Autonomous, intelligent, cloud-based networked system for real-time water quality measurements and monitoring

Subnero Water Assesment Network

A White Paper

SUBNERO

Water Quality Monitoring

Why is this important to us?

We need to safeguard our scarce water resources as worldwide demand continues to increase.

71%

Earth's surface covered by water.[1]

50%

World population living in water-stressed areas by 2025.[2]

0.007%

Water in the Earth available for use for food or other purposes.[3]

Footnotes:

1: USGS.gov, 2020. Article entitled *How Much Water is There on Earth?*

2. WHO.int, 2019. Article entitled *Drinking Water*.

3. Nationalgeographic.com, 2020. Article entitled *Competing for Clean Water Has Led to a Crisis*.

The Pressing Issue

The Thirst for Water and its Data

Water is crucial for the sustenance of life. Our food source either comes from it or depend on it for growth and agriculture. Our ecosystems require it to function and maintain its balance.

Additionally, information from our water bodies is used by a wide number of industries for a multitude of purposes. For instance, various government agencies, water utilities, and industries such as agriculture, aquaculture, food and beverage (F&B), marine energy production, and organizations studying the effects of climate change in our world, use this information about our water.

Many of these industries require prompt or real-time access to the water data for making informed decisions, which has a direct impact on our lives, our resources, and the economy.

The Challenge with Water Data Collection

Conventional methods deployed to collect water data are usually time-consuming, labor-intensive, and expensive. Methods typically used involve manual water sampling from a single location over time using water quality probes or static buoys or towing of sensors from boats, or diving, etc.

Some of these methods do not allow for real-time data collection. They may also be affected by limited coverage or connectivity network issues in remote areas.

Moreover, the gathering of information from multiple sources is a complex process. The user needs to manage the data from different sensors and robots deployed, which is challenging.

It is detrimental if these challenges delay the response required to resolve urgent water problems.

Toxic Algal Blooms

When water problems are undetected or not treated promptly, it can result in serious issues such as toxic algae blooms in our waters. These blooms threaten our ecosystems and livelihoods.

Early warnings of blooms can greatly reduce the time and resources required to treat polluted waters.

Our Solution

Enabling remote and smart monitoring.

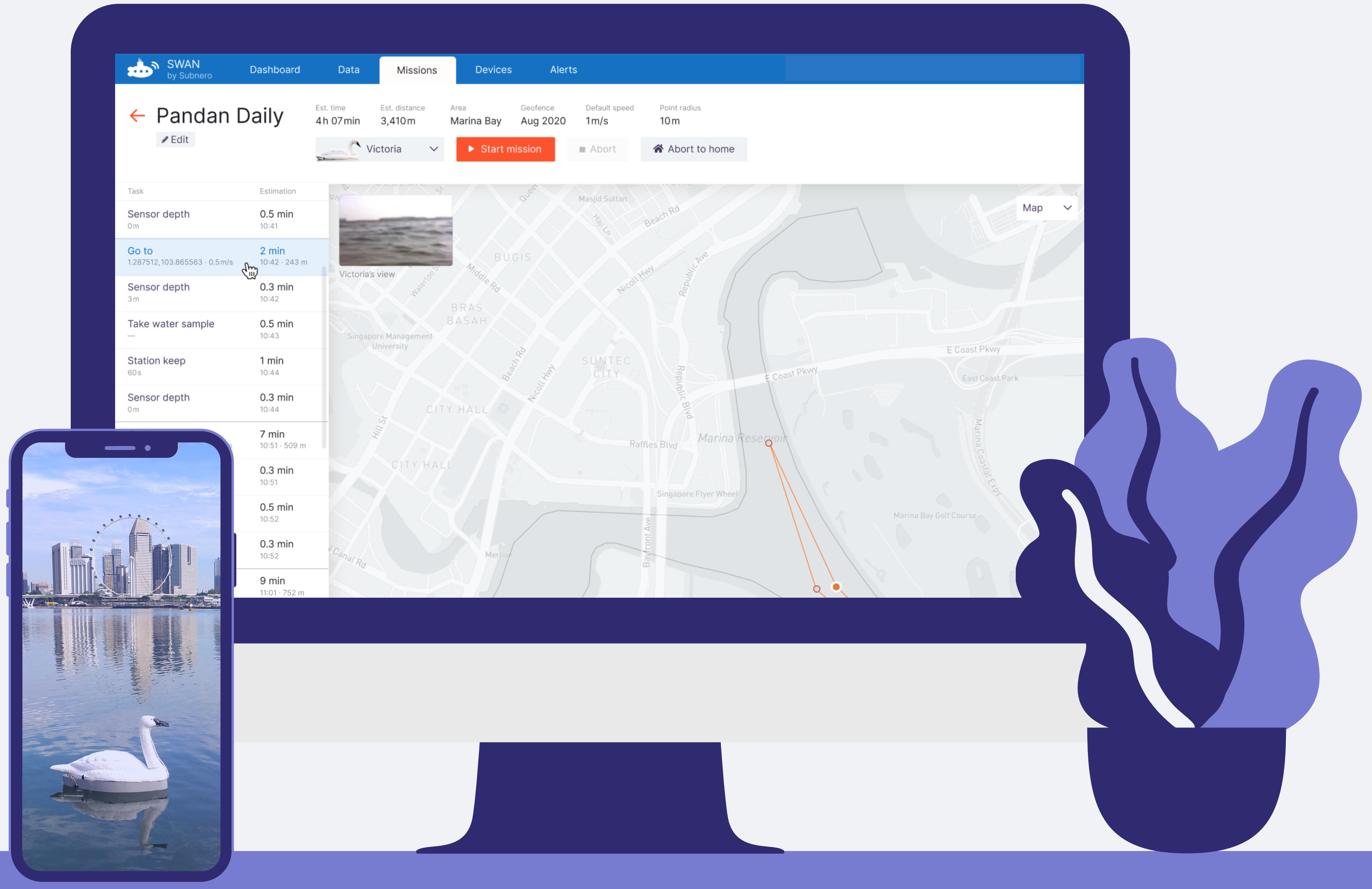
The Subnero Water Assessment Network (SWAN)

