Implementing Industry 4.0 solution with legacy informational systems

Kocho Hrisafov, Nayden Chivarov
Institute of Information and Communication Technologies at
Bulgarian Academy of Science, Sofia, Bulgaria
khrisafov@hotmail.com, nchivaroav@gmail.com

Abstract: *This paper discusses a case of implementing Industry 4.0 solutions with existing legacy informational system in cement-producing factory. One of the main reasons the company wants to keep its existing ERP solution is because is too complex and cannot be ported to a contemporary computer architecture. The plant also needs to automate and modernize the process of loading their products, but the company management does not want to invest in modern computer servers and a new ERP system. That's why they decided to implement a hybrid solution – a modern Industry 4.0 IoT devices with .NET client application using the existing legacy DEC Alpha as a server. Here, the required technologies used for developing that software solution are overviewed and all parts of the software solution are described. Finally, the benefits and effectiveness of such a hybrid software solution are shown.*
Keywords*: Industry 4.0, IoT, RDB, ODBC, VAX, Alpha, ERP, OpenVMS, .NET*

1. Introduction

When computers started to be used in Industry 3.0, it was a big and hard change thanks to the addition of an entirely new technology. Now, when Industry 4.0 is implemented, computers are networked and ultimately make decisions without human involvement. A combination of cyber-physical systems, the Internet of Things and the Internet of Systems make smart factory a reality. As a result - smart machines that are getting smarter as they get access to more data, our factories will become more efficient and productive. At the end, the network of these machines creates and share information that results in the true power of Industry 4.0. Legacy computer systems are socio-technical computer systems. The arrangement of their components – hardware, software, data and business processes – directly affect the established policies and functioning of the organization. Any change to any part of the system affects the overall functioning of the system. The costs of change and the danger of losing crucial data are often reasons why organizations decide that the only remaining option is upgrading and partial modernization. In this article we will show how Industry 4.0 solution was implemented in a cement-producing factory that wants to perform an automation and modernization process of loading their products and does not want to replace existing legacy systems. The reason for this is because of its performance in the daily operation of the plant. The system cannot be easily replaced because of the application which allows for the operation of the plant – it is an ERP system made for a DEC Alpha system. Also, financial terms or costs associated with the introduction of a new modern computer system with a new ERP system should also be taken into account. That is why the company opted for a hybrid solution: using the existing legacy system's DEC Alpha as server and implementing IoT devices and with modern .NET client applications running on PCs with integrated touch screens [1]. The application is built according to strict company requirements considering tools and technologies, where .NET is the only allowed programming technology. Cloud SaaS (software as a service) is also excluded because this application should work without an Internet connection. Also, there is a limitation to which Oracle instruments can be used because they are not supported on a legacy RDB database.

2. Definition of a legacy systems

Before we talk about the specifics of legacy systems in the context of computer technology, we should primarily define the idea what the term means. In general, it is about computer systems, programming languages or software used versus upgraded versions available. Also, the term could be correlated with processes that are more applicable in contemporary contexts. In theory there is no reason why a company or organization would not keep pace with the latest technological innovations but in practice very often these same companies have legacy systems. The problem here arises in compatibility and lack of security support [2].

We can conclude that legacy computer systems are essentially designed for the purposes and needs of organizations that operate for a longer period of time. These include systems designed many years ago but due to their age are not able to implement and use new technologies. But these systems are very important because they are still crucial for the functioning of many business organizations [3].

Even small changes to any part of the system can lead to a range of changes in the other components. Therefore, decisions relating to it are not always governed by objective criteria, but engineering is in direct correlation with organizational strategies and policies. Here we will present the specifics of each component separately as follows:

• System hardware - in many cases the systems are designed for hardware that is not in use, and therefore they are expensive to maintain which in turn may not be appropriate in terms of organizational IT plans and cost estimates.

• Software support - legacy systems can rely on a variety of software support of the operating system and tools offered by manufacturers of hardware compilers used for system development.

• Application software - an application system that provides business services and usually consists of several separate programs that have been developed at different times. Sometimes the term refers to the legacy application software system instead of the system as a whole.

