Construction of the Cloud Intelligent Control System for Logistics as Service (LaaS)

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***Abstract*— Over the past few years, information and communications technology has developed rapidly and has been applied in many industries. In particular, cloud data connectivity has been recognized as an essential competency of the 21st century. With the increasing need to have flexible working practices and immediate availability of information, data transfer tends to be based on cloud communication. Traditional logistic information systems (LISs) are often run on local servers, and users are constrained by place and time during executing logistic activities. Hence, logistics as a service (LaaS) has recently attracted a lot of attention. In this study, we propose a cloud-based intelligent control system (CICS) for logistics automation. This system consists of three parts: data-acquisition, supervisory control, and data visualization. It can be employed to manage production facilities and logistic activities of a retailer in order to increase LaaS efficiency.**

***Index Terms*—Logistics as a service, LaaS, cloud, data visualization, supervisory control**

I. Introduction

Recently, the rapid development of cloud infrastructures has caused many business owners to move from traditional information systems to cloud-based systems. For example, IBM reported that companies that adopt cloud-based solutions can double their revenue growth and achieve a 2.5 times higher profit than that of nonadopters. Gartner indicated that cloud-based logistics software can accurately trace and track shipments in real-time [1]. It is estimated that the adoption of such software increased in the logistics industry by 40% in 2017. However, logistic activities face the following two challenges: integration of diverse information and data processing. It was recognized that it is difficult to integrate information from different logistic information systems (LISs) in different countries because of the diversity of data formats. These complex but globally consistent retailer environments can be managed through a cloud infrastructure offering the logistics as a service (LaaS) technology.

The aim of this study is to enhance the efficiency of logistic operations. In particular, we developed a cloud-based intelligent control system (CICS) to enable an intelligent retail facility for retailer activities. This system provides real-time supervisory control and data-acquisition services to various stakeholders on demand. As these services are cloud-based, users can monitor information about their facilities at any time and any place. The goals of this study are as follows:

- To develop data-acquisition tools in order to obtain real-time data using the MQTT protocol.
- To process diverse data formats from different LISs and integrate logistic information from different branches around the world.
- To achieve real-time supervisory control and data visualization in order to enable timely decision-making.

II. Related Work

A. Retail Logistics

Originally, logistics used to refer to the need for planning the movement of large volumes of goods and ammunition to the location of army troops. Nowadays, it refers to the processes involved in the commodity flow from supply lines to customers. Retail logistics is the process of managing the flow of products or services from the supply source to the customer. Many researchers have indicated that logistics transformation is influenced by customer, service, and cost requirements, as well as retailer changes [2-3]. High customer satisfaction occurs when customers get the right products at the right place and time and in the right quantity. Retail logistics systems ensure the smooth flow of goods to customers through the efficient movement of logistics.

Owing to changes in the consumer's behavior, retail stores have been constructed widely and are kept open for 24 hours. Retailers provide different services to customers in their stores, such as coffee and warmer equipment, and offer online shopping delivery. Fig. 1 demonstrated that the different services are provided by retailer in the retail store. Maintaining equipment such as coffee and warmer machines affects the business revenue. Malfunctioning equipment cannot provide related services to the customers, and hence their requirements will not be satisfied. From the marketing viewpoint, different LISs lack an integration mechanism; the retailer needs to obtain the information required for maintenance from different systems. Hence, administrating the diverse facility equipment in the retail activities is a challenge for

Manuscript received March 8, 2019; revised November 8, 2019.

doi: 10.18178/joace.7.2.102-106

retailers. Improving the logistics accuracy and effectively managing the ever-increasing amount of retail equipment using cloud automated systems for e-commerce are considered a critical issue for retail logistic operation activities.

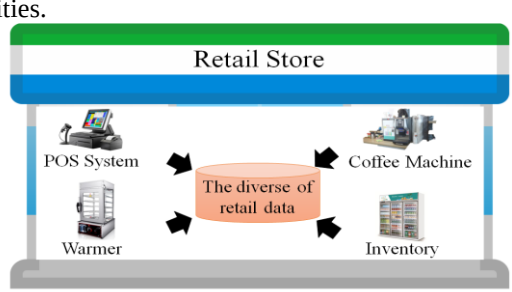

Figure 1. The diverse of retail information.

