Chapter 4
The Mechanics of Technology and Digital

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Abstract In this short chapter an overview of technology currently in use in health care is discussed. Both hardware and software are explained offering the reader a high level summary of critical components used in conventional computing. Comparisons between computer functionality and human activity such as riding a bike or driving on a motorway are described. Cloud computing is introduced and the example of how mobile technology applications on health and wellbeing can be used is discussed.

Keywords Hardware · Software · ICT · Cloud computing · Architecture · Digital

Key Concepts
Hardware
Software
ICT
Cloud Computing
Mobile Applications
Digital

Learning Objectives for the Chapter
1. Understand foundation concepts relating to hardware and how hardware is used in delivery of computer programmes.
2. Acquire a foundational understanding of software and its relationship to emerging developments in computer science such as cloud computing.
3. Determine how software applications are acquired and how mobile applications are sourced.

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We don't know where we get our ideas from. What we do know is that we do not get them from our laptops .....

—John Cleese

4.1 Introduction

Society is increasingly technologically knowledgeable and yet increasingly dependent. Rather than relying on information committed to memory, our brains "outsource" information to repositories accessed through smart phones and computers. Consider how many phone numbers people memorize compared to a number of years ago? The availability and power of technology impacts our behavior; it influences how we socially communicate, how we write, read, and what we choose to remember. As a healthcare professional, it is crucial to have an appreciation of the latest advances with digital technologies and a basic understanding of how they operate. This understanding is needed as technological breakthroughs with Artificial Intelligence and Machine Learning are constantly being uncovered in the pursuit of improved patient outcomes, and to improve the care delivery process for clinicians. These topics are discussed in detail in Chaps. 2 and 16 (AACC 2020).

This chapter presents an overview of technology that is in use today and provides a brief explanation as to how they operate in society both in communities and in our health care organisations. It also offers some insight into the emerging paradigm in communications technology mTechnology and offers one example of how mobile applications can be used in healthcare.

This chapter will focus on the fundamentals of computing technologies. It will also explore some of the more recent technologies and explain how they can support eHealth solutions to assist health care professionals and individual patients in their daily practice and lives.

4.2 What Is a "Computer"

The vast array of twenty-first century technological advances have made it difficult to use the term "computer" to convey the conventional desktop or laptop models. Today, computers exist in almost every part of day-to-day life, from the fuel management system in a car, the program selection unit in a washing machine, the digital temperature control gauge in a refrigerator, to a Smartphone. In this sense, technology and computers are considered ubiquitous, since they are a part of everyday life activities, and so common that most people no longer consider them to be out of the ordinary, their uptake and use in society is inevitable.

Despite the many different appearances and occurrences of computers, they are all composed of two elements—hardware and software. The hardware of a computer can be defined as being the physical components that create the computer and the software can be defined as being the stored set of instructions that allow computers to do what they do. While the overall complexity of computers today may initially seem daunting, it is important to remember that every computer is based on Boolean logic. The term Boolean relates to mathematical algebra and can be associated with variable values. Simply stated Boolean values offer a true and false variable often denoted as either 1 or 0 (on or off) in the field of computer science. This simple true/false or on/off logic forms the platform upon which all computer functionality is built. In order to achieve this Boolean functionality, computer manufacturers use electronic components called Transistors.

A transistor can be described as a semi-conductor device, which essentially amplifies and switches electronic signals and power. Transistors build upon the differentiation between off and on Boolean logic to create complex processes that integrate together to achieve the final communications and processing tool, that is the end-user's computer.

4.2.1 Hardware

Hardware consists of the physical elements of a computer. Essentially, hardware can be defined as being the physical computer itself. A conventional computer model's hardware would consist of a Central Processing Unit (CPU), a monitor, a mouse and a keyboard. These components are the "seen" elements of a computer. The term hardware also covers the unseen or internal elements of a computer such as the computer's motherboard, ram, graphics card, hard drive. Table 4.1 lists some hardware components and briefly explains their function.