The Subnero Water Assessment Network (SWAN) is an integrated cloud-based networked system that enables real-time water quality data collection and visualization using an autonomous platform.

SWAN was developed to monitor the quality of our water resources in an intelligent, efficient, and cost-effective manner.

Robust communication links can be built using the SWAN across various robots, sensors, and data analytics systems, thereby streamlining the process of collecting data from all the assets deployed. This includes assets on the water surface, above water or underwater; such as mobile robots, static buoys, drones, weather stations, etc.

Through the use of SWAN, we are able to tackle the aforementioned challenges which are typically associated with conventional methods of water data collection, with huge savings in both time and resources.



SWAN Capabilities

1. Real-time water quality monitoring & sampling

The autonomous SWAN robot monitors water quality parameters while navigating the water surface. A centralized cloud server collects the water quality data transmitted by the SWAN robots and other water assets, and displays data in real-time on a web interface. Users can access the data from diverse platforms, including tablets and mobile phones.

2. Intelligent & configurable missions

SWAN robot missions and tasks, such as robot movement and water sampling, can be pre-programmed or adapted by intelligent mission algorithms. SWAN utilizes machine learning enabled algorithms to intelligently adapt ongoing missions for smarter water quality monitoring.

3. Multi-modal heterogeneous network system

SWAN links all assets deployed across various locations, through different networking technologies comprising cellular network (i.e. 4G/5G), wireless local area network (i.e. Wi-Fi), satellite communication technology, or underwater acoustic networks (when assets are located underwater), etc. SWAN provides a secure environment by following industry-standard network security encryption protocols.

