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Development of a service oriented SCADA system

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Abstract

Monitoring and control of technological process, in many cases spread out over small or large geographical areas, are achieved with supervisory control and data acquisition SCADA. This is a fact imposed by technological requirements and also by economical aspects. This approach raises a number of problems, starting from the design and implementation solutions as well as security and safety in these systems. This paper makes a brief analysis of these issues, and starting from this point authors propose a solution based on Service-Oriented Architecture SOA which may represent a solution to some of the identified challenges. For the proposed solution a study is performed. The results are used to conclude on applicability conditions and recommendations on the design and implementation of monitoring and control systems in case of database-as-a-service DbaaS approach.

Keywords: SCADA; web service; service oriented architecture; database as a service; XML; WSDL;

1. Introduction

Organization of many production facilities and the nature of technological processes require the using of the advanced techniques for monitoring, control and supervising. Systems designed for this purpose are called supervisory control and data acquisition systems SCADA. When we consider SCADA systems we may think about a structure composed of the following components Ludovic at al., 2008, Egea-Lopez, E., et al. 2005.

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- the human–machine interface or HMI that represents physical or software devices through which the human operator is able to monitors and controls the process;
- the supervisory system with the main role of gathering data from the technological process, generate commands and sending these commands to the technological process;
- remote terminal units RTUs with the main functions of converting signals obtained from sensors to digital data and sending them to the supervisory system;
- field devices, nowadays implemented with programmable logic controller PLCs because of theirs economical, versatile, and configurable advantages;
- data communication infrastructure;
- various process and analytical instrumentation.

The structure and implementation of SCADA systems may vary depending on adopted technical solutions. If we refer to HMI components we can choose starting from dedicated solutions to web-based and mobile solution Chen, Q. at al., 2006, Turc, T. et al., 2011, Kirubashankar, R., et al., 2011. Some solutions propose advanced virtual instrumentation based HMI Turc et al. 2010.

An interesting approach we may found in case of supervisory systems that consist in case of small SCADA systems from a software application running on a single workstation or in case of larger SCADA systems from distributed software applications running on multiple machines. Some times complex SCADA systems benefit of complex redundant and disaster recovery solutions or in addition to common functionalities we may found new features consisting from decision support infrastructure Gligor A. et al. 2011.

SCADA systems offer several advantages such as:

- possibility of centralized process control, supervision and optimization of entire technological flow of a company;
- facile control over remote equipment that leads to reduced operational costs, increased equipments life, effective maintenance of equipment, etc.;
- scalability by allowing to extend an existing configuration with new process variables, more clients, etc.;
- availability of processes history by data storage;
- redundancy and increased reliability, etc.

The above advantages mainly lead to reduced operational costs, improved system efficiency and performance. In addition we must not neglect some of disadvantages of SCADA systems. Among them we mention those of:

- communications issues related to radio communications or protocols;
- dependability and security issues Gustavsson, R., 2006, Robles, R. J. et al. 2009;
- installations costs;
- issues related to system upgrade, etc.

In this paper we propose a solution to solve some of these problems.

Following we will briefly present the technologies proposed to be used, the system architecture and discussions on solution through the experimental results.

2. SCADA systems and service-oriented perspective

The SCADA systems in terms of computer science fits in the field of distributed computing domain. We have some data sources that communicate with their beneficiaries through a communication infrastructure. For properly operation, the source and recipient must be implemented in a manner that allows this communication. This raises a number of issues such as:

- in case we extend such a system there is necessary of using already implemented interfaces and protocols. Adding new features may require in some cases even to replace the entire existing system, but this may leads to raise the associated costs. Adding new features often requires considerable effort, high costs and even occurrence of security issues

- the evolution of the existing system while preserving existing stored data can be a real challenge.

Systems implemented based on the SOA have been developed as a branch of distributed computing. The difference between classical approach for SCADA systems and that based on service-oriented approach consist on tied loosely coupled nature of the components in the second case. This is because the interface of these components is independent of their implementation.

