

SYSTEM INTEGRATION

Research Opportunity Notice

Overall Objective

The objective this Research Opportunity Notice (RON) is to solicit R&D proposals for developing enabling technologies for integrating utility business and engineering information systems in support of dynamic tariffs and demand response (DR). Proposed R&D may address part or all of the technologies and/or any related technologies which further the goals described in this RON. R&D projects should focus on developing enabling technologies for system integration as opposed to commercial product development.

Specific Goals

The proposed R&D projects for system integration technologies in support of DR should also support the following goals:

- The concept of measured once and used many times
- Sharing of stored data within all utility information systems
- Support legacy systems as well as pathways to future unknown systems
- Common methods of sending and receiving data messages
- Automated initiation of new and innovative utility business processes

The Need for System Integration

Traditionally, information systems have been isolated within each utility department. Historically the various departments developed the systems with the intent that the system hardware and information databases are the best to support the department's functions. Systems were incompatible because:

- Many computing hardware platforms
- Many operating systems
- Different mainframe/client-server/web-based systems
- Many component technologies (CORBA, DCOM, Enterprise Java Beans)

This historical legacy also created islands of information within the utility. Consider an example of the power transformer data from the perspective of several utility departments.

- Planning Department. In order to plan for a new transformer, the planning department will need data from the inventory database (will the new transformer come from the utility warehouse?), the purchasing and test and measurement database (what are the tested impedance?), the operations database (real loads, generation dispatches), the construction database (when and what is installed), etc. Once the data is collected, the planning department keeps the data in the planning department database.
- Design Department. To create the initial design and budget for a substation, the design department will need data from the purchasing database (prior costs), the manufacturer's Computer Aided Design (CAD) files (equipment layout), control and protection department data (prior performance), etc. Once the data is collected, the design department keeps the data in the design department database.
- Maintenance Department. While the transformer is in service, the maintenance department needs Geographic Information Systems (GIS) data to locate the transformer,

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maintenance data, test and measurement data, operations data, and purchasing and inventory data.

- Operations Department. The operations department needs present and anticipated loading data, planned switching or maintenance activity of the transformer, and transformer rating data.

As this illustration shows, there's a multitude of databases and departmental data requests for just one single piece of equipment. Imagine the level of complexity when this scenario is expanded to cover the entire utility's business.

In summary, the drawbacks of such islands of information are:

- Duplicate entries for the same data in multiple databases
- Each duplicate data entry may not be synchronized
- Data from one system usually must be entered by hand into another system - high probability of human error
- Non-critical data are rarely updated and accuracy of the data is suspect
- Locked into legacy proprietary systems
- Difficult to introduce new systems into the utility

Utility Industry System Integration Related Initiatives

Aware of the above drawbacks, utilities, through the Electric Power Research Institute (EPRI) and other standards committees, have started several projects. These include:

- Utility Communications Architecture (UCA)
The UCA began as a project at the EPRI in 1988. The UCA specification was developed as a communications roadmap for supporting a competitive integrated utility. UCA is a flexible and scaleable architecture that provides communications solutions from simple devices to control centers all based upon compatible, standard and interoperable communications protocols and device object models. The current version of UCA, UCA 2.0 has been merged with similar work of the International Electrotechnical Commission (IEC) Technical Committee (TC) 57 into the IEC 61850 standard.
- Inter-Control Center Communications Protocol (ICCP)
Developed initially as part of UCA. It is now also known as IEC-870-6 TASE.2 (Telecontrol Application Service Element). ICCP/TASE.2 enables real-time data exchange over WAN's between utility control centers, power pools, regional control centers, and non-utilities.
- Control Center API (CCAPI)
EPRI led an industry-wide effort, called CCAPI, to develop open, interoperable applications in the electric power control center environment through the use of standardized interfaces. Central to the CCAPI are the concepts of the Common Information Model (CIM) and the Utility Integration Bus (UIB).
- Common Information Model (CIM)
CIM defines a utility industry standard data object-model for the development and integration of applications used for electric power systems engineering, planning, management, operation, and commerce. CIM continues to be extended by IEC TC57 Working Groups WG13 (Energy Management System Application Program Interface – EMS API) and WG14 (System Interfaces for Distribution Management – SIDM) in collaboration with EPRI.
- Utility Integration Bus (UIB)
UIB provides a common way to automate communications between applications within the utility. UIB is designed to allow applications to use message broker technology, component technology (CORBA, DCOM, Enterprise Java Beans), and XML formatted

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messages. IEC TC57 WG13 and WG14 are also working on UIB. (Integration Bus is sometimes also called Message Bus)

- Integrated Energy and Communications Systems Architecture (IECSA)
EPRI and the Electricity Innovation Institute (E2I) formed the Consortium for Electric Infrastructure to Support a Digital Society (CEIDS). The goal of the CEIDS IECSA Project is to develop an open, standards-based architecture for the data communications and distributed computing infrastructure that will enable the integration of a wide variety of intelligent electric power system components.