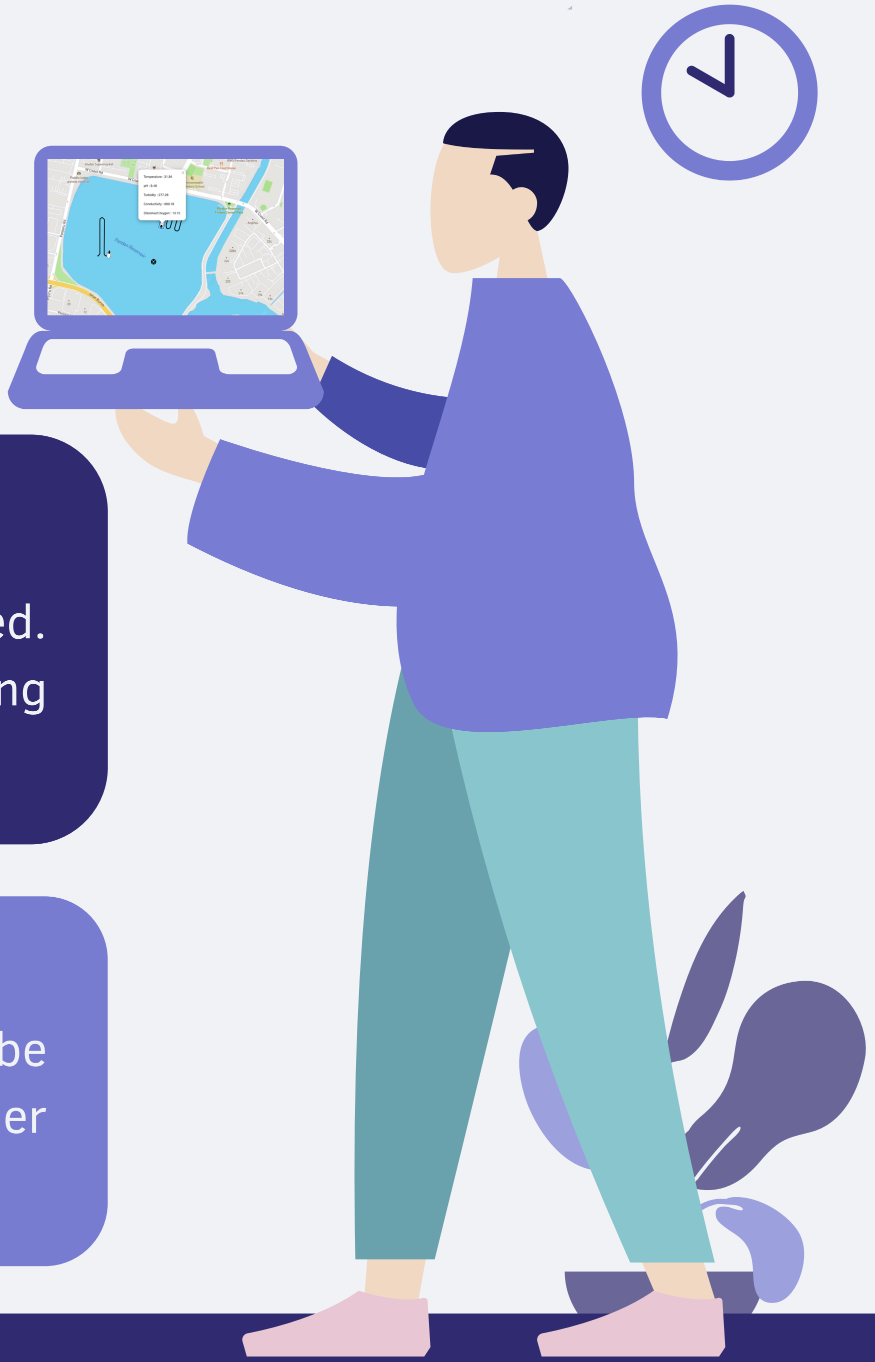
SWAN Capabilities

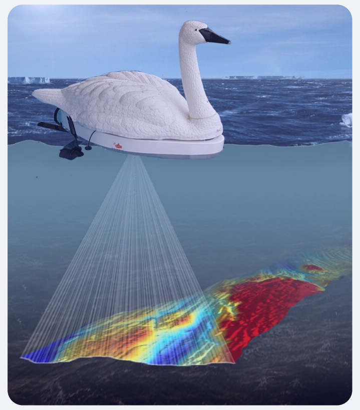
4. Disruption tolerant network (DTN)

SWAN incorporates Disruption Tolerant Network (DTN) technology, which enables seamless data transmission in areas with intermittent network connectivity, variable propagation delays, and asymmetric data rates, which could arise due to the location of deployment.

5. Bevy intelligence (BI)

SWAN is scalable to allow a bevy (or group) of SWAN robots to be deployed, in order to achieve faster, more efficient and intelligent monitoring over a larger area.





6. Bathymetric & topographic surveys

The SWAN robot, fitted with an echo sounder, enables active depth and temperature to be logged. This enables bathymetric surveys and mapping of underwater topography to be performed using SWAN.

