Development of User Interface for Cyber Physical System (CPS) Integrated With Material Handling System

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ABSTRACT – Cyber-physical system (CPS) is one of the key technologies of Industry 4.0. CPS is a crossing system structure between physical and software component to enable different component to exchange information. The existing open platform communication (OPC) has enabled researchers to communicate between programmable logic controller (PLC) and simulation software, thus becoming the based structure for CPS. To interact with the physical system, a user interface was developed. It can control a dedicated material handling system. Hence, the objective of this investigation is to develop a user interface that will improve the performance and capabilities of the system.

1. INTRODUCTION

Cyber-Physical System (CPS) is one of the key technologies of Industry 4.0. It is a technology that incorporate physical assets and computational entities [1-2] by bridging technologies, disciplines and domains. It also enables full control, sensing and computing for any logical control of manufacturing systems.

CPS can record physical information through sensors. It will then evaluate the information gathered to affect or react to physical processes such as actuators. For reliable communication, the CPS is connected through network either wireless or wired [3].

At the early stage of CPS initiation, a prototype architecture for CPS was proposed by Tan [4]. The research discusses on the gap of embedded system that lack public or private communication for the system to subscribe to the data in which it can limit the large-scale system. Moreover, the embedded system is an isolated system and the simulation of a complex system is time consuming, expensive and error prone. A prototype architecture of CPS was proposed by synchronizing the global reference time, event driven and subscribing data to meet the requirement and characteristic of CPS.

On the other hand, another CPS architecture for industry 4.0 had been proposed by Jay Lee [1]. The architecture is based on the 5C architecture which consist of smart connection, data to information conversion, cyber, cognition, and configuration level. Jiang [5] then improve 5C architecture by adding coalition, customer and content and become 8C architecture which is to be referred by CPS researchers.

In real environment, CPS can be realised by establishing communication between programmable logic controller (PLC) or input/output module, plant simulation system software and open platform communication (OPC). PLC is a physical machine controller that is mostly used in manufacturing line. Plant simulation software is the control system that compute data and control logic of CPS. OPC enable data access between plant simulation software and PLC system [6]. The existence of OPC creates transparency in data exchange among different entities. The integration between PLC, OPC and simulation software needs to be extended by creating user interface to allow user to be able to interact with the physical system. Thus, the objective of this paper is to develop a user interface for material handling system. This paper will explain the proposed architecture in methodology and development of user interface in results and discussion.

2. METHODOLOGY

The base structure of a CPS is based on Figure 1. It shows the relationship between physical component and computational system bridging by OPC.

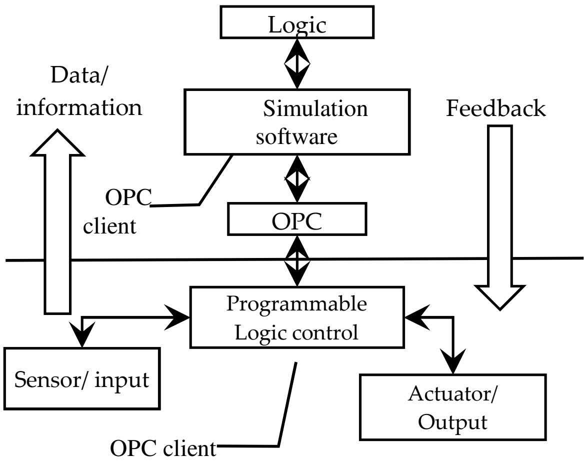

Figure 1: Base structure for automation CPS for material handling system equipment

A user interface is needed to control the physical system of the material handling system. Therefore, a user interface has been developed and integrated in the simulation software. The simulation software that had been used in this study is a plant simulation software (Tecnomatix) which can communicate with the physical system. It uses Simtalk programming language [7-8] for communication.

The main purpose of implementing CPS on material handling system is for identifying objects or materials upon arrival, for automatic routing and for intelligent decision-making system. The development of the user interface is based on production of 5 product with different station sequence.

The material handling system that was used in this study is a conveyor system that consist of shuttles as the carriers. The carrier or shuttle itself can be identified and re-identified using intelligent routing module (IRM), which is connected to PLC through serial communication.