• Application data - are actually the data processed by the application system. Some systems over time accumulated vast amounts of data that are often going to be replicated in different folders.

• Business processes - the processes that are used within the operation to reach business goals. An example of such a business is with insurance policies in an insurance company, or the policies of receiving and processing orders in a factory.

• Business policies - rules with which a business should be accomplished and done. Such rules are very important factors in the functioning of the legacy system [4].

3. Significant role of the legacy systems in the companies

Despite recent technological innovations that offer great advantages and benefits for functioning, many companies still use outdated systems. There are several reasons for this but the most frequent are the risks and costs of the system to change. There is a danger that the change might be unsuccessful, which would indirectly have a negative impact on the credibility of the IT sector and the careers of responsible managers.

The transition time and testing of the new system versus a stable platform which already operates is a dilemma with which companies are confronted. So, if something is already operational and performs the necessary functions there is almost no reason for a change. Stability without turbulent changes acts as a more attractive option for the management. That is why some companies usually decide to modernize rather than replace their platforms. Those who decide to modernize for example take advantage of XML-based Web services, middleware and portal technologies work environments that enable them to maximize the operating systems from the early eighties, such as VMS, AS / 400 and UNIX. At the same time, integrating the operating systems of different areas is not as difficult as before. Tools like IBM WebSphereMQ message broker can serve 50 operating systems, providing a simple way of conveying messages between applications running incompatible operating systems. Also, a problem for the change is safety. At the most basic level, password protocols can lead to a difficult change. Maintaining the security of a legacy system can be quite difficult because the user cannot expect automatic protection from new threats and dangers [5].

4. Technologies used for the software solution

Oracle RDB database

Oracle RDB is a relational database management system that is used in mission-critical applications on OpenVMS platform [6]. Some of its advantages are:

- Big performance delivery of real-time data;
- Extreme reliability, enabling security and constant availability of the database;
- Extremely high-availability – requirements for planned maintenance are minimal;
- Easy sustainability;
- Low cost.

Oracle SQL/Services for OpenVMS Alpha

A client-server system, in its simplest form, consists of client, network, and server system. The client is a software program that uses an application programming interface (API) to access and to make requests to the server. The client can be on the same platform as the server. Usually, the client application is running on a workstation or computer and is accessing the database of large server platforms using the network that supports multiple transport protocols. Oracle SQL / Services is a collection of cooperative processes on a node that includes a process dispatcher and a container of executive processes acting on behalf of the service.

A dispatch process takes care of network communication between the client and the server. It reads customer requirements, arranges them in rows of these requirements for executive processes, and returns responses from these processes back to the client. An executive process runs on behalf of the Service, accepts the customer requirements from among the dispatcher calls the mechanism of database processing of those requests, and returns the results back to the dispatcher. The service is a set of attributes that describes how clients access the database [7].

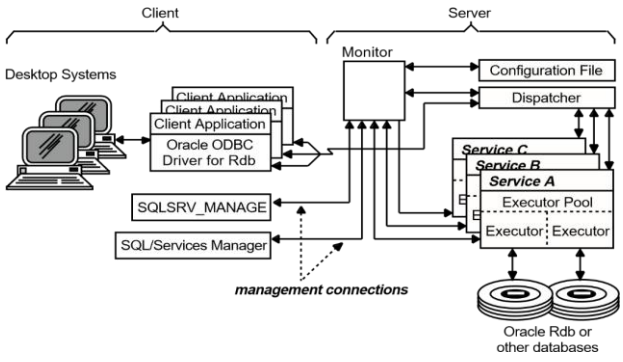

Fig. 1. *Oracle SQL / Services - Client / Server Architecture [8]*

Oracle ODBC Driver for RDB

Oracle ODBC driver provides Microsoft® Windows applications that implement Microsoft Open Database Connectivity (ODBC) API way to read and write data to Oracle RDB databases and databases available through Oracle DB Integrator family of gateways. The Oracle ODBC Driver for RDB distribution kit includes clients necessary to allow access to the Oracle RDB ODBC enabled applications regardless of the programming language [8].

