Power Sector SCADA: Person-Centric Graphical User Interface

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Abstract-- **The Perspective of the same real time data set at different levels are required for different aspects. It is required to have customized and intended data set for a particular user. This paper addresses a person-centric GUI (graphical user interface) to empower power sector as well as the whole SCADA (Supervisory Control and Data Acquisition) implementation .This paper presents newer and innovative approach to realize configurable, personalized and scalable GUI and how the web portal can be helpful for the SCADA application to make the GUI person-centric.**

The display of real time data set as visualized by the individual user will be depicted on login. The person-centric GUI will be helpful to depict the default GUI for a particular user on the basis of the configuration made by the user and day to day activities traced by the intelligent system, running on the web server. The display adapts to the context of the system and the behavior of the user. The proposed approach enhances ease of usability of GUI, the speed up, granularity of data and controls the network traffic as well.

Index Terms -- **EMS, GUI, HMI, MMS, RTU, SCADA, SLD**

I. INTRODUCTION

The SCADA system is a computer system for gathering and analyzing real time data. As the name indicates it is not a full fledged control system rather a supervisory system which accumulates real time data and presents it for different level of monitoring depending upon authorization level of user. The SCADA system includes various sub systems like data configuration system, HMI (Human Machine Interface) and the data acquisition system to get data from RTU (Remote Telemetry unit). The same set of real time data needs to be depicted differently for different users or SCADA operator depending upon their authorization and needs.

The HMI is one of the subsystems of SCADA system which is basically responsible for the visualization of real time data where adaptive and person-centric GUI plays a vital role in depicting the real time data set. This paper is concerned with the visualization part of the real time data set and how effectively the proposed system can handle it. The paper describes the design of GUI in order to get better ease of usability and personalization of GUI according to user's preferences, as much as possible [10], [11] and [14].

The rest of the paper is organized as follows. Section II gives an overview of the basic architecture of SCADA system. Section III describes person-centric GUI with respect to the SCADA system. Section IV discusses the proposed GUI architecture for SCADA system as well as the system design and implementation issues and features of the proposed system. The web portal for SCADA is discussed in section V. The C-DAC utility portal is discussed in section VI Finally, Section VII summarizes our discussion.

II. BASIC ARCHITECTURE OF SCADA SYSTEM

The basic architecture of SCADA system includes three major components namely RTU's, communication system and HMI. The functionality of RTU is to gather required data from the site, communication systems involve communication between different levels like RTU to master system and master system to various control centers and the HMI is required to visualize data. Modern SCADA systems are designed as distributed System. The communication media can be private media like private wire, wireless, microwave or public media like leased line wired connection, telephone line and satellite or other media like Wi-Fi.

The architecture of SCADA system should be distributed and hierarchal to have more reliable and robust system. The SCADA system must include redundancy at hardware level as well as software level in order to avoid failure and to have high performance which is required for critical and real time application like EMS (Energy Management System).

The SCADA solution can be intranet based, internet based or both according to the client's requirements. The HMI, which is required for visualization of GUI for a user or a SCADA operator, is the concerned area of discussion which has been discussed in this paper.

III. PERSON-CENTRIC GUI

The person-centric GUI is the user adaptive GUI which has the ability to adapt itself according to the user's preferences. In real time application like SCADA the HMI must be person-centric where different user and SCADA operators have their own perspective to visualize the real time data set. In order to incorporate adaptive and person-centric GUI, there must be some intelligent system to track down the user's behavior in order to depict GUI according to the user's activities. The personalization of GUI for any application will enhance the ease of usability of the application as it will facilitate with configurable user's personal preferences as well as application based user's preferences. So the users can personalize and configure their desktops according to their requirements and

likes.

Same set of real time data can be visualized by different control center operator with the different perception. In Fig. (1). we have shown how the same data can be seen with the different perception. The intelligent system always tracks the activities of the operator and according to their activities; the intelligent system will depict the GUI when user logs in. For each operator default set up will be different. The advantage of the person-centric intelligent system based GUI is no manual configuration of required component on the web every time it will be depicted automatically.

Person-centric GUI for the SCADA gives the ease of usability for actual user like Control Center operator as well as for the light user like top level authority, those who want to visualize data occasionally .The light user of the SCADA System can also configure his requirements and he can visualize the data with own perception . It is also possible to depict GUI based on the events triggered based on the time constrain. It is also possible to have different profile for the same user. So we can access the history of the user's activities if required.

