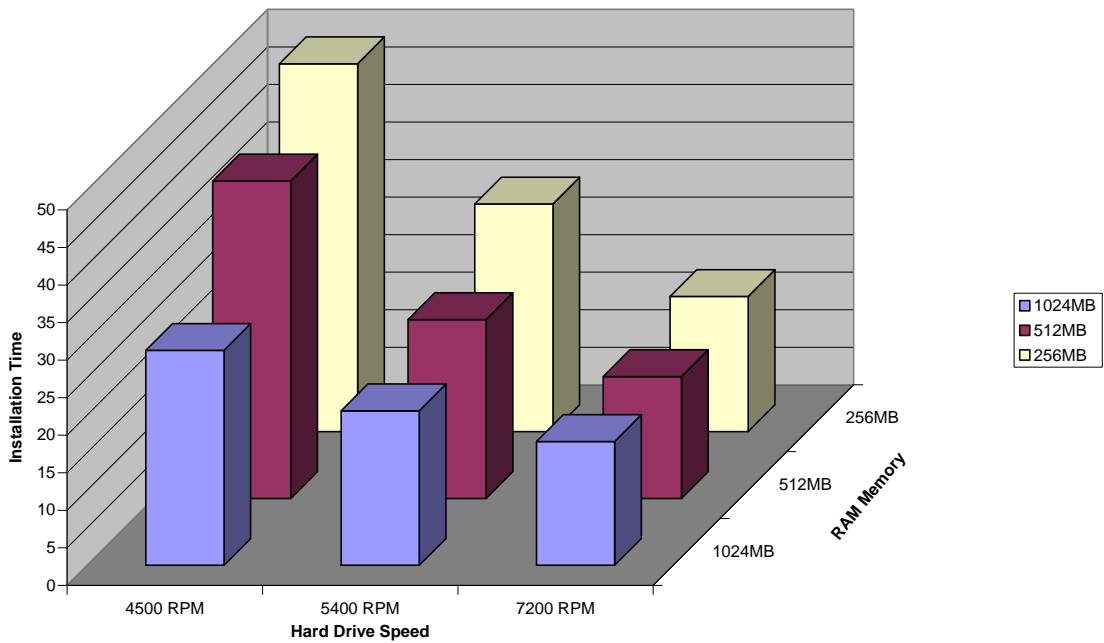
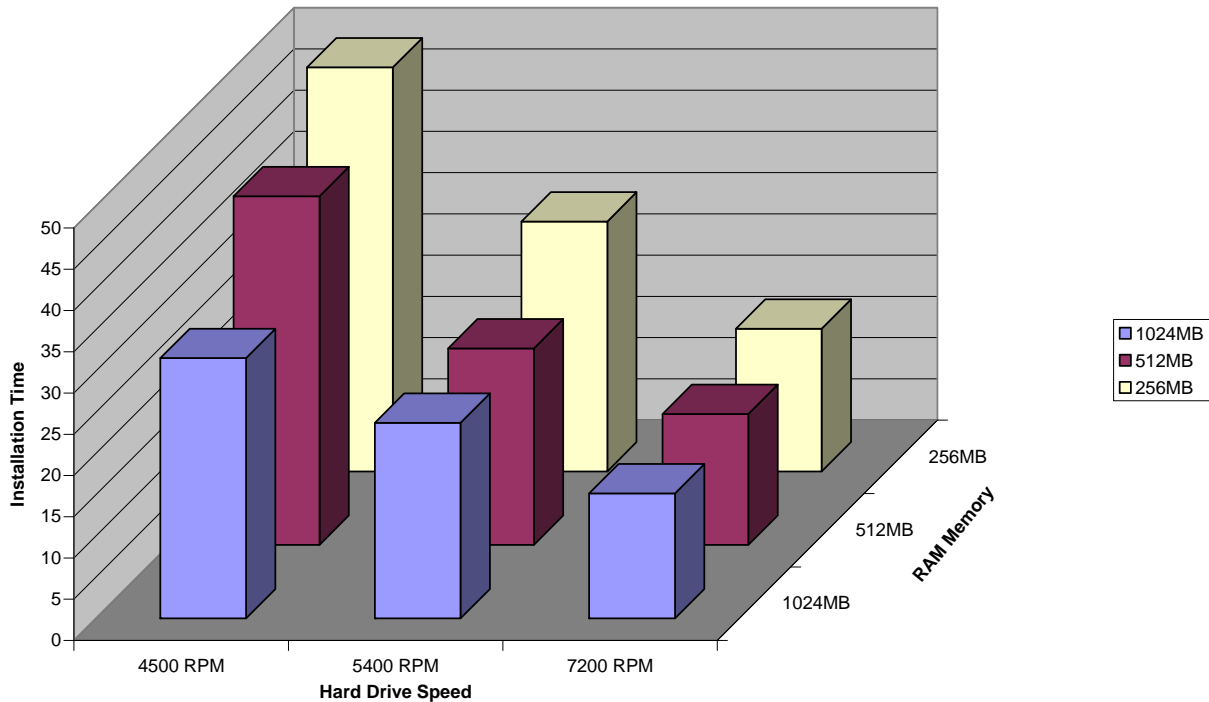


Figure 5

**Windows XP™ Install Times For AMD 2200+ Processor
As A Function of Hard Drive Speed and RAM Memory Size**



The main statistical analysis performed is to calculate a two-sided t-test of the average install time for each hardware configuration against the null hypothesis of Microsoft's 39 minute prediction for Windows XP. The two-sided t-test is frequently used in industrial experiments when comparing the mean value from an experiment against a known standard when one wants to know if the experimental result is different from the standard in either a smaller or larger direction (Box, Hunter and Hunter, 1978; Peck and Devore, 2005; National Institute of Standards and Technology, 2006). The two sided t-test is straightforward to program in Excel (Berk and Carey, 2003), by taking the difference between the mean install time for the hardware configuration and subtracting off 39 minutes. This number is then divided by the standard error of the mean, which is the standard deviation divided by the square root of the sample size, which is 10 minus 1 (to correct for small sample bias). This quantity $(\text{mean install time} - 39) / (\text{standard deviation} / \sqrt{10})$ is the calculation for the t-statistic noted earlier. The t-statistic is larger (in absolute value terms) the larger the difference between mean install time and 39 minutes, the smaller the standard deviation, or the bigger the sample size. To get the probability that the difference reflected in the size of the t-statistic is due to random sampling variability in the runs, the t-statistic is compared to the t-distribution ($df=n-1$) and a probability level is obtained. Large t-statistics in absolute value terms result in small probability levels. The two most common probability levels used are .05 (95% confidence level) and .01 (99% confidence level). Excel has built-in functions for calculating averages, standard deviations, and the t-distribution.

Table 3
Two Sided t-Tests of Null Hypothesis of 39 Minute Windows XP™ Install Time
For 27 Different Hardware Configurations

Hardware Configuration	Mean Install Time	Install Time Standard Dev.	t-test Versus 39 Minutes	Probability of t-statistic
A1, B1, C1	12.49	0.29	-291.90	p < .001
A1, B1, C2	21.69	0.30	-184.77	p < .001
A1, B1, C3	29.16	0.35	-89.66	p < .001
A1, B2, C1	12.04	0.24	-349.82	p < .001
A1, B2, C2	23.85	0.28	-169.43	p < .001
A1, B2, C3	35.12	0.26	-47.84	p < .001
A1, B3, C1	11.19	0.18	-47.89	p < .001
A1, B3, C2	28.89	0.98	-32.73	p < .001
A1, B3, C3	36.19	0.24	-36.27	p < .001
A2, B1, C1	16.50	0.43	-163.72	p < .001
A2, B1, C2	21.21	1.35	-41.76	p < .001
A2, B1, C3	34.33	1.93	-7.656	p < .001
A2, B2, C1	16.24	0.33	-218.41	p < .001
A2, B2, C2	30.21	2.51	-11.07	p < .001
A2, B2, C3	42.28	1.53	6.80	p < .001
A2, B3, C1	16.11	0.41	-175.10	p < .001
A2, B3, C2	35.61	0.44	-24.29	p < .001
A2, B3, C3	43.89	0.91	17.01	p < .001
A3, B1, C1	15.17	0.30	-251.98	p < .001
A3, B1, C2	23.71	0.43	-113.06	p < .001
A3, B1, C3	31.56	0.40	-59.09	p < .001
A3, B2, C1	15.88	0.46	-159.02	p < .001
A3, B2, C2	33.08	0.65	-28.94	p < .001
A3, B2, C3	44.29	0.35	47.37	p < .001
A3, B3, C1	17.31	0.51	-134.43	p < .001
A3, B3, C2	35.95	0.61	-15.68	p < .001
A3, B3, C3	44.11	3.10	5.21	p = 0.001

