

CVG VENALUM POTLINE SUPERVISORY SYSTEM

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Abstract

This paper describes architecture and features of CVG Venalum aluminum reduction Cell Supervisory System (SSC) which, besides the standard characteristics of a supervisory system (real time parameters display, historic trends, operation tracking, etc.), allows effective (easy interpretation), accurate (allows quantitative evaluation) and adaptable (serves multiple needs) data visualization and analysis of potlines. The SSC has an outstanding performance compared with other supervisory systems. It has been tested in CVG Venalum potlines, where a desktop PC serves each line. In addition, the potlines have been integrated in a high-level system in order to visualize the whole plant. The SSC is part of the V-350 cell technology and it will be used in CVG Venalum and CVG Alcasa expansion plans. The system was developed using open source platform: LAMP (GNU/Linux-Apache-MySQL-Php) and C++. The Human Computer Interface is web based, allowing the user to interact easily with the system using a web browser.

Introduction

An aluminum potline comprises a large number of independent production cells, which need to be handled as a single unit. The supervisory system plays an important role to achieve this. It works with the pot controllers and helps to reduce labour efforts, allowing the inspection of operational status of the potline in a simple, fast and reliable manner. This allows for detecting process disturbances in early stages, and taking right actions in time.

On the other hand, information technologies have gained importance in the organizations worldwide due to their efficiency at low costs. Over the last few years web technology has grown very fast, and web applications have been integrated in all fields of the industry, delivering quick and timely access to the information anytime and from anywhere.

Thus, integration of web technology in the supervision system could deliver the benefits of this technology to the aluminum reduction process.

This paper describes the supervisory system developed at CVG Venalum, which makes intensive use of web technology and open source software, allowing a low cost system that meets the organization requirements.

The system presented in this paper has been tested in CVG Venalum potlines and it will be used in CVG Venalum and CVG Alcasa expansion plans. The system is part of the V-350 cell technology and it can be adapted to several control technologies.

This paper is focused on the architecture of the solution, the performance of the system and the features implemented.

The Cell Supervisory System

The purpose of the Cell Supervisory System is to provide users with the tools, facilities and information to help reduction line management to accomplish its goals, increasing productivity and improving quality.

The SSC has multiple functions and features to make it reliable, intuitive and pleasant for use, but it also has been designed to be reliable, secure and very accessible. It has been built on a widely-accepted open source software platform and with architectural features that admit easy addition of new components.

System Functions

The SSC has several features to provide the different users with the tools they need. It offers actual information in real time basis and historic information too. These features are:

- A functional and intuitive web interface.
- Monitoring and planning of the daily operations.
- Predefined and per user defined reports.
- Interconnectivity with other systems, such as ERP, cashouse, etc.
- Alternative information delivery systems, such as e-mail, SMS, pagers, etc.
- Event-triggered user-programmable reports.
- Web-based query and modification of parameters for authorized users.
- Managing of different communications media (Serial, Ethernet, etc.) and protocols (TCP, UDP, etc.) simultaneously.

Furthermore, the System has been designed to be adaptable to different control system architectures and database technology. The communication modules can be adapted or new drivers can be added to work with different technologies. Because of its centralized database, the database module can be modified to work with different database engines.

System Architecture

The SSC liberally uses GNU/Linux resources as it does from other associated software as the web server and the database which has facilitated its development and operation. One of the most important aspects of the SSC is its modularity. The System is divided in two modules, which have been named as the

Supervision Core (SSC Core) and the Supervision Interface (SSC Interface) as shown in Figure 1.

The SSC Core is in charge to manage communication, data and system variables. It runs independently from the SSC Interface. It receives the information from the pot controllers and processes it. It also manages the outgoing information to the controllers and to other resources. The SSC Core puts the processed data in the shared memory and in the database where the SSC Interface will retrieve it.

The SSC Interface provides the way for the user to access the information of the system. It has several ways to represent this data; there are real time bar graphics and plots, charts, trends, reports, etc. The interface also has a number of ways to customize the data representation to satisfy the user needs. The interface has two parts: the server side, where the applications reside, manages and processes all the information (Apache and PHP), and the client side, which has the front-end, interacts with the users.

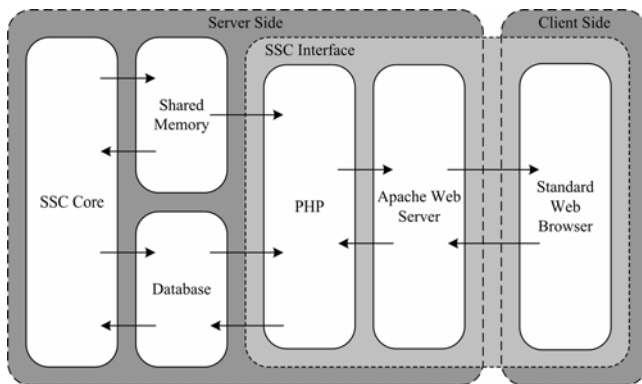


Figure 1. Cell supervisory system architecture.