In case of service-oriented applications key solution lies in implementing its functionality as services based on the data request-reply design paradigm. Such data sources are presented as service for client/consumer modules.

Service-oriented architectures have the following key characteristics Shah, D., N., 2009, Erl, T., 2005:

- SOA services have self-describing interfaces based on platform-independent XML description. Services are described by using Web Services Description Language WSDL standard.
- SOA services communicate with messages defined via XML Schema. Communication among system components is possible in heterogeneous environments, with little or no knowledge about the provider implementation.
- SOA services are maintained in the enterprise by a registry that acts as a directory listing. Applications can look up the services in the registry and invoke the service. Universal Description, Definition, and Integration UDDI is the standard used for service registry.
- each SOA service has a quality of service QoS associated with it. Some of the key QoS elements are security requirements, such as authentication and authorization, reliable messaging, and policies regarding who can invoke services.

The conclusion that can be drawn here is that SOA is suitable through its features and benefits to the implementation of SCADA systems. Adoption of this type of solution can offer the advantage of eliminating the drawbacks related to the expansion and evolution of the system in case of the conventional SCADA systems implementation.

3. Architecture of the service oriented SCADA system

There are a large variety of SCADA applications. We mention here in case of the small-scale industrial plants examples such as: facilities in the chemical and petrochemical industry, pharmaceutical manufacturing; water management systems; metallurgical process plants; traffic monitoring and coordination, or in case of large-scale applications we can mention: electric-power transmission and distribution systems; generating power plants; oil and gas transportation systems; environmental control systems. Therefore it is difficult to adopt a universally solution. Following we will present a generic solution which can be adapted to the specifics of each application.

The proposed idea is based on identifying all system functionalities and implementing them as services. Thus as shown in Fig. 1, we need to find all functions that have a local role and functions that are at the system level.

At the local level is proposed to implement a Local Directory Service that can provide a description of local services available and how to access them, the description and how to access the central system services.

When implementing a new control or monitoring module we will record the description and how to access it in the Local Directory Service. A generic description can be based on a template, obtained from a Directory Service or may be created a new description.

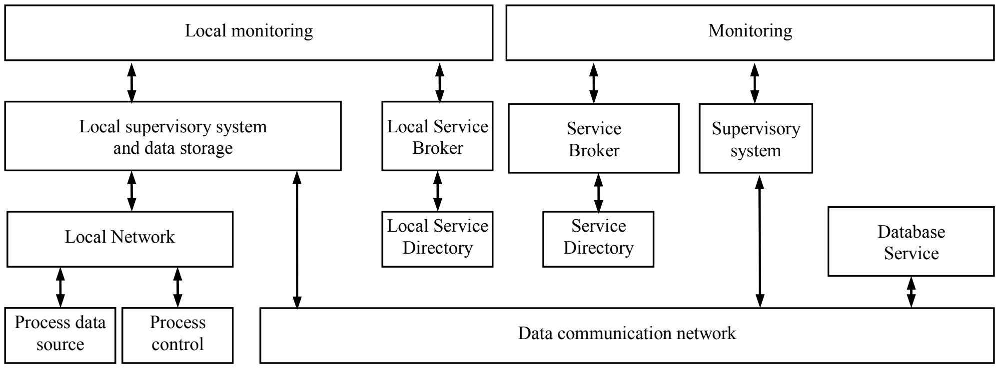


Fig. 1. Service-oriented SCADA system architecture

An item of description will contain records related to the associated Local Supervisory System wherewith will communicate. The Local Supervisory system will be designed to take data or provide data to the monitoring or control module. This data will be stored temporary locally and then by the Database Service will be stored in a database system. The latter can be centralized or distributed database.

If possible we recommend using the Database as a Service DbaaS technology in order to obtain high performance in terms of access and data security.

