



REAL-TIME-SIMULATION OF A LOGISTIC-SYSTEM INCLUDING DRIVES AND SENSORS FOR TESTING PLC-SOFTWARE BY SOFTWARE

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ABSTRACT. While installation of warehouse-managing-systems, storage- and transport-systems and their PLC problems and errors are caused by untested software. Repairing the defects causes delay of time and stress with deadlines. Insufficient tests of PLC-Software cause nearly 40% failed systems. More complicated functions in storage- and transport-systems demand a linking of hundreds of drives and sensors. Furthermore PLC-Software is installed after hardware as the last step of installation of a logistic-system. Therefore PLC-Software is getting the responsibility of failure and delaying.

Testing PLC-Software before real-operation avoids those defects and problems. The company Swisslog AG, Switzerland asked us to develop a real-time Simulation System called E-Control. E-Control is such a testing system. It shows the whole of an operating Logistic-System on a PC including all drives and sensors. Inspection of the PLC-Software takes place by watching the events and the movement of objects on the monitor of the PC without the construction of the real Logistic-System. The Simulation considered a high degree of details in pictures and movement as well as the capture of the positions of the objects (containers or pallets).

On the other hand E-Control produces all signals for the PLC which is connected with Simulation-PC by real network. The signals represent the events of the visual simulation. E-Control replaces the real Logistic-System by means of a virtual system on the PC. The amount of the signals between PLC and PC and their timing correspond with the reality. The software of the connected PLC gets these Signals and reacts corresponding of the PLC-Software. The PLC with its software will be the original system later on installed into the real Logistic-System. This cooperation: the simulated visual events of a Logistic-System and the PLC with software makes possible testing and improving the PLC-Software.

Key words: logistic, software, PLC, simulation, testing, education.

INTRODUCTION

Simulation is one of the most important tools for planning and realization of logistic systems. Of course there are different demands on simulation systems. For example you want to know the performance, the capacity or the time running through of a future system you can use suitable simulation systems. In a next step using another simulation you get information about the performance of single machines such as storage machines, rotating tables or distributing vehicles. In this step of planning a logistic system you can improve performance of the entire system by changing the number, the grouping and the selecting of these machines.

Required part of those automatic logistic systems are different layers of computing and controlling, For testing warehouse-managing-systems or material-flow-systems before constructing and

installation you can use a model of simulation (Fig. 1) about communication of the computers between the different layers.

