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SERVICE ORIENTED ARCHITECTURE FOR THE BATCH CONTROL DOMAIN

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Abstract: Traditionally batch process control is one of the most difficult and complex control domain for implementation since it includes feedback controllers as well as logic control operating under supervisory recipe-based sequential control. Because of the focus on dynamic cross-organizational integration, Web Services technologies complement rather than compete with existing distributed computing technologies. The overall aim of the Web Services is to enable interoperability and to improve the integrated problem solving in adaptive, dynamic and multi-institutional organizations. It focuses on allowing services, which can be composed of resources, systems, programs, applications, raw data, etc. to be published, found, and invoked by other applications at run-time, as well as design-time, language and operating systems independent. The focus of this paper is to present the benefits of web-driven technologies for batch control domain and to propose the service oriented architecture for batch control processes.

Key words: Service Oriented Architecture, Web Services, Automation Systems, Batch Control Processes

INTRODUCTION

Hybrid processes are often found in chemical industry. Batch control is an important concept in this area. It describes the continuous production of finite quantities of materials (batches) in chemical processes. The increasing demands on flexibility and customer-driven production lead to an increased interest in batch processes, which are more economical for small-scale production. Batch Processes systems can achieve optimal performance only using industrial automation systems, which are well designed, installed and commissioned. From the other site the technical requirements are changing rapidly in today's industrial environments and this increases the need for managing and maintaining the hardware and software used.

The powerful solutions for automation process services are based on web-driven technologies and approaches. This is because of the fact that web services are created from existing systems with a small amount of custom code and this way saving team valuable time and money.

A Service Oriented Architecture (SOA) is a software model in which the concept of a 'service' is an abstraction of a function used by an application and provides an architectural approach that brings the flexibility and agility required by today's global business environment [1]. SOA addresses the business demand for applications to be responsive to business needs and to adapt to dynamic business environments. In terms of automation, service orientation is a distinct approach for analysis, design and development, which defines the principles of building communications, architecture, and implementation of processing logic [3]. Different architectures and models for Service Oriented Environments are known. Some of the most popular as for example W3C Web Service Architecture, OASIS SOA Reference model, ebXML, Semantic Web Services, JINI, OSGi etc [4]. All these initiatives are collections of best practice principles and patterns in service-oriented design. The W3C Web Services Architecture as one of the most promising architectures identifies the functional components of Web Service architecture and defines the relationships among those components in order to affect the desired properties of the overall architecture [2, 5].

Some of the authors of this paper suggest in a number of publications different approaches for enabling component based control of batch plants. In [6] a new approach for sequential control at the supervisory level of a batch plant is suggested, in [8, 9] the idea of creating and reusing component based library in this domain is realized and presented. Common intelligent software components have been built and reused for different application. The components are managed in a control recipe that describes their execution schedule. In [10] an approach supporting the application of analyzable formal models, re-usable basic components, and re-configurable distributed implementation is proposed. The efficiency and effectiveness of all these approaches may be sufficiently improved through development and use of Engineering Support System based SOA architectures such as this of W3C Web Services.

This paper focuses on the build aspect of the service-oriented architecture of the industrial plant for distillation of sulphate turpentine. To achieve that goal, it is necessary to describe the design and development requirements of web services. The paper proposes the service oriented architecture and the solution is designed to ensure that they are flexible and can be adapted when the need arises to change.

CASE STUDY: DISTILLATION OF SULPHATE TURPENTINE

Crude sulphate turpentine is a complex mixture of C10 monoterpene hydrocarbons composed mostly of alpha pinene (60-65%), beta pinene (25-35%) and Δ3-carene, which are the derivate products and the starting materials for the synthesis of a wide range of fragrances, flavours, vitamins and polyterpene products.

A widely used technology to separate turpentine uses batch rectification. The P&I diagram of the installation studied is shown in Fig.1 [6]. The equipment may be classified in the following main categories: Tanks (B-01, B-02, B-03, B-04), Evaporator, reboiler (W-01), Rectification column (K-01), Condensers (W-02, W-03, W-04), Pumps (P-01, P-02, P-03, VP-01, PV-01), many different types of valves, an air compressor system, a steam ejector system, and a vacuum creation system.

