Executive Summary

We are witnessing the modernization of electricity systems around the world. Today’s electricity grid is technologically complex, but conceptually simple – it moves electricity from generators to consumers and measures how much is used. However, the use and production of electricity are changing quite significantly. Consumers are able to contribute to the production of electricity using solar panels and wind turbines. Electric cars will be able to return some of their stored energy to the grid during times of peak demand. And, consumers need more control over the use of electricity in the face of rising prices.

The future electricity grid will be one where consumers and producers interact to their mutual benefit. Electric devices will automatically participate in the conservation and management of electricity. This intelligent electricity grid is the Smart Grid. The Smart Grid will use automation, communication and computers to improve the production, distribution and consumption of electricity.

Early initiatives in the deployment of the Smart Grid have focused on electricity meters and using them to provide detailed usage information to the consumer and distributors. Smart meters collect usage data on a regular basis and transmit them to back-office systems where they can be used for billing, reporting and analysis.

Today’s solutions for Smart Grid communications are proprietary and monolithic – as expected for a market in the innovation phase. An open, standards-based architecture for Smart Grid communication is now required to allow the market to cross the chasm to mainstream acceptance and deployment. Governments and power authorities have recognized this need and are moving quickly to provide funding for those companies and projects whose products and technologies are open and based on standards that allow interoperability, especially Internet technologies.

The American Recovery and Reinvestment Act of 2009 recognizes the importance of an open, standards-based approach for Smart Grid communication (P.30, Section 405):

“(F) Open protocols and standards. DOE shall require as a condition of receiving funding under this subsection that demonstration projects utilize open protocols and standards (including Internet-based protocols and standards) if available and appropriate”

The Ontario Smart Grid Forum, a group of industry leaders in Ontario, Canada, conducted a comprehensive study of the smart grid and developed recommendations for advancing it in Ontario. The forum’s recommendations regarding communications technologies for the smart grid reinforce the position taken by American legislators:
The developing nature of smart grid technology has three significant implications for communications. First, smart grid communications development must match smart grid development. While the initial communications deployment can be configured and sized to accommodate the first generation of smart grid equipment, such as smart meters; ultimately the communications infrastructure must be capable of servicing the full range of smart grid equipment installed.

Second, smart grid communications must be developed based on open standards so that the widest possible range of devices can be employed and the development of new devices and entry by new vendors is encouraged.

Third, communications must be designed with interoperability as a requirement. While standards allow many different devices to interact over a given communications technology, interoperability allows a variety of technologies to work together. “(1)

The telecommunications industry had an almost identical set of requirements for its technological revolution some decades ago. The Session Initiation Protocol (SIP) emerged as the leading solution for these requirements. SIP further evolved to create a new generation of multi-media, unified communication that has proven to be the real revolution.

SIP is an application-level communication protocol conceived using Internet concepts and provides all the openness, standardization and interoperability required by the Smart Grid architects. As SIP is based on internet protocol (IP), it leverages all of the functionality provided by an IP network (e.g. TCP, UDP, QoS, routing).

SIP is a mature protocol and has proven to be reliable, secure and scalable. SIP has also proven to be easily extensible and, by definition, independent of the specific data exchange requirements of the communicating devices.

The implementation of SIP in the enterprise and carrier markets has resulted in the creation of network elements such as proxy servers, device registration servers and session border control servers that have made widespread deployment easy and secure. These same network elements are required for the Smart Grid and can be readily adapted for rapid implementation.

SIP is consistent with all current standards and architecture initiatives for the Smart Grid, filling many of the device communication requirements specified by the technical committees. For example, the American National Standards Institute (ANSI) standard C12.22 defines interfaces and network elements for two-way metering communication
systems. Many of the network element concepts defined in ANSI C12.22 are already developed and verified for SIP networks.

SIP can provide the communication semantics to support device-to-device, device-to-back-office and back-office-to-device communication, while allowing the use of data models such as the International Electrotechnical Commission’s (IEC’s) Common Information Model CIM for the device-specific data exchange protocol. SIP’s payload-independent design allows a payload such as ANSI C12.19 tables to be transported exactly as they are defined in the standard, providing automatic compatibility at the syntax level with existing applications.

