Abstracts for the technical presentations made during the ENTSO-E workshop at CERN on 12th-13th September

As part of the ENTSO-E workshop hosted at CERN on 12th-13th September, several presentations will be given on possible collaboration areas (see the Indico page of the event). This document gives a brief overview of the technical subjects covered and their use at CERN.

White Rabbit Collaboration

Abstract: In an accelerator complex as big as CERN's LHC, time synchronization is critical to ensure a smooth and efficient operation of the multiple machines in the tunnel. In 2008, upgrades for the timing system of several facilities were discussed at CERN. The vision relied on three pillars:

1. High-performance: sub-nanosecond accuracy and picosecond precision of synchronization as well as deterministic data transfer for large distributed systems
2. Standardization: extension of the IEEE1588 Standard which defines the Precision Time Protocol (PTP).
3. Open-source: hardware, gateware, firmware and software all under open-source licenses. Active contributing community.

The White Rabbit Technology relies on a set of open-source basic blocks which can be assembled to implement Switches and Nodes, which can in turn be connected to create a Network. The goal is to provide a common notion of time over Ethernet networks.

This technology is used at CERN in the large distributed systems to support data acquisition and trigger distribution.

White Rabbit has also been demonstrated over distances of more than 1000km and could play a key role in the future landscape of global time dissemination technologies, which currently rely heavily on satellites. Governments and industry across the globe are striving to find alternatives to distribute a reference time, such as the one WR could offer via optical fiber, with telecom and power grid companies starting to test WR in their networks.

The development of White Rabbit was a collaborative endeavor between several institutes and industries since the beginning, more than 10 years ago. In 2020, the concepts behind White Rabbit were incorporated in the IEEE 1588-2019 High Accuracy Profile industry standard and in 2024, CERN launched the White Rabbit Collaboration to further foster the uptake of the technology by industry. The Collaboration is a membership-based global community reuniting stakeholders of the technology, contributing to developing the technology and forming a network of experts and potential commercial partners.

Point of contact: White Rabbit Collaboration Bureau, bureau@white-rabbit.tech.

References: The White Rabbit Collaboration

CERN launches the White Rabbit Collaboration

RF over WR to control accelerating cavities at CERN

WR Trigger Distribution for distributed oscilloscope at CERN

SCADA Modular

Abstract: Supervisory Control And Data Acquisition (SCADA) is a combination of software and hardware for monitoring and controlling processes in industrial systems. Components are equipped with sensors which are then connected to servers for immediate or future analysis, enabling smarter decision-making and optimization. They provide real-time data acquisition, process control, and event handling, enabling operators to maintain optimal system performance and safety. SCADA systems are designed to handle large amounts of data from diverse sources, offering a centralized platform to monitor and manage complex operations efficiently.

There are over 850 production SCADA systems at CERN in different domains: from the LHC Experiments to Accelerators and Technical Infrastructure, all built with a standardized technology stack composed of WinCC OA and two component-based frameworks: JCOP and UNICOS. These complex SCADA Applications built on top of the frameworks by engineers at CERN and in over 150 collaborating research institutes achieve unprecedented homogeneity and integrability. With almost 25 years of experience, we are convinced that our organization of the JCOP and UNICOS projects allowing to reduce efforts and costs by promoting the reuse-and-share concept and centralizing expertise and maintaining necessary experience in an organization with a high turnover of personnel may be used as a model for collaborative development also in the domains employing industrial control technologies. An interesting example of tailor-made solution built upon the experience and with the elements of the Framework is the CERN Electrical Network SCADA (PSEN) which will be briefly described.

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References: CERN BE-CIS group

Digital Twin

Abstract: A Digital Twin is a virtual representation of a physical object or system, providing real-time data and enabling simulations for analysis and optimization. It serves as a dynamic counterpart, enhancing understanding, monitoring, and decision-making throughout the lifecycle of the corresponding physical entity. It is used for monitoring and predictive maintenance and can also drive design decisions by giving an overview of the system. Its level of details varies depending on the available information and user needs.

Digital Twins in industrial automation

In this talk, we will explore the application of digital twins in the industrial automation domain, focusing on how this cutting-edge technology is transforming operations and decision-making. Digital twins enable real-time monitoring, predictive maintenance, and optimisation of industrial processes. By using digital twins companies can enhance productivity, reduce engineering time, optimise industrial processes and safety. This presentation will highlight key benefits, including operational efficiency, and will feature several real-world examples showcasing successful implementations of digital twins.

Developing Digital Twins for Accelerator Magnets

Magnetic measurement data is collected at various points in an accelerator magnet's life cycle. It is used, for example, to calibrate model parameters in the prototyping phase, for quality assurance and fault detection in the production phase, and for state observation and prediction during magnet operation. In all cases, the numerical model of the accelerator magnet is at the center of the analysis.

Although magnetic measurement data is highly accurate, it is typically incomplete, i.e., the state space is not observable by a finite number of magnetic field sensors. On the other hand, numerical field simulations can predict the magnet state but are limited in accuracy and often fall short of the stringent requirements for magnet operation. For this reason, measurement data must be integrated with numerical field calculations to enable predictions with the required accuracy of one unit in 104 to 105.

To cope with the abovementioned challenges, we are developing application-specific hybrid models in all stages of the accelerator magnet lifecycle based on the principles of Model-based systems engineering, which focuses on models and simulations rather than documents for operation, performance evaluation, maintenance, and information exchange. This presentation will give an overview of the latest advances in the development of digital twins for accelerator magnets.

Development of a Digital Twin for the FCC

The Future Circular Collider (FCC) demands extremely stringent vibrational stability and precise alignment of its arc cell components. This short talk focuses on the development of a digital twin for the FCC arc cell mockup to address these critical mechanical challenges. The digital twin integrates comprehensive vibrational analysis data to create an accurate virtual model of the physical structure. The ultimate goal of the Digital Twin is to simulate the behavior of the arc cell under various operational conditions to help predicting and mitigating issues related to vibrational instability and misalignment. This approach not only enhances the predictive capabilities of the model but also provides valuable insights for optimizing the design and operation of the FCC, ensuring it meets the demanding requirements for mechanical performance and stability.

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References: Digital Twins at CERN and beyond

CERN-ABB collaboration

CERN Environmental Modelling and Prediction Platform project (EMP2)

Web Energy

Abstract: Web Energy is an energy management system (EMS) developed at CERN for monitoring and forecasting the electricity consumption of the organization. Its public dashboards are accessible by everyone at CERN. The core of the system (configuration management and forecasting) is the main tool used by the energy management experts in EN/EL for the management of the electricity contract. The insights about the electrical consumption provided by the system, enable the energy management team to reduce the environmental impact of the organization and achieve significant cost savings. The data and findings from Web Energy are discussed regularly in the Energy Management Panel. In addition, the system raises the awareness of users about their energy consumption, enabling them to identify early, potential improvements of their energy profile.

The system is actively supported and maintained by EN/EL and has been custom built to address CERN's needs. Through the Knowledge Transfer group, funds have been allocated to further develop this tool to integrate Machine Learning, gas and water consumption monitoring, KPIs and general enhancement of the platform for use outside of CERN.

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References: WebEnergy2.0Release