The adaptive ness of the GUI with respect to the SCADA System is discussed below. The GUI is configurable and the default GUI will be depicted automatically with the help of user's activities traced by the intelligent component. Same plant data set can be seen differently by the different user in both intranet and internet scenario. Among the Configured SLD's of the plant the different SLD can be visualized by the different operator on the basis of their configuration as well as activities traced by the intelligent components.

Here we have shown the block diagram on that basis we can describe the adaptive ness of the GUI with the operator, the actual user of GUI as well as the light user like top level authorities.

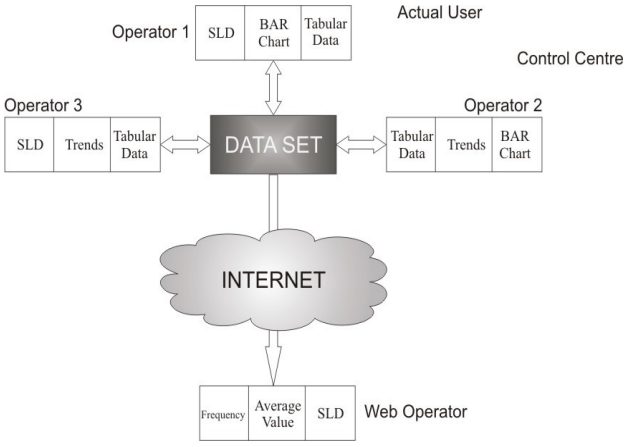

Fig. 1. Adaptive GUI with different operator

Here the 1st operator and 2nd operator can visualize the same set of data with the different perception depending upon the configuration made by the individual operator. The same control center operator can login remotely through the internet as web operator. Here we can also observe the perception of the light user, who rarely visualize the GUI but there will be provision according to their configuration and on the basis of triggered events, the particular GUI will be depicted.

IV. System design and implementation

The Object Oriented Design (OOD) approach has been taken into consideration and implementation of the proposed system is java based and there is no native code support.

A. Architecture of Proposed System

The proposed GUI for SCADA has two different aspects i.e. user interface for internet and intranet specific architecture. Both the internet and the intranet based architecture must have intelligent system to facilitate the user or SCADA operator to have customized, configurable and personalized user interface as shown in Fig.(2). The main functionality of the intelligent system is to gather the user specific information, process the stored information and depict personalized GUI to the user. The web portal is also a part of the design and implementation of proposed system which will let the user and SCADA operator to be more interactive with the user specific requirement as well as SCADA system related information which will become single point of access. So the web portal for SCADA system will revolutionize and personalize the application [1].

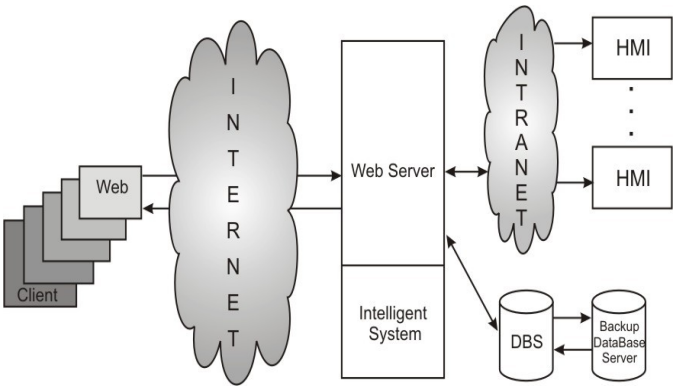

Fig. 2. Overview of Proposed System

In Fig. (2), the proposed architecture of the system is depicted which includes the various components. The description of the components is as follows.

1.) Database Server: The Database Server is the relational database engine which stores all real-time operational data, historical data gathered from field and person–centric information. The data is organized properly to meet the real-time application requirements. The database server component is a robust, high –performance and fully scalable sub system. The person-centric data stored is retrieved by the intelligent system for personalization of GUI. As far as real time data is concerned, the data access latency should be less to have faster response.

2.) Intranet Clients: The Intranet client is the part of intranet specific architecture. It communicates with the database server through the web server in order to depict person-centric GUI with the help of intelligent system. Intranet clients contain the stand alone GUI with all facilities needed for the operators to configure the desired component on HMI.