Purpose of This RON

The purpose of this RON is to solicit proposals for R&D tasks to develop enabling technologies that will improve the integration of utility information systems. A main goal of funded R&D under this RON is to create enabling technology that will lead to an order-of-magnitude (10 times) increase in functionality while reducing total installed costs to one tenth (1/10th) of equivalent technology used at the present time.

R&D Task Goals

- Support the concept of measured once and used many times
This idea of this concept is that measured data should be read once and stored in a common database for access by multiple systems. This process reduces message traffic (utility systems need not make redundant independent reads of the same data) and ensures the data is accurate, valid, and up-to-date.
- Support sharing of stored data within all utility information systems
A common database avoids redundancy of data stored in multiple locations. Additionally, the data at any particular location may be of questionable quality (accurate and current). To avoid this concern, utility systems may make independent data reads to ensure the data is current. However, this can cause data from the same source to be not synchronized between systems. Thus the data is not usable for any type of correlation studies/reports that crosses multiple systems.
- Support for legacy systems as well as pathways to future unknown systems
Utilities cannot replace legacy systems that were large investments. Any enabling technologies must support these legacy systems. Legacy systems may not be able to provide the rich content of common data sets that may exist in the future. However, the enabling technology should maximize the transfer of data from the legacy system to the common data set. The enabling technology should also contain pathways to future systems by adhering to open and industry accepted standards.
- Support common methods of sending and receiving data messages
A common message protocol ensures applications are "plug" compatible. The utility is not locked into proprietary systems. Only one interface is needed to stored data from the messages into the common database instead of one unique interface for each system (unique interfaces are still needed for legacy systems)
- Support automated initiation of new and innovative utility processes
With common data access and common message communications, software agents can be developed to automate new and innovative utility processes that cannot be implemented with the current utility systems. With regards to DR, these processes can include automated price signal initiation and automated generation of customer bills based on dynamic tariffs. Other innovative utility process can be an outage detection system that can detect and locate the outage, plus dispatch the repair crew.

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Current Utility Business Environment

In California, before the electricity industry restructuring, there were three major Investor-Owned Utilities (IOU), Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E). These utilities were traditional vertically integrated regulated monopolies in their operating regions. The utilities owned and operated all components of the electricity market; from power generation, to transmission, to distribution, to the meter located at the electricity end-user's premise.

After the electricity industry restructuring, the utilities divested their ownership of the generation plants, but retained ownership of the transmission and distribution systems. Although in most part, the utilities owned the transmission system, operation and maintenance were coordinated by the non-profit entity, the California Independent System Operator (CAISO). The CAISO acts as an electronic auction house, coordinating the sale of electricity between buyers and sellers. The CAISO maintains the balance of the transmission system, matching supply and demand.

PG&E, SCE, and SDG&E became Utility Distribution Companies (UDC), owning and operating the distribution systems that provide electricity to the retail customers. The distribution system consists of breakers, conductors, transformers, fuses, capacitors, switches, monitoring and control systems, communication systems, above and underground structure assets. UDC's also own meters and provide meter reading service. However, this asset and service can be provided by third parties other than the UDC's.

Example System Integration with AMR

Traditionally, meter reading is performed by a human walking up to the meter and manually reading the meter. The meter register value is entered and stored into a handheld device. At the end of the day, all the meter register values read are uploaded from the handheld device to the utility's Customer Information System (CIS). The CIS uses the meter register values to generate the monthly bills. A step up from the human meter reader are Automatic Meter Reading (AMR) systems. One type of AMR system is a drive-by system. In a drive-by system, a van drives along the meter reading route and uses a wireless transmitter to query the electronic meters. Upon being queried, the meters transmit the meter register values to a wireless receiver on the van. The meter register values are uploaded to the CIS when the van returns to the utility. Other AMR systems utilize telephones, 2-way pagers, cellular phone systems, or fixed wireless systems to transmit meter register values back to the utility. In most cases, the AMR data residing on the CIS database(s) are not utilized by any other business systems within the utility. There's little or no integration among the various utility business systems.

Now consider an AMR system deployed for the purpose of DR with all utility business systems fully integrated. With up-to-date information available system wide, an intelligent agent for automatic outage detection and repair crew dispatch can be envisioned.

The agent will use Artificial Intelligence (AI) to detect outages based on the real-time information from the Advanced Metering (AMR) and Distribution Automation (DA) Supervisory Control and Data Acquisition (SCADA) systems. Once an outage is detected, the agent will retrieve associated information from the CIS and the Automated Mapping/Facilities Management and Geographic Information Systems (AM/FM/GIS) and using AI again, will prioritize a list of the possible outage scenarios. Each scenario is a combination of the possible outage location and the most likely cause of the outage (down line, blown transformer). Next, the agent will interrogate the Work Management System (WMS) to determine the best crews and equipment needed for each of the possible outage scenarios. Finally, the agent will alert and present the scenarios to the operator(s). An operator can decide which of the scenario should be acted on. The agent will complete the process by sending out the appropriate dispatch notices.