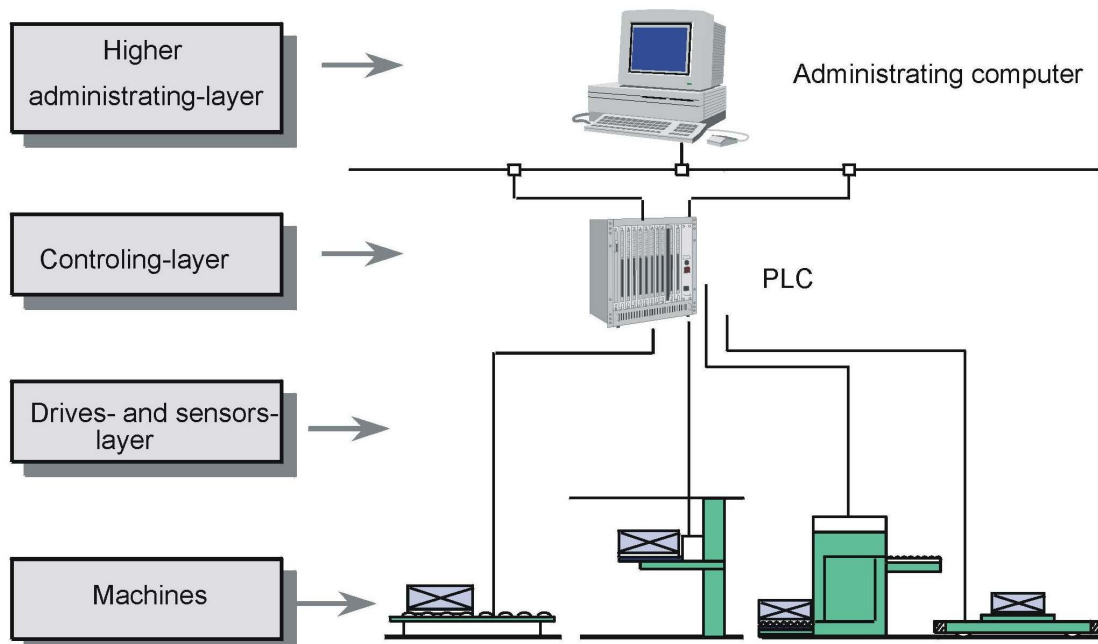


Fig. 1. Participating layers
 Rys. 1. Struktura warstw

For testing the coupling there are simulation systems required which shows all structures of the communication. After using these systems the exchange of messages is checked and the correctness of communication is reached.

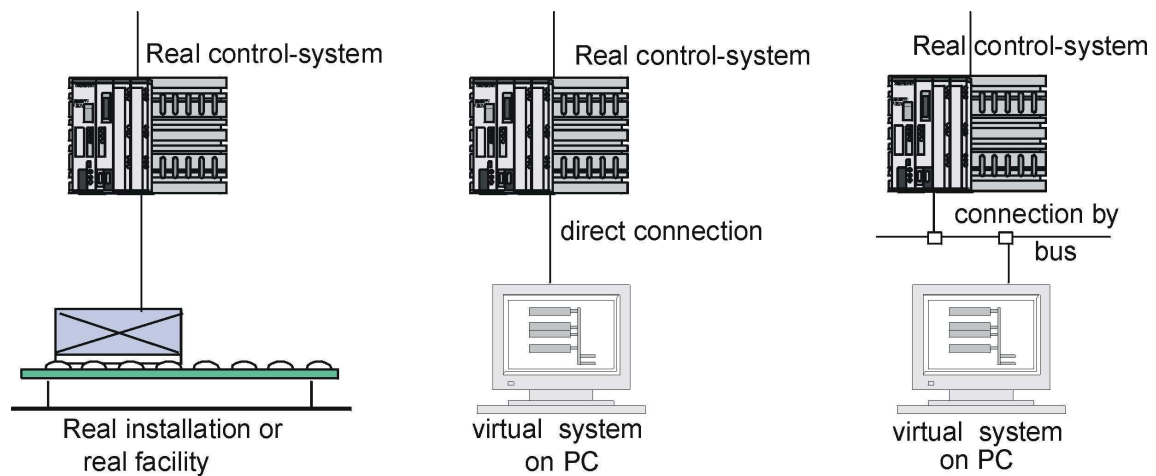


Fig. 2. Software-testing concept
 Rys. 2. Koncepcja programu testującego

CONCEPT OF REALTIME-SIMULATION

In contrast to the systems mentioned before this simulation system which I am talking about is developed for real logistic systems including drives and sensors in real time. In most cases the control-layer is realized by PLC for example Siemens S7, but this is not a condition.

The exchange of the drives- and sensor-signals between the animation on PC and a PLC in real time is the core of this system. Real time means that the signals appear in the same sequence of time as in the later installation. This is an important advantage of this simulation system which got the product name E-Control.

Therefore E-Control got an interface in form of original PLC-input and -output. The core of E-Control is the exact simulation of movements of the containers and pallets through the transport system. With E-Control the real system is replaced by a virtual one on the PC. The PLC is connected with the virtual facility.

The import of the virtual facility is based on technical drawings in form of CAD-data, which were accepted by a CAD-core of E-Control. In these the elements for simulation are entered true to scale. A simple configuration is shown in Fig. 3.