Processors

A1=AMD 3500+
A2=AMD 2800+
A3=AMD 2200+

Memory Sizes

B1=1 GB
B2=512 MB
B3=256 MB

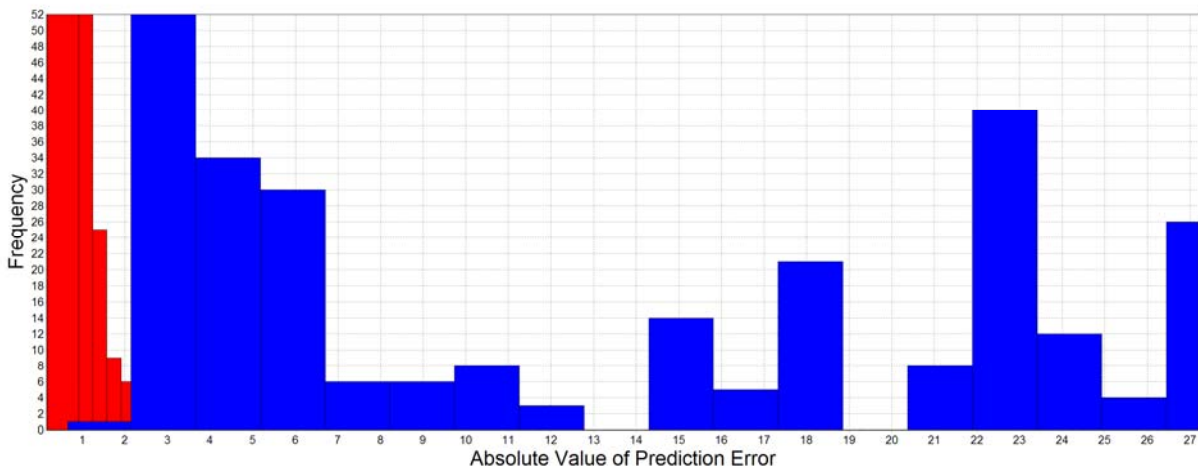
Hard Drive Speeds

C1=7200 RPM
C2=5400 RPM
C3=4500 RPM

VIII. Predictive Models

Using the average Windows XP install time from the particular hardware configuration results in a dramatic improvement in the absolute value of the prediction error, from an average error of 13.17 minutes using Microsoft's 39 minute prediction, to an average error of 0.66 minutes,. Figure 6 shows a histogram of the prediction errors in absolute value terms, as predictions that are too long or too short have been assumed to be equally bad.¹⁰

Figure 6
Histogram of Absolute Value of Windows XP™ Install Time Prediction Errors



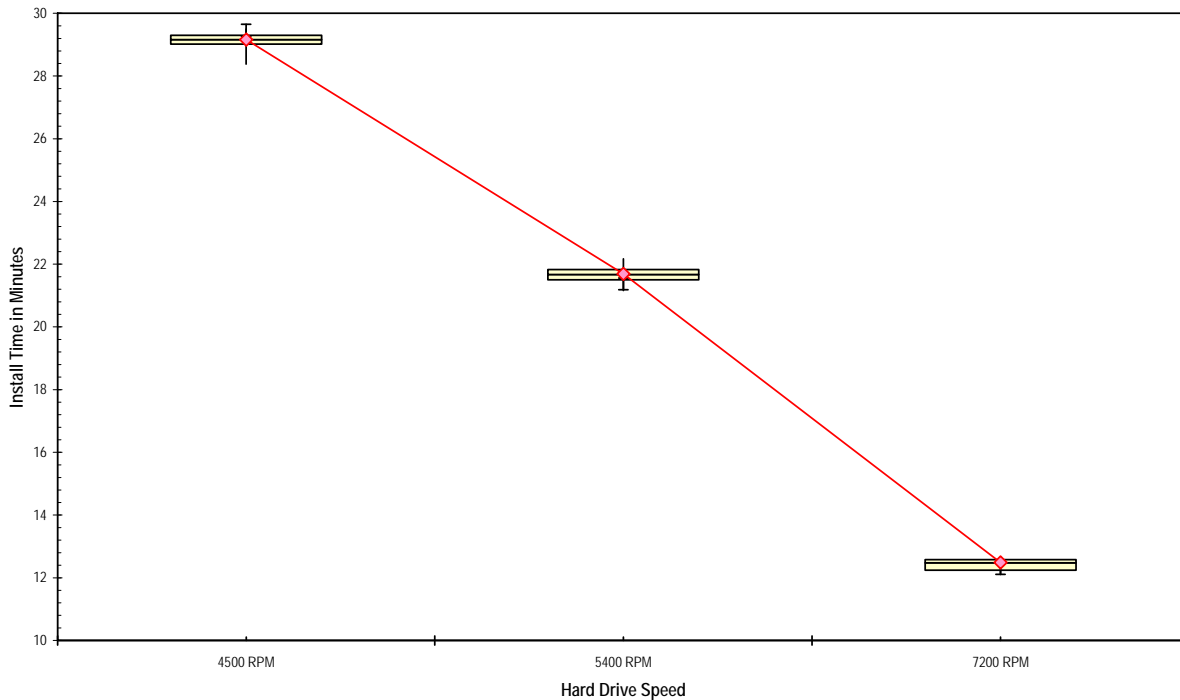
Mean of Install Time from Specific Hardware Configuration as Predictor (Red)
Microsoft's 39 Minute Prediction (Blue)

This approach to predicting XP installation times works well because the variability in install times with the same hardware configurations is small relative to the degree of variability seen between many hardware configurations as shown in the Box and Whisker Plot (Figure 7) for three different hard drive speeds using AMD 3500+ processor speed and 1GB of memory. The black line in the middle of the yellow box is the median install time with top and bottom of the box indicating the 75th and 25th percentiles and the vertical line indicating the range of the data from the maximum to the minimum. For all three hard drive speeds, and, particularly for the 7200 RPM drive, the variability of the runs is quite small.

¹⁰ Figure 6 was plotted using Fast Stats, an Excel add-on package (<http://www.fatesoft.com>). Figure 7 uses an Excel macro from John Peltier: <http://www.peltiertech.com/Excel/Charts/ComboCharts.html#BoxWhisker> that was free of charge. The regression models in this section were estimated using another Excel add-on package called Analyse-it (<http://www.analyse-it.com>).

Figure 7

Box and Whisker Plot
10 Replications for Each Hard Drive Speed
Holding AMD 3500+ and 1GB Memory Configuration Constant



Using the average install time for a particular hardware configuration also works well because it is equivalent to a regression model with the main effects and all of the interaction terms from the 3 x 3 experimental design used (National Institute of Standards and Technology, 2006). All of the other variation in install runs has to be from random fluctuations from things such as temperature and the particular physical location on the hard drive where the install process started. Since Microsoft tests a large number of hardware configurations, it would be possible to record these and simply look up the mean install time for a particular configuration in a table at the beginning of installation.

An interesting question is whether a much simpler regression model using just the main effect levels for processor speed, RAM memory size, and hard drive speed predicts almost as well. The statistical results for this model using indicator variables (1,0) for the presence of particular hardware are provided in Table 4.¹¹ Table 4 shows the expected result, that what matters most is hard drive speed. The 7200 RPM hard drive (HD7200) is 24.3 minutes faster than the 4500 RPM hard drive and the 5400 RPM hard drive (HD5400) is 11.1 minutes faster than the 4500 RPM hard drive. The AMD 3500+ processor (AMD3500) is 4.9 minutes faster than the AMD 2200+ processor, while the AMD 2800+ processor (AMD2800) is only 0.5 minutes faster, which is the only model parameter which is not significantly different from zero (the base configuration) at the $p = .05$ level. The 1GB memory size (Mem1GB) is 1.7 minutes faster than the 256 MB size and the 512 MB memory (Mem512MB) is 1.7 minutes faster than

¹¹ The omitted reference levels are the slowest/smallest hardware level for each factor.

the 256 MB size. This model explains 93% of the variability in the installation times. The prediction errors (average absolute prediction error is just over 8 minutes) from this model are substantially better than those from Microsoft’s stated 39 minutes which has an average absolute prediction error over 13 minutes.

Table 4
Main Effects Linear Regression Model Predicting Install Time*

Term	Coefficient	Standard Error	p-Value
Intercept	43.4857	0.4719	<0.0001
AMD3500	-4.8530	0.4369	<0.0001
AMD2800	-0.4504	0.4369	0.3036
Mem1GB	-6.2380	0.4369	<0.0001
Mem512MB	-1.7093	0.4369	<0.0001
HD7200	-24.3000	0.4369	<0.0001
HD5400	-11.1033	0.4369	<0.0001
Sample Size 270	R-square 0.93	Regression SE 2.9308	

*Base configuration is AMD2200+ processor, 256 MB memory and a 4500 RPM hard drive.

The problem with forecasts based on the model in Table 4 is that the best hardware configurations are predicted to have install times that are too fast. For instance, looking at the average install times in Table 2, increasing memory does no good (and perhaps even a little harm) once one has a fast processor and a hard drive. Table 2 shows there are other combinations of hardware components where increasing the level of one of the components does not decrease the average install time. This may be because one of the components is serving as a bottleneck to further reduce the install time. Table 5 contains a regression model with the main effects (processor, memory, and hard drive speed levels) and the nine interaction terms that were significant at the $p = .05$ level (the other interaction terms were dropped). This model has a much smaller average absolute prediction error of (~1.5 minutes) and explains 98% of the variability in install time.