A key element of many Smart Grid initiatives is support for Plug-in Electric Vehicles (PEVs). PEV batteries need to be charged from the grid, of course, but they can also contribute energy to the grid during peak usage times. Both of these operations require sophisticated metering to support the debiting and crediting of energy accounts associated with the using of and feeding to the grid. Further, as PEVs are automobiles, they will require support for mobile metering. For example, the owner of a PEV who needs to charge the battery when away from home will want to have the cost of that energy debited to their account, not to the account of the owner of the home they happen to be visiting. SIP’s location register provides native support for device and user mobility. A SIP user can be found independent of the location and network connection. This functionality is critical to support of mobile metering where the PEV, for example, needs to connect to a back-office energy system different than the one used by the local fixed meter.

Security is very important in Smart Grid communications and must address, among other things, device identification, intrusion prevention, data integrity and privacy. SIP supports all modern security mechanism for internet communication, including IPSec, Secure MIME and TLS. Further, SIP’s extensible design allows for support of new security mechanisms as they emerge and evolve. This flexible security design allows for implementation in high-security environments such as those involving a substation as well as less stringent environments such collection of usage data from smart meters.

Finally, SIP brings native voice, video and text communication to the Smart Grid, as well as advanced communication concepts such as presence and location. Enabling a mobile workforce is a key business driver for many utility companies and an architecture that supports both Smart Grid and mobile communication is a compelling advantage.
It’s clear that the aggressive evolution and development of the Smart Grid requires the use of open, standards-based technologies. But, this is not enough; it also requires the use of protocols and solutions that have been proven to be functional, scalable, secure and of high performance. The use of SIP for Smart Grid device communication provides an opportunity to jump-start Smart Grid deployment while supporting existing standards and architecture evolution. SIP brings a robust unified communication capability to the Smart Grid, which no other protocol can provide. This allows the Smart Grid infrastructure to be used to enable a mobile workforce and automate many other business processes, an important addition to the business case for Smart Grid.

The following quote from the GridWise Architecture Council provides an excellent summary of SIP’s value proposition for the Smart Grid:

“Adoption of Appropriate Material from All Sources: avoid inventing principles or approaches where leadership is exhibited elsewhere (e.g., communication protocols, information technology paradigms, and infrastructure are being driven by the information technology industry). Keep creative focus on concerns unique to the energy system communication and control problem domain while adopting appropriate solutions that have more general applicability.” (2)
Introduction

“If Thomas Edison came back to life, he'd recognize our electric utility system immediately – and that's not a good thing.” This quote from Jesse Berst, Executive Editor of Smart GridNews.com, highlights the technological state of the American electric power infrastructure (the grid). This statement can be applied to many other power grids around the world – they haven't changed much in the last 50 years.

The Smart Grid initiative will modernize power grids using contemporary technologies in support of more efficient power usage, more control and management of the power system, and the opportunity for consumers to participate actively in the management of their power consumption. The Smart Grid is envisioned to be:

- Smart electrical devices that participate in the reporting of electricity usage and implementation of usage policies.
- Advanced control systems used by utility companies to analyze and manage the grid. Some of these will be used by consumers to view and adjust their electricity usage.
- A two-way communication network that connects the smart devices to the control systems and the users to the control systems.
Additionally, the Smart Grid will support local energy generation and storage options such as wind turbines, solar panels and capacitor banks and electric cars.

While the two-way communication network will provide connectivity for smart devices and control systems, a communication protocol is required to enable secure, effective message passing. The Session Initiation Protocol (SIP) is such a protocol. SIP was created for the telecommunications industry and has served to revolutionize it. Its easy-to-implement nature, flexibility and extensibility have propelled the use of Voice over IP (VoIP) for enterprise and consumer telecommunication services into the mainstream.

The revolutionary affect of SIP was in the creation of a new, multimodal method of communication which has come to be known as Unified Communication (UC). SIP’s ability to enable concurrent communication using text, audio and video while providing open interfaces to business applications and business processes has made it the de facto standard for UC. The addition of device-to-device communication required for Smart Grid devices is a natural extension for SIP.

SIP has matured and hardened in the telecommunications industry, making use of internet technologies to provide secure, robust and scalable communications. Network elements have evolved to allow for very complex network topologies, such as extranets, survivable branch offices, service provider trunking and NAT-traversal of local networks.

SIP is an application-layer protocol that is independent of the underlying physical network. It can be carried over any wired and wireless (WiFi, GSM, WiMax, etc) network that is capable of supporting Internet Protocol (IP). SIP and its associated network elements can be used to accelerate the development and deployment of the Smart Grid. Some enhancements and changes will be required, but these are far less complex and involved than reinventing and recreating similar components from the ground up.

