Case Study

Siemens Energy & PTC Perc Partner to create Real-Time Automation Controller

State-of-the art multi-unit district heating with sustainable source BioWarmte Installatie Lage Weide in Netherlands utilizes Siemens Energy's SPPA-T3000 I&C System

About Siemens Energy

Siemens Energy is one of the world's leading energy technology companies. The company works with its customers and partners on energy systems for the future, thus supporting the transition to a more sustainable world. With its portfolio of products, solutions and services, Siemens Energy covers almost the entire energy value chain – from power generation and transmission to storage. The portfolio includes conventional and renewable energy technology, such as gas and steam turbines, hybrid power plants operated with hydrogen, and power generators and transformers. More than 50 percent of the portfolio has already been decarbonized. A majority stake in the listed company Siemens Gamesa Renewable Energy (SGRE) makes Siemens Energy a global market leader for renewable energies. An estimated one-sixth of the electricity generated worldwide is based on technologies from Siemens Energy. Siemens Energy employs around 91,000 people worldwide in more than 90 countries.

PTC Perc Provides SPPA-T3000 with:

- Ahead-of-Time compilation for fast startup, eliminates byte code obfuscation
- Pre-emptible Garbage Collection technology ensures determinism and predictability
- Real-time Java using standard APIs rather than a complex framework such as RTSJ

SPPA-T3000 I&C System

Raising performance in power plant operation

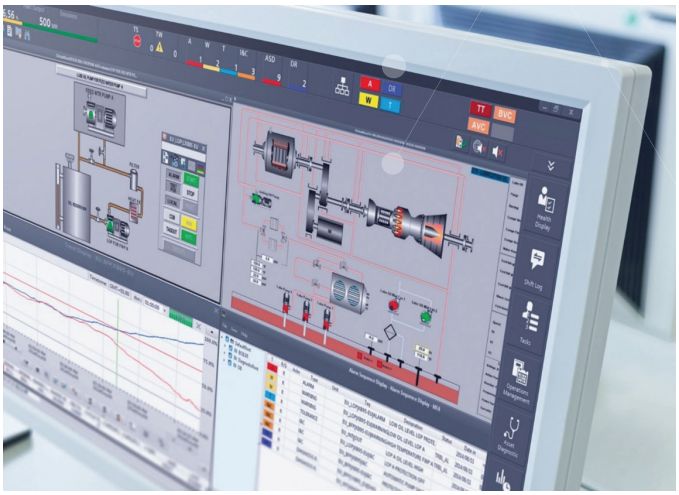
Conditions in the energy industry are getting tougher and thus, there is a greater need to focus on increasing plant performance, including maximizing commercial availability.

The operator's effectiveness and efficiency are crucial to the performance of the entire plant. Reliability and predictability of the plant's operation depends heavily on the operator's ability to do the right things at the right time. SPPA-T3000 is precisely geared to the tasks of control room operators.

SPPA-T3000 puts the operator in the focal point. The operator-centric approach provides functionalities regarding look & feel, ergonomics and the access to applications which are helpful for the daily routine of an operator.

Major benefits of the SPPA-T3000 Control System:

- Improved plant availability, e.g., by predictive data analytics
- Quick reaction of the system or guided by the operator in critical situations
- Clear instructions and transparency of upcoming issues available
- Integrated workflows 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®



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.

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 Java Virtual Machine (JVM) and supports cycle times for execution of automation function blocks down to 20ms. The AS3000 uses PROFINET and PROFIBUS DP to communicate with field devices and can also be used for advanced control, e.g., Gas Turbine combustion optimization.

AS3000 real-time controller based on Intel CPU with PROFINET & PROFIBUS interface

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 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 to exchange byte arrays of a predefined fixed length on OSI layer 2 (Data Link). 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 is configured by end users via graphical function diagrams. Any modifications can be activated within the controller in a bumpless switchover from the previously executed program to the updated program. Hereby any changes in the program are prepared within the controller in a non-real-time context and a subsequent atomic switchover to the new automation program, including the update of a redundant 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 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 interfering with program execution.

