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The Internet of Things (IoT): The Network of Networks

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It was around five decades ago (1983) that Internet was introduced to the world for the very first time. Seven years later (1990), the 'World Wide Web' made a debut, which also marked the time that computing and communications went under revolution. Shortly after, the term 'smartphone' emerged in 1995, which allowed users to send and receive emails, faxes and pages in addition to its calling capabilities. New technology breakthroughs have revolutionized and digitalized these inventions making them easier, more accessible, cheaper, faster and more convenient in almost every way, especially in the cutting-edge digital world that we are living in right now. Here are some fact checks about how technology has advanced in the past several decades. It only took seven years for the Internet to reach 50 million users while Facebook and WeChat needed 4 years and 1 year respectively (Desjardins, 2018). But this is not the end. The awestruck product that had the fastest global reach was Pokémon Go, achieving the reach of 500 million users in only 19 days (Desjardins, 2018). But the next big thing is yet to be revealed. It is the cool trend of the wireless and sensory technology that cut through the barriers between physical and virtual world and that is no other than the 'Internet of Things' (IoT). It is calculated that every second, there is an average of 127 new devices being connected to the internet. At this rate, it would only take approximately 4 days and a half to reach 50 million devices. And as you are reading this, there will be at least 7,600 new devices being added on the internet during the past minute you had spent.

But what exactly is the Internet of Things, and what are those 'things' of the Internet of Things? What is so special about this IoT that is growing rapidly and steadily like this? The answers to these questions will be discussed extensively below.

❖ Tracing the Definition and Root of the IoT

The origin of the Internet of Things can be traced back to 1999 when Kevin Ashton, a co-founder of the Auto-ID Center at MIT, mentioned this term in his presentation about radio frequency identification (FRID) and sensory technologies. Inspired by the cool trend of the internet in 1999, Ashton entitled his presentation the "Internet of Things". In his article in the FRID Journal, Ashton suggested that:

> "If we had computers that knew everything there was to know about things – using data they gathered without any help from us – we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best." – Kevin Ashton, 1999

However, Kevin Ashton was not the first person who developed the idea of connecting devices. It was since 1970s when a similar concept of IoT was conceived on the ground of pervasive computing or ubiquitous computing. This idea sought to embed computational ability into daily objects so that they can communicate and perform tasks in a way that requires minimal human intervention (Rous, Shea, Tang & Ferguson, n.d.). This kind of connection

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can be made with whatever devices, at whatever time, at wherever, and in whatever data format across its network. Owing to its early conception, it is considered as the predecessor of the IoT and has laid the foundation for IoT to grow from. The only thing that makes pervasive computing distinctive from the IoT is that the former relies more on computing power while the later requires less computing power.

There has also been a debate about the first IoT invention. Some people argued that the first IoT device was the coke machine, invented by David Nicholas in the early 1980s used to track the supplies of coke without having to go to the actual machine sites (Teicher, 2018). However, the other side of the argument believed that it was until 1990 that the very first IoT device was developed. That particular device was a toaster created by John Romkey that could be controlled over the Internet to turn them on and off (Harwood, n.d.). Such controversy arises because there is neither exact definition of the Internet of Things that everyone uses nor precise definition one can ever give. Since people give different interpretations about the IoT, they are having a hard time coming into a common ground about the first IoT invention. Nevertheless, almost everyone who has formed different perspectives of the argument agrees on the common features of the IoT. First of all, it is a network of physical objects or things. Secondly, those objects are connected to the internet. Thirdly, they are able to communicate and transfer data with each other. Fourthly, the communication is made through radio frequency identification and sensory technologies. Last but not least, it functions with minimal human intervention possible, and sometimes no human intervention at all. Thus, if we combine these features together, we can conclude that the IoT is a convergence of operational technology (OT) and information technology (IT), breaking through barriers of networking technologies and physical or wired communications and integrating the physical into the visual world. Thus, the IoT ecosystem is an environment where almost everything can be connected and communicated in any possible smart way. In the simplest term, the Internet of Things is “the network of networks”.