B. LaaS

The aim of LaaS is to develop prototypes of flexible and modular logistic IT services and infrastructures (see Fig. 2). These services are designed to provide comprehensive support ranging from design and planning to operational management of supply chains, as well as individual combinability in a cloud infrastructure [4]. LaaS has attracted significant attention from researchers and decision-makers in various organizations. Business analytics is another new trend that allows companies to obtain value from an increasingly massive amount of data and to gain a powerful competitive advantage [5-7]. Supply chain analytics (SCA), where business analytics is applied to supply chain management, is an IT-enabled, analytical, dynamic facility composed of supply chain performance management, data management, and analytical supply chain process capabilities [8]. It has been pointed out in previous studies that SCA is focused mainly on different supply chain perspectives and analyzing definitions [6]. In this study, the collected data can be utilized within a third-party analytic tool to perform SCA. The proposed system supports complete information flow from data collection to data visualization, offering an intelligent system for LaaS.

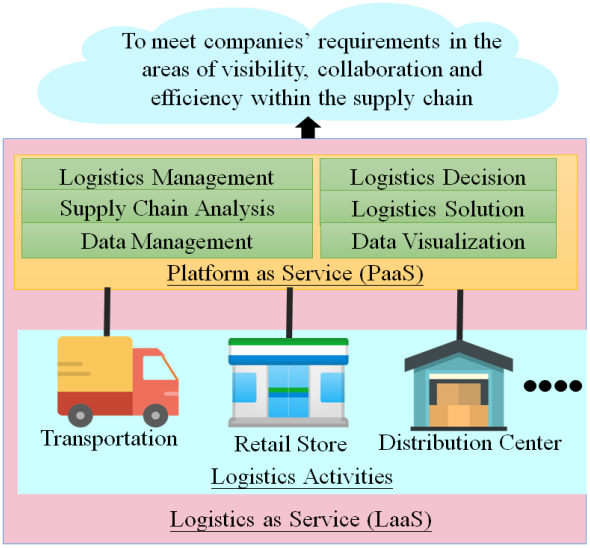

Figure 2. The framework of LaaS.

III. System Design

We developed the CICS, a LaaS solution for logistic operation activities, in order to meet the users' requirements in the areas of visibility, collaboration, and efficiency within retail logistics. CICS is an automatic cloud service that increases the efficiency of retail logistic activities and provides real-time visibility of significant data and events by leveraging extensive collaboration between all players in the network. The proposed system aims to manage the complexity and dynamics of logistic activities. The framework consists of a data-acquisition module, a supervisory control module, and a data visualization module. Fig. 3 showed the framework of the proposed system.

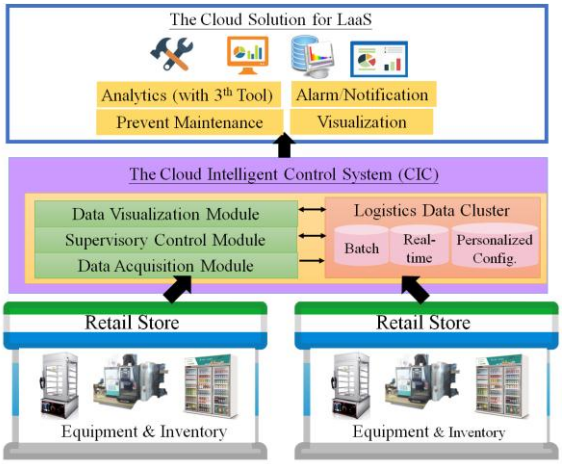

Figure 3. The framework of the proposed system.