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

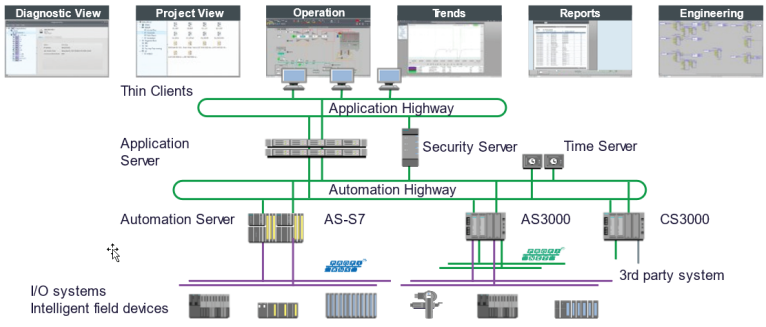
The controller communicates with the SPPA-T3000 related application servers via an in-house developed communication protocol based on TCP/IP instead of using Java Remote Method Invocation (RMI) to have more control over the allocated resources and threads.

The Challenge:

Design and implement a highly configurable real-time controller that supports online modification and upgrade mechanisms for almost every scenario. 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:

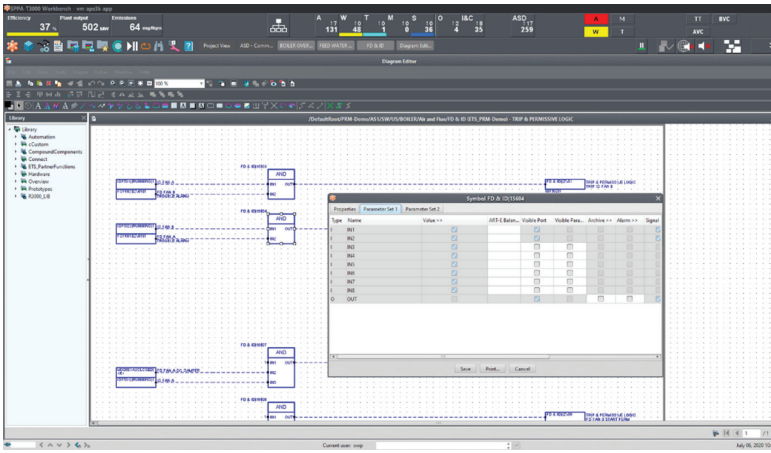
Due to the well-known advantages of the Java language versus native programming, including dynamic class-loading, Siemens Energy chose Java even for the automation layer. This approach allows usage of a standard hardware and a software platform for the Automation Controller (shown in Figure 1 below) instead of special, expensive hardware. This leads to greater standardization and simplified design by utilizing the same development environment for both application services (engineering and monitoring) and the automation controllers themselves.



SPPA-T3000 Architecture [Fig. 1]

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 intended 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 to 7-week training program down to 4 days.



SPPA-T3000 HMI [Fig. 2]

Selection of the Java Solution:

In advance of electing a real-time Java solution, Real-Time Specification for Java (RTSJ)'s NoHeapRealtimeThreads and scoped memory model was considered and determined not to be an option due to the online configurability requirement of the end system. The approach of the PTC Perc real-time JVM, providing real-time determinism using "standard Java"

APIs was the better choice. A preemptible garbage collector combined with transparent prioritization of critical threads were the convincing factors for building a deterministic, robust, and maintainable solution.

Another decisive factor was the Ahead-Of-Time (AOT) compilation mechanism available with PTC Perc that was required for faster startup of the application, as well as to prevent jitter when loading additional classes without disturbing the currently running program. As a result, it was also essential that AOT-compilation be applied to individual 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 Drebinger, Siemens Energy**

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 a prerequisite for upgrading automation functions online without interrupting the automation program execution.

By having a preemptible garbage collector, it becomes possible to take advantage of the benefits of Java even in the development of automation controllers, leading to more maintainable software and shorter development cycles.

How PTC Perc Met Siemens Energy's Requirements:

