A SURVEY OF NEW TEHCHNOLOGIES IN A MODERN EMS

Naser Mahdavi Tabatabaei[1] **Leila Zeini[2]** **Ata Fakhri[2]**

1 Electrical Engineering Department, Azarbaijan University of Tarbiat Moallem, Tabriz, Iran
n.m.tabatabaei@gmail.com
2 Electrical Engineering Department, University of Tabriz, Tabriz, Iran

Abstract- With the rapid development of computer communication network and information technology, as well as the demand of power market, developing of the new generation EMS is necessary and possible. This paper introduces the evolution of energy management systems and present the attributes of new technology are used in modern EMS.

Keywords: SCADA, EMS, DBEMS, WWW, GVM

I. INTRODUCTION

Energy Management System and Supervisory Control And Data Acquisition (EMS/SCADA) have previously been constructed as centralized systems using proprietary control computer and operating systems. But a centralized system imposes a burden on power utility company in the sense that it is sometimes difficult and uneconomical to expand or upgrade the system. When a utility wants to improve and/or add some functions, it sometimes has to upgrade the Existing computer's memory capacity or replace it with a higher-grade computer. On the other hand, a recently emerging trend in the development of computer and communication technology has been making it possible to establish open distributed computer systems [1].
The static world with a closed control room within the utility industry is changing to an environment. The driving force for this is the need for utilities to have accurate data available for quick business decisions on a deregulated market. Cost reduction and quality improvement facilitated by increased information exchange is a strong incentive for utilities to require open system enabling integration. Constantly, changing requirements force the utility industry to establish communication between new combination of systems and changing sets of application within a system. This results in new requirements on flexibility and openness for systems and applications.

II. EVOLUTION OF ENERGY MANAGEMENT SYSTEMS

A. First Generation EMS

The first generation of power system control center appeared in 1970s .It was based on the computational architectures available at that time [2]. The first generation EMS was a SCADA system based on special electrical computer and special operation system. This system could complete the fundamental SCADA function and had no application functions. This generation of control center has been successful in enhancing the quality of supervision and control of power systems.
But the computational architecture included some hidden problems. The computers and software used soon became obsolete, and the dynamics of the market eliminated many of their original manufacturers. To keep the control centers operating properly, utilities needed to replace defective components, add new functionality and increase the computational load. But the deep connection among software components and hardware made it very difficult to update or expand both hardware and software. Maintenance was increasing and expensive,

with low performance and decreasing reliability. Those control centers were not able to follow the evolving operational requirements [2].

B. Second Generation EMS

The second generation EMS was developed in 1980 and has quite perfect SCADA function and some application functions [2]. At that time the appearance of low cost but powerful computers, together with the evolution of networks, allowed for the emergence of distributed processing. Networks of workstations and personal computers quickly replaced the old mainframes. This decentralization led to a rush for standardization in different fronts, because standards were essential to connect the various network computers. The C programming language, Windows and Unix are some of the standards, that appeared. To avoid the problems of the first generation of EMS/SCADA system, most control center software developers adopted the generalized use of standards.

C. Third Generation EMS

The third generation EMS developed in 1990s that was a Risc/Unix based distributed open EMS. Previous generation of EMS/SCADA systems have been centralized systems using proprietary control computer and operating systems. But a centralized system imposes a burden on power utility company in the sense that it is sometimes difficult and uneconomical to expand or upgrade the system. When a utility wants to improve or add some functions, it sometimes has to upgrade the existing computer's memory or replace it with a higher-grade computer.

The problems of centralized systems are [1]:

i) The function, performance, and number of input control points designed at the initial design stage are fixed and it is normally difficult to change such parameters;

ii) If the utility tries to prepare a system considering future expansion to higher functions, higher performance, and more input control points, it must prepare large computers than required at the initial stage, which raises the initial investment;

iii**)** It is generally difficult to connect the system whit other systems because the operating system and interface are proprietary. On the other hand, a recently emerging trend in the development of computer and communication technology has been making it possible to establish open distributed computer systems. Such technology has also been introduced into EMS/SCADA systems.

In order to solve for the problems related to the centralized systems problems the distributed open EMS has been developed. This generation EMS adopted business relational database, advanced graphic display technology and SCADA functions were more mature and standardized. EMS application functions were more perfect and it has made great contribution to the stable and safe operation of power systems. But development of computer technology and power industry and the third generation EMS deficiencies was affected industry standards, poor user interface openness, lacking flexibility and portability.

D. Modern EMS

Appearance of powerful computers and the fast development of communication networks and databases technology make developing the fourth generation EMS necessary and possible.