A. Data Acquisition Module

Deficits of traditional LISs need to be addressed with new approaches to handle the increasing need for flexible and dynamic logistic operations. CICS supports personalized database maintenance services. Fig. 4 demonstrated the framework of the proposed module. Users can configure the database schema and data sources using a cloud infrastructure. The data-acquisition module can support two types of data: batch data and real-time data. The real-time data agent gets real-time data using the MQTT protocol. MQTT is an ISO standard messaging protocol (ISO/IEC PRF 20922) for using small sensors and mobile devices on top of TCP/IP. It can publish messages and offers a mechanism of topic-based filtering of messages for the connected broker. Each message must contain a topic that will be used by the broker to forward the message to interested clients subscribed to this topic. The batch data agent can automatically transfer data of different formats (e.g., CSV, JSON) in the specified format and match the processed data to a personalized data schema. The main characteristic of LaaS is individual combinability; the data-acquisition module provides a personalized data schema that can be configured by the users. Batch and real-time data from retail logistic activities with functionalities such as returns handling, promotions, and other value-added services can be imported into the personalized data schema.

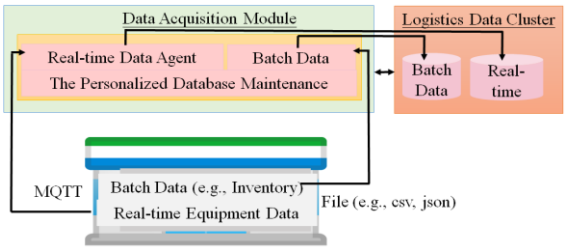

Figure 4. The framework of the data acquisition module

B. Supervisory Control Module

Logistics data supervisory control has become more important owing to the trends in globalization, leading to massive reallocation of production-related advantages. Fig. 5 demonstrated the supervisory control module. In the supervisory control module, the dashboard agent can integrate data as personalized information and display it in the system. The user can configure the data threshold values, and if a data value exceeds the threshold value, the system displays an alarm notification. The configuration agent applied the configured information in the personalized configuration database. If the data value excesses the threshold value, the alarm agent also displays the alarm notification for system and notifies the users. The proposed system is based on a cloud infrastructure. Logistic information from different branches around the world can be displayed on the dashboard of the supervisory control module.

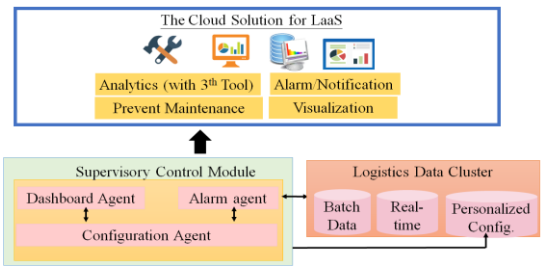

Figure 5. The framework of the supervisory control module.

C. Data Visualization Module

In this study, information can be displayed with different types of graphics. D3.js was used in the data visualization module, which supports data binding to a document object model and then applies data-driven transformations to the document [9]. D3.js can be used to create an interactive SVG bar chart with smooth transitions and interactions or to generate an HTML table from an array of numbers. It can also efficiently manipulate documents based on data. This avoids proprietary representations and affords extraordinary flexibility, exposing the full capabilities of web standards such as HTML, SVG, and CSS. With a minimal overhead, D3.js is extremely fast, supporting large datasets and dynamic behaviors for interaction and animation. Logistic data can be presented with a diversity of charts using D3.js. The chart selecting agent offer the diverse type of chart though using the D3.js. for user present the data. The visualization agent used the logistics data with the selected chart format (see Fig. 6).

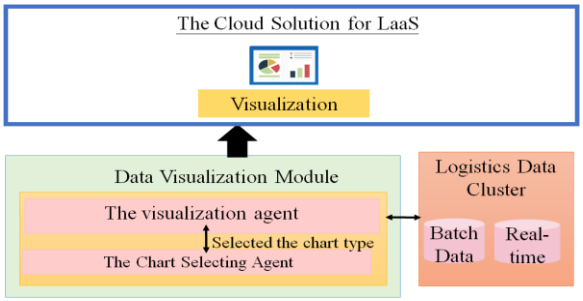

Figure 6. The framework of the data visualization module.

