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# How to Deal With Speed Degradation in Computers of Today and What Causes It

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## Abstract

Newly installed computer systems are always running fast, but as time increases, more and more computer system speed will gradually become slower. This is a big headache for most of the computer users. Therefore it is important to find out what causes the computer system speed degradation. In this study, we developed a cleaning product called “FlexClean” as a basic case study. We also reviewed related literatures, and used appropriate research methods to conduct qualitative interviews with 37 Windows OS users. The users consist of three different groups, which were students, company personnel, and home users. The interviewees were asked some questions around issues that cause computer system speed degradation. After that we summarized the data from the case study and the interviews. The research results have been divided into six key issues, which acted as a basis for discussions about computer system speed degradation. Then we gave out the final sum-up of this study.

**Key words:** computer system speed degradation, FlexClean, Windows OS

## 1. Introduction

Because of an increased widespread application of computers, more and more areas of work have become inseparable from the use of computers. The computer becomes an indispensable entertainment tool in human being’s leaning and working. Microsoft Windows XP and Windows Vista are computer operating systems (OS), which many computer users are using nowadays.

Newly installed computer systems are always running fast and smoothly, but as time increases, they become slower. A search for “Computer is slow” returned approximately 68,800,000 query results from GOOGLE. A search for the same question using other languages would result in millions of query results again. Nowadays there will be about 1 billion computer users in the world. In a word, it can be said that nearly every computer user will face or have faced the computer system speed degradation. A search for “Windows is slow” received approximately 52,200,000 query results. As known, most of computer users are using Windows OS. So many Windows users had headache when they were affected by this problem, hence, it is important to

find out the issues that cause the computer system speed degradation.

The aim of this study is to find out issues that cause the computer system speed degradation. The study is based on a developing case study which is FlexClean, and three groups’ qualitative interviews with Windows users. The effort gathered from both the case study and the interviews are served as research results. The research results are discussed in order to give a solution for the computer system speed degradation.

This study does not investigate all of the computer degradation problems but only focuses on the problems of key issues to cause the computer system speed degradation.

So the research question is: **What are the key issues that cause computer system speed degradation?**

The structural overview of this study is:

In the next chapter is the related literatures presented. In chapter three, the research methods that are used in this study are presented. Chapter four summarizes the results from the case study and the interviews. The research results are discussed in chapter five. The final chapter gives out the final sum-up of this study and referred to the future study that needs to be done.

## 2. Literature Review

There are two areas that could impact the computer system speed degradation. These are the internal issues and the external issues. The related literatures studies of the internal issues are talked mostly about the computer system speed degradation in two parts: the software settings, and the software changes in using process, which causes the computer system speed degradation. The external issues are subordinate but they are also usual. So this chapter is structured as follow: software settings and changes, and hardware settings.

### 2.1 *Internal: Software settings and changes*

One cause of the computer system speed slowdown is too much data [1] in the hard disk. The hard disk probably could be crammed with many **useless files**, such as remnant left over from re-installs and uninstalls [2], temporary and backup files that the programs create stealthily [3] in the background.

Temporary Internet Files are such **temporary backup files** that use more disk space than specified. This could be a reason for the computer to slow down in tasks such as start-up [17].

The **registry** is one more useless file. After uninstalls most of the registry info remain. The corruption or overload of the registry can cause performance problems. One of those is slow Windows start-up [2].

Users who are aware of the need to delete unused data from the hard disk are seemingly deleting unused data. But the computer does not always handle the deletion very gracefully [21]. Over time, the computer files are scattered over the hard disk, which is called **fragmentation** [2]. Too much fragmentation can increase the quantity and frequency of gaps, which slows down the speed at which files can be searched and accessed [1]. It can be imagined as a queue of persons in which it is easy to point out one person, but it is difficult to do from a scattering crowd.

Over a period of months or years, the speed of **start-up** may slowly degrade. When the users install additional programs, they accept to add them into the start-up list. The more programs that are loaded at start-up, the slower the start-up [2]. It is recommended to remove the unused or unwanted programs from the start-up. Not only the customized programs, but also some unneeded Windows services that can be turned off [11].

A computer that suddenly becomes slow may have a **virus** or **spyware program** installed [18]. Viruses, spyware and other malware can slow down the computers, either by taking up the processor's time, clogging memory with dozens of application windows, or running introducing programs surreptitiously in the background [21].

