

Internet of Things (IoT) Driven Innovation in Fisheries and Aquaculture

Ms. Geetha M, Dr. Gomathy V and Dr. G. Arul Oli

Department of Fisheries Extension, Economics and Statistics,

Fisheries College and Research Institute, Thoothukudi, 628 008, Tamil Nadu, India

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1. Introduction

Fisheries and Aquaculture in India remain as an important source of livelihood for 28 million of fishers and fish farmers. The total fish production of the country was 1.75 million tonnes in the financial year of 2022-23 (Handbook of Fisheries Statistics, 2023). The future development of aquaculture depends on the adoption of new and innovative production technologies, management and utilization of under-exploited water resources and proper business collaborations (Dhenuvakonda and Sharma, 2020). Embracing the new technologies such as Internet of Things (IoT), block chain technology and AI will facilitate the unravelling of immense potential of fisheries sector. This article aims to describe the basic concepts of IoT and its scope in various regimes of fisheries.

2. Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of physical devices such as appliances, equipment, vehicles that are embedded with sensors, software and network connectivity which enable them to collect and share data without human intervention. It involves the creation of a vast network of interconnected devices that can communicate with each other and other internet-enabled devices. It enables these devices to exchange data and perform various tasks autonomously. IoT devices also known as “smart devices” can range from simple wearables like smart watches to complex industry machinery. Technologists are even envisioning entire “smart cities” predicated on IoT technologies.

The Internet of Things transforms physical objects into an information ecosystem shared between wearable, portable, and even implantable devices, making our life technology and data rich. IoT makes networking smarter and more advanced. Nowadays, one can imagine that more devices are being added to connect to the Internet every day.

2.1 Key components of IoT:

- i. **Device:** Device is an object that has been invented for a particular purpose. For example, Communication device – Mobile phone, Storage device – pen drive, Input device – keyboard etc.
- ii. **Sensor and Actuators:** Sensor is a device that receives different kinds of signal i.e. physical, chemical or biological signal and converts them into an electric signal (Patel *et al.*, 2020). In other words, a sensor is a translator that converts a non-electrical value to an electrical value. Sensors are classified into different types based on the applications, input signal, and conversion mechanism, material used in sensor characteristics such as cost, accuracy or range.
- iii. **Gateway:** Devices are connected to internet via gateways. Gateways are also used for collecting, incorporating and transferring the sensor input to cloud processing/Network domain and vice versa.
- iv. **Cloud computing:** Cloud computing is an appropriate Internet platform for storing smart device data.
- v. **User Interface:** User interface is the means by which a user and a computer system interact. Eg. Mobile applications

2.2 Functioning of IoT:

In less than a decade, technology has gone from ‘using our fingers to interact with a device’ to ‘being able to talk to our devices’ to ‘devices talk to each other without our help’. For example, “the first touch screen devices” to “asking Google on your laptop” to “Mobile phone telling the apartment thermostat that one have reached home and to turn on the A/C”.

Device will be connected to the internet by using gateways. The sensors fitted into the device receive different kinds of signal from the environment and convert them into electrical signal (data). Data produced by the sensors will be collected, incorporated, and transferred to the cloud by the gateway.

will store the data. The data stored in the cloud will be processed and projected to the user interface monitoring or transferred appropriate device for necessary action to be taken via gateways.