In summary, CICS includes the following two features:

- Visibility. This addresses the issues of data connectivity and communication in retail logistic activities. CICS, as the ultimate enabler for accessing and sharing information, is a platform for collaboration and integration between retailers, suppliers, equipment fixers, and service providers.
- Efficiency. This is responsible for operational optimization and real-time process control. The combination of cloud technologies enables control extension to all areas and users along retail logistic activities. The simplicity and usability of the proposed system together with the acquisition of structured or unstructured data enable effective and collaborative management of operations throughout retail logistic activities.

IV. Experiment

The proposed system was applied to simulated cases in order to demonstrate how it enables intelligent retail logistic activities. In this study, the node.js is employed to simulate the sensor data connectivity. Table I shows the attribute of the simulation data. As an example of this, consider the case of a retailer who has 10 branches in different countries. First, the users need to configure a personalized information schema or use an existing schema from a data source. They can also design a personalized LaaS solution with the defined input schema, a supervisory control method, and visualization. After data-acquisition module receive the simulated data, the automation procedure trigger. This case aims to prevent retail equipment anomalies in a retail store and to manage logistic information. The experiment includes the following three steps: data-acquisition, supervisory control, and data visualization. (see Fig. 7).

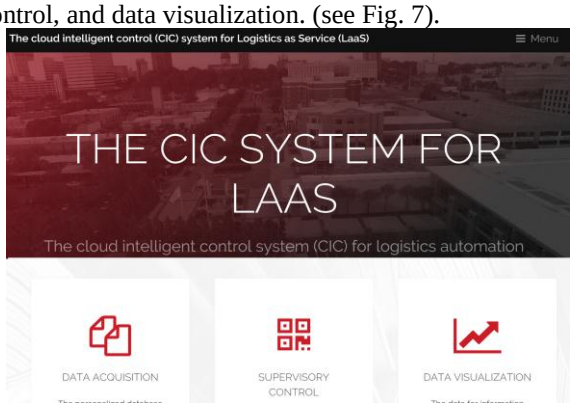

Figure 7. The user interface of the proposed system.

TABLE I. THE ATTRIBUTE OF SIMULATION DATA

Name	Description
Eqipment_ID	The unique identification of the equipment :Simulation Equipment A-H.
Eqipment_Temperature	The temperature of the equipment
Eqipment_Status	Normal, Fail, Stop
Product_ID	The unique identification of the product
Inventory_Location	The inventory location: Branch1, China/Branch2, Taiwan/ Branch3, US/ Branch4, China/ Branch5, Taiwan/ Branch6, US/ Branch7, China/ Branch8, Taiwan/ Branch9, Korean/ Branch10, UK
Inventory_Quantity	The quantity of inventory
Sales Volume	The volume of sales
Supplier	The supplier name
Telephone Number	The telephone number of supplier

A. *Data Acquisition Module*

The data-acquisition module offers a highly flexible configuration mechanism for the users to make a personalized acquisition solution. First, the users should choose a personalized information schema or apply an already existing one. Both batch and real-time data can be collected and stored in the CICS. For example, historical data, such as monthly inventory data, can be uploaded to the system using the data-acquisition module. The proposed module supports commonly accepted data types. Batch data with the specified format can be imported into the personalized database. Fig. 8 demonstrates how monthly data are being imported and displayed in the database. In addition, real-time data can be uploaded to the CICS using the MQTT protocol and can be saved to the personalized database.