SSC Core Architecture

The SSC Core is composed of different processes. The processes and the interaction between them (as shown in Figure 2) have been designed to allow the system to keep running even when one of the processes is not working.

These processes manage the resources and facilities of the system and the computer. They interact between each other, using different elements of the IPC (Inter-Process Communication) provided by the OS, e.g., shared memory, semaphores and queues.

The use of shared memory facilitates the interprocess communication and helps in having a fast web interface. The semaphores are used to control the access to the shared memory and queues. The queues are used to pass information from a process to another and as buffers if one of the processes is busy.

The system has the security mechanisms to keep all the processes up and running, reducing human intervention to a minimum.

The processes of the SSC Core are described as follows.

Interpreter: This is the most important as well as the most complex process of the SSC Core. It validates and manages the information received from the pot controllers, taking most of the actions based on the information that comes in the messages. It sends the new data to the database module and updates it in the

shared memory. It turns almost every alarm and warning signal on and off. It generates the messages for the speech manager. Almost every action concerning to data is taken here.

Communication driver: this process can have various instances, because it manages different form of communication. Nowadays it manages serial communication for most of the CVG Venalum potlines and UDP for the V-350 cells. It can be adapted to work with other protocols and it will manage the different protocols simultaneously to help in an eventual pot controller technology update. This process takes the message from the port, verifies its origin and validity before sending it to the interpreter and replies to the pot controller with a message of acknowledgement. The communication driver also receives every message to be sent from the system to the controllers.

Transmission manager: It manages the outgoing transmission cycle. It receives a message to be sent from the computer and decides when this message will be transmitted. It controls the timeout and the retries.

Database manager: This process has a permanent connection with the database and receives messages from the rest of the processes with information to be updated in the database.

Message generator: This process receives from the web interface the requests for transmit information to the pots. It manages the requests, builds the messages and sends them to the Transmission Manager.

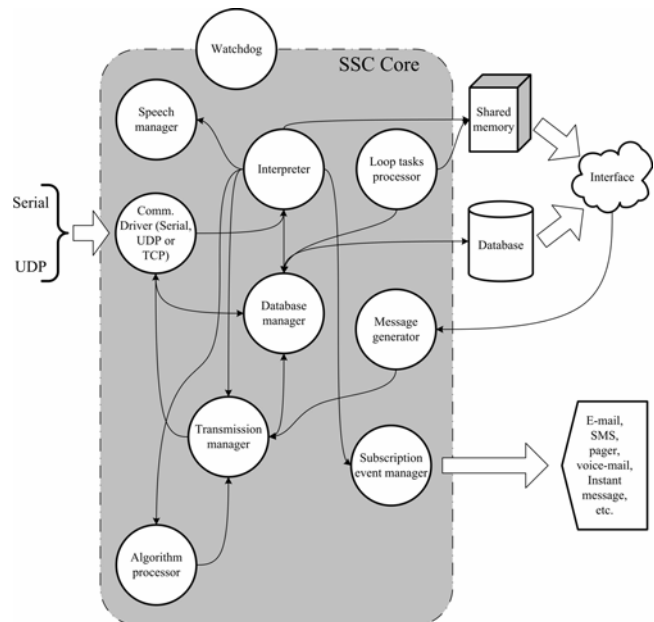


Figure 2. SSC core architecture.

Loop tasks processor: This process makes a constant loop for cyclical operations; for example, it verifies the communication with the pot controllers. Some of its functions have been extracted to become independent processes that are executed by the GNU/Linux service Cron.

Speech manager: This process generates the warnings voiced in the pot room. It controls the frequency of persistent messages. Nowadays this process only speaks out several messages created

from a group of pre-recorded words. Eventually it can use a text-to-speech solution to admit the speaking of any phrase in different languages with little or no effort. This can be helpful for different situations like voicing some information from the web interface.

Watchdog: It is the first process to start. This process checks that all the other processes are working. If any of them is not working properly, the watchdog stops it and restarts it again.

Subscription event manager: This process manages the subscriptions made by the user. It queries and collects the information necessary to meet the user needs. It can send the information by different ways. At the moment it has been tested with e-mail and SMS, but it can be configured to send the information to other devices like printers, instant message clients, voice mail, RSS clients, etc. The characteristics of the device will limit the amount and the presentation of the information to be sent.

