Automated vending machine with IoT infrastructure for smart factory application

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Abstract. Vending Machine (VM) is a beverage that can operate in a standalone manner to serve beverage or snack purchase transactions. VM technology, especially in the development of the Internet and smart business, has progressed and easier for users, in this case, the seller, the buyer, and the developers. The Internet of Things (IoT) is a new technology paradigm envisioned as a global network of machines and devices capable of interacting with each other. The IoT is recognized as one of the most important areas of future technology and is gaining vast attention from a wide range of industries. The true value of the IoT for enterprises can be fully realized when connected devices can communicate with each other and integrate with vendor-managed inventory systems, customer support systems, business intelligence applications, and business analytics. This article offers a conceptual VM, the system design using e-money payment and online information management. Major components of the machine are, a scanner to take the input from users, large storage space to store the beverages and snacks, sensors to detect the motion, inventory monitoring system to keep track of the storage, and an inventory monitoring system.

1. Introduction

Vending Machine (VM) is a beverage VM that can operate in a standalone manner to serve beverage or snack purchase transactions [1]. VM requires exact change according to the price of products in doing its duty to provide the desired product by the buyer. It will be difficult if the buyer does not have the correct change. Research conducted by [2] and [3] proves a theory using Greedy algorithms, that refunds to buyers who purchase products with more money are feasible in the VM. VM technology, especially in the development of the Internet and smart business, has progressed and easier for users, in this case, the seller, the buyer, and the developers. Another research by [4] discusses an automatic medicine VM with a self-contained on-site pill dispensing mechanism and a storage facility for the plurality of pills that can be dispensed based on the user requirement. Moreover, The Finnish law obliges a store to refund the deposits on returned beverage containers if the store sells any beverages with a deposit. To process the large volume of returned containers, stores have automated the recycling by using reverse VM, which automatically determines the amount of refund and typically sort the containers based on their material [5]. The current lifestyle of humans is inseparable from the smartphone. This can provide other flexibility, especially opportunities in the field of research. Smartphones today not only a mere communication device but also support the needs of the human thirst for information. Besides, the importance of social connectedness remotely, even as a means of payment. With a smartphone in hand, humans can make payment transactions with e-money (virtual wallet), or by scanning a QR or barcode. Transactions that are running on a VM can also use a barcode scanner [5]. Whereas [4] made a design
regarding the mechanism of automatic pharmacies, or special drug VM. In this case, the development of an automatic payment system is very possible to be applied to the VM. [6] proposes the concept of community-based wireless IOT infrastructure using vending machines everywhere, as an innovative strategy to popularize the wireless IOT solution to a social problem in Japan.

Another new thing that will be done in this research is the management VM remotely or online. [1] also revealed that the existing conventional VM currently has a shortage, where the manager has not been able to have online information that can be accessed at any time. For example, the results of sales transactions, stocks of products stored on the machine, cooling machine conditions and others. This article discusses the application of smart factory infrastructure that utilizes the Internet of Things (IoT) technology with the design of the system that runs in it. VM design as an implementation of the smart factory application can make payments with e-money and can have an online information system making it easier to manage. The Internet of Things (IoT), also called the Internet of Everything or the Industrial Internet, is a new technology paradigm envisioned as a global network of machines and devices capable of interacting with each other. The IoT is recognized as one of the most important areas of future technology and is gaining vast attention from a wide range of industries. The true value of the IoT for enterprises can be fully realized when connected devices can communicate with each other and integrate with vendor-managed inventory systems, customer support systems, business intelligence applications, and business analytics. IoT applications need to be built with intelligence so devices can monitor the environment, identify problems, communicate with each other, and potentially resolve problems without the need for human intervention. Applications with IoT as a value-added benefit to enhance customer value by monitoring and control as a tool [7].

From the perspective of production, production logistics is an organic system that is responsible for the process of moving the physical state of the material, raw material purchasing, distribution, and flow together with the production cells, for the manufacture and storage [8].

Our contribution in this paper, we propose the logistics of production and data traffic by preserving privacy, availability and fair trade. This article offers a conceptual VM, the system design using e-money payment and online information management. The advantage of this infrastructure is to increase the practicality of the fair distribution of logistics and trade by utilizing a smart protocol that ensures the availability of trade data.

2. Theoretical background

2.1. System

The system is a collection of components that implement modeling requirements, functions, and interfaces [9]. In another meaning, a system is a group of interrelated components that function together to achieve the desired result [10]. A system has some characteristics and certain properties. It has components, system boundaries, outside the system environment, link, input, output, processing, and targets or goals [11]. First of all, the system component consists of interrelated components (a relationship exists between parts and the whole). Then, the boundaries of System Boundary are artificial: systems are components of another larger system. Afterward, systems can be opened (influenced by their environment) or closed (not influenced by their environment). Outside the system, the environment is whatever outside from the system boundaries which has some effect on the system operation. Thereafter, systems must have inputs, processes, outputs, and feedback loops. And last, a system has goals or objectives, if the system doesn't have a goal, then the system will be useless. The Input to the system and the output from the system is very determined by the goal or objective. A system is said to be successful when it has achieved the goals or objectives of information.

In human terms and the broadest sense, information is anything that you are capable of perceiving. This can include written communications, spoken communications, photographs, art, and music, nearly anything that is perceivable. This includes an enormous assortment of stimuli, but, realistically, everything you come in contact with is capable of providing and does provide you with some sort of information [12].
Information technology is a contemporary that describes the combination of computer technology with telecommunications technology (data, image, and voice networks) [10]. Information system an arrangement of people, data, processes, and information technology (IT) that interact to collect, process, store, and provide as output the information needed to support an organization.