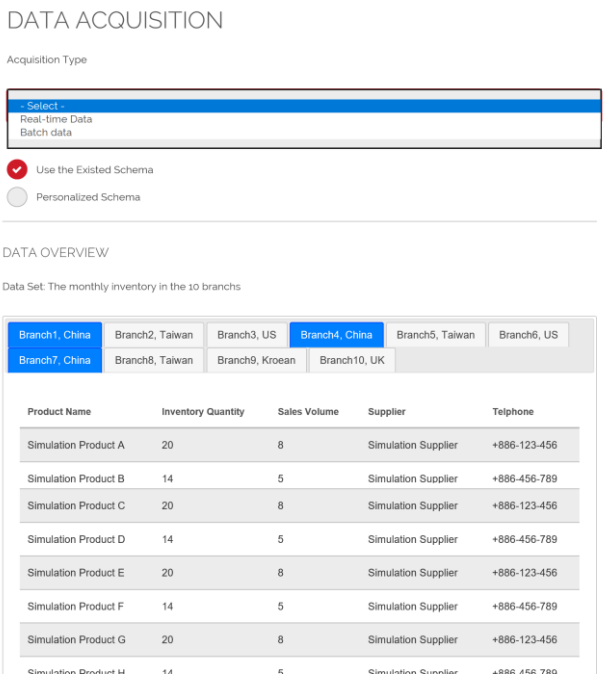

Figure 8. The result of the batch data acquisition

B. *Supervisory Control Module*

Personalized logistic data were applied in the supervisory control module. The users can configure the alarm threshold for a specific feature such as economic ordering quantity (EOQ) or equipment temperature. The proposed module also provides different types of management calculations (e.g., EOQ) for the users to manage their inventory during logistic activities. Fig. 9 shows a supervisory control dashboard of monthly inventory data and real-time equipment data. When a data value exceeds the threshold value, the proposed module sends an alarm message to the user.

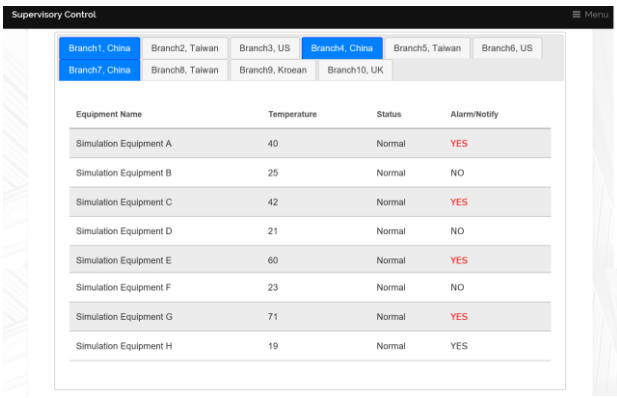

Figure 9. The real-time equipment supervisory control.

C. *Data Visualization Module*

CICS not only provides a supervisory control dashboard for the users to monitor the status of logistic activities but also offers a visualization tool to assist in business intelligence or decision-making. The data visualization tool includes many chart widgets, and the user can generate creative and colorful charts and build a personalized visualization dashboard. The data visualization module is dedicated to enhancing the users' graphic design and storytelling skills, while providing efficient decision support. Fig. 10 demonstrates the revenue data from the 10 retail branches.

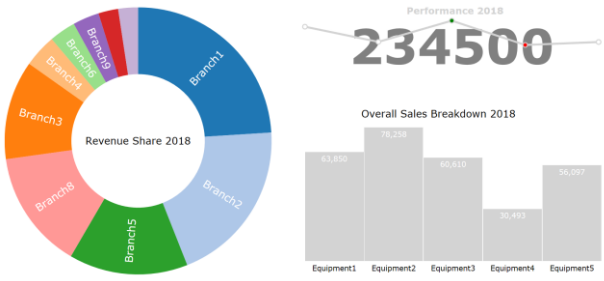

Figure 10. The data visualization for the 10 retail branches.

V. CONCLUSION AND DISCUSSION

In this paper, we proposed a control system, CICS that can provide a flexible and personalized solution for retailers to manage their logistic activities and assist in decision-making. For example, it can facilitate maintenance support to prevent equipment failures that may negatively affect the quality of customer service.

The study focused on the user-driven design, where each module was included as a personalized mechanism for various stages of data handling, from data-acquisition to its visualization. Third-party machine-learning tools can be additionally used for data analysis, whereas data visualization can be configured according to the complexity of logistic activities. Recently, there have been changes in consumer requirements and beliefs; the availability and high quality of a product is expected more than ever. Accordingly, logistics systems that get products from production through retailing to consumption should also be transformed. In the future, more logistic activity conditions will be considered, including capacity issues, real-time driver behaviors, carrier costs, and customer service demands.

ACKNOWLEDGMENT

This research is funded by the Ministry of Science and Technology (MOST), Taiwan, under Grant no. 108-2410-H-224-001-MY2. We thank the MOST Department of Humanities and Social Sciences for support.

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