7. 24 hours surveillance & security

In lakes and reservoirs, the SWAN robot is able to blend in naturally with the surroundings. It is fitted with a camera that can be used for surveillance, which can be streamed for real-time viewing by the user. Options are available to the user to integrate other sensors such as a thermal camera for night vision capabilities.

Comparing Water Monitoring Technologies

The table on the right shows a comparison of the various solutions available and their typical uses. The best fit for your application depends on your resources and constraints.

Technologies	Definition	Advantages	Disadvantages	Typical Uses
Manual Method	Involves measurements taken by personnel on a boat or by divers	Repetitive and Predictable	• Time-consuming • High risk and dangerous • Weather-dependent • Delay in data collection • High operational & manpower cost	Measuring of multiple water parameters, or water sampling of large capacity.
Smart Meter	Electronic device that records consumption patterns and communicates the information live to the user	• Real-time data acquisition • Scalable	• Fixed monitoring area • Fails to work when network is down/limited	Households, electric companies, flow or leak detection, pipeline pressure monitoring
Sensor Buoy	Surface buoys integrated with sensors	• Real-time data acquisition • Low maintenance • Low relative cost	• Fixed monitoring area • Limited payload • Difficult to deploy in areas with limited/no network	Ocean and environmental monitoring
Remotely Operated Vehicle (ROV)	Tethered submersible vehicles controlled from the surface by an operator	• Real-time data acquisition • Human manoeuvre of vehicle movement & tasks • At-depth monitoring & sampling	• Skilled personnel required for operation • Monitoring area limited to tether length • Medium - High capital and operational costs	Underwater data collection and photography, pipeline inspection
Unmanned Surface Vessel (USV) i.e. SWAN	Vessels that operate on the water surface without crew onboard, like the SWAN robot	• Scalable • Operable in poor weather conditions or remote and inaccessible areas. • Real-time data acquisition • Low operational cost	• Limited depth of monitoring & sampling • Difficult to deploy in areas with limited/no network • Medium - High capital costs	Unmanned data collection, bathymetric surveys, surveillance

SWAN Components

SWAN offers a complete monitoring solution, providing economical real-time data monitoring and visualization, network reliability, and streamlined management of multiple complex data assets.

1. SwanBot

A portable, light-weight, energy-efficient, and user-friendly Unmanned Surface Vessel (USV) in the form of a swan that navigates on the water surface to collect water data. The SwanBot may be equipped with the following features:

- **SwanSense -** A suite of sensors that can be customized by the end user. The typical SwanSense package includes a multi-parameter probe, a camera, an echo sounder, and GPS for localization. The user can also decide the water quality parameters to be monitored, or choose a specific probe for integration onto the SwanBot.
- **SwanSampler -** A watertight container that automatically captures water samples up to 1 liter capacity and 1.5m depth, when ready to sample.

2. SwanCloud

The cloud-based software for managing the SWAN, that aids in decision-making and provides mission planning directives for SwanBots to navigate and acquire data efficiently.

- **SwanViz -** The user interface that displays the collected spatio-temporal data and the progress of various missions in an interactive manner for the user to visualize. Users can also configure and update existing missions of the SwanBot.
- **Bevy Intelligence -** Intelligent plug-ins for multi-node data analysis and path planning.

3. SwanNode

A static node (e.g. buoy) running software capable of connecting to the SWAN. The SwanNode may be equipped with the following features.

- **SwanSense -** A suite of sensors that can be customized by the end user and attached onto the SwanNode, and in-turn connected into SWAN.

SwanBot Technical Specifications

Key Features at a Glance

- Deployable by a single person
- Configurable to move autonomously or using a remote control
- Mission commands can be sent via phone or desktop user interface
- Long runtimes of 6 - 8 hours

FEATURES	DETAILS
Dimensions (L x B x H) Weight	0.8 m x 0.5 m x 0.8 m 18 Kg
Control & Navigation	Autonomous (GPS based), 2.4 GHz Radio Transceiver
Communication Interfaces	3G/4G, Wi-Fi (802.11g 2.4GHz)
Software & User Interface	Web-based
Endurance	6 -8 hours (depending on mission setup)
Battery	Li-ion Chemistry, Rechargeable
Storage	Cloud Storage
Supported Sensors	Camera, Echosounder
Supported Water Quality Probes	Eureka Manta +35, YSI 6000
Water Sampler	2 bottles of 1 liter capacity each

SwanCloud Architecture

Modular Unetstack framework

The SwanCloud uses the *UnetStack** framework, an agent-based network stack with a robust messaging system as its basis. This modular framework is designed for creating networks in resource-constrained environments, and comes with building blocks for supporting DTN technology within the network.

