1. Introduction

This report will cover the development of the digital computer, the differences between CISC (complex instruction set computer) and RISC (reduced instruction set computer) and a prediction of developments in computing over the next 10 years.

2. Key Milestones in the Development of the Digital Computer

Devices that can be considered computers have been around as far back as 2600 BC however the modern digital computer didn't come about until 1936 when Konrad Zuse created the first programmable digital computer. Digital means that information is stored as binary data (0 or 1). This was made possible by the vacuum tube; invented 22 years earlier by John Ambrose previously invented by Thomas Edison but discarded as worthless. The vacuum tube is a valve which can be used as a switch for the storage of the two binary values. Vacuum tubes where at the heart of computers including: Colossus (used by the British during World War 2 to crack German codes) and ENIAC (used by the U.S. army to calculate missile trajectories). The vacuum tubes that made these computer possible where also their greatest flaw, they required 200 kilowatts of electricity and produced so much heat that components of the computer would literally melt. The solution had been invented several decades earlier in 1926 – a semiconductor transistor which did the same job as a vacuum tube but produced a fraction of the heat and was considerably smaller. Computers continued to be built with vacuum tubes until 1954 however, until a way was devised to produce transistors from silicon commercially was developed by Texas Instruments.

Computers went in mass production in 1954 with the introduction of the IBM 650, a vacuum tube computer. In 1956 the first transistorized computer was built at the Massachusetts Institute of Technology. In 1958 the first integrated circuit was created by Texas Instruments, combining 5 components and the circuitry connecting them on a single piece of silicon, this would lead to the modern microprocessor which was created in 1971 (the Intel 4004, made up of 2,300 transistors). By 1960 there where over 2,000 computers in the U.S. Vacuum tube had been superseded by transistors, the IBM 650 was replaced by the transistorized IBM 700.

Computers continued to grow smaller and more powerful over the next 15 years but they were so expensive that only businesses were able to afford them, this all changed in 1975 however with the release of the Altair 8800 – the first personal computer. It had no screen, no keyboard and didn't even come already assembled. At $397 it included the Intel 8080 processor and 256 bytes of memory. Programs and data where input using a series of switches and output came in the form of flashing lights. It wasn't the most user friendly computer and for this reason was really only used by hobbyists and hackers who would devise clever ways of expanding its usefulness.

Hackers where abundant in southern San Francisco which became known as Silicon Valley because it was home to many silicon chip innovators and manufactures. It was also home to Steve Jobs and Steve Wozniak who created a personal computer which came complete with a display, built in keyboard and disk storage. They named it the Apple, inspired by the apple which fell on Isaac Newton's head, and started showing it at computer clubs. Each Apple was assembled by hand and sold for $666.66. The Apple II was launched at the West Coast Computer Fair and featured colour

graphics and, unlike its competitors, a 5 ¼ inch disk drive. The computer isn't the only component required for success; there is also the need for a "killer application". For the Apple II there was VisiCal, a spreadsheet application

In 1981 IBM decided to enter the world of personal computers and did so with the IBM PC. To reduce development time and keeps costs down it was an open architecture computer meaning that it was created with "off the shelf" components. The only patented component was the Basic Input Output System (BIOS). The design of the computer was readily available to competitors and companies such as Compaq where able to create clone computers, duplicating the design of the IBM PC and creating their own BIOS chip by reverse engineering IBM's. Computers have continued to get smaller and grow more powerful into the computers, laptops and portable devices we use today.

3. RISC and CISC Architectures

The Central Processing Unit (CPU) of a computer is a device which performs all of the calculation required to computer programs to operate. There are many different types of CPU each using a different architecture. Characteristics of different CPU architectures include: the number of registers, methods of addressing memory and the design of instruction set. CPU architectures today can be placed in one of two categories: CISC or RISC.

3.1. Reviewing CPU Architecture

In the late 1970's and early 1980's several studies where published on the draw backs of CPU design, particularly looking at usage of instruction sets by assembly and high-level languages. We know referee to these architectures as CISC. A study in 1987 showed that only 10 instructions made up 71% of instructions run by the IBM 370. Optimizing the performance of these instructions would greatly increase the efficiency of the CPU. Other studies observed that in CPU's where more complex instructions were available they were rarely if ever used. 85% of code used in high-level languages consisted of assignment statements, IF statements and procedural calls. Studies showed that these procedural calls were responsible for a large amount of the execution time because of the need, within the processer, to pass parameters from one procedure to another and return the result. It is necessary that each procedure has full access to the registers within a CPU meaning when one procedure calls another it needs to store its parameter in memory to prevent them being overwritten by the next procedure. It was these reasons that prompted a redesign of CPU architecture, removing unused instructions and increasing efficiency of instructions which had lengthy execution times. The result: RISC.