For local monitoring operations, if we know the parameters of the Local Supervisory System we will access its services. Otherwise in the first phase via the Local Service Broker we will obtain the necessary data from the Local Directory Service

The system can be implemented based on a single centralized node or distributed nodes depending on imposed functionalities and requirements. Each central node consists of a Supervisory system, Service Broker, Service Directory and Database Service responsible for data storage from its own SCADA segment.

This approach is very flexible; allowing a facile system extending through adding new functionalities to existing services or defines new ones in accordance with needs and formulated requirements. It can also be reused existing services in the form in which they are or can be extended to implement new features.

This last feature will depend greatly on the technology used for implementation. But currently existing platforms allow such characteristic.

System evolution is also supported. It is possible to migrate from an old to a new configuration with gradual decommissioning of the old system by using as required the facilities with old and new features in parallel.

Also in this version of the proposed solution will better satisfy the requirements of security in the sense that the system can be corrected on the fly in terms of security.

The goal to obtain systems at lower costs may represent a disadvantage of this architecture due to higher resources requirements than in conventional variant. In the future we will see this problem solved by optimization provided for development platforms and the evolution of computers and devices used in SCADA systems in terms of price and available resources.

4. Implementation and experimental result

For testing purposes was built a generic web-based SCADA system following the proposed architecture. The testing prototype consists from some nodes spread on a large geographical area. As data integrity was a requirement the most suitable solution for given approach is to use cloud technology. Among available alternatives we choose to use for data storage the service offered by Xeround with cloud data center provided by Rackspace US ORD1 Chicago. The solution consists on a database-as-a-service for MySQL applications. This was an ideally environment for testing the migration of data from an old database to new technology. However as the service was provided free of costs the available resources were limited. To have more realistic approach we implemented some local supervisory systems on various platforms: Windows and Linux on three testing node. Table 1 shows the average of database service machine response for each testing node.

Table 1. Database service server response

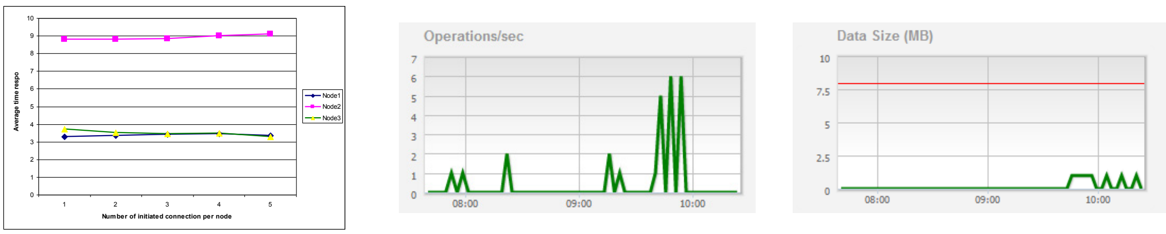
Node	Platform	Hardware configuration	Average time response (ms)
Node 1	Linux	Pentium(R) Dual-Core CPU E5200, 2.50GHz	134
Node 2	Linux	Intel(R) Pentium(R) Dual CPU E2140, 1.60GHz	156
Node 3	Windows	Inter(R) Core(TM) i7-2630QM, 2.00 Ghz	125

In the first scenario we tested the speed and the availability for data store process. There were conducted two type of test: data storing without and with persistent connection. The main results are presented in Table 2 where data packet consisted from few numerical values of some process monitoring variable. It can be observed that in case of complex communication network topology, as it is available for Node2, we obtained higher values for time response. If we have periodically available data, storage in persistent connection mode gave better results. The results show that significant influence on performance is related to the communication infrastructure.

Table 2. Data storage performance tests

Node	Average time response for one packet of data (s)	
	Non—permanent connection	Permanent connection
Node 1	0.9180	0.1343
Node 2	6.1201	0.3088
Node 3	0.8851	0.1341

In Fig. 2 are presented some performance related to using a SCADA system with the data storage provided by a service located in a cloud.



a) b) c)

Fig. 2. a) Database service response b) Cloud database usage operation/sec c) Data size

5. Conclusions and future works

This paper presents an improved SCADA system architecture based on service oriented technology approach. The proposed solutions enable migrations of existing SCADA systems progressively, without decommissioning of the existing system. This can be a seamlessly solutions for critical system that do not permit to be turned off.