Table 4.1 Components of computer hardware

Component	Description
Monitor	Computers screen, used for viewing output from a computer
Mouse	Input device used to obtain motion-based input from the user
Trackpad	Similar to a mouse but obtains data directly from user's touch
Keyboard	Input device used to obtain static predefined symbol input
CPU (Central Processing Unit)	Processes tasks given to it by the computers operating system (explained later)
RAM (Random Access Memory)	RAM is used as temporary storage space for task data that is being processed
ROM (Read Only Memory)	ROM is a type of computer memory used mainly to store core computing software
Hard Drive	Is used to store data that will persist after the computer has powered off
Graphics Card	Used to compute the image values to be displayed on a graphical output
Bus	A network architecture in which a set of clients are connected via a shared communications structure in the single cable called a bus
Cache	A collection of data duplicating original values stored elsewhere on a computer
Persistent data	Information that continues to be stored even after power is no longer applied to it

Random Access Memory (RAM)

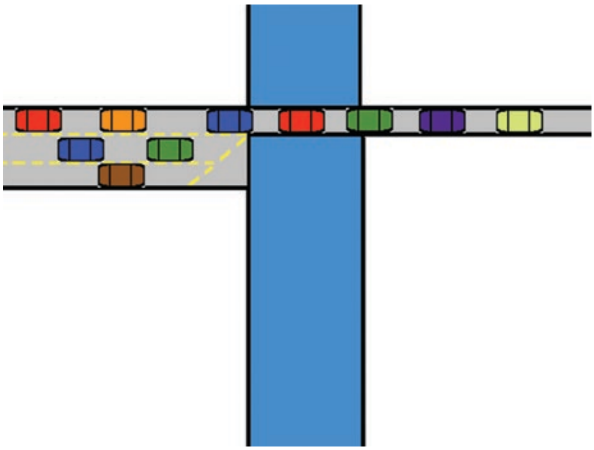
The term, memory, in computing has a lot of confusion surrounding it. People often automatically equate memory with storage, which although technically correct, uses the word memory out of context. Memory, as part of a computer's specifications, does not relate solely to the amount of storage capacity a computer has. Memory on a computer is not about how many movies, songs or photos it can hold.

Computers require a minimum amount of "memory" or working capacity in order to process information and execute the various programs in use. Thus, the term memory relates both to how much storage memory (See section on ROM below) and also how much random access memory (RAM) a computer has available to engage in processing information.

RAM can be thought of as the platform on which tasks are processed by the machine's processor. The processing unit runs the programme by fetching the instructions from RAM evaluating the programmes in sequence and executing them. In a way, it can be compared to a bridge on a highway where cars are tasks, the motorway's speed limit is the processor's speed and the lanes on the motorway are the processor's speed capability. When traffic converges onto the bridge, if the bridge doesn't have enough lanes or capacity to deal with the number of cars (tasks) that the highway is capable of processing then there is going to be a traffic jam. This process is demonstrated in Figs. 4.1 and 4.2.

Adding another lane (RAM memory bank) to the bridge will significantly increase the amount of traffic crossing the river. The processor speed still has a major contribution to the overall processing of tasks. There is no point in having a four-lane bridge on a small highway that has a speed limit of 30 km/h as most of these lanes would be left idle.

Fig. 4.1 RAM Functionality 1



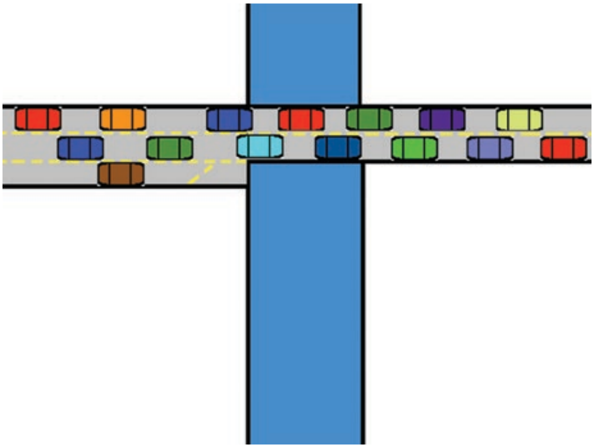


Fig. 4.2 RAM Functionality 2

ROM (Read Only Memory)

