Quest for Apple

Abstract

Apple computer is a unique product in personal computer market. Although Apple computer's share in PC market had dropped from 9% to 3.45% within two years since 1995, and remains only around 2.0% after that [1], it is still well survived and its market value keeps rising. We are curious about the history of Apple computer, i.e. how its OS evolves, how its microprocessor evolves? Why Apple's computers are expensive? What did they do when Windows95 appeared? Why had it persisted to use PowerPC instead of mainstream microprocessor (Intel, AMD, etc) until 2005? Will Apple give up Mac OS and switch to MS windows?

Price of Apple computer

Apple computer has a long history back when Mr. Steve Wozniak designed Apple I in 1975. As Mr. Steve always believed, he wanted to design computers that everybody could easily use and could afford to have one. They sold Apple I at a lower price compared to the price people thought it would be in 1975. However, after thirty years, it is commonly conceived that Apple is selling the most expensive personal computers in the world, compared to PCs sold by other vendors, e.g. Dell, Lenovo, HP, etc. We would like to know why Apple computers are expensive.

Why Apple computers are expensive?

We compare the high end 17' Macbook pro with comparable Lenovo Tseries notbook and Dell Inspiron notebook.

Machine Model	***Macbook Pro 17'***	***Lenovo T60***	***Dell Inspiron 9400***
Hardware			
CPU	Intel Core 2 Duo processor T7600	Intel Core 2 Duo processor T7600	Intel® Core™ 2 Duo processor T7400
Memory	2 GB PC2-5300 DDR2 (up to 3GB)	2 GB PC2-5300 DDR2 (up to 4GB)	2 GB PC2-5300 DDR2 (up to 2GB)
Hard Drive	100GB 7200rpm	100GB 7200rpm	160GB 5400 RPM SATA
Graphic Card	ATI Mobility Radeon X1600 graphics with 256MB SDRAM	ATI Mobility Fire GL V5250 256MB	256MB ATI MOBILITY™ RADEON® X1400
DVD/CD Drive	8x double-layer SuperDrive	DVD Recordable 8x Max Dual Layer	8x CD/DVD burner (DVD+/-RW) with

Machine Model	*Macbook Pro 17'*	*Lenovo T60*	*Dell Inspiron 9400*
			double-layer
Screen	17 inch Wide Screen	15 inch Wide Screen	17 inch UltraSharp™ Wide Screen UXGA Display
Fancy	Isight	Fingerprint	N/A
Software			
Antivirus	N/A	Symantec Norton Antivirus 2006 Retail Box	McAfee Security Center w/ VirusScan, Firewall and Privacy, 90-day trial
OS	Mac OS v10.4 Tiger	Genuine Windows XP Professional	Genuine Windows XP Professional
Price	$2699	$2603.99	$2484

We also compare the low end 13' Macbook with comparable Lenovo and Dell notebooks.

Machine Model	*Macbook 13'*	*Lenovo X60*	*Dell XPS M1210*
Hardware			
CPU	1.83GHz Intel Core 2 Duo	1.83GHz Intel Core Duo	1.86GHz Intel Core 2 Duo
Memory	512MB 667 DDR2 SDRAM	1GB 667 DDR2 SDRAM	1GB 667 DDR2 SDRAM
Hard drive	60GB 5400rpm	60GB 5400rpm	80GB 5400RPM
Graphic card	Intel GMA 950 graphics processor with 64MB of DDR2 SDRAM shared with main memory	Integrated graphics processor	Integrated Intel® Graphics Media Accelerator 950
DVD/CD drive	DVD-ROM/CD-RW	DVD-ROM/CD-RW	24X CD Burner/DVD Combo Drive
Screen	13.3 inch wide screen	12.1" XGA TFT with Bluetooth	12.1" XGA
Software			
OS	Mac OS v10.4 Tiger	Microsoft Windows XP	Microsoft Windows XP

Machine Model	*Macbook 13'*	*Lenovo X60*	*Dell XPS M1210*
		Professional Edition	Professional Edition
Anti-virus	N/A	N/A	Norton Internet Security™ 2006 Edition 15-months
Price	$1099	$1583	$1348

We found that Apple's Macbooks are actually not as expensive as we thought! The reason we think Apple is expensive is that it doesn't have real low-end machines. The most low-end laptop of Apple computer is the 13-inch Macbook with 1.83GHz Intel duo 2 core, which is priced $1099. While the low end laptops of other vendors are much cheaper, for example, Dell's Inspiron B130 is only $499, Lenovo's R60 starts from $565.

Therefore, Apple has a much more narrow product spectrum than other computer vendors, and it only competes in the high end of the PC market. Market analysis shows that only few PC sold are high end, as showed in Figure 1[2]. Consequently, people thought Apple's computers are more expensive.