If the computer has been running at a normal speed before much installation of certain programs and has crucially slowed down with time, it indicates that More **RAM** (Random Access Memory) is needed in the computer system [17]. When the system meets this situation, hard disk space will be used as **virtual memory**. The application of the virtual memory manager always reads and writes frequently on the hard disk, which could generate a large number of the fragment, so that to cause the computer system speed slow down.

## 2.2 External: Hardware settings

If optimizing the computer system, by changing the software settings, and the computer system is

still slow, you should check the hardware. You should especially check the RAM, CPU (Center Processing Unit), hard disk, and other weak links in the hardware.

The speed of a computer depends mainly on the power and CPU [18]. Do not, in order to save money, buy a **low-end CPU**, which is like buying a car with a lawnmower engine. Other hardware issues could also happen, such as a **bad RAM**. The users would like to keep the old RAM that to use on the new computer without consideration of the hardware compatibility.

A **slower hard disk** leads to more delays if you have **insufficient RAM** than if you use a fast hard disk [16].

There are some more assortments of things that can happen to the hardware, for instance, **wear and tear**, overheating, and dust [2]. If the **CPU is overheating**, it will reduce its processing speed for self-protection.

## 3. Research Method

Research is to study a certain problem, through several steps: problem analysis, information gathering, performing research process, etc. To use research methods is the best way, and it helps us to solve these steps. In this chapter, we present the research methods that are used in order to answer the presented research question.

### 3.1 Qualitative Study

Before deciding on whether to use qualitative research methods or quantitative research methods, it is better to consider some common distinctions between them. "*Quantitative research methods were originally developed in the natural sciences to study natural phenomena. Qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomena* [4]". Quantitative data is simple, but qualitative data is more richful. By using a qualitative method, we aim gather an in-depth understanding about why and how humans made decisions not just about what decisions they made. In this study, we decided to choose qualitative research methods because, we would like to talk with the computer users about why and how their computer system speed get slow.

According to Cresswell (1994) [5] described in his/her paper, we think a qualitative research method is quite helpful to collect issues and computer users' responses when they are facing

the problem because qualitative research method is looking closely at their words, actions and records. In contrast to using quantitative study, because a qualitative study enables communication with the computer users and facilitates an understanding of their needs and perspectives. Also, a qualitative study will be better at interpreting and interacting with computer users. In this study, we want to directly communicate with the computer users and to gather their stories.

*“Qualitative researchers typically rely on four methods for gathering information: (1) participation in the setting, (2) direct observation, (3) in depth interviews, and (4) analysis of documents and materials [6]”*. In the later section, interviews will be elaborated as one of the chosen methods for gathering information.

As a real human being, the computer system could be sick, such as having ‘upset stomach (too much junk food in the stomach)’. Nordic Information Security Group (abbreviation: NordicIS) is a Swedish security software company, which wants to be a ‘doctor’, who can help Windows users to cure the computer system. We would like to help NordicIS to develop a cleaning product, which is called FlexClean, for both Windows XP and Windows Vista to clean ‘the stomach of the computer system’. We helped NordicIS to develop FlexClean. The development of FlexClean is served as a case study for this study, and during the software development to find out the reasons of the computer system speed degradation.

The computer system speed degradation is a very common problem that nearly every computer user has faced or will face. Developing FlexClean is the best starting point when we try to find out issues to cause the computer system speed degradation. We see some necessary features to be implemented in the requirement specification of FlexClean. After doing an analysis of these features, all theory of these features and how they should work are clear to us. The aim is to find out what features could degrade the speed of the computer system. Based on this development of FlexClean, we found out some general issues gathered from interviews. All these issues are served as the result.

## **3.2 Data Collection**

### **3.2.1 Case Study**

Qualitative research could look past people’s words, actions and records. *“Case study research is the most widely used qualitative research*

*method in information systems research [7]”*. What is a case: is it an object, or an event? For this study a case can be one computer user who has the computer system speed degradation, third-party cleaning software using, and working principle of Windows operating system. But the main case of this study is the development of FlexClean.

We organized and conducted the case study according to the following six steps [10]. They are:

*“Determine and define the research questions*

*Select the cases and determine data gathering and analysis techniques*

*Prepare to collect the data*

*Collect data in the field*

*Evaluate and analyze the data*

*Prepare the report”*

- Determine and define the research questions

Our research question is:

**What are the key issues to cause the computer system speed degradation?**

- Select the cases and determine data gathering and analysis techniques

In this study the case is carried out on developing a cleaning product that is called FlexClean, because NordicIS is in need of a new cleaning product to expand their product portfolio.

