**CS4182 Foundations of Computer Science**   
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The Internet of Things (often referred to as IoT) is a very broad concept overall. It is the interconnection of everyday devices, such as home appliances and vehicles, and is the way that machines communicate with each other (without requiring human to human or human to computer interaction) for the purpose of improving automation and therefore increasing efficiency.  
  
This definition of Internet of Things has evolved throughout the years due to the rapid development, improvement and innovation in technology as developers are coming up with innovative ways for people’s lives to become more convenient through the use of interconnected internet devices. Before it had the name of Internet of Things, the first use of a network of smart devices was in early 1982, where a team at Carnegie Mellon University created the first Internet-connected appliance with a modified Coca-Cola vending machine. The vending machine had an implemented sensor that tracked the information useful for a vending machine, such as the current stock of each specific drink, which would be sent to the development team’s computer. Although this is standard and looks simplistic to today’s standards, this was a massive breakthrough that many didn’t think would spiral into what it is today. For the time, it allowed for a slight technological advantage to the companies that implemented it, getting over some of their rivals.  
  
It wasn’t until later in 1999 that the name Internet of Things came about. It is not known for definite who came up with the name, but it was likely Kevin Ashton who worked for the prestigious company Procter & Gamble. Although at this time the definition was very basic, he said it was “simply the point in time when more ‘things or objects’ were connected to the Internet than people”. The “point in time” was between 2008 and 2009 with the things/people ratio growing from 0.08 in 2003 to 1.84 in 2010. In 1999 the essential component to the Internet of Things was radio-frequency identification (RFID), this uses electromagnetic fields to automatically identify and tracks tags attached to objects (like a bar code).  
  
A reliable and massive Internet of Things network will require a compatible standard for all the connected devices as they need to able to communicate with each other to transfer the data that each device is storing. Multiple different standards would make the communication between the devices more complicated. In 2016 this problem was made less of a problem, with the introduction of the Hypercat standard. It is now supported by major firms, such as ARM, Intel and Accenture, which have agreed on a format that will allow for a broader range of products to compatible with each other. Matthew Evans, the IoT program head at TechUK, said “there is a high cost of not intervening” (Burgess 2018), this was in the thought of creating a worldwide standard sooner will be more beneficial than allowing for an increase in the number devices using different standards. Microsoft has tried to introduce their own system that helps businesses a managed central platform for setting up their IoT devices, called IoT Central. Microsoft claim that the IoT Central will help simplify the creation of IoT networks.

Two of the biggest technological advancements in terms of Internet of Things is with automobiles and people’s homes. The advancements in home appliances has allowed for the present “smart homes”. The Internet of Things has allowed home owners to have automatic heating through devices such as the ‘Nest learning thermostat’, and it also allowed for increased security and convenience through the use of the ‘Ring doorbell’ which allows the owner to use a security camera when the doorbell rings which is connected to the internet. The vehicle manufacturer Tesla has also had an innovative breakthrough as it was the first car to update its Tesla model x through the use of the internet. This has allowed for companies to constantly improve a current car instead of waiting to implement the improvement to the next future car, most people would agree that this has allowed for the industry to be more consumer friendly. However, people have had worries about the security issues and possible errors that these Internet of Things devices could bring.

The Internet connectivity has made it possible for the threat of potential hackers interfering with your devices, such as when a hacker got into a couple’s Google Nest in Wisconsin, USA and started to talk to them and increased their heat (Peterson 2019). On the other hand, this has been a pretty isolated incident with very few instances of a hacker being able to get into people’s devices being reported and Google claimed that there was not a breach on their half, but rather a fault on the couple’s password strength. Another major concern with a growth in Internet of Things is the fact that humans can be out of the equation if IoT continues to grow. Bill Gates stated that lower end of skill set jobs such as drivers and factory workers may soon see their jobs be taken over by robotics that can be self sufficient without the need of human interaction (Bort, 2014).  
  
Commercially IoT has a wide variety of applications whether it’s through V2X communications, Home Internet or the Healthcare sector. V2X involves “new generation of information and communication technologies that connect vehicles to everything” (Wang, J., 2019). Specifically, it combines the smaller niche types of communications under one umbrella, V2I, V2N, V2V, V2P, V2D, V2G. These systems rely on two underlying technologies wireless local area networks known as WLAN, and cellular networks.   
  
