SPPA-T3000 Distributed Control System

Siemens AG

State-of-the-art Lausward combined cycle power plant in Düsseldorf Germany utilizes Siemens’ SPPA-T3000 Distributed Control System
About Siemens AG

Siemens is a global powerhouse focusing on the areas of electrification, automation and digitalization. One of the world’s largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of systems for power generation and transmission as well as healthcare. In infrastructure and industry solutions the company plays a pioneering role.

Power and Gas

The Power and Gas Division (PG) is the trusted partner for world-class products and solutions. PG helps customers worldwide to successfully operate fossil fuel power plants and to meet their specific economic and ecological challenges in their market environment.

SPPA-T3000 Distributed Control System (DCS)

Raising performance in power plant operation

Conditions in today’s power generation industry are getting tougher. Now more than ever, power generators have to rely on top plant performance, which is ultimately powered by dependable and predictable operation. Power plant control and automation solutions can help reach those goals.

Suited for all types of power plants

SPPA-T3000 has been designed to perform all power plant automation tasks: turbine control, boiler control including boiler protection, balance of plant (BoP) and integration of third party systems. Thereby SPPA-T3000 accommodates all types of power plants and works with turbines and generators of all other manufacturers and with each OEM-System.

Operator centric approach

SPPA-T3000 Cue, the new release of Siemens’ worldwide leading distributed power plant control system, has evolved under an operator centric approach. It is infused with innovations specially designed for effective and efficient operation. By supporting operators with the right tools, targeted cues, and guided procedures for sound operation, SPPA-T3000 Cue provides the platform to increased power plant performance.
Optimized workflows thanks to a clever HMI-Interface - help plant operators perform their day-to-day work more efficiently and more effectively, and react reliably and more quickly in critical situations.

Major benefits of the SPPA-T3000 Control System:

- Improved plant availability, e.g. by predictive data analytics
- Quick reaction of the system or of the guided operator in critical situations
- Clear instructions and transparency of upcoming issues available
- Integrated workflows also beyond a classical DCS
- Simple and reliable day-to-day I&C operation
- Optimal support of work processes and ergonomic design
- Almost entirely implemented in Java®

AS3000/CS3000

Alongside SIMATIC S7 the AS3000 / CS3000 represent the automation controller in the SPPA-T3000 control system. It is based on embedded PC hardware with a real-time Linux operating system. The so-called real-time runtime container is almost entirely implemented in Java executed within the PTC Perc real-time Virtual Machine (VM) and supports cycle times for execution of automation function blocks down to 20ms. The AS3000 uses PROFIBUS DP to communicate with field devices and can also be used for advanced control e.g. Gas Turbine combustion optimization.
Beside automation functions, the CS3000 supports a variety of different protocols for communicating with other devices on the network like MODBUS, IEC60870, IEC61850 or DNP3 to name just a few.

Both types of controllers can be deployed in a standalone and redundant configuration. A redundant setup consists of two devices, which are coupled with each other by two point-to-point connected Ethernet links. For the underlying real-time communication mechanism only a very small and simple native library is required in order to exchange byte arrays of a predefined fixed length on ISO-level 2. The handling of the bi-directional data transfer, including the redundancy protocol, has been completely implemented in Java.

As there is no TCP/IP stack or any other high level communication layer involved, the communication mechanism has been proven to be strictly deterministic and highly performant. The resulting transmission rate of the data is only slightly less than the physical bandwidth of the Ethernet link.
The automation program will be configured by end users via graphical function diagrams. Any modifications can be activated within the controller in a seamless switch-over from the previously executed program to the updated program. Thereby any changes in the program are prepared within the controller in a non-real-time context and a subsequent atomic switch-over to the new automation program, including the update of a redundancy partner. An internal transaction mechanism automatically switches back to the previous program when a cycle-time overflow has been detected or if the user explicitly forces a rollback of the activation.

In addition to the online configurability, the automation controller supports a so-called fast parameter change of module parameters and the forcing or simulation of every module port. Moreover, even automation function types can be upgraded online without interference to the program execution.

Furthermore the controller is capable of exchanging signals with other controllers, whereas the signals exchange is graphically engineered and supports the online handling as well.