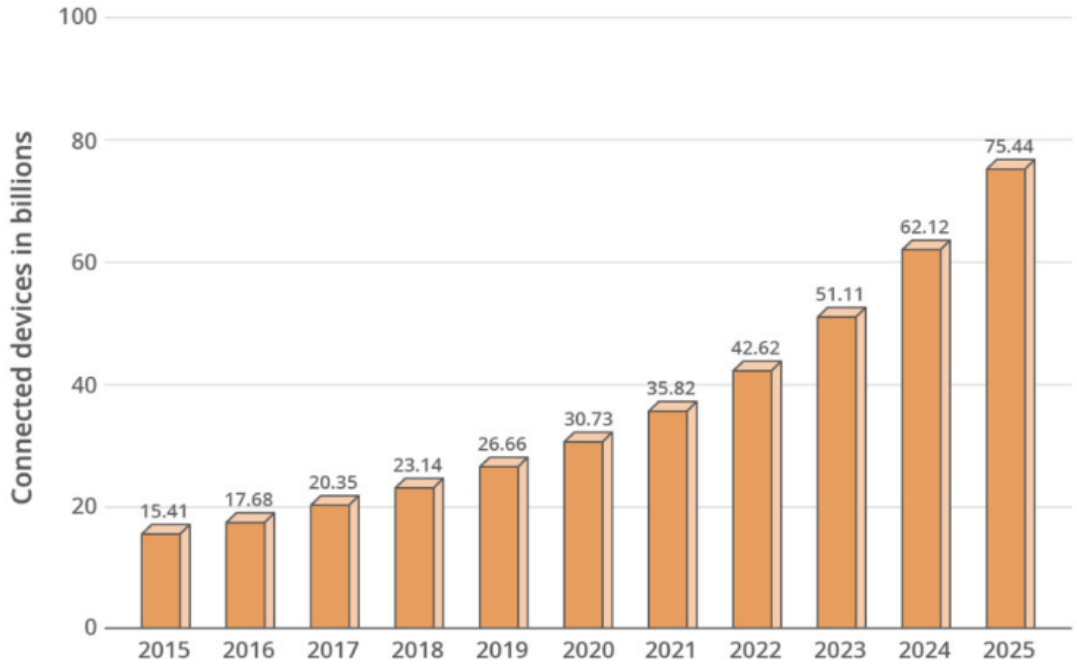
Source: Storyblocks Video

Another perspective from the professionals in the field, Cisco Internet Business Solutions Group (IBSG), which is a company best known for its technology and internet-oriented business, has defined the IoT as a breaking point in time when the number of devices connected to the internet exceeds the number of humans connected to the internet (Evans, 2011). Using that definition, IoT only emerged between 2008 and 2009, the time that the number of connected devices surpassed the number of human populations[1].

❖ The IoT is Bigger Than You Imagine

From computers to phones, vehicles, homes, pens, coffee makers, plants, pets and clothing on your body, IoT connects with just literally everything and anything. IoT comes to claim a distinctive entity when it was known that objects become connected to the Internet more than people. The IoT proliferated in a very fast and uncontrollable pace, which in 2008 the number of devices connected to the Internet surpassed the total population of human around the world if compared to 2003 when the rate was approximately 0.08 device in every head count (Evans, 2011). Notwithstanding, the ratio of the number of connected devices to human rose to 1.84 in 2010 when the human population was only 6.8 billion compared to 12.5 billion connected devices (Evans, 2011). A projection of the IoT proliferation made by Statista suggested that with the current number of connected devices, the IoT system is expected to continue to expand to 75 billion by 2025 (see the figure below), which will be fivefold growth from the 15.41 billion in 2015 (Horwitz, 2019). Within only a short period of time, IoT grew very rapidly, the kind of progress that cannot be underestimated. As of August 2019, the number of connected devices that internet received was 26.6 billion active devices, a jaw-dropping increase compared to the previous years. In addition to the massive rise by number of devices getting connected to the internet, the global market value of the Internet of Things is forecasted to hit approximately 1.6 trillion USD by 2025 (Liu, 2019).

Number of IoT Connected Devices from 2015-2025 (in Billions)



Source: iProperty Management, Horwitz 2019

[1] See: Evans, D. (April, 2011). *The Internet of Things: How the Next Evolution of the Internet Is Changing Everything.* Retrieved from CISCO: https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf.