ADO.NET is a set of software components that developers can use to access data and data services on the basis of datasets and XML files. It is a part of the library of base classes that is included in the Microsoft .NET Framework. It is commonly used by programmers to access and modify data stored in relational database systems, but data in non-relational sources can also be accessed.

It provides consistent access to data sources such as SQL Server and XML, and data sources exposed through OLE DB and ODBC. User applications use ADO.NET to connect and search, process and update the content in these data sources. ADO. NET separates data access from manipulating them into discrete components that can be used separately or as a group. It enables .NET Framework data providers to connect to the database, execute commands, and retrieve results [9].

5. Architecture of the software solution

The database which the software solution accesses is the existing Oracle RDB installed on the DEC Alpha Server on OpenVMS with predefined tables that are already in use by the legacy application. This will ensure consistency and continuity in the work. A legacy software solution will be used until new modules are activated. It will also provide a migration test period when both the old and the new software operate in parallel. Thus, with the testing of the application and the correction of errors, the process of loading will be functioning unhindered. On each computer that will be installed on the stated positions, an Oracle RDB ODBC driver will be installed, which will provide the link between the software solution and the database. The software solution will be programmed in the ASP.NET 4.5 technology. Using the ODBC driver allows for the most modern access to the database and ability to use all the tools and features that Microsoft Visual Studio provides. Thus, the same functionality is obtained from Oracle RDB as a legacy database, compared to more modern databases such as: Microsoft SQL Server, Oracle, PostgreSQL, SAP HANA and others.

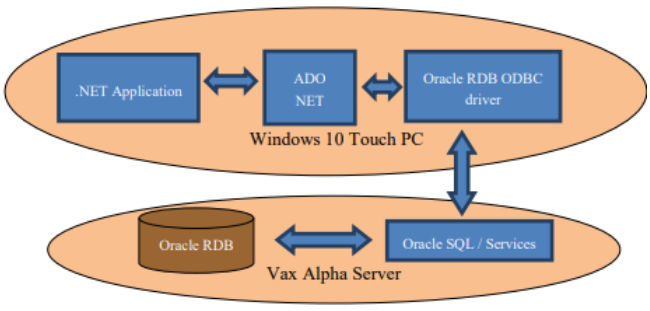

Fig. 2. *Schematic representation of the communication between Oracle RDB and client .NET application*

6. Overview and segments of the Industry 4.0 solution

The purpose of the system is to allow entry of trucks, loading and output with minimal or no impact on human resources. The goal is to eliminate the human factor and the possibility of making mistakes and mismanagement. The entire implementation is divided into several segments, in order to identify the necessary resources, the system needs for a location, to allow for greater independence of

the system from one location to another, and to enable parallel implementation of all locations in the facility that are components of this system. All positions use Windows 10 touch PC's.

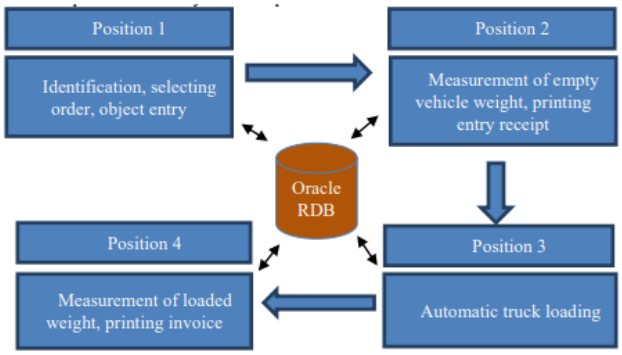

Fig. 3. *Segments and flow of the software solution*

Position 1: Identification of entry, selecting order, object entry

With the implementation of the system, each company will be awarded a certain number of RFID tags for identification of orders. In issuing the order, the tag will bind with the order number and represent the identification order. Tags generally will be provided to companies and/or a tag is associated with a driver.
When registering, the driver may be shown more than one option. Namely, if the tag is associated with several orders, the driver sees all of them and he selects one of the orders and confirms.