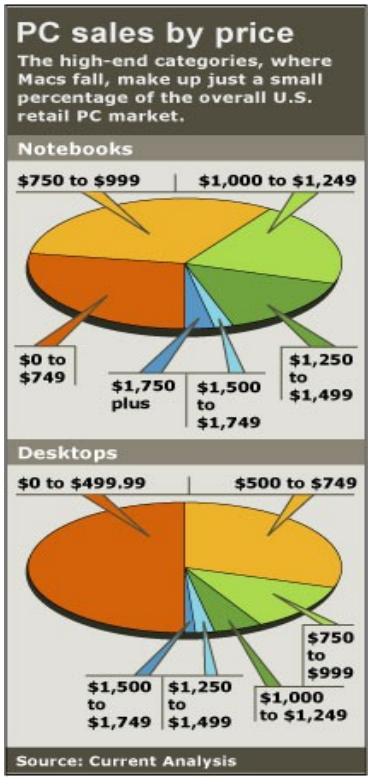

Figure 1: PC sold by price

Why doesn't Apple computer have a broader product line?

We think one reason is the microprocessor. We guess PowerPC has a more narrow product line than Intel microprocessors. Since Apple has switched to use Intel processors instead of Power PC now, we could expect there will be a broader product line in future.

PowerPC microprocessor

Birth of AIM and PowerPC

Before talking about PowerPC, let us look at POWER first. POWER stands for "Performance Optimization With Enhanced RISC", which is IBM's RISC architecture mainly developed for use in mainframes and servers.

Before 1993, Apple had been using Motorola's 68000 (a.k.a 68K) processor in its desktop computing line. However, the 68K processor was not performing well as Apple has hoped. What's more, its more advanced 88K processor did poorly in market due to the lack of backwards compatibility with 68K.

In the very early 90s, IBM approached Apple with the goal of collaborating on the development of a family of single-chip microprocessors based on the POWER architecture. Soon after, Apple, as one of Motorola's largest customers of desktop microprocessors, asked Motorola to join the discussions

because of their long relationship, their more extensive experience with manufacturing high-volume microprocessors than IBM and to serve as a second source for the microprocessors. Therefore, the Apple-IBM-Motorola alliance, known as AIM, was born.

In short, Apple needed a CPU for its personal computer that would be both cutting-edge and backwards compatible with 68K. IBM intended to turn POWER into a wider range of computing line besides mainframes and servers. And Motorola would like a high-end RISC microprocessor to compete in RISC market. Also, at that time, there was a growing dominance of Microsoft and Windows as well as Intel processors in personal computing. The AIM alliance jointly designed PowerPC to counter the growing Microsoft-Intel dominance of personal computing. PowerPC was most successful in the personal computer market in Apple's Macintosh line from 1994-2006 before Apple's transition to Intel. PowerPC is based on RISC architecture, as opposed to CISC approach adopted by Intel microprocessors. In this section, we would like to go through all the PowerPC microprocessors adopted in Apple's computer. The references where we retrieve the direct information include [16][17][18][19][20].

PowerPC 600-series

The PowerPC 600-series consist of 601, 603, 603e and 604. We will talk about them respectively. In 1993, AIM alliance released PowerPC 601, which was based on IBM's RISC Single Chip processor, combined IBM's POWER architecture with the 60x bus developed by Motorola for use with their 88000, and was designed to serve as a "bridge" between POWER and PowerPC. Some of its characteristics are summarized in table1.

Table 1. PowerPC 601 Summary

Introduction date	March 14, 1994
Process	0.60 micron
Transistor Count	2.8 million
Die size	121 mm^2
Clock speed at introduction	60-80MHz
Cache sizes	32KB unified L1
First appeared in	Power Macintosh 6100/60

PowerPC 603 and 603e were successors to 601, summarized in Table 2**.**

Table 2. PowerPC 603 and 603e Summary

	PowerPC 603	**PowerPC 603**
Introduction date	May 1, 1995	October 16, 1995
Process	0.50 micron	0.50 micron
Transistor Count	1.6 million	2.6 million
Die size	81mm^2	98mm^2
Clock speed at introduction	75MHz	100MHz
Cache sizes	16K split L1	32K split L1
First appeared in	Macintosh Performa 5200CD	Macintosh Performa 6300CD

Notable thing about PowerPC 603 is that it was designed with low power in mind because of Apple's need for a chip for its PowerBook line. Therefore, the processor had a very good performance-per-Watt ratio on native PowerPC code. 603 supports classic RISC four-stage pipeline like 601, but it has two more execution units than 601, i.e. load-store unit (LSU) and system unit. The LSU is dedicated for effective address calculation and store-data operators, thus easing the burden of integer unit, which allows it to focus on integer arithmetic and improves 603's performance on integer code.

The problem of 603 is that the smaller cache size prevented it from emulating the legacy 68K code which formed a large part of Apple's OS and applications. Therefore, 603 was used in the very lowest end of Apple's product line. At the same time, a tweaked version with an enlarged 32K split cache, called 603e was developed. The 603e did a better job in emulating 68K code, and was widely used in PowerBook line. The 603 architecture is direct ancestor to the PowerPC 750 architecture, marketed by Apple as the PowerPC G3.