The following chapters will explore the practicality of using SIP for the Smart Grid as well as how it can augment existing Smart Grid standardization and architecture initiatives.
SIP and Smart Grid architectures and standards

There are several ongoing efforts to define architectures and standards for the Smart Grid. Consistently, leaders of these initiatives are recommending the use of modern information technology and related architectures and standards. None of the architecture and standards initiatives have recommended or selected specific technologies, but they all recommend open, proven technologies with an emphasis on interoperability – a natural fit for SIP.

The GridWise Architecture Council is leading the definition of architectures and standards for the American Smart Grid. The council was formed by the American Department of Energy (DOE) in order to promote and enable interoperability among the many entities that interact with the electric power system. The council provides guiding principles for the Smart Grid architecture as well as a framework for the development of architectures.

The following key attribute of the architecture is indicative of the council’s support for use of protocols such as SIP:

"Adoption of Appropriate Material from All Sources: avoid inventing principles or approaches where leadership is exhibited elsewhere (e.g., communication protocols, information technology paradigms, and infrastructure are being driven by the information technology industry). Keep creative focus on concerns unique to the energy system communication and control problem domain while adopting appropriate solutions that have more general applicability." (2)

The OpenAMI Task Force is another initiative aimed at providing guidance to Smart Grid projects. The task force is an international, industry-wide initiative whose objective is to develop a recommended open, standards-based information/data model, reference designs and interoperability guidelines for advanced metering networks and demand/response solutions. A set of high-level requirements have been published (3) that request secure, scalable, two-way communication technologies for the next generation advanced metering infrastructure. The requirements are, however, still at the concept stage and require some refinement in order that they can assist in the selection of specific technologies.
Substations are an important part of the Smart Grid, but require a more stringent level of engineering than other parts owing to the safety- and mission-critical nature of their role in the distribution of electricity. For example, communication between devices in a substation must be protected against the effect of strong electromagnetic fields that don’t exist near a meter. The International Electrotechnical Commission (IEC) has written standard IEC 61850 that defines the communication technologies, methods and data models for devices (Intelligent Electronic Device – IED) in a substation.

IEC 61850 defines two distinct LANs for the substation: the station LAN and the process LAN. The station LAN connects all of the IEDs to one another and to a router for communicating outside the substation onto a WAN. The process LAN conveys raw power system data (e.g. voltage and current samples) from switchyard devices to the relays or IEDs that process the data. As IEC 61850 is a very mature and well-specified standard, there is no need to use SIP between IEDs.

SIP can be used, however, on the station LAN and for station devices that don’t require IEC 61850. An IEC 61850-to-SIP gateway would provide an architecturally consistent way to connect the IEDs (or aggregated IED data) to the back-office or other Smart Grid devices. The use of SIP on the station LAN would additionally allow for the deployment of communication and monitoring devices such as IP telephones and IP video cameras in the substation.

The most comprehensive initiative to date is IntelliGrid from the Electric Power Research Institute (EPRI). The IntelliGrid initiative has produced four volumes of documentation covering user guidelines, functional requirements, a reference model of open distributed processing and technical analysis principles and results. One of the key results of IntelliGrid is an architecture that is:

“…an open-standards, requirements-based approach for integrating data networks and equipment that enables interoperability between products and systems.”

The IntelliGrid architecture, like the GridWise Architecture Council, provides guidance for analysis, selection and deployment of architectural components, but does not specify specific technologies. One of the key benefits of the IntelliGrid Architecture is the capturing and recording of requirements for the Smart Grid, the first set of which are communication configuration requirements (4):

1. Communication Configuration Requirements
   - Provide point-to-point interactions between two entities
   - Support interactions between a few ‘clients’ and many ‘servers’
   - Support interactions between a few ‘servers’ and many ‘clients’
   - Support peer to peer interactions
   - Support interactions within a contained environment (e.g. substation or control center)
   - Support interactions across widely distributed sites
   - Support multi-cast or broadcast capabilities
   - Support the frequent change of configuration and/or location of end devices or sites
   - Support mandatory mobile communications
- Support compute-constrained and/or media constrained communications

SIP supports and enables each of these types of communication.