The SOA based solution enables integration of heterogeneous solutions by using the XML standard in operation of the system software components.

Service-oriented approach offers the advantages of a flexible and open solution adaptable to the needs for entire lifecycle of the system. Depending on existing requirements it can be adopted synchronous and asynchronous access approach.

Migration of existing system and data to the new platform is possible to be done without loss of data loose due to the transparent manner in terms of data storage offered by the database as a service available solutions.

Service-oriented architecture allows developing more advanced SCADA system by using new technology such as agent based and multi agent systems.

Security of newly or existing system can be improved by on-the-fly system redesign and implementation. In more advanced way by using security implemented by services will allow fast security problems corrections.

The benefits set out are not just on the technical aspects, but contribute fully to the economic advantages in terms of lowering operational and upgrade costs.

In future we intend to continue development of the proposed system and conduct studies on the security vulnerabilities and system performances.

References

Chen, Q., Ghenniwa, H., Shen, W., 2006. Architecture of a Web-Based Power SCADA System Using J2EE Technology, in "*Information Technology for Balanced Manufacturing Systems*", Weiming Shen, Editor, Springer series in Computer Science, NY, pp. 377-384.

Egea-Lopez, E., Martinez-Sala, A., Vales-Alonso, J., 2005. Wireless communications deployment in industry: a review of issues, options and technologies, in "*Computers in Industry*", No. 56, Elsevier, Weiming Shen, Editor, Springer series in Computer Science, NY, pp. 29-53.

Erl, T., 2005. Service-Oriented Architecture: Concepts, Technology, and Design, Prentice Hall, NJ., pp.219-276.

Gligor, A., Dumitru, C.-D., 2011. Agents-Based Distributed Processes Control Systems, in Proc. of "*The 5th Edition of the Interdisciplinarity in Engineering International Conference, Tîrgu Mureş, Romania, 2011*", Petru Maior University Press, pp. 121-125.

Gustavsson, R., 2006. Ensuring Dependability In Service Oriented Computing, in Proc. of "*The 2006 International Conference Securuty and Management*", Hamid R. Arabnia and Selim Aissi, Editor, CSREA Press, Las Vegas, Nevada, USA, pp. 3-11.

Kirubashankar, R., Krishnamurthy, K., Indra, J., Vignesh, B., 2011. Design and Implementation of Web Based Remote Supervisory Control and Information System, in "*International Journal of Soft Computing and Engineering (IJSCE)*", Vol. 1, issue 4, Shiv K Sahu, Shachi Sahu, Editors, India, pp. 43-51.

Ludovic, P.-C., Pascal, S., 2008. Cryptographic Key Management for SCADA Systems, Issues and Perspectives, in "*International Journal of Security and its Applications*", Vol. 2, No. 3, J. H. Abawajy, B. Bhargava, Editors, SERSC, Sandy Bay, Tasmania, Australia, pp. 31-40.

Robles, R. J., Choi, M.-k., 2009. Assessment of the Vulnerabilities of SCADA, Control Systems and Critical Infrastructure Systems, in Int. Journal of *"Grid and Distributed Computing"*, vol. 2, No. 2, Osvaldo Gervasi, Editor, SERSC, Republic of Korea, pp.27-34.

Shah, D., N., 2009. A Complete Guide To Internet And Web Programming, Dreamtech Press, New Delhi,

Turc, T., Gligor, A., Dumitru, C., Morar, A., 2010. Development of extensible virtual instruments for SCADA applications, in Proc. of *"2010 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)"*, vol. 3, pp.1-5.

Turc, T., Gligor, A., 2011. Development Of Service Oriented Web-Based Scada Application, in *"Scientific Bulletin of Petru Maior University of Tirgu Mures"*, vol. 8, nr. 2, Petru Maior University Press, pp.119-122.