Case Study

Distributed Real-time Data Acquisition System for a Nuclear Research Reactor

Industry

Process Automation

Partners

• Russian National Research Centre “Kurchatov Institute”
• National Instruments
• Spetzproekt

Hardware

20 custom-built real-time controllers operated by National Instruments NI-RT operating system

Kurchatov Institute Company Profile

Kurchatov Institute was founded in Moscow in 1943 in order to solve a defense issue of the nuclear weapon development. It was also known as a “Laboratory N2 of the USSR Academy of Sciences”.

The Institute has played a key role in the maintenance of the country’s security and the development of the most important strategic directions. The Institute created the first atomic reactor in Eurasia (1946), the first domestic atomic bomb (1949), the first thermonuclear bomb in the world (1953). The first nuclear power plant in the world (1954), the first tokamak installation (1955), atomic reactors for ice-breakers (1957), submarines (1958) and space engineering were developed under the scientific leadership of Kurchatov Institute.

National Instruments Company Profile

National Instruments Corporation founded in May 1976 is engaged in designing, manufacturing and selling tools to engineers and scientists. These industries include a diverse market for design, control and test applications. The Company provides graphical application software and modular hardware to create measurement, automation and embedded systems. Its segment is based on geographic regions which are the Americas, Europe and Asia Pacific. It offers a line of measurement and automation products helping engineers and scientists to create automated test, industrial control and embedded design applications. The Company’s product range includes off-the-shelf application software and modular, hardware components together with related driver software.

Spetzproekt Company Profile

“Spetzproekt” CJSC specializes in design of scientific and research complexes, industrial buildings and facilities, experimental nuclear research reactors, ionizing emission sources,
and radioactive material storage facilities. The company comprises constructional and logistics subdivisions.

**Challenges**

For a long time, nuclear research industry in Russian Federation was experiencing a serious demand in high-output constant neutron sources. The high-flux beam neutron reactor built in Saint-Petersburg Institute of Nuclear Physics (which has recently become a part of Kurchatov Institute) solved this by generating high-density neutron streams suitable for a wide range of scientific experiments.

According to the design project, the whole reactor complex should be supervised by a single data acquisition and monitoring system to ensure centralized control. SCADA system requirements assumed collection, storage and visualization of 11000 I/O channel values measured at 10 Hz rate, considering future extension to 15000 I/O channels.

**Solution**

Spetzproekt has selected AggreGate SCADA/HMI as a core supervision system for the reactor itself and all associated processes and systems. The research institute facilities and the whole area are also monitored by AggreGate.

A dedicated team in the Russian office of Network Instruments has developed a new AggreGate device driver for retrieving real-time data from specialized controllers running the NI-RT operating system. The driver is using JSON protocol for exchanging data with controller chassis providing extremely high data transfer rate of over than 150 000 tag values per second. All received values are streamed to a dedicated file-based storage for maintaining data history.

The failover architecture of AggreGate installation comprises four fully equal pairs of SCADA servers and database servers. Those pairs act independently ensuring high availability of the system and multiple copies of all historical values.
Over 50 custom-designed HMIs cover supervision of all processes and systems including fuel cluster, deuterium core reflector, reactor circuits and sump, pressure control, chilling and emergency cooling, water and pressurized air purification, recirculating water supply, radiological situation, nitrogen utilities, and radioactive drains. Another series of HMIs visualize the state of the reactor neutron and technological parameters.

A specialized trend browsing system properly matches metric values and their hardware-side timestamps, providing detailed monitoring for thousands of real-time parameters. It allows selecting multiple parameters to compare their trends on a single chart. All controllers and AggreGate servers synchronize their real-time clocks with stratum one time servers using SNTP protocol.

High system reliability is additionally ensured by:

- Connection of measurement hardware, controllers and AggreGate servers via two independent power sources
- Connection of controllers to AggreGate servers through a pair of Gigabit Ethernet interfaces
- Duplicate logging of errors to hard disk drives of data acquisition controllers and AggreGate servers
- Constant control of controller cabinet environmental parameters through a separate set of SNMP-enabled controllers
- Usage of custom-developed test beds for checking the whole data communication path starting from physical connectors up to HMI visualization
- Independent measurement data logging to tape storage arrays
- Self-testing of controller and cabinet equipment power supplies performed by additional sensors connected to NI chassis
All SCADA/HMI and database servers run under ALT Linux Centaurus operating system certified by Russian Federal Service for Technical and Export Control.
Benefits

AggreGate SCADA/HMI provides umbrella control and monitoring for all processes and systems of the neutron reactor complex, eliminating necessity to operate multiple systems and tightly integrate them for offering unified view in control rooms.

Very high data throughput and 4-node failover should have required several powerful servers. However, AggreGate settings were optimized to cut major part of database I/O during normal operation of the whole system, making it possible to use 12-core HP servers with just 16 Gb of RAM as primary SCADA cluster nodes. This has seriously optimized the overall project budget.

About Tibbo

Located in Taipei, Taiwan, Tibbo Technology Inc. brings simplicity to the automation world defined by enormous complexity of operating systems, programming languages, and design tools. Tibbo’s programmable hardware and the AggreGate Platform offer a complete solution for delivering robust, distributed automation and monitoring systems.