Table 5
Main Effects Plus Interaction Terms Regression Model Predicting Installation Time

Term	Coefficient	Standard Error	p-Value
Intercept	44.0074	0.2744	<0.0001
AMD3500+	-7.2236	0.2636	<0.0001
AMD2800+	-0.8972	0.2636	<0.0001
Mem1GB	-9.1674	0.4371	<0.0001
Mem512MB	0.3447	0.2636	0.1921
HD7200	-26.3331	0.2636	<0.0001
HD5400	-7.8176	0.3487	<0.0001
AMD3500*Mem1GB	7.1119	0.4566	<0.0001
AMD2800*Mem512MB	1.3406	0.4566	0.0036
Mem1GB*HD7200	6.0992	0.4566	<0.0001
Mem1GB*HD5400	-5.7635	0.5104	<0.0001
Mem512MB*HD5400	-4.0936	0.4566	<0.0001
Sample Size 270	R-square 0.98	Regression SE 1.4437	

The standard approach to predicting install times is to look at how much of the program has installed versus how much time has passed to forecast the remaining time left until completion. This approach has the disadvantage of not having an accurate forecast when the installation process starts but it may provide a more accurate forecast after some point in the install process has been reached.

The first entry in the Windows XP system event log is the assignment of an internal computer name. The regression model shown in Table 6, using the time between when the installation starts and TimeToName as the only predictor variable, results in prediction errors somewhat larger than the simple regression model, with only the main effects (Table 4) or the more complicated model with interaction terms (Table 5). This was somewhat surprising as it suggests that knowing the hardware configuration is more important than even knowing how fast the first third of the installation had taken when predicting the final installation time.

Table 6
TimeToName Linear Regression Model Predicting Install Time

Term	Coefficient	Standard Error	p-Value
Intercept	0.1689	0.6020	0.7792
TimeToName	2.9795	0.0619	<0.0001
Sample Size 270	R-square 0.90	Regression SE 3.5195	

Adding the variable TimeToName to the regression model with main effects and interaction terms (Table 7) further increases the percent of the variability in the dependent variable explained to 99%. The average absolute prediction error for this model is now under one minute. Implementing this model would require rewriting the installation timer software to record TimeToName. The value of this variable could then be used with the estimated coefficients from the regression model in Table 7, and the hardware configuration to provide a

more accurate updated estimate of installation time at the point where the machine was named. This should not be a difficult feature to program into an operating system installer and may be particularly useful if installation time information for the computer's specific hardware configuration is not available from prior testing. This issue is considered further in the next section.

Table 7
Main Effects Plus Interaction Terms and TimeToName Regression Model

Term	Coefficient	Standard Error	p-Value
Intercept	35.4168	1.0767	<0.0001
AMD3500+	-5.6101	0.3067	<0.0001
AMD2800+	-0.7888	0.2355	0.0009
Mem1GB	-8.4701	0.3992	<0.0001
Mem512MB	0.4545	0.2355	0.0548
HD7200	-21.5071	0.6342	<0.0001
HD5400	-6.3940	0.3563	<0.0001
AMD3500*Mem1GB	5.5240	0.4511	<0.0001
AMD2800*Mem1GB	0.8439	0.4118	0.0036
Mem1GB*HD7200	6.0578	0.4074	<0.0001
Mem1GB*HD5400	-4.3462	0.4871	<0.0001
Mem512MB*HD5400	-3.4237	0.4154	<0.0001
TimeToName	0.6313	0.0771	0.0001
Sample Size 270	R-square 0.99	Regression SE 1.2881	

IX. Threats to Study Validity & Suggestions for Further Study

Source of Variability Not Considered

Since this is an experimental study, the main threat to the validity of its results, other than incorrect implementation, is the possibility that other important sources of variability have been overlooked.¹² These largely revolve around the properties of the hardware tested. The problem occurs on several levels. It was assumed that the performance variability associated with the particular 200 GB Western Digital 7200RPM hard drive used in the trial runs is the same for all 200 GB Western Digital 7200RPM hard drives. This is not likely to be the case. Two different hard drives, motherboards, or processors of the same make and model can have different average performances and degrees of variability. It is well known, for example, that particular batches of processors over-clock better and/or are more resistant to heat. It would be possible to look at this additional source of variability by not only running replications with the same components but also with different components of the same make and model. This would likely show the

¹² The distributional assumption underlying the t-tests conducted might also be questioned. This assumption can be checked by using non-parametric one-sample Wilcoxon signed rank tests. Entering the install times into the statistical program R from the experiments and using the function `wilcox.test()` with 39 minutes as the null hypothesis, still results in a rejection of the null hypothesis for each hardware configuration tested at $p < .01$.

absolute prediction errors to be somewhat larger than those in this report. However, the effect might not be that large if one is running common components as is the case in this report, since those components are usually thought to be manufactured to fairly high quality control standards.

The problem becomes much harder, though, if all that is being read off the BIOS is the size, speed, and make of the hard drive.¹³ The second generation 10,000 RPM Western Digital Velociraptor is much faster than its predecessor, whose speed is now matched by some recently released 7200 RPM drives. What this means is that the number of hardware configurations that would need to be examined for a table lookup approach to be successful has grown enormously and it is easy to see why Microsoft or any other operating system designer cannot possibly test all of the possible hardware configurations to get install time estimates.

There are other sources of variability that have also not been taken into account. Noted earlier was the use of similar but not identical NVIDA motherboards, one an NFORCE2 board and one an NFORCE4 board, as well as two different ATI video cards. In both cases, the drivers being loaded were either similar (NFORCE) or identical (ATI) but it is possible that the speed of the particular hardware component plays some role. A matched pair of DVD drives was used in this experiment, but optical drives can also vary in read speeds. Another potential source of variability is environmental conditions, particularly temperature level; for instance, extreme heat slows down processor speed. All tests reported here were conducted indoors during the winter with a fairly limited temperature range (~20F). The role of temperature could be examined by running one of the hardware configurations in a room heated to different temperatures. Another possible influence on installation time is the presence of other components in the system. Older computers once had separate sound cards and network cards. These are now incorporated into modern motherboards, so the experimental hardware configurations used in this report would be typical in this respect; however, high-end systems often incorporate expensive sound cards and RAID controllers. It would be possible to run experiments with such components in the computer to see how they influence installation time. Finally, and most obviously, only a small fraction of the possible hardware configurations has been tested. In particular, no Intel processors have been considered nor have any motherboards been considered that use Intel chipsets.

Estimating a More General Predictive Model

Estimating a more general predictive model for the Windows XP installation time is one way to address the additional sources of hardware variability noted above and for dealing with the issue of obtaining installation time predictions for new hardware that had not been previously tested. Ideally, this predictive model would be based on a regression equation that used as its inputs short performance speed tests (*e.g.*, hard drive write speed) on each of the key components carried out at the very beginning of the install process. Many such performance tests have been proposed and reported in computer magazines. It is unclear which would serve as the best predictors of install time, but this is a variable selection problem (Neter, Wasserman and Kutner, 1996). Developing a set of data on which to estimate such a forecasting model and the specification of such a model are considerably beyond the scope of this report, although the methodology for doing so is well developed (Neter, Wasserman and Kutner, 1996). In addition to the statistical issues in deriving an experimental design to collect the data for estimating this model, it would require access to the operating system installer in order to embed routines to test component performance.

¹³ The alternative is to read off the exact model identification number from the BIOS but this requires that the properties of the specific component that relate to XP install time be stored within the XP installation files.

X. Conclusion

The null hypothesis that Windows XP always installs in 39 minutes irrespective of the hardware configuration of the computer is clearly rejected in favor of the alternative, that the hardware configuration influences install time. Average install time was statistically different from 39 minutes in all 27 hardware configurations tested at the 99% confidence level.

Given the rejection of 39 minutes as an unbiased installation time estimate for any of the 27 hardware configurations, can a more accurate prediction be developed? From Table 2, the hard drive speed had the largest and most consistent effect on the average install time. For instance, the 7200 RPM hard drive is always at least 16 minutes faster than the 4500 RPM hard drive across all hardware configurations. In contrast, while increasing processor speed or RAM memory size usually increases average install time, this is not always the case; suggesting that one of the hardware components is the bottleneck to further decreases in install time.

The variability of install times for a particular hardware configuration is usually quite small. This was particularly true for runs with the 7200 RPM hard drive, the most common speed installed in new computers. In contrast, differences in average install times for different hardware configurations are often quite large. Using mean install time for a particular hardware configuration results in an average (absolute) prediction error of 0.66 minutes. In contrast, using Microsoft's 39 minute forecast, the average (absolute) prediction error is over 13 minutes.

Since Microsoft tests a very large number of hardware configurations to help reduce compatibility problems with Windows XP, it would be possible to place the average from each configuration in a database table. Motherboard chipsets and processors (including Intel processors not covered in this experiment) are the most extensively tested. This table could be accessed at the time Windows XP started to install to get the prediction of the install time by reading the essential hardware configuration information from the computer's BIOS.

New hardware may still produce some problems. While all 7200 RPM hard drives may be sufficiently alike from an install time perspective, the new 10,000 RPM Western Digital Velociraptor dramatically cuts Windows XP install time (to under 7 minutes). It should be possible to develop a predictive model using short performance tests on the key hardware components as the inputs which would overcome both the problem of individual component variability and that of new components. Selecting these performance tests, programming them into installation software, and assembling a database on which to construct a more general installation time prediction model is the logical next research step to take.