FlexClean consists of several essential features, which we need to analyze and design. These features should fulfill usability for different types of users. Hence, interviews are the primary data gathering method chosen for this study. The interviews are conducted on a one-on-one basis with three groups of experienced Windows users. Both closed and open questions are used to gather interviewees’ stories and opinions. Observation [22] has not been chosen for this study because we could not provide a lab or office to meet those selected users. Although we decided to use a qualitative research method to collect more complex data, it is possible to use a questionnaire as a supplementary choice. Analysis techniques are chosen within-case and cross-case examination [8].

- Prepare to collect the data

We prepared to collect data from three groups of Windows users: different organizations, students, and normal home users. We design the semi-structured interview [9], which is described in the

next section.

- Collect data in the field

We arranged to make interviews within three users' groups. We scheduled 30 individual interviews to be conducted, one third of the interviews could be conducted at different organizations, one third of the interviews are conducted at schools, and one third of the interviews are being conducted in the street.

- Evaluate and analyze the data

Each one of us studied an open question as a separate case using within-case analysis, and categorizes answers and finds out similarities and differences. We examine a category of cases for differences, and dissimilar categories for similarities.

- Prepare the report

In a word, a case study is the best method to look and study past people's events and to get necessary data, which this study needs. All answers gathered from the interviews are used as a basis for developing FlexClean, and has the basis of the results for the issues that cause the computer system speed degradation.

### 3.2.2 Interview Design

Interviews [20] can be one of the major methods of data collection chosen to be used to capture people's words and actions, which represents the data of qualitative inquiry. Interview is a joint product of organizing by asking and answering questions of what both interviewees and interviewers talk about. The records of the interviews are documented to be used in work of analysis and interpretation of the problem.

However, preparing proper questions for an interview is very critical and difficult. According to the literature [20] there are three types of interviews: Structured interviews, Unstructured interviews, and Semi-structured interviews. We decided to use the Semi-structured interview. Questions can either be open or closed, but in this study, we prepared almost all questions as open questions. These questions were answered by the interviewees very specifically. The interviewees are free to talk and to answer the open questions. Doing the open questions have more opportunities to express their feelings and perspectives.

Another important consideration is which kinds of people's words and actions should be captured.

Windows users who have the experiences of the computer system speed degradation are the focus of the interviews. We collected more events of the computer system speed degradation, and more different interviewees' standpoints of why the computer system speed becomes slower.

The following table illustrates which groups of interviewees and their amount that we planned to choose.

Group	Amount	Note
From different organizations	10	The group will be divided into separate groups based on whether they work with high computer knowledge or not. At least one organization will be chosen that works with IT.
From schools	10	This group will focus on the choice of students in different majors. One or two students will be chosen from the computer major.
From normal home users	10	This group is a random choice. We will choose interviewees in the street.

### 3.3 Data Analysis

It has been declared in the former section that we planned to use within-case and cross-case analysis techniques. We only made within-case analysis due to time limitation. We studied all open questions together and categorized the answers. We picked out the primary events from each interview answer, and assigned each event of the computer system speed degradation into two groups: (i) Software settings and changes, and (ii) Hardware settings. We also identified what depth each event has, in order to find out what are the key issues that cause the computer system speed degradation. The big benefit of using the qualitative interview is to get more respondents' opinions, for instance, most of the interviewees have already used some optimization software. And these interviewees gave us much more perspectives and suggestions to the coming

software of FlexClean. We tabled the events grouped, the interviewees' opinions, and the developing features of FlexClean. In the table is clear to see the common issues that cause the computer system speed degradation. In the next chapter the results are presented. And we especially defined the key issues that cause the computer system speed degradation.

### 4. Result

In this chapter the results of the case study and qualitative interviews are presented.

In three groups 37 windows users have been interviewed: 12 workers from different organizations, 12 normal home users, and 13 students from random majors. Around 93% of the interviewees have problem with the computer system speed degradation, but the remaining 7% of the interviewees who may have but were not aware of the computer system speed degradation. Over 70% of the interviewees have found more than three different issues in their computers. More than 80% of the interviewees think virus infected and downloading too much from the Internet are major issues that cause their computers become slower. Only 40% of the interviewees could endure their computers becoming slower. And most of the interviewees have tried to solve the problem, or would like to know how to solve it perfectly.

The following table illustrates more in detail the quantitative results from the interviews.

