# AQUACULTURE CLOUD MANAGEMENT SYSTEM

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**Contribution to the state of the art**

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**Abstract:** This study proposes an aquaculture system combining wireless sensors with the Internet of Things and expert system concepts. Built on the accumulated expertise and experience of professionals and researchers, the knowledge base advises aqua-farms on relevant farming practices. We hope that this system will conserve resources and secure product quality. The system also provides production data to consumers, thus facilitating information transparency and allowing consumers to purchase products with full knowledge and guarantee of food safety.

**Keywords:** Expert system, Internet of Things, Cloud services.

## INTRODUCTION

As technology and medical sciences advance, the public has become increasingly concerned with food hygiene, quality of life and prevention of illness (Fig. 1). With no sign of slowing in global population growth, there is a need to forecast consumer demand for aqua-farm products. Global marine yield has declined in recent years, as the proportion of overfished species increases and under fished species are neglected. The global fishing industry is facing an unprecedented bottleneck.

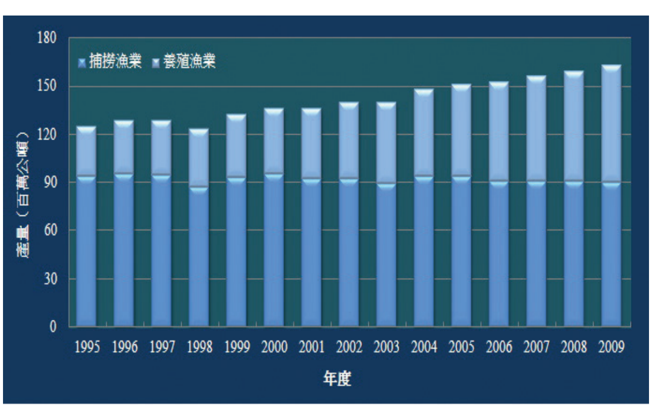


FIG. 1. – 2009 YIELD FROM WILD FISHING AND AQUA-FARM INDUSTRIES

A majority of seafood in Taiwan comes from enclosed aqua-farms. The farming process is not only labour-intensive but also leads to problems such as over-pumping of groundwater, ecological damage and subsidence due to poor management. Traditional fish farms use electric motors –or, at an even earlier point in time, water wheels - to change groundwater. As governments worldwide promote energy conversation, these practices could be argued to be a waste of power and water resources. Using automated mechanisms in place of traditional methods for routine farming activities (with inspections on an irregular basis) would save electricity and manpower, as well as reduce farming risks.

Our objective was to design a cloud management system for aqua-farms that would facilitate 24 hour monitoring of facilities while reducing consumption of resources. We interviewed experts on aqua-farming and collected data which was compiled and stored in the database. The inference engine was then used to store the data in the knowledge base, achieving the aim of knowledge management.

Using the Internet of Things concept, we employed sensors to monitor the aqua-farms, allowing personnel to keep tabs on the facilities at any time. They can also search for solutions to problems via the cloud management system, and record and report the results, thus maintaining the usability and effectiveness of the system. We hope that the aqua-farm cloud management system will achieve the following goals:

1. High quality aqua-farming results: Consistent quality that is not affected by differences in time, region or species.
2. Conservation of resources: We recruited industry experts and academics to regularly maintain and update the data in the knowledge base. If aqua-farmers operate their businesses based on the guidance provided by the knowledge base, they will be able to conserve resources and improve their efficiency.
3. Transparency: The public is increasingly concerned over food safety. The system can upload data on the aqua-farming process to a public cloud, through which consumers can access production-relevant information.

As Fig. 2 shows that we hope to conserve resources and reduce costs through the aqua-farm cloud management system, as well as enhance industry competitiveness and maintain the quality of aqua-farmed products, thus maximizing allocation of resources and benefiting local aqua-farmers.