It reflects badly on the reliability of Windows XP, Microsoft's most commonly used operating system, to be so far off the mark in its first task of predicting install time. Failing to provide an estimate of installation time at all, as Vista now does, is not the right solution. My results show that the Windows XP install time forecast problem can be fixed. The approaches developed in this report could also be used in other operating systems including Windows 7 and Linux. The key insight is that since there are no other processes going on, such as internet downloads or other programs running in the background that could influence installation speed, install times for an operating system can be predicted to an acceptable degree of accuracy using the characteristics of a relatively small number of hardware components.

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XII. Appendices

Appendix A: Detailed Hardware Configurations

Appendix B: Excel Spreadsheets

1. Spreadsheet programming notes
2. Spreadsheets for each of the 27 Hardware Configurations (10 Runs Each)
 - a. AMD 3500+ Computer Runs
 - b. AMD 2800+ Computer Runs
 - c. AMD 2200+ Computer Runs

Appendix A

Detailed Hardware Configurations

Hardware Configurations for Computer 1

ASUS A8N-E Motherboard with ethernet and sound

AMD 3500+ (can be over but not under clocked)

1G Memory (OCZ DDR400 Premium) in two 512MB modules

Can remove one 512MB module to get 512MB Configuration

Have 256 MB Corsair DDR400 module

Motherboard will not accept lower than 256MB module

Three Hard Drives Can Be Easily Swapped Out

4500 RPM 4.3 GB Seagate ST3434A2

5400 RPM 4.3 GB Western Digital Caviar AC24300

7200 RPM 200 GB Seagate Barracuda 7200.7 Plus ST3200822A

16X Pioneer DVD Reader

Pioneer DVD Writer (installed but not used)

ATI Radeon 9700 Video Card

Dell Ultasharp 1900FP LCD Monitor

Hardware Configurations for Computer 2

ASUS A7N8X-X Motherboard with ethernet and sound

AMD 2800+ (can be under clocked and recognized as AMD 2200+)

1G Memory (Corsair DDR400) in 2 512MB modules

Can easily remove one 512MB module to get 512MB Configuration

Have matching 256MB Corsair DDR400 module

Motherboard will not accept lower than 256MB module

Three Hard Drives Can Be Easily Swapped Out

4500 RPM 4.3 GB Seagate ST3434A2

5400 RPM 4.3 GB Western Digital Caviar AC24300

7200 RPM 200 GB Seagate Barracuda 7200.7 Plus ST3200822A

16X Pioneer DVD Reader

Pioneer DVD Writer (installed but not used)

ATI Radeon 9800 Pro Video Card

Viewsonic VX 900 Monitor

Appendix B

Excel Spreadsheets

Programming Notes For Experiment Recording Spreadsheet

1. Enter hardware specifications at bottom of sheet for process, memory, and drive
2. Enter date of experiment in month/day format
3. Enter h:mm:ss AM/PM for times
4. Col F is E – C in time format
5. Col G is E – C converted to fractions of a minute using $(E - C) * 24[\text{hours}] * 60[\text{minutes}]$ to convert Excel's internal time recording format
6. Col H is D – C converted to fractions of a minute
7. Col I is G – mean [G13]
8. Average is of G2:G11
9. Standard deviation is of G2:G11
10. t-test is $(G13 - 39)/(G14/\text{sqrt}(10))$
11. Prob(t-statistic) is TDIST(abs(G15), 9, 2)
12. Format decimal columns to show 2 decimal places except for Prob(t-statistic) which gets 3 places

Spreadsheets for the 27 Hardware Configurations (10 Runs Each)

Ordered by process speed, memory size, hard drive speed

AMD 3500+ Computer Runs

Ordered by memory size then hard drive speed

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
9/29	9:24:08 PM	9:31:40 PM	9:35:33 PM	9:44:38 PM	0:12:58	12.97	3.88	0.48
9/29	9:55:45 PM	10:02:20 PM	10:06:59 PM	10:15:13 PM	0:12:53	12.88	4.65	0.39
9/29	10:19:24 PM	10:26:02 PM	10:30:31 PM	10:38:34 PM	0:12:32	12.53	4.48	0.04
9/29	10:44:32 PM	10:51:07 PM	10:55:25 PM	11:03:17 PM	0:12:10	12.17	4.30	-0.32
9/29	11:10:31 PM	11:17:03 PM	11:21:31 PM	11:29:44 PM	0:12:41	12.68	4.47	0.19
9/30	9:29:02 AM	9:35:33 AM	9:39:47 AM	9:47:49 AM	0:12:16	12.27	4.23	-0.22
9/30	11:21:41 AM	11:28:11 AM	11:32:33 AM	11:40:37 AM	0:12:26	12.43	4.37	-0.06
9/30	12:01:28 PM	12:08:14 PM	12:12:19 PM	12:20:25 PM	0:12:11	12.18	4.08	-0.31
9/30	12:35:24 PM	12:41:51 PM	12:46:09 PM	12:54:24 PM	0:12:33	12.55	4.30	0.06
9/30	5:05:38 PM	5:12:13 PM	5:16:24 PM	5:24:27 PM	0:12:14	12.23	4.18	-0.26
Average						12.49		
Stand. Dev.						0.29		
t-test v. 39min						-291.90		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	1 GB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
10/2	10:20:30 AM	10:38:33 AM	10:47:56 AM	11:00:50 AM	0:22:17	22.28	9.38	0.59
10/2	4:40:35 PM	4:28:42 PM	4:37:51 PM	4:50:31 PM	0:21:49	21.82	9.15	0.13
10/2	11:07:54 PM	11:16:12 PM	11:25:28 PM	11:38:08 PM	0:21:56	21.93	9.27	0.24
10/2	11:50:10 AM	11:58:35 AM	12:07:29 PM	12:20:09 PM	0:21:34	21.57	8.90	-0.12
10/2	12:24:48 PM	12:32:43 PM	12:43:31 PM	12:54:24 PM	0:21:41	21.68	10.80	-0.01
10/3	1:02:54 AM	1:10:43 AM	1:19:42 AM	1:32:31 AM	0:21:48	21.80	8.98	0.11
10/3	10:10:12 AM	10:18:10 AM	10:27:01 AM	10:39:44 AM	0:21:34	21.57	8.85	-0.12
10/3	10:53:52 AM	11:01:41 AM	11:10:27 AM	11:23:20 AM	0:21:39	21.65	8.77	-0.04
10/3	7:26:29 PM	7:34:16 PM	7:45:48 PM	7:55:32 PM	0:21:16	21.27	11.53	-0.42
10/3	8:01:48 PM	8:09:38 PM	8:18:12 PM	8:30:57 PM	0:21:19	21.32	8.57	-0.37
Average						21.69		
Stand. Dev.						0.30		
t-test v. 39min						-184.77		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	1 GB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/12	12:47:16 AM	12:55:14 AM	1:06:45 AM	1:24:25 AM	0:29:11	29.18	11.52	0.02
12/12	1:33:20 AM	1:42:20 AM	1:53:55 AM	2:11:38 AM	0:29:18	29.30	11.58	0.14
12/12	2:42:15 AM	2:51:12 AM	3:02:44 AM	3:20:20 AM	0:29:08	29.13	11.53	-0.03
12/12	3:27:45 AM	3:36:38 AM	3:48:24 AM	4:06:28 AM	0:29:50	29.83	11.77	0.67
12/12	4:26:26 AM	4:35:30 AM	4:47:04 AM	5:04:56 AM	0:29:26	29.43	11.57	0.27
12/12	5:21:42 AM	5:30:36 AM	5:41:43 AM	5:59:37 AM	0:29:01	29.02	11.12	-0.14
12/12	9:50:34 AM	9:59:39 AM	10:10:15 AM	10:28:41 AM	0:29:02	29.03	10.60	-0.13
12/12	10:54:03 AM	11:02:50 AM	11:13:55 AM	11:31:33 AM	0:28:43	28.72	11.08	-0.44
12/12	11:39:18 AM	11:48:00 AM	11:59:31 AM	12:17:19 PM	0:29:19	29.32	11.52	0.16
12/13	1:52:14 AM	2:01:04 AM	2:12:06 AM	2:29:42 AM	0:28:38	28.63	11.03	-0.53
Average						29.16		
Stand. Dev.						0.35		
t-test v. 39min						-89.66		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	1 GB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
9/30	5:35:15 PM	5:41:45 PM	5:45:43 PM	5:54:00 PM	0:12:15	12.25	3.97	0.21
9/30	6:32:47 PM	6:39:23 PM	6:43:31 PM	6:51:53 PM	0:12:30	12.50	4.13	0.46
9/30	7:07:18 PM	7:13:50 PM	7:17:46 PM	7:25:54 PM	0:12:04	12.07	3.93	0.03
9/30	8:02:55 PM	8:09:29 PM	8:13:30 PM	8:21:44 PM	0:12:15	12.25	4.02	0.21
9/30	9:13:47 PM	9:20:16 PM	9:24:08 PM	9:32:13 PM	0:11:57	11.95	3.87	-0.09
9/30	9:53:42 PM	10:00:12 PM	10:04:03 PM	10:12:19 PM	0:12:07	12.12	3.85	0.08
10/1	10:22:12 AM	10:28:50 AM	10:32:31 AM	10:40:41 AM	0:11:51	11.85	3.68	-0.19
10/1	10:45:00 AM	10:51:29 AM	10:55:13 AM	11:03:24 AM	0:11:55	11.92	3.73	-0.12
10/1	11:12:29 AM	11:18:55 AM	11:22:36 AM	11:30:39 AM	0:11:44	11.73	3.68	-0.31
10/1	8:36:17 PM	8:42:42 PM	8:46:07 PM	8:54:28 PM	0:11:46	11.77	3.42	-0.27
Average						12.04		
Stand. Dev.						0.24		
t-test v. 39min						-349.82		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	512 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
10/10	9:00:31 PM	9:09:00 PM	9:16:01 PM	9:33:14 PM	0:24:14	24.23	7.02	0.38
10/10	9:41:27 PM	9:49:41 PM	9:56:36 PM	10:13:37 PM	0:23:56	23.93	6.92	0.08
10/10	10:36:14 PM	10:44:09 PM	10:51:07 PM	11:08:18 PM	0:24:09	24.15	6.97	0.30
10/10	11:26:47 PM	11:34:32 PM	11:41:27 PM	11:58:34 PM	0:24:02	24.03	6.92	0.18
10/11	12:05:47 AM	12:13:38 AM	12:20:21 AM	12:37:25 AM	0:23:47	23.78	6.72	-0.07
10/11	12:48:07 AM	12:56:06 AM	1:02:59 AM	1:20:09 AM	0:24:03	24.05	6.88	0.20
10/11	1:27:23 AM	1:35:37 AM	1:42:16 AM	1:59:11 AM	0:23:34	23.57	6.65	-0.28
10/11	10:01:28 AM	10:09:15 AM	10:15:54 AM	10:32:59 AM	0:23:44	23.73	6.65	-0.12
10/11	6:20:47 PM	6:28:46 PM	6:35:19 PM	6:52:23 PM	0:23:37	23.62	6.55	-0.23
10/11	8:48:56 PM	8:57:08 PM	9:03:31 PM	9:20:29 PM	0:23:21	23.35	6.38	-0.50
Average						23.85		
Stand. Dev.						0.28		
t-test v. 39								
min						-169.43		
Prob(t-test)						0.000		

