DevOps in IoT: Solution or challenge for sustainable development?

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1 Introduction

In a culture where technology is constantly evolving and expanding to every aspect of society as we know it, rarely do we stop to consider how these advancements impact the world that we live in. Sustainability is a hot topic in current society and dominates many discussions. This essay aims to give a well-founded and nuanced depiction of how the growth of IoT in a DevOps culture impacts sustainability. It is worth noting that there exist many DevOps-related technologies and this study only covers some technologies.

1.1 Internet of Things

Internet of things (IoT) is the concept of the interconnection between ordinary objects[1] like for example coffee-machines, toaster, refrigerator and much more. The idea that different devices communicate with each other without any human involvement can be regarded by many as the inevitable future of society. IoT may take form in technologies such as smart phones, cars, homes and cities. The purpose of IoT is to make life more comfortable for people and optimize the usage of technologies. IoT also highlights the requirements of software automation, computer security and reliability, which are challenges that needs to be tackled before introducing it to the broad public. There are both environmental benefits and issues regarding to IoT, on one side it increases the energy efficiency, but at the same time it requires resources (e.g. hardware resources for IoT devices) which is responsible for greenhouse gases emissions. Ethical questions about data integrity and privacy is of course another aspect of IoT technologies.

1.2 DevOps

DevOps is a broad and relatively new concept. The word was first coined in 2009 and although it is used in multiple contexts and doesn't have one true definition it is usually defined as "a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality" [2]. The key focus in DevOps is on culture, process, velocity, feedback loops, repeatability via automation, responsiveness to change, and continuous improvement [3].
The word DevOps itself is the result of joining the two words development and operations, which are two contentious groups within the IT organizations. On

the one hand, you have application development, which is primarily measured on the number of changes and features that are able to be pushed out into production. Whereas IT operations are primarily measured on system stability, reliability and availability. As a result this causes a conflict of interest due to one group working towards pushing more changes, and then the other trying to maintain stability. DevOps is a set of practices that is trying to bridge the gap between operations and developers in each stage of DevOps life cycle by creating a culture shift toward cross-functional teams collaborating rather than isolated groups working on functionality separately [4].

1.3 Sustainable development (SDG)

In 2015 the United Nations (UN) adopted a plan for moving towards a better and sustainable future for all people on the planet[5]. Although it was not the first time the UN set similar goals for the future, where plans such as the Millennium Development Goals MDG were developed, which focus on eradicating poverty. The SDG unlike MDG does not only address poverty, but also sustainable development which includes gender equality, environmental protection and economic growth. UN has set the deadline for fulfilling the 17 SDG (see figure 1) to year 2030 for all countries. Scientists has a couple of decades warned about that if the current modern society does not become sustainable, it will have devastating impacts on many people around the world. Even though the goals set by the SDG are probably not going to be fulfilled, it still can help to change the worldview regarding these issues. There are many ways to achieve a more sustainable society, not too seldom one of the solutions are often digitization and automation.

Figure 1: The 17 Sustainable Development Goals of UN[6]

2 Discussion

2.1 Tiny ML & Cloud Computing

Smart City is a concept to build a city that is based on a system that applies features such as internet-applications and automation principles. The characteristics of a smart city system is that it is interconnected and based on artificial intelligence[7]. Additional requirements of the system used in smart cities are that it needs to be user-friendly and agile integration of resources. DevOps practices is identified as the a major factor for smart city administrators in order to increase adaptability, efficiency and speed.

Another technology relevant to the smart city concept is a software that utilizes machine learning and IoT devices called Tiny Machine Learning (Tiny ML). The Tiny ML[8] technology can be used to create embedded devices that have a low energy consumption, where small scale farmers may be one of the groups that benefits of this kind of technology. Tiny ML directly addresses the 11 and 13 SDG, where it lowers the emissions of green house gases (energy consumption

in general) and becomes a part of sustainable cities concept. Microsoft Azure Devops is a DevOps tool that can be used in order to automate the Tiny ML sensors, which beside automation also provide cloud deployment.

Cloud computing has been recognized as a key factor in smart energy conservation systems [9]. One major challenge of smart cities is to store and process data related to energy consumption. While private servers can be enough for smart homes cloud computing is imperative in the concept of smart city. The main advantages of cloud computing are its availability of on-demand data and processing. Decentralized cloud computing is also safer in regarding to malicious attacks than centralized. Smart homes facilities have been shown to reduce energy usage between 12-20%[10] versus non-smart home facilities.

2.2 IoT's impact on sustainability

With the exponential growth of IoT, many aspects of society have reaped the benefits such as reduction in operational cost, large gatherings of rich data, enhanced safety, and many more. From a sustainability perspective, IoT solutions enable technology to progress many sectors of the sustainable development goals. While DevOps is not a technology in and of itself, but rather a culture shift, it does encourage rapid and continuous feedback from operations to development in order to identify and resolve issues. Adopting automated deployment and delivery in IoT systems allows for accelerated maintenance as well as increased availability which can be used for solving problems related to the sustainable development goals.

The UN sustainable development goal which concerns good health and well-being aims to "ensure healthy lives and promote well-being for all at all ages". Smart and connected health care is one of the many applications being enabled by Internet of Things. The ability to monitor the health of patients, both physically and mentally, by capturing rich information using networked sensors can bring about a positive transformative change in the health care landscape [11].

Another sustainable development goal, affordable and clean energy, aims to "ensure access to affordable, reliable, sustainable and modern energy for all". IoT deployed in Electric Power and Energy Systems have shown to utilize energy more efficiently [12]. The ability of monitoring and controlling power absorption have shown results such as less energy waste and reduced carbon emissions. [12]

Third, water quality monitoring systems using IoT technologies can help better monitor the quality of water and protect against polluted water that might be used for drinking [13]. This relates to the sixth sustainable development goal which is clean water and sanitation. According to estimates by the World Health Organization, 3.575 million people die every year from water-related diseases. Using IoT technology such as collecting data using water quality sensors and automating the monitoring the quality of the water in real time could potentially save lives.

However, with IoT devices and solutions comes big data which require housing of servers in order to store, manage and process data. [14] These data centers consume an increasing quantity of energy to run their operations and cool down the servers. In the event of a power outage, diesel generators are needed to keep the servers running, which results in further greenhouse gas emissions which has consequential impacts on climate change. According to studies, data centers have the fastest growing carbon footprint in the entire ICT (Information and Communication Technologies) sector due to developments in cloud computing and in the usage of Internet services [14].
Another major problem with IoT solutions and ICT solutions in general is the electronic waste[15]. Much of the electronic waste (such as phones, PCs and other electronic devices) does not get recycled, but instead dumped or incinerated, which is an increasing problem. While mining for metals and production of new electronic devices have an negative impact on the environment

3 Conclusion

This essay aimed to depict the different ways in which IoT impacts sustainability, as well as the role that DevOps as culture plays in the growth of IoT. Multiple innovations enabled by IoT technology have come forward with solutions to many of the UN's development goals such as good health and well-being, affordable and clean energy, and clean water and sanitation. However, as we've discussed in this essay, many negative impacts come with IoT solutions such as electronic waste and greenhouse gas emissions. Furthermore, the question arises whether the solution to some of the world's greatest issues can be solved by IoT, or any piece of technology remains to be unanswered. As Abraham Maslow said

in 1966, "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail." While IoT in a DevOps culture could be the technology that saves the world it could also be just any other technology.

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