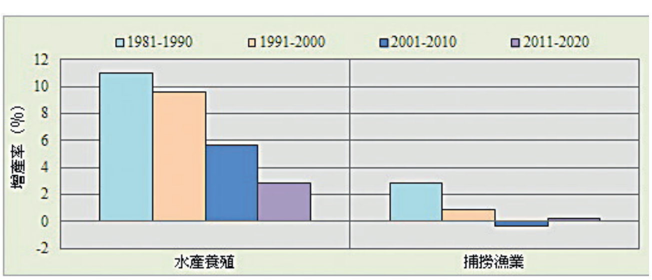


**Fig. 2.** Global growth in wild fishing and fish farming industries

## Literature review

### Expert system

An expert system is simulated judgment and behavior of a person or an organization of professional knowledge and experience in specific areas of computer programs. This system includes a knowledge base comprising knowledge and experience accumulated to be applied to the program described in each specific case of a set of rules. Expert systems can be complex and increase the knowledge base or the set of rules is enhanced (Fig. 3).The development of expert systems has changed dramatically in recent years and it is based largely on concepts dealing with artificial intelligence. These efforts are evolving from very specific, academically oriented efforts, such as medical diagnosis, to more managerially oriented corporate issues. Unfortunately, many proponents of these systems may be overlooking possible legal ramifications related to both the development and use of these systems[5]. The use of computers to process data began in the 1970's. By the 1980's, the trend had begun moving towards knowledge processing, as computer functions were gradually developed to mirror the functions of the human brain. Many studies have found that the anticipated performance benefits of using an expert system-such as increases in decision quality or speed of decision making-can lead to increases in expected usage. At this point, a milestone concept – artificial intelligence – was born, the most commonly known application of which is expert systems [1]. Expert systems solve problems raised by users through repeated inferences using relevant data in the knowledge base. Building the inference engine and knowledge base of an expert system is a daunting task [2].

Expert systems can have some disadvantages[13]:

1. Cannot easily adapt to the environment.
2. Expert systems are more professional, ordinary people cannot be easy to use.
3. Expert systems do not have the basic knowledge.

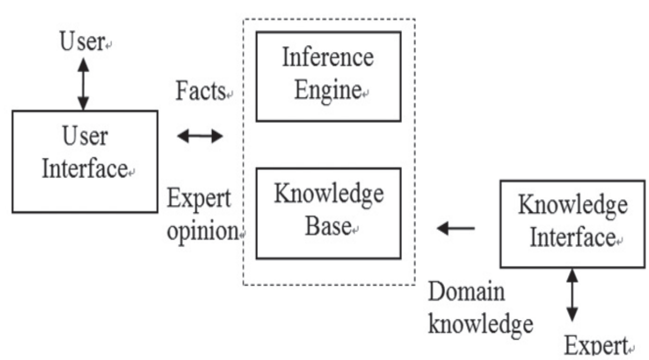


**Fig. 3.** Expert system

- User interface: Communication channel between system and users
- Inference engine: Extracts the facts from the knowledge base and finds the most appropriate answer [7]
- Knowledge base: Stores and categorizes the solutions provided by experts
- Knowledge interface: Converts and stores the experience and skills of experts as the knowledge base [12]

**Internet of Things**

The Internet of Things (IoT) provides anywhere, anything, anytime connections for which user privacy is vulnerable and authentication methods that favour policy over attributes are essential[14]. However, the term "Internet-of-Things" is used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities[10]. Underpinning the development of the Internet of Things is the ever increasing proliferation of networked devices in everyday usage. Such devices include laptops, smart phones, fridges, smart meters, RFIDs, etc.

Radio Frequency Identification RFID is a non-contact automatic identification technology, which signals through radio frequency automatic identification and access to relevant target data, no need for manual intervention to identify job, can work in a variety of harsh environment[11]. The Internet of Things uses RFID technology and sensors to join physical objects into an Internet-like structure, the aim of which is to support interaction between identifiable objects [8]. Mechanisms such as RFID technology, wireless detection and embedded smart chips are used to exchange information on physical objects [9]. The Internet of Things consists of three layers (Fig. 4): sensory, network and application. The sensory layer monitors the environment through sensory devices (for example, through volume perception).

The main function of the network layer is to transmit the data collected in the sensory layer to the data centre using wired and wireless networks. Lastly, the application layer applies technology to provide the desired results based on the needs of different industries.

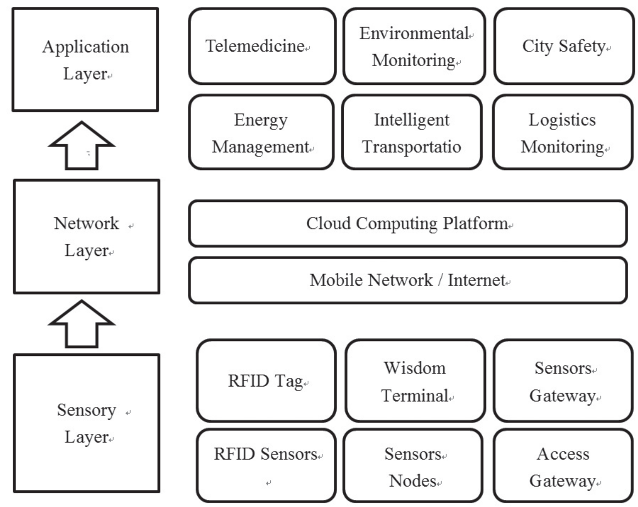


**Fig. 4.** RFID architecture Data source: Institute for Information Industry

**Traceability**

Consumers worldwide have become more concerned with the safety of the food they consume. The Food Traceability System has been introduced in many countries to reduce the uncertainties originating in the food purchasing process by providing information about the entire food process, from farm to table, in terms of quality and safety[3].