Equipment	Specification
Processor	Athlon 3500+
Memory	512 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/11	4:55:37 AM	5:04:31 AM	5:16:15 AM	5:39:45 AM	0:35:14	35.23	11.73	0.11
12/11	5:55:24 AM	6:04:19 AM	6:15:57 AM	6:39:39 AM	0:35:20	35.33	11.63	0.21
12/11	7:01:04 AM	7:10:16 AM	7:21:40 AM	7:45:18 AM	0:35:02	35.03	11.40	-0.09
12/11	8:06:04 AM	8:15:40 AM	8:27:24 AM	8:51:14 AM	0:35:34	35.57	11.73	0.45
12/11	9:20:47 AM	9:30:00 AM	9:41:36 AM	10:05:20 AM	0:35:20	35.33	11.60	0.21
12/11	10:16:50 AM	10:25:45 AM	10:37:16 AM	11:00:53 AM	0:35:08	35.13	11.52	0.01
12/12	12:05:48 PM	12:14:27 PM	12:25:44 PM	12:49:16 PM	0:34:49	34.82	11.28	-0.30
12/12	1:21:58 AM	1:30:42 AM	1:42:01 AM	2:05:48 AM	0:35:06	35.10	11.32	-0.02
12/12	9:28:19 AM	9:37:23 AM	9:48:43 AM	10:12:09 AM	0:34:46	34.77	11.33	-0.35
12/12	11:17:05 AM	11:26:11 AM	11:37:32 AM	12:01:03 PM	0:34:52	34.87	11.35	-0.25
Average						35.12		
Stand. Dev.						0.26		
t-test v. 39 min						-47.84		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	512 MB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/24	7:45:39 PM	7:51:04 PM	7:55:36 PM	8:02:25 PM	0:11:21	11.35	4.53	0.16
12/24	8:10:16 PM	8:15:42 PM	8:20:12 PM	8:26:57 PM	0:11:15	11.25	4.50	0.06
12/24	8:33:40 PM	8:39:07 PM	8:43:37 PM	8:50:43 PM	0:11:36	11.60	4.50	0.41
12/24	8:55:27 PM	9:00:52 PM	9:05:16 PM	9:12:09 PM	0:11:17	11.28	4.40	0.09
12/24	9:15:55 PM	9:21:19 PM	9:25:37 PM	9:32:24 PM	0:11:05	11.08	4.30	-0.11
12/24	9:36:10 PM	9:41:37 PM	9:45:56 PM	9:52:42 PM	0:11:05	11.08	4.32	-0.11
12/24	9:57:24 PM	10:02:36 PM	10:06:51 PM	10:13:37 PM	0:11:01	11.02	4.25	-0.17
12/24	10:17:50 PM	10:23:16 PM	10:27:33 PM	10:34:26 PM	0:11:10	11.17	4.28	-0.02
12/24	10:41:01 PM	10:46:21 PM	10:50:26 PM	10:57:23 PM	0:11:02	11.03	4.08	-0.16
12/24	11:01:42 PM	11:07:07 PM	11:11:16 PM	11:18:10 PM	0:11:03	11.05	4.15	-0.14
Average						11.19		
Stand. Dev.						0.18		
t-test v. 39min						-478.89		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	256 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
10/26	10:52:14 AM	11:00:15 AM	11:07:54 AM	11:28:42 AM	0:28:27	28.45	7.65	-0.44
10/26	11:38:20 AM	11:46:33 AM	11:54:31 AM	12:15:48 PM	0:29:15	29.25	7.97	0.36
10/27	12:29:55 PM	12:38:07 PM	12:46:02 PM	1:07:14 PM	0:29:07	29.12	7.92	0.23
10/27	3:54:32 PM	4:01:39 PM	4:08:34 PM	4:30:08 PM	0:28:29	28.48	6.92	-0.41
10/27	4:44:12 PM	4:52:19 PM	5:00:05 PM	5:21:34 PM	0:29:15	29.25	7.77	0.36
10/27	5:31:58 PM	5:40:40 PM	5:48:32 PM	6:10:12 PM	0:29:32	29.53	7.87	0.64
10/28	6:01:39 PM	6:09:50 PM	6:17:52 PM	6:40:00 PM	0:30:10	30.17	8.03	1.28
10/29	8:48:03 PM	8:56:14 PM	9:04:09 PM	9:26:09 PM	0:29:55	29.92	7.92	1.03
12/30	8:08:50 PM	8:15:09 PM	8:24:10 PM	8:42:42 PM	0:27:33	27.55	9.02	-1.34
12/30	10:12:02 PM	10:18:48 PM	10:27:23 PM	10:45:57 PM	0:27:09	27.15	8.58	-1.74
Average						28.89		
Stand. Dev.						0.98		
t-test v. 39 min.						-32.73		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	256 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
11/7	7:48:15 AM	7:57:14 AM	8:09:08 AM	8:33:56 AM	0:36:42	36.70	11.90	0.51
11/7	7:14:15 PM	7:23:12 PM	7:34:48 PM	7:59:15 PM	0:36:03	36.05	11.60	-0.14
11/7	8:38:20 PM	8:47:10 PM	8:58:49 PM	9:23:30 PM	0:36:20	36.33	11.65	0.14
11/7	9:36:14 PM	9:45:14 PM	9:56:54 PM	10:21:27 PM	0:36:13	36.22	11.67	0.03
11/8	6:51:21 PM	7:00:05 PM	7:11:47 PM	7:36:11 PM	0:36:06	36.10	11.70	-0.09
11/8	7:50:32 PM	7:59:43 PM	8:10:53 PM	8:35:27 PM	0:35:44	35.73	11.17	-0.46
11/8	9:03:31 PM	9:12:15 PM	9:23:52 PM	9:48:34 PM	0:36:19	36.32	11.62	0.13
11/8	9:56:01 AM	10:04:46 PM	10:16:24 PM	10:40:53 PM	0:36:07	36.12	11.63	-0.07
11/8	11:01:53 PM	11:10:47 PM	11:22:19 PM	11:46:58 PM	0:36:11	36.18	11.53	-0.01
11/9	12:27:03 AM	12:35:50 AM	12:47:18 AM	1:12:00 AM	0:36:10	36.17	11.47	-0.02
Average						36.19		
Stand. Dev.						0.24		
t-test v. 39								
min						-36.27		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 3500+
Memory	256 MB
Hard Drive Speed	4500 RPM