New technologies such as Common Information Model (CIM), Control Center Application Program Interface (CCAPI), Object Oriented Relational Database (OORDB), Java, Multi Tiered Architecture, Multi Agent System and Artificial Intelligence are applied in a modern EMS.

The attributes of modern EMS are:

1) Expandability and flexibility

2) Scalability

3) Conformity to international standards
4) High reliability
5) High functionality and high performance
6) High level human interface

III. New Technology in Modern EMS A. OORDB Technology

Object oriented technology with respect to reusage, encapsulation, inheritance, and openness and also by introduction of object oriented analysis and programming affected software engineering. Object oriented technology developed by object-oriented language such as C++, Java and Unified Modeling Language (UML). Object oriented technology affected the development of database technology. Relational database are suited for practical on line applications [3].
Relational model instead with object model and developed object oriented relational database. Object oriented relational database have advantage such as clear database structure, more independent database objects and easy to reuse.
In the modern power system, one object oriented relational database management system (OORDBMS) can be employed to replace all the special purpose proprietary databases found in the EMS.
If necessary, a centralized master database can replicate its contents to multiple distributed databases based on the use of one of OORDBMS technologies.

A. Artificial Intelligence in EMS

In the past several years, artificial intelligence technology has profoundly affected dispatching automatic system. Expert System, Artificial Neural Network, Fuzzy Logic, Genetic Algorithms and Petric Net have been applied into many aspects such as intelligent alarm system, short term load forecasting, unit commitment, reactive power optimization and other EMS applications [4].

B. Multiagent System

Multiagent system (MAS) technology is a new multidiscipline research field regarding computer technologies and distributed artificial intelligence.
It is one of the strongest tools for constituting large scale distributed and open computer based systems which are widely needed in the field of scientific computing, mechanical engineering, enterprise management and power system.
The development of power market demands high ability of EMS short-term decision and interoperation among EMS application. MAS can be used to improve the interoperation ability.
MAS offers an effective solution to the limitations associated with the current approaches to systems integration by offering a common communication language. Each system can be thought of as an "agent" operating within a community of agent, namely the MAS. An agent can be considered as a piece of software or system with enough intelligence to manage its own processes and communication with other agents. Thorough a process of inter agent communication, each agent can cooperate to provide all the benefits of system integration in a flexible and open manner [5].
MAS technology has been usefully used in EMS for short term load forecasting and security constrained optimal power flow.
Another promising way of the mass application in EMS is MAS based EMS architecture. The MAS architecture of EMS combines the advantage of component technology and multi agent technology.
The software agent consists of two parts: logical communication and control module and function implementation module. Figure 1 shows the MAS based EMS architecture.

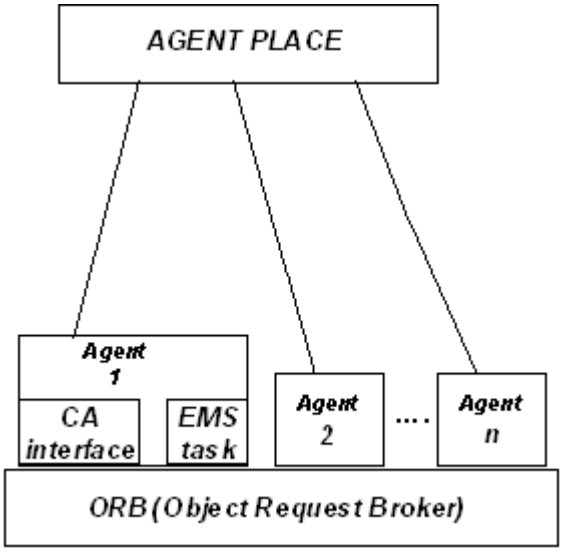

Figure1. MAS based EMS

This architecture will make the EMS run more robustly and flexibility and meet the ever-increasing requirement of reliability and interoperability for new generation EMS.

C. Web Based EMS

Nowadays, the web is becoming a universal access interface for a high number, and different kinds of information services. One of the demanding field concerns SCADA systems used at industrial environment or big control infrastructures.

The web is not only used as a medium to data, information, and knowledge, but also used as general distributed computing environment for offers common user interface, richer interaction possibilities, and platform independent features.

The World Wide Web (WWW) has become a convenient way to access information on the net because the WWW browser integrates different network services into a common easily accessible user interface.