PowerPC 604 was released at the same time as the original 603. It was targeted at Apple's high-end desktop products, with a much higher power and transistor budget than 603/603e. 604 had a deeper pipeline of 6 stages than that of 601 and 603 with only 4 stages. The lengthened pipeline enables 604 to reach higher clock speeds than its predecessors, because each pipeline is simpler, thus taking less time to complete. Besides, the two more stages dispatch and complete make out-of-order execution possible. Another factor that distinguishes 604 from other 600-series PowerPC is its wider execution core, which can execute up to six instructions per clock cycle.

In summary, the 600-series gradually evolved into a mature RISC microprocessor that brought Apple's PowerMac workstation to the lead of personal computing performance. Noticeably, at the 600-series' reign time, transistor budgets were still relatively small according to today's standards, so RISC-based PowerPC architecture has a clear performance, cost and power-consumption advantage over x86 competitors. However, when the transistor counts and MHz numbers became much higher conforming to Moore's law, the relative cost of supporting legacy x86 began to decrease and the PowerPC ISA's RISC advantage began to decrease.

PowerPC G3

G3 are used to denote PowerPC 750 (refer to Table 3) and its immediate successors, which are widely used across Apple's whole product line, both laptops and workstations.

Table 3. PowerPC 750 summary

Introduction date	November 10, 1997
Process	0.25 micron
Transistor Count	6.35 million
Die size	167mm^2
Clock speed at introduction	233-266MHz
Cache sizes	64KB unified L1, 512KB L2
First appeared in	Power Macintosh G3/233

G3 didn't support vector computing capability and was stuck in the scalar computing world. On the contrary, comparable PC processors from Intel and AMD supported SIMD through the vector extensions to the x86 instruction set.

PowerPC G4 and G4e

The PowerPC 7400/7410 microprocessors all go under the name of "G4". And G4e denotes PowerPC 7450. Table 4 summarizes some of 7400's characteristics.

Table 4. PowerPC 7400 summary

Introduction date	August 31, 1999
Process	0.25 micron
Transistor Count	10.5 million
Die size	83mm^2
Clock speed at introduction	350-450MHz
Cache sizes	32KB L1 (instructions), 32KB L1 (data), 512KB L2
First appeared in	Power Macintosh G4/400

PowerPC 7400 is widely used as an embedded processor, designed primarily for routers and other non-PC devices which require low power consumption and strong DSP capabilities. Apple had used 7400 in their first version of their G4 workstation line, and later replaced it with 7410, then 7450.

Essentially, PowerPC 7400/7410 had no much difference with 750 other than the addition of vector computing unit and support of SIMD capability. This was enabled by a joint effort of Motorola and IBM to develop a set of SIMD extensions to PowerPC ISA. Such extensions are called VMS by IBM and called AltiVec by Motorola. Other minor changes included more CQ (complete queue), which helped reduce the bottleneck of dispatching instructions to additional execution units.

The main problem of 7400/7410 was that it only has a short four-stage pipelines, which limited the upwards scalability of its clock rate. And 7400/7410 had been stuck around 500MHZ for quite a long time. Therefore, Apple's x86 soon surpassed it in both clock rate and performance. To alleviate the challenge, Apple turned to SMP approach to increase its desktop performance. It offered computers where two G4s worked together to gain more processing power in a way that didn't reply on the clock rate speedup. It wasn't until the 7450 came out that the per-processor performance of Apple's desktop improved.

7450 (refer to Table 5) was a quite different design from 7400/7410. It breaks G4's classic four-stage pipeline into seven stages, consisting of Fetch1, Fetch2, Decode/Dispatch, Issue, Execute, Complete and Commit. Issue stage is where G4e differs most from G4. It has three issue queues between the dispatch stage and the reservation station, which eliminates the dispatch bottleneck commonly seen in G4. Although 7450 boosts the clock speed and performance, it was not enough to re-gain the leading status in performance game. Intel and AMD had strived very hard to improve the performance of their microprocessors.

Table 5. PowerPC 7450 Summary

Introduction date	January 9, 2001
Process	0.18 micron
Transistor Count	33 million
Die size	106mm^2
Clock speed at introduction	667-733MHz
Cache sizes	32KB L1 (instructions), 32KB L1 (data). 256KB L2, 512KB-2MB L3
First appeared in	Power Macintosh G4/667

Actually, there have been constant rumors about Apple's transition to x86 processors during 7400's clock speed drought. In the beginning of 2002, the performance situation of Apple's desktop line looked incredibly unsatisfactory when it seemed such a switch was inevitable. However, in the middle of 2002, IBM decided to produce an AltiVec-enabled version of its popular 64-bit POWER4 line whose main customer was Apple. This processor eventually became known as PowerPC 970. The advent of 970 was very exciting news for Mac users who are interested to see how Big Blue brings 64-bit RISC computing out of the server to the desktop.

PowerPC G5

The PowerPC 970, 970FX, 970GX and 970MP, also collectively known as the PowerPC G5. We talk about 970 here.