AMD 2800+ Computer Runs

Ordered by memory size then hard drive speed

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/26	1:22:10 PM	1:35:14 PM	1:42:17 PM	1:52:23 PM	0:17:09	17.15	7.05	0.65
12/26	2:29:54 PM	2:41:16 PM	2:48:06 PM	2:58:03 PM	0:16:47	16.78	6.83	0.28
12/26	3:01:54 PM	3:13:03 PM	3:19:51 PM	3:29:53 PM	0:16:50	16.83	6.80	0.33
12/26	3:59:02 PM	4:12:55 PM	4:19:40 PM	4:29:40 PM	0:16:45	16.75	6.75	0.25
12/26	4:44:28 PM	4:56:18 PM	5:02:57 PM	5:13:05 PM	0:16:47	16.78	6.65	0.28
12/26	6:25:33 PM	6:39:11 PM	6:45:38 PM	6:55:36 PM	0:16:25	16.42	6.45	-0.08
12/26	7:07:43 PM	7:21:03 PM	7:27:26 PM	7:37:21 PM	0:16:18	16.30	6.38	-0.20
12/26	7:51:01 PM	8:03:30 PM	8:09:05 PM	8:19:19 PM	0:15:49	15.82	5.58	-0.68
12/26	8:27:54 PM	8:41:40 PM	8:47:50 PM	8:57:52 PM	0:16:12	16.20	6.17	-0.30
12/26	9:34:04 PM	9:45:14 PM	9:51:03 PM	10:01:09 PM	0:15:55	15.92	5.82	-0.58
Average						16.50		
Stand. Dev.						0.43		
t-test v. 39 min.						-163.72		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	1 GB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
10/9	8:25:20 PM	8:38:17 PM	8:45:33 PM	8:59:04 PM	0:20:47	20.78	7.27	-0.43
10/9	9:13:11 PM	9:26:31 PM	9:33:39 PM	9:47:15 PM	0:20:44	20.73	7.13	-0.48
10/9	10:19:58 PM	10:31:39 PM	10:38:44 PM	10:52:23 PM	0:20:44	20.73	7.08	-0.48
10/9	10:58:33 PM	11:10:15 PM	11:17:17 PM	11:31:08 PM	0:20:53	20.88	7.03	-0.33
10/10	3:33:35 PM	3:42:46 PM	3:49:46 PM	4:03:20 PM	0:20:34	20.57	7.00	-0.64
10/10	4:29:51 PM	4:40:28 PM	4:47:21 PM	5:00:53 PM	0:20:25	20.42	6.88	-0.79
10/10	6:24:07 PM	6:35:44 PM	6:42:19 PM	6:56:01 PM	0:20:17	20.28	6.58	-0.93
10/10	7:21:14 PM	7:34:28 PM	7:41:03 PM	7:54:43 PM	0:20:15	20.25	6.58	-0.96
10/13	7:44:45 PM	7:57:46 PM	8:07:59 PM	8:21:44 PM	0:23:58	23.97	10.22	2.76
10/13	10:31:15 PM	10:44:35 PM	10:54:37 PM	11:08:04 PM	0:23:29	23.48	10.03	2.27
Average						21.21		
Stand. Dev.						1.35		
t-test v. 39min						-41.76		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	1 GB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
1/1	5:41:24 PM	5:56:26 PM	6:08:40 PM	6:28:22 PM	0:31:56	31.93	12.23	-2.40
1/1	6:49:07 PM	7:03:45 PM	7:16:08 PM	7:36:06 PM	0:32:21	32.35	12.38	-1.98
1/1	9:19:05 PM	9:35:04 PM	9:48:20 PM	10:10:09 PM	0:35:05	35.08	13.27	0.75
1/1	11:39:37 AM	11:55:11 AM	12:08:04 PM	12:30:35 PM	0:35:24	35.40	12.88	1.07
1/1	1:00:45 AM	1:14:03 AM	1:27:27 AM	1:49:09 AM	0:35:06	35.10	13.40	0.77
1/2	1:58:51 AM	2:14:49 AM	2:28:07 AM	2:50:03 AM	0:35:14	35.23	13.30	0.90
1/2	2:59:40 AM	3:14:24 AM	3:27:58 AM	3:51:07 AM	0:36:43	36.72	13.57	2.39
1/2	10:13:42 AM	10:27:24 AM	10:40:47 AM	11:02:20 AM	0:34:56	34.93	13.38	0.60
1/2	2:37:08 AM	2:48:31 AM	3:03:57 AM	3:24:17 AM	0:35:46	35.77	15.43	1.44
1/2	8:49:51 PM	9:05:10 PM	9:17:46 PM	9:35:57 PM	0:30:47	30.78	12.60	-3.55
Average						34.33		
Stand. Dev.						1.93		
t-test v. 39min						-7.656		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	1 GB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
11/9	11:15:57 AM	11:27:14 AM	11:33:35 AM	11:43:48 AM	0:16:34	16.57	6.35	0.33
11/11	10:03:02 AM	10:17:09 AM	10:23:24 AM	10:33:50 AM	0:16:41	16.68	6.25	0.44
11/11	10:39:01 AM	10:52:18 AM	10:58:29 AM	11:08:42 AM	0:16:24	16.40	6.18	0.16
11/11	11:27:03 AM	11:40:19 AM	11:46:19 AM	11:56:27 AM	0:16:08	16.13	6.00	-0.11
11/12	12:19:50 PM	12:30:32 PM	12:36:33 PM	12:46:49 PM	0:16:17	16.28	6.02	0.04
11/12	11:14:07 AM	11:24:27 AM	11:30:31 AM	11:41:01 AM	0:16:34	16.57	6.07	0.33
11/12	12:18:41 PM	12:29:52 PM	12:35:40 PM	12:46:07 PM	0:16:15	16.25	5.80	0.01
11/12	12:55:36 PM	1:07:18 AM	1:12:53 AM	1:23:12 AM	0:15:54	15.90	5.58	-0.34
11/12	1:46:44 AM	1:59:04 AM	2:04:37 AM	2:14:44 AM	0:15:40	15.67	5.55	-0.57
11/12	4:01:39 AM	4:15:05 AM	4:20:34 AM	4:31:02 AM	0:15:57	15.95	5.48	-0.29
Average						16.24		
Stand. Dev.						0.33		
t-test v. 39min						-218.41		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2800 +
Memory	512 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
1/2	7:44:52 AM	7:59:08 AM	8:10:52 AM	8:33:04 AM	0:33:56	33.93	11.73	3.72
1/2	10:42:05 AM	10:54:50 AM	11:06:28 AM	11:23:00 AM	0:28:10	28.17	11.63	-2.04
1/2	11:42:51 AM	11:57:41 AM	12:09:15 PM	12:25:42 PM	0:28:01	28.02	11.57	-2.19
1/3	12:35:02 AM	12:49:06 AM	1:00:24 AM	1:17:14 AM	0:28:08	28.13	11.30	-2.08
1/3	7:35:26 AM	7:49:44 AM	8:00:51 AM	8:17:33 AM	0:27:49	27.82	11.12	-2.39
1/3	11:15:48 AM	11:30:29 AM	11:41:22 AM	11:57:54 AM	0:27:25	27.42	10.88	-2.79
1/9	5:32:41 AM	5:46:09 AM	5:57:18 AM	6:17:47 AM	0:31:38	31.63	11.15	1.42
1/9	6:25:14 AM	6:39:05 AM	6:51:52 AM	7:10:57 AM	0:31:52	31.87	12.78	1.66
1/9	9:45:20 PM	9:58:21 PM	10:09:43 PM	10:31:11 PM	0:32:50	32.83	11.37	2.62
1/9	10:46:27 PM	10:59:20 PM	11:10:03 PM	11:31:38 PM	0:32:18	32.30	10.72	2.09
Average						30.21		
Stand. Dev.						2.51		
t-test v. 39min						-11.07		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	512 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/24	9:49:02 AM	10:04:01 AM	10:19:24 AM	10:48:26 AM	0:44:25	44.42	15.38	2.14
12/24	10:57:46 AM	11:12:25 AM	11:27:59 AM	11:56:56 AM	0:44:31	44.52	15.57	2.24
12/25	12:21:56 AM	12:36:49 AM	12:51:30 AM	1:19:33 AM	0:42:44	42.73	14.68	0.45
12/25	1:27:24 AM	1:45:19 AM	1:56:57 AM	2:25:02 AM	0:39:43	39.72	11.63	-2.56
12/25	11:19:12 AM	11:34:12 AM	11:48:37 AM	12:16:26 PM	0:42:14	42.23	14.42	-0.05
12/25	12:23:35 PM	12:39:49 PM	12:54:34 PM	1:22:26 PM	0:42:37	42.62	14.75	0.34
12/25	1:41:14 AM	1:55:45 AM	2:10:15 AM	2:38:02 AM	0:42:17	42.28	14.50	0.00
12/25	2:45:08 AM	2:57:24 AM	3:11:53 AM	3:40:01 AM	0:42:37	42.62	14.48	0.34
12/25	3:49:14 AM	4:03:50 AM	4:16:21 AM	4:44:16 AM	0:40:26	40.43	12.52	-1.85
12/25	10:39:42 AM	10:55:01 AM	11:08:47 AM	11:36:17 AM	0:41:16	41.27	13.77	-1.01
Average						42.28		
Stand. Dev.						1.53		
t-test v. 39								
min						6.80		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	512 MB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/26	10:28:12 PM	10:40:11 PM	10:46:04 PM	10:56:55 PM	0:16:44	16.73	5.88	0.62
12/26	11:22:11 PM	11:36:06 PM	11:41:56 PM	11:52:26 PM	0:16:20	16.33	5.83	0.22
12/27	2:43:29 PM	2:53:39 PM	2:59:08 PM	3:10:06 PM	0:16:27	16.45	5.48	0.34
12/27	3:33:50 PM	3:47:57 PM	3:53:30 PM	4:04:11 PM	0:16:14	16.23	5.55	0.12
12/27	4:09:31 PM	4:23:24 PM	4:28:53 PM	4:39:33 PM	0:16:09	16.15	5.48	0.04
12/27	5:05:03 PM	5:18:37 PM	5:24:07 PM	5:34:57 PM	0:16:20	16.33	5.50	0.22
12/27	6:13:27 PM	6:27:06 PM	6:32:29 PM	6:43:09 PM	0:16:03	16.05	5.38	-0.06
12/27	7:05:29 PM	7:18:47 PM	7:24:01 PM	7:34:37 PM	0:15:50	15.83	5.23	-0.28
12/27	8:04:52 PM	8:15:21 PM	8:20:33 PM	8:30:57 PM	0:15:36	15.60	5.20	-0.51
12/27	9:32:41 PM	9:46:20 PM	9:51:07 PM	10:01:41 PM	0:15:21	15.35	4.78	-0.76
Average						16.11		
Stand. Dev.						0.41		
t-test v. 39								
min						-175.10		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	256 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
1/2	3:49:34 PM	4:04:06 PM	4:15:55 PM	4:39:15 PM	0:35:09	35.15	11.817	-0.46
1/10	5:45:33 PM	5:59:01 PM	6:09:27 PM	6:34:01 PM	0:35:00	35.00	10.433	-0.61
1/10	6:43:31 PM	6:55:19 PM	7:07:03 PM	7:31:10 PM	0:35:51	35.85	11.733	0.24
1/10	7:38:37 PM	7:53:05 PM	8:04:35 PM	8:28:42 PM	0:35:37	35.62	11.500	0.01
1/10	9:34:40 PM	9:49:14 PM	10:00:41 PM	10:24:38 PM	0:35:24	35.40	11.450	-0.21
1/10	10:50:16 PM	11:02:57 PM	11:14:28 PM	11:38:09 PM	0:35:12	35.20	11.517	-0.41
1/10	11:46:43 AM	11:59:58 AM	12:11:18 PM	12:35:24 PM	0:35:26	35.43	11.333	-0.18
1/11	12:43:41 AM	12:58:22 AM	1:10:23 AM	1:34:36 AM	0:36:14	36.23	12.017	0.62
1/11	6:17:18 PM	6:29:21 PM	6:41:25 PM	7:05:28 PM	0:36:07	36.12	12.067	0.51
1/11	7:16:41 PM	7:30:50 PM	7:42:53 PM	8:06:55 PM	0:36:05	36.08	12.050	0.47
Average						35.61		
Stand. Dev.						0.44		
t-test v. 39min						-24.29		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	256 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/29	2:50:37 PM	3:05:54 PM	3:19:04 PM	3:50:42 PM	0:44:48	44.80	13.17	0.91
12/29	4:10:59 PM	4:25:58 PM	4:39:05 PM	5:10:30 PM	0:44:32	44.53	13.12	0.64
12/29	5:28:54 PM	5:43:50 PM	5:56:54 PM	6:28:45 PM	0:44:55	44.92	13.07	1.03
12/29	6:39:38 PM	6:52:50 PM	7:05:47 PM	7:37:04 PM	0:44:14	44.23	12.95	0.34
12/29	9:00:04 PM	9:14:57 PM	9:27:49 PM	9:59:10 PM	0:44:13	44.22	12.87	0.33
12/29	11:16:23 AM	11:29:04 AM	11:41:18 AM	12:12:23 PM	0:43:19	43.32	12.23	-0.57
12/29	12:30:14 AM	12:45:15 AM	12:57:42 AM	1:29:16 AM	0:44:01	44.02	12.45	0.13
12/29	1:45:09 AM	1:58:54 AM	2:11:20 AM	2:42:48 AM	0:43:54	43.90	12.43	0.01
12/29	10:31:34 AM	10:46:48 AM	10:57:54 AM	11:28:42 AM	0:41:54	41.90	11.10	-1.99
12/29	5:50:39 PM	6:06:03 PM	6:18:02 PM	6:49:09 PM	0:43:06	43.10	11.98	-0.79
Average						43.89		
Stand. Dev.						0.91		
t-test v. 39 min.						17.01		
Prob(t-test)						0.000		