The process starts with pumping a batch of liquid feed into the batch tank B-01. When the tank is about 80% full, the feed is stopped and the content of the batch tank is heated to boiling by the preheated steam in the reboiler W-01. Once the mixture starts to boil, vapour is carried up the packed column K-01 and is condensed in the overhead condenser – W-02. Vapour rising through a column above the tank combines with reflux coming down the column to effect concentration. The condensate flows either to a reflux drum or to a decanter. Reflux is then pumped back to the top of the column. At start up, the system is operated at total reflux until the required purity of the most volatile component is achieved. At this point, the product is withdrawn at a rate controlled by the reflux ratio. The reflux ratio is set according to data from an on-line analyzer or temperature profile in the column. When the reflux ratio becomes too high (typically 15 or 30 to 1), then it is no longer economical to continue producing a top product. The flow is diverted to slop out tank, and the reflux ratio is reduced. Eventually the most volatile component will be completely driven off. The steps can be repeated for each volatile component required recovering.

The installation is controlled by some pneumatic feedback controllers. The most important of them, which are taken into consideration here, are: pressure feedback at the top of column; pressure difference feedback in the column, level feedback in B-02, and time based reflux ratio control. Currently all discrete control activities are manually done by two operators. This way, the defined three operating phases have the following duration of the processes: 2.83 hours for the start-up, 36 hours for the separation and 8 hours for the shutdown. The process requires considerable operator intervention and the development of an automatic discrete control system is expected to: improve the quality of products and increase the system reliability.

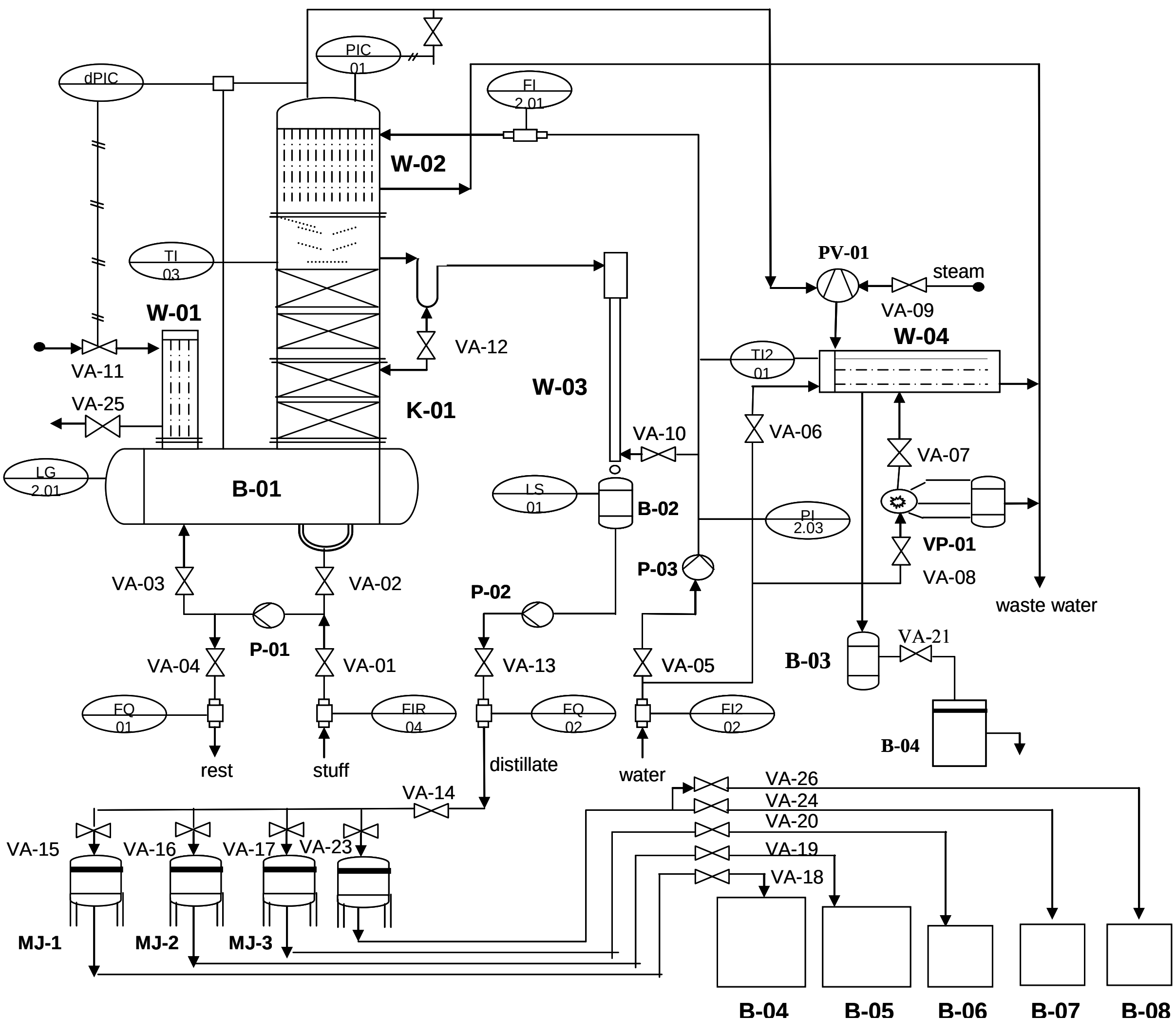

Fig.1: P&ID of the Industrial plant for Distillation of Sulphate Turpentine (UNIT according to S88 Batch Control Standard)