When discussing RAM, we considered real-time processing of tasks and how RAM integrates into a computer. The downfall of RAM is that its memory is not persistent through a cut-off of power. As RAM is only capable of storing memory when power is supplied to it, another type of memory is also needed to create a conventional computer. As it would be very inefficient to constantly apply power to the computer to store information that is infrequently accessed and not likely to be modified. Persistent data is needed in computing to store the start-up instructions of a computer, i.e. "boot "the computer. ROM differs from RAM in that its stored data persists even after power is no longer applied to it. Thus, ROM is ideal for use as the computer's booting memory. ROM is also the type of memory used in hard drives to store data such as movies, music and documents. The higher the ROM capacity, the greater is the storage capability available in a computer.

Operating Systems (OS)

The computer's operating system is the fundamental set of instructions that drives the operation of the computer. It manages all the computer's hardware and ties it to the computer's software. Technically speaking, the computer's operating system is software, but it is the main software that interprets all other software.

There are predominantly two types of Personal Computer (PC) operating systems. These are Win and Unix systems. These types of systems are the basis for the Windows and Macintosh (Mac) operating systems, with the Windows operating system being developed by Microsoft and the Mac operating system being developed by Apple.

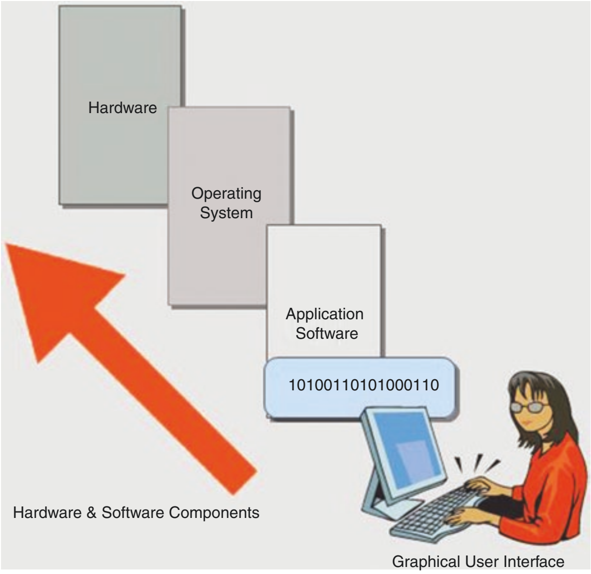


Fig. 4.3 An overview of basic computing architecture

As illustrated in the diagram below, the operating system for a computer can be interpreted as sitting between the hardware and application software for a computer (Fig. 4.3).

The Apple or "Mac" the overall layout, functionality and file structure is different to that of a conventional windows (Microsoft) personal computer. This is not because of the hardware that is used in producing the different machines; it is because of the operating system that they are using.

The operating system in an Apple "Mac" uses different system architecture than a traditional windows machine and therefore, has different capabilities and ways of doing things. In order to get a better understanding of a computer's hardware specification, Table 4.2 outlines some perspective, relative to computing technology in 2013.

Networks

The topic of networks is a broad and comprehensive subject that has changed dramatically over the past 30 years. Briefly, a network is comprised of two or more nodes that can transfer data between each other. These nodes can be classified as any entity capable of interpreting the data that it receives. In computing terms, the node will mainly refer to some form of computational device. The computational device can refer to a large spectrum of entities. On a large scale, it can refer to a server but if we reduce our spectrum, we can technically define a computer itself as being a network.