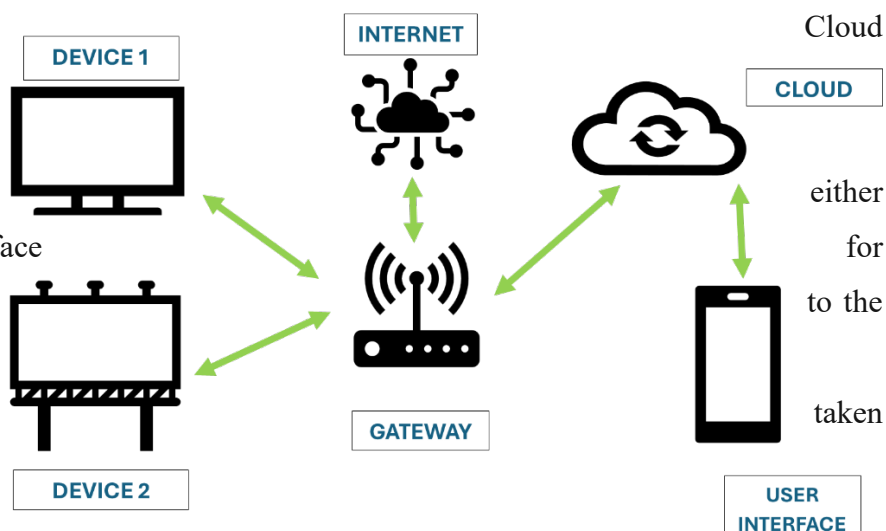


Figure 1. Components of IoT and its functioning

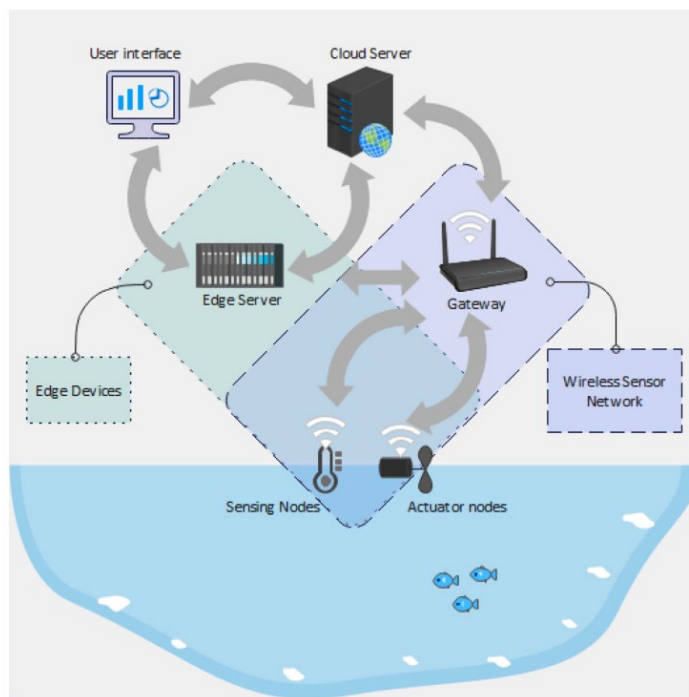
IoT has effectively demonstrated its enormous potential in almost all sectors in the most recent years and fisheries is not an exception to it.

3. Scope of IoT in Fisheries

Aquaculture refers to the farming of aquatic species under controlled conditions. Maintenance of proper water quality, providing proper nutrition and prevention of the occurrence of disease are the crucial factors deciding the success of the culture. These processes can be simplified by the integration of IoT with the management and operations of aquaculture systems. Designing of IoT system for aquaculture should focus on the type of system, type of species and accessibility of the farm such as availability of reliable source of electricity and internet.

3.1 Water quality Monitoring

Most of the proposed IoT systems are focusing on monitoring water quality factors such as temperature, pH, alkalinity, and nitrate level wherein the devices are connected to a wireless sensory network. Sensors and actuators are placed in the physical environment. Sensors detect different water quality parameters while the gateways receive the data from the sensors and transfer it to the cloud for storage. Then, the data will be sent to the user interface and at the same time it will be transferred to the actuators which will be turned on or off based on the range of the data (Fig 2).



Source: Rastegari *et al*, 2022

Fig 2: Interaction of the components of IoT in Aquaculture system

Eruvaka Technologies from Andhra Pradesh established in 2012, is involved in building IoT system that help measure different water parameters that are crucial for the growth and survival of shrimps in an aquaculture pond. Information collected includes oxygen levels, temperature, and

pH range in the pond. Besides accessing information through the app, it can also be transmitted via SMS or Voice call. However, this type of water quality monitoring system still needs widely distributed monitoring nodes in the fish farms, which will be a big problem for the supply of electricity and the maintenance of equipment. In addition, the sensor needs to be regularly calibrated to improve the sensing accuracy, and frequent equipment calibration requires considerable human resources.