As mentioned above, PowerPC 970 was based on POWER4, which is recognized as a milestone in the IBM POWER family. One of IBM's major strengths is its system expertise -- the ability to design multiple parts in a consistent and synergistic manner. In that light, POWER4 cannot be considered only a chip, but rather an architecture within which a set of chips are designed together to realize a system.

POWR4 implements and extends in a compatible manner the 64-bit PowerPC Architecture. It leverages IBM technology using an 0.18-*1*m-lithography copper and silicone-insulator (SOI) technology.

Power4 is the first microprocessor to incorporate dual cores in a single die. Each Power4 chip has two identical processors, which provide a 2-way SMP model to software. Each processor contains several execution units, separate L1 instruction and data cache. A novel technique adopted by Power4 is the concept of group of instructions. As we know, it is important to record program order when executing out-of-order. To minimize the logic necessary to track a larger number of in-flight instructions, in Power4, instructions are grouped in groups. The individual groups are tracked through the system. Any exception causes the machine to be restored to the state of the oldest group prior to the exception.

Apple's transition from PowerPC to Intel's x86 [23][24]

In the 2005 Worldwide Developers Conference, Apple's CEO Steve Jobs made a historic announcement that Apple would transition from the use of PowerPC microprocessors supplied by IBM and FreeScale (formerly Motorola) in their Macintosh computers, to x86 processors designed and manufactured by Intel, which was a chief supplier for most Apple's competitors.

The transition was said to begin in June 2006 and finish by the end of 2007, but actually proceeded much more quickly. Although Apple had been used to bash Intel's chips during the 10 years of its adoption of PowerPC, there were several significant reasons why it decided to transition to Intel, and such a transition is not sudden.

According to several sources familiar with the partnership, Apple has discussed potential deals with Intel and AMD over the years. Actually, the relationship between Apple and IBM has been rocky at times. Apple had openly criticized IBM for chip delivery problems, though Big Blue said it fixed the issue. More recent concerns, which helped spur the Intel deal, included tension between Apple's desire for a wide variety of PowerPC processors and IBM's concerns about the profitability of a low-volume business.

Recall that back in 2003, Steve announced that a 3GHZ G5 would be shipped by mid-2004, a promise that is still unfulfilled. And G5 has never been put into use in laptop. Apple has gradually lost patience with the pace of processor development by IBM. On the other hand, from the business aspect, IBM isn't too fond of making chips for a niche market that Apple has, it has already shown concern about the profitability of such operations. Besides, IBM has other ventures for the POWER architecture in mind that are more profitable, such as the Cell in the upcoming PS3.

On the Intel side, it shows a better growth path for chips and showed much more vigor in its chip's R&D than AIM alliance. The performance of Intel's chip is quite comparable to PowerPC. In 2006, Apple website said "Combined with 4MB L2 cache and a myriad of other engineering leaps, the Intel Core 2 Duo boosts performance up to 39% higher than the previous MacBook Pro and over 7x higher than the fastest PowerBook G4." Intel has strong competition from AMD, which is a very important driving factor for it to strive hard in its chip R&D. While AIM, on the other hand, has no such worries to drive them. Besides, as the leading supplier of microprocessors in the market and being good at massive production, Intel can supply Apple with chips at lower cost than IBM is.

Apple Computer's Operating Systems

Introduction

Window XP market share reached 90% by the end of November, 2006, as showed in Figure 2 [3]. Mac OS market share rose to 5.21% by the end of October, 2006[4], and the Mac OS X Intel increased from 0.84% in September 2006 to a 1.12% in October. In this section, we will investigate the history of Mac operating system and compare Mac OS X Tiger with Windows XP according to our own experiences.

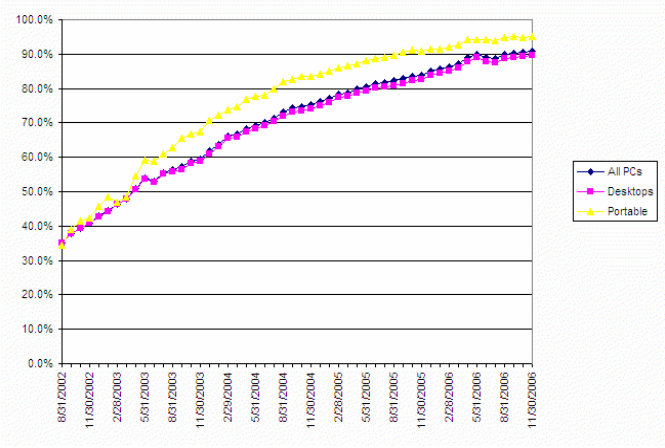

Figure 2: Win XP market share

History of Mac OS [6][7][8]

In 1976, Apple I was released. The Apple I came with a firmware resident System Monitor, a program that can be thought of as its operating system. The System Monitor program was 256 bytes in size, and used keyboard and TV as display to present the user with a command line for viewing memory contents, typing and running programs, etc. Compared to the UNIX general-purpose time-sharing system, which was in its Sixth Edition at that time, the Apple I's "operating system" was not a real operating system. But Apple I, sold for $666.66, was much cheaper than machines running Unix, which might cost over $10,000. The Apple I was an attempt to make computer affordable for everyone. A picture of the “OS” of Apple I was shown in Figure 3.