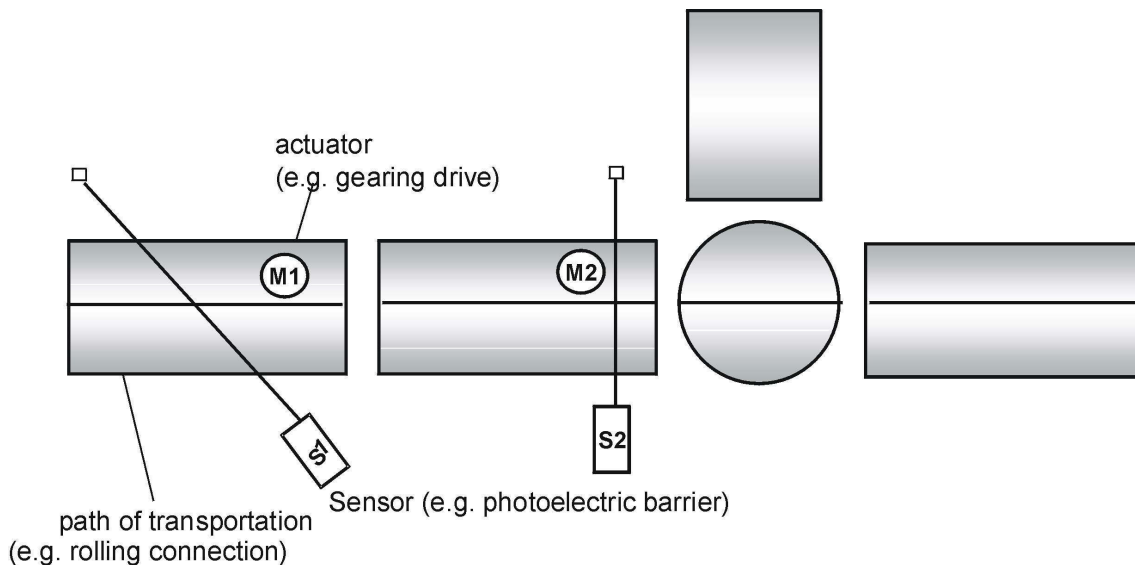


Fig. 3. Simple example of conveyor
Rys. 3. Prosty przykład przenośnika

Beside of the movement of the standard logistic machines E-Control does simulate the movement of the containers or pallets as a reaction of the signals of the connected PLC.

Therefore the following data are required:

- list of symbols,
- description of material flow,
- conditions of movements,
- technical data of the machines,
- configuration of the PLC,
- data of drives, valves etc.
- description of sensors, scanners, RFID-readers.

Because of the exact details of movements and events in the visual system on the screen of the PC E-Control is able to exchange the signals with a connected PLC in real time. The objects containers or pallets are animated and are moving through the visual system. Each object can get an individual identification or number, which scanners or RFID-readers can read.

RUNNING A SIMULATION

Fig. 4 shows an example of a configuration of a simulation system. Usually one PC is sufficient. However whether one PC or more they are connected (as in the real system later on) by bus such as Profibus, Interbus, Industrial Ethernet and so on. To describe running a simulation we assume all CAD-data about the hardware of the designed logistic system is stored.

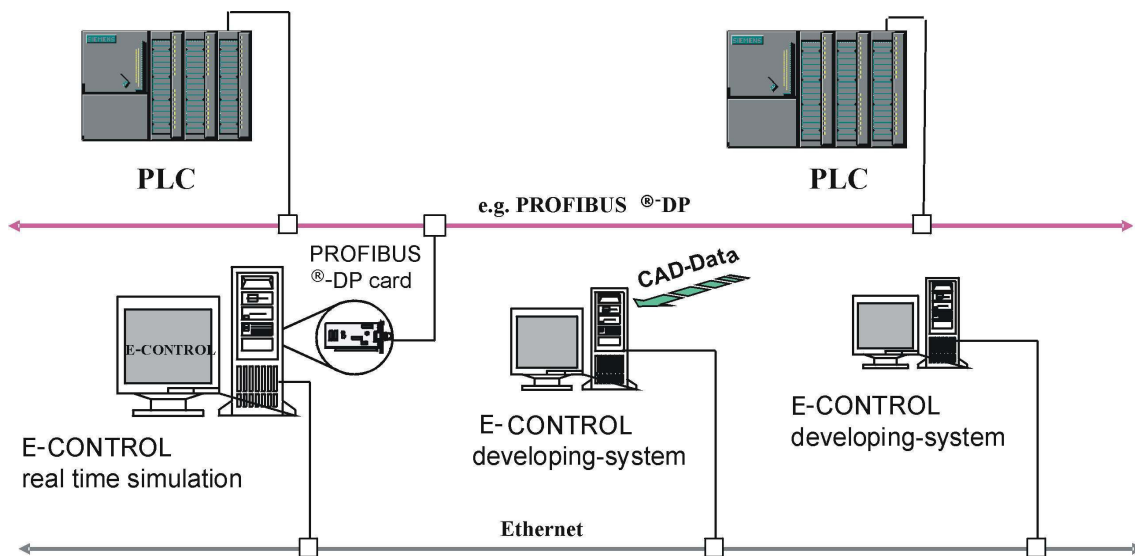


Fig. 4. E-control simulation system (exemplary configuration)
Rys. 4. System symulacyjny kontroli elektronicznej (przykładowa konfiguracja)