2.2. Application
The application sometimes called a program that is a series of instructions that the hardware executes one after another [6]. In information technology, an application is the use of technology, system, or product. The term application is a shorter form of an application program. An application program is a program designed to perform a specific function directly for the user or, in some cases, for another application program. Examples of applications include word processors, database programs, Web browsers, development tools, drawing, paint, image editing programs, and communication programs. Applications use the services of the computer's operating system and other supporting applications. Information system design is defined as those tasks that focus on the specification of a detailed computer-based solution. It is also called physical design. Thus, whereas systems analysis emphasized the business problem, system design focuses on the technical or implementation concerns of the system [12].

System modeling shows how the system should be working. Use this technique to examine how various components work together to produce a particular outcome. These components make up a system, which is comprised of resources processed in various ways (counseling, diagnosis, treatment) to generate direct outputs (products or services), which in turn can produce both direct effects [13].

2.3. Internet of Thing (IoT)
The idea of a smart factory that can communicate all the machines in forming a new type of manufacturing industry has emerged. The concept of smart factories is emerging as an extended method of operating factories technologically by integrating ICT (Information Communication Technology) technology into manufacturing industries. At this time, IoT (Internet of Things) is a key factor connecting all the machines. However, in a small-sized company, a smart factory is configured according to a manufacturing environment, and a general company that manages actual data needs to centrally manage all data. At this time, there is a need for a new type of cloud that can be used both by the Smart Factory and the general company [14]. In addition to manufacturers’ adoption of the IoT, various service industries are in the process of adopting the IoT to increase revenue through enhanced services and become leaders in their markets. The adoption of this technology is rapidly gaining momentum as technological, societal, and competitive pressures push firms to innovate and transform themselves. As IoT technology advances and increasing numbers of firms adopt the technology, IoT cost-benefit analysis will become a subject of great interest. Because of the potential but uncertain benefits and high investment costs of the IoT, firms need to carefully assess every IoT induced opportunity and challenge to ensure that their resources are spent judiciously [7]. One form of realization of this concept is the intelligent manufacturing system (IMS), which is considered to be the next-generation manufacturing system that is obtained by adopting new models, new forms, and new methodologies to transform the traditional manufacturing system into a smart system. Therefore, on-demand use and efficient sharing of resources can be enabled by the application of IoT technologies in manufacturing. The IoT is considered to be a modern manufacturing concept under Industry 4.0 and has adopted recent advances, such as cutting-edge information technology (IT) infrastructure for data acquisition and sharing, which greatly influence the performance of a manufacturing system [15].

3. Design
In this section, the application is designed using the Unified Modelling Language (UML). This is done to facilitate to provide a preliminary sketch of applications, in addition to the use of UML is more suitable for use in designing an object-oriented application. Designing applications that the authors did use UML tools include design use case and activity diagram. A use case diagram in the Unified
Modelling Language (UML) is a type of behavioral diagram defined by and created from a use case analysis. The main purpose of a use case diagram is to show what system functions are performed for which actors. The roles of the actors in the system can be depicted. This research is designed to make the Customization of VM namely payment using QR / barcode scanning from a virtual wallet, and the transaction information system of the VM in real-time and online. Figure 1 shows the use case diagram in the Automated VM.

**Figure 1. Automated VM Use Case Diagram**

In the picture, all parties are considered important in terms of the seller, buyer, and administrator. The buyer side, in which case demand-side management is an important function in the management of the future smart factory, which provides support towards smart factory functionalities in various areas such as electricity market control, management, and infrastructure construction. It is based on customers' behavior that is modeled by a decision-making chain, and smart appliances' use for demand-side management. Smart appliance interface modeling with data and signal inputs and outputs are given. Then UML allows us to obtain a Java bone code for proposed architecture and then customer behavior is modeled using the decision-making chain. Activity diagrams describe the workflow behavior of a system. Activity diagrams are similar to state diagrams because activities are the state of doing something. The diagrams describe the state of activities by showing the sequence of activities performed. Activity diagrams can show activities that are conditional or parallel. Here in Figure 2 shows the activity diagram for the use case model.
Major components of the machine are, a scanner to take the input from a user, large storage space to store the beverages and snacks, sensors to detect the motion, and inventory monitoring system to keep track of the storage, and industrial standard vertical foam fill machine to pack it separately and a non-contact laser inkjet printer to print the receipt which includes the time at which the beverages and snacks must be taken. The inventory monitoring system also keeps track of the expiry date of each beverage and snacks and sends alerts to refill the storage when it runs out. It also holds an inbuilt system to receive money from the user. All these systems are monitored by a central microprocessor, which is programmed to receive input from the user via the scanner and to actuate and control all the necessary components required to dispense the medication requested by the user. The machine can be viewed as an automated VM placed on a commercial scale so that the infinite number of users will be able to access it anytime.

4. Future developments and scope of the invention
We proposed the concept of a community-based wireless IoT infrastructure using ubiquitous vending machines. For the next research, it could be shown the design applying the concept to the real vending machines as well as the estimation of the coverage. The working scope of afore-described vending machines can be further improved by expanding the database adding more functionality. Then, to avoid
interruption of power outages, a vending machine can be connected to the UPS it can perform its function. Because the internet is a public communication media, it is important to pay attention to data security issues in reducing fraud. A simple example is encrypting data before sending over the internet. On the receiver side, the encrypted data will be decrypted first to get the real data.

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