3.) Web Server: The web server is the entry point of all HTTP requests and it serves the user's HTTP request with the intelligent HTTP response. The intelligent system makes the web server more intelligent by serving the user's HTTP request according to user's previous browsing history. Web server also contains the information about online users. When a particular user is logged in with proper authorization, the web server sends intelligent, dynamic and person-centric GUI as a response. The intelligent system is for processing the user's data and making web server more intelligent to response dynamically.

4.) Web Clients: The web client is the system which makes HTTP request to the web server and gets access to real time data set with proper authorization and authentication. The web clients get HTTP response from the web server according to users' request with processed data which gets depicted graphically to the web client. Here the web client gets the web pages which are dynamically generated by the web server with the help of intelligent system's person-centric processed data and the configuration made by the users according to their requirement. The web pages viewed by the web client will be adaptive according to the system, for example mobile, laptop or PC.

5.) Intelligent System: The intelligent system tracks the user's activities and according to the activities, the intelligent component provides the GUI for the particular user. It runs on the web server which keeps track of all intranet and internet client behavior and depicts GUI accordingly. When user logs in and sends the request to the server the intelligent system on the web server tracks the user's activities and when the user logs out off the session the intelligent system updates user specific preferences to the data base [3].

6.) Back up Database Server: In order to provide reliability to SCADA system there must be a back up system or redundant database server to avoid failure. The database is replicated since real time application like SCADA, the real-time data is critical for controlling purpose. According to the above sub component specification and description the proposed system architecture can be classified as internet based, intranet based or combination of both depending upon the requirement of the application client.

7.) *Human Machine Interface*: The HMI is supported by the configured SLD's and displayed on web browser with the support of AJAX [Asynchronous JavaScript and XML] technology. The values of the component placed in the HMI will be updated on run time. The HMI also contain various components like IPSGE (Integrated Power System Graphics Editor), XPMS, trends and various diagrams.

The IPSGE is Graphics editor to design the SLD and various components configured in the HMI, based on Java Swing technology and all components are configurable and supported with the XML file. The XPMS (X–Para metering System) is for configuring the tags for HMI, which has the configurable GUI supported with XML for all types of configuration and database connection.

B. Internet and Intranet Model

1.) Internet Specific Person-centric GUI: In web based person-centric GUI, the proposed system follows the 3-tier client-server architecture where the intelligent system resides on web server which is the middle layer's part of 3-tier architecture as shown in Fig(3) .The middle layer is totally responsible to process the users request and manipulates the presentation layer accordingly[5]-[7]. When authorized user sends the request for logging in, the web server sends the intelligent response with updated and intended real time data set to depict GUI at run time. The web based design of GUI for internet includes personalized, configurable person – centric information to depict it graphically. It also increases the granularity of data as it receives only desired real time data set.

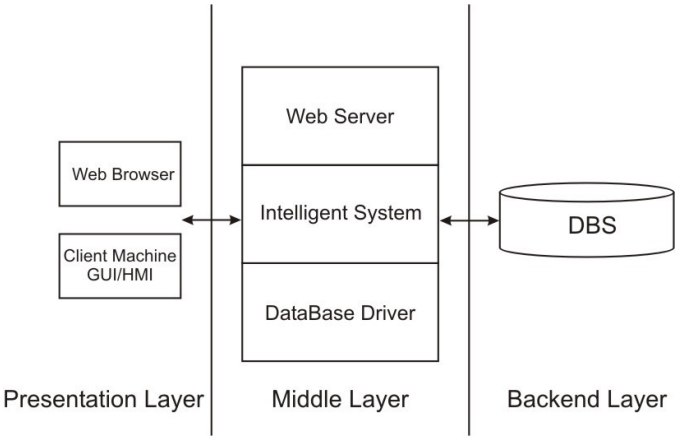

Fig. 3. Three- tier Architecture of proposed System

Following are the features of the internet specific person-centric GUI.

a) Optimization of data: In the heavy internet traffic it is important that the data which is sent to the browser is as small as possible and it should meet the user requirements. So the data which is sent to the user is fully user specific. For example if the user wants the backup data then he should be provided with the backup data which is only related to that particular region. But if he wants some more data then according to user's authorization, the GUI will be facilitated with the desired data set.

b) Intelligence of GUI: It is necessary to know the user requirements at runtime. For example if the user navigates through some required links frequently then the intelligent system at the web server should track it and send him the html page created dynamically which has the direct links to the pages where he navigates frequently or it should depict the pages on current page in small window in future access.