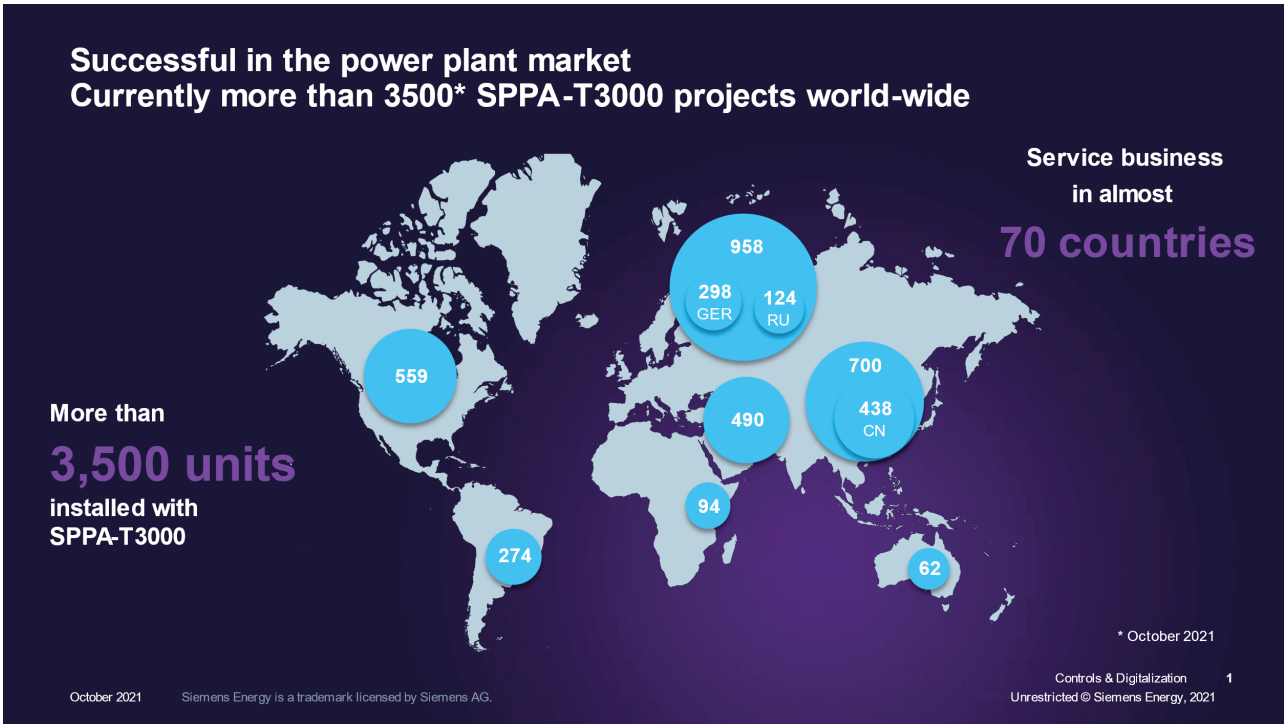
The PTC Perc Java Virtual Machine paves the way for using Java for real-time embedded development without the necessity of having an additional, complex framework such as RTSJ. It also adds the following benefits:

- Perc "Ahead-of-Time" compilation guarantees faster application startup and makes byte code obfuscation unnecessary by stripping the byte code from the final jar files.
- Perc's preemptible garbage collector ensures determinism and predictability.
- PTC's 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 Energy*

Field Proven Success:

SPPA-T3000 was introduced to the market in 2006 and, as of October 2021, it is now deployed in more than 3,500 projects world-wide.



[Fig. 3] SPPA-T3000 installations in the power plant market worldwide:
As of October 2021, about 3,500 projects have been deployed

BioWarmte Installatie Lage Weide (BWI), Netherlands

Resilience and high flexibility with SPPA-T3000

The Plant

The BioWarmte Installatie Lage Weide (BWI) is the first plant for district heating realized in Utrecht, Netherlands that uses a sustainable source. The BWI processes Dutch residual streams of wood (biomass) and converts them into sustainable district heat.

The Task

Annually, the BWI processes up to 180,000 tons of biomass. The SPPA-T3000 system is used to control and monitor the complete process of converting biomass into energy.

The Solution

The BWI is equipped with the proven SPPA-T3000 automation system. The control system of the BWI is integrated in a multi-unit configuration with the SPPA-T3000 systems of the two gas-fired district heating plants in Utrecht. This way a single control room with a uniform Human Machine Interface (HMI) has been realized for all three plants.

BioWarmte Installatie Lage Weide(BWI), Netherlands

© 2022, PTC Inc. (PTC). All rights reserved. Information described herein is furnished for informational use only, is subject to change without notice, and should not be taken as a guarantee, commitment, or offer by PTC. PTC, the PTC logo, and all PTC product names and logos are trademarks or registered trademarks of PTC and/or its subsidiaries in the United States and other countries. All other product or company names are property of their respective owners. The timing of any product release, including any features or functionality, is subject to change at PTC's discretion.

189450_Siemens_Energy_Case_Study_05_22