Group	Amount	Note
From different organizations	12 (2 of 12 from IT section)	11 have the problem
		6 can endure
From schools	13 (3 of 13 from IT section)	13 have the problem
		6 can endure
From normal home users	12 (around 70% of 12 do not have jobs or are retired)	10 have the problem
		3 can endure
Sum	37	34(93%) have the problem

		15 (40%) can endure
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Below is a listing of the most common situations that the interviewees have faced that they think have resulted in a slower computer.

Start-up is slow	48.6%
Slow to open a file	27%
Slow to execute a program	75.67%
Browsing the Internet is slow	83.7%
Operate response is slow	64.86%

The ranking of issues order by interviewee

Virus	83.7%
Useless files	54.05%
Temporary Internet Files	48.6%
Startup	27%
Fragment	13.5%
Useless Registry Key	10.8%
Services Option	2.7%

The Statistics shows how many interviewees could endure the issues

Startup slow	54.05%
Slow to open the file	75.67%
Slow to perform a program	62.16%
Browse Internet slow	94.59%
Operate response slow	64.86%
Whole issues	40.05%

When comparing the interview results with analysis each feature of FlexClean, we defined six key issues that cause the computer system speed degradation. However, in the following two sections, in which to enumerate all possible issues that were analyzed from the interviews. It is arranged in the similar structure as the literature review chapter. In section 4.3 the key issues were picked out from the results list.

### 4.1 Internal: Software settings and changes

When the computer system speed degrades, firstly you should check the software settings or changes.

#### Useless files

More than half of the interviewees have bad habits of often installation and downloading, especially, for most of the home users and students. Most of the students have to install much studying software. However, after a period of time more and more

studying programs are installed, the hard disk becomes nearly full. After that they have to remove the unused software. It is well-known that the evolution of the software market is fast; almost every day there are one or more programs that are updated.

Too frequent installation, deletion, updating, and even downloading could cumulate to more and more unwanted files in the computers. This results in both a loss of much precious hard disk space, and a slower computer system.

A few of the interviewees have used some cleaning software to periodically clean up their computers. According to the literature review, useless files exist in different types. This corresponded with the analysis of the interviews.

### **Temporary Internet Files**

All interviewees surf the Internet almost every day, and all of them use the default Internet settings, which store recent 20 days temporary Internet files and all cookies [12].

Temporary Internet Files [19] are stored in the directory of Windows operating system. It stores pages from visited websites to the cache. It allows such websites to load faster when users visit these websites again. Usually, while users are using Microsoft Internet Explorer, more files are downloaded with each web page that is visited (including html, images, Cascading Style Sheets and JavaScript scripts). All these files are saved into the Temporary Internet Files folder, which creates a cache of the web page into the local computer. If users visit the websites that have been cached, the system only needs to change the content different from the cached content.

Most of the interviewees do not think to store temporary Internet files that could cause the computer system speed degradation. It cannot be said that temporary Internet files could cause the computer system speed degradation. However, there are many events collected from the interviews, for instance, the computer runs normally but slows to a crawl when the interviewees open the Internet Explorer or a page. Of course there could be other reasons causing this problem, but the prime culprit is temporary Internet files.

FlexClean has a feature called Disk Clean, which is compared to other similar products at the market. All of them defined the temporary Internet files to be garbage. Because of the network's fast growth,

every website also improves its pages very fast. The temporary Internet files are overdue fast as well, which is not convenient for users at all.

### **Useless Registry Key**

Windows registry [13] is a database of settings used for Windows operating systems. It stores configuration settings for hardware, software, and user profiles. A registry contains an entry, which is called registry key, and its associated values. After a long period of use of the computer, because of frequent installation or un-installation of some third-party software, more useless entries in the registry file are generated. The long period of time accumulation will lead to the computer system speed degradation.

A few of the home users at least know the registry keys, and some students or workers who are not from the computer area know the registry keys too. The interviewees, who study or work in the computer area, are familiar with registry keys, and even they have used some software to clean up the registry periodically.

Most of the interviewees do not know why and how the registry keys could cause the computer system speed degradation. However, analyzing the interviews events gathered, we found out that all those events were caused by the useless registry keys somehow, for example, start up is slow.

### **Services Option**

A Windows service is a long-running executable, which performs specific functions, and users could not intervene. Usually, Windows services start when Windows operating system boots and then run in the background as long as Windows is running. Services option is not an important issue that causes the computer system speed degradation, only some services are working but never used. Most of those services usually start with Windows, which is part of the issue of start-up (described below). Non-Windows experts will never change Windows services option abruptly, and this is a potential reason that could cause the computer speed degradation.

