Implementation of Task Routing on SCADA-Based Modular Production System Using Topkapi Vision Software

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Keywords: Supervisory Control Theory, Task Routing System, Modular Production System, Topkapi Vision.

Abstract: Task Routing System (TRS) applies a series of routes created on the station module in carrying out products to work efficiently in terms of time and safe operation. The system creates to know the value of process time and the level of security when simulating a production line on MPS. The station module on this system is a Modular Production System (MPS) that works with sub-module stations with different interfaces and controls production simulations. The test results consist of 4 routes. The first route, testing – pick & place - handling - storing - separating obtained an average time of 507.3 seconds and had 1 unsafe condition. A second route, testing - handling - storing - separating - pick & place gets an average time of 481.6 seconds and had 2 unsafe conditions. A third route, testing - storing - separating - pick & place - handling got an average time of 434.3 seconds and had 3 unsafe conditions. A fourth route, testing – pick & place - storing - separating - handling takes an average time of 443.3 seconds and had no unsafe conditions. So the recommendation of task routing on the MPS station used is on route 4.

1 INTRODUCTION

The application of technology has been widely applied in the industrial field, but there are still those who use simple or conventional technology so it requires a lot of energy, takes a lot of time and the results are limited (Setiawan, 2012). Then the development of technology in the industry at this time is so fast and followed by an increasingly high level of competition. One of the technologies that are progressing is automation technology. The development of automation systems aims able to guarantee the quality of products produced, reduce production time, and reduce costs for human labour so that the demands of the production process more quickly and efficiently can be achieved (Mandala et al., 2015). One of the automation technologies used by most industries is the Supervisory Control System and Data Acquisition (SCADA) (Roop, 2016).

SCADA systems can increase production and make it easier for operators to monitor and control directly in real-time against ongoing processes (Carmona et al., 2016).

The application of SCADA systems in conducting control and surveillance systems can be used for automated manufacturing systems, one of which is in Modular Production Systems (MPS) as a prototype used in education for production simulation (Diogo et al., 2008). For the application of the system on MPS, it is necessary to know how the production system is carried out so it is important to follow the methods that allow the integration of all areas involved in the production process on MPS (Scotti et al., 2015). The purpose of this method is to avoid a production process that is not properly monitored which will hinder the production process (Nugroho, 2015).

The development of automation technology becomes a change in the manufacturing system used in the industrial field because of the many variations in consumer demand for a different product so that it takes technology that can run with different workflows automatically in increasing efficiency and high productivity (Subakti, 2003). Flexible Manufacturing Systems (FMS) is generally considered the answer to building flexibility and speed in a production system. These two things are

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needed so that the production system can produce products that vary according to customers' wishes quickly. This application is an example of a production system where the concept of automation is applied in different workflows (Pakpahan et al., 2019).

In the application of production to MPS, many stages of product manufacturing work process stations that allow for diversity of products to be carried out when sorting products that will take a lot of time and human manpower so that the process is made with a series of routing tasks to optimize and analyze the production flow process based on different station standard specifications, to adjust production capacity and functionality efficiently so that the process is made with a series of routing tasks to optimize and analyze the production flow process based on different station standard specifications, to adjust production capacity and functionality efficiently (Rogers & Bottaci, 1997).

Task Routing Systems (TRS) on MPS is integrated with surveillance control systems to properly monitor and execute production machines. These control systems are usually implemented by a programmable logic controller (PLC), which is monitored and controlled by the SCADA (Supervisory Control and Data Acquisition) system to maintain security in the observed production process (Automation, 2001).

Then from the above can be done research by integrating the implementation of task routing or Task Routing System on Modular Production System as a field level of a plan which is then controlled and monitored using SCADA system using Topkapi vision software to monitor the system.

2 METHOD

The research method in this study refers to the Supervisory Control Theory (SCT) method (Lopes et al., 2016). Supervisory Control Theory (SCT) is the theory of a framework on a system for synthesizing controlling elements, and then carrying out supervision called supervisors. This method is used to be able to test the implementation of task routing on SCADA-based MPS. In addition, the purpose of this method is to avoid a production process that is not properly monitored which will hinder the production process (Nugroho, 2015).