The controller communicates with the SPPA-T3000 related application servers via an in-house developed communication protocol based on TCP/IP instead of using Remote Method Invocation (RMI) to have more control over the allocated resources and threads.

The challenge

Design and implementation of a highly configurable real-time controller, which supports online modification and upgrade mechanism for almost every scenario. Hereby a strict separation of real-time and non-real-time tasks is required with well-defined synchronization points to guarantee deterministic and predictable behavior.

The solution

Due to the well-known advantages of the Java language versus native programming, including the dynamic class-loading mechanism; Siemens chose Java even for the automation layer. This approach allows the usage of standard hardware and a software platform for the Automation Controller (shown in fig_1 below) instead of special, expensive hardware. This leads to a greater standardization and simplified design by applying the same development environment for the application services (engineering and monitoring) and the automation controllers as well.

Now, the algorithms of the function blocks can be written in the same programming language (Java) as all other components of the DCS system.
As shown in figure 2 below, the system programs like a DCS using symbols, faceplates, and other common elements designed for power plants. The new software, with an IDE, has made the system much easier to use and understand. With this feature, the basic training program for the software has been reduced from a 5-7 week training program to 4 days.
Selection of the java solution

In advance of selecting a real-time Java solution, Real-Time Specification for Java (RTSJ) No Heap Real time Threads in conjunction with the scoped memory model was considered and determined to not be an option due to the highly online-configurability requirement of the end system. The approach of the PTC Perc real-time VM, providing real-time determinism by using “standard Java” was the method of choice. A pre-emptible garbage collector combined with a transparent prioritization of the involved threads was the convincing base for building a deterministic, robust and maintainable solution.

Another decisive factor was the Ahead-Of-Time (AOT) compilation mechanism available with PTC Perc which is required for faster startup of the application, as well as to prevent jitter when loading additional classes without any disturbing influence on the currently running program. As a result, it is also essential that the AOT-compilation mechanisms can be applied on single jar-files, maintaining the deployment packages of the application.

Productivity and robustness determined our decision to use Java particularly for the implementation of the real-time automation controller. PTC® Perc® offers real-time performance and determinism without adding complexity.”

Andreas Drebiner
Siemens AG

The results

The AS3000 / CS3000 automation controller has been proven to be fully deterministic and a robust automation platform for SPPA-T3000 and will be used in many different environments, such as turbine control, coupling of third party systems, etc. The ability to minimize native coding wherever possible has been proven to be a major success factor.

The dynamic class loading mechanism of Java offers greater flexibility regarding the configuration of the automation controller. In addition it is the prerequisite for upgrading automation functions online without interrupting the automation program execution.

By having a preemptive garbage collector, it becomes possible to make use of the advantages of Java even in the development of automation controllers, leading to maintainable software and shorter development cycles.
How PTC perc met siemens PG's requirements

PTC Perc virtual machine paves the way for using Java for real-time embedded development without the necessity of having an additional, complex framework in addition to the following benefits:

- Perc “Ahead-of-Time” compilation guarantees faster application startup and makes byte code obfuscation superfluous by stripping the byte code from the final jar files.
- Perc's pre-emptible garbage collector ensures determinism and predictability.
- PTC outstanding technical support facilitates further optimizing system performance and efficiency.

“Throughout the whole life-cycle, PTC engineers were very responsive to support requests and provide outstanding support for solving any issues, regardless of the direct cause (Perc VM, operating system, platform).”

Andreas Drebinger, Siemens AG

Field proven success

SPPA-T3000 was introduced to the market in 2006 and, as of April, 2016, is now deployed in 2395 projects world-wide.
Hellischeidi I, Geothermal Plant: a new DCS designed to last

The plant:

• Location: Hellischeidi, Iceland
• Geothermal plant, six high pressure and one low pressure unit
• Supply: 303 MW of electricity & 130 MW of thermal energy using steam from the depth of 2000 m

The task:

• Due to extensions, the existing PCS7 units need to communicate with new DCS

Our solution:

• Installation of SPPA-T3000 for new units
• Furthermore other control systems can communicate with SPPA-T3000 like those of the existing units
• Migration to SPPA-T3000 still possible later

The result:

• Lasting DCS that Never Goes Obsolete during power plant lifetime due to the hardware-independence of the software
• High programming flexibility thanks to online configuration and the drag and drop system