Intelligent Software

The SwanCloud infrastructure contains an intelligent node management application programming interface (API) that enables the cloud to connect to the various nodes available and collate all of their data.

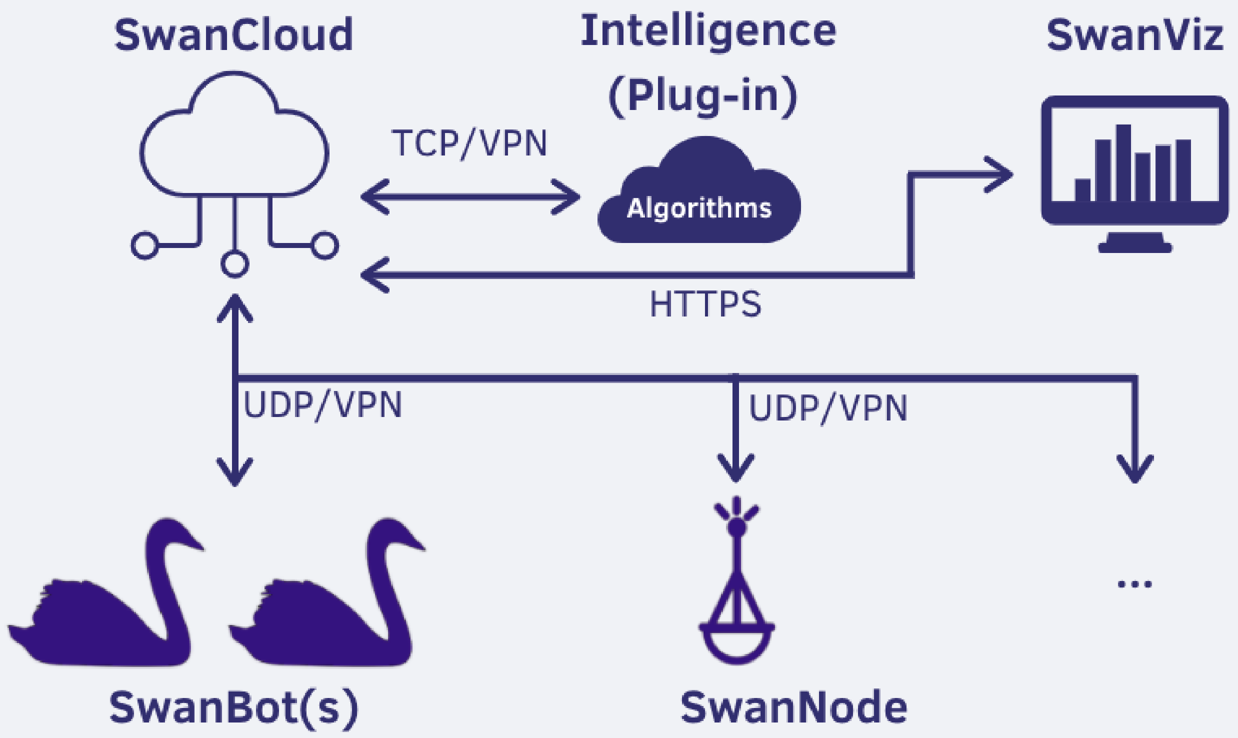
In SWAN, data can still be aggregated although it comes in varying formats, resolutions, dimensions, and scales from different sensors or drones.

Connected mobile nodes will also be able to receive updated mission and operational planning directives from the SwanCloud and be directed to move to the relevant areas.

Extensible mechanism to support new plug-ins & functionalities

The extensible architecture of the SwanCloud enables a variety of assets to be supported as well as new functionalities added to the system, allowing for continual developments in the SWAN.

The architecture also supports advanced functionalities, such as intelligence plug-ins to aid in intelligent mission planning of the SwanBot.



SWAN Software Architecture Block Diagram

*For more details on Unetstack, refer to link: https://unetstack.net/

Contact us

For pricing, support and technical enquiries, you may contact us at one of the following channels or visit our website for more details.

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