3.2. The Differences between CISC and RISC

CISC processers have very few registers, several addressing techniques, numerous complex instructions and instruction anywhere from 1 to 15 bytes in length. RISC processors on the other hand have many registers, only one mode of addressing and a fixed instruction length of 4 bytes. Although initially RISC processors where designed to have fewer instructions than CISC processors, the amount of instructions for RISC has increased to match that of CISC, however, unlike CISC, RISC has very few specialised instructions.

RISC processors make more use of registers than memory for storing data. Memory is a lot slower meaning that using registers greatly decreases the time it takes to store and load data. There are not nearly as many specialised instructions in a RISC processor than in a CISC processor and the instructions themselves are simpler. As instructions are hard coded, a RISC processor has much simpler hardware, putting less stress on the instruction decoder. Instructions in a RISC processor are simple enough that they are able to run in the same time that it takes a CISC processor to run one of many steps of its instructions. The length of the instructions in a RISC processor is fixed, meaning that the op code and address is always located in the same position. This means that the instruction decoder does not need to wait until the length of the previous instruction is known (as in a CISC processor) before it can fetch and decode the next instruction, this means instructions can be decoding in parallel.

Many RISC processors utilise a circular buffer of registers. It is divided up into 21 blocks. Each instruction uses 3 blocks: one to store the input parameters, another to store intermediate variables and another to receive the output. When the instruction is complete the pointer moves along by 2 blocks to execute the next instruction, the output of the first instruction has now become the input of the second. This gives the processor a fast and convent way to pass parameter from one instruction to the next.

3.3. Usage of CISC and RISC

RISC processors are used in devices such as: Apple iPhone/iPod, Nintendo DS and Sony/Nokia phones using the ARM processors, IBM's and Freescale's processors (formally Motorola) are used in all IBM supercomputers, servers and work stations, several games consoles including WII and PS3, the old Power PC Apple Macintosh and also embedded devices such as printers and cars. CISC processors dominate the PC market some examples are: Motorola's 68000, Intel’s 80x86 and the Pentium series.

3.4. Today’s Strategy of CPU Architecture

There has been much debate for many over the advantages and disadvantages of RISC and CISC processors and although each side has merit no real conclusions have been reached and both architectures are still used. As mentioned earlier, RISC processors have grown their instructions since the 1980’s to match that of CISC processors. Also the development of both architectures has seen elements of each combined. For example, CISC processors are increasingly using more registers than memory and some (Pentium for example) CISC processors are implemented with a RISC based instruction set that can translate the complex instructions into fixed length decreasing their execution time.

4. Predictions for Computer Development

Despite the credit crunch continuing to inflate prices, development of new technologies in the computer market seems unaffected. Experts expect that Moor’s Law will continue to be valid until 2022. Today’s largest chip (the Intel Quad Core) has 2 billion transistors. With things going the way they are, processors could contain 4 billion in 2010 and a staggering 32 billion by 2018. In terms of

speed, the world's current fastest processor is the new Intel Core i7. The i7 supports more threads, delivers more bandwidth and reduces latency meaning it enjoys greater parallel processing capability. Intel describes the i7 as the first in a new generation of processors designed for the coming age of visual computing – highly visual applications such as intelligent video, advanced graphical interfaces and context-aware computers that have the ability to track and intemperate human behaviour.

Processing power has increased 20,000 times since the IBM PC, this has resulted in problem with memory, the speed of which has struggled to keep up at an increase of only about 10 times. The static RAM currently employed is well overdue for an overhaul and 3D memory chips are set to be the way forward. These new chips would be manufactured with copper needles which stick out through the silicon making contact with the top metallic layer of the chip below. This would provide thousands of connection between the processor and the memory, making it much faster than connectivity currently provided by buses.

4.1. Cloud Computing

Online applications have been increasing in complexity and functionality for years but up till now they have only complimented desktop applications, cloud computing is set to replace desktop applications with their online counterparts. Microsoft recently unveiled its next operating system (OS): Windows Azure. It has been designed with cloud computing in mind, applications such as Mail and Movie Maker are no longer part of the OS but will be available online. As the applications will not be part of the OS, system resources will be freed up considerably and downloading updates will be a thing of the past. Cloud computing means that your data and files are stored remotely, where they are vulnerable to attack and downtime. The company hosting those files could suddenly start charging users denying access to your own data until you pay, the companies themselves could also go under. While events like these may seem unlikely where large companies like Microsoft and Google are concerned, it happens. In the last year, there have been 12 outages of cloud based services including Google Docs and Amazon S3. Most were caused by system failure but Google Docs was the culprit of a hacking effort. Many experts including: Larry Ellison (oracle founder) and Richard Stallman (GNU founder) believe that cloud computing is an incredibly bad idea – as it is essentially like passing your files to someone else over which you have no control. With cloud computing set to be the basic of Azure however uses may have no choice but embrace cloud computing.