Table 4.2 Computer components specification

Specification detail	Low	Medium	High
Processor	1 GHz	2.0 GHz	3 GHz
Memory	2 GB	8 GB	32 GB
Hard Drive	128 GB	750 GB	2 TB
Graphics Video Card	Graphics cards vary depending make and model. In order to get a better understanding of a particular model, searching through reviews will provide some great insight		
Sound Card	Sound card quality tends to be consistent through computer manufacturers. Like graphics cards, it would be best to find reviews online		
Disk Drive	Disk Drive specifications on average are very similar for most computers. The only distinction between most would be different capabilities such as the ability to burn DVD's		
Screen	Screen specifications have a lot of different contributing factors. These include screen size, resolution capabilities and display technology i.e. LCD, HD		

LCD liquid-crystal-display, *HD* high definition, *GB* gigabyte, *TB* terabyte, *GHz* gigahertz, *MB* megabyte, *DVD* digital video disk

Computers are comprised of multiple pieces of hardware communicating with each other through internal networks managed by the computer's operating system. This concept of sharing data between small components to create a computer can be expanded to sharing data between computers to create a larger network such as an in-office emailing system or chat network. This concept of communication gave rise to what we know today as the Internet. The Internet isn't a physical entity, it's a term used to describe the global exchange of data between computers and servers worldwide. This exchange of data is most commonly facilitated by a network protocol known as Hyper Text Transfer Protocol (http). Additional detail relating to networks can be sourced from the www3Schools resource and a related paper on machine learning from the perspective of clinical laboratory (AACC 2020; WWW3 Schools 2020).

4.2.2 Software

Computer software can be defined as the stored procedures that control the internal workings of a computer. The role of software can be illustrated in the example of riding a bicycle (Fig. 4.4). In order for a person to ride a bike, their brain has a set of instructions to make the overall process possible. The rider's brain has a stored set of instructions to keep their legs peddling while maintaining balance with their overall body positioning and movement. This is exactly what software is,—in order to run a program (a game for example) on a computer, the computer has a stored set of instructions to display images on the screen and to compute the physics required to make the game realistic.

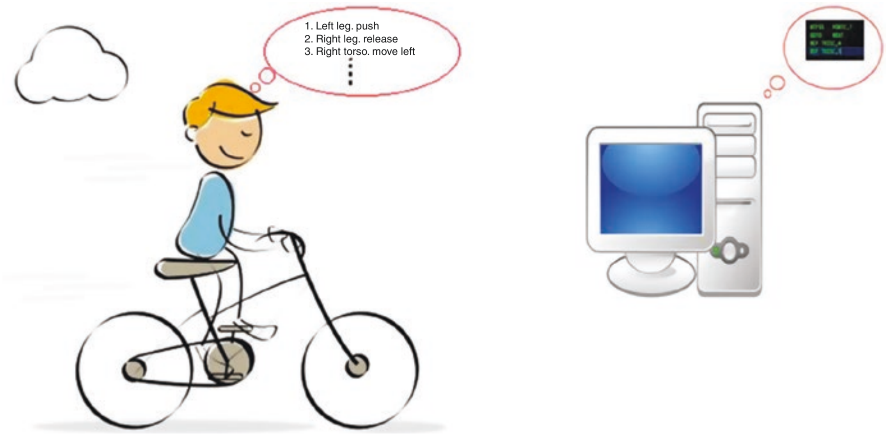


Fig. 4.4 Computer functionality

4.3 Emerging Technologies for eHealth Solutions

As computing advances in fifth generation computing, services such as cloud computing and services orientated architecture come to the forefront. Here we briefly outline some of the addtional elements that are required to deliver the fifth generation computing paradigm.

4.3.1 Service Orientated Architecture (SOA) and Web Services

Service oriented architecture can be described as a dynamic framework, which establishes a set of protocols to deliver integrated services across different health care providers.