c) Communication with Operators and Other web clients: The authorized user should be able to communicate with other users at the control center and web clients. For this purpose, there should be a provision for chatting window.

d) There should also be provision for sending the offline messages.

e) Important News Displayed Continuously: There are some important and critical news which are not confined to any particular user, so the news should be continuously displayed on the web browser. The news, specific to a particular user should also be displayed continuously at some part on the browser. So the intelligent system on the web server should know the particular user and provide him the required news.

f) Adapting According to the End User System: The GUI should adapt to the system on which the user is working on. So if the user is using his personal computer, laptop or mobile the GUI should adapt to the system and give the user the best possible view.

2.) Intranet Specific GUI: In intranet specific person-centric GUI, the intelligent system resides on the web server. The intelligent process is always running like other processes to track user activities during login session. The intelligent system depicts the customized GUI for operator depending upon their privileges and authorization when they login next time. The intelligent system makes the operator's notebook displayed for the next session operator in order to convey previous session's important notes to the next operator and also escalates to the higher level if it is critical.

In distributed architecture of SCADA system, different data set is used by the various users depending on their requirements. Every control center operator or intranet based client may have different perspective of the same data or operators may have restriction to visualize the data so it is not required to transfer all data set through the network.

The proposed customized and person-centric GUI enhances various measuring parameters in order to achieve better performance of SCADA as well as ease of usability.

In Fig. 4(a.) and Fig. 4(b.), we have shown the snapshot of the SLD (single line diagram) and trend curve configured in HMI respectively. In this way operator can configure the figures as required. So the real time values will be shown at the respective places. Similarly many diagrams like trend, pie chart, bar graph etc can be configured by the user. So in this way a same value can be seen with different perceptions.

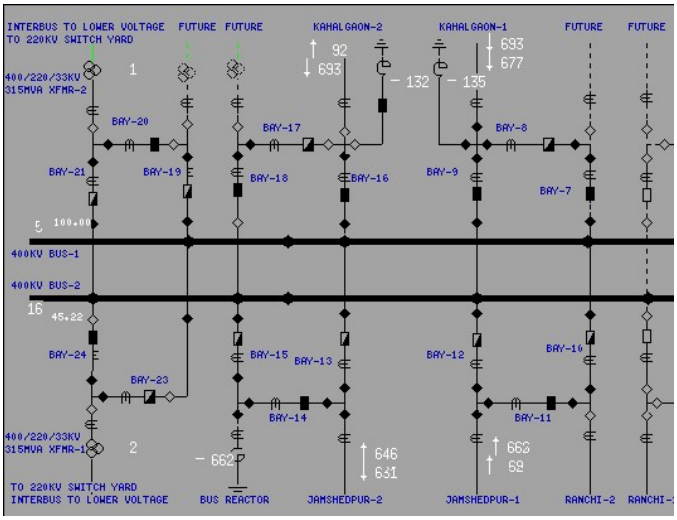

Fig. 4(a). Snapshot of SLD configured in HMI

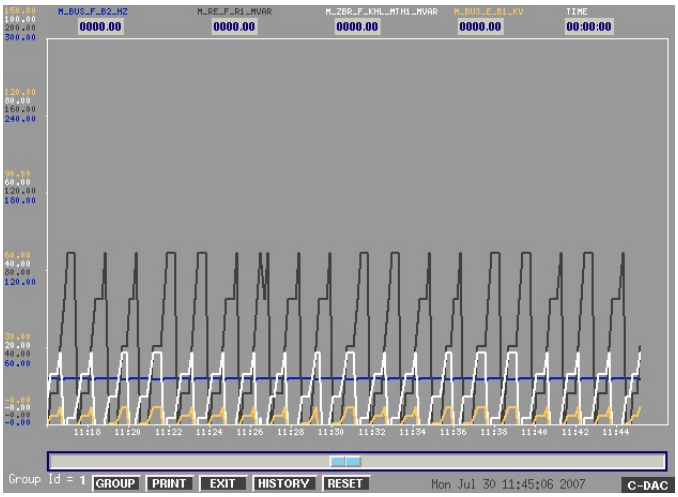

Fig. 4(b). Snapshot of trend curve configured in HMI

Following are the features of the intranet specific GUI. Optimization of data and network traffic: As only the required and intranet client specific real time data will be transferred through communication channel so it will be helpful to reduce network traffic. As far as the performance of SCADA system is concerned, network traffic will be less as real time data set will be accessed in minimal time.