In a first step courses or segments are to specify where the containers or pallets have to run through. These elements get drives. Parameters of a drive are speed, changing the speed, signal to switch on the drive and so on. Beside drives sensors are to be placed. Beside the position sensors are represented by light-barriers. Sensors get the parameters kind of signal (high or low), line of operation and the number of signal which the PLC will get later on. All parameters are stored into variables you get to know by usual programming languages. The advantage of using variables is demonstrate later on. Up to here you have integrated all relevant elements for a simulation such as crossing points, rotary desks, distributing vehicles and so on. So far we suppose there is no PLC until yet. Then you can program the conditions of movements, the logic of controlling and the order of events. You can reproduce the controlling-software by script-languages such as Visual-Basic-script or Java-script (Fig. 5: stand-alone-mode). But this is not the main goal of E-Control. The main purpose for developing E-Control is testing PLC-Software by a virtual Logistic system on PC. The script-programs are running in background of visual simulation in cooperation with variables I mentioned before.

Therefore in the next step (Fig. 5 develop-mode) the PLC is connected with the simulating PC. In this step the controlling-software is developed on PLC online. The correctness and functioning of the PLC-software is tested by the virtual system on PC. As I said before virtual system and PLC exchange signals in original PLC-kind and in real time.

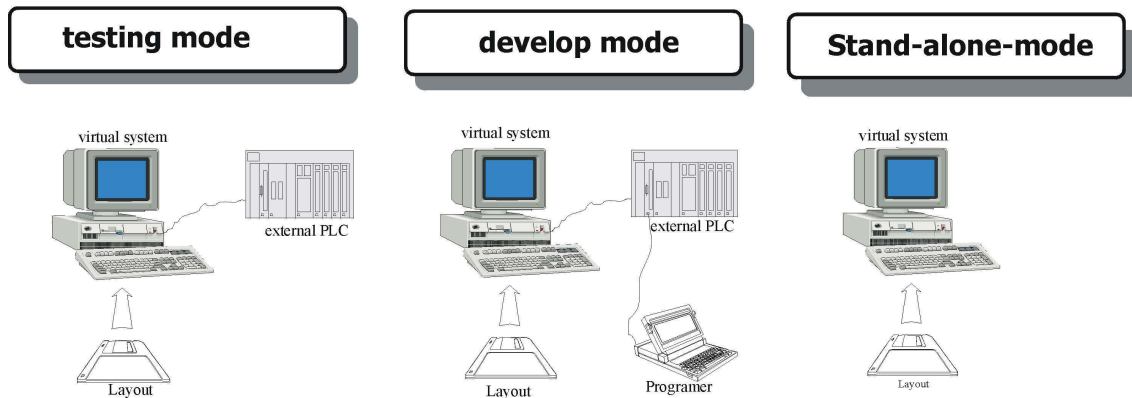


Fig. 5. Kinds of modes
Rys. 5. Rodzaje modeli

In the last step the developed PLC-software is tested without the script background programs as a whole.

FUNCTIONS OF E-CONTROL

Beside of the possibility integrating CAD-data E-Control is marked profitable because of:

- the state of the controlling-lines of drives, sensors and so on are shown with a time-based-line (Fig. 6),
- several windows can be opened during simulation in addition with a function like a magnifying glass,
- parts of conditions are represented by script-functions,
- a high flexibility is reached by list of variables for managing the system,
- analysis of single functions or signals.

Especially the integration of a list of variables, which represent the state of system and the order of events of the simulation allows high flexibility and wide application. The list of variables (Fig. 7) is used by several trends and changed by the following:

- by the script functions,
- by the progress of simulation,
- by real signals of PLC.

