Prospectus

IoT Sensor Network for early detection of Forest Fires

(Technical Topic)

Case Study: Utilizing Actor Network Theory to analyze the deployment of e-Government Services in Stockholm, Sweden

(STS Topic)

By:

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

During the year 2020, heat waves and drought have left a thick layer of dry vegetation easily sparked by people and lightning. In Australia, this has led to some of the worst instances of large spread wildfires in recorded history, with millions of acres decimated, thousands of homes destroyed and numerous people displaced. Similarly, there have been countless wildfires ravaging select areas in Washington, Oregon, and California causing millions of acres of land to be burned while displacing many families and calling for massive evacuations. Furthermore, due to climate change, it is predicted that forest fires will become an even greater occurrence, and is projected to cost human lives as well as millions of dollars in damages every year.

In order to combat the spread of forest fires, it is imperative that people tasked with responding to such an incident have access to reliable and accurate data about the location and spread patterns of forest fires. Early access to such data can inform the strategies and actions taken by first responders, government bodies and other relevant authorities, and it could aid in rescue efforts, as well as reduce the danger to the lives of the first responders, as well as the victims affected by this natural phenomenon. The technical solution that I envisioned is an early fire detection and alert system utilizing low-cost and low-power embedded systems, wireless signaling and an array of sensors, and deploying this system in the forested regions of at-risk areas (such as California and Australia) to enable human operators to detect early instances of forest fires, and relay that data to first responders so that they can respond proactively to minimize casualties and property damage by taking action early.

When building a commercial product that involves cooperation between governments, the general citizenry, researchers and corporations, a whole host of factors are needed to ensure the success of the product. In 2007, the city government of Stockholm, Sweden allocated 70 million euros for an information and communication technology (ICT) initiative to provide the citizens of Stockholm with over e-government services. By 2013, the initiative was lauded a success with over 50 successful services launched (BIS, 2013). To better understand the social, economic, policy, financial factors that led to the success of this initiative, I will be using Actor Network Theory to study the factors behind the success of the e-Government services initiative in Stockholm, Sweden (BIS, 2013), to better understand the role of corporate network builders, and how their contributions managed to coalesce all the relevant heterogeneous actors around the Stockholm initiative.

To design this sensor network and properly deploy it in the field, both technical and social aspects of the problem must be addressed. Below, I outline the technical process currently being taken to build all the hardware and software components of such a wireless sensor network system, by utilizing low-power low-cost embedded systems, cloud technologies and wireless signaling. I also use the success of the Stockholm e-government initiative as a case study to understand the role that corporations can play in the creation of a successful socio-technical product. Both technical and STS research projects serve to inform me about the factors needed to ensure that this IoT sensor network product is properly deployed and managed on the field.

Technical Project

The 2019-2020 bushfire season in Australia destroyed an estimated 46 million acres and close to 6000 buildings in the span of a few months (Center for Disaster Philanthropy, 2020). Similarly, in 2020, there have been countless wildfires ravaging areas in Washington, Oregon, and California causing approximately $10 billion in damages while displacing over 500,000 people and calling for massive evacuations (Grzeszczak, 2020).

Attempts have been made to use satellite systems equipped with sensors (Alkhatib, 2018) to detect temperature, humidity, air quality, among other metrics. However, any satellite-based observation systems have limitations (long distance readings are often less accurate than the ones closer to the ground) which often leads to failure in the speed of detection, the quality of the sensor data or the running cost to produce effective control for forest areas.

Since fire detection systems dependent on satellite systems, are expensive to build and maintain, they are usually used by federal agencies, well-funded research institutes and private corporations (Aeris, 2020) and consequently the high cost of building such a system puts it out of reach of state and local first responders, as well as who are often on the front lines when dealing with disasters such as forest fires.

Building a sensor system by leveraging the latest innovations in low-power low-cost embedded systems and ubiquitous wireless technology is easier to build and deploy, and the low cost aspect also enables the solution to be scaled in situations with limited capital, making it possible not only for well-funded federal emergency response departments, but also a feasible solution for underfunded (and often more vulnerable) state and local fire departments, especially if they are located in areas that have higher occurrences of forest fires.

The goal of the technical project is to design a wireless (FCC, 2012) sensor network utilizing low-cost low-power embedded systems, wireless transmission and retrieval of sensor data, and cloud-based monitoring and analytics to enable human operators to detect early indications of forest fires and respond appropriately.

There are three major tasks that our team will be undertaking in order to bring this from a concept to a minimum viable product. The first task involves the building a circuit board that integrates a humidity sensor, a temperature sensor, and a gas sensor onto the board, along with connectors that attach it to the embedded system.

The second task involves writing firmware code that enables the embedded system to communicate with the 3 sensors via the I2C protocol (which is an serial interface intended to enable you to connect and address multiple peripherals in series to the same set of electrically connected and addressable ports on the embedded system I/O ports) , use the communication channel to acquire temperature, humidity, and smoke detection readings from the 3 sensors into the local memory of the embedded system, store and packetize that sensor data and transmit the data via the Message Queuing Telemetry Transport (MQTT) protocol (machine-to-machine messaging) from the embedded systems to a cloud database via Wi-Fi. This process is automated to deliver data every 15 minutes for every sensor node (embedded system) and the data transmitted via MQTT is tunneled into the cloud.