2.1 Modular Production Systems

In this stage, an understanding of the basic theories related to the system is to be tested, namely in the form of descriptions of plants, working functions on plants and plant flowcharts (Scotti et al., 2015). This information facilitates the analysis and understanding of systems and provides the basis for the system modelling stage.

Table 1: Software & Hardware.

No	Specification	
	Device	Specification
1	Software	- TIA PORTAL V13 - Topkapi Vision V5.1 - KepserverEX V6.6
2	Hardware	- 1 Personal Computer (PC) - 5 Power Supply 24V - 3 PLC Siemens S7-1200 - 2 PLC Siemens S7-300 - Festo MPS® Unit - 1 Router TP-Link - 5 Ethernet

2.1.1 Testing Station

MPS Testing Station in Figure 1 serves to identify the characteristics of the object inputted to then be sorted automatically using a diffuse colour sensor that detects the difference in the colour of the object (Ebel & Pany, 2006).

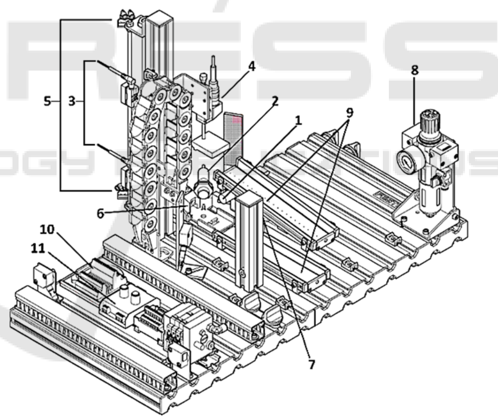


Figure 1: Sensor and actuator on Testing Station.

Table 2: Testing Station Specification.

No.	Specification	Type
1	Capacitive Proximity Sensor	Sensor
2	Optical Proximity Sensor	
3	Inductive Proximity Sensor	
4	Analogue Sensor	
5	Lifting Cylinder	Actuator
6	Ejecting Cylinder	
7	Air Cushion	
8	Pneumatic Supply	Additional Part
9	Slide module	
10	I/O Terminal	
11	Comparator	

2.1.2 Pick and Place Station

MPS Pick & Place Station serves to provide accessories to the workpiece to be placed by holding the workpiece using a holding plate and detected by infrared proximity sensors and then given accessories that have been smoked by vacuum and placed on the workpiece, both red, black and silver workpieces (Didactic, 2016).

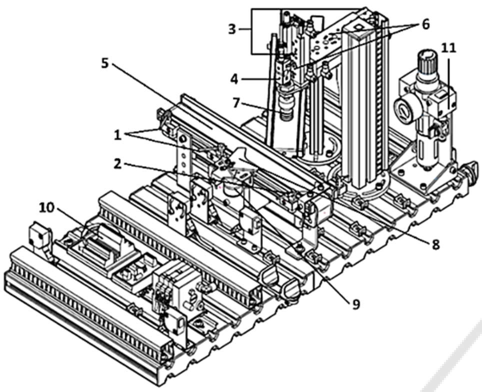


Figure 2: Sensor and actuator on Pick & Place Station.

Table 3: Pick and Place Specification.

No.	Specification	Type
1	Optical Diffuse Sensor	Sensor
2	Optical Proximity Sensor (Through Beam)	
3	Inductive Proximity Sensor	
4	Pressure Switch sensor	
5	Conveyor Belt	Actuator
6	Linear Drive 2 Axis	
7	Suction Cup	
8	Separator Valve Block	
9	DC Gear Motor	Additional Part
10	I/O Terminal	
11	Pneumatic Supply	

2.1.3 Handling Station

MPS Handling station (handling) is a sub-function of a material flow. Additional sub-functions are the transfer process and storage process. Referring to the VDI 2860 standard, a handling station is a process of drafting, defined as changing or temporarily placing an object in a predetermined layout (Ebel & Pany, 2006). Functions on the handling station are as follows: Determine the material characteristics of an item, Move work objects from the original place, Move workpieces based on metallic (red) or black and Move the workpiece to the next station.