The web is very successful as a generic user interface to a wide number of Information and Communication Technology (ICT) services, because of its popularity, the low cost of graphical environment compared to custom, programs and its flexibility. There exists a lot of interest in providing access from the web to control applications. It is found a great diversity of solutions depending on the specific control system, like the integration of web servers into microcontrollers, the use of dedicated web servers for SCADA software written as attached module to it, and so on [6]. EMS developers are currently promoting internet technology in place of the user interface. The attributes of internet technology are popularity, standardization, and low cost, high degree of portability over a wide range of computing platforms.

SCADA systems are usually big and complex programs written for a specific platform such as Windows and Unix. To access them we need to call function belonging to their modules.

In the future the browser technology will replace most vender proprietary user interfaces. All EMS displays will be web page used to view, modify, monitor and control the execution of the EMS functions. The difficulties here are system on line diagram display and dynamic data refresh. Already, the use of Java and CAD tools can provide sophisticated graphic capabilities that rival the proprietary one line EMS displays in aspect of quality and performance [7].

Java is a general purpose, high level programming language and a powerful software platform. It is object oriented, robust, secure, architecture neutral, portable, and

multithreaded. Its executable code runs on any hardware and software platforms, provided that a Java runtime system called Java Virtual Machine (JVM) is present.
Java language offers unique and powerful features such as zero client installation, on demand access and platform independence to the design of the EMS system, particularly to SCADA system. Java is the first programming language designed from the ground up with networking in mind. Java strictly realizes the fouler main features of object oriented technology: encapsulation, polymorphism, inheritance, and dynamic binding. It provides solutions to a number of problems, which are difficult to address have multithreading and safety. Java makes writing networking programs easy. It is relatively straightforward for Java applications and applets to send receive data and to communication across the internet, limited only by security measures such as firework, user identification, encryption, and other. These features are especially suited to the SCADA system.
Java executed in a run time environment called a JVM. The JVM executes byte code that a Java compiler generates and it can be incorporated or embedded in web browser, or the kernel of the operating system. A Java based SCADA system can run across different platforms without any modification. Hence, Java becomes a good platform for writing client/server web based applications.

D. Multi Tiered EMS Based on Java

The three tiered client/server architecture in the three generation SCADA/EMS system is adopted. This system can be divided into three layers. The first one is Remote Terminal Unit (RTU), which are in charge of collection and transmission of the data of field devices. The second layer is the most important on that can mask the intricacy of data exchange with RTU and the third layer. Through it the programmers in the third layer can transparently read or write data of device without knowing the specific device. The device driver software is just installed in this layer. The third layer is client terminal that is the interface between human and machine [8].

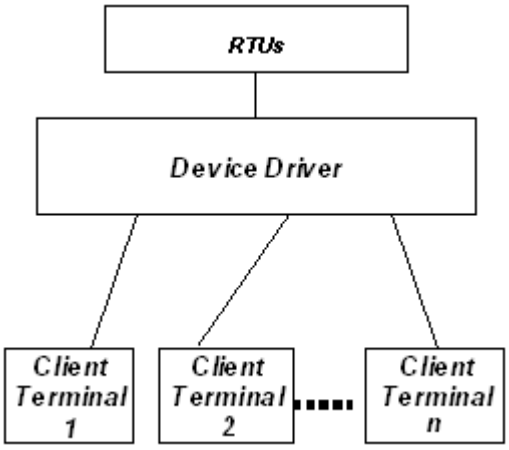

Figure 2. Three layer model SCADA

Three tiered client/server provided the stability and robustness required to support mission critical applications through the dispatcher can control and monitor the status of field devices by client terminal. Figure 2 represents the three-layer model of SCADA systems with enterprise comprising thousands of users. But with the development of computer technology and the construction of power markets, this client/server architecture has the problems of system resources shortage and security. In order to improve the system efficiency, the multi tiered software architecture appears as shown in Figure 3.
The system consists of four tiers: client tier, web top tier, application tier and database tier.

Client tier is the presentation layer where the client machine is located. It is a Graphic User Interface (GUI). Web top tier works as a proxy programs and static data and provide the ability of local resources access. The Application tier is the application server, which implements the application logic to process data request. Application tier is the most important one in multi tiered structure. All the database access operations are complete in this tier a web server is running on the machine to receive server request from clients, and send response back to client [9]. The advantage of multi tiered EMS are:

1) Reduce of data transferred through Wide Area Network (WAN) because of the use of WebTop tier

2) Improvement of system security because all client ends can not access database directly

3) Easy to management

4) Client ends do not connect with database directly, the system can complete the client request with fewer resources.