Equipment	Specification
Processor	AMD 2800+
Memory	256 MB
Hard Drive Speed	4500 RPM

AMD 2200+ Computer Runs

Ordered by memory size then hard drive speed

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
11/14	7:51:25 AM	8:03:00 AM	8:07:25 AM	8:18:18 AM	0:15:18	15.30	4.42	0.13
11/14	8:30:18 AM	8:41:28 AM	8:45:48 AM	8:56:10 AM	0:14:42	14.70	4.33	-0.47
11/14	9:30:17 AM	9:43:21 AM	9:47:56 AM	9:58:31 AM	0:15:10	15.17	4.58	0.00
11/14	10:33:48 AM	10:48:01 AM	10:52:16 AM	11:02:59 AM	0:14:58	14.97	4.25	-0.20
11/14	11:14:35 AM	11:27:57 AM	11:32:05 AM	11:42:57 AM	0:15:00	15.00	4.13	-0.17
11/16	5:46:21 AM	5:59:31 AM	6:04:11 AM	6:14:52 AM	0:15:21	15.35	4.67	0.18
11/16	6:17:48 AM	6:33:40 AM	6:38:56 AM	6:49:19 AM	0:15:39	15.65	5.27	0.48
11/16	6:52:00 AM	7:07:10 AM	7:12:55 AM	7:22:40 AM	0:15:30	15.50	5.75	0.33
11/16	7:44:36 AM	7:58:19 AM	8:02:42 AM	8:13:08 AM	0:14:49	14.82	4.38	-0.35
11/16	8:38:30 AM	8:48:20 AM	8:52:35 AM	9:03:32 AM	0:15:12	15.20	4.25	0.03
Average						15.17		
Stand. Dev.						0.30		
t-test v. 39								
min						-251.98		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	1 GB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Time to MN	Prediction Error
10/8	5:11:28 PM	5:24:16 PM	5:33:18 PM	5:47:40 PM	0:23:24	23.40	9.03	-0.31
10/8	6:57:37 PM	7:10:50 PM	7:20:03 PM	7:33:56 PM	0:23:06	23.10	9.22	-0.61
10/8	11:11:11 PM	11:24:30 PM	11:34:07 PM	11:47:48 PM	0:23:18	23.30	9.62	-0.41
10/8	11:51:29 PM	12:04:51 AM	12:14:34 AM	12:28:21 AM	0:23:30	23.50	9.72	-0.21
10/9	12:39:16 AM	12:53:46 AM	1:03:24 AM	1:17:21 AM	0:23:35	23.58	9.63	-0.13
10/9	10:18:02 AM	10:30:54 AM	10:41:18 AM	10:55:22 AM	0:24:28	24.47	10.40	0.76
10/9	10:59:01 AM	11:10:50 AM	11:24:05 AM	11:35:06 AM	0:24:16	24.27	13.25	0.56
10/9	11:40:47 AM	11:54:05 AM	12:04:13 PM	12:18:03 PM	0:23:58	23.97	10.13	0.26
10/9	12:21:28 PM	12:33:05 PM	12:43:02 PM	12:56:50 PM	0:23:45	23.75	9.95	0.04
10/9	1:04:01 PM	1:17:20 PM	1:27:09 PM	1:41:04 PM	0:23:44	23.73	9.82	0.02
Average						23.71		
Stand. Dev.						0.43		
t-test v. 39								
min						-113.06		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	1 GB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
11/5	7:31:50 PM	7:47:03 PM	8:00:42 PM	8:19:22 PM	0:32:19	32.32	13.65	0.76
11/5	9:05:06 PM	9:20:19 PM	9:33:50 PM	9:51:50 PM	0:31:31	31.52	13.52	-0.04
11/5	10:20:31 PM	10:35:21 PM	10:48:37 PM	11:06:53 PM	0:31:32	31.53	13.27	-0.03
11/6	12:20:48 AM	12:35:46 AM	12:49:17 AM	1:07:29 AM	0:31:43	31.72	13.52	0.16
11/6	1:15:09 AM	1:29:57 AM	1:43:20 AM	2:01:32 AM	0:31:35	31.58	13.38	0.02
11/6	9:38:45 AM	9:53:41 AM	10:06:57 AM	10:25:27 AM	0:31:46	31.77	13.27	0.21
11/6	11:14:22 AM	11:29:12 AM	11:42:22 AM	12:00:40 PM	0:31:28	31.47	13.17	-0.09
11/6	12:14:32 PM	12:29:14 PM	12:42:19 PM	1:00:56 PM	0:31:42	31.70	13.08	0.14
11/6	1:13:35 PM	1:28:50 PM	1:41:13 PM	1:59:37 PM	0:30:47	30.78	12.38	-0.78
11/6	5:08:29 AM	5:23:18 PM	5:36:00 PM	5:54:28 PM	0:31:10	31.17	12.70	-0.39
Average						31.56		
Stand. Dev.						0.40		
T-test v. 39 min						-59.09		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	1 GB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Time to MN	Prediction Error
11/12	7:51:38 AM	8:02:12 AM	8:07:48 AM	8:18:39 AM	0:16:27	16.45	5.60	0.57
11/12	9:29:45 AM	9:41:58 AM	9:47:27 AM	9:58:24 AM	0:16:26	16.43	5.48	0.55
11/13	10:21:27 AM	10:32:09 AM	10:37:29 AM	10:48:15 AM	0:16:06	16.10	5.33	0.22
11/13	11:10:54 AM	11:22:07 AM	11:27:43 AM	11:38:23 AM	0:16:16	16.27	5.60	0.39
11/13	12:44:59 PM	12:58:48 PM	1:03:38 PM	1:14:26 PM	0:15:38	15.63	4.83	-0.25
11/13	2:17:05 AM	2:28:45 AM	2:33:54 AM	2:44:51 AM	0:16:06	16.10	5.15	0.22
11/13	3:58:10 AM	4:12:50 AM	4:16:46 AM	4:27:55 AM	0:15:05	15.08	3.93	-0.80
11/13	4:39:23 AM	4:53:01 AM	4:57:40 AM	5:08:25 AM	0:15:24	15.40	4.65	-0.48
11/13	5:40:39 AM	5:53:32 AM	5:58:15 AM	6:09:10 AM	0:15:38	15.63	4.72	-0.25
11/13	10:23:00 AM	10:36:24 AM	10:41:04 AM	10:52:05 AM	0:15:41	15.68	4.67	-0.20
Average						15.88		
Stand. Dev.						0.46		
t-test v. 39								
min						-159.02		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	512 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
1/2	6:22:35 AM	6:47:15 AM	6:59:05 AM	7:21:28 AM	0:34:13	34.22	11.83	1.14
1/3	6:22:24 AM	6:37:40 AM	6:47:44 AM	7:09:58 AM	0:32:18	32.30	10.07	-0.78
1/3	7:42:57 AM	7:55:01 AM	8:05:34 AM	8:27:53 AM	0:32:52	32.87	10.55	-0.21
1/3	9:58:41 AM	10:14:15 AM	10:24:42 AM	10:47:02 AM	0:32:47	32.78	10.45	-0.30
1/4	2:54:42 AM	3:06:27 AM	3:17:15 AM	3:39:59 AM	0:33:32	33.53	10.80	0.45
1/4	4:38:20 AM	4:52:56 AM	5:03:37 AM	5:26:30 AM	0:33:34	33.57	10.68	0.49