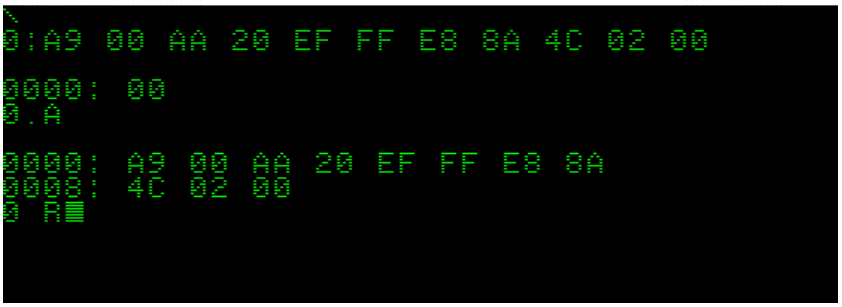

Figure 3: System Monitor for Apple I

In 1977, Apple II was released. Several Operating Systems were developed for Apple II. Apple DOS 3.1 was one of them, as shown in Figure 4. Although the name sounded like MS-DOS, they were different. At that time, many "disk operating systems" had the term DOS in their names. Apple Pascal is another OS developed for Apple II. It was derived from UCSD Pascal II and lasted for five years. The interface of Apple Pascal is shown in Figure 5.

Figure 4: Apple DOS 3.1

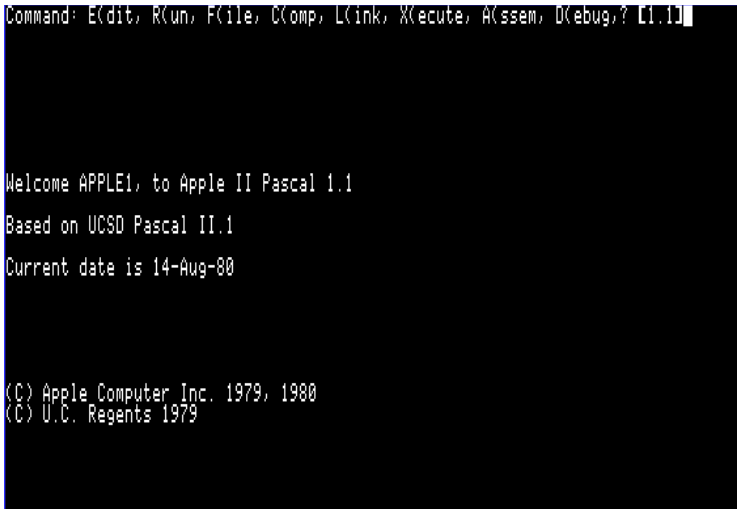

Figure 5: Apple Pascal

The Apple III was introduced in 1980 as a business computer. It had a new operating system called Apple SOS (shown in Figure 6), which stood for "Sophisticated" Operating System.

In October 1983, Apple ProDOS was released as the replacement for DOS 3.3. Apple ProDOS was based on SOS. It provided better support for programming in BASIC, assembly language, and machine language, better interrupt handling, faster disk I/O with direct block access, and so on. It also had a relatively sophisticated hierarchical file system.

Figure 6: Apple SOS

Apple released the Lisa in January 1983. It was commonly believed that Lisa was inspired by the work at Xerox PARC. Lisa's operating system had a fully graphical user interface. It came with a spreadsheet (LisaCalc), a chart tool (LisaGraph), an outline builder (LisaList), a project scheduler with integrated PERT/Gantt (LisaProject), a drawing program (LisaDraw), a DEC VT/ANSI terminal emulator (LisaTerminal), and some other software.

Lisa introduced several aspects that would become part of Apple's systems to come. It had a menu bar at the top of the screen, although without an Apple menu. Menu commands had an Apple symbol however (instead of the cloverleaf symbol used later). Double-clicking an icon caused the resulting window to come up. Items were deleted by dragging them to a trash can icon.

Macintosh was released on January 24, 1984. Later known as the Mac 128K (due to the 128 KB of built-in RAM), it had an 8 MHz Motorola MC68000 processor, and a built-in 9-inch black-and-white monitor. There was a 3.5" floppy drive that accepted 400 KB disks. The Macintosh ran a single-user, single-tasking operating system, initially known as Mac System Software (Mac OS 1 or System 1). The default application running as the system came up was called the "Finder". It was an interface for browsing the file system and launching applications. The single-tasking nature of the system required the user to quit a running application in order to work in the Finder. The Macintosh File System (MFS) was a *flat* file system: all files were stored in a single directory.