Using WLAN, it communicates vehicles with vehicles and between vehicles and the Infrastructure, V2I and V2V respectively. Its low latency makes it ideal, the technology is part of ITS-G5, as a subset in the WLAN IEEE 802.11 family of standards (ETSI, 2020). Whereas cellular networks boast to be a better choice as it is scalable, future proof and provides a clear path from LTE to 5G, using conventional mobile network to enable the vehicle to receive information about road conditions and traffic in the area.  
  
Cellular networks continue to evolve and offer far more than V2X, it’s used to connect all machines to machines. With 2G phased out prioritizing 3G, LTE and the development of 5G, network speeds are becoming faster and faster, one key use of these networks in Ireland is to provide Internet access to remote regions of the country ignored by fiber optic technology. With 5G speeds estimations of up to and over 2 Gbit/s, it’s an exciting development on the peak capacity of 4G, 400Mbps. High-band 5G uses frequencies of 25 - 39 GHz, near the bottom of the millimeter wave band, while 4G uses a frequency between 2 - 8 GHz. (Simkó and Mattsson, 2019).  
  
Two industries currently being shaped by IOT are manufacturing and agriculture, used to connect equipment with equipment, locations and people. As industry scales up IOT makes everything more efficient and economical. In manufacturing, the integration of many different devices on a production line is vital to keep the process moving. It’s estimated that Industrial IOT could generate so much business that it will eventually lead to the Fourth Industrial Revolution, potential growth generating twelve trillion dollars of global GDP by 2030 (Holwerda, 2015). Examples include Digital Control Systems, predictive maintenance, statistical evaluation, and smart grids.   
  
In farming IOT technology to collect, sort and store and types of data is a huge benefit. Data collection on temperature, rainfall, humidity, wind speed, pest infestation, soil pH, and livestock quantity, as a huge industry in Ireland, IOT has a huge possibility to change the industry into a more efficient and competitive market to compete in Europe. Fish Farming also benefits, A partnership between Toyota Tsusho and Microsoft was created in 2018 with the plan to develop water management technologies using the Microsoft Azure application suite fir IoT technologies. A water pump mechanic that uses artificial intelligence that counts the number of fish on a conveyor belt, analyses the quantity of fish and deduces the effective water flow from the data the fish provide. The project lead specified, “If we can use AI to automate and mechanize simple judgment tasks, we can reduce the number of workers needed from three to two, which will allow that third person to do other work or make it easier for the workers to take breaks and improve work efficiency.” (Spencer, 2018)  
  
IOT and its security misgivings are important topics to discuss when you see how far reaching it’s become. With it so involved in a wide range of sectors from the commercial to the agricultural, impact on society is great and with that serious damage, disruption and disarray will follow. The damage is far from hypothetical, for example, a Stuxnet worm has done great damage to control systems. A Stuxnet targets supervisory control and data acquisition systems and is believed to be responsible for causing damage to the Iranian nuclear program. One study found that “70% of the most commonly used IoT devices contain security vulnerabilities and there is an average of 25 security concerns per device." Further security risks include Lack of transport encryption, Insecure software/firmware and Poor physical security. (Tankard, 2015)  
  
Even though it has security issues, as a technology it can still provide a sense of security. Like most technology developed throughout history it found success through it being applicable in the military. The Internet of Military Things is focused on applying technology with the idea that future military conflicts and wars will be dominated by Artificial Intelligence and cyber warfare. Serval military programs have been developed but the most interesting is dubbed “Ocean of Things”, announced by DARPA in 2017, plans to apply these technologies on a scale literally the size of oceans. Thousands on interconnected floats spanning hundreds of kilometers to measure ocean temperature, boat activity and even aircraft. A system not just for defense but for rescue, providing real time analysis to detect, track, and identify both military, commercial, and civilian vessels.   
  
With such scoping plans IoMT technology is aware and adapting to security risks, a compromised system would cause catastrophic damage, in the form of leaks, disinformation and infrastructure damage of hardware. Subverting these issues requires developing measures at the same rate of scale the technology grows, creating impenetrable defense's or employing counterintelligence ploys such as honey potting. (A. Kott, et. 2016)

There are many benefits of the Internet of Things (IoT) in today's technological era, but we must also remember that with benefits there also con's, these may involve also challenges and problems that simply can't be left aside.