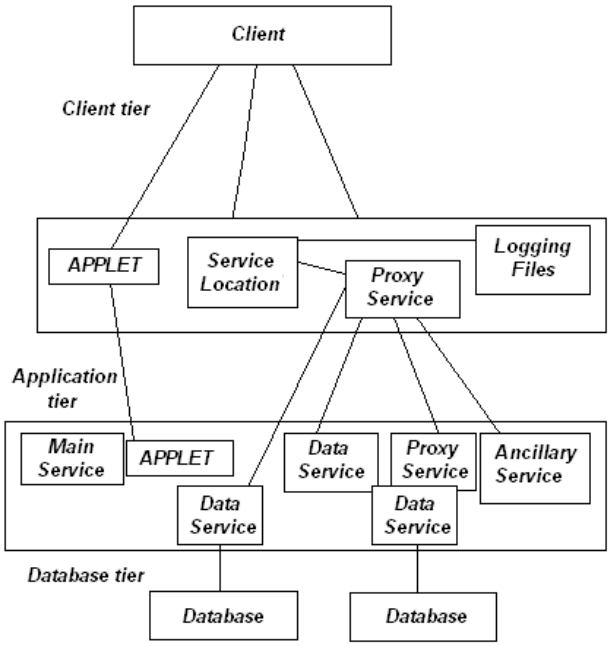

Figure 3. Multi layer EMS

IV. CONCLUSIONS

The rapid development of computers, database technologies and demand of power markets cusses the developing of the new generation EMS necessary and possible. In this paper the evolution of energy management systems is introduced and presented the attributes of new technology used in modern EMS such as CIM, CCAPI, MAS, OORDBMS, Artificial intelligence, Web based EMS, Java and Multi tired EMS.

V. REFERENCES

[1] N. Toshida and M. Uesugi, "Open Distributed EMS/SCADA System," Hitachi Review, vol. 47, no. 5, pp. 209-213, 1998.

[2] G.P. Azevedo and A.L Oliveria Filho, "Control Centers with Open Architectures," IEEE Computer Application in Power, pp. 27-32, October 2001.

[3] Lars Grasberg and Lars-Ola Osterlund, "SCADA EMS DMS - A Part of Corporate IT System," IEEE, 2001.

[4] D. Junwei and S. Yaming, "Short Term Load Forecasting Algorithms for Neural

Network," Automation of Power Systems, vol. 24, no. 2, pp. 32-35, Jan. 2000.
[5] J.A. Hossack and J. Menal, "A Multiagent Architecture for Protection Engineering Diagnostic Assistance," IEEE Transaction on Power Systems, IEEE Transaction on Power Systems, vol. 18, no. 2, May 2003.
[6] W. Adnan and M.I. Yusof, "Web Based Application for Energy Management System in UiTM," Student Conference on Research and Development Proceedings, Shah Alam, Malaysia, pp. 444-447, 2002.
[7] D.Th. Askounis and E. Kalfaoglu, "The Greek EMS-SCADA: from the Contractor to the User," IEEE Tran. Power Systems, vol. 15, no. 4, pp. 1423-1427, November 2001.
[8] N. Fullerton, "EMS Architecture," in Colloquium on the New NIE Energy Management System: IEE 1998.
[9] A. Moser and G.C. Ejeb, "Network and Power Applications for EMS within a Competitive Environment," IEEE Trans. Power Systems, pp. 280-285, 1999.

ELEKTRİK ENERJİSİNƏ MÜASİR NƏZARƏT SİSTEMLƏRİNİN YENİ TEXNOLOQİYASI ÜZRƏ İCMAL

TABATABAEİ N.M., ZEYNİ L., FƏXRİ A.

Kompüter şəbəkələrin və informasiya texnologiyalarının sürətli inkişafı və eyni zamanda elektroenerji bazarının tələbləri şəraitində elektrik enerjisinə nəzarət üzrə yeni sinif sistemlərin işlənilməsini vacib etmişdir. Məqalədə elektrik enerjisinə nəzarət üzrə olan yeni sistemlər haqqında və yeni texnologiyaların xarakteristikaları üzrə məlumatlar verilmişdir.

ОБЗОР НОВЫХ ТЕХНОЛОГИЙ В СОВРЕМЕННЫХ СИСТЕМАХ КОНТРОЛЯ ЭЛЕКТРОЭНЕРГИИ

ТАБАТАБАЕИ Н.М., ЗЕЙНИ Л., ФАХРИ А.

В условиях ускоренного развития компьютерных сетей и информационных технологий, а также потребностей рынка электроэнергии, необходима разработка нового поколения системы контроля энергии (СКЭ). В статье приводятся данные об эволюции СКЭ и характеристиках новой технологии, применяемой в современных СКЭ.