Three interviewees mentioned such an event is relevant to services option. When they optimized their computers, a few services that they think were of no need were stopped, and simultaneously they optimized their start-up as well.

### **Start-up**

The start-up function starts programs when Windows starts. Some users would like their customized programs to start with Windows start-up, and they think it is quite convenient. However, too much programs in Windows start-up will prolong the start-up time, and sometimes those programs may be not used by users at all.

Half of the home-user interviewees have the problem of Windows start-up. Computers run normally after start-up, but they take forever to start, sometimes they take 10 or 15 minutes. When users installed some software by themselves, they chose the default settings or choices, such as start with Windows, or sometimes the users think it is useful to let all customized programs start with Windows. Sometimes human-beings are greedy. Even more customized programs that start with Windows and this leads to slower start-up.

### **Fragmentation**

Several interviewees talked about the following event: when they opened a file, the hard disk kept beeping and the light of the hard disk was flashing frequently. We faced the same event normally during a period of usage. Such kinds of problems are caused by file fragmentation in the computer.

Fragmentation is usually called file fragmentation, because files have been separated and saved into different places in the hard disk non-sequentially. This phenomenon usually happens when an application cannot get enough physical memory. Normally when the system meets that situation, which will create some temporary files in the hard disk, and space of those files have been taken away is called **virtual memory**. The application of the virtual memory manager always reads and writes frequently in the hard disk, which could generate a large number of fragments. Users browsing through websites with Internet Explorer can also generate lots of fragments due to the caching performed by Internet Explorer. Although, the file fragmentation could not make a serious problem for the system, too much file fragmentation will result in difficulties in finding a wanted file. Hence, reduce the performance of the computer system, and cause hard disk failure. Too much file fragmentation could make the hard disk lose data.

Not all interviewees have used or known of the possibility to use the Windows disk defragmenter. Some of the interviewees use it periodically by manually starting the defragmenter. Some interviewees said that the Windows disk

defragmenter is automatically executed periodically on their computers. Other interviewees have never or rarely used it.

### **Virus**

Over 80% of the interviewees mentioned that virus can cause the computer system speed degradation.

A computer virus is a computer program that can copy itself and infect a computer without permission or knowledge of the users. The original virus may modify copies, or the copies may modify themselves, as occurs in a metamorphic virus. If a computer gets infected by a virus, the virus program will occupy the computer's memory and force CPU to execute much useless junk programs, which leads to a slowing down of the computer system.

Viruses are an undeniable issue that could cause the computer system speed degradation suddenly and terribly. However, from the interviews, three interviewees had gotten infected by a computer virus that did not slow down their computers. All interviewees stated that they had used an anti-virus program.

### **Desktop Icons and Background**

Some of the home users and students like to accessorize their computers with beautiful, cool or luxuriant backgrounds. Nowadays it can be said that there is at least one game installed in a computer. Some heavy gamers had ten games or more installed on their computers. Too many icons on the desktop, and too different programs, will reduce the speed during start-up. Each time Windows starts and displays the desktop, it needs to find the desktop shortcut icons and load them one by one, the more icons, the longer time it will take.

The beautiful background that has been placed on the desktop and this can waste much more computer resources. Not only that, but also slow down the computer system speed in the implementation of applications.

## **4.2 External: Hardware settings**

Sometimes hardware settings could also cause the computer system speed degradation. Below several issues about hardware settings are described. These issues have been summarized from the interviewees' stories.

### **Abnormal operations by CPU and Fan**



One interviewee talked about this relevant story that the fan of CPU was aged, so that the CPU was hotter and became slower.

If the CPU fan slows down, the CPU's temperature will rise. In order to protect the CPU from damage, the CPU will automatically reduce the operating frequency, which results in system speed degradation.

### **Various Drivers**

A few of the interviewees who work in an organization have computers which are always connected to scanners, printers, external hard disks, USB flash drives, etc. Starting Windows with all these devices connected and their drivers extends the computer's start-up time.

### **Poorly Configured System Accessories**

Some home users construct their own machine. Doing so, they often overlook some small things, which result in a bad configuration. It causes a speed bottleneck. For instance, some configuration uses a high-grade CPU, but the sound card and other accessories may have been bought at a bargain price. A cheap sound card can occupy more CPU resources which slow down the transmission, often giving rise to pause the sound, and even leads to intermittent procedure operation.

