SENSORNET

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Table of Contents

1.0 Executive summary

1.1 Problem statement

This proposal shall focus on Point 1 – Post-Pandemic:

> As we emerge stronger from COVID-19, how might we leverage technology to evolve emergency response and public safety strategies to enhance the capability and resilience of SCDF to respond better in a pandemic situation?

1.2 Vision

To enhance mission response in time-sensitive environments.

1.3 Mission

Enhance capability & resilience of SCDF to react and respond smarter and more efficiently by utilising automation & gathering actionable intelligence.

1.4 Introduction

Sensornet aims to enhance the capability & resilience of SCDF to respond smarter and more efficiently by utilising automation & gathering actionable intelligence. It does this by using multiple sensors (data sources such as 995 calls, myResponder, fire alarms, CCTV & drones) and leveraging technology such as 5G, AI & Cloud Computing.

2.0 Deep dive into Sensornet

2.1 Types of sensors

Sensornet is a **modular** and **scalable** network and it taps on existing sensors. Sensors are basically any source that can provide data.

Existing sensor infrastructure includes:

1. Building Fire Alarm System
2. Public Agency CCTV cameras (such as LTA, Police)
3. 995 Phone Calls - The public
4. myResponder app - The public

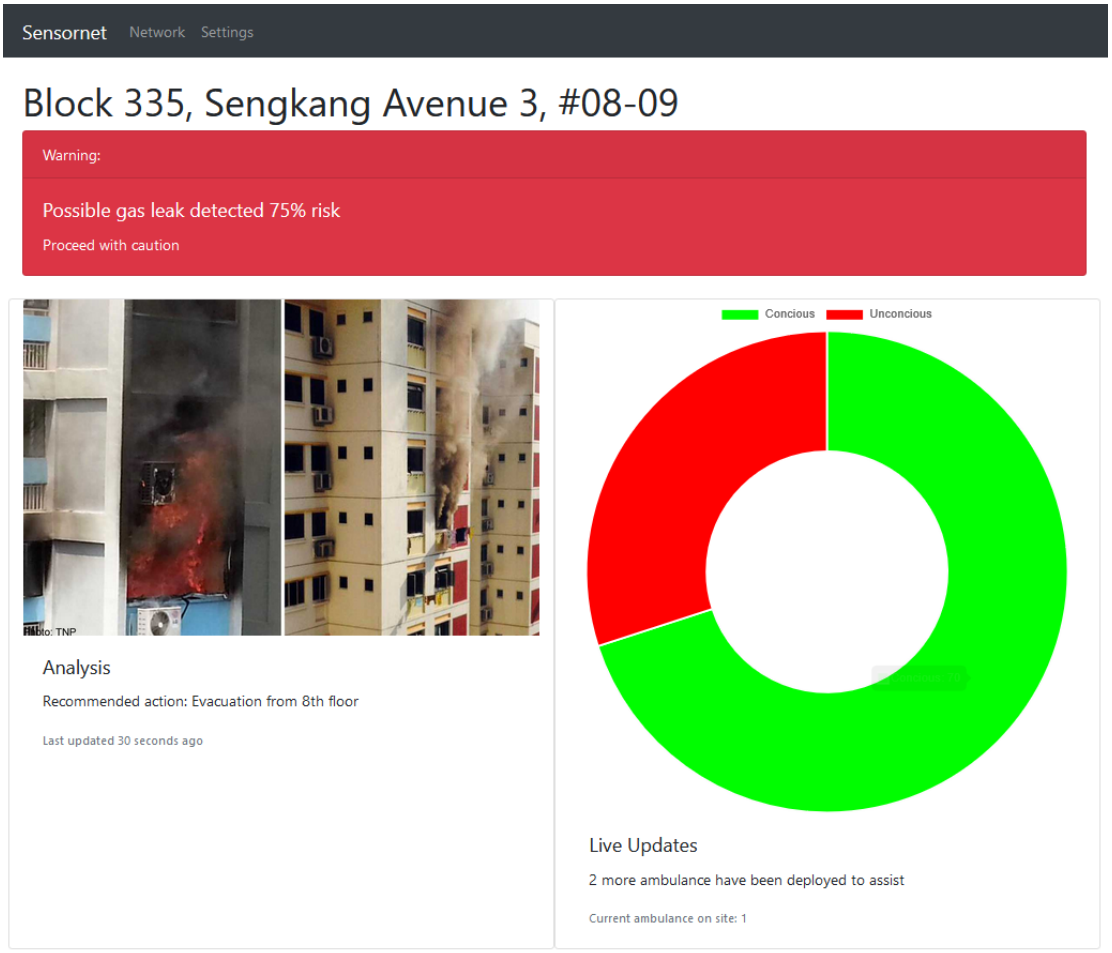
As more sensors come online, Sensornet will scale accordingly. As it is an integrated Sensor Platform, it will inter-link existing & new sensors together to gain insights on the ground.

Our solution in this proposal recommends drones as a new sensor that can be deployed. It is an existing technology, however, its potential is still not fully maximised. It can serve as a key source of data for SCDF to use in their operations.

