Design and Implementation of Manufacturing Execution System with open hardware *Diseño y aplicación de un sistema de ejecución de fabricación con hardware libre*

Roberto Alcalde-Delgado, Miguel Á. Manzanedo-Del Campo, Lourdes Sáiz-Bárcena, María Alonso-Manzanedo and Ricardo del Olmo-Martínez

Dpto. de Ingeniería Civil. Área de Organización de Empresas. Escuela Politécnica Superior. Universidad de Burgos. C/Francisco de Vitoria, s/n. 09006. Burgos, Spain

roberto.alcalde.delgado@gmail.com, mmanz@ubu.es, lsaiz@ubu.es, rdelolmo@ubu.es, mariaalonsomanzanedo@gmail.com

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Abstract: The aim of this work is to design and validate a prototype low cost manufacturing execution system, which consists of software development and hardware configurations free (arduino). The prototype can record and monitor status changes of different production lines or sensors, as well as obtain performance reports. It can be used even in cases where no controller or PLC. Furthermore, the system is scalable and configurable. It analyzes the data, to obtain reports more clear and concise information.

Keywords: manufacturing, MES, open source hardware

Resumen: El objetivo de este trabajo es diseñar y validar un prototipo de bajo coste de un sistema de ejecución de manufactura (MES), que se compone de desarrollos de software y configuraciones de hardware libre (arduino). El prototipo permite registrar y monitorizar los cambios de estado de diferentes líneas de producción o de los sensores, así como obtener informes de rendimiento. Se puede emplear incluso en los casos en los que no hay un autómatas o PLC. Además, el sistema es escalable y configurable. Este permite analizar los datos obtenidos, para obtener informes con información más clara y concisa.

Palabras clave: fabricación, mes, hardware libre.

1. Introduction

Manufacturing Execution Systems (MES) are the interface between the planning layer (Enterprise Resource Planning – ERP) and the production layer (Flexible Manufacturing System – FMS, Supervisory Control and Data Acquisition - SCADA, Programmable Logic Controller - PLC). Therefore, they are an information system designed to support shop floor processes and their integration into companies' information system architectures (Louis and Alpar, 2007, Günther et al., 2008, Choi y Kim, 2002).

Although, the industries have made great economical, structural and organizational efforts, MES implementation is lagging, because in principle expected a strong and productive economic impact of the implementation of ERP and FMS layers, before starting an integration project. ERP implementation have not shown the expected returns, due to lack of use of information for decision making, the dependence of human resources for the upgrade of the systems, the amount of information to be handled in the transactions, the mass data collection and lack of exter-

nal connectivity with internal developments for handling proprietary modules, amongst others (Mauricio Zambrano-Rey G., et al. 2010). Furthermore, many MES software companies will not be willing to provide detailed information about the implementation of their products (Fowler J.W, et al. 2004).

The MESA (Manufacturing Enterprise Solutions Association) International definition of MES is: «MES delivers information that enables the optimization of production activities from order launch to finished goods. Using current and accurate data, MES guides, initiates, responds to, and reports on plant activities as they occur. The resulting rapid response to changing conditions, coupled with a focus on reducing non value-added activities, drives effective plant operations and processes. MES improves the return on operational assets as well as on-time delivery, inventory turns, gross margin, and cash flow performance. MES provides mission-critical information about production activities across the enterprise and supply chain via bi-directional communications».

In figure 3 shows an example of data sent, which are received on the server that makes data recorder on database.

Figure 3
Example of the messages sent OSC

Schmeder (2010) says «A common transport protocol used with the OSC format is UDP/IP». UDP is classified as a transport layer or number 4 of the seven layers OSI model and provides end-to-end communication services for applications. UDP is often utilized for broadcasting, because it has no handshaking dialogue.

Additionally, other protocols are used as data exchange. The most common is the OPC, which has become a widely accepted solution for intercommunicating different hardware and software (Taihoon 2010, Iwanitz, 2006). There are also examples of using the XML (eXtensible Markup Language) protocol. (Tao et al. 2004). In this prototype we used the OSC protocol, since it is very simple and easy to implement in low-cost hardware called Arduino.

2.2. Data Recorder

Development software on a PC receives UDP data frames. Depending on the device, the received data are combined with the date / time of pc for storage

in the table on the database. This application has an ini file which associates the device's ip to the table of the database.

2.3. Data Warehouse

The database stores all data, but to minimize the space without losing information, a record is saved only when a change in status or value of the analog signal are done. To achieve this efficiently, the firmware of the hardware device is set on condition that only send data when a change occurs. This is a significant difference compared to other protocols such as OLE for process control (OPC), in which the communication is synchronous or asynchronous, but never when the value of the signal (Grega 2010).

Fig. 4 Raw data store in a table.

2.4. Server of online analytical processing

This server performs an analysis of the raw data to determine the prevailing status and duration. At the same time, keep the information gathered in another table to speed up subsequent queries.

Since it can take multiple statuses at once, you must set one that is principal. As shown in Table 1, this will allow obtaining a report with length of time for each principal status.

Figure 4
Raw data store in a table

179601	08/03/2010	15:15:40	10.23.1.252	in	8	0	0
179602	08/03/2010	15:15:40	10.23.1.252	in	9	1	0
179603	08/03/2010	15:15:40	10.23.1.252	in	8	1	0
179604	08/03/2010	14:33:28	10.23.1.252	adc	3	0	0
179605	08/03/2010	14:33:27	10.23.1.252	adc	3	3	0
179606	08/03/2010	14:31:32	10.23.1.252	adc	3	0	0
179607	08/03/2010	14:31:31	10.23.1.252	adc	3	9	0

Fig. 4 Raw data store in a table.

Table 1
Example of report of status

Group of status of the production line of cutting/slide	%	Length of time	
		Minutes	Hours
1.- Stop	9,9	47,367	0,789
2.- Run	42	200,317	3,339
3.- Introduction raw material	35,4	168,75	2,812
4.- Extraction raw material	7	33,517	0,559
5.- Removal raw material	4,4	21,017	0,35
6.- Partition raw material	1,3	5,983	0,1
Total	100	476,95 min.	7,949 hours

For analogical values, these can be grouped by rank, to facilitate data interpretation. In the prototype, the analog variable used is the line speed. This can be seen in Table 2.

Table 2
Example of report of speed

Processing Speed (meters/ min)	Length of time minutes	Length of time hours
Speed 1 - 49	56	0,933
Speed 50 - 99	26	0,433
Speed 100 - 149	32,15	0,536
Speed 150 - 199	20,833	0,347
Speed 200 -	59,2	0,987
Total	194,183	3,236
Mean Speed		125,5 meters/minute

2.5. Web Server

Many researches on the Web-based monitoring are performed for remote process control using information technology (Jung et al., 2001, Yu et al., 2004)

For the prototype, a web server has been used. It facilitates to monitor and generate reports from any computer with a browser. Although an internet information server from Microsoft was used, it could be used others.

3. Conclusions

A low-cost prototype of MES system has been designed and produced. It is valid for all cases in which you can get a digital or analogical signal from a sensor or a gauge.

This prototype has been validated in a manufacturing environment, where there have obtained excellent results. It has allowed improving the cycle time of the production line. It has revealed differences between the statements wrote down manually and machine status.

Therefore, in the implementations of continuous improvement, like Lean Manufacturing, we are recommended to use a system like this prototype, in order to monitor whether targets are achieved. Another substantial novelty of this prototype in comparison with other systems is that it maintains an asynchronous communication and only sends a data when a variation occurs.

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