Algorithm processor: It handles all the control activities that need to be carried in the supervisor system. Its function is to run any model that is under test or too complex to be run in the pot controller.

SSC User Interface

The system interface is web based. This architecture was selected because of the richness and responsiveness that new technologies like AJAX (Asynchronous JavaScript + XML) have achieved on the web.

Since the application is web, users can gain quick and timely access to the application anytime and from anywhere without installing any client software, only with a standard web browser.

The system security is guaranteed with user authentication and IP authorization for operations related to the cell controller's communication.

The system is real time and gets data from the supervisory computer at exact time intervals that users define previously. The user can define time intervals from 5 to 30 seconds. To assure performance, all real time options work directly with the shared memory of the supervisory system and only access the supervisory database for the display and analysis of historical data.

The system is designed to provide users with information concerning the entire potroom, or on an individual pot basis. The main components of the user interfaces are:

- Potline data visualization
- Historic cell data visualization
- Cell Control Communication
- Report and Trends Configuration
- Event Subscription

Potline data visualization: It allows monitoring operation parameters of a potline in an easy and integrated way. The most important functions are:

Real time parameters monitor: Using graphics objects and color codes the user can visualize one parameter for the whole line or *n* parameters of one section in real time. It shows the actual value of the parameter for each cell using color codes to present whether the parameter is in range or not. In this way the user can concentrate his attention only on those cells out of range. Additionally it summarizes the information for the whole line and each section (min, max, avg, etc.). The user can configure the parameters to visualize, the analysis range of every parameter and the real time update interval. This information can be saved as user preferences.

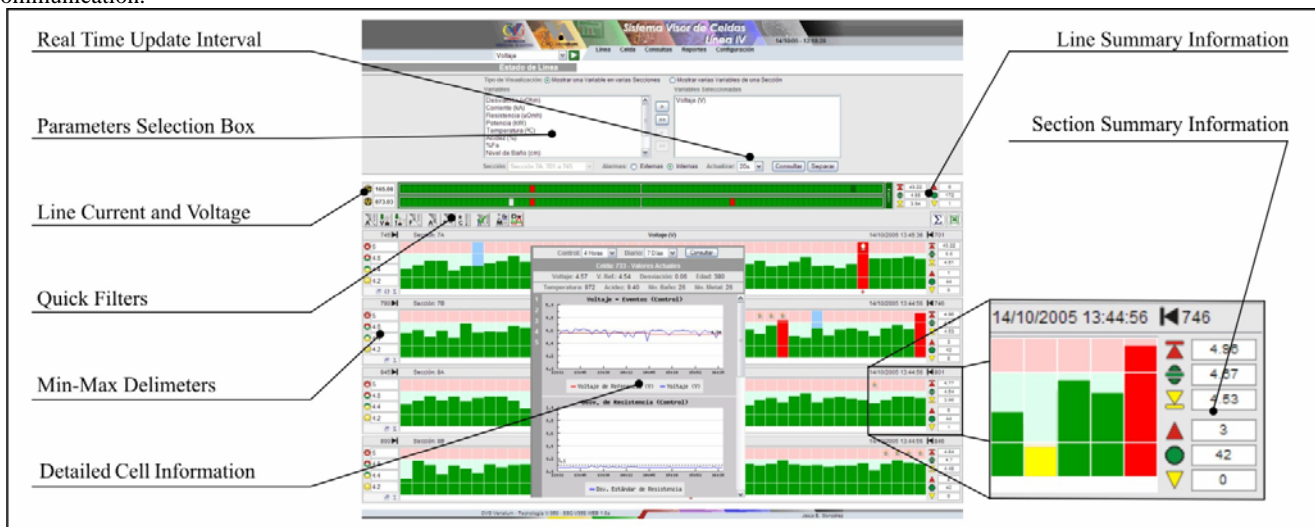


Figure 3. Real time parameters monitor

Since it is a web application, there are many hyperlinks with more detailed information showing the evolution of the selected parameter in the last few hours or days for each cell. Figure 3 presents the main components of this interface.

Real time operation management: The system allows real time tracking of operation in the potroom using graphics icons. The user can configure up to 5 operations to visualize at the same

time. The system shows the status of the operations planned and realized in each cell in real time. Like the previous interface it presents summary and detailed information, allowing the user to detect deviations in the potroom operations. If an operation is behind schedule the system helps in the rescheduling process. Figure 4 shows an example of this interface.