So several scenarios of simulation can use the list of variables:

- by PLC from real elements of the system,
- by script-programs,
- offline by script-functions without connection to a PLC.

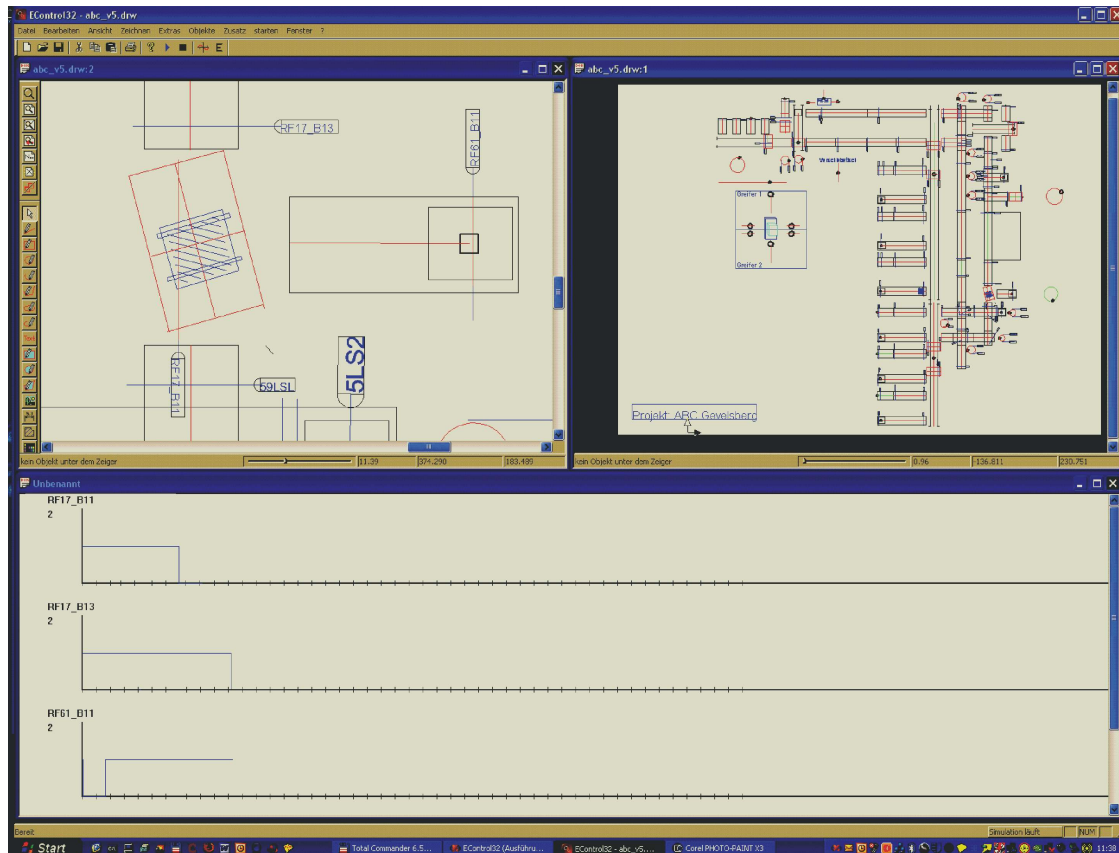


Fig. 6. E-control functions
 Rys. 6. Funkcje E-kontroli

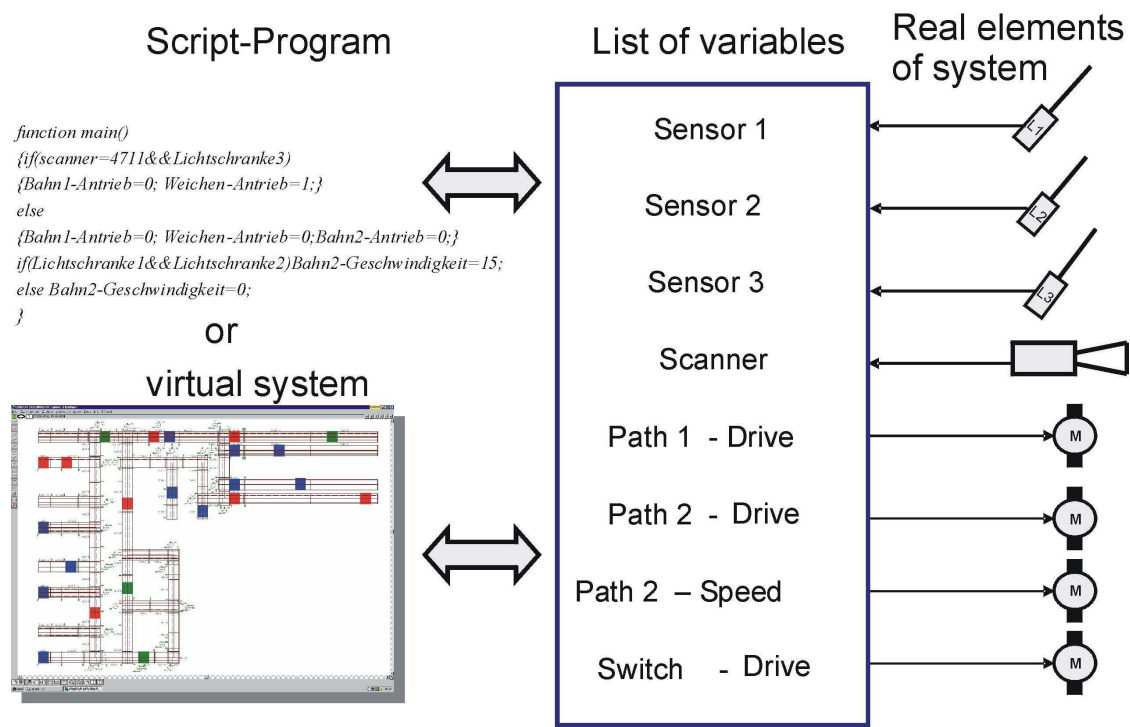


Fig. 7. Integration of variables and script functions
 Rys. 7. Integracja zmiennych i funkcji skryptowych

CONCLUSION

Using such sources of help for testing software there is to discuss expenditure and advantage. Beside of investment for hardware and software costs for preparing the simulation model and for doing the tests are to consider. Compared with this essential advantages are to mention:

- testing the PLC-software with regard to correctness,
- testing the communication between PLC and administration layer,
- description and inspection of single signals,
- opportunity for inhouse-tests, not on the building site,
- acceptance by an inspection-team of the customer,
- savings by reducing the time of installation about 30% to 40%,
- using the simulation for documentation and training.

Therefore E-Control is very useful in education of our students in programming PLC-software.

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SYMULACJA W CZASIE RZECZYWISTYM SYSTEMU LOGISTYCZNEGO OBEJMUJĄCA NAPIĘDY I SENSORY DO TESTOWANIA OPROGRAMOWANIA STEROWNIKÓW LOGICZNYCH PRZEZ PROGRAM KOMPUTEROWY