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Candidate Enabling Technologies for Use in Systems Integration:

- Additions and/or enhancements to the CIM and UIB
Enhancements can be new and innovative technologies that are applicable for use in CIM or UIB.
- Software wrappers or applications interfaces
Software wrappers or applications interfaces are needed to support legacy systems and current component technologies (CORBA, DCOM, Enterprise Java Beans), as well as pathways to future unknown technologies.
- Intelligent agents
With an environment of common data access and common messaging for all utility information systems, new and innovative intelligent agents can be formulated and implemented. Based on events, conditions, and rules, these agents can automatically push data to other agents or applications, pull or retrieve data as needed, or monitor utility operations and system security and initiate alarms when abnormal conditions exist.
- Knowledge rules (ontologies)
Build ontologies for new and innovative processes within the utility business. These ontologies will be the AI engines in the intelligent agents.

Summary

The purpose of this RON is to solicit proposals for R&D tasks related to enabling technologies for integration of utility information systems. The outcome of these R&D tasks is not to produce a product but to advance enabling technology for use in systems integration.

Proposals may address part or all of the technologies, and/or any related technology, which furthers the goals described herein.

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Acronyms

A/D	Analog to Digital
AI	Artificial Intelligence
AM/FM/GIS	Automated Mapping/Facilities Management and Geographic Information Systems
AMR	Automatic Meter Reading
ANSI	America National Standards Institute
API	Applications Program Interface
CAD	Computer Aided Design
CAISO	California Independent System Operator
CATV	Cable TV
CCAPI	Control Center API
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CEIDS	Consortium for Electric Infrastructure to Support a Digital Society
CIM	Common Information Model
CIS	Customer Information System
CORBA	Common Object Request Broker Architecture
DA	Distribution Automation
DCOM	Distributed Component Object Model
DR	Demand Response
DSL	Digital Subscriber Line
E2I	Electricity Innovation Institute
EM	Electromechanical
EMS API	Energy Management System Application Program Interface
EPRI	Electric Power Research Institute
GIS	Geographic Information Systems
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HVAC	Heating, Ventilation, and Air Conditioning
ICCP	Inter-Control Center Communications Protocol
iDEN	Integrated Digital Enhanced Network
IEC	International Electrotechnical Commission
IECSA	Integrated Energy and Communications Systems Architecture
IOU	major Investor-Owned Utilities
LAN	Local-Area Network
LEO	Low Earth Orbit
NOC	Network Operating Center
PG&E	Pacific Gas and Electric
R&D	Research and Development
RF	Radio Frequency
RON	Research Opportunity Notice
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SIDM	System Interfaces for Distribution Management
TASE	Telecontrol Application Service Element
TDMA	Time Division Multiple Access
TC	Technical Committee
TOU	Time-of-Use
UCA	Utility Communications Architecture

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Acronyms

UDC	Utility Distribution Companies
UIB	Utility Integration Bus
WAN	Wide-Area Network
WMS	Work Management System
XML	Extensible Markup Language

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Definitions

ANSI C12	Series of ANSI standards that pertain to electricity metering.
Apparent Power	Apparent Power (Kva , kilovolts-amps) is the vector sum of the Real Power and Reactive Power. (See Real Power, Reactive Power, and Power Factor)
Demand Response	Reducing demand in response to a curtailment notification or short term price signal.
Dynamic Tariff	A tariff in which the retail electricity rate is characterized by one or more dispatchable prices intended to reduce and/or shift peak load. (See Tariffs)
Firmware	Software that is embedded in the electronic device.
Local-Area Network	A network consisting of nodes that are confined within a localized area. For example, a floor of a building, or the building itself. (See Wide-Area Network)
Modulation	Method of superimposing a signal on a carrier wave form. For example, in radio broadcasts, AM (amplitude modulation) and FM (frequency modulation) are used.
Multi-phase	Alternating current (AC) electricity that consists of more than one phase of current. For example, common residential 240V AC power used for electric ovens and clothes dryers is multi-phase. (See Single-phase)
Non-contact	No physical connection to the current-carrying wire.
Platform	Hardware and software with the ability to perform multiple functions
Power Factor	Ratio of Real Power to Apparent Power. Also the cosine of the angle between the Real Power vector and the Apparent Power vector. (See Apparent Power, Real Power, and Reactive Power)
Reactive Power	Electrical power (Kvar, kilovolts-amps reactive) consumed by a capacitive or inductive load. The Reactive Power vector is orthogonal to the Real Power vector. (See Apparent power, Real Power, and Power Factor)
Real Power	Electrical power (KW, kilowatts) consumed by a resistive load and is the power that is used for real work. The Real Power vector is orthogonal to the Reactive Power vector. (See Apparent power, Reactive Power, and Power Factor)
Revenue Meter	Meter that can be used for billing purposes.
Revenue-grade	Measuring accuracy that meets the requirements needed for billing purposes.
Single-phase	Alternating current (AC) electricity that consists of one phase of current. For example, common residential 120V AC power is single-phase. (See Multi-phase)
Soft	Can be re-programmed with new software.
Stranded	Made obsolete because the technology is no longer supported.
Tariffs	The effective rates for electricity that includes rules, rate schedules, and service area maps.
Wide-Area Network	A network consisting of nodes that are dispersed over a wide area. For example, nodes that are located in different buildings, or in different cities. (See Local-Area Network)
Wireless	No wires between source of information and receiver of the information

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