American National Standards Institute (ANSI) C12.22 (5) follows C12.18 and C12.21 and describes how to transport meter data tables (ANSI C12.19 - Utility Industry End Device Data Tables) over an arbitrary network. C12.22 is more abstract than its predecessors and has therefore defined generic network elements required for communication. Many of these elements map directly to similar network elements in a SIP network:

<table>
<thead>
<tr>
<th></th>
<th>SIP</th>
<th>C12.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-points</td>
<td>UA, client, server</td>
<td>Node, client, server</td>
</tr>
<tr>
<td>Message management</td>
<td>UA to UA, Proxy, Multiple Proxies</td>
<td>Node to node, Relay, Multiple Relays</td>
</tr>
<tr>
<td>Message encoding</td>
<td>ASCII Text, XML (any format for payload)</td>
<td>ASN.1, BER</td>
</tr>
<tr>
<td>Messaging model</td>
<td>Request/Response</td>
<td>Request/Response, Blurt</td>
</tr>
<tr>
<td>Registration</td>
<td>Registrar, location server</td>
<td>Authentication Host, Notification Host</td>
</tr>
<tr>
<td>Address resolution</td>
<td>DNS, location server, redirect server</td>
<td>Relay</td>
</tr>
<tr>
<td>Translation to legacy systems</td>
<td>Gateway</td>
<td>Gateway</td>
</tr>
<tr>
<td>Payload / Media</td>
<td>RTP, MIME, HTTP, any format</td>
<td>C12.19</td>
</tr>
<tr>
<td>Network communication</td>
<td>Ethernet adaptor, others</td>
<td>Communication Module</td>
</tr>
<tr>
<td>Physical access</td>
<td>N/A</td>
<td>Local port</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>MTU, Ethernet fragment / IP fragmentation</td>
<td>C12.22 fragmentation algorithm</td>
</tr>
<tr>
<td>End-point identification</td>
<td>URI, URL</td>
<td>ApTitle, AeTitle (ISO Universal Identifier)</td>
</tr>
<tr>
<td>Encryption</td>
<td>Any</td>
<td>AES in EAX Mode</td>
</tr>
<tr>
<td>Action messages</td>
<td>DO method (proposed), any command syntax in payload</td>
<td>EPSEM service definition</td>
</tr>
<tr>
<td>Short messages</td>
<td>Blind NOTIFY, new message</td>
<td>Blurt</td>
</tr>
</tbody>
</table>

The items highlighted with a 🌒 symbol are those where the C12.22 standard has introduced specific concepts or algorithms that already exist in a SIP network. For example, C12.22 describes a unique packet fragmentation and reassembly algorithm that is to be used in C12.22 devices. Using Ethernet and IP for transport would obviate the need to describe such an algorithm and for vendors to implement and prove it in their products.
The items highlighted with a symbol are not currently available in a SIP implementation and would have to be developed as they would for a C12.22 implementation. For example, a gateway that translates proprietary device protocols to and from the Smart Grid protocols is required regardless of the communication protocols chosen for Smart Grid. The short, session-less message defined as a “blurt” by C12.22 can be implemented as a SIP “blind NOTIFY” or as a new SIP message if additional functionality is required.

A more detailed investigation of how SIP fits into Smart Grid architectures will be the topic of a subsequent white paper. That paper will also investigate the advantages of a SIP-based architecture when compared to a traditional client / server model where, for example, all meters connect directly to a central back-office server.
SIP is mobile

SIP supports personal mobility by design. The SIP registration and location services allow a user to be found independent of location and the network device they are using (e.g. PC, wired IP phone, WiFi IP phone, etc.). This is implemented in SIP using redirection during call establishment (response “302 Moved” to INVITE message). It is also implemented when using a proxy server by virtue of the proxy server’s use of the location register. In this case, the calling party does not need to supply the current location of the called party, as the proxy server will discover it via the location register.

The step from personal mobility to IP mobility is simply that a user can change their IP address during a traffic flow. Therefore, in order to support IP mobility, SIP supports the ability for the device to move while a session is active. This can be done using Mobile IP1 or via the native SIP support for mobility. For example, when a device sends an INVITE to a mobile device, the SIP redirect server has current information about the mobile devices’ location and redirects the INVITE there. If the mobile device moves during a session, it simply sends a new INVITE to the correspondent device using the same call identifier as in the original call.

Enabling mobility as just described is critical for support for Plug-in Electric Vehicles (PEVs), which are one of the key catalysts of the Smart Grid. PEV batteries need to be charged from the grid, of course, but they can also contribute energy to the grid during peak usage times. Both of these operations require sophisticated metering to support the debiting and crediting of energy accounts associated with the using of and feeding to the grid. Further, as PEVs are automobiles and hence mobile, they will require support for mobile metering.