However, though what have been discussed earlier are mostly concerned with connecting objects or things with each other but the IoT ecosystem stretches far beyond that. As the technology keeps advancing from time to time, so do the IoT solutions. It is no longer a connection between only electronic devices. The IoT solutions now cover a wide and various rage of connections to even living things such as livestock, pets, your plants or crops. What does it mean to digitalize biological things? Here is the deal. When the crops are connected to the internet, it will become smart or others may call intelligent. Thus, the farmers will be informed about what types of soil is perfect for the crops, under what temperature, how much water is needed and even how much fertilizers shall be deployed for a healthy growth and production. Furthermore, the farmers can also track the timeframe of their crops to see if they are ready to be harvested. This is the promising and convenient way for farming, which is normally believed to be a kind of extremely unpredictable business. Apart from farming, IoT is also building a ground in the livestock sector where microchips, using radio frequency ID tags, are implanted in the livestock to track their whereabouts and most importantly their health condition. This tool is normally used on cows and chickens to detect diseases like mad cow and bird flu so that farmers can take early action on the sick animals so as not to spread to other animals. Though this technology innovation is not widely practiced yet, the IoT solutions in agricultural sector have been continuously developed in a slow but steady leap.

❖ Living with the Internet of Things

Truth be told, we cannot ignore the impacts that IoT has on so many aspects of our daily life, not to mention that the proliferation of IoT is expected to grow very fast forward, not backward. What we can do is to embrace and live with it. The most obvious example of IoT application is the smart cities[2] because IoT technology is an essential component for building smart city infrastructure. The smart streetlights, smart buildings, smart homes, smart energy, smart traffic management and everything that makes up the smart cities depends on the sole functions of the IoT. Whatever benefits smart city can provide, the IoT is able to do the same. Cost-saving, time-reducing, user-friendly and sustainability-drive are among what the IoT offers. As discussed in the definition section, IoT connects devices, makes decisions and acts on their own from the least human intervention to no intervention at all. In a smart city, IoT networks will collect data throughout the entire city, including the information about traffics, weather, waste management, the people, infrastructure, buildings and so on. The data that is received will then be computably analyzed on real-time so that IoT devices will function accordingly and wisely. For instance, the sensory technology embedded in IoT devices measures real-time air quality levels and detect pollution. The data will then be transferred for analysis and inform the users to avoid areas that are most polluted or trigger public actions by Pollution Control Station to temporarily close the roads. Such detection is made possible by installing sensors in public spaces such as telephone poles, public phone booths or central office. But another way to detect it is by using the data from the users themselves and combine them with the data received from other users' sensors. This is how IoT networks function and communicate with each other.

Another benefit that IoT has to offer to its users is personalization capability, which comes in many forms ranging from eating to working, living to walking and even sleeping. The IoT-inspired personalization is more than just being connected, but it acts like a personal life planner. Everything that an individual does in daily function is enormously, if not entirely, influenced by IoT solutions. If we talk

[2] See: Muykim, C. (24 June, 2019). All You Need to Know About Smart Cities. *Cambodia Development Center.* Retrieved from: http://cd-center.org/en/all-you-need-to-know-about-smart-cities/

about marketing advertisement, it is no longer about one-fit-all commercial but rather customized relevance and needs. People will be recommended only with products that they need after they have been identified and classified by the advertisement agencies, using the data retrieved from their clouds which includes everything about their habits on online platforms. Supposed that your shopping habit is tracked and stored in the IoT cloud, then the advertisement agency will use the data to analyze your shopping preferences and make recommendation just for you. This is the next generation of life hacks. Another example of IoT combined with personalization is controlling the room temperature, where individuals will experience the IoT appliance which is able to detect the body temperature and send the information to the smart AC which is also connected with the IoT. Considering your health status, your surrounding environment and your current body temperature, the AC will automatically adjust the right temperature that is best for your body.

Beyond that, IoT also has a great potential to expand the market and boost business operation. Using the customized advertisement again, it is undeniable that business will do better with personalized ads because with all the retrieved data they are able to suggest the right things that people like, need and want, which is close to 100 percent reliable when such data derives entirely from the users' living habits. It does three things: target, promote and suggest. When people see those ads, they are bound to purchase it. This will in turn increase the sales of the companies and also improve customer satisfaction. But there is one more thing that IoT does best, which is predictive analytics. By combining data, statistical modeling and machine-learning, companies can make a prediction about future trends and preferences allowing the companies to optimize their strategies in advance and enable them to become competitive and be on the right path. According to Microsoft's report on IoT signals, 94 percent of business will use IoT solutions by the end of 2020 (Mindbowser, 2019). Asides from marketing, industrial automation also reaps the gains from IoT applications. Currently, the top industry that actively adopts the IoT applications is manufacturing. Based on the survey conducted on 200 automation executives, the most critical drivers for IoT adoption in manufacturing are improved operational efficiency and productivity (Morgan Stanley, 2016). When things are connected as a network of IoT, the work processes are cut down. Technicians do not have to walk directly to the machinery to monitor or examine the process, they can just tap a few things on the tablets and the analytic results will be digitally generated. Likewise, the managers can monitor the work processes of the employees and production process in general on the tablets, where records are automatically stored and administered. With such advanced potentials, Morgan Stanley estimated that the IoT industry market value will expand from $90 billion to $100 billion by 2020 (Morgan Stanley, 2016).