a) Adaptive, personalized and intelligent GUI: In the Intranet based GUI the depicted graphics on the system will be according to user preferences, authorization level and required data set with user specific view. So, GUI will be designed automatically based on the user's previous activities which will help users and operators to achieve personalized desktop.

b) Private and public Notebooks: Private and public notebooks are required when operator logs out from the present session, in order to transfer the critical and important observations to the next session or the next user. This can be achieved through the public note book which will be available for all present logged operators and next session operators. There should be private notebook for operator's future references.

c) Alarm propagation and alarm processing: In the real time application, in critical situations alarms are required for alerts. The alarm can also be customized and configured according to the operator preferences. This alarm should be prorogated to other intranet clients like control center operator as well, so that the supervisory level control can be initiated by the operators as soon as possible. With the alarm propagation, alarm processing can be done by the intelligent system running on the web server according to users' preferences.

d) Chat facilities with the other intranet Clients: The proposed GUI will have the chat facilities so that the operator can chat with other logged operators for troubleshooting of any system specific problems. The operator can view all operators on his desktop and can chat online or send offline message to other operators.

e) Chat facilities with online web Clients: The proposed GUI will have the chat facilities with online web clients and operators through web server. All online web client information will be on web server and control center operator can chat with web client via the web server.

f) Multi media messaging system facilities: The proposed system is incorporated with MMS (multimedia facilities) .The operator can take screen shot of pictures after marking and highlighting the problem area and can send it through the network or on mobile to the concerned authorities and other operators.

C. Software Technologies: The proposed System is based on three tier architecture and the underlying implementation includes various Software technologies, which has been described below.

1.)*Java Language:* Java is the best suited language to develop the network and web based application as SCADA application. A Java based SCADA system can execute across the platforms without any modification. Java has a lot features which encourages the developer to use java for SCADA application. Java based application can execute across the platform with the help of JVM (java virtual Machine).

2.)Database Technologies: In the proposed architecture, MySql is used as database as it is open source but any database will serve the same.

3.)AJAX (Asynchronous JavaScript and XML) : AJAX is a technology which includes various web standards like Java Script, XML and HTML which realizes asynchronous data transfer (HTTP requests) between the browser and the web server, allowing web pages to request small bits of information from the server instead of whole pages. So it is will be useful for creating faster and more interactive, which is required for Real time application like SCADA application.

With AJAX, the JavaScript can communicate directly with the server, using the JavaScript XMLHttpRequest object. With this object, the JavaScript can update data with a web server, without reloading the whole page. In GUI context AJAX is useful to update different values associated with SLD with the time. Here we have shown the internal working of AJAX with the SCADA application to update the required set of data.

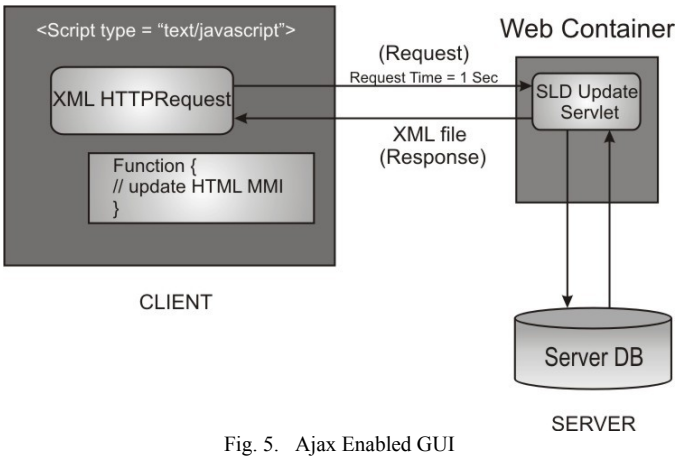

Fig. 5. Ajax Enabled GUI

4.)XML: The entire configuration will be stored in XML file and all the GUI component and system related configuration will be accessed via XML.