1/4	5:54:56 AM	6:08:13 AM	6:18:02 AM	6:41:59 AM	0:33:46	33.77	9.82	0.69
1/4	6:23:08 AM	6:35:15 AM	6:45:36 AM	7:07:56 AM	0:32:41	32.68	10.35	-0.40
1/4	7:29:08 AM	7:44:18 AM	7:54:31 AM	8:16:40 AM	0:32:22	32.37	10.22	-0.71
1/4	10:32:23 AM	10:44:29 AM	10:54:30 AM	11:17:10 AM	0:32:41	32.68	10.02	-0.40
Average						33.08		
Stand. Dev.						0.65		
t-test v. 39min						-28.94		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	512 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/31	10:26:08 AM	10:40:02 AM	10:55:07 AM	11:24:39 AM	0:44:37	44.62	15.08	0.33
12/31	11:39:26 AM	11:55:27 AM	12:10:42 PM	12:40:18 PM	0:44:51	44.85	15.25	0.56
1/1	1:06:47 AM	1:19:44 AM	1:34:50 AM	2:04:23 AM	0:44:39	44.65	15.10	0.36
1/1	2:18:10 AM	2:35:27 AM	2:49:30 AM	3:19:56 AM	0:44:29	44.48	14.05	0.19
1/1	3:27:41 AM	3:42:28 AM	3:57:20 AM	4:26:26 AM	0:43:58	43.97	14.87	-0.32
1/1	10:30:28 AM	10:45:26 AM	11:00:13 AM	11:29:42 AM	0:44:16	44.27	14.78	-0.02
1/1	11:37:39 AM	11:50:48 AM	12:05:18 PM	12:34:32 PM	0:43:44	43.73	14.50	-0.56
1/1	12:42:12 PM	1:00:39 PM	1:15:11 PM	1:44:43 PM	0:44:04	44.07	14.53	-0.22
1/1	2:29:51 PM	2:43:48 PM	2:58:11 PM	3:27:59 PM	0:44:11	44.18	14.38	-0.11
1/1	3:41:33 PM	3:56:21 PM	4:10:45 PM	4:40:24 PM	0:44:03	44.05	14.40	-0.24
Average						44.29		
Stand. Dev.						0.35		
t-test v. 39								
min						47.37		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	512 MB
Hard Drive Speed	4500 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
12/10	4:47:10 AM	5:00:31 AM	5:07:13 AM	5:18:25 AM	0:17:54	17.90	6.70	0.59
12/10	5:27:27 AM	5:40:53 AM	5:48:36 AM	5:58:40 AM	0:17:47	17.78	7.72	0.47
12/10	7:23:56 AM	7:37:30 AM	7:45:03 AM	7:55:27 AM	0:17:57	17.95	7.55	0.64
12/10	8:00:50 AM	8:14:07 AM	8:20:27 AM	8:31:50 AM	0:17:43	17.72	6.33	0.41
12/10	11:09:51 AM	11:20:15 AM	11:26:13 AM	11:37:12 AM	0:16:57	16.95	5.97	-0.36
12/10	11:52:04 AM	12:05:33 PM	12:11:41 PM	12:22:48 PM	0:17:15	17.25	6.13	-0.06
12/11	12:26:41 PM	12:37:45 PM	12:43:37 PM	12:54:51 PM	0:17:06	17.10	5.87	-0.21
12/11	1:08:27 AM	1:19:24 AM	1:25:19 AM	1:36:38 AM	0:17:14	17.23	5.92	-0.08
12/11	10:33:14 AM	10:44:00 AM	10:49:27 AM	11:00:26 AM	0:16:26	16.43	5.45	-0.88
12/11	11:04:42 AM	11:18:15 AM	11:23:53 AM	11:35:04 AM	0:16:49	16.82	5.63	-0.49
Average						17.31		
Stand. Dev.						0.51		
t-test v. 39								
min						-134.43		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	256 MB
Hard Drive Speed	7200 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Minutes to MN	Prediction Error
1/2	4:50:56 PM	5:05:03 PM	5:17:08 PM	5:40:42 PM	0:35:39	35.65	12.08	-0.30
1/11	8:14:29 PM	8:30:20 PM	8:42:34 PM	9:07:05 PM	0:36:45	36.75	12.23	0.80
1/11	9:23:47 PM	9:38:21 PM	9:50:31 PM	10:14:38 PM	0:36:17	36.28	12.17	0.33
1/11	10:46:35 PM	10:59:12 PM	11:11:12 PM	11:35:29 PM	0:36:17	36.28	12.00	0.33
1/11	11:44:41 AM	11:58:57 AM	12:10:43 PM	12:35:11 PM	0:36:14	36.23	11.77	0.28
1/12	12:53:35 PM	1:08:18 PM	1:20:07 PM	1:44:53 PM	0:36:35	36.58	11.82	0.63
1/12	1:52:23 AM	2:04:43 AM	2:16:17 AM	2:40:44 AM	0:36:01	36.02	11.57	0.07
1/12	3:35:44 PM	3:50:02 PM	4:01:30 PM	4:25:02 PM	0:35:00	35.00	11.47	-0.95
1/12	4:35:59 PM	4:50:40 PM	5:01:58 PM	5:25:36 PM	0:34:56	34.93	11.30	-1.02
1/12	6:02:23 PM	6:17:03 PM	6:28:24 PM	6:52:51 PM	0:35:48	35.80	11.35	-0.15
Average						35.95		
Stand. Dev.						0.61		
t-test v. 39min						-15.68		
Prob(t-statistic)						0.000		

Equipment	Specification
Processor	AMD 2200+
Memory	256 MB
Hard Drive Speed	5400 RPM

Experiment Date	Start Partition	Start XP Install	Machine Named	Setup Finished	Install Duration	Install Minutes	Time to MN	Prediction Error
12/28	12:25:32 AM	12:41:36 AM	12:56:52 AM	1:30:13 AM	0:48:37	48.62	15.27	4.61
12/28	1:41:50 AM	1:55:41 AM	2:11:08 AM	2:45:38 AM	0:49:57	49.95	15.45	5.94
12/28	12:34:08 PM	12:47:15 PM	12:59:13 PM	1:28:25 PM	0:41:10	41.17	11.97	-2.84
12/28	1:39:03 PM	1:54:04 PM	2:06:24 PM	2:35:36 PM	0:41:32	41.53	12.33	-2.48
12/28	9:03:28 PM	9:16:05 PM	9:29:34 PM	10:00:44 PM	0:44:39	44.65	13.48	0.64
12/29	12:04:28 AM	12:20:04 AM	12:33:22 AM	1:04:45 AM	0:44:41	44.68	13.30	0.67
12/29	1:14:41 AM	1:32:32 AM	1:45:46 AM	2:17:23 AM	0:44:51	44.85	13.23	0.84
12/29	2:32:37 AM	2:45:34 AM	2:56:46 AM	3:27:44 AM	0:42:10	42.17	11.20	-1.84
12/29	11:06:58 AM	11:21:59 AM	11:34:13 AM	12:03:20 PM	0:41:21	41.35	12.23	-2.66
12/29	12:19:34 PM	12:35:08 PM	12:47:01 PM	1:17:14 PM	0:42:06	42.10	11.88	-1.91

Average 44.11
 Stand. Dev. 3.10
 t-test v. 39
 min 5.21
 Prob(t-statistic) 0.001

Equipment	Specification
Processor	AMD 2200+
Memory	256 MB
Hard Drive Speed	4500 RPM