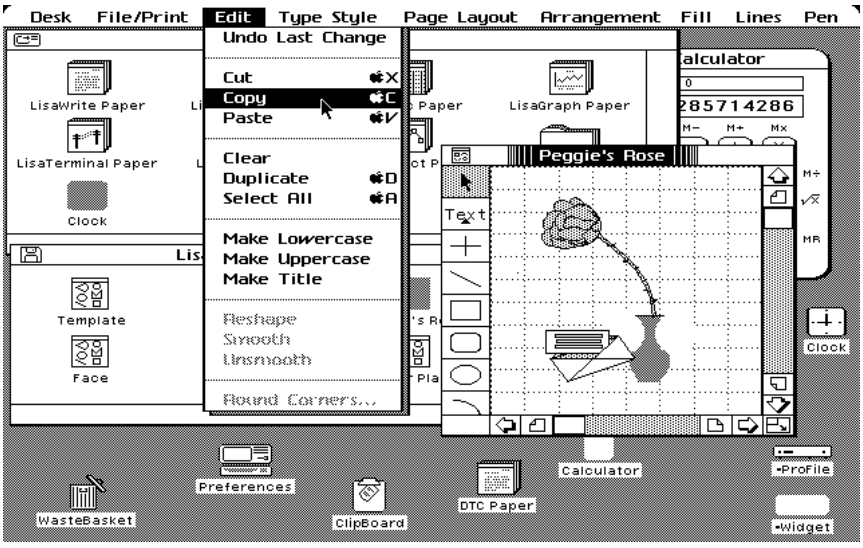

Figure 7: Apple Lisa Screenshot

The Macintosh inherited many of the Lisa's characteristics, such as a menu bar at the top and an iconic trash can (that was automatically emptied every time the system booted).

After Mac OS 1, Apple released Mac OS 2-6 in the next few years. Some improvements made during this time included: [7]

- Continued speed improvements for the Finder, including a disk cache and a "minifinder" to make application launch faster
- Commands for common tasks such as shutting down, creating new folders, ejecting disks, etc.
- A hierarchical file system (HFS) that supported *true* hierarchy
- Support for multiple monitors
- Support for large disk drives

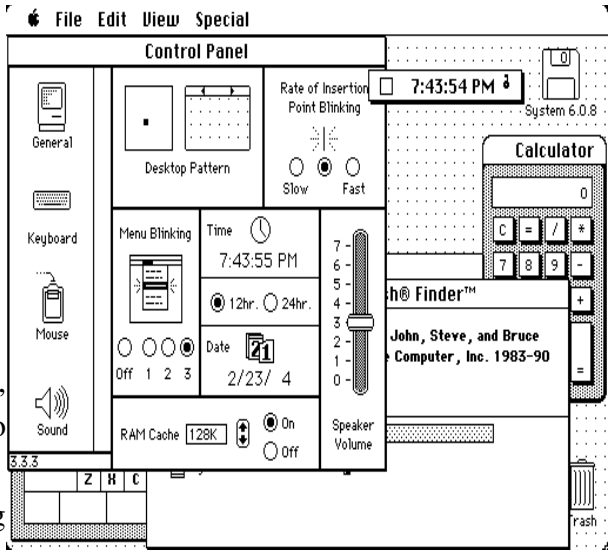

Figure 8: Mac OS 6

Mac OS 7 was released in 1991. Some of its new features were:

- Built-in networking (via AppleTalk) and file-sharing (via AppleShare)
- Support for 32-bit memory addressing
- **A virtual memory (VM) implementation**

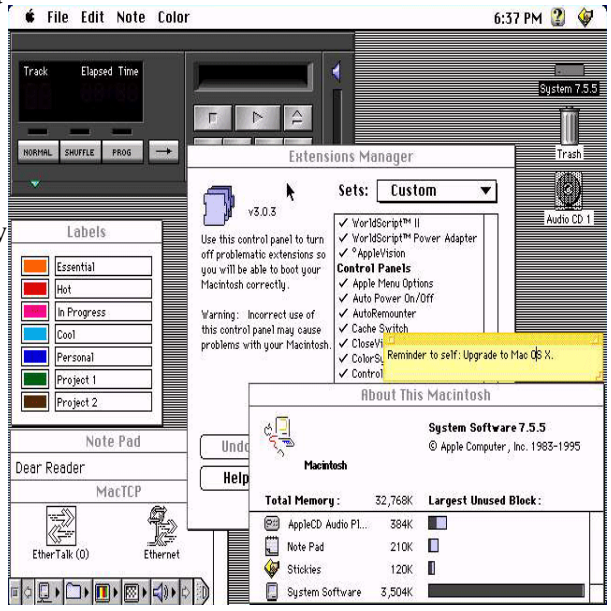

Figure 9: Mac OS 7

Mac OS 7, shown in Figure 9, was a multi-task operating system that supported multimedia. It had ColorSync, which managed the color system; QuickTime, which could view and edit images, audio and audio, etc. It also brought some fancy features such as dragging text from one window to another.