2.2 Technologies Used

2.2.1 Dashboard

To build the dashboard for the commanders, we made use of ***Flask***, which is a web framework written in Python. The dashboard makes use of modern open-source frameworks like ***Bootstrap 5.0 and Chart.js*** to provide an intuitive interface to understand what is happening.



2.2.2 Artificial Intelligence

Artificial Intelligence plays a big role in Sensornet as it provides actionable intelligence as well as suggested recommendations to commanders. Artificial Intelligence can help perform tasks such as:

- ★ Counting the number of casualties as well as locating them
- ★ Identifying undetected fires

The potential that artificial intelligence can play is limitless.

The prototype uses an open-source model which was trained based on the COCO (Common Objects In Context) dataset which contains about 330 thousand images of objects spanning 80 categories and was trained using ***Python 3, Keras, and TensorFlow***. The model is a Region Based Convolutional Neural Network, which separates various objects in the video, and consists of a Feature Pyramid Network (FPN) and a ResNet101 backbone.

2.2.3 5G

As Sensornet will be working predominantly in the city and heartlands, the various internet-connected sensors make use of the 5G network for *increased redundancy* and to provide *low-latency* data transfers to the Sensornet.

2.2.4 Cloud Computing

We also leverage Cloud Computing as it is cost-effective and can scale as Sensornet grows.

2.3 Actionable Intelligence

With more sensors, SCDF can 1. Respond to incidents faster (as it happens or when it is just starting out) 2. Respond to incidents more efficiently.

The incident scene generates data at great volume, velocity and variety (commonly known as the 3 V's).

The main driving force for Sensornet is its use case in time-sensitive environments to translate data into actionable intelligence. With actionable data, the ground commanders can spend more time choosing the right course of action as they receive more timely intelligence. This is done simultaneously even before the task force/first responders arrive at the scene. As the situation on the ground is fluid and dynamic, Sensornet can help to reduce human error during decision making. It also allows the first responders to be more efficient on scene and possibly spend less time & effort.

2.4 Scenarios - How it is applied

As Sensornet is built to be modular, scalable, this means Sensornet is flexible and can be expanded to cover some scenarios. Below are some scenarios we expect Sensornet to cover:

1. Any sensor in the network which detects a fire will alert Sensornet. Sensornet will deploy drones to access the incident site and provide intelligence, even before the first responders reach the scene. Sensornet can help to identify the exact location of the fire, identify obstacles, identify open windows for entry, and casualty identification. This allows the first responder to respond more efficiently.
2. A person faints or suffers a cardiac arrest at a low-traffic location in view of CCTV. This can be at a park or a void deck. Current methods involve a passer-by coming across the casualty and this can lead to delayed medical treatment. However with Sensornet, if the CCTV detects a person who collapsed, it can send out an alert on myResponder for the Community First Responder to do first-aid/CPR. If there is a need, an ambulance can be dispatched to convey the casualty to the hospital.
3. Sensornet also has built-in anomaly detection. An example would include detecting a surge (E.g. 30) in the number of people coming down the staircase via CCTV. There is a possibility that there is a huge fire and people are evacuating. There are no calls to 995 yet as everyone wants to evacuate to a safe spot first. The fire team is placed on high alert and a drone is activated to perform a visual sweep if there is a fire in the vicinity.
4. A shopping centre building fire alarm system goes off and it notifies SCDF as well. The fire command centre team in the shopping mall tries to verify if it is a false alarm. The drone being situated at the Hub (More in 3.1 & 4.1) which is a shopping centre will also automatically launch and provide a second level of confirmation to SCDF if there is a fire.
5. Other possibilities also include:
    a. Bush fires (Early detection)
    b. Fumigation (Sensornet can verify if it's a rubbish fire or fumigation if the public makes a fire report)
    c. Drowning cases in open sea

3.0 Effectiveness & Feasibility

3.1 Modular Network

Sensornet is a modular and scalable network. We can leverage existing sensors which are deployed currently. The focus will be to integrate the various types of sensors as well as to train the AI model. Due to it being on the software side, the costs to build up a platform is significantly lower, which will result in Sensornet being able to be rapidly deployed and shorten the **time-to-market**.

In the longer term when deploying newer technology such as drones to join the network, we can start small scale trials in a *sandbox* environment to test if they work. For example, one-north has been designated as Singapore's first drone estate (The Straits Times, 2018). Conducting trials also allows us to observe how they will work in real world situations and also give more time for the technology to mature, thereby **driving costs down**. When drones are deployed in residential areas such as HDB estates, we want to adopt a *Hub* & *Node* model. In every HDB estate (approx. 1km vicinity) there will be a node, which has 5 drones (Subject to change based on operational requirements after trials). There will also be a hub at key points of interest in every town centre. These hubs help to augment the nodes by housing more powerful drones for bigger operations.