The framework comprises of a set of methods for specifying and standardizing services and includes a dynamic model for detailing interactions between and among these services. SOA emerged from the progression of delivering web-based services to advance integration and access of health data across and between service providers. Briefly, web services can glue together applications running on different messaging platforms and enable information from one application to be used by others. Web services software has grown to include a rich set of specifications and standards to facilitate interoperability across and between services. These include the ability to describe, compose, package, and transport messages and ensure that security in service access is accomplished. In the domain of healthcare a state of the art application used for message transfer is entitled Fast Healthcare Interoperability Resources. This specification is developed by Health Level Seven International (commonly known as HL7), and it supports interoperability specification for the exchange of healthcare information electronically. This specification is described in detail in Chap. 5 (Health Level 7 2020).

Clinicians will see SOA in action when clinical records using information from diverse sources (laboratory, radiology, primary care providers, hospital information systems, etc. can be viewed with a single sign on an integrated record of health information.

Despite the rapid progression of web services within the business and financial industry, its growth within the healthcare industry has been slower than in other service industries. A key reason for this directly relates to the limited uptake of health informatics standards in the healthcare industry. Although there is potential for this to advance now with the introduction of a web services such as Fast Healthcare Interoperability Resources Specification FHIR (Health Level 7 2020) In addition, healthcare information is considered to be sensitive data, therefore for successful implementation of shared or integrated records a robust security and data privacy platform from which healthcare service professionals can access and transfer patient records is essential. The topic of standards in healthcare is discussed in Chap. 6 and patient safety and confidentiality will be discussed in detail in Chap. 10.

4.3.2 Cloud Computing

Demand for persistent and accessible data storage has contributed to the genesis of virtual storage platforms. The technologies which focus on the delivery of a virtual system, such as cloud computing aim to facilitate access to large amounts of computing power by aggregating resources and offering a single system view to the user often referred to as a portal or platform. This view is however usually at a cost and is based on a business model for the "on demand" delivery of computing power or in recent developments, can be pre-purchased based on expected usage.

The utility service for cloud computing includes the processing of information, the storage of information and the associated data and software resource requirements (Foster 2003). As a relatively new phenomenon several definitions exist on what cloud computing is. Additional information relating to the deliverables of cloud computing eHealth and digital is available to view in Chap. 2.

4.3.3 Wireless Technologies and the Mobile Internet

Wireless technologies are a means of transferring data from one entity to another without the use of a cable or wire. This means of communication typically relies on radio waves with specific frequencies (Marshall and Wilson 2020). The mobile internet is a term used to describe internet access using Smartphones or other mobile technologies. The most common type of this communication today is known as mobile broadband, which relies on encrypted radio waves resonating at high frequencies. The progression of fifth generation technologies in society is having a direct impact on not only how we communicate, but also how we observe the physical space in which we live. By combining the power of cloud computing, search engines, and databases, individuals will have immediate access to information using mobile technology anytime and anywhere (Raychaudhuri and Gerla 2011, p. 10).

Within the domain of healthcare, mobile technology and sensors are considered significant tools for future healthcare provision, enabling remote monitoring and improved access to health information for both clinicians and consumers. Chapters. 2 and 3 describe case examples of how these technologies are being used in healthcare. Due to the low cost of deployment associated with wireless devices, wireless networks will continue to be an attractive option for connecting to the Internet of the future. Such new perspectives also present several challenges.

As wireless networks become more integrated into the design of future eHealth systems, questions arise as to how secure the network infrastructures can or will be used most effectively and ethically particularly from a patient centered perspective. Traditional healthcare systems that functioned in isolation will not be able to provide wider access for mobile and eHealth resources and new security protocols are progressing (Trappe et al. 2011). This topic is explored further from a health care perspective in Chaps. 5 and 10.

4.4 A Mobile Application within Health Care

One simple example of technology use in contemporary society is in the case of individuals managing their health and wellbeing. This is particularly relevant for individuals who wish to manage chronic disease and monitor their symptoms thus recognizing early any deterioration of their health. In addition, push notification through alerts can assist individuals to actively engage in health seeking behaviors such as a planned exercise regime and or healthy eating. An example of a smartphone WHO application that supports active health and wellbeing is featured through Digital Health article (Downey 2019) and additional access to World Health Organisation Digital Health Atlas is available from this link https://digitalhealthatlas.org/en/(World Health Organisation 2020). Further information on smart digital app to enhance health and wellbeing of individuals is included in Chap. 15.

