

Test Bed for a Cyber-Physical System (CPS) Based on Integration of Advanced Power Laboratory and eXtensible Messaging and Presence Protocol (XMPP)

This paper illustrates integration of Advanced Power Laboratory with Supervisory Control and Data Acquisition (SCADA) as a test bed for a Cyber-Physical System (CPS). Such integration has large-scale application in smart grid realm as well as in power engineering education and professional development for energy professionals. As a result, a complete smart grid training system including generation, high voltage transmission, and medium and low voltage distribution was developed.

Integration of advanced power laboratory has been performed with Lucas-Nülle (LN) smart grid training systems and Schweitzer Engineering Laboratories (SEL) protective relays at the joint xxx and xxx Smart Grid Laboratory at xxx. One of the key features of the test bed is utilization of eXtensible Messaging and Presence Protocol (XMPP). The use of XMPP allows multiple users, devices, and applications to share critical information in power applications. The laboratory system includes a model of long-distance transmission line combined with fault protection system by SEL. During the fault conditions, SEL relays operate as intended to clear the fault. Information of the system state is collected from Smart Grid laboratory sensors (smart meters and relays) and transferred via MODBUS TCP protocol to Supervisory Control and Data Acquisition (SCADA) system to display parameters of the system's state.

The XMPP system interface establishes secure session with registered users, devices, and applications. The link provides metadata to enable sensor data to be viewed by others. These notifications can be directed to operators that can control other equipment in response to the event. The XMPP link utilizes Transport Layer Security (TLS) to encrypt the data links. Actions by an operator can also be sent to remote devices extending the SCADA capability over any wired or wireless networks including the Internet.

The use of XMPP provides multicast capabilities and provides secure communications without the need for a Virtual Private Network (VPN). XMPP has been used to provide secure session initiation for many years but had not been used in CPS power applications. The capabilities can be used with mobile devices to provide alerts to maintenance and operations personnel. The event can also be shared with emergency response personnel who are trusted to receive this information.

The integrated CPS test bed provides real-time data, including power flow and information flow, to power system operators and other authorized personnel, which aids them in making more effective and intelligent decisions.

The test bed provides educational and research experience to undergraduate and graduate students and significantly raises their interest in energy field and broader areas of cyber-physical systems and provides unique experience with important aspects of the modern grid.