The third task is for us to build a data pipeline to aggregate our sensor data into a cloud database and build an analytics frontend to retrieve and display all the sensor data to a human operator. This is done via the use of Amazon Web Services (AWS) Internet of Things (IoT) Application Programming Interfaces (APIs) that integrate the MQTT data being transmitted from the embedded systems and uses a TCP tunnel (transport layer protocol for delivering packets) to deliver that data into AWS cloud databases where it will be utilized by an analytics frontend web application. The analytics frontend web app will be built using the open-source JavaScript framework called AngularJS and it will communicate with an Amazon DynamoDB database instance via a REST API, and this web app will be the user’s view of all the data collected from the sensors nodes in the network.

STS Project

In early 2007 the Chief Executive Office of the city government of Stockholm, Sweden established an initiative to utilize information and communications technology (ICT) in creating e-government services. With an initial investment of 70 million euros, Stockholm took a citizen-centric approach to smart city investments (BIS, 2013) with the goal of undertaking novel and untested technology projects to create benefits for the citizens and all other stakeholders involved. As of 2013, the initiative has been lauded a success with over 50 digital services launched since 2007, drastically cutting management costs and improving citizen access to services and meaningful data (that enabled better decision-making), lowering the time and cost of communications between businesses and customers, and improving traffic and other civil infrastructures (BIS, 2013).

Why did this particular network form successfully in comparison to others? What factors contributed to the stability and viability of this network? According to Staffan Ingvarsson, Vice CEO of Stockholm who led the smart city initiative for 5 years starting in 2007, an emphasis on focus and a strong long-term vision, was a prerequisite to the proper execution of this initiative. During his tenure, Ingvarsson made sure that his political statement was clear and firm, to inform the stakeholders about the services being created by the government, to help them adapt to it. Strong and consistent leadership on the part of the government was also cited as another important factor behind the success of the network. Ingvarsson discussed how his actions regarding continuous discourse with the citizenry about the benefits of digitization contributed to the public approval of these initiatives.

However, the emphasis on the contributions of politicians and government organizations overlook the importance of ICT corporations and how their contributions were integral in the formation and stability of this initiative. For example, the telecom industry has a legacy spanning

100 years in Stockholm, largely in part due to telecom giant Ericsson. Furthermore, Stockholm is known as the financial centre of Scandinavia, and its focus on research and innovation is supported by one of the world's largest ICT clusters largely due to the proximity of large corporations such as Ericsson, Microsoft and IBM in the city.

Since these actors were so important if we overlook their contributions, we risk incorrectly assessing the factors that led to the success of the network. For example, during one of the e-government initiatives called the Kista Science City, which has been described as a creative melting pot where companies, researchers and students collaborate in order to develop and grow, over a thousand ICT companies (including Microsoft, IBM, Ericsson), 6,800 students studying ICT courses at Stockholm University and the Royal Institute of Technology have joined as part of this initiative. For the purposes of this research project, I intend to investigate and demonstrate how the contributions of the numerous ICT companies have contributed to the success of the Stockholm smart city initiative.

I will be using Actor Network Theory as the primary framework to understand the role of all the heterogeneous actors in this socio-technical network and how the contributions of the corporate actors (both human and non-human entities) have contributed to the successful building of the network of the e-government initiative in Stockholm, Sweden. Specifically, I will use Michel Callon's concept of translation, which describes the process of network formation, by examining the corporate network builders such as ICT companies (Microsoft, IBM, Ericsson, among others) as well as their interactions with the government network builders such as the state-owned company Stokab (a publicly owned company est. 1994, who by 2007 had laid down the vast fibre network throughout the city) and the office of the Vice CEO of Stockholm, to examine how the contributions of ICT enterprises laid the foundation for the successful building of the network. I will also examine the numerous actors that have contributed to the success of this network, such as the (established) fiber optic network, Stockholm's financial institutions, the numerous ICT students and researchers that took part in the smart city initiative, the general citizenry that approved of the ICT initiatives, the elected officials that took part in outreach and informing the public about the technical details of the various e-government services, the beneficiaries of the open data initiative, etc. By not accounting for the contributions made by the corporate entities, we risk losing out on the financial, intellectual and human capital contributed by the various corporate actors that have contributed to the building and stabilization of the network.

Conclusion

The technical report will deliver a novel approach for an IoT sensor network system tailored to aid in the early detection of instances of forest fires in at-risk areas. This product will leverage ubiquitous low-cost low power embedded systems, cloud database and analytics engine, wireless signaling technology such as Wi-Fi, as well as open-source internet protocols such as MQTT, to ensure a low cost of development and maintenance on the part of the human operators and customers. The STS paper seeks to provide insight into the social, economic, policy, financial factors behind the success of the Stockholm e-Government initiative in 2007 by utilizing Actor Network Theory to study the contributions of corporate network builders in the formation of the network.

The results of the technical report intends to provide a solution to the broad socio-technical issue of early detection and prevention of forest fires by utilizing open source software technology and ubiquitous, low-cost hardware technology to build a commercial product. The findings of the STS paper will also explore the importance of cooperation between private corporations and local governments as well as the detrimental effects of not accounting for the corporate actors during the development of this socio-technical product.

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