3. RESULTS AND DISCUSSION

The user interface was developed in Tecnomatix simulation software using both Simtalk 1.0 and 2.0. User interface developed is the evidence of the capabilities from cyber physical system architecture that been proposed.

A case was created so it can support product order. A different product was created based on different path in which the shuttles travel. There are 3 stations and 5 different paths in this simulation. 5 different paths will travel the station in different sequence. The order list of items will also go through the first station shuttle arrived where all the shuttles will be renamed based on the order. Similarly, in the simulation, the carrier or transporter will be renamed based on the product.

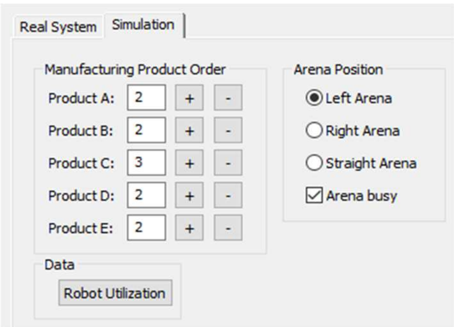

Figure 2: Simulation user interface

Figure 2 shows the user interface in simulation environment. In the simulation environment, there are input boxes for Manufacturing Product Order and conveyor control. In the arena position group, it will show the position of conveyor path during the simulation activity where it will return the value of conveyor path position to the user interface. Arena is the path controller for the conveyor system used in this project. In addition, the Manufacturing Product Order group is for controlling and storing order information. For example, the "+" and "-" signs are for increasing or decreasing order. Nevertheless, the order of the product can also be input manually. During operation, Station 1 will refer to the keyed-in value at the user interface. As the order passed by, the last station will decrease the number of order. The sequence will then continue until all the products order is finished. Priority also can be set to suit the requirement in the system. Finally, shuttle will stop at Station 1 if there is no more order to execute.

In real system, the user interface was created to monitor the position of shuttles, conveyor control and data presentation. In IRM ID group shown in Figure 3, the ID of a shuttle will be shown at each station as IRM1 to IRM3 which represent station 1 to station 3 respectively. Meanwhile, the Control interface can control the conveyor manually without control logic in case of emergency. Moreover, IRM status shows the status of shuttle either it goes or stop at station.

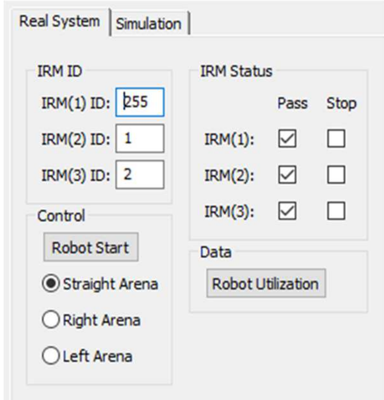

Figure 3: Real system user interface

4. CONCLUSIONS

In conclusions, the development of user interface for CPS at material handling system improve the control abilities of conveyor system. From the user interface, the system can be controlled effectively. The user interface can also show the data collection activities in both the simulation and real system environments. Additionally, there will be numerous functions that can be created at the user interface to suit the requirement of the system.

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REFERENCES

[1] J. Lee, B. Bagheri, and H.A. Kao, *Manufacturing Letters,* vol. 3, pp. 18-23, 2015.

[2] L. Monostori, B. Kadar, T. Bauernhansl, S. Kondoh, S. Kumara, G. Reinhart, O. Sauer, G. Schuh, W. Sihn, and K. Ueda, *Manufacturing Technology,* no. 65, pp. 621-641, 2016.

[3] S.A. Haque, S.M. Aziz, and M. Rahman, *International Journal of Distributed Sensor Networks,* vol. 10, no. 4, pp. 1-20, 2014.

[4] Y. Tan, S. Goddard, and L.C. Perez, *Deeply embedded real-time computing,* vol. 5, no. 26, pp. 1-2, 2008,

[5] J. Jiang, *Proceedings IEEE International Conference on Applied System Innovation (ICASI),* 2017, pp. 918-920.

[6] I. Gonzalez, A.J. Calderon, A.J.B. Pina, J.M.A. Marquez, *Sensors*, vol. 17, no. 7, pp. 1-26, 2017.

[7] S. Bangsow, *Manufacturing Simulation with Plant Simulation and SimTalk,* 1st ed. Verlag Berlin Heidelberg: Springer; 2010.