For example, the owner of a PEV who needs to charge the battery when away from home will want to have the cost of that energy debited to their account, not to the account of the owner of the home they happen to be visiting. SIP’s mobility design and functionality can therefore play a key role in the establishment of a Smart Grid that fully supports PEVs.

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1 Mobile IP is an IETF standard communications protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent IP address. Mobile IPv4 is described in RFC 3344 and mobile IPv6 is described in RFC 3775.
SIP is secure

Security is of particular importance when considering the modernization of the electricity grid. The Smart Grid requires connecting devices in every home, business and substation to essential computer systems that operate and manage the grid. Beyond the challenges this poses for cyber security, these devices will likely be deployed in locations that are physically accessible to a potential hacker.

Further, deployment of the Smart Grid will undoubtedly require use of public networks provided by third parties. These networks will connect smart devices to back-office systems, will cross organizational boundaries between partners, suppliers and consumers. Comprehensive security and privacy mechanisms are required that protect the Smart Grid from attackers. These security mechanisms must also enable deployment in complex network topologies. Such mechanisms are currently available and in use in SIP networks.

Security for SIP networks is described in detail in RFC 3261 (6), the principles of which are:

> “… we gather that the fundamental security services required for the SIP protocol are: preserving the confidentiality and integrity of messaging, preventing replay attacks or message spoofing, providing for the authentication and privacy of the participants in a session, and preventing denial-of-service attacks. Bodies within SIP messages separately require the security services of confidentiality, integrity, and authentication. Rather than defining new security mechanisms specific to SIP, SIP reuses wherever possible existing security models derived from the HTTP and SMTP space.”

The security models referred to above have proven very effective for Internet communications and serve to secure SIP as well. These models and protocols are implemented by SIP user agents as well as intermediate devices such as proxy and registrar servers.

- HTTP Digest authentication (also prevents replay attacks).
- S/MIME to authenticate and encrypt the message bodies.
- SIPS URI scheme which indicates that each hop of the message flow must be secured with TLS.
- TLS or IPSec for transport and network layer security

Advanced communication protocols such as SIP pose some challenges for network devices intended to create security domains within enterprises and between enterprises. Network elements have been developed through the course of SIP deployments to enable SIP to be securely transported through such complex network topologies. For example, several initiatives have resulted in solutions that allow SIP to be used with Network Address Translation (NAT) and therefore allow its use with secured interfaces between unrelated networks:
• Session Traversal Utilities for NAT (STUN) (7) is a process implemented in a server that is located on the public side of a NAT server and provides information about NAT addresses to devices on the private side of a NAT server. A SIP user agent on the private side of a NAT server uses the information from the STUN server to adjust address information during the construction of messages.

• Traversal Using Relay NAT (TURN) (8) is an evolution of STUN that is most useful in networks that require communication to specific clients on the private side of the NAT server. The most significant difference between STUN and TURN is that TURN acts as a relay for the communication payload itself, whereas STUN servers provide reference information only.

• Interactive Connectivity Establishment (ICE) is an IETF draft RFC that describes how a client can dynamically select the best solution for traversing networks where one or more NAT servers are used. The ICE protocol is already enabled for use with SIP and greatly simplifies the deployment of SIP networks.

• “Managing Client Initiated Connections in SIP” is an IETF draft that describes how a client-initiated session can be reused to provide NAT traversal without any intermediary servers such as STUN.

STUN and TURN servers enable SIP to be securely transported across private / public network boundaries, but do not address the requirement to implement policies for extranet communication. The Session Border Controller (SBC) is a network element that addresses this. A SBC is a session-aware device that manages SIP sessions at the borders of an IP network.

One of the key functions of the SBC is the ability to provide SIP services across NAT and firewall devices located at a customer premise or within the network. SBCs provide traversal of NAT and firewall servers without additional customer premise equipment, and do not require the replacement of existing firewall and NAT servers.

Smart Grid business models will require interconnection of private and public networks, connection of multiple private partner networks and control of these connections. SIP networks and implementations have addressed this and these solutions can be applied directly to a SIP-based Smart Grid communication protocol.
SIP performance, scalability and reliability

SIP software stacks have been developed for all operating systems and for just about all CPU types. SIP implementations can be found for devices ranging from compact mobile phones to large, highly redundant server complexes.