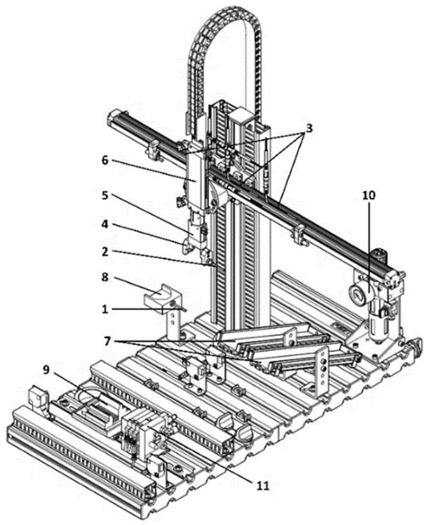


Figure 3: Sensor and Actuator on Handling Station.

Table 4: Handling Station Specification.

No.	Specification	Type
1	Optical Diffuse Sensor	Sensor
2	Fibre-Optic Sensor	
3	Inductive Proximity Sensor	
4	Pneumatic Gripper	Actuator
5	Linear Flat Cylinder	
6	Lifting Cylinder	
7	Slide Module	Additional Part
8	Receptacle Module	
9	I/O Terminal	
10	Pneumatic Supply	
11	Valve Terminal	

2.1.4 Storing Station

MPS Storing station serves to sort and separate workpieces based on the colour of the workpiece. This is because there is a colour sensor that will be active if it detects the workpiece according to the colour detected (Ebel & Pany, 2006).

Table 5: Storing Station Specification.

No.	Specification	Type
1	Optical Diffuse Sensor	Sensor
2	Colour Diffuse Sensor	
3	Inductive Proximity Sensor	
4	Linear Drive Axis	Actuator
5	Rotary Drive Servo Motor	
6	Storage Module	
7	Pneumatic Gripper	
8	Pneumatic Supply	Additional Part
9	Rack Module	
10	Holder Module	
11	I/O Terminal	

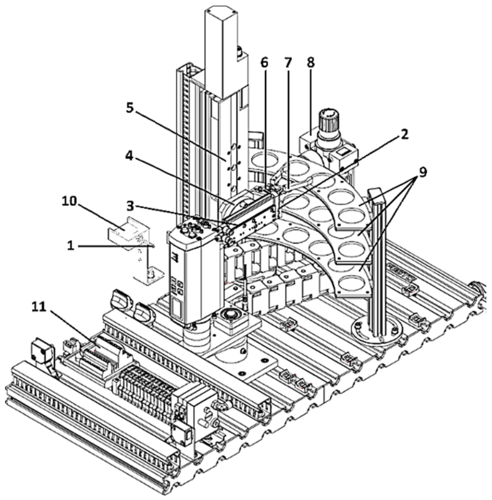


Figure 4: Sensor and Actuator on Storing Station.

2.1.5 Separating Station

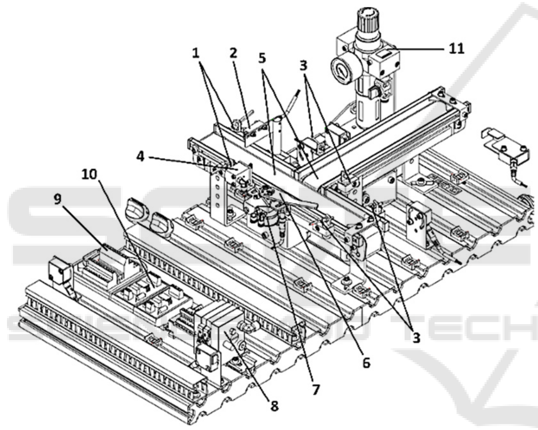


Figure 5: Sensor and Actuator on Separating Station.