Traceability also known as production resumes, which is mainly used to record production, processing and marketing of agricultural, fishery and livestock products; such as stage, so that consumers have a record of the products are available for queries related problems.

Country of origin labelling has implications for traceability systems in agri-food supply chains. The ability to provide consumers with information on the country of origin requires a basic level of traceability, although does not necessarily imply full traceability throughout the supply chain to the farm[4]. Food traceability systems are an important means to provide food safety and quality information to consumers[6].

Traceability verification framework mainly refers to the organization through a third-party verification to view agricultural presence in the production process; thus, through the establishment of agricultural system, hoping to achieve a number of objectives, such as agricultural information transparency. The ultimate goal is to make consumers eat more safely. Farmers will learn simple system operation, and the information can be uploaded to the traceability of agricultural products traceability system, whereby the production and marketing of agricultural products is done from the shelves of goods to other processes. Consumers can understand the production process through a system of agricultural products, thereby shorten the distance between farmers and consumers.

## Research design

**System architecture**

Our system can be divided into two modules (Fig. 5): the monitoring system and the production data module. Using wireless sensor, the first module monitors the aqua-farm and transmits data whenever required to the persons responsible, enabling them to stay updated on the current state of the farm. The production data module records data on the aquaculture process, from hatching to sale. Through the aquaculture cloud management system, consumers can check to see whether products are in line with food safety regulations.

If downstream companies discover that products are detective, they can track the problem to upstream companies to identify the cause.

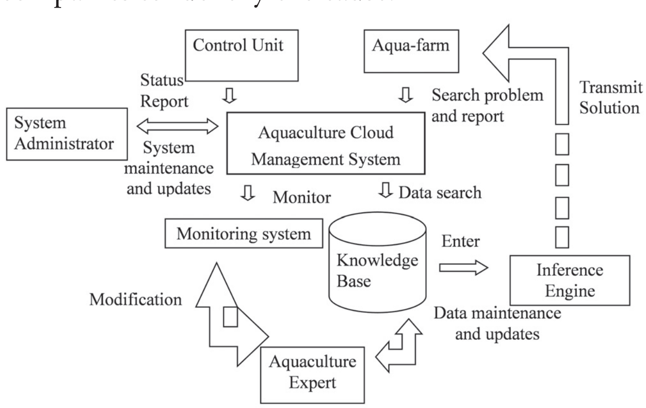


Fig. 5. Aquaculture cloud management system

**Monitoring system**

Through the control unit, the monitoring system monitors the state of the aqua-farm (such as PH value and oxygen concentration) and transmits this data using a wireless network (Fig. 6). The system also feeds the organisms through an automated feeding system. In the event of an incident or emergency, the control unit automatically activates functions to alert personnel, demonstrating advantages of speed and convenience.

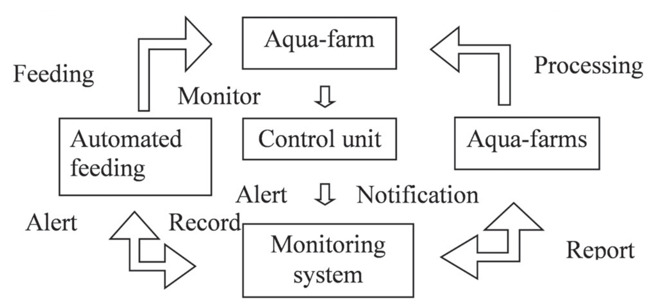


Fig. 6. Monitoring System

### 3.3 Production data module

The production data module tracks the product from breeding to transport and sale (Fig. 7). The source and destination of relevant products at each phase can be found through the module, allowing consumers to make educated decisions about purchasing products. Should problems, such as outdated or poor quality products arise, downstream companies or consumers can search the system for the product source using the identification tag, and identify the cause of the problem within a short period of time.

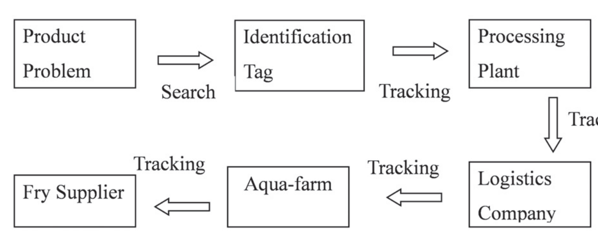


Fig. 7. Tracking product path

## Conclusion

Apart from helping aqua-farms conserve resources and improve quality, our aquaculture cloud management system allows consumers to understand the production process and make informed purchasing decisions. We hope our system will resolve the current lack of information transparency surrounding aquatic products and contribute to strong supply chain relationships, creating greater commercial opportunity and benefit for the aquaculture industry in Taiwan.

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