The processes are divided into three unit procedures: Preparing, Rectification, Shutting down. These three unit procedures of the plant are controlled by using functional components such as valves and pumps along with some analogue indicators. The reuse of software components depends on the functional requirements of each unit procedure. At the procedure level, these units will be run in series for the batch process: <Preparing, Rectification, Discharging (Shutting down)> (Fig.2). After the batch is done, a new batch can be processed.

According to ANSI/ISA SP88 batch control hierarchy, we proposed the service oriented architecture and appropriated web services for unit procedures: <Preparing, Rectification, Discharging (Shutting down)>.

BATCH PROCESS DOMAIN: NEED OF WEB BASED SERVICE SYSTEM

The high-performance level of batch operation, control and quality may be achieved by integrating the web based services systems with the concept of the standard for Batch Control, ANSI/ISA SP88, shortly known as SP88 or S88.

The main idea of SP88 is to separate the product knowledge from the equipment used. According to the standard, the batch process is defined as "a process that leads to the production of finite quantities of material by subjecting quantities of inputs materials to an ordered set of processing activities over a finite period of time using one or more pieces of equipment" [7].

Batching activities are focused on units, defined as "a collection of process and control equipment, and the associated control logic that carry out one or more major processing activities" [7].

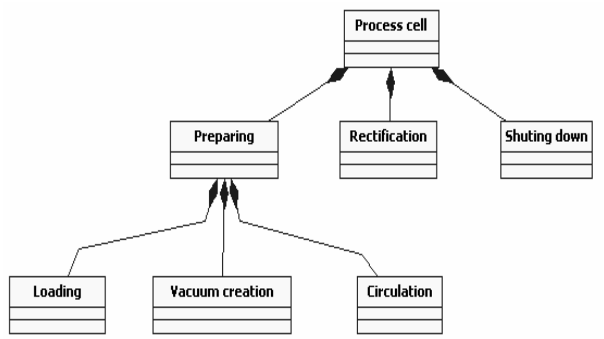

Fig.2: S88 hierarchy of the Industrial plant for Distillation of Sulphate Turpentine

An equipment module according S88 standard is "a functional group of equipment that can carry out a finite number of specific minor processing activities". This module may include control modules or other equipment module. In some cases, equipment modules can be replaced from control module. Control modules are treated as basic elements of the S88 physical hierarchy. They are defined as "collections of sensors, actuators, other control modules and associated process equipment that, from the point of view of control, is operated as a single entity" [7].

SERVICE-ORIENTED ARCHITECTURE FOR DISTILLATION OF SULPHATE TURPENTINE

Fig.3 shows the general structure of service-oriented architecture which contains of service consumer sending a service request message and service provider that returns a response message to the service consumer.

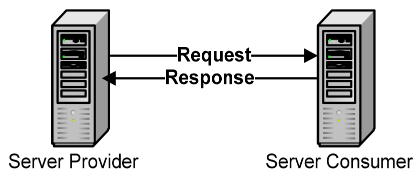

Fig.3: Service-Oriented Architecture

The web services provide the effective role and connection point between the batch process and data store at the one hand, and batch process and user interface at the other hand. When transforming the architecture to a SOA, one of the most important steps is the definition of services [11, 12, 13, 14].

Fig.4 shows the proposed service-oriented architecture using Web services for batch process system. Web services adapters transform non-XML formats into XML formats and back again and allow web services connections to systems. The application server provides middleware security services, state maintenance, data access and persistence.

The defined web services use Web Services Description Language (WSDL). The service provider describes its service using WSDL, which is published to a directory of services (Universal Description, Discovery, and Integration - UDDI). The service determines how to communicate with that service and uses the WSDL to send a request to the service provider. The service provider provides the expected response to the service consumer [15, 16].