MPS Separating station serves to separate or sort workpieces made of metal and non-metallic ones. This is because there is a proximity sensor that will be active if it detects a workpiece made of metal, and then will activate the separator (in the form of a slab that is moved with pneumatic) (Ebel & Pany, 2006).

Table 6: Separating Station Specification.

No.	Specification	Type
1	Optical Diffuse Sensor	Sensor
2	Inductive Proximity Sensor	
3	Optical ProximitySensor (Through Beam)	
4	Pneumatic Stopper	Actuator
5	Conveyor Belt	
6	Swiveling Wing	
7	DC Gear Motor	Additional Part
8	Valve Terminal	
9	I/O Terminal	
10	Analog Terminal	
11	Pneumatic Supply	

2.2 Configuration of Communication System

The method of data collection that will be done is to look at the results of sampling the incoming data in the Topkapi Vision software when the process is running and completed.

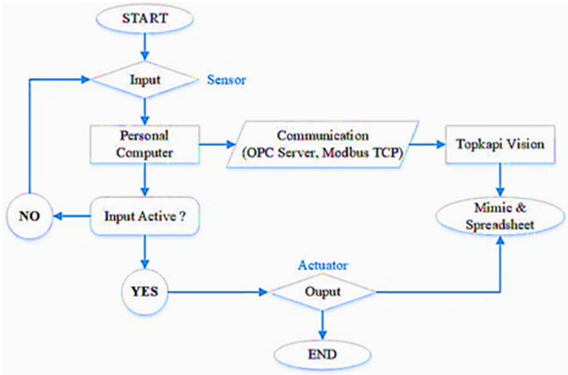


Figure 6: Communication System.

When the initial input is provided by the button, both in the PLC and in HMI, the system will run and the value in the form of the digital data type will go to the PLC and HMI through the communication of data that has been connected. HMI on Topkapi vision sampling data when receiving output results from sensors and actuators on the plant and then stored in the database on Topkapi Vision to get the data needed in this study, namely processing time at MPS.

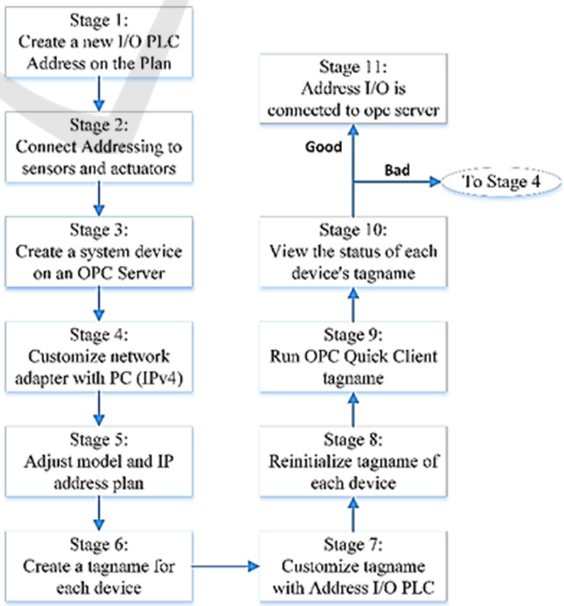


Figure 7: Flow of OPC Server Communication.

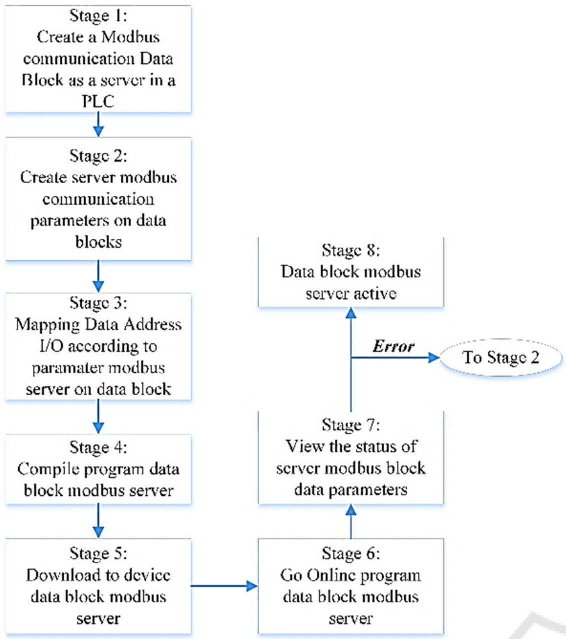


Figure 8: Flow of Modbus TCP Communication.