### **Insufficient Memory**

One of the advantages of Windows operating system is multi-linear and multi-tasking. The system can use CPU to carry out time-sharing operation, so users do a lot of things at the same time. But multi-tasking operation also puts forward higher requirements for the machine. Even one of the most commonly used software of Microsoft Word also requires at least around 16MB of memory. In order to run large-scale software, such as 3D MAX, 64MB of memory is not enough. Therefore, at these times the system will automatically use the hard disk as virtual memory. There is a big difference in speed between the hard disk and the RAM, since the hard disk is a mechanical structure and RAM is an electronic structure. Hence, usage of the hard disk as virtual memory will lead to a significant reduction in computer speed.

### **Too Much Hard Disk Partition**

Most interviewees' computers have at least 300GB hard disk space that is partitioned into at least three partitions. One interviewee had three hard disks with eight partitions. One of the hard disks broke

down, and it was removed from the computer. This interviewee felt that the computer booted faster afterwards.

If there are too many disk partitions in the computer, then start-up or even hang will become very long.

## **4.3 Key Issues**

The previous text mainly dealt with issues regarding software settings and changes. Six issues from section 4.1 are defined to be key issues that cause the computer system speed degradation; these are concluded to be the following:

1. **Useless files:** Garbage files use much of your precious hard disk space which also slows down the computer system speed. (>50% of the interviewees have this problem)
2. **Temporary Internet Files:** Nowadays temporary Internet files become overdue very fast, so they become one kind of garbage in your computer as well, which will degrade the computer system speed terribly. ( $\approx$  50% of the interviewees have this problem)
3. **Useless Registry Key:** During frequent installation or deleting, much useless registry keys remained, over a long period of time this will lead to computer system speed degradation. (>10% of the interviewees have this problem)
4. **Startup (includes Services Option):** More and more customized programs start with Windows which slows down the start-up. This is one of the intolerable computer system speed degradation. (=27% of the interviewees have this problem)
5. **Fragmentation:** It takes time to find a wanted file since fragmentation, reduces the performance of the computer system. It also tears on the hard disk, and this will degrade the computer system speed. (=13.5% interviewees have this problem)
6. **Virus:** The virus program will occupy memory and force CPU to execute much more useless junk programs, which lead to slower computer systems. (>80% of the interviewees think this is the most significant issue that affecting degradation of the computer system speed)

## 5. Discussion

The discussion chapter of this paper discussed the results in contrast to the literature review in chapter two. This chapter aims to validate whether the issues defined from the results really could cause the computer system speed degradation, and whether the key issues summarized in the results have answered the research question exactly.

### 5.1 Internal: Software settings and changes

#### Useless files and registry keys

It is difficult to find any idiographic events to explain the problems caused by useless files and registry keys. As mentioned from the literature, too much data in the hard disk could degrade the computer system speed. Usually, these issues are concurrent with other issues, like fragmentation or temporary Internet files. Furthermore, during the interviews we found out that more than half of the interviewees think the hard disk has too many useless files that could make the computer's space saturate, which slows down the computer system. However, only a few of the interviewees think the hard disk has too many registry keys that could slow down the computer system speed. The issue of registry has been supported in the literature. We made an additional test, in order to confirm whether the computer has lots of useless files and registry keys that slow down the computer system speed. This test let ten interviewees use a prepared computer for a short time. After that we cleaned the registry and the hard disk from useless files with cleaning software (wopti [14]). Then the interviewees used that computer again. From this we found out that only three interviewees thought the computer was faster than before, but it was not very significant.

The literature has described how many different useless files are crammed into the hard disk. When a computer becomes gradually saturated, the computer system speed becomes slower as well inconspicuously. Most interviewees would like to clean their computers to free up disk space and not because the computer is slow. In a word, useless files are indeed a potential key issue that slows down the computer system speed.

Compared to DOS Windows is too large. The daily operations and installations of new software or new games make Windows even more massive.

Another big difference between Windows and DOS is that if a program is uninstalled in Windows, there may still be unused DLL files in the computer. Therefore, over a long period of time there might be a lot of unnecessary DLL files that are loaded each time Windows start-up, and the speed of the natural system is increasingly slower.

In conclusion the useless registry keys could be another potential key issue that degrades the computer system speed.