V. WEB PORTAL

A web portal is a single point of access to information which is linked from various logically related internet based application as well as user's preferences. The proposed web portal for power sector will help to gather real time data from diverse sources to single window, which will really help the operators or authorized users to visualize different data from a single portal. Web portal must be customized, adaptive and personalized. Web portals can be of various types like regional web portal, corporate web portal, domain specific web portal etc. [13]. The proposed web portal application represents the domain specific portal related to power sector. The next section will describe how web portal will be helpful for SCADA solutions [9], [10].

A. Advantages of web portal for customers

Creating web portal for customers will enable easy information, spot billing and power trading facilities to them. An interactive portal can provide latest information about power sector specific issues, policy measures and developments. The portal also provides information pertaining to tenders/ bids of various entities in the power sector like

Central Public Sector Undertakings, State Electricity Boards, State Power Development Corporations, statutory/ autonomous organizations, Electricity Departments of various States/ Union Territories, etc. Web portals will provide customers with email facility, information about financial systems, events, search engines facility etc. Clients can get other customized daily news from such portal. Customers can personalize the view according to their needs.

B. Advantages of web portal for a Power company

With the same portal, company can provide different views for operators and customers. Information regarding the generation, customers and employees will be properly organized and viewed. Any changes regarding the generation, policies and important news will be conveyed easily to the customers and employees.

C. Advantages of Web Portal for Operators

Operators can have access to different data from the same window. Whether they want to know about their salary or some data of the field or the other happenings around the world, they don't have to go and open different sites, they just have to click on the particular link. They can personalize their account easily to access the information of their interest. So whether it is a cricket score or some important data on field, they can easily access anything.

VI. C-DAC UTILITY (POWER) WEB PORTAL APPLICATION

C-DAC utility (Power) Web Portal is an application being developed at C-DAC which incorporates the techniques mentioned in this paper. The view varies according to the user authorization. For example the operators can visualize and configure HMI through the web portal. So the web portal will be the entry point for all the users and operators. Through the web portal the operator can operate the SCADA system from the remote place with the same authorization as of the control center with proper authentication.

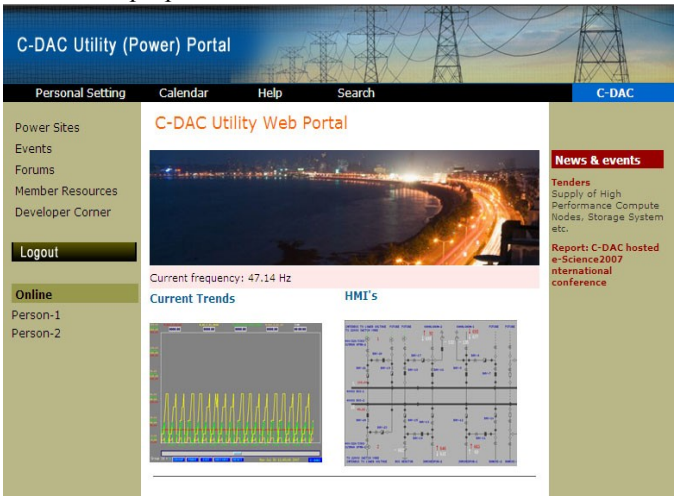

Fig. 6. C-DAC utility (Power) Web portal application: personalized page

In Fig. (6), we have shown how the GUI and hyperlinks for the web portal for power sector can look like after login. As the user logs in, the user gets the person-centric page as shown in Fig. (6). the page will differ from user to user according to user's personal settings. So the web portal is the single window through which the user can have easy access to the desired links. All the links related to the power sector are depicted based on user's activities and their interest. These links will vary from user to user according to the personal configuration made by the user and the activities of user traced by the intelligent system. So the user can get access to the information through same window. The information is easily available for the users for quick decision making. In this way user can also easily organize the personal and desired interest on the web portal. So the portal will bridge the user's work related interests and personal interests.

VII. CONCLUSION

In this paper, we have proposed the adaptive, person – centric configurable GUI for EMS which implements the SCADA. The GUI is vital to any application and personalization of GUI facilitates the users to view according to their preferences. In SCADA application or EMS, the HMI plays an important role in visualizing real time data.

Every user has his own perception for the same data so it is important that the GUI should act according to the perception of the user and present the same data in different ways for different users. It is also important that GUI should adapt to user's activities and act accordingly. It will increase the speed of working as well as ease of usability of GUI. We have shown that intelligent system keeps track of user's activities and presents the user with the best suitable GUI. We have also shown how the web portals will be helpful for the SCADA application.

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