4.5 Conclusion

This chapter presented the basic components of computers for traditional and current computing, while exploring some of the emerging technologies of fifth generation computing. (Segars 2019). We have considered how technology is changing our behaviour. The pace of development in ICT over the past 30 years has been rapid and as we currently exist in a digital world, it is difficult to estimate just how mTechnology will impact on future healthcare provision. Current mTechnology such as android phones offer a resource for outsourcing information and designing new ways to communicate, read and write. This chapter concludes with revisiting the opening quote from Mr. John Cleese which suggests that: We don't know where we get our ideas from. What we do know is that we do not get them from our laptops …. John Cleese (2010). Outsourcing some of our memory to smart phones and laptops should leave time for reflection; create a space for creativity, and the development of some smart ideas to enhance individual care. In many instances this is not the case. A core function of nursing informatics may then be to create time to consider just how technologies can be harnessed through design science to offer additional time to enhance direct care. This theme will be revisited in the proceeding chapters of this edition.

Glossary

API Application Programmable Interface—Essentially documentation around the capabilities of a certain technology

ASCII American Standard Code for Information Interchange, common form character encoding

Asynchronous Non-synchronized usually applies to network communication where communication is event based rather than time based

Bit Digital Unit, one bit can either be represented by a 1 or a 0

Browser Used to visually/audibly interpret data received either locally or via a form of transfer protocol

Byte Digital Unit, one Byte is a representation of 8 bits and can store a value of up to 2^8 or 256

Cache Usually applies to the storage of retrieved data, most networks have a cache to prevent the need to request the same information multiple times from the same source

Clinical decision support Clinical decision support—Tools used in clinical practice for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve health and healthcare delivery

Cloud A term used to describe a new form computing, "cloud" computing relates to remote based computing, instead of storing and processing all of your information locally, all computation and storage is done remotely on the "cloud" which is an external server or network of servers

CPU Central Processing Unit—the primary mechanism of processing driving the core operations of a computer

Database Database Most common form of persistent data storage

Encryption Mathematical operation to change the original format of data

Ethernet Form of computer networking technology, commonly used for Local Area Networks (LAN)

External hard drive A data storage device
GUI Graphical User Interface, where icons are used to identify programs, files, and other processing options
Interface Multiple meanings, in oop programming an interface is a blue print for a class, can be used as another term for GUI as well
Interoperability The ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organisations, through the business processes they support, by means of the exchange of data between their respective ICT systems. Source EIF Report http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KK0113147
Interoperability Framework An interoperability framework is an agreed approach to interoperability for organisations that wish to work together towards the joint delivery of public services. Within its scope of applicability, it specifies a set of common elements such as vocabulary, concepts, principles, policies, guidelines, recommendations, standards, specifications and practices
LAN Local Area Network
Modem Physical device used to transmit digital data through analogue communication
PDA Personal Digital Assistant, can be used to describe a range of digital devices
Protocol In ICT a set of invisible computer rules that govern how an internet document gets transmitted to your screen
RAM Random Access Memory
ROM Read Only Memory
Secure Sockets Layer Most commonly used as an encryption layer for Hyper Text Transfer Protocol (HTTP)
Semantic interoperability Semantic interoperability refers to the ability of computer systems to transmit data with unambiguous, shared meaning
Synchronous Usually applies to network communication where both ends of the network are synchronized to expect communication at particular time
USB Universal Serial Bus—form of data transfer
Use case Specific scenarios designed to illustrate and provide context for testing a specific digital task or functionality
VPN A virtual private network which extends a private network across a public network such as the Internet
VOIP Voice Over Internet Protocol
Wide Area Network Wide Area Network
WLAN Wireless Local Area Network

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