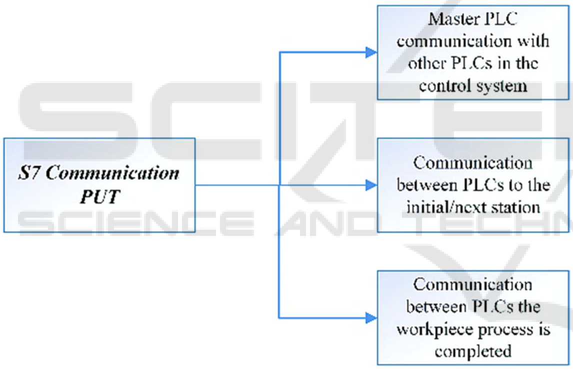


Figure 9: S7-Communication PUT.

2.2.1 Implementation of SCADA System

Implementation of SCADA SystemPerform SCADA systems by monitoring the operator control system and monitored on PCs using Topkapi Vision to run the system on modular production systems. Implements the entire SCADA system on elements in the modular production system, by building a control system on Topkapi vision software for PLC through an OPC server intermediary for MPS modules: Testing station, Pick&Place station, Storing station, Separating station, and Handling station. after implementing the entire SCADA system, then running the entire SCADA system on a modular production system.

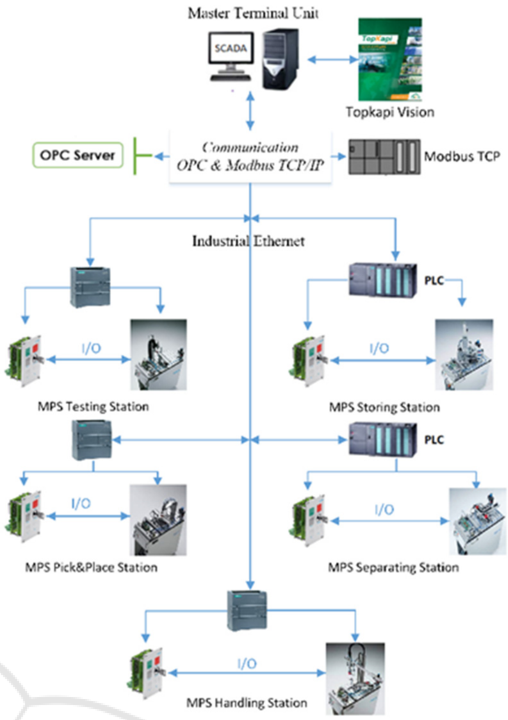


Figure 10: SCADA Architecture.

2.2.2 Implementation Task Routing System

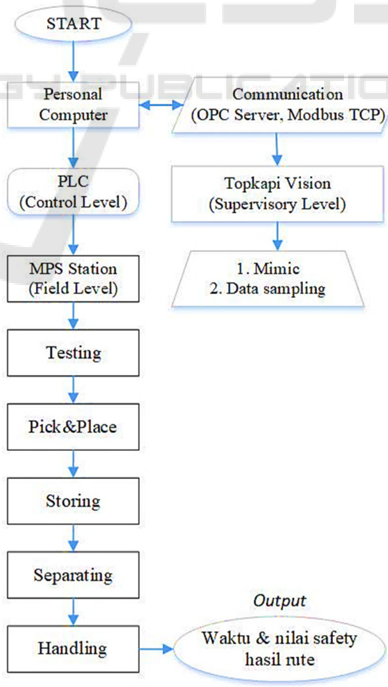


Figure 11: Task Routing System Flow Diagram.