4.2. Grid Computing

Grid computing is similar to cloud computing in the way that it makes use of computer network infrastructure. Grid computing aims to use the Internet to provide any hardware or software that a user will ever need. Essentially there would be two providers: one for software, one for hardware. When you are using you computer to perform a task, a virtual organisation will be created online, it will retrieve the required software from the software provider and utilise system resources from the hardware provider to execute the application

returning the result. It is essentially like turning the end user's PC into a dumb terminal, it would mean that any application could be run by any user no matter how much memory or processing power is required – it would also mean upgrading hardware or software would no longer be required.

With the Internet becoming such a crucial part in the usage of computers, sharing system resources, hardware and software over this huge network infrastructure seems set to be the way ahead.

2,207 words

Glossary

Assembly Language

A low level computer language which uses symbolic representation of machine code (binary) to program a particular type of CPU architecture.

Assignment Statement

A line of code in a computer programming language which set or resets the value of a variable.

Binary

A base-2 counting system utilised in computers for the storage of data as only two possible values: 0 or 1.

BIOS

Basic input output system. This referees to the ROM chip which contains a hard coded set of instructions the computer uses when booting to load the operating system.

Bit

A single binary digit: 0 or 1.

Byte

A set of 8 bits, for example: 10110011 which equates to 179.

Central Processing Unit

A device which carries out all of the computers processing. Its basic contents include: the Arithmetic Logic Unit which performs calculations, Registers which store small amount of data, the Program Counter which keeps track of which instruction is being executed.

Dumb Terminal

A computer which does not have any software or even an operating system, it requires a network connection to provide it with the files for the OS and any required applications when it boots.

Hardware

The physical components of the computer, for example: the hard drive, CPU, BIOS chip and memory to name but a few.

High Level Language

This is programming language which is separated from the processes run by the CPU making it cross platform. It is more plain English and understandable.

IBM

International Business Machines, also known as Big Blue because of their corporate colour and cooperating size, a large company, so much so it was considered to be its own country, utilised a bureaucratic structure. They started out as the Tabulating Machine Company in 1896 and started manufacturing vacuum tube computer in the mid 1900's moving onto transistor based computers in the 1960's. They entered the personal computer market with the IBM PC utilising Microsoft's DOS as its operating system. They failed to see that a Graphic user interface was the way forward and had Microsoft develop OS2. Today they produce mainly mainframes and servers.

IF statement

A programming statement that tests the value of a variable to decide to execute 1 set of statements if true and another if false.

Instruction Decoder

The part of the CPU which reads the instruction currently being performed by the processor and sends the component pieces of that instruction to the appropriate destinations.

Internet

A global network which follows the mesh topology, in which every device is connected to every other. The Internet provides many services including the World Wide Web which offers users the ability to view trillions of pages of varying content.

Killer Application

A name given to the crucial piece of software essential to make a computer successful.

Memory

Also referred to as Random Access Memory (RAM). It stores data required by applications which are currently running.

Microprocessor

See CPU.

Microsoft

A company who, among other things, have created the windows series of operating systems.

Moore's Law

A prediction made by Gordon Moore of Intel in 1965. He suggested that computers will double in power every 18 months to 2 years.

Open Architecture

A way of bringing together existing components to create a computer, usually the plans for which are readily available.

Operating System

The software on a computer which provides the user with an interface, controls, protects and manages hardware and other devices and also provides the support for other applications to run.

Register

A very small amount of memory within the CPU, used for storing intermediate variable used during instructions and, in RISC processors, used for passing parameters from one procedure to the next.

Reverse Engineering

The process in which a device is deconstructed so that a clone can be created. For patent reasons, the specifications and requirements of the original device are calculated and then given to the developer who has no knowledge of the original and can create a new device from scratch based on those specifications thus not infringing patent laws.

Silicon

A metal required for the creating of semiconductor transistors used in the construction of computers.

Silicon Valley

The name given to southern San Francisco due to the large amount silicon chip innovators and manufactures that resided there. The availability of such technologies made silicon valley home to many innovators in the computer industry, include: Apple and Microsoft.

Spreadsheet

An application used for calculating finances and performing scenarios such as cash flow predictions.

Texas Instruments

A company located in Dallas, famous for their work in commercialising semiconductors and many other elements of computer technology.

Transistor

An electronic devices used to amplify or switch electronic signals.

Vacuum Tube

A valve used to amplify, switch or modify an electric signal by controlling the movement of electrons in a low pressure space.

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