STRESZCZENIE. W trakcie instalacji oprogramowania systemu zarządzania magazynami i transportem można napotkać problemy ze sterownikami logicznymi oraz błędy spowodowane przez nieprzetestowane oprogramowanie. Usuwanie napotkanych błędów powoduje opóźnienie pracy i niemożność dotrzymania ustalonego wcześniej harmonogramu wdrożenia. Niewystarczająco przetestowane oprogramowanie sterowników może być powodem nawet 40% przypadków nefunkcjonowania systemu. Bardziej zaawansowane funkcje w systemach magazynowych i transportowych opierają się na współpracy i połączeniu setek napędów i sensorów. Oprogramowanie sterowników logicznych jest instalowane po podłączeniu całego sprzętu, jako ostatni etap instalacji systemu logistycznego. Z tego też powodu to właśnie ta część systemu w postaci oprogramowania sterowników jest obarczana często winą za opóźnienia i komplikacje przy wdrożeniu. Proces testowania oprogramowania sterowników przed jego ostatecznym wdrożeniem pozwala uniknąć tych problemów. Firma Swisslog AG ze Szwajcarii zwróciła się do nas z prośbą o opracowanie systemu symulacyjnego w czasie rzeczywistym, nazwanego E-Control. E-Control jest systemem testowym. Przedstawia na komputerze całość systemu logistycznego wraz z wszystkimi napędami i sensorami. Testowanie systemu sterowników logicznych polega na obserwacji na ekranie monitora komputera zachowań i przemieszczania się obiektów bez konieczności budowania rzeczywistego

systemu. Program ten pozwala obserwować wysoki poziom szczegółów na rysunkach i w trakcie ruchu, jak również śledzi pozycje obiektów (pojemników lub palet).

