AMI-Enterprise

System Requirements Specification

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1. Introduction

AMI-Enterprise (AMI-ENT) is a utility led initiative under UtilityAMI and Open Smart Grid (OpenSG) within the UCA International Users Group (UCAIug). The AMI-Enterprise Task Force defines systems requirements, policies, principles, best practices, and services required for information exchange and control between AMI related systems and utility enterprise front and back office systems. AMI-ENT, as a utility led and vendor participant forum, is developing a set of utility-ratified requirements and specifications for utilities to adopt and for vendors to implement. The end-state of this effort will contribute to the development of open and interoperable AMI solutions. To that end, AMI-ENT will work very closely with relevant Standards Development Organizations (SDOs) such as IEC TC57 WG 14, MultiSpeak, and others to ensure that AMI-ENT work products are compatible with their directions and specifications and will be adopted as standards.

The AMI-ENT group is organized with four sub-groups:

- ***Use Case Team***: to develop business process models and functional requirements, which include basic AMI functionality, Demand Response, Third party data access etc.
- ***SRS Team***: to develop overall systems architecture principles, integration requirements and specifications.
- ***Service Definition Team***: to develop standards-based, platform independent integration services that support the business processes, adhere to the architecture principles and patterns, and are open and interoperable when adopted by vendor products.
- ***Testing and Interoperability Team***: responsible for the definition and development of test plans, unit, compliance, and interoperability tests, based on the services that have been defined as part of this standard.

The main goal of the task force is to work with utilities to develop requirements and specifications necessary to enable vendors to deploy open and standards-based interoperable AMI solutions. This will be achieved by defining and making the following AMI-ENT related items available to the market:

- Common business processes
- Common architecture principles and patterns
- Common information model
- Common integration services (functional & informational)
- Compliance and interoperability testing of and between vendor products

1.1 Purpose

The purpose of this document is to provide both the functional and technical requirements needed to serve as the "rules of engagement" for how vendors and utilities could implement recommended requirements and design specifications in order to achieve interoperability. The focus of the AMI-ENT is integration among systems and/or applications to enable AMI business processes at the inter-systems level within utility enterprise as well as between utility and other entities (ISO/RTOs, other utilities, customers (residential and C&I), and third party service providers). The functional requirements will be driven by business processes and the technical requirements will be driven by desired architectural principles and best practices.

1.2 Scope

The scope of AMI-ENT is the systems and/or applications within and around the utility enterprise and the inter-systems related business functions and stops at the boundaries of applications and the edge of utility enterprise. The focus is on how these systems are to be integrated and composed to support AMI related business processes and functions. Edge applications are those applications that communicate with networks and devices in the field, as well as those that communicate with other businesses or enterprises (generally defined as third parties). Examples of those applications are typically AMI Head-End system, Demand Response Control, Distribution management and operation (DMS/SCADA), Energy Management, Power Trading, etc. The SRS will define a list of logical components and business functions and suggest a typical landscape of application components to support these AMI-ENT functions to ensure applicability and reusability of requirements and services across different vendor product suites and across different utility AMI implementations. It includes scope, goals and objectives, architectural principles, architecture considerations and patterns, AMI-ENT reference architecture; and specific requirements. The SRS will also reference AMI-ENT use cases, functional requirements and service design approach and artifacts.

The scope of AMI-ENT SRS document is to describe what AMI-ENT is as an ecosystem of integrated applications, what collective functions it intends to provide, what system architecture is required to deliver the intended functions, and what individual applications and the underlining technology infrastructure it requires to support the establishment of AMI-ENT as such a system. This will lead to open and interoperable components that can be delivered with different vendor products and/or solutions within the scope of AMI-ENT.

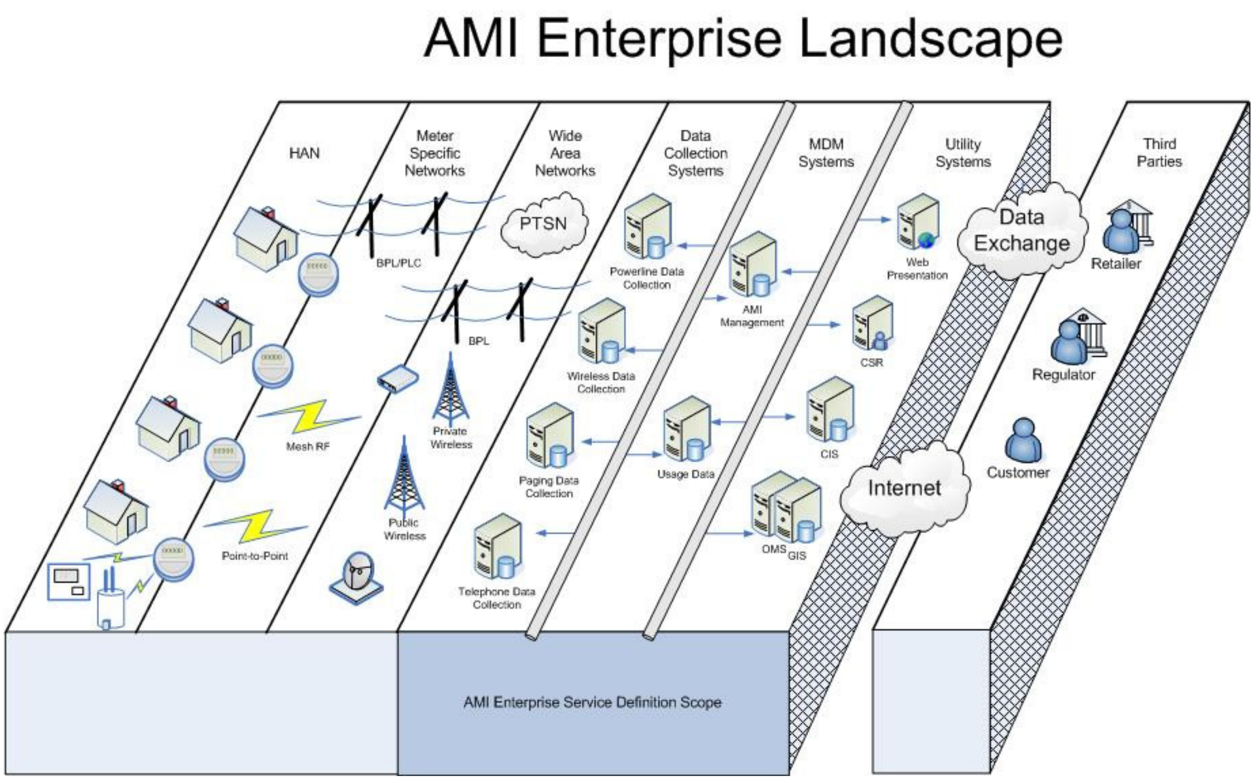


Figure 1. AMI Enterprise Landscape diagram showing the scope of the service definition effort.

AMI-ENT SRS intends to leverage available and applicable industry best practices and standards for this work, and to tie the required pieces together to support the stated goals of AMI-ENT as an ecosystem of AMI related processes, applications, and infrastructure technologies. From the overall enterprise architecture standpoint, the SRS will leverage The Open Group Architecture Framework (TOGAF) 9.0 from The Open Group, which will serve as the framework for what needs to be defined and how they relate to each other to support AMI-ENT systems requirements. From the integration architecture standpoint, the SRS will leverage best practices and standards defined for Service-Oriented Architecture (SOA) and its related technologies such as Web Services and XML Schema, as well as IEC 61968-1 specification which defines standards for Systems Interfaces for Distribution Management for electric utilities.

AMI-ENT SRS does not include the following items that are typically a part of solution architecture. Some of them are or have been addressed by other parts of the UtilityAMI initiative. Others will need to be dealt with specifically for each implementation.

- Security architecture (AMI-SEC)
- Network and hardware infrastructure architecture (AMI-NET)
- Operational architecture (TBD)
- Testing methodology and architecture (TBD)
- Application internal architecture (vendor product specific)

1.3 Acronyms and Abbreviations

This subsection provides a list of all acronyms and abbreviations required to properly interpret the UtilityAMI AMI-ENT System Requirements Specification.

AMI	Advanced Metering Infrastructure
AMI-ENT	AMI-Enterprise
SRS	System Requirements Specification
SOA	Service-Oriented Architecture
ESB	Enterprise Service Bus
SDO	Standards Development Organization
CIM	IEC TC57 Common Information Model
TOGAF	The Open Group Architecture Framework
UML	Unified Modeling Language
DDL	Data Definition Language
XSD	XML Schema
WSDL	Web Services Definition Language
ESM	Enterprise Semantic Model
ETL	Extra, Transform, Load
EDI	Enterprise Data Integration
MDM	Meter Data Management
MDUS	Meter Data Unification System (a light weight MDM)
EII	Enterprise Information Integration
CEP	Complex Event Processing
BI	Business Intelligence
WS-I	Web Service – Interoperability
OASIS	Organization for the Advancement of Structured Information Standards

1.4 External Considerations and References

The work of AMI-ENT SRS is dependent upon the best practices available from the following entities and standards organizations:

- IEC TC57 Working Group 14 (IEC 61968) series of standards, including the Common Information Model
- MultiSpeak
- GridWise Architecture Council
- Service-Oriented Architecture Standards from W3C, WS-I and OASIS
- The Open Group, TOGAF 9.0

1.5 Document Overview

TOGAF 9.0 defines four architecture domains that are commonly accepted as subsets of overall enterprise architecture, all of which TOGAF is designed to support, see Figure 1:

- **Architecture Vision** defines overall architecture guiding principles, goals and objectives and desired traits.
- The **Business Architecture** defines the business strategy, governance, organization, and key business processes.
- The **Data Architecture** describes the structure of an organization's logical and physical data assets and data management resources. This is part of the **Information Systems Architecture**.
- The **Application Architecture** provides a blueprint for the individual application systems to be deployed, their interactions, and their relationships to the core business processes of the organization. This is part of the **Information Systems Architecture**.
- The **Technology Architecture** describes the logical software and hardware capabilities that are required to support the deployment of business, data, and application services. This includes IT infrastructure, middleware, networks, communications, processing, standards, etc.

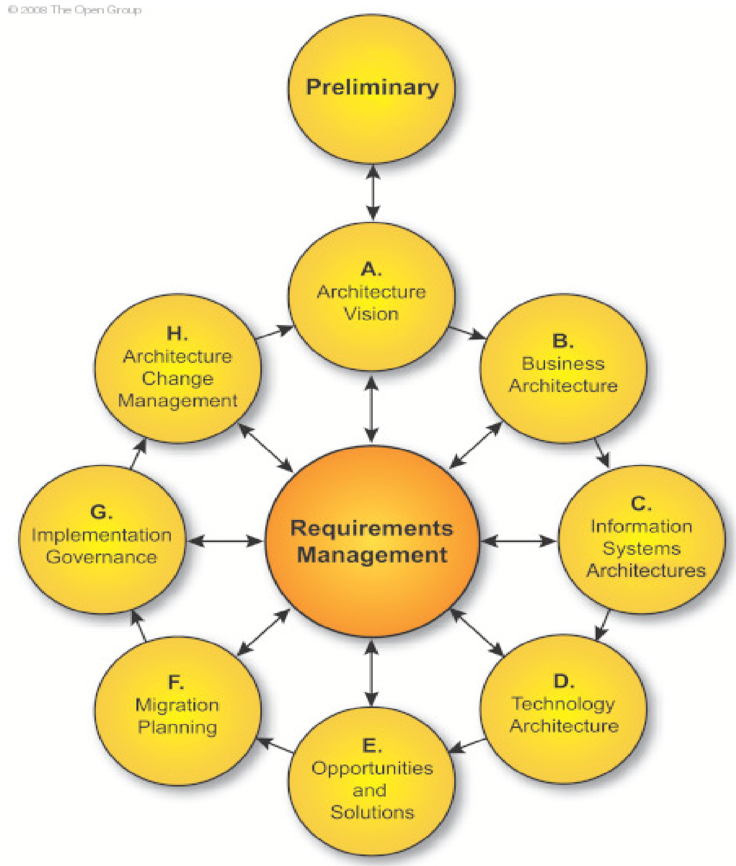


Figure 2. The Open Group Architecture Framework (TOGAF) showing the architecture development cycle.

As such, the document will be structured as follows:

Section 2 describes the overall Architecture Vision for the system, including Guiding Principles, Architectural Considerations, and the AMI-ENT Reference Model, all relevant to providing a consistent framework within which the four architecture components can be developed.

Section 3 provides the details of the four architecture components:

1. **Business Architecture:** This will refer to work products produced by the Use Case and Service Definition Teams of AMI-ENT, which includes the list of use cases and integration requirements and business services at the functional level.
2. **Data Architecture:** This provides the technical level requirements relative to how the AMI-ENT data should be modeled and represented consistently across all integration services to ensure semantic interoperability.
3. **Application Architecture:** This provides the technical level requirements relative to how applications are modeled as logical components, and what services each logical components may provide or consume. This should be an instantiation of the business services identified within the Business Architecture.
4. **Technology Architecture**: This provides the technical level requirements relative to how services will interact with each other to support end-to-end AMI business processes.

Section 4 contains the Appendices, which includes terms and definitions, logical components list, integration requirements list, and integration services view.

2. Architecture Overview

2.1 Architecture Vision

As the enabler of smart grid solutions, AMI systems for utilities are still evolving as market, regulatory policy and technology solutions evolve. As a whole, AMI systems consist of the hardware, software and associated system and data management applications that create a communications network between end systems at customer premises (including meters, gateways, and other equipment) and diverse business and operational systems of utilities and third parties, see Figure 2.

AMI-ENT is primarily concerned with the applications and technology infrastructure within the boundary of a utility's enterprise, that are necessary to integrate and deliver the desired business processes. Figure 2 also shows representative components of AMI-ENT. For a complete list of AMI-ENT logical components, please go to the Appendix.

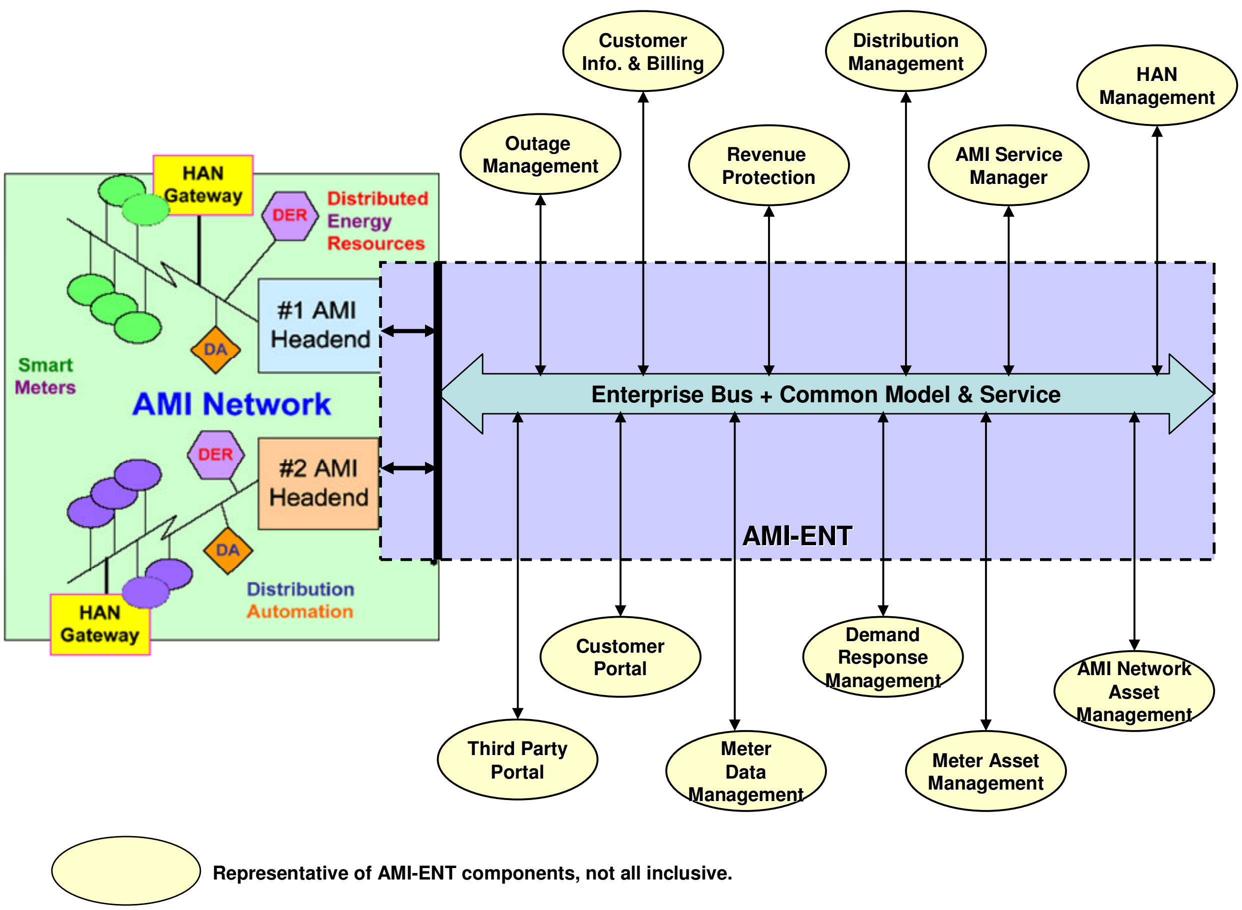


Figure 3. AMI Systems Landscape

To achieve service-oriented integration design, technical interoperability (using standards such as Web Services) and semantic interoperability (using standards such as IEC CIM) must both be addressed. As such, a critical part of achieving desired architecture guiding principals (see the next section) is to introduce consistent semantics throughout the architecture, shown in Figure 3.

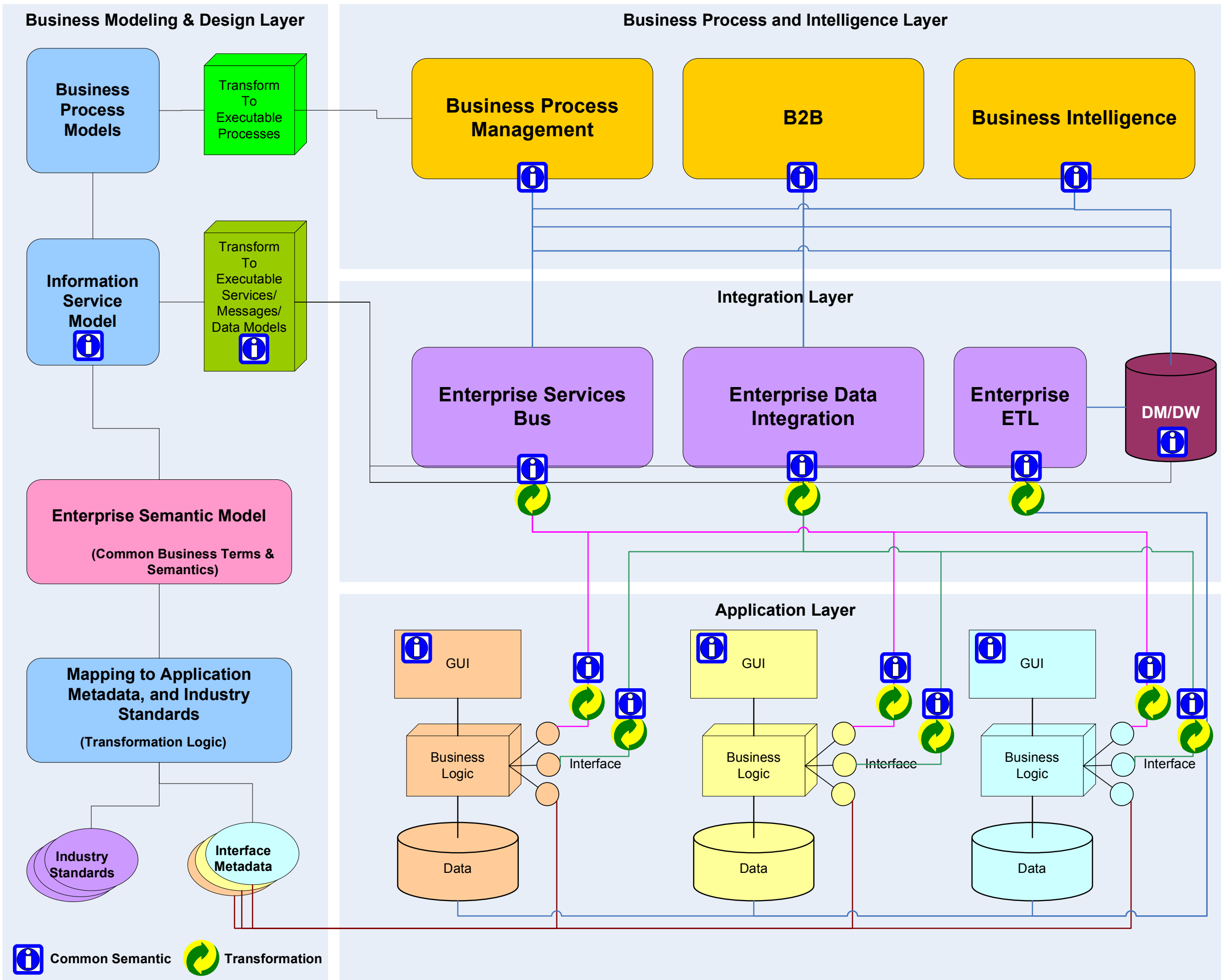


Figure 4. Achieving technical and semantic interoperability; the relationship between business modeling and design layer, business process and intelligence layer, integration layer, and application layer.

Figure 4 lists four major components of how to introduce consistent semantics into solution architecture.

Business Modeling and Design Layer: Typically, business process modeling and design are done on a project by project basis, governed, if available, by a corporate IT lifecycle process. What is missing is how to introduce and manage consistent business semantics at design time. The Business Modeling and Design Layer show that business process models will drive information service models, which are supported by an Enterprise Semantic Model (ESM). The information service models are collections of the services, operations, and messages utilized for information exchange. The ESM is developed through a combination of industry standards, internal application metadata, and business terms and definitions; and is defined using UML constructs. This model is transformed into WSDL and XSD definitions for transaction message exchange or DDL for database information exchange. The output of the process and information service models will drive the run time environments in the three layers on the right.

At the business process level, the recommended standard for integration between the modeling and the process management applications is BPEL. Process models could be generated in the form of BPEL and can be easily transformed to executable processes. This is critical to achieve business process level interoperability. According to Wikipedia, BPEL is an Orchestration language, not a choreography language (Web Service Choreography). The primary difference between orchestration and choreography is executability and control. An orchestration specifies an executable process that involves message exchanges with other systems, such that the message exchange sequences are controlled by the orchestration designer. Choreography in this context, specifies a protocol for peer-to-peer interactions, defining, e.g., the legal sequences of messages exchanged with the purpose of guaranteeing interoperability. Such a protocol is not directly executable, as it allows many different realizations (processes that comply with it). A choreography can be realized by writing an orchestration (e.g. in the form of a BPEL process) for each peer involved in it. The orchestration and the choreography distinctions are based on analogies: orchestration refers to the central control (by the conductor) of the behavior of a distributed system (the orchestra consisting of many players), while choreography refers to a distributed system (the dancing team) which operates according to rules but without centralized control.

Application Layer: With the increasing amount of Commercial-Off-The-Shelf (COTS) applications being implemented at utilities, the ability to dictate how internal application data is modeled and represented is very limited. Utilities can enforce consistent semantics on applications within an enterprise that need to exchange information and provide services outside of the application boundaries. Additionally, applications today are capable of being configured with fields that represent how a utility wants to see their data, thus enforcing consistent semantics at the GUI and reporting levels. Ideally, service end points at the application boundary will adhere to the semantics of the ESM. When that is not the case, the technologies such as ESB or EII (Enterprise Information Integration) can be leveraged to provide proxy services and transformation services to still exposed ESM based data to the enterprise or outside of an enterprise.

Integration Layer: In today's enterprise, several integration technologies coexist. For example, the ESB for process and services integration and EDI/ETL/EII for data integration co-exist in an enterprise. The key to introducing consistent semantics is to have an ESM to drive both the design of integration services (typically in WSDL/XSD format) and the design of the data services (ETL tables) and database models (DDL). This ensures that what is exposed to the enterprise is a consistent representation of the information. The ESB provides a number of important functions within an enterprise integration infrastructure, such as abstraction (proxy), managed integration, guaranteed delivery, protocol mediation, etc. The data integration technologies can be used to implement an ESM regardless of the physical structure of the data on the backend systems. Within the context of Smart Grid and AMI, one must consider the performance and security aspects of the utility operational needs versus the regular business process integration and automation needs of back/front office systems and design the integration layer accordingly. There is an increased desire to implement an operational ESB that can be design to provide secure and scalable complex event processing capabilities in real time, as well as real time business intelligence driven data integration.

Business Process and Intelligence Layer: At the business process level the need to orchestrate multiple applications to accomplish process automation or process management may exist. There is also the need to exchange data with applications or users outside of the enterprise (B2B), as well as to present business data in a way that intelligence can be mined. All of these issues speak to the necessity of a consistent representation of business meaning (semantics). For Smart Grid and AMI, B2B integration takes the form of utility systems integrated with systems from ISO/RTO, C&I customers (for example, large building energy management), retailers, and other third party service providers. These integration points may very well exist within an end-to-end business process (for example, a Demand Response event).

2.2 Architecture Guiding Principles

Architecture guiding principles are rules of engagement designed to ensure that all aspects of the implementation fit within a well-defined framework. These principles, discussed and agreed upon with all stakeholders of the AMI-ENT, are used to drive the architectural approach and patterns to be implemented. These principles should not be taken lightly as they imply what and how the overall goals of AMI-ENT will be met. Each of the principles has a level of effort and cost implications for utilities and vendors looking to adopt this specification. Adherence to these principles can be adjusted for specific cases driven by time and budget constraints. These exceptions should be approved by all stake holders and must be documented.

#	Name	Description	Rationale	Implication
1	**Utility driven and open process**	The process for developing, reviewing and ratifying the AMI-ENT specifications and artifacts including the SRS should be driven by utilities and contributed to by vendors. It shall be open to all members of UCAIug.	This is to ensure that the end product will reflect collective views, desires and goals of utilities and be consistent with the capabilities of the technologies and solutions on the market, while being vendor agnostic.	Need to ensure a good number of representative utilities and solution perspectives to participate and contribute to the effort. Utilities need to work together to develop common business processes to drive down cost and risk of AMI and Smart Grid.
2	**Business driven architecture and design**	Requirements and architecture patterns and designs of this effort shall be driven by real world business requirements of AMI.	This will ensure that recommended solutions deliver real and specific business requirements and benefits.	This will require a top down approach for driving AMI-ENT deliverables, starting from business processes and functional requirements (use cases)
3	**Open interoperability**	The IEEE defines interoperability as: the ability of two or more systems or components to exchange information and to use the information that has been exchanged. A complete interoperable solution requires systems or components to interoperate at both the technical and semantic levels.	Systems that have greater interoperability have lower TCO and lower risks of implementation. Interoperability is manifested in ease of operation. It is not just interoperability within the organization, but across utility systems, which requires an open process and open access for the market place.	When custom integration is required for each implementation, it is not interoperable. Open interoperability implies adopting relevant standards where existence and promote to standards as de facto implementations where standards gap exist. Adoption of an open interoperable solution requires public trust of wide acceptance.
4	**Leverage and collaborate with industry standards**	Where relevant industry standards exist to provide references, best practices, existing work products, and future directions, they should be leveraged to reduce time and increase quality of this	Standards are the means and vehicles for this effort to be successful. This is also a way to provide concrete and organized input into the standards process. Standards that are	Start with standards that are relevant. For example, IEC WG14, MultiSpeak, W3C (Web Services, Schema, etc.). Collaborate and contribute to the standards

#	Name	Description	Rationale	Implication
		effort. The goal of AMI-ENT, however, is to define requirements and drive towards truly implementable standards.	almost, but not quite, good enough may be worse than no standard at all.	process to ensure compatibility and eventual adoption by the standards organizations.
5	**Actionable, testable, and transferable work products**	Any work (artifacts) that are created can be used by the audience for this work, e.g. utilities, vendors, regulators, etc. There needs to be clear, explicit guidance for how to use the artifacts. There is an expectation that the work products are useful at lower levels of design	Such work products will promote market adoption, and minimize the cost and risk of adoption. Leverage open and best practices and establish repeatable processes, patterns, and template for all work products.	The use of common tools and methods will be fostered. Organizations that do not follow the use of the common tools and methods may have more difficulty implementing the artifacts.
6	**Platform Independence**	Requirements and design artifacts shall be platform independent. Implementation technologies shall be chosen due to its level of acceptance at the marketplace as open standards.	There is an expectation of differentiation and innovation in the marketplace. With greater dependence on a specific platform there may be less architectural flexibility.	To achieve both technical and semantic interoperability, certain lower level technologies will need to be chosen. For example, Web Services technology is widely used for integration, and UML is widely used for modeling.
7	**Common and Logical Reference Model**	Common components with known definitions that can be agreed upon; that they contain a common functionality that can be defined. This may be organized as logical business applications; there is an understanding of what applications will provide/consume what services.	Interoperability depends on having a common set of components (with typical realizations to applications) and understanding what the boundaries of the functions are. Applications are defined as the embodiment of business functionality.	Implies that there is an agreed set of categories of business functions; this produces the reference model for the service catalog. This does not imply that every implementation has to conform to this reference model.
8	**Common Information Semantics Across Design**	Common definition of meanings and relationships of how to represent information that are often context dependent.	Without common information semantics to represent the meaning of the data, it will be impossible to achieve process and systems interoperability at an open and large scale.	Implies a common information model and common representations at the context level consistent with the services to be defined and implemented. Vendors and utilities may need to review, change, or map their existing data models to comply with this definition.
9	**Extensibility**	This activity will prioritize functions with a focus on AMI functions, but does not preclude future extensions of	Business requirements evolve over time; the location of business function may change.	This implies that technologies and methods chosen to develop the work products shall be

#	Name	Description	Rationale	Implication
		the architecture; e.g. smart grid. Implementation of AMI will also vary from utility to utility.	This group recognizes that smart grid represents a set of business functions and that AMI is a subset of that capability.	easily extended to enhance and maintain them and their resulting implementations. And of course, be extended into new areas of business functionality.

2.3 Architectural Considerations

AMI-ENT as a system needs to be architected with requirements that cover the entire spectrum of business, technical, and market needs. The following list of architecture attributes will be used as guideline for AMI-ENT systems requirements development.

- System quality attributes discernable at runtime
  - Performance, Security, Availability, Functionality, Usability, Scalability
- System quality attributes NOT discernable at runtime
  - Modifiability, Portability, Reusability, Integratability, Testability
- Business Qualities
  - Time to market; Cost; Projected life time of the system; Targeted market; Rollout schedule; Extensive use of legacy system
- Qualities directly related to the architecture
  - Conceptual integrity; Correctness and completeness; Buildability

2.4 Security Considerations

Scope

The details regarding design and implementation of various aspects of security are outside the scope of this document. This information is within the scope of the AMI-SEC working group. This document, however, describes architectural assumptions and impacts of AMI-SEC requirements specification to AMI-ENT systems requirements.

Architectural Assumptions

We assume that the systems described in this document will be implemented over a wide variety of infrastructures. Designs may include both wired and wireless communications as well as a mix of public and private networks. The applications which run over this blend of underlying infrastructures must be capable of implementing risk-appropriate security strategies in order to mitigate the impact of a range of threats. Security for information exchange between applications will be supported by both the end points that either consume or provide the information, as well as the middleware (if any) that provide the transport and orchestration environment.

In particular, the system as a whole may be exposed to several types of threats:

- Compromise of control (i.e., system intrusion)
- Misuse of identity or authority to gain inappropriate depth of access
- Exposure of confidential or sensitive information
- Denial of service or access
- Breach of system, import of errors (integrity)
- Unauthorized use (authorization)
- Unidentified use/misuse (authentication)
- Manipulation and destruction of records (auditability/proof)
- Delayed/misdirected/lost messages (reliability)
- Loss due to system (loss/damage)

Because of the large number of products and technologies which will be used in AMI deployments, this system assumes that layered security architecture will be designed and implemented. Such architecture allows for a blending of different cost-effective technologies with suitable risk mitigation techniques, including using compensating controls in the case that some system components are not inherently secured. Several mechanisms may be employed across the layers of infrastructure, data management, and applications to provide an appropriately secured system. As an example, it may be possible to use relatively unprotected wireless infrastructure assuming that the applications which rely on that infrastructure take suitable steps to protect themselves from the types of threats noted above. In the case that infrastructure is better hardened against threats, it is possible that applications can be streamlined with a lighter weight security approach.

Applying AMI-SEC Specification to AMI-ENT

From utility enterprise and AMI enterprise level integration perspective, there are three predominan integration environments to consider for security purpose:

1. Utility mission critical operational systems and data access/exchange.
2. Utility internal enterprise front and back office applications and data/exchange.
3. Utility external application and data access/exchange.

Security requirements will need to be developed to support the specific needs of these environments.

AMI-SEC has published a general set of security requirements, which will need to be mapped onto the AMI-ENT requirements for the purpose of securing the integration of applications. Here is an initial analysis in terms of applicability and impact of AMI-SSR requirements to AMI-ENT SRS.

AMI-SSR Requirements Category (From AMI-SSR v1 Final.)	**Impact to AMI-ENT SRS**	**Recommendations**
Confidentiality and Privacy (FCP) This class contains confidentiality and privacy requirements. These requirements provide a user, service or object protection against discovery and misuse of identity by other users/subjects.	Data that is classified as confidential would need to be protected when in transit (between application boundaries).	Define data classification to drive confidentiality and privacy requirements.

AMI-SSR Requirements Category (From AMI-SSR v1 Final.)	Impact to AMI-ENT SRS	Recommendations
Integrity (FIN) "Maintaining a control system, including information integrity, increases assurance that sensitive data have neither been modified nor deleted in an unauthorized or undetected manner. The security controls described under the system and information integrity family provide policy and procedure for identifying, reporting, and correcting control system flaws. Controls exist for malicious code detection, spam protection, and intrusion detection tools and techniques. Also provided are controls for receiving security alerts and advisories and the verification of security functions on the control system. In addition, there are controls within this family to detect and protect against unauthorized changes to software and data, restrict data input and output, check the accuracy, completeness, and validity of data, and handle error conditions."	Data in transit should not allow to be altered, unless it is specifically designed through the orchestration.	Data integrity should be designed as default. Orchestration where changing data in transit is desirable is permissible only by specific requirements.
Availability (FAV) This involves the ability of the system to continue to operate and satisfy business/mission needs under diverse operating conditions, including but not limited to peak load conditions, attacks, maintenance operations, and normal operating conditions.	Availability of integration services will depend on the nature of business processes they support.	In general, availability should be defined and may be supported through SOA policy management.
Identification (FID) This section covers requirements around who an actor claims to be.	The identities of both consumer and provider of a service should be authenticated.	Identify management should be part of the integration environment and be supported by end points.
Authentication (FAT) This section covers requirements around the proof of identity of an actor.	The identities of both consumer and provider of a service should be authenticated.	Authentication services should be part of the integration environment, and be supported by end points.
Authorization (FAZ) Authorization is the approval of an actor to perform an action.	Only authorized consumer(s) of a service can invoke the service provider.	Authorization should be supported by the integration environment and/or the end points that provide the service.
Non-Repudiation (FNR) Non-repudiation is the ability to irrefutably, tie an actor to an action.	Non-Repudiation of integration services will depend on the nature of business requirements they support.	Non-Repudiation may not be required unless specified.
Anomaly Detection Services (FAS) Detection services detect events outside of the bounds of normally anticipated or desired behavior	Need to know the difference between a normal service invocation or an attempted	Integration service exception handling and monitoring capabilities may be enhanced

AMI-SSR Requirements Category (From AMI-SSR v1 Final.)	Impact to AMI-ENT SRS	Recommendations
such as attacks, intrusions, or errors.	malicious call.	to provide anomaly detection.
Boundary Services (FBS) This section provides requirements around boundary services. Boundary services provide isolation between system elements or between the system and external entities. Boundary services explain what occurs at the transition between two separate security domains such as examination or changing constraints on the border relationship. Boundary requirements are oriented towards maintaining the strength and integrity of the boundary (isolation) between inside and outside of the system boundary. The requirements for a firewall configuration are one set of examples.	This may apply to data exchange between the three integration environments: • External to utility enterprise • Internal to utility enterprise • Utility operational systems	Develop specific security requirements for each environment as well as integration needs between the environments.
Cryptographic Services (FCS) Cryptographic services include encryption, signing, key management and key revocation. The security function may employ cryptographic functionality to help satisfy several high-level security objectives. These include, but are not limited to identification and authentication, non-repudiation, trusted path, trusted channel and data separation. This class is used when the security component implements cryptographic functions, the implementation of which could be in hardware, firmware and/or software.	Underlying technology used for the implementation of various security services.	Required to support various level of security implementation for integration: • Transport • Message • Service • Orchestration
Notification and Signaling Services (FNS) Notification and signaling services are oriented towards providing system activity information and command result logging.	Apply to service monitoring and exception handling.	Integrate service exception handling and monitoring with Enterprise Management capabilities.
Resource Management Services (FRS) This section covers resource management services requirements. Resources Management Services include management of runtime resources, such as network/communication paths, processors, memory or disk space (e.g., for audit log capacity), and other limited system resources.	Apply to services management and run time environment management.	Integrate service exception handling and monitoring with Enterprise Management capabilities.
Trust and Certificate Services (FTS) Description of relationships between entities and the faith placed on the relationship certificates that have uses outside of cryptography for example, material relating to creation, storage, and revocation of certificates.	A supporting technology	It is required, especially for inter-enterprise integration.
Assurance	Implemented by each utility as a general set of security	Should apply to AMI-ENT as well.

AMI-SSR Requirements Category (From AMI-SSR v1 Final.)	Impact to AMI-ENT SRS	Recommendations
• **Development Rigor (ADR)** • **Organizational Rigor (AOR)** • **Handling/Operating Rigor (AHR)** • **Accountability (AAY)**	measures.	
Access Control (AAC) "The focus of access control is ensuring that resources are only accessed by the appropriate personnel and that personnel are correctly identified. The first step in access control is creating access control lists with access privileges for personnel. The next step is to implement security mechanisms to enforce the access control lists. Mechanisms also need to be put into place to monitor access activities for inappropriate activity. The access control lists need to be managed through adding, altering, and removing access rights as necessary. Identification and authentication is the process of verifying the identity of a user, process, or device, as a prerequisite for granting access to resources in a control system. Identification could be a password, a token, or a fingerprint. Authentication is the challenge process to prove (validate) the identification provided. An example would be using a fingerprint (identification) to access a computer via a biometric device (authentication). The biometric device authenticates the identity of the fingerprint."	This would apply to the access control of administration of end point service consumers and providers as well as the middleware environment.	Administration of integration end points and middleware environment needs to have the same level of security access control implementation as the applications.

2.5 AMI-ENT Reference Model

In order for utilities to build and vendors to deliver AMI solution with interoperable components, a reference model for AMI-ENT is needed. This reference model will include all major components of AMI-ENT and depict how they relate to each other to function as a system. Figure 4 below shows the AMI-ENT Systems Reference Model.

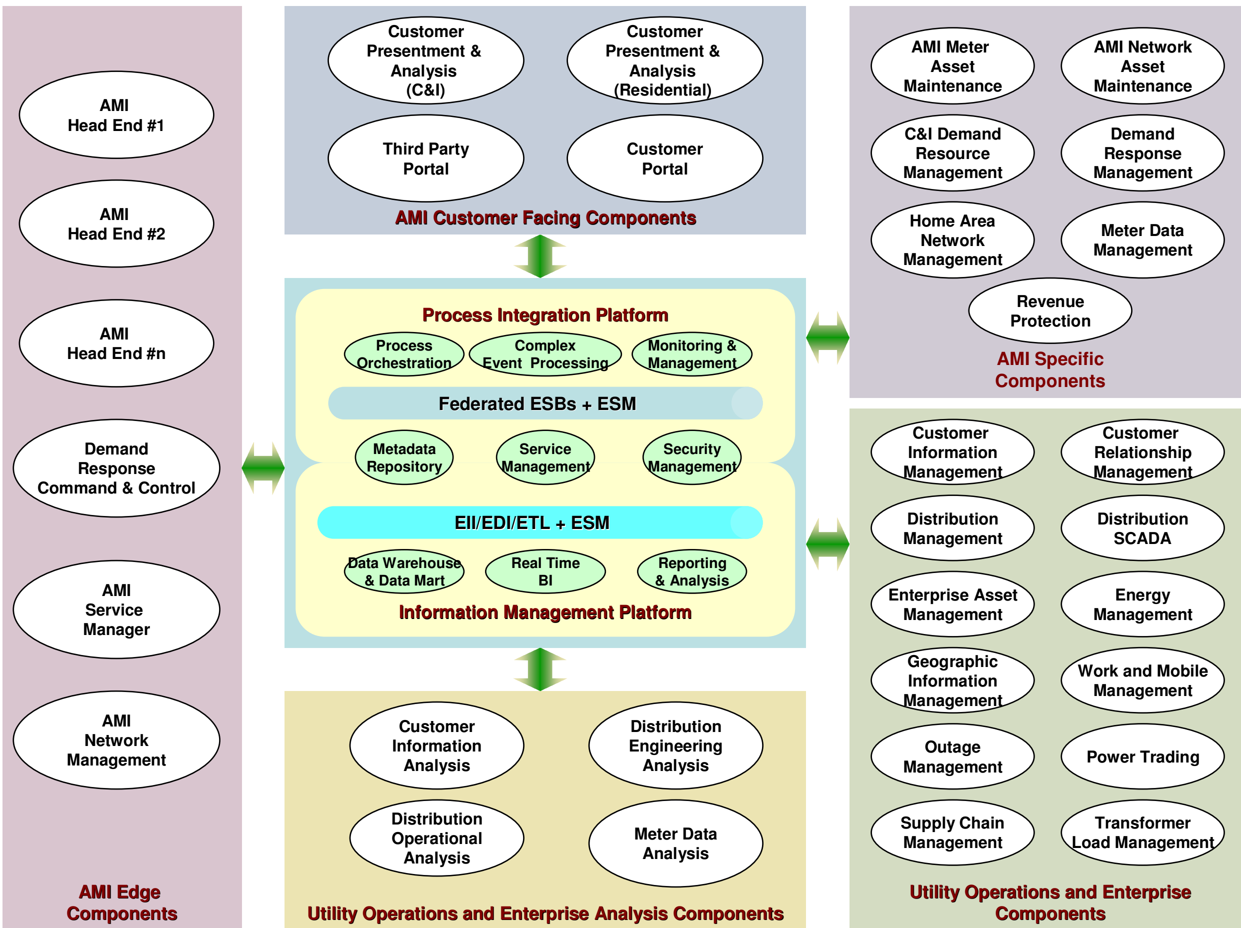


Figure 5. AMI-ENT Systems Reference Model

This reference model includes the following key categories of components:

1. Functional Components:
   - AMI Edge Components
   - AMI Customer Facing Components
   - AMI Specific Components
   - Utility Operations and Enterprise Analysis Components

- Utility Operations and Enterprise Components

2. Technical Components
   - Process Integration Platform
   - Information Management Platform

The intent of this reference model is to include all potential logical components of the AMI-ENT, given the current understanding of the business needs of AMI for Smart Grid. As the Smart Grid vision and capabilities continue to mature and as AMI technologies and applications continue to evolve, this reference model will evolve as well. The technical components of the reference model is based upon the current understanding the best practices for enterprise IT, including the use of Service-Oriented Architecture for integration and informality management, and the use of real time data management and business intelligence technologies to support the future operational needs of Smart Grid.

Each utility AMI implementation will need to map its business requirements, application portfolio and existing technology infrastructure to this AMI-ENT reference architecture. Where gaps exist, each implementation will evaluate alternative solution for supporting this architecture.

The following table describes each component of the AMI-ENT reference architecture. In each of the following architecture views, details of these components will be further specified.

Category	Name	Note
Technical Platforms	**Federated ESB + ESM**	1. ESB refers to a middleware platform that could enable application and process integration through services to ensure technical interoperability. ESB is not required but desirable for many reasons. 2. ESB also offers the typical middleware features such as service abstraction; guaranteed delivery, routing, transformation where necessary, protocol mediation, monitoring & exception handling and basic orchestration. Web Services is the preferred technology for services design and implementation, although other techniques should also be considered for performance and/or volume/size reasons. 3. Due to different performance and security requirements between utility operations and business management functions, a federated ESB environment may be required to support the future Smart Grid requirements. 4. ESM refers to an information model that is used to drive all payload definition (canonical models) of services to ensure semantic consistency and interoperability. ESM is required to derive consistent semantics in the canonical models. ESM for AMI-ENT must be semantically consistent with the industry standard models such as CIM, MultiSpeak, etc. to ensure open interoperability.
	Process Orchestration	Process orchestration may be needed for long running transactions, processes, and for complex and/or composite services management.
	Complex Event Processing	Complex event processing will be required to support AMI and Smart Grid needs as grid operations will leverage AMI infrastructure to drive more real time decision making and operational activities.

Category	Name	Note
	Monitoring & Management	Basic Monitoring and management of services for exception handling and issue resolution. Advanced Business Activity Monitoring (BAM) capabilities may be used to collect and analyze AMI related business process performance metrics.
	EII/EDI/ETL + ESM	1. EII/EDI refers to Enterprise Information Management and Enterprise Data Integration. ETL refers to the traditional data integration tool (Extract, Transform and Loading) for data warehouse. 2. ESM in this case refers to use the same information model as used in the process integration to drive the metadata and data warehouse model design and to drive ETL transformation design. 3. There will be needs for both process integration and data integration, and both of them will be increasingly more real tine.
	Data Warehouse and Data Mart	This can be both operational data market for specific domain and utility enterprise data warehouses.
	Real Time BI	This component will become more critical as the requirements of AMI and Smart Grid will drive more real time BI and reporting. The boundary between process integration and data management will blur even more as business operations demand more real time data and analysis.
	Reporting and Analysis	Business intelligence and reporting for data and information across multiple applications and processes to support traditional business analysis and decision making needs.
	Metadata Repository	This is to capture business and technical metadata for integration and BI/DW. Most utilities do not have this in place, but increasing information management needs will put this technology into forefront of enabling IT infrastructure.
	Services Management	Service registry, repository and version management. Dynamic discovery is not an initial requirement but may provide benefits for overall service lifecycle management.
	Security Management	Identify management Security enablement The use of XML Appliance technology for performance and security implementation.
AMI Edge Components	**AMI Head End #1** **AMI Head End #2** **AMI Head End #n**	There could be multiple AMI Network and Metering technologies for a given utility enterprise.
	AMI Event Service Manager	AMI event management for multiple AMI Head Ends for all event handling and management. May be provided by a MDMS vendor or leverage ESB infrastructure and SOA design or a custom developed component for specific AMI technologies.
	Demand Response Command & Control	Provides DR related messaging and command and control, may go through AMI network or use its own network. Simple one way paging or two way communication.
	AMI Network Management	Managing AMI network operations, as part of the utility communications group, or other means. May be leveraging other communication provider infrastructure.
AMI	**Customer Portal**	A general purpose customer information web site. With increasing

Category	Name	Note
Customer Facing Components		information about DR programs, etc.
	Third Party Portal	A web site for third parties to access AMI related data.
	C&I Customer Presentment & Analysis	Provides C&I customers with their specific views into their energy usage data and analysis.
	Residential Customer Presentment & Analysis	Provides residential customers with their specific views into their energy usage data and analysis. Could leverage the Customer Portal infrastructure
AMI Specific Components	**AMI Meter Asset Maintenance**	Provides the AMI meter testing, tracking and maintenance activity planning.
	AMI Network Asset Maintenance	Manages the maintenance of the AMI network assets.
	C&I Demand Resource Management	Manages the information that is provided by C&I customers including large building owners on the ability of their buildings to handle price signals and demand response requests.
	Demand Response Management	Manages the demand response programs from utility point of view, includes load control, integration with DMS, and DR program management.
	Home Area Network Management	Allows utilities to send messages (such as pricing, billing, usage or alarms) to customer display devices (IHDs). Manages the enrollment of devices in specific home area networks, management the enrollment of those devices in programs, manages the de-enrollment in programs and from the HAN
	Meter Data Management	Manages all AMI meter reads and provides necessary validations, and analytical and reporting functions.
	Revenue Protection	Help identify potential energy theft activities, and generate energy theft related service orders.
Utility Operations and Enterprise Analysis Components	**Customer Information Analysis**	Leverage new meter interval data for customer data analysis
	Meter Data Analysis	Meter reading and meter asset specific analysis
	Distribution Operational Analysis	Leverage meter data, load data and new distribution device/sensor data for operational support and decision making.
	Distribution Engineering Analysis	Leverage new load profile data for engineering planning purposes.
Utility Operations and Enterprise Components	**Customer Information Management**	Customer information, billing, and issue resolution management.
	Customer Relationship Management	Support customer AMI and demand response program campaign and management
	Distribution Management	Distribution management functionality enabled by AMI
	Distribution SCADA	SCADA for distribution automation and management
	Enterprise Asset Management	Generic enterprise asset management that may be configured for AMI network and meter assets.
	Energy Management	Bulk energy management and control
	Geographic Information Management	AMI network and meter spatial data management
	Work and Mobile Workforce Management	AMI network and meter service order management
	Outage Management	Outage prediction, analysis, restoration and reporting.
	Power Trading (MP)	Energy trading as market participates
	Supply Chain Management	AMI network and meter installation support

Category	Name	Note
	Transformer Load Management	More accurate load profile data for transformer asset management

3. AMI-ENT Systems Architecture

3.1 AMI-ENT Business Architecture View

3.1.1 Integration Requirements Framework

Integration requirements development is critical to ensure that the implemented solution delivers the intended business functions and benefits. Figure 5 shows the approach to identify the integration requirements and develop the associated services. These services will be implemented to support the business processes that ultimately enable the business benefits intended by an AMI program. The use cases and scenarios captured as part of the AMI-ENT Use Case team is really a representation of business processes and sub-processes, so they are considered equivalent in the context of the requirements development.

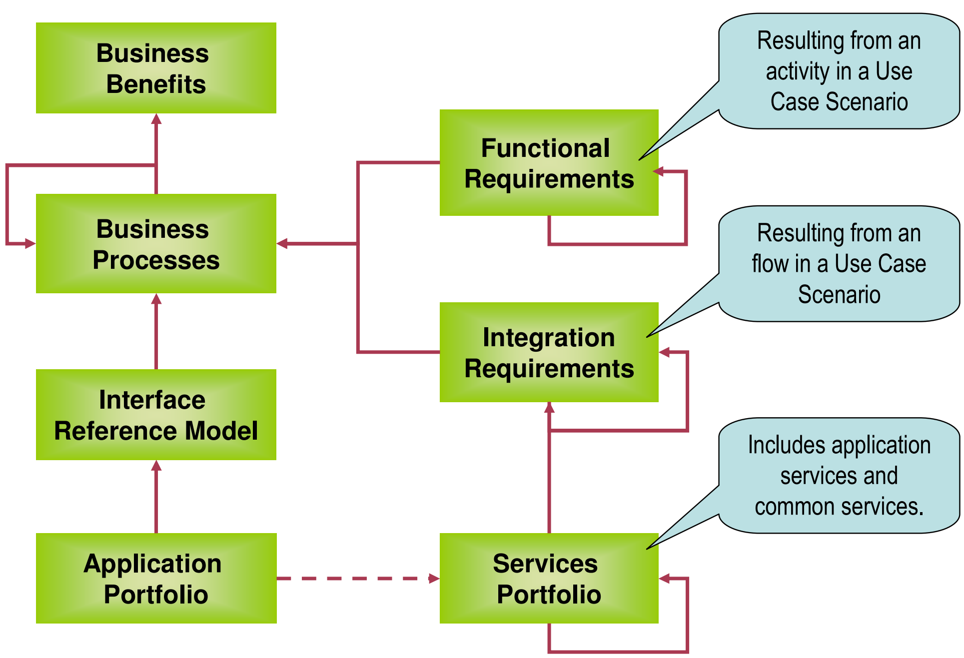


Figure 6. Integration Requirements Development Approach

This approach has the following steps:

- **Business benefits to business process:** typically business benefits are a flat list with assigned value in cost savings or revenue enabled, which is mapped with one of more business processes (at sub-process or scenario level).
- **Business process to functional and integration requirements:** each use case and/or activity within a scenario would typically result in a functional requirement; and each interaction

(information or functional flow) between two activities (especially if they come from different systems or functional areas) would result in an integration requirement.

- **Business process to IRM:** the current scenario (sub-process) uses a defined set of systems from SRS as swim lanes; this would be mapped to an Interface Reference Model (IRM) for separation of function and system. The IRM for AMI-ENT is the Logical Components Model, see Appendix.
- **IRM to Application Portfolio:** the candidate or legacy applications that support a particular IRM component will be mapped to show the enablement of a specific component of the IRM.
- **Integration requirements to services:** Enterprise Services will be defined per integration requirements and mapped to both the IRM and application portfolios.

3.1.2 Business Architecture Components

3.1.2.1 Business Organizational Actor List

A recent paper published by 12 large North America utilities, titled "Accelerating Utility Industry Standards Adoption" highlighted the need for standards to support inter-system interactions as shown in the following diagram.

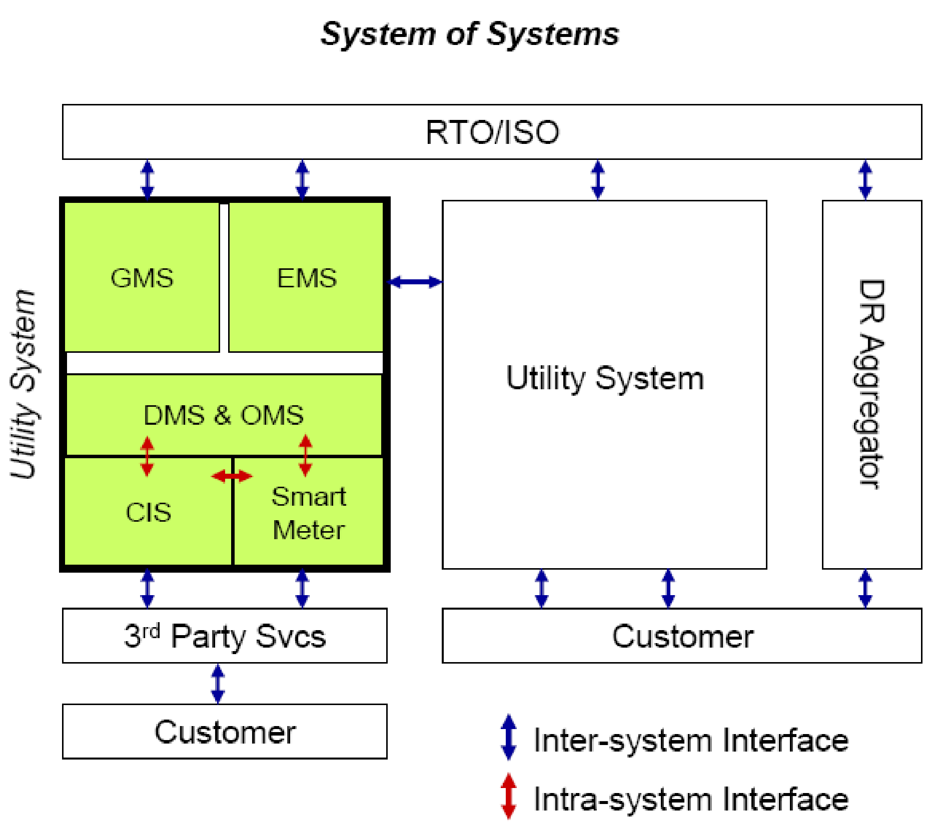


Figure 7. Smart Grid System of Systems

AMI-ENT covers both the intra-system interfaces within a utility enterprise and the inter-system interfaces between utility and other organizations shown in the diagram. The following table lists the organizational actors that will participant the AMI and Smart Grid business processes.

Organizational Actor Name	Actor Description
ISO/RTO	Independent System Operator / Regional Transmission Operator
Residential Customer	Less than 20kwh consumption for a year
Small to Medium C&I Customer	About 20-200 kwh consumption for a year
Large C&I Customer	More than 200kwh consumption for a year
Demand Response Aggregator	A business that aggregates DR capacity on behalf of a group of energy consumers.
Generator	Power generation
Utility – Energy Network Operation	Utility energy delivery network and management organization
Utility – Communication Network Operation	Utility communications network and management organization
Utility – Customer Service	Utility customer services organization
Utility – Engineering	Utility engineering and design organization
Utility – Field Operation	Utility field service and construction organization
Third Party Service Provider	Business that provides value added services on top of the basic energy services that utility provides.

3.1.2.2 Logical Components List

Logical Components are one way to organize interfaces (integration services) for AMI-ENT. Following is a table listing all major logical components that will provide some functions to support AMI business processes. This logical component list serves as the IRM for AMI-ENT. All services will be organized accordingly.

#	Acronym	Logical Components	Description / Key Business Functions	Notes	Map to IEC 61968-9
1	**AMI HE**	**AMI Head-End**	A system that acts as a gateway to communicate between utility enterprise systems and field devices (mostly AMI meters) through AMI network. Allow two way communications between enterprise systems and AMI network and devices.	Each Head-End typically works with a vendor specific AMI network technology	**Metering System**

#	Acronym	Logical Components	Description / Key Business Functions	Notes	Map to IEC 61968-9
2	**AMI MAM**	**AMI Meter Asset Maintenance**	A system that helps the AMI meter testing, tracking and maintenance activity planning.	An EAM may not be specific enough to support all AMI meter related testing and tracking needs.	**Metering Maintenance**
3	**AMI NAM**	**AMI Network Asset Maintenance**	A system that manages the maintenance of the AMI network assets.	May be part of a utility enterprise asset management system or part of the utility telecommunication network assets maintenance system	
4	**AMI NM**	**AMI Network Management**	A system that manages the operations of the AMI network and devices.	May or may not be part of the AMI Head-End	
5	**AMI SM**	**AMI Event Service Manager**	This is a system that sits on top of the AMI HES and provides a way for someone who wants to poll a specific meter to be able to do so transparently. A system that acts as a gateway to communicate between utility enterprise systems and field devices (mostly AMI meters) through AMI network. Ability for Customer Service Representatives and other business personnel to query specific devices to resolve issues in a short period of time. Routing of alert and alarms in near real time	This assumes that there are multiple head ends – either from a single vendor (scale of implementation) or multiple AMI vendors on site. Most AMI HES are not designed to pass near real time information and are typically polled.	
6	**C&I DRM**	**C&I Customer Demand Resource Management**	Manages the information that is provided by C&I customers including large building owners on the ability of their buildings to handle price signals and demand response requests. Ties the C&I customer needs including building management systems into the DR world	This system is the larger site brother to the HAN MS and manages the intelligent building system signals to large commercial and industrial sites	
7	**CIA**	**Customer Information Analysis**	A date warehouse that includes customer data and new AMI meter interval readings and consumptions	May be part of a utility Enterprise Data Warehouse	
8	**CIM**	**Customer Information Management**	A system that manages customer interaction, billing and issues resolution.		**Customer Information and Billing (61968-8)**
9	**CPA (C&I)**	**Customer Presentment & Analysis (C&I)**	A system (Portal) for C&I customers to access and analyze interval data for their energy management needs		
10	**CPA (Residential)**	**Customer Presentment & Analysis (Residential)**	A system (Portal) for Residential customers to access and analyze interval data for their energy management needs		
11	**CRM**	**Customer Relationship Management**	A system to manage customer relationship including marketing campaigns, programs, promotions, etc. A system that can notify customers (especially C&I customers) via email/page/SMS about upcoming events (such as DR, price triggers, etc.). This system may provide grouping facilities, ability to set event priorities, customize messages, etc.	This may be used for Demand Response program management relative to AMI.	

#	Acronym	Logical Components	Description / Key Business Functions	Notes	Map to IEC 61968-9
12	DEA	Distribution Engineering Analysis	A database that provides network, equipment/asset, load profile, and other engineering related data for engineering analysis and reporting needs.		Load Management System
13	DMS	Distribution Management	A system that manages the distribution network operations.	May include advance distribution automation features of a typical Smart Grid capabilities.	Network Operations (61968-3)
14	DOA	Distribution Operational Analysis	A database that provides distribution operational history and near real time data for operational analysis and reporting.		Network Operations (61968-3)
15	DRM	Demand Response Management	A system that manages the demand response programs from utility point of view. Includes load control, integration with DMS, and DR program management. Uses historical and externally input data to make predictions and what-if analysis for DR purposes		Load Management System
16	DSCADA	Distribution SCADA	A SCADA system for the purpose of distribution operation.		Network Operations (61968-3)
17	EAM	Enterprise Asset Management	A system that manages the utility enterprise assets including network equipments and others.	May be sufficient for substation equipment asset management and Reliability Centered Maintenance (RCM)	Meter Asset Management
18	EM	Energy Management	A system that manages the transmission network operations		
20	GIM	Geographic Information Management	A system that provide spatial management capabilities for utility facilities and assets.	May include a GIS based graphical design tool.	
21	HANM	HAN Management	A system that allows utilities to send messages (such as pricing, billing, usage or alarms) to customer display devices (IHDs). Manages the enrollment of devices in specific home area networks, management the enrollment of those devices in programs, manages the de-enrollment in programs and from the HAN	This is similar to an asset management system, but takes on the role of facilitating which HAN Devices are registered with the utility or a third party and can receive signals. The HANM may know the command protocol for each type of HAN Device and the relationship of the HAN device to a load at the customer site. HANM may also serve small businesses as well as residential customers	
22	MDM	Meter Data Management	A system that manages all AMI meter reads and provides necessary validations,	Could also act as a gateway for AMI HE systems to communicate to other utility enterprise systems.	Meter Data Management

#	Acronym	Logical Components	Description / Key Business Functions	Notes	Map to IEC 61968-9
23	MDT	Mobile Data Terminal	A mobile data platform with applications to support field technician needs, which often include maps, facility data, service orders, customer information, meter information, etc.	Maybe separate application in one or more mobile platforms.	Work Management
24	MWFM	Mobile Workforce Management	A system that manages mobile workforce, which typically focuses on service (short duration) and emergency work orders.	Integrates with a mobile platform	Work Management
25	OM	Outage Management	A system that helps locates and restores outages.		Outage Management
26	PM (ISO)	Power Market Management (ISO)	A system that helps ISO manages power trading and clearing in forward and real time markets.		
27	PT (MP)	Power Trading (MP)	A system that enables a Market Participant (MP) to trade power with others through ISO power market. Enables a market participant to bid load (potentially aggregated) to the ISO for demand response		
28	RP	Revenue Protection	A system to help identify potential energy theft activities, and generate energy theft related service orders.	Revenue protection analysis using AMI meter data and other related data (customer profile, weather, consumption pattern, etc.)	
29	SPM	Supply Chain Management	A system to manage materials and equipment purchasing, inventory and vendors.		
30	TLM	Transformer Load Management	A system that gathers load profile data at the transformer level.	Load data from AMI meters will be more granular and accurate.	Load Management System
31	TPP (AMI)	Third Party Portal (AMI)	A system that allows third parties (non customer entities) to request actions and have access to AMI related data for their meters, etc.	This would apply to utility AMI deployment for non-utility own meters or devices.	
32	WM	Work Management	A system that helps manage utility capital projects and new business related work.		Work Management
33	WS	Work Scheduling	A system that helps manage and schedule long duration, short duration and emergency types of work for a utility enterprise.	May be managed by separate systems if an enterprise wide scheduling system is not available.	
		Gas related components?			

3.2 Integration Requirements Specification

3.2.1 Functional Requirements – Business Processes

The business processes that have been developed as part of AMI-ENT are listed as follows. Note that link to the www.SmartGridiPedia.org for details of each business process (use case).

- B1 - Meter Reading
  - B1 - Scenario 1 - AMI Meter completes scheduled read request
  - B1 - Scenario 2 - AMI Meter completes an on-demand read
  - B1 - Scenario 3 - AMI Meter transmits non-usage (event) messages
  - B1 - Scenario 5 - Data users successfully retrieve either raw or bill ready usage data
  - B1 - Scenario 6 - AMI Head End manages the meter reading schedule
  - B1 - Scenario 7 - Third party accesses AMI data
  - B1 - Scenario 8 - Third Party uses Utility's AMI Network to read their meters
  - B1 - Scenario 9 - Meter does not communicate remotely during default schedule read
  - B1 - Scenario 12 - Field Service Rep retreves data directly from the AMI Meter
  - B1 - Scenario 15 - The Meter Data Unification System issues communications service order for failure to retrieve billing data
  - B1 - Scenario 16 - Meter does not respond to an on-demand read
  - B1 - Scenario 17 - Meter Read Request
- B2 - Remote Connect/Disconnect
  - B2 - Scenario 1 - Customer requests routine electric service turn off (Move out)
  - B2 - Scenario 2 - Customer requests routine electric service turn on (Move in)
  - B2 - Scenario 3 - Utility disconnects customer for credit or collection cause
  - B2 - Scenario 4 - Utility reconects customer following credit and collection disconnect
  - B2 - Scenario 5 - Field Person performs local electric service connection or disconnection
  - B2 - Scenario 6 - Utility limits customer's electric service due to credit or collection causes
- B3 - Detect Theft
  - B3 - Scenario 1 - Meter removal
  - B3 - Scenario 3 - Meter is inverted

- I3 - Scenario 4 - Utility upgrades NAN technology
- I3 - Scenario 5 - Utility upgrades WAN technology

- S1 - AMI System Recovery
  - S1 - Scenario 1 - AMI Head End detects individual meter communiations failure
  - S1 - Scenario 2 - Meter responds to communications failure
  - S1 - Scenario 3 - AMI Head End detects Meter failures in an area

The demand response management related use cases are being developed and will be posted to the same web site as they become available. Here is an initial list of DR related business processes under development. As the DR use cases are fully developed, the integration requirements and services will be developed thereafter.

- Manage DR program
- Provision Demand Response Equipment
- Manage Demand for Economic Dispatch
- Manage Demand for Grid Reliability
- Manage Energy Procurement
- Manage Field Services & System Recovery
- Perform Installation and Maintenance
- Provide Customer Service and Billing
- Day Ahead Planning

3.2.2 Functional Requirements – Integration Services

Using a consistent methodology to identify integration requirements from the use cases list above, the Services Definitions Team identified the following requirements and applies services naming patterns, see Technical Architecture section, to derive the following list services and its providers. For more details about these integration requirements and services, please go to www.SmartGridiPedia.org. Please note the each requirement has a use case scenario number, such as B1-S1, to tie it back to the business process.

Use Case Scenario	Integration Requirement	Functional Description of the Service	Operation Pattern	Service Name	Service Provider
B1-S1	REQ-B1004	MDUS receives the meter reading results on scheduled basis.	Created	MeterReading	MDUS
B1-S12	REQ-B1011	MDUS receives meter reads	Created	MeterReading	MDUS
B1-S15	REQ-B1012	MDUS notifies meters with reading problems	Created	MeterSystemEvent	MDUS
B1-S15	REQ-B1013	AMI Head End operator receives meter service orders	Created	MeterServiceOrder	Head End
B1-S17	REQ-B1014	Request billing determinant	Create	BillingDeterminantRequest	MDUS
B1-S17	REQ-B1014	Request billing determinant	Created	BillingDeterminant	CIS
B1-S2	REQ-B1001	Head End receives the request for a meter reading on demand	Create	MeterReading	Head End
B1-S2	REQ-B1002	MDUS receives a meter reading on demand	Created	MeterReading	MDUS
B1-S2	REQ-B1003	A user or system receives a meter reading on demand	Created	MeterReading	TBD
B1-S3	REQ-B1006	CIS receives meter event	Created	MeterSystemEvent	CIS
B1-S7	REQ-B1009	MDUS receives the request for meter readings	Create	MeterReading	MDUS
B1-S7	REQ-B1010	Third party receives the meter readings	Created	MeterReading	Third Party Portal
B1-S8	REQ-B1009	MDUS receives the request for meter readings	Create	MeterReading	MDUS
B1-S8	REQ-B1010	Third party receives the meter readings	Created	MeterReading	Third Party Portal
B2-S1	REQ-B2001	Send scheduled shut off notification	Created	ScheduledEvent	Head End
B2-S1	REQ-B2002	Send scheduled shut off command	Create	ConnectDisconnect	Head End
B2-S1	REQ-B2003	Send scheduled shut off command confirmation	Created	CommonConfirmation	CIS
B2-S1	REQ-B2004	Send meter read (final)	Created	MeterReading	MDUS
B2-S2	REQ-B2005	Request AMI Meter status	Get	MeterStatus	Head End
B2-S2	REQ-B2006	Send AMI Meter status	Created	MeterStatus	CIS
B2-S2	REQ-B2007	Send scheduled turn on command	Create	ConnectDisconnect	Head End
B2-S2	REQ-B2008	Send scheduled turnon command confirmation	Created	CommonConfirmation	CIS
B2-S2	REQ-B2009	Send meter read (initial)	Created	MeterReading	MDUS
B2-S3	REQ-B2010	Send on demand shut off command	Create	ConnectDisconnect	Head End
B2-S3	REQ-B2011	Send on demand shut off command confirmation	Created	CommonConfirmation	CIS
B2-S3	REQ-B2012	Send meter read (final)	Created	MeterReading	MDUS
B2-S6	REQ-B2013	Send load limit command	Create	LoadControlCommandRequest	Head End

Use Case Scenario	Integration Requirement	Functional Description of the Service	Operation Pattern	Service Name	Service Provider
B2-S6	REQ-B2014	Send load limit command confirmation	Created	CommonConfirmation	CIS
B3-S1	REQ-B3001	Send meter system event	Created	MeterSystemEvent	MDUS
B3-S3	REQ-B3001	Send meter system event	Created	MeterSystemEvent	MDUS
B3-S4	REQ-B3001	Send meter system event	Created	MeterSystemEvent	MDUS
B3-S5	REQ-B3001	Send meter system event	Created	MeterSystemEvent	MDUS
B3-S6	REQ-B3001	Send meter system event	Created	MeterSystemEvent	MDUS
B4-S1	REQ-B4001	Third part portal receives request for meter reading (none electric)	Created	MeterReadingSchedule	Third Party Portal
B4-S1	REQ-B4002	AMI Management System receives request for meter reading (none electric)	Created	MeterReadingSchedule	MDUS
B4-S1	REQ-B4003	MDUS receives the meter reading results (none electric)	Created	MeterReading	MDUS
B4-S1	REQ-B4004	Portal receives the meter reading results (none electric)	Created	MeterReading	Third Party Portal
B4-S1	REQ-B4005	Third party receives the meter reading results (none electric)	Created	MeterReading	Third Party Portal
B4-S5	REQ-B4006	Third party portal receives request for meter events to be monitored (none electric)	Create	MeterSystemEvent	Third Party Portal
B4-S5	REQ-B4007	Head End receives request for meter events to be monitored (none electric)	Create	MeterSystemEvent	Head End
B4-S5	REQ-B4008	Third party portal receives monitored meter event data (none electric)	Created	MeterSystemEvent	Third Party Portal
B4-S5	REQ-B4009	Third party receives monitored meter event data (none electric)	Created	MeterSystemEvent	Third Party
B4-S6	REQ-B4010	Third party portal receives monitored meter event data (none electric)	Created	MeterSystemEvent	Third Party Portal
B4-S6	REQ-B4011	Third party receives monitored meter event data (none electric)	Created	MeterSystemEvent	Third Party
C1-S2	REQ-C1001	Send Demand Response token	Create	CommonConfirmation	MDUS
C2-S1	REQ-C2001	Send electric price token	Created	ServiceToken	Head End
C2-S2	REQ-C2004	Send HAN device registration	Create	HANAsset	Head End
C2-S2	REQ-C2005	Confirm HAN device registratopm	Created	HANAsset	CIS
C2-S5	REQ-C2002	Send HAN token	Created	ServiceToken	Head End
C2-S5	REQ-C2003	Confirm HAN token receipt	Created	CommonConfirmation	CIS
C3-S1	REQ-C3001	Send prepayment service token	Created	ServiceToken	Head End
C3-S1	REQ-C3002	Send prepayment rate update	Changed	ServiceToken	Head End
C3-SX1	REQ-C3001	Send prepayment service token	Created	ServiceToken	Head End
C3-SX2	REQ-C3002	Send prepayment rate update	Changed	ServiceToken	Head End
C4-S1	REQ-C4001	Send HAN Command	Create	ServiceToken	Head End
C4-S1	REQ-C4002	Send HAN Command Response	Created	CommonConfirmation	Utility Website
CDRALC	REQ-CDR001	Send load shed report	Created	HANAsset	Grid Control Center
CDRALC	REQ-CDR002	Request load control	Create	LoadControlCommandRequest	DRM
CDRALC	REQ-CDR003	Send load shed control notification	Create	LoadControlCommandRequest	Head End

Use Case Scenario	Integration Requirement	Functional Description of the Service	Operation Pattern	Service Name	Service Provider
CDRALC	REQ-CDR004	Send load shed control confirmation	Created	CommonConfirmation	MDUS
CDRALC	REQ-CDR005	Send load shed control start confirmation	Created	CommonConfirmation	MDUS
CDRALC	REQ-CDR006	Send load control end confirmation	Created	CommonConfirmation	MDUS
CDRALC	REQ-CDR007	Send load shed event end	Created	CommonConfirmation	DRM
CDRALC	REQ-CDR008	Send load shed command	Created	LoadControlCommand	Head End
D2-S1	REQ-D2001	Power Quality Event Controller receives the power quality event data	Created	MeterSystemEvent	DMS
D2-S1	REQ-D2002	Head End receives the request for additional power quality event data	Create	MeterSystemEventRequest	Head End
D2-S1	REQ-D2003	Power Quality Event Controller receives additional power quality event data	Created	MeterSystemEvent	DMS
D2-S3	REQ-D2007	Head End receives the requests for meter reading data	Create	MeterReadingRequest	Head End
D2-S3	REQ-D2008	Capacitor Bank Controller receives meter reading data	Created	MeterReading	Capacitor Bank Controller
D2-S3	REQ-D2009	Head End transmits turn on/off command to capacitor bank	Create	HeadEndCommandRequest	Head End
D3-S1	REQ-D3001	Send distributed generation enrollment	Change	MeterAssetRequest	MDUS
D3-S1	REQ-D3002	Execute distributed generation request	Changed	MeterAsset	Head End
D3-S1	REQ-D3003	Acknowledge meter DG setup	Created	MeterStatus	MDUS
D3-S1	REQ-D3004	Acknowledge meter changed to DG	Created	MeterStatus	CIS
D3-S1	REQ-D3006	Send a scheduled meted reading (same as B1004)	Created	MeterReading	MDUS
D3-S2	REQ-D3005	Send a DG meter event (same as B1006)	Created	MeterSystemEvent	MDUS
D3-S3	REQ-D3007	Publish a meter event (same as B1005)	Created	MeterSystemEvent	MDUS
D3-S3	REQ-D3008	Send a meter event (same as B1006)	Created	MeterSystemEvent	CIS
D4-S1	REQ-D4001	Show AMI device event	Created	MeterSystemEvent	MDUS
D4-S1	REQ-D4003	Show updated AMI device event	Changed	MeterSystemEvent	MDUS
D4-S1	REQ-D4002	Send AMI device event	Created	MeterSystemEvent	OMS
D4-S1	REQ-D4005	Publish outage record	Created	OutageRecord	Third Party
D4-S1	REQ-D4004	Send updated AMI device event	Changed	MeterSystemEvent	OMS
D4-S1	REQ-D4006	Publish updated outage record	Changed	OutageRecord	Third Party
D4-S1	REQ-D4007	Send meter service order request from OMS to AMI Management System	Created	MeterServiceOrder	MDUS
D4-S2	REQ-D4002	Send AMI device event	Created	EndDeviceEvent	OMS
D4-S2	REQ-D4005	Publish outage record	Created	OutageRecord	Third Party
D4-S2	REQ-D4004	Send updated AMI device event	Changed	EndDeviceEvent	OMS
D4-S2	REQ-D4006	Publish updated outage record	Changed	OutageRecord	Third Party
D4-S3	REQ-D4008	Send planned outage event	Created	ScheduledEvent	MDUS
D4-S3	REQ-D4008	Send planned outage event	Created	ScheduledEvent	Head End
G1-S1	REQ-G1001	Retrieve gas meter readings by zone	Create	MeterReadingRequest	MDUS
G1-S1	REQ-G1001	Retrieve gas meter readings by zone	Created	MeterReading	Gas Measurement System

Use Case Scenario	Integration Requirement	Functional Description of the Service	Operation Pattern	Service Name	Service Provider
G2-S1	REQ-G2001	Send Low Pressure Flags	Created	MeterSystemEvent	MDUS
G2-S1	REQ-G2002	Send Gas System Event	Created	MeterSystemEvent	Gas Outage Management System
G2-S1	REQ-G2004	Request Gas Meter Status	Create	MeterStatus	MDUS
G2-S1	REQ-G2005	Send Gas Meter Status Command	Get	MeterStatus	Head End
G2-S1	REQ-G2006	Send Gas Meter Status	Created	MeterStatus	MDUS
G2-S1	REQ-G2007	Send Gas Meter Status Notification	Created	MeterStatus	OMS
G2-S2	REQ-G2009	Send Customer LP Report	Created	ActivityRecord	DMS
G3-S1	REQ-G3001	Request end device asset for corrosion and rectifier data	Create	ComMediaAssetRequest	MDUS
G3-S1	REQ-G3001	Request end device asset for corrosion and rectifier data	Created	ComMediaAsset	GIS
G3-S1	REQ-G3002	Send Connect Disconnect switch commands for corrosion and rectifier data	Create	ConnectDisconnect	MDUS
G3-S2	REQ-G3003	Send meter system event list for methan sensor data	Create	MeterSystemEventRequest	Methan Alarm Application
G3-S2	REQ-G3004	Show a list of meters that exceed methan limit	Created	MeterSystemEvent	Dispatch Centre
I1-S1	REQ-I1001	Add Meter Asset	Create	MeterAsset	MDUS
I1-S1	REQ-I1002	AMI management system sends work order out	Created	MeterServiceOrder	Construction Maintenance Acct
I1-S1	REQ-I1003	Publish meter status	Created	MeterStatus	MDUS
I1-S1	REQ-I1004	Reconfigure meter asset	Changed	MeterAssetConfig	Head End
I2-S1	REQ-I2008	Send meter service order to MWMS	Created	MeterServiceOrder	EAM
I2-S1	REQ-I2009	Close out meter service order and send status to AMI Management System	Closed	MeterServiceOrder	MDUS
I2-S2	REQ-I2003	Send meter service order request from Head End due to communication error	Create	MeterServiceOrderRequest	MDUS
I2-S3	REQ-I2004	Send meter service order request from CIS due to customer complaints	Create	MeterServiceOrderRequest	MDUS
I2-S4	REQ-I2005	Send meter testing service request	Create	MeterServiceOrderRequest	MDUS
I2-S6	REQ-I2006	Send meter service order request from MDUS due to meter data error	Create	MeterServiceOrderRequest	MDUS
I2-S6	REQ-I2007	Send closed meter order to MDUS	Closed	MeterServiceOrder	MDUS
I2-S7	REQ-I2001	Send meter service order request from Head End due to tempering	Create	MeterServiceOrderRequest	MDUS
I2-S8	REQ-I2002	Send meter service order request from Head End due to meter error	Created	MeterServiceOrder	MDUS
I3-S1	REQ-I3001	Send meter reading request	Create	MeterReadingRequest	MDUS
I3-S1	REQ-I3002	Send meter reading	Created	MeterReading	AMI Management System
I3-S1	REQ-I3004	Send updated firmware	Changed	EndDeviceFirmware	Head End
I3-S1	REQ-I3006	Send execute firmware command	Create	HeadEndCommandRequest	Head End

Use Case Scenario	Integration Requirement	Functional Description of the Service	Operation Pattern	Service Name	Service Provider
I3-S2	REQ-I3003	Send HAN device assets	Created	HANAsset	MDUS
I3-S2	REQ-I3005	Request ping AMI device	Created	HeadEndCommand	Head End
I3-S3	REQ-I3003	Send HAN device assets	Created	HANAsset	MDUS
I3-S3	REQ-I3005	Request ping AMI device	Created	HeadEndCommand	Head End
S1-S1	REQ-S1002	Send activity record	Created	ActivityRecord	MDUS
S1-S1	REQ-S1002	Send activity record	Created	ActivityRecord	OMS
S1-S1	REQ-S1004	Outage record request	Create	OutageRecordRequest	OMS
S1-S1	REQ-S1004	Outage record request	Created	OutageRecord	MDUS
S1-S1	REQ-S1005	Work order request	Create	WorkOrderRequest	WMS
S1-S1	REQ-S1005	Work order request	Created	WorkOrder	MDUS
S1-S1	REQ-S1001	Send meter event	Created	MeterSystemEvent	MDUS
S1-S3	REQ-S1004	Outage record request	Create	OutageRecordRequest	OMS
S1-S3	REQ-S1004	Outage record request	Create	OutageRecordRequest	Telecom Control Centre
S1-S3	REQ-S1004	Outage record request	Created	OutageRecord	MDUS
S1-S3	REQ-S1005	Work order request	Create	WorkOrderRequest	WMS
S1-S3	REQ-S1005	Work order request	Created	WorkOrder	MDUS
S1-S3	REQ-S1003	Send meter reading request	Create	MeterReadingRequest	Head End
S1-S3	REQ-S1001	Send meter event	Created	MeterSystemEvent	MDUS

3.2.3 Technical Requirements – Integration Services

Integration services that are well defined, understood and managed are the linchpin of an open and interoperable AMI implementation both within a utility enterprise and between the utility enterprise and other business entities. Following is a list of guiding principles for integration services design:

- Common protocol and business semantics should be used to achieve loosely coupling of end-point service (directly or indirectly)
- Services should be representative of a unique unit of work and reusable across business functions.
- Services should be reusable across common practices of utilities.
- Service design should be driven by business requirements and reflected in the architecture.
- Service design should be governed with a common approach and framework to achieve conceptual integrity.
- Services should be abstract, precise (no overloading, but allow for polymorphic services), atomic but composable, testable, etc.
- Integration layer is preferable (but not required) to achieve guaranteed delivery, managed integration, etc. and to enable process orchestration and complex event processing where necessary.
- Services to support B2B integration scenarios shall be identified to allow for more specific security and Service Lever Agreement (SLA) implementation requirements.
- Service level agreement should be defined to support key architecture qualities: security, reliability, performance, availability, scalability, data quality, information fidelity, etc.

Based upon the above-mentioned guiding principles for services design, here is the table of integration services attributes to be defined for each of the business and physical services of AMI-ENT. The collection of the services attributes constitutes the integration technical requirements of AMI-ENT.

Integration Services Attribution Name	Description
Service Identifier	Unique identifier for each service that is provided by a logical component.
Service Name	Name of the service
Business Scenario Identifier	The business process to which the service is derived and supports.
Integration Requirement Identifier	Unique identifier for the integration requirement upon which the service was identified.
Integration Requirement Name	The description of the integration requirement.
Service Status	The status of the service
Service Version	The version of the service. (A version mechanism needs to be developed, which may contain a timestamp on when it is operational.)
Interaction Pattern	Identify a desired interaction pattern for this service: fire-forget, request-reply, etc.

Integration Services Attribution Name	Description
Interaction Type	Type of interaction (real time, batch, event driven)
Service Choreography	Define the need for complex service interaction between provider and consumer, or participate in a stateful business process.
Service Operation	Applied service patterns for service operation (such as create, created, etc. see patterns section).
Information Object	The associated information object for the service for input and/or output.
Service Message Size	The average size of each message or file.
Service Message Volume	The average number of messages or files per time interval.
Service Frequency	The frequency of each transmission for batch type interactions (e.g. as needed, hourly, daily, weekly)
Service Peak Factor	Peak payload size and peak volume, and peaking factor.
Service Availability	Availability requirements to support business process and business continuity.
Service Level Security	Service level security requirements for authentication and authorization.
Data Level Security	Payload security requirements to drive encryption at whole message level or element/attribute level.
Service Owner	The owner of the definition of the service.
IEC 61968 Message Type	The corresponding IEC 61968 message type (XSD) name for the Information Object, if applicable.
MultiSpeak Service and Message Type	The corresponding MultiSpeak service and message payload, if applicable.

3.3 AMI-ENT Application Architecture View

AMI-ENT application architecture view provides a list of Logical Components and the integration services they either provide or consume. A utility or a vendor could map their actual application portfolio for their AMI solution and derive at the services that their physical applications will need to provide or consume.

The following diagram shows, from a Logical Component point of view, the integration services they either provide or consume. They also show the corresponding Logical Components and their related services. This logical view of application services does not imply a point-to-point service interaction, but rather indicates the functional provider-consumer relationship. This can be implemented via direct service interaction or via an ESB platform. Following is an example of services provided and consumed by the “Customer Information System” component of the AMI-ENT.

Please note that the view still shows the systems listed in the requirements list table and has not been converted to the Logical Component List, it will be updated once the Logical Component List is finalized.

The diagrams only include those Logical Components that have services identified. As more use cases and services are identified, they will be updated accordingly.

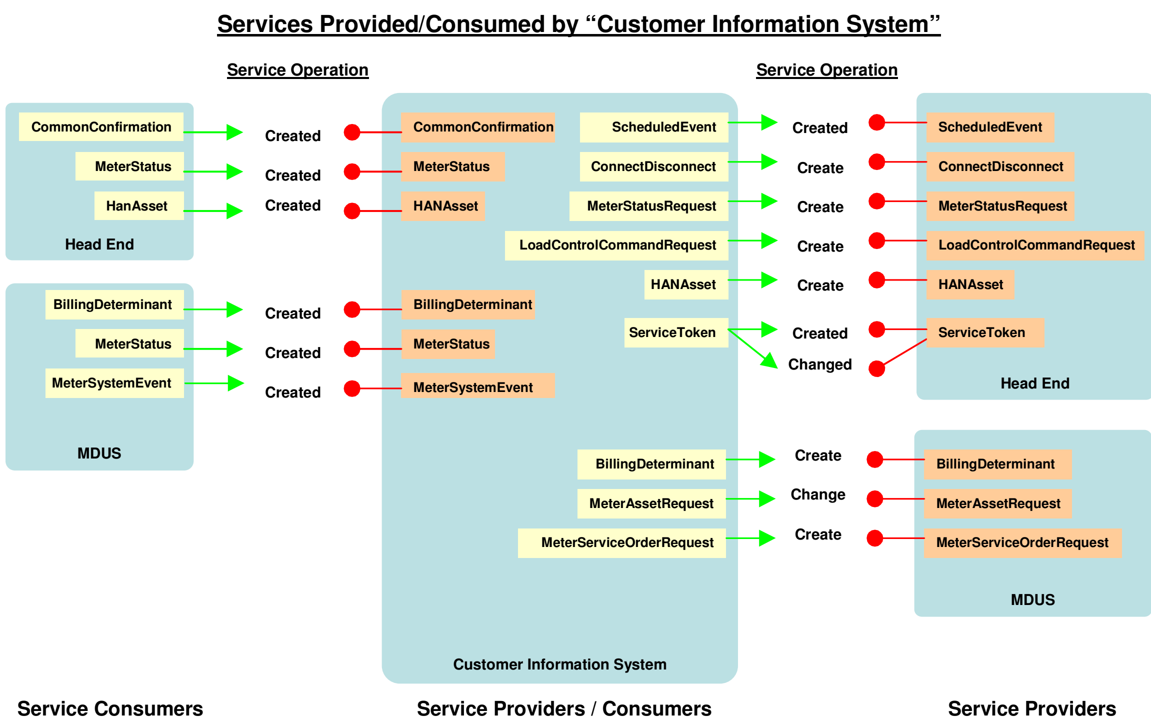