Sensornet benefits from Metcalfe's Law (Network effect) as it is a modular network. As more sensors join the network, they will form our eyes and ears on the ground. The value and insights gained from Sensornet will increase exponentially as these systems become increasingly integrated, providing more timely and better intelligence. Furthermore, there are more technologies that we have yet to imagine (such as satellites) that may be incorporated in the future. We want these future technologies to play a part in the network too.

3.2 Artificial Intelligence (AI)

As mentioned in 2.3, data is being generated with increasing **volume, velocity and variety**. AI can help to translate this data into actionable intelligence, regardless of whether it is for the Ops centre operator to dispatch or for the ground commander to gain more timely information.

With advancements in computing (CPU, GPU), HPC (High performance computing), AI models and the availability of more quality datasets, the AI will have fewer false positives and will be more accurate. With cloud processing, this means that it can take advantage of the latest and most accurate model.

<u>False Positive</u>

By building the process to be secure by design, this means that **safeguards** and **fail-safes** will be implemented. There will be **redundancy** built into the system. For example, although AI will power the video analytics and navigation on the drone, we will build in manual takeover. We also want the **AI to be explainable** and in some scenarios, the AI will act as an advisor giving suggestions and helping the ground commander to make more informed decisions.

<u>False negative</u>

With AI, we understand that there will be false negatives. In this case, it means not picking up a fire or a person collapsing when there is actually one. Current methods rely on the public to report an incident. Without Sensornet, we would have to rely on the public to come across a fire or a person who has collapsed and make a report. In short, comparing Sensornet with current methods, there is either a gain in efficiency and timeliness of getting alerts or no difference (Gain in efficiency>=0). It will not result in any safety issues.

However that does not mean false negatives are not important. Improving AI models and accuracy is a *Work-in-Progress*. What we can do is to learn from such situations, improve the model so that it becomes more accurate and will be able to detect something similar next time.

To assess feasibility, the team did a prototype of a simple object detection model. A more detailed description of the technology has been placed in Point 2.2.

3.3 Cloud

Through the pay-as-you-use model, the cost of running the system is minimised due to economies of scale. A service of interest is the IBM High Performance Compute Services. The computing instance can be scaled up or down as necessary. If the network grows, cloud computing allows for easy upgrading on-the-fly. This ensures high availability and reliability for such critical systems. Additionally, usage costs can be further reduced via commitment contracts.

4.0 Limitation and Mitigations

4.1 Drones

Drones are not new technology. Drones range from hobbyist ones such as those used for filming to those used by the military which can fly at high altitude. However drones have not been heavily used in urban environments for operations. There are some trials ongoing, such as using it for food delivery, parcel delivery, shipping surveillance in the maritime industry or even to deliver medication to remote areas in other countries.

We envision a future where drones as a sensor will start to be more heavily involved in SCDF's operations. There are current limitations with drone technologies, but as the technology matures, it will get better.

- Limitations on withstanding fire
    - SCDF has deployed fire-fighting robots to work alongside SCDF officers (The Straits Times, 2018)
- Drone navigation
    - It can be either manual or automatic controls. Automatic control shall incorporate self-navigation which relies on GPS location services and 5G networks.
- Engineering Capabilities
    - Drones will have limitations in terms of battery, its size, number of sensors (payload) it can carry. However, we believe different drones can be developed to suit various operational requirements.

Sensornet employs a Hub and Node concept. In every HDB estate, there will be a Node. In each Node, there can be 5 drones. These are parameters that can be adjusted after trials have been carried out. When a drone runs out of battery, it will fly back to the node to recharge and another will take over. In an event of a prolonged incident or a bigger incident, drones can be deployed from Hubs located at key areas. These drones may be bigger and better equipped and can have longer flying hours.

4.2 Privacy concerns

In an emergency situation, privacy concerns need to be addressed. However, privacy would not be sacrificed if there are safeguards built in place. This platform should still be built to the highest cybersecurity standards and employ end-to-end encryption to safeguard data. *Building trust with the citizens is critical to ensure high support and overall success.*

This project should also be held to the same standards that apply to the government. “Data management in the public sector is governed by the Public Sector (Governance) Act (“PSGA”) and the Government Instruction Manual on IT Management (“IM on IT Management”)” (Source)

4.3 Places where sensors cannot be deployed

Sensornet aims to bring onboard as many sensors as possible. However, due to certain laws or restrictions, it will not be possible to tap on every sensor located in Singapore. For example, drones cannot fly near air-bases or airports as there are no fly-zones. Another example is military camps where we will not be able to leverage on the cameras or fly drones near camps due to security reasons. Sensornet will try to tap on as many sensors and as provide as much coverage as reasonably possible **without compromising on SECURITY OR SAFETY**.

In places where drones cannot be deployed, for example at Changi Airport, we can still leverage on other sensors such as CCTV’s or the building fire alarm system if we can cooperate with Changi Airport Group (CAG). In summary there will be no net loss in deploying Sensornet, because in places where there is no sensor coverage there is just no net gain. However in places with sensor coverage there will be a net gain as SCDF can respond to the incident smarter and more efficiently.