Our ability to access information is one of the things that IoT enables us to do, without the internet we wouldn't be able to have vast amounts of information to aid us in our everyday life. This is because of the network of these devices that give us this access to every part of this world, " You can easily access data and information that is sitting far from your location, in real-time" (Advantages and Disadvantages of Internet of Things! - RedAlkemi, 2020). This makes everyday life more efficient as we don't need to be there to learn about certain situations. We have access anywhere we go improving our knowledge and making us humans develop more and more.

There are vasts amount of positive contributions for IoT technologies in education "The advances in sensors, nanoelectronics, smart objects, cloud computing, Big Data, and communication on a wide scale will make innovation continuous in IoT" (Kassab, DeFranco and Laplante, 2019). These allow us to collaborate work in groups, cloud computing will back up your information to the system after use, giving you access to it anywhere on the domain & network, reducing expenses and improving productivity for UL in the future, allowing us as a computer science student's access our needs. We are constantly making technology smaller, nanoelectronics gives us energy-efficient tools in order to improve our performance in computing technologies for the future.

The benefits in agriculture with IoT has been an important domain, manually monitoring the status of the fields can prove to be inaccurate and slow, while integrated sensors can continuously monitor the wind speed, precipitation as well as ecosystem control. One of these has a four-layer task mechanism to manage the ecosystem. "Each layer is responsible for a specific task and together the framework is able to achieve a better ecosystem with reduced human intervention" (Qiu T, Xiao H, Zhou P 2013). Storing collected data helps monitor climate conditions and automates agriculture and crop monitoring, this will in return provide a higher quality of crop benefiting the needs of many who consume these products.

Interconnected devices over networks allow us to communicate with each other as efficiently as possible, even if we are connected to machinery or computers we are allowed to send messages and communicate freely over a common network, in big corporations the interconnected devices allow the transfer of data flow efficiently allowing us to allocate time in different sector's that we're not available to us before the advances in IoT. This has an effect to make tasks more cost-effective as this saves time and money transferring packets of data over a network.

A crucial benefit to IoT is the Automation of devices, this is needed to complete task without human interaction being needed, this helps boost time and quality of service, becoming more efficient for a business to use.

With the share of information over these devices becomes an issue of privacy and security, as we share countless amounts of information across platforms that anyone can access personal information can be leaked or even hacked "Hacking is more than just manipulating computers, hacking can be performed on anything " (Wang, 2006). Security is a big aspect as we become more connected to these devices. The transfer of information that is personal to us is shared amongst them, giving us a sense of vulnerability, people you never met before know you in some way or form due to this, making your data known to everyone to use and manipulate your control, this can affect your whole life as all your information can be hijacked, including devices and cameras.

The complexity of the networks of IoT is interesting, as a loophole in this data can cause an effect to all the networks in this system. This loophole of information is a dangerous factor of the internet.

With the automation of devices by interconnected methods isn't always good as it affects people's lives, as we can now do things without our interaction jobs are being made redundant and people are losing forms of income. This is noticeable as the number of jobs is decreasing due to tasks being made easier by machines, the loss in jobs has an effect on people's professions as human labor isn't required.

Our dependability on IoT is also affecting us as technology advances, we rely more and more on it to assist us, this has become a big part of our lives. If we don't know the answer to situations, we turn to technology to provide it for us. If we become too dependent on this technology it will impact us negatively, even my use of the computer to complete assignment's or for entertainment has affected my social life as well as my physical day to day living, I've had to start wearing glasses because my eyesight is becoming poor due to my dependency of the computer for happiness, negatively affecting my day to day life.

In conclusion, Internet of Things has allowed for a network of devices to be interconnected that ultimately adds convenience to a user’s life and work. It was only introduced in 1992 by 1 vending machine, but its rapid development has been seen across the world and also in every area of a person’s livelihood. IoT has granted businesses to become more consumer friendly and also more efficient as they are able to track their products’ data even after it has left their factories. It has also become a staple in many people’s homes with an increase in security and convenience. However, you could argue that it has come with some drawbacks. There have been instances of devices (as they are connected to the internet) being hacked into and putting the consumer’s safety and security at risk. Also some prolific businessmen, such as Bill Gates and Elon Musk, have expressed their opinions on the impact that IoT will have in the future of human jobs becoming redundant. Even with the drawbacks in mind, IoT has been an outstanding invention that will only improve as the years go by as more devices will become compatible with other devices.

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