Another current top IoT industry is healthcare. Adoption of IoT in healthcare is made to reduce errors, increase efficiency and improve medical treatment. In 2015, the IoT healthcare market was at $24.2 billion, and the value is expected to exceed $33.7 billion by the end of 2025 (Bustamante, n.d.). Likewise, people can use IoT devices to monitor and take a good care of their health without having to be physically present at hospitals. For instance, the Proteus Digital Health system has introduced the ingestible sensors to help monitor medicine intake of the patients. According to the study by the World Health Organization in 2003, 50% of chronic disease patients do not adhere to medicinal prescription (WHO, 2003). For this reason, the Proteus Digital Health has created a pill that digests in the stomach and produces a small signal which is then picked up by a sensor equipped on the human body (Econsultancy, 2019). This information is then delivered to the smartphone application which indicates that the patient has taken their medication.

This digital health tracking system had collaborated with Otsuka Pharmaceutical Company in 2017 to create an antipsychotic medication, and eventually became the first smart pill sensor to receive US FDA approval (Econsultancy, 2019).

❖ IoT Implementation in the Region

In regional framework, ASEAN countries are racing up in the IoT competition, and on top of the list is Singapore. Guided by a Smart Nation ambition, Singapore becomes the top country among other ASEAN fellows who invests the most on digital infrastructure along with IoT integration. IoT market in Singapore grows from the government's needs to digital almost every aspect of life, including mobility, healthcare, financial services and energy management, amongst others. Second of the list is Malaysia. In 2018, Malaysia spent approximately $46 million (RM 190 million) on the development of smart classroom and another roughly $60 million (RM 245 million) on businesses to upgrade their operation processes so that it depends on the IoT (Lim, 2018). Followed by Malaysia is Thailand. In line with Thailand 4.0 initiative, the Thai government announced in 2017 the plan to establish an institute specifically designated for the Internet of Things (Lim, 2018). This institute is tasked to develop IoT in important sectors such as automation and robotics, bio-energy, public health, aerospace and so on. Likewise, the IoT industry in Thailand is projected to reach $1 billion by 2020. Meanwhile, in Indonesia, three smart city models have been implemented and have also integrated the IoT solutions for improved living conditions. As for Vietnam, though the IoT applications and implementation remain limited and minimal, the Vietnamese government has been taking baby steps little at a time by launching the first IoT lab in 2016, which is expected to support technology start-ups in the country, and the government sees such move as essential for future growth and development of IoT industry in Vietnam. Whereas, the Philippines is also stepping up their IoT market investment as an emerging tech ecosystem in the region. The Philippines government has been investing heavily in digital infrastructure – as much as $26 million on public Wi-Fi – and smart city projects that have the potentials to spur economic growth, more importantly the digital one (Asia IoT Business Platform, n.d.).

As for Cambodia, although we have witnessed significant attention has been given the industry 4.0 as well as digital economy, including various government policies, initiatives and priorities in developing masterplan and digital infrastructure such as integrating digital literacy into education system, building digital platforms and incentives among the startups and relevant stakeholders, much more is still needed to be done in bringing benefits for the country and its citizen from these superfast and super-advanced technology trends. The IoT market in Cambodia, in particular, is still at its embryonic stage. The Smart City Projects under the ASEAN Smart Cities projects, for instance, have long been approved since the last two years, but concrete actions are yet to be carried out. All things considered, there are many challenges that hinder a proper adoption of IoT in Cambodia and the most challenging issue are investment from both government and private business on appropriate technology and human resources that stand at the heart of IoT technology development, application and implementation. The initial step for Cambodia would be to build an IoT lab or institute and expand government and private funding to research institutes and think-tanks for the building and development practical and pragmatic plans and actions towards the digitalization of Cambodian society as the government has planned. Among these, priority to accelerate the IoT development by allocating enough budget is certainly helpful to leap forward.

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