# DevOps in IoT: Solution or challenge for sustainable development?

Charlotte Andersson
Lazar Cerovic

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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 in terms of the UN's Sustainable Development Goals (SDG). It is worth noting that there exist many DevOps-related technologies and that this essay will only cover a few.

## 1.1 Internet of Things

Internet of things (IoT) concerns the networked interconnection between ordinary objects, for example, coffee machines, toasters, refrigerators, and many more [1]. 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 smartphones, cars, homes, and cities. The purpose is to make life more comfortable for people and optimize the usage of technologies. Further, IoT highlights the requirements of software automation, computer security, and reliability, that are challenges that need to be tackled before being introduced to the public. There are both environmental benefits and drawbacks regarding IoT. While it increases energy efficiency, it also requires resources (e.g. hardware resources for IoT devices) that are responsible for greenhouse gas emissions.

## 1.2 Sustainable Development Goals (SDG)

In 2015 the United Nations (UN) adopted a plan for moving towards a better and sustainable future for all people on the planet[2]. It was not the first time the UN set similar goals for the future, such as the Millennium Development Goals (MDG), whose focus was 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 year 2030 as the deadline for all countries to fulfill the 17 SDG (see figure 1). Scientists have for a couple of decades warned us that if society does not become sustainable, it will inevitably have devastating impacts around the world. Even though the goals are probably not going to be fulfilled by 2030, they can still help change the worldview regarding these issues. There are many ways to achieve a more sustainable society, not too seldom one of the solutions is often digitization and automation.


Figure 1: The 17 Sustainable Development Goals of UN[3]

## 1.3 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" [4].

The word DevOps itself is the result of joining the two words development and operations, which are two contentious groups within organizations. On the one hand, you have development, which is primarily measured on the number of changes and features that can be pushed out into production. Whereas operations are primarily measured on system stability, reliability, and availability.

DevOps is a set of practices that are trying to bridge the gap between these two by creating a culture shift toward cross-functional teams collaborating rather than isolated groups working on functionality separately [5].

# 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 are that it is interconnected and based on artificial intelligence[6]. Additional requirements of the system used in smart cities are the need to be user-friendly and agile integration of resources. DevOps practices are identified as a major factor for smart city administrators 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[7] technology (see figure 2) can be used to create embedded devices that have a low energy consumption, where small-scale farmers may be one of the groups that benefit from this kind of technology. Tiny ML directly addresses SDG 11 and SDG 13, where it lowers the emissions of greenhouse gases and energy consumption in general and becomes a part of the sustainable cities concept. Microsoft Azure DevOps is a DevOps tool that can be used to automate the Tiny ML sensors, which besides automation also provides cloud deployment.

Cloud computing has been recognized as a key factor in smart energy conservation systems [8]. 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 advantage of cloud computing is its availability of on-demand data and processing. Decentralized cloud computing is also more reliable regarding malicious attacks than centralized, since if one server gets taken out then the whole cloud fails. Smart home facilities have been shown to reduce energy usage between 12-20%[9] versus non-smart home facilities.

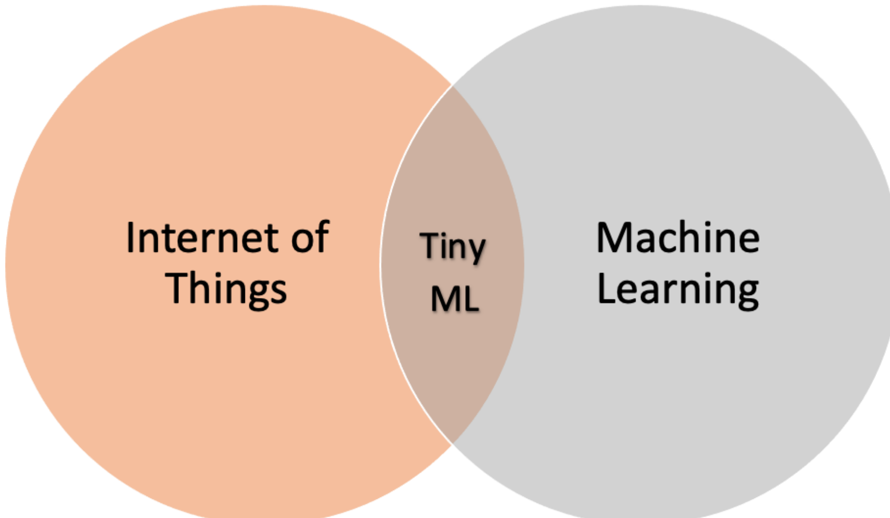


Figure 2: An illustration of the Tiny ML concept

## 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 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 SDG.

SDG 3 concerns good health and well-being and 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 IoT. 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 [10]. A research article found that WANDA, an end-to-end remote health monitoring and analytics system for heart failure patients, was "capable of predicting the worsening of patients' heart failure symptoms with up to 74% accuracy while improving the sensitivity performance by more than 45% compared to the commonly used thresholding algorithm based on daily weight change´´. [11]

Another goal, SDG 6 is about affordable and clean energy and aims to "ensure access to affordable, reliable, sustainable and modern energy for all". IoT deployed in Electric Power and Energy Systems has shown to utilize energy more efficiently [12]. Being able to monitor and control power absorption has shown results such as less energy waste and reduced carbon emissions [12].

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 SDG 6 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. Collecting data using water quality sensors and automating the monitoring of the quality of the water in real-time could potentially save lives.

However, with IoT devices comes big data which requires the housing of servers 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. This results in further greenhouse gas emissions that have consequential impacts on climate change. According to studies, data centers have the fastest growing carbon footprint in the entire Information and Communication Technologies (ICT) sector due to developments in cloud computing and the usage of Internet services [14].

Another major problem with IoT and ICT solutions, in general, is electronic waste[15]. Much of the electronic waste does not get recycled, but instead dumped or incinerated, which is an increasing problem.

# 3 Conclusion

This essay aimed to depict the different ways in which IoT impacts sustainability, as well as the role that DevOps as a 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 of whether the solution to some of the world's greatest issues can be solved by IoT, or any piece of technology, remains 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." [16]. While IoT in a DevOps culture could be the solution that saves the world, it could also be just any other technology.

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