Z drugiej strony E-control stosuje wszystkie formy sygnalizacji sterowników. Sygnały reprezentują poszczególne zdarzenia, które zachodzą w trakcie symulacji. Tak więc E-control jest wirtualnym odtworzeniem rzeczywistego systemu logistycznego. Ilość sygnałów, jakie są przekazywane pomiędzy sterownikami a komputerem odpowiada ich ilości i czasowości w warunkach rzeczywistych. Oprogramowanie sterowników logicznych odbiera te sygnały i reaguje w odpowiednio zaprogramowany sposób. Sterowniki te wraz z ich oprogramowaniem zostaną później, jako oryginalny system, zainstalowane w rzeczywistym systemie logistycznym. Ta współpraca: symulowane wizualizowane zdarzenia systemu logistycznego w połączeniu ze sterownikami logicznymi i ich oprogramowaniem umożliwiają testowanie jak i poprawę oprogramowania tych sterowników.

Słowa kluczowe: logistyka, oprogramowanie, sterowniki logiczne, symulacja, testowanie, edukacja.

ECHTZEIT-SIMULATION VON LOGISTISCHEN SYSTEMEN EINSCHLIEßLICH ANTRIEBEN UND SENSOREN ZUM TESTEN VON SPS-SOFTWARE MIT SOFTWARE

ZUSAMMENFASSUNG. Während der Inbetriebnahme von Warenverteilanlagen, Lager- und Transportsystemen und den zugehörigen Steuerungen entstehen Probleme und Fehler durch nicht getestete Software. Durch die Reparatur der Fehler entstehen Zeitverschiebungen und Probleme mit dem Fertigstellungstermin. An unzureichenden Tests der SPS-Software scheitern fast 40% der Software Installationen. Da Materialflusssysteme mit zunehmender Vielfältigkeit der Aufgaben immer komplexer werden sind hunderte von Antrieben und Sensoren anzuschließen. Da die Software nach der Hardware als letztes Glied in der Installationskette steht wird ihr zwangsläufig eine fehlgeschlagene Inbetriebnahme verantwortlich zugeschoben.

Ein Test der SPS-Software vor der Inbetriebnahme vermeidet diese Fehler und Probleme. Die Firma Swisslog AG, Dortmund beauftragte uns ein Echtzeit-Simulationssystem mit der Bezeichnung E-Control zu entwickeln. E-Control stellt ein solches Testsystem zur Verfügung. Es stellt das gesamte logistische System mit allen Antrieben und Sensoren visuell auf einem PC dar. Die Untersuchung der SPS-Software geschieht durch die Überwachung der Ereignisse und der Bewegung der Objekte auf dem Bildschirm ohne den Aufbau der realen Anlage. Die Simulation stellt mit genauer Auflösung die Bewegungen und die Positionen der Behälter oder Paletten dar.

Darüber hinaus erzeugt E-Control alle Signale für die SPS, die über übliche Bussysteme mit dem PC verbunden ist. Diese Signale entstehen aus der visuellen Simulation. E-Control ersetzt das reale logistische System, an dessen Stelle tritt das virtuelle System auf dem PC. Die Anzahl der Signale, die zwischen PC und SPS ausgetauscht werden entsprechen auch in ihrem Zeitverhalten der Realität. Die Software der angeschlossenen SPS empfängt die Signale und antwortet entsprechend der programmierten Software. Die SPS und die getestete Software sind dann das Original-System, das später in der realen logistischen Anlage installiert werden. Dieses Zusammenwirken: Die simulierten Ereignisse eines logistischen Systems und der SPS mit der Software ermöglichen das Testen und Überprüfen der SPS-Software.

Codewörter: Logistik, Software, SPS, Simulation, Test, Ausbildung.

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