Even with all these improvements, Mac OS 7 only did cooperative multi-tasking, and was lack of memory protection. At this time, Apple computer formed an alliance with IBM and Motorola that devised PowerPC. Switching to PowerPC required fundamental changes in the design of the Mac OS. Mac OS 7.1.2 was the first to support the PowerPC.

However, Macs running the Mac OS 7 crashed a lot. It was commonly believed that Mac OS 7 was weak and unreliable. Around that time, Microsoft released their Windows NT 3.0 with multimedia support, as shown in Figure 10. Windows NT 3.0 was the first commercially successful operating system of Microsoft. The success of MS Windows (WinNT and upcoming Win95) pushed Apple computer into a very struggling circumstance.

During this period (around 1992-1996), Apple failed in many projects on developing the new operating systems, e.g., Star Trek, Raptor, NuKernel, Copland and Gershwin. Apple even considered partnering with Microsoft to create an new Apple OS based on Windows NT. But none of these worked.

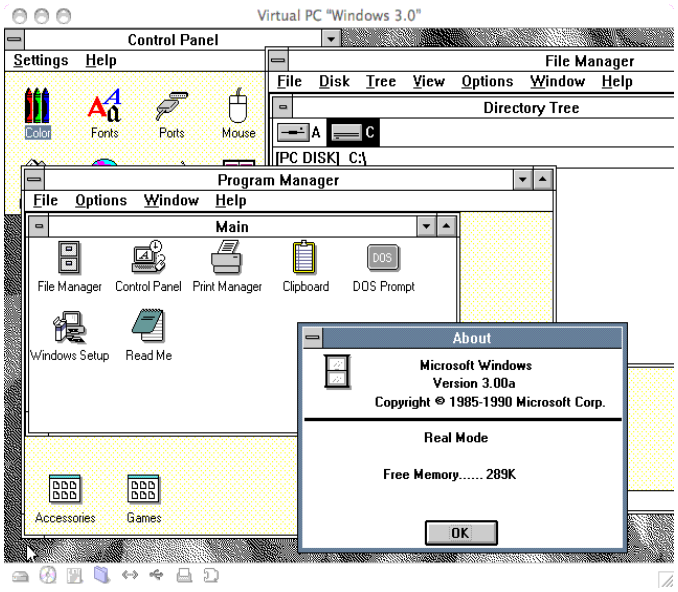

Figure 10: Windows NT 3.0

Finally, Gil Amelio, the CEO of Apple computer, made the decision to buy a new operating system-NeXT, which was the company started by Steve Jobs after he left Apple. An interesting story is : Steve Woznaik, the creator of Apple I and Apple II believes Mac OS 7 is just great, and it is not necessary to write a new operating system because he believes that the crash problem of Mac is caused simply by the web browser IE [5](p295). But, nobody would listen to him, and NeXT was acquired for $400 million in 1997.

Mac OS 8 was released on July 26, 1997, shortly after Steve Jobs returned to Apple Computer. It was mainly released to keep the Mac OS moving forward during a difficult time for Apple, when Mac's market share dropped from 9% to 3% within two years. Mac OS 8 had a multi-threaded Finder that allowed several simultaneous file-oriented operations, contextual menus activated by a control-click, and important enhancements to power-management, USB and FireWire. Microsoft Internet Explorer and Netscape Navigator were also bundled. Apple's implementation of the Java runtime environment, the Macintosh Runtime for Java, was incorporated in Mac OS 8.

Mac OS 9, shown in Figure 11, came out in 1999, and was advocated by Apple as the *"best Internet operating system ever"*. It was the first Mac OS version that could be updated over the Internet. It included useful security features such as file encryption and the "Keychain" mechanism for storing passwords. It could also use the AppleTalk protocol over TCP/IP.

Figure 11: Mac OS 9.2

While it retains the same name as its predecessors, Mac OS X (Xis a Roman numeral and officially pronounced as "ten". People commonly pronounced as the letter X) is largely independent. It is primarily based on a Unix core known as Darwin, while older versions are based on a proprietary core (the same basic core was in use from Mac OS 1 up to Mac OS 9). Here is the time line of Mac OS X releases:

1. On March 24, 2001, Mac OS X v10.0 (Cheetah)
2. On August 24, 2002, Mac OS X v10.2 (Jaguar)
3. On October 24, 2003, Mac OS X v10.3 (Panther)
4. On April 29, 2005, Mac OS X v10.4 (Tiger)

Figure 12: Mac OS X tiger: Dashboard

Mac OS X Tiger has many fancy features:[15]

- Spotlight: A content and meta-data based file search tool
- Dashboard: Dashboard allows for Widgets to be superimposed over the desktop. See Figure 12.
- Smart Folders: A virtual folder that uses Spotlight to populate the file listing instead of showing a true folder on the file system.
- A new version of iChat: A new version supports the H.264/MPEG-4 AVC video codec for conferencing and allows for multi-party audio and video chats. Support for the Jabber online instant messaging protocol is also introduced.
- QuickTime 7: the new version includes H.264 support and a completely re-written interface.
- Automator: automates repetitive tasks without programming.
- VoiceOver: A built-in screen reader for those with vision disabilities.
- Core Image and Core Video: allows additional effects in video and image editing to be performed in real time.
- 64-bit memory support for the new G5 for programs or program parts without a graphical user interface, with an LP64 programming model (graphical user interface front ends still must be programmed in 32-bit).
- Updated Unix utilities, such as cp, mv and rsync, now respect HFS Plus metadata and resource forks. (cp in 10.4 is like CpMac, mv is now like MvMac, compatibility issues naturally arise.)
- An extended permissions system using access control lists.
- A brand-new Application Programming Interface called Core Data, which greatly faciliates the management of application data in Cocoa applications.