In the implementation of the task routing system, there are 5 stations in sequence according to the layout of MPS station modules, namely testing stations, pick&place stations, handling stations, storing stations and separating stations. On this route, there will be a process of simulating the production of workpieces in sequence by conducting communication between PLC level control and monitoring of SCADA systems. Then the results will be obtained time during the process of simulating the production of workpieces as well as security in carrying out task routing.

3 RESULTS

This section shows the results of research that has been made before

3.1 Protocol Communication System with Topkapi Vision

Data from the study showed the results of input/output PLC addressing communication connected to sensors and actuators in the Modular Production System as well as the name of the sensor and actuator name based on the model and specifications from the station to the SCADA Topkapi Vision software.

3.2 Visualization of SCADA System Interface on Topkapi Vision

In the visualization of the control interface station, there are inputs and output signal values on each station. Each station has its controls. In the control station, there is also a centralized control as a master on all stations, namely SCADA system control that will control all stations in integration at each station.

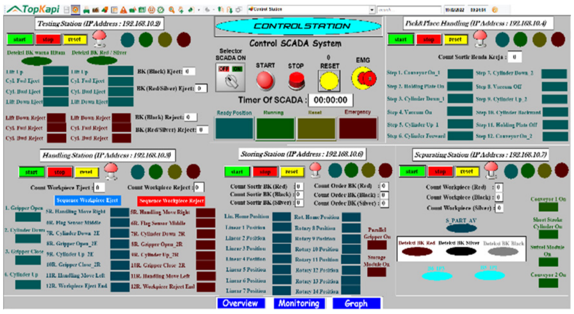
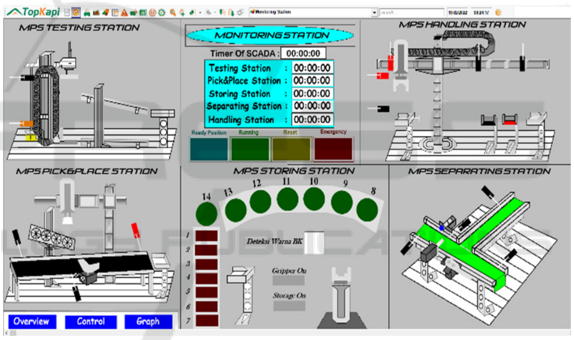


Figure 12: Visualization of control station interface.

In the visualization of the monitoring station interface, there is visual image modelling on each station. Each station will be monitored through visual image modelling that has been created at the monitoring station. Visual images at this monitoring station will later change the signal value when doing work processes or the production of workpieces.



Nama	PLC	KepserverEX		Topkapi Vision	
	Address	Tagname	Address	Tagname	Address
Infrared Sensor (PART_AV)	%I0.0	2Infrared_PART_AV	I0.0	2INFRPART AV	Separating 2Infrared_PART_AV
Proximity Sensor (B3)	%I0.1	2Proximity_B3	I0.1	2PROXB3	Separating 2Proximity_B3
Proximity Sensor	%I0.2	2Proximity Inductive	I0.2	2PROXINDUCT	Separating 2Proximity_Inductive
Proximity Sensor (B5) (NC)	%I0.4	2Proximity_B5	I0.4	2PROXB5	Separating 2Proximity_B5
Proximity Sensor (B6 IP3) (NC)	%I0.5	2Proximity_B6_IP3	I0.5	2PROXB6IP3	Separating 2Proximity_B6_IP3
Fibre Optic Sensor (B7 IP2)	%I0.6	2Fibre Optic_B7_IP2	I0.6	2FIBOPTB7IP2	Separating 2Fibre_Optic_B7_IP2
Pushbutton Start	%I1.0	1START Sepa	I1.0	1START SEPA	Separating 1START Sepa

Figure 14: OPC Server Addressing.