#### Temporary Internet files

It is also annoying when the computer runs normally but the browser is slow. The interviewees were stated that the most common reason for a slow browser was the temporary Internet files. However, the temporary Internet files are quite convenient to use. For instance, most of the interviewees would like to keep the track of browsed websites, which are stored as recently browsed URLs. This because it is very convenient to just type a letter to find the whole web address. The cookies record their IP addresses, user names, passwords and other user information, which give a fast way to connect with the associated websites. All of this sounds very convenient and lazy but also dangerous to use. Nowadays most of the websites are designed and built luxuriantly. When a user browses these websites, all the files are downloaded in each page. These files consist of html, images, CSS, and JS. All of them are saved to the temporary Internet files folder. However, the network grows fast, and every website also updates their web pages very fast, a great deal of the files will never be used but still take away the user's hard disk space and sometimes when a user visits those websites, the system has to review the old files to compare to the current webpage to see whether it matches with the webpage in the web browser cache. It takes too much time and takes away too much computer memory. It has been supported in the literature that the temporary files will tend to be memory consuming. That is the subjective reason that reduces the speed while browsing the website.

To store thousands of temporary Internet files is an awful risk that causes computer system speed slow down. It can be proven that the temporary Internet files are the key issue to degrade the computer system speed.

#### Start-up

Start-up contains programs that are to be started together with Windows during start-up. It only

affects the speed of Windows while booting. This issue cannot be avoided over a period of months or years. Many of the interviewees said there were too many programs being started with Windows start-up. The computer needs a long time to start them up and during that time they could not do anything. The literature [2] supports the negative affect the Windows start-up has on the boot speed.

Most Windows XP users wanted to install the Vista sidebar (it includes weather, stock, news, etc) after it was released with Vista. This added additional programs that needed to be started at boot time. Hence, computers need extra time to start from then on, and most of the antivirus software takes long time to start as well during Windows start-up. The main reason for a slower start-up is too many additional programs in the start-up list.

Services are not a major factor for the computer speed degradation at start-up. Only some services are started without being used. Most of those services usually start with Windows, which are similar to start-up. Non-Windows experts will never change Windows services option abruptly. There are some unneeded services listed in the literature [11] that can be turned off.

If a computer has been used over a long period of time and boots slowly, then the primary recommendation is to check the start-up list.

### **Fragmentation**

From the theory of fragmentation we found out that it is a phenomenon for the computer system speed degradation. Usually some of the interviewees confuse it with the problem with too many useless files. The interviewees stated that the reason for a slow process when opening files was too many useless files. However, opening a file slowly and having a hard disk that frequently beeps is caused by the files being fragmented. Normally after using Defragmenter to clean the hard disk and re-open that file, everything works well: there is no noise and the light is not flashing frequently. The literature [2] also supports that fragmentation causes longer access and read times for files. In another word, a mass of fragments are going to add burden to the hard disk and extend the time it takes to open the file. According to the interviewees is opening a file from a very fragmented hard disk is similar to looking for a needle in a haystack. It is also the major reason for seeing the hard disk lights flashing frequently while opening a file. However, this reason is

unknown for the users. During the interviews only 13.5% of the interviewees thought fragmentation is the reason that slows down computer system speed, but in fact the biggest issue that slows down the process of opening a file is fragmentation.

### **Virus**

A virus always copies itself again and again. This takes away a lot of resources and generates lots of useless files. Together this will result in a significant loss in system speed. If a computer is infected by a virus, then the system will significantly slow down the programs operating speed. After a virus is intrusive, it first occupies the memory, where it makes an endless number of copies of itself, which results in lack of main memory. This results in the computer becoming slower during the normal run-time. At the same time, the virus will force the CPU to execute useless junk implementation procedures, which makes the system always in a hurry, thus affects normal operation of the procedures, and leads to a slower computer system. The literature [18] supports that viruses and spyware program are one of the key issue that suddenly slows down the computer system speed.

There are lots of examples of viruses that slow down the computer system speed. The effect of a virus can be messages automatically being sent to other computers, the computer shutting self down, prevention of opening the Antivirus software, occupation of all the CPU resources (up to 100%), and so on. Some virus can even destroy the computer.