Steve Jobs stated that OS X Leopard will be available in "Spring 2007". it will support both PowerPC and Intel x86-based Macintosh computers. On April 5, 2006 Apple released a beta version of an application called Boot Camp, which eases the installation of Microsoft Windows XP on Intel Macs alongside Mac OS X in a dual boot configuration. Boot Camp is currently in public beta, with the final version intended to be included in Leopard. Meanwhile, copies of the Intel version of Mac OS X were released onto the Internet and a community effort called OSx86 started up to help get Mac OS X running on non-Apple hardware.

Compare Mac OS with WinXP

There is a detailed comparison of Mac OS X and WinXP in [10]. Here we also summarized our own feelings of using Mac OS X.

Advantages of Mac OSX

- *Reliability*
  A big headache of WinXP is reliability. We have to restart the machine often because it freezes up frequently. Compared to WinXP, Mac OS X doesn't freeze up that often. This, we believe, is because Apple produces operating system as well as the hardware, so it's possible for Apple to throughly test the whole system before a release. On the contrary, WinXP is designed to run on any IBM-compatible machines. Since the hardwares come from various manufactures, it is difficult for Microsoft to test its operating system for each of the hardware configurations.
- *Mac OS X has better support for open source software*
  Open source softwares could be run on Mac OS easily. For market strategy reason, Microsoft doesn't support open source to much extent. To use open source software in a Windows system, you either need to install a second operating system which is inconvenient to switch between operating system, or install virtual machine (e.g., vmware) which is fairly slow and consume many resources. According to our experience of using open source software in Mac OSX,
- *Mac OS is more secure than Windows*
  It's true that there are more virus under WinXP than Mac OSX. But it's not true that Macs can not get viruses. From the perspective of a virus-maker, Mac OSX is only a small target, since it takes up only 5% of the market share. He would design his virus for the much bigger WinXP market.
- *User interface design*
  Mac OS X is designed for easy use. The interface is simple, for example, program installation is simpler. Mac OS X has more fancy features: iSight, Dashboard, time machine, etc.

Disadvantages of Mac OSX

- *Need to upgrade Operating System almost every year and it's not free.*
  It costs hundreds of dollars to upgrade Mac OSX almost every15 months. If you don't upgrade, then you can not install many new softwares either. While windows OS upgrades every a few years. (This probably an advantage of Mac OS X. Apple engineers work harder than people in Microsoft.)
- *Application compatibility on Intel Mac*
  Apple has put a great deal of work into ensuring their new machines (Intel Mac) to be as compatible as possible with existing PowerPC software. Rosetta technology essentially allows software written for the PowerPC machines to run on Intel powered Mac hardware with no modification. However, Rosetta brings delay as it translates the instructions. Running some applications, like Photoshop, on Inte Mac may not bring noticeable speed advantage to the users.

Conclusions

Mac is not as expensive as it was thought if we don't consider the OS upgrading cost. Its products are in the relatively high end market only. This is partly because of the PowerPC's narrow product line, we guess. Mac OS is a comparable OS with WinXP. It's more reliable and has better user interface. Its application compatibility problem, we believe, will be solved in a couple of years. Apple made the switch from PowerPC to Intel in 2006. The official reason is that IBM doesn't provide fast enough chips. While some people believed that the decision is nothing but an attempt to beat Microsoft[13]. Even if the official reason is the real reason, is Intel's chip really faster than PowerPC? Some people just would not believe it[14]. Personally, we agreed that the decision was not made simply for the speed of processor. There must be some strategy consideration.

In future, Apple computer will allow more flexibility of its products: User can install MS windows on a Macbook, or install Mac OS on a IBM compatible PC. This will probably increase the market share of Apple OS and computer. But, with the wide distribution of Mac OS X, it will become a bigger target of virus, so we believe that in the next few years viruses targeted at Mac OSX will be more than before, and anti-virus software for Mac OS X may be a new business.

"On January 13, 2006, Apple's market cap surpassed that of Dell[11], whose CEO, Michael Dell, had said, "I'd shut it down and give the money back to the shareholders," when asked on Oct. 6, 1997, what he would do if he owned Apple[12]. On Nov. 24, 2006, shares of Apple hit an all-time split-adjusted high of $91.63 a share." [10]

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