Nama	*PLC*	*MB SERVER*	*Topkapi Vision*		
	Address	Address	Tagname	Address	Object Type
Pushbutton Emergency	%M4.1	%DB9.DBW0	1EMGTEST	0	Logic, bit of word
Pushbutton Reset	%I1.5	%DB9.DBW2	1RESETTEST	1	Logic, bit of word
Pushbuton Stop (NC)	%I0.7	%DB9.DBW4	1STOPTEST	2	Logic, bit of word
Pushbutton Start	%I0.6	%DB9.DBW6	1STARTTEST	3	Logic, bit of word
Capacitive Proximity Sensor (PART_AV)	%I0.0	%DB9.DBW8	2PARTAVTEST	4	Logic, bit of word
Optical Proximity Sensor (B4)	%I0.1	%DB9.DBW10	2B4TEST	5	Logic, bit of word
Analogue Sensor (B5)	%I0.3	%DB9.DBW12	2B5TEST	6	Logic, bit of word

Figure 15: Separating Station Specification.

3.3 Control System Testing

This test aims to find efficient time value as well as security on the MPS station route during the process.

3.3.1 Task Routing Route-1

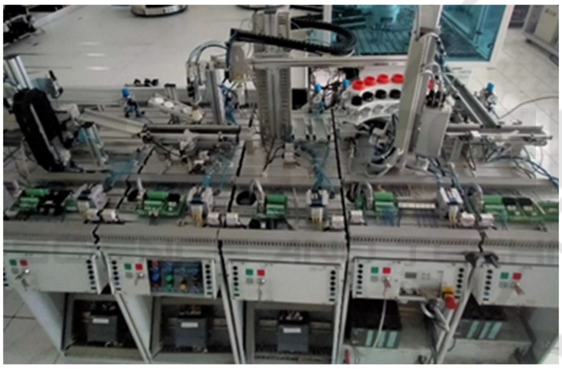


Figure 16: Task routing system route 1.

TRS route 1 test result on MPS station with the order of station module layout: Testing – Pick&Place – Handling – Storing – Separating.

Table 7: Result Route 1.

Result experiment	Process Time	
	SCADA integration mode	Unsafe
1st	508 s	1 condition
2nd	508 s	
3rd	506 s	
Average	**507,3s**	

The table above is a comparison of testing on the route 1 task routing process with an average process time value of 507.3 seconds.

3.3.2 Task Routing Route-2

TRS route 2 test results on MPS station with the order of station module layout: Testing – Handling – Storing – Separating – Pick&Place.

Table 8: Result Route 2.

Result experiment	Process time	
	SCADA integration mode	Unsafe
1st	484 s	2 condition
2nd	482 s	
3rd	479 s	
Average	**481,6 s**	

The table above is a comparison of tests on the task routing process route 2nd with an average process time value of 481.6 seconds.

3.3.3 Task Routing Route-3

TRS route 3 test results on MPS station with the order of station module layout: Testing – Storing – Separating – Pick&Place – Handling.

Table 9: Result Route 3.

Result experiment	Process time	
	SCADA integration mode	Unsafe
1st	431 s	1 condition
2nd	435 s	
3rd	437 s	
Average	434,3 s	

The table above is a comparison of tests on the 3rd route routing task process with an average process time value of 434.3 seconds.

3.3.4 Task Routing Route-4

TRS route 4 test results on MPS station with the order of station module layout: Testing – Pick&Place Storing – Separating – Handling.

Table 10: Result Route 3.

Result experiment	Process time	
	SCADA integration mode	Unsafe
1st	431 s	1 condition
2nd	435 s	
3rd	437 s	
Average	434,3 s	

The table above is a comparison of testing on the 4th route routing task process with an average process time value of 443.3 seconds.

3.4 Task Routing Test

Table 11: Result Route.

System Task Routing	Process time (Average)	Unsafe
	SCADA integration mode	
Route 1st	507,3 s	1
Route 2nd	481,6 s	2
Route 3rd	437 s	1
Route 4th	443,3 s	0

The table above shows the process time value and the non-safety value on each route in the task routing system. The route that has a more efficient time value is the route 3 task routing system with an average process time of 443.3 seconds.