### **Desktop Icons and Background**

Nowadays, not only appearance of the computer becomes luxuriant, but also appearance of the computer system. Many young people would like to use colorful icons, background, or external effects to accessorize their systems and even more and more high-grade games are released. Normally each game consists of several icons which users would like to put on the desktop. Indeed, many users have bad habits of storing .doc files, .txt files, or images on the desktop. After a long period of time the desktop becomes very messy. When Windows boots and displays the desktop, it needs to find each of the desktop shortcut icons and load them. This is done by one icon at the time. It can be assumed that the time needed to load the icons for a desktop of 10 icons is not the same as a desktop that contains 50 icons. Too many colors in the background could also slow down the

computer speed. This is the case since it takes much computer resources. However, this issue is not supported by any literatures, and no interviewees thought this issue could degrade the computer system speed. Most of the interviewees would like to keep those icons and could endure the additional time it takes to load those icons.

## **5.2 External: Hardware settings**

### **CPU and Fan of Abnormal operation**

The CPU fan is what keeps the temperature down and the CPU speed up [15]. The warmer the CPU the computer will become slower. It also increases the possibility of hardware burnout. A qualified CPU fan is needed, which is recommended in the literature. Monitoring the CPU temperature regularly is also quite significant.

### **Various Drivers**

While Windows starts it checks to see if one or more CD-ROM drives are in place and loads appropriate drivers. Windows does the same thing for each USB device, scanner, etc. All of this makes the boot process slower than if one or more devices were not connected. To decrease the start-up time, some unnecessary external hardware should be disconnected when Windows starts.

### **Poorly Configured System Accessories**

Perfectly configured system accessories are quite an important footstone for a computer. Some old machines are upgraded with some new components. Users are often reluctant to change the memory in the computer. The literature states that this is like having a modern car with a lawnmower engine. If the old memory is slow, the rest of the system often reduces the speed of the new components to be in phase with the old memory. This reduces the performance of the computer.

### **Insufficient Memory**

In previous sections, insufficient memory has been mentioned many times. Insufficient memory could be caused by different software and hardware reasons. Computer memory refers to a device that is used to store data temporarily or permanently. Virtual memory is a computer system technique that improves the computer performance by using the hard disk space to extend available storage space for random access memory. The virtual memory automatically adjusts the size of the swap files according to demand of the different procedures, which will give an additional burden

on the system that causes the running speed to become slower. In view of this, users will be the best to define the virtual memory minimum and maximum size.

### **Too Much Hard Disk Partition**

Disk partitioning is an act that allows users to divide a hard disk into multiple partitions. Users like to split a hard disk into multiple partitions in order to organize data more effectively. Windows must load each partition at boot time. With the increase in the number of partitions, the amount of time to complete this operation will be growing too.

## **6. Conclusion**

This paper has presented a study on the computer system speed degradation. The purpose of this study is to find out the key issues that degrade the computer system speed in today's computers. The whole study is based on the Windows platform. To be able to address this, the investigation has collected a great deal of information about the computer speed degradation from a case study of development of FlexClean and qualitative interviews. We conducted 37 qualitative interviews in three different groups. Based on both the case study and the interviews, we collected and summarized the data into three groups' issues that cause the computer system speed degradation. Finally, six key issues have been defined as the results: Useless files, Temporary Internet Files, Useless Registry Key, Startup (includes Services Option), Fragmentation, and Virus.

During this study, we collected many typical events about the computer system speed degradation. After that we analyzed these events to define the key issues. After this study is done, we hope the best effort gained from it is not only to find out issues that cause the computer system speed degradation, but also to let users know why their computer system speed degraded. From our perspective, the primary outcome gained from this study is to know how to use research method to do a study. As a whole, via the case study and interviews, much valuable data was collected which helped us a lot. In the beginning, the aim of choosing a qualitative method was to collect more "participants own words". With more "words" we were able to make a better analysis which could show on more results. Interviews are absolutely the best choice of method to collect "words". In a word, the stories or events gained from the

interviews are one of the biggest treasures in this study.

From the six key issues that were defined made us and all the participants better at knowing computers, how to avoid the computer system speed degradation and how to solve it. For instance, maybe more users would like to use at least one kind of optimizing software periodically or appropriately to change their bad habit based on these six key issues.

Because of the limited human resource and time pressure, this investigation did not deeply research all issues that could cause the computer system speed degradation. The study only focus on some frequently asked issues. Some other small issues which we did not considered, for instance: slow when switching between programs with “Alt + Tab”, slow to install a software, take long time to execute a program, and after the computer is running a long time that the speed of the computer obviously gets slow, etc. For future research we suggest a focus on those non-studied or potential issues and more deeply looking at the key issues that cause the computer system speed degradation.

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