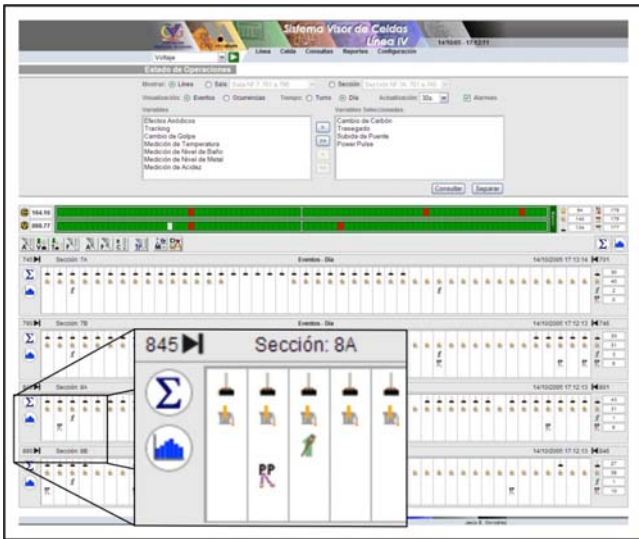


Figure 4. Real time operations management

Potline trends: The system allows monitoring of potline parameters. The trends could be generated for the whole line, rooms or sections, and can be group daily, weekly or monthly.

Mini-graphs: As shown in Figure 5, the system displays mini-graphs of a given parameter for a selected section, giving a quick overview of each cell condition. The user can change the graph being displayed, the time frame as well as the number and size of graphs.



Figure 5. Mini-graphs

Historic cell data visualization: It displays detailed information concerning the operation of a single pot. Information is presented regarding several important cell issues like voltage, noise, events, metal level, bath level, current efficiency, etc. All the graphics and data can be downloaded to other productivity software like Excel. The user can configure the graphics and data showed according to his needs. This module also allows historical data analysis using a query generator.

Cell control communication: This option allows the user to communicate with the cell controllers, to request information or change a parameter. The system allows sending messages to multiple cells at the same time. This option is only available to authorized users and additional IP verification is performed.

Reports and trends configuration: The system allows achievement through collaboration. In addition to standard trends graphs and reports, an experienced user can define new trends graphs or reports online to be shared with all the users of the system. This is carried out with no intervention of computer programmers.

Events subscription: The user can subscribe to receive information, as detailed as the user requires, of specific events at the moment of occurrence or after the system receives and processes user selected information. The user can be informed through e-mail, SMS, pager or other media.

Additionally to the features already described, a web interface for wireless devices has been developed using the same software platform (PHP-Apache). This interface allows the operator to visualize cell parameters and communicate with controllers. It has been designed to keep system efficiency with a low data rate. Figure 6 shows the device and one of the interfaces designed.



Figure 6. Wireless interface

Besides the supervisory system for the potline, there is a system that integrates all reduction lines in the factory on a single screen.

The user chooses the parameter to visualize and the system displays it in real time, using the same color codes that are used in the potline data visualization. Additional to the graphics parameters display, the system presents a summary of the main operations and events for each line, split into working shifts. Figure 7 shows an example of this interface.



Figure 7. Factory reduction lines front-end

Software Platform

GNU/Linux was selected as platform due to its stability, well-known features, software availability and low-cost, in addition to its large and active community of users and developers. The Fedora GNU/Linux distribution was selected due to its ease-of-use.

The core of the system was programmed using C++. The rest of the system was developed using the LAMP (GNU/Linux, Apache, MySQL, PHP) platform for being one of the most accepted platforms in the Open Software community and for its features and performance.

There are trials in process with other GNU/Linux distributions such as Debian, and another database engine like PostgreSQL, to assure a product-independent system.

Results

The system has been installed in four CVG Venalum potlines of 180 cells each. Each potline supervisory system is running in a PIV desktop computer 2.0 GHz, 1 GB RAM. Each one has an average of 10 users connected simultaneously and the performance is outstanding.

The system has an excellent acceptance, because the user has an easy and intuitive access to information practically unreachable in the past. Moreover, it has dramatically reduced the information access time expended and improved efficiency on some routine tasks.

From the operational point of view, the system has the following benefits:

- Online access to all the information available in the cell controller.

- Graphical information with an overview of all the alarms and selected parameters for all cells.
- Access to the system from every computer in the plant.
- Real time tracking of the operations carried out in the potroom.
- Easy identification of disturbances.

Conclusion

As a result of this project, which is still in the development phase, the following could be concluded:

- Web-Based Systems satisfy real time requirements of a reduction line.
- Standard PC could be used for supervision of a reduction line.
- Improved access to current data increases the overall effectiveness of information use.
- Effective visualization and analysis of potline data facilitate management of the aluminum reduction process.

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