4 CONCLUSIONS

In this study, it can be known which MPS layout sequence is safe and efficient in terms of time implementation of Task Routing on Modular Production System based SCADA using Topkapi Vision software, the result is that the route 4 task routing system has a good efficiency time value of 443.3 seconds and is safe for production simulation, which is 100%.

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REFERENCES

Automation, I. S. of. (2001). *Enterprise Control System Integration Part 2 : Object Model Attributes*.

Carmona, J. A. R., Benítez, J. C. M., & Garćia-Gervacio, J. L. (2016). SCADA system design: A proposal for optimizing a production line. *2016 International Conference on Electronics, Communications and Computers, CONIELECOMP 2016*, 192–197. https://doi.org/10.1109/CONIELECOMP.2016.7438574

Didactic, F. (2016). *Pick & Place station 8034567*. https://www.festo-didactic.com/int-en/services/mps-the-modular-production-system/stations/pick-place-station-8034567.htm?fbid=aW50LmVuLjU1Ny4xNy4zMi4xNDkwLjc4MDA

Diogo, R. A., Vicari, C. A., Loures, E. de F. R., Busetti, M. A., & Santos, E. A. P. (2008). An Implementation Environment for Automated Manufacturing Systems. In *IFAC Proceedings Volumes* (Vol. 41, Issue 2). IFAC. https://doi.org/10.3182/20080706-5-kr-1001.01787

Ebel, F., & Pany, M. (2006). *Bestimmungsgemäße Verwendung / Intended use*.

Lopes, Y. K., Trenkwalder, S. M., Leal, A. B., Dodd, T. J., & Groß, R. (2016). Supervisory control theory applied to swarm robotics. *Swarm Intelligence*, *10*(1), 65–97. https://doi.org/10.1007/s11721-016-0119-0

Mandala, H., Rachmat, H., Sukma, D., & Atmaja, E. (2015). Perancangan Sistem Otomatisasi Penggilingan Teh Hitam Orthodoks Menggunakan Pengendali PLC Siemens S7 1200 dan Supervisory Control and Data Acquisition (SCADA) di PT . Perkebunan Nusantara VIII Rancabali. *Jurnal Tugas Akhir | Fakultas Rekayasa Industri*, *2*(1), 1–8.

Nugroho, C. E. (2015). Sistem SCADA untuk Pengepakan Produk. *Compare A Journal Of Comparative Education*, 77.

Pakpahan, E. K. A., Kristina, S., & Setiawan, A. (2019). Model Simulasi untuk Sistem Manufaktur Fleksibel. *Jurnal Telematika*, *13*(2), 119–126.

Rogers, G. G., & Bottaci, L. (1997). Modular production systems: A new manufacturing paradigm. *Journal of Intelligent Manufacturing*, *8*(2), 147–156. https://doi.org/10.1023/A:1018560922013

Roop, D. W. (2016). Power System SCADA and Smart Grids. *IEEE Power and Energy Magazine*, *14*(1), 115–116. https://doi.org/10.1109/MPE.2015.2481786

Scotti, W. A. F., Portilla, N. B., De Queiroz, M. H., & Cury, J. E. R. (2015). Modular and systematic design of supervisory control system integrating PLC, SCADA and task routing for a modular production system. *IEEE International Conference on Automation Science and Engineering*, *2015-October*, 807–812. https://doi.org/10.1109/CoASE.2015.7294180

Setiawan, H. (2012). pengaruh orientasi pasar, orientasi teknologi dan inovasi produk terhadap keunggulan bersaing usaha songket skala kecil di kota Palembang. *Jurnal Orasi Bisnis*, *8*(2), 12–19. https://jurnal.polsri.ac.id

Subakti, M. M. I. (2003). *Simulasi Dan Fleksibelitas Pengurutan Pada Flexible Manufacturing System*.