Fig. 4. *Cabinet and touch pc / driver operation*

In case that a need arises for a confirmed order to be deregistered and changed to a new order, the process can only be done in the sales department and as long as the truck is not on a measurement platform. If the truck is already measured, then the order can be reversed or loading can be continued with.
If the first confirmed order is for a packed article, then the driver can select other orders as well, but only if it is for a packaged article, the same driver, the same registration, and as long as the sum of the average truck weight and confirmed orders is less than 40 tons. The average truck weight is based on the history of previous entry weights for the truck, but if the truck enters the plant for the first time, then the average weight is determined as its carrying capacity taken from the driving license. Data from the driving license for a truck are entered when the process of registration of the driver and truck by the Sales Department. It will also allow the average weight to register at entry scales as a combination of a tractor and trailer. If the truck is out of the factory for less than 30 minutes, then there is no possibility to apply for a new order. At the end of a successful pro-cess, the driver drives to position 2.

Position 2: Measurement of empty weight, printing an entry receipt

After the truck is stopped, the driver is identified with an RFID tag. Before taking the measurement, several series of programming inspections (such as types of items etc.) must be performed.
Once the weight is measured, a series of program checks are performed. If all checks pass, the entry receipt is printed and the truck can continue towards position 3. If one of the tests does not pass then the display shows the relevant message.

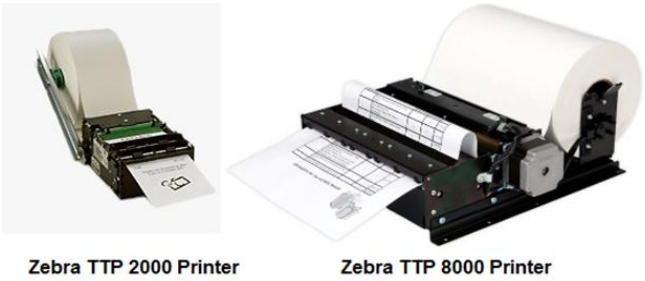

Fig. 5. *Zebra thermal receipt printers [10]*

Position 3: Loading of materials

Loading of materials will be performed in the facilities that are designed for the specified material.
For bulk material

After positioning the truck on a scale, the driver gets identified with the RFID tag and checks that the truck is positioned in the right place. After successful identification, communication is established with a PLC computer via a web service (application). The PLC computer and the software solution exchange messages to control the loading process. If the checks are successful, then the PLC computer will start the loading process. After the completion of the loading, the truck can head for position 4.

Fig. 6. *Unistream PLC [11]*

For packed material

Once the truck arrives at the warehouse, the driver is identified with an RFID tag. An RFID tag is attached to a suitable place where the truck can easily be identified. After identification and verification, the operator can see on the screen how many pallets have to be loaded and what kind of material. After the completion of the loading process, the truck can head for position 4.

Position 4. Measurement of a loaded truck, invoice printing

After the truck stops on the output scale, the driver gets identified (using the RFID tag) and takes a measurement. If all checks are successfully completed, then the printer automatically prints three invoices – two invoices remain for the plant, one invoice goes to the driver.

After the invoices are taken at the truck exit stop, a series of program checks are made and, if all the checks pass successfully, then the ramp is raised and the truck can leave the facility.

Fig. 7. *A driver takes an invoice*

Conclusion

The implementation of this software solution improves the efficiency of repetitive processes and reduces the need for manual data entry. An additional benefit is the reduction of the cost of the whole process - eliminating the labour required to manually perform all stages of loading the goods. The implementation of this software solution speeds up the process of entry, exit and loading trucks. From this we can conclude that the automation of manual processes with modern soft-ware and technical systems all linked together in the ERP system have substantial benefits for the company.

It can be concluded that the use of legacy systems is still possible and efficient. They are fully able to perform all duties associated with the functioning of companies and thereby can be effectively used as a server allowing an operation of new and advanced client applications. Old and new can work in a functional symbiosis.

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