Smart Grid deployments will consist of hundreds of thousands of devices per domain. Communication technologies for the Smart Grid must therefore provide the necessary throughput and response times, must be efficient in using CPU and memory, especially for client-side applications and be conservative with network bandwidth utilization.

A typical client-side SIP software stack has the components shown in the adjacent diagram.

In a Smart Grid device such as a smart meter, the RTP, codecs and applications are not required. Further, the more complex SIP call flows common in telecommunications applications are not required in devices such as smart meters and therefore the SIP and SDP component can be further compressed. Today’s SIP software stacks can be as small as 128K bytes. A SIP software stack for a smart meter can be constructed with an even smaller memory footprint.

Scalability of SIP servers is another critical requirement considering the very large number of client devices that will form the Smart Grid. SIP registrar and proxy servers have

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2 While 128K bytes is a tiny footprint in today’s world of inexpensive memory and CPU processing power, the author acknowledges that this represents a significant requirement for existing electricity meters. The evolution of the Smart Grid towards internet technologies will require, however, that meters and similar devices evolve to modern computing platforms regardless of the communication protocols used.
evolved in the service providers and multinational enterprises environment to be able to handle hundreds of thousands of clients. Sophisticated, multi-CPU server configurations provide continuous availability while processing thousands of transactions per second.

The Standard Performance Evaluation Corporation (SPEC) has developed a benchmark for SIP (9) and has published performance results for many test suites and computer configurations. It’s clear from these test results that a high volume of SIP transactions can be processed using commercially available computing platforms. Further, the benchmarks show that throughput scales significantly simply by using multi-CPU computing platforms.

Note that SIP transactions processed by registrar and proxy servers do not include the application-specific transactions (e.g. RTP media streams for audio). The distributed nature of SIP enables the entire system to scale far beyond the capabilities of the servers themselves.

While it may be argued that the telecommunications infrastructure is not as critical as the electricity grid, its availability is nonetheless of critical importance. Reliability and availability solutions have evolved in the IT industry that provide near continuous operation. Use of redundant hardware configurations, execution and memory mirroring on adjacent computer systems and fault-tolerant operating systems have enabled the use of general purpose computing platforms where dedicated hardware solutions were previously required.

These solutions have been applied to SIP servers and networks and have proven to be very effective at providing a highly reliable telecommunications infrastructure for service providers and enterprise users alike.
SIP can help justify the Smart Grid

Many power utilities are having difficulty justifying the expense of deploying the communication infrastructure required for the Smart Grid. While the infrastructure must be designed and deployed such that it can support the anticipated advanced smart applications, the initial application is typically automated meter reading. This provides some advantage, but not enough for most utility companies to launch their Smart Grid projects.

The use of SIP for Smart Grid device communication will provide significant opportunity to leverage the infrastructure and derive immediate additional business value. Concurrent workforce mobility projects can be initiated using the communication infrastructure and SIP services used to enable the initial Smart Grid applications.

Communication-enabled mobile field applications have proven to be much more effective than their off-line equivalents. Such applications provide real-time access to back-office support staff through audio, video and text messaging. Further, the availability of presence information\(^3\) in applications such as service scheduling greatly reduces errors in scheduling and increases customer service.

A SIP infrastructure in substations enables low-cost audio and video services to be deployed, such as local telephone service or SIP-enabled video cameras. WiFi wireless connections in substations with SIP will further enable advanced mobile applications such as fixed-mobile convergence (FMC). With FMC, employees can use a single telephone handset and telephone number for both cellular and office environments. The FMC handset will automatically roam between the cellular network and the private network without interrupting active telephone calls to optimize telecommunication costs. It will also make available advanced PBX features such as multi-party conference and local dialing when using the cellular network.

The quality of service mechanisms of the IP and SIP infrastructure will allow sharing of a single communication infrastructure for the Smart Grid, rather than dedicated networks for device communication and a separate network for workforce and business process automation. This will support a business model where a telecommunications company can provide a common communications infrastructure for the Smart Grid and perhaps even the SIP servers.

Another important feature of SIP networks that can be exploited for the Smart Grid is the multi-tenant deployment scenarios. This model is common in the telecommunications industry and allows a single, large SIP server to support multiple logical business entities. Subscriber traffic is directed to the appropriate set of resources (e.g. trunks and gateways) according to their registration records. This functionality supports the de-

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\(^3\) Presence is the ability of a person or device to communicate with others and to display levels of availability. Presence awareness is the knowledge of the person or device's availability. Knowing a person's level of availability, you can instantly know whether or not that person is available to take your call.
regulated nature of the telecommunications industry by allowing subscribers to move service providers fairly easily.