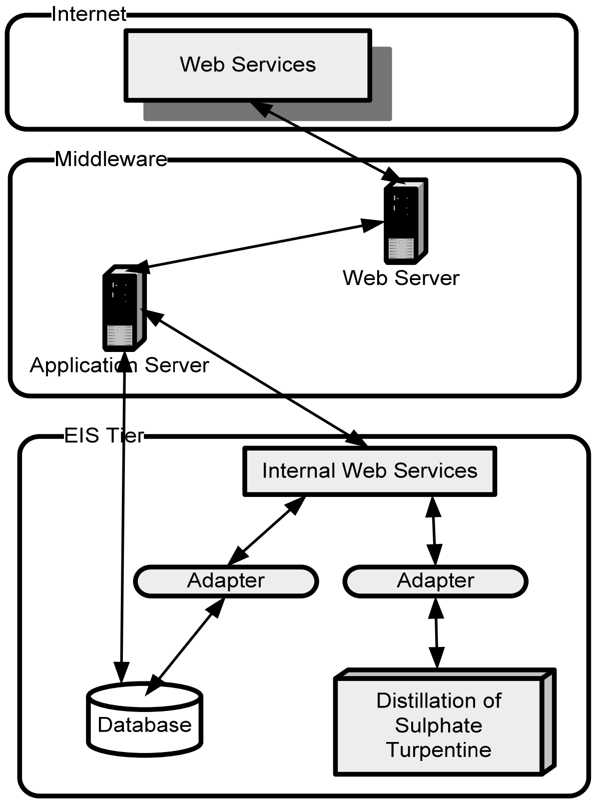

Fig.4: Web Service Architecture of Batch Process

Fig.5 provides a brief look at capabilities, how they fit into an SOA approach, and the technologies that support them. Data Service will be responsible to support the sharing and integration of data, for example enabling access to information stored in databases using in the batch process. Access Control Service includes mechanisms, which are required so that the identity of individuals and services can be established. Information Services include execution management, accounting services, problem determination and batch processes monitoring. Visualization Service will be responsible for the presentation of the visualized data. Client or interface will provide a way to define processing routine for a given data to manage the visualization process. Monitoring Service will be responsible for information, which is carries a field for batch processes, can be used for monitoring.

Preparing Phase Service collects data from control modules: valves, air compressor, ejector system and pump in preparation batch unit procedure. Rectification Phase Service includes control module of rectification unit procedure of the distillation plant compound of heating, cooling, refluxing and distillation operations. Shutting Down Phase Service will be responsible for stopping the plant control modules: all valves, pumps and systems in distillation plant.

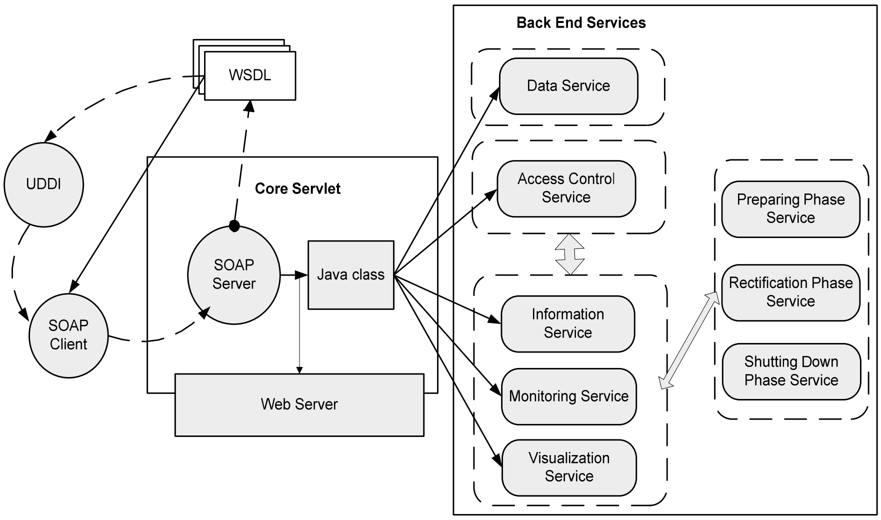

Fig.5: Web Service Architecture of Batch Process

CONCLUSIONS AND FUTURE WORK

Web Services have emerged as an important new field, distinguished from conventional distributed computing by its focus on loosely-coupled, self-describing, modular applications that can be published, located and invoked based on a set of Web-enabled standards. Over the last years, research and development efforts within the Web Services community have produced protocols, services and tools addressing precisely the challenges that arise when seeking to build interoperable integration.

In this paper, we proposed a service oriented architecture for batch control domain and appropriated web services for further process monitoring and visualization.

The future work of the team is to implement the proposed Web Services and performance evaluation in Web Services technology with respect to the Batch Control Domain.

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