3.2 Fish Disease Monitoring

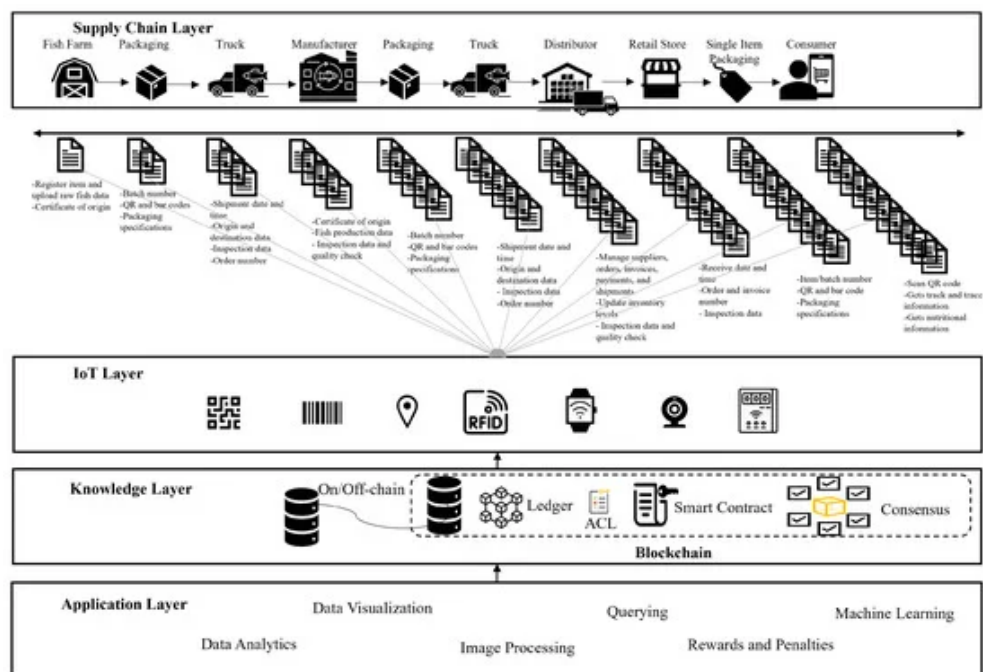
Diseases are a major cost driver in aquaculture. AI-based devices have been implemented for disease management by several companies in the world. Notably “AquaCloud” a cloud-based application developed in Norway in 2017 for forecasting and preventing the occurrence of fish lice infection in marine cages, “FarmMOJO” for anticipating the occurrence of fish disease in the shrimp farms developed by Aquaconnect an Indian based company. IoT can be used to access the real time water quality data which results in the elimination of stressors and fish pathogens (Li and Li, 2020). The measurement is performed using an optical sensor placed inside the culture system, and the results are shown on an electronic device connected to the culture system. The electronic device may also wirelessly transmit data over the internet to users' phones or laptops at predetermined intervals for appropriate actions to be taken (Yang *et al.*, 2020).

3.3 Fish Supply Chain Management

Trading of fish and fish products internationally and domestically is a most common practice. Traceability plays an inevitable role in trading of aquatic products. Blockchain coupled with IoT is a recent technology, promoted to address the raising issues in traceability and authenticity. Wireless sensors, Radio Frequency Identification (RFID), GPS chips and spectroscopy, imaging devices which are enabled with IoT are used to sense, actuate, and collect data. These securely registered data are distributed to database system available for stakeholder access.

Ismail *et al.*, (2023) proposed framework for Blockchain IoT-enabled fish Supply Chain (SC) framework consists of four architectural layers: SC, IoT, knowledge, and application. The SC layer depicts the interactions between the actors who play the role of nodes that are communicating and transacting with each other in the chain's physical flow. The IoT layer is presented by the IoT-enabled devices, sensors, and actuators that are connected through the IoT cloud to the SC system to monitor and collect traceability data and to be stored in the Blockchain. The knowledge layer, or Blockchain layer, stores all data activities, or transactions, that occur during the SC operations in the form of data blocks that are encrypted and controlled by the smart contracts and distributed to each involved entity. The application layer primarily provides the applications that extract the different functionalities and then integrates the end-users with system services so that they can

access the data.



Source: Ismail *et al.*, 2023

Figure 3. Layered architecture of the proposed Blockchain IoT-enabled SC system

3.4 Internet of Underwater Things (IoUT)

IoUT is an innovative concept has its application in terms of marine life observation, water contamination measurement and for making smart oceans. It incorporates several underwater communication technologies based on magnetic induction, optical signals, radio signals and acoustic waves. It is an emerging communication ecosystem which can reveal a new era of research, business, and naval application (Mohsan *et al.*, 2022). The IoUT technology is intricately linked with intelligent boats and ships, smart shores and oceans, automatic marine transportations, positioning and navigation, underwater exploration, disaster prediction and prevention, as well as with intelligent monitoring and security. The network architecture of IoUT is intrinsically heterogeneous and should be sufficiently resilient to operate in harsh environments. This creates major challenges in terms of underwater communications, whilst relying on limited energy resources.

Conclusion:

Water quality management, Fish disease monitoring, IoT enabled fisheries supply chain management and Internet of Underwater Things are the major areas in which considerable amount of exploration has been made to collaborate fisheries related activities with IoT. It is noteworthy that IoT can facilitate the complex task of discovery and recovery of underwater environment and objects in fisheries but only few studies have investigated the utilisation of IoT in fisheries which is also only on an experimental level. With the rapid evolution of technology, embracing

innovation is crucial for sector's growth. Taking this into account, research should be channelled for the effective utilization of IoT in various paradigms of fisheries for the sustainable development of the sector.

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