One can image a similar model for the electricity industry where a meter, for example, would connect to and exchange data with the electricity provider currently contracted by the customer based on registration records.

While network elements such as registration and proxy servers are almost always present in a SIP network, they are not mandatory. SIP can operate very well in a peer-to-peer network where end-points communicate with each other directly without the need for registration and proxy support. This functionality can be very useful in allowing smart devices to communicate with each other for localized scenarios.
Some enhancements are required for Smart Grid devices

There are a few enhancements and extensions to SIP if it is to be used effectively by smart devices. Most important is the development of a data exchange protocol specific to the Smart Grid. When using SIP for an audio session, SDP is used by the end-points to negotiate the parameters of the session and then RTP is used to transport the audio payload itself.

An extension the protocol (either SDP or in supported headers) is required to allow smart devices to describe and negotiate the data exchange session. Meter table data version and network bandwidth requirements are examples of parameters that can be negotiated and selected. Once the session is established, a data and command exchange protocol is required - Device Messaging Protocol (DMP). The definition of such a language is a can evolve directly from the C12.22 definition of services and the EPRI initiative to harmonization the definition of meter data (10).

Network elements such as session border controllers that recognize and process SDP and related protocols will require enhancement to be able to recognize DMP.

Additions to the SIP protocol may be required in order to accommodate what C12.22 calls a “blurt”. A blurt is a single short message such as an alarm or piece of data sent by a device and that does not require acknowledgment. A blurt does not require a session, but does require authentication and routing. The SIP “blind NOTIFY” can possibly be used to implement a “blurt”. The “blind NOTIFY” is a SIP NOTIFY message that carries with it an implicit SUBSCRIBE and therefore is very similar on concept to the “blurt”. A new message can alternately be defined for SIP to implement the “blurt”, requiring some additional work with the IETF standards.

While not a SIP enhancement, a server that converts SIP, SDP and DMP to proprietary back-office protocols is also required. This server would implement a SIP user agent towards the Smart Grid devices and the specific protocol required by the back-office systems towards the back-office servers.
Vision of a SIP-enabled Smart Grid

A SIP enabled Smart Grid provides secure, reliable communication for smart devices and a mobile workforce. The standards-based infrastructure allows equipment from diverse vendors to interoperate on the network. The flexibility of topologies supports a number of business models where network elements can be owned or provided by services providers. The dynamic nature of SIP networks allows customers to choose their electricity supplier and have their registration and data flow to the provider’s back-office systems automatically.

SIP allows the utilities industry to focus government stimulus funding and their own research and development funds on yet-to-be-encountered technical issues rather than reinventing solutions to problems that have already been solved. SIP has proven to be easy to understand and easy to implement. Its use of internet technologies is completely in line with stated directions and requirements for the Smart Grid.

A SIP enabled Smart Grid would also provide benefit to the SIP community. The inevitable improvements and additions to SIP that will result from use in the electricity industry will be fed back to the SIP community to the advantage of all SIP users. Service pro-
providers, for example, can use a single set of SIP servers to provide telecommunications and utility services, which will reduce their costs and therefore their customers’ costs.

SIP has proven to be an enabler of change for the telecommunication industry. It was a key factor in the move to internet technologies for voice and video communications. Its straight-forward, modular technical design accelerated its implementation by allowing the use of general purpose computing platforms. The electricity industry can benefit from SIP in the same way, while simultaneously providing a platform for communication-enabled business processes.
Quotations


About Siemens Enterprise Communications Group (SEN Group)

The SEN Group is a premier provider of enterprise communications solutions. More than 14,000 employees in 80 countries carry on the tradition of voice and data excellence started more than 160 years ago with Werner von Siemens and the invention of the pointer telegraph. Today the company leads the market with its "Open Communications" approach that enables teams working within any IT infrastructure to improve productivity through a unified collaboration experience. SEN Group is a joint venture between the private equity firm, The Gores Group, and Siemens AG and incorporates Siemens Enterprise Communications, Enterasys Networks, SER Solutions, Cycos and iSEC.

For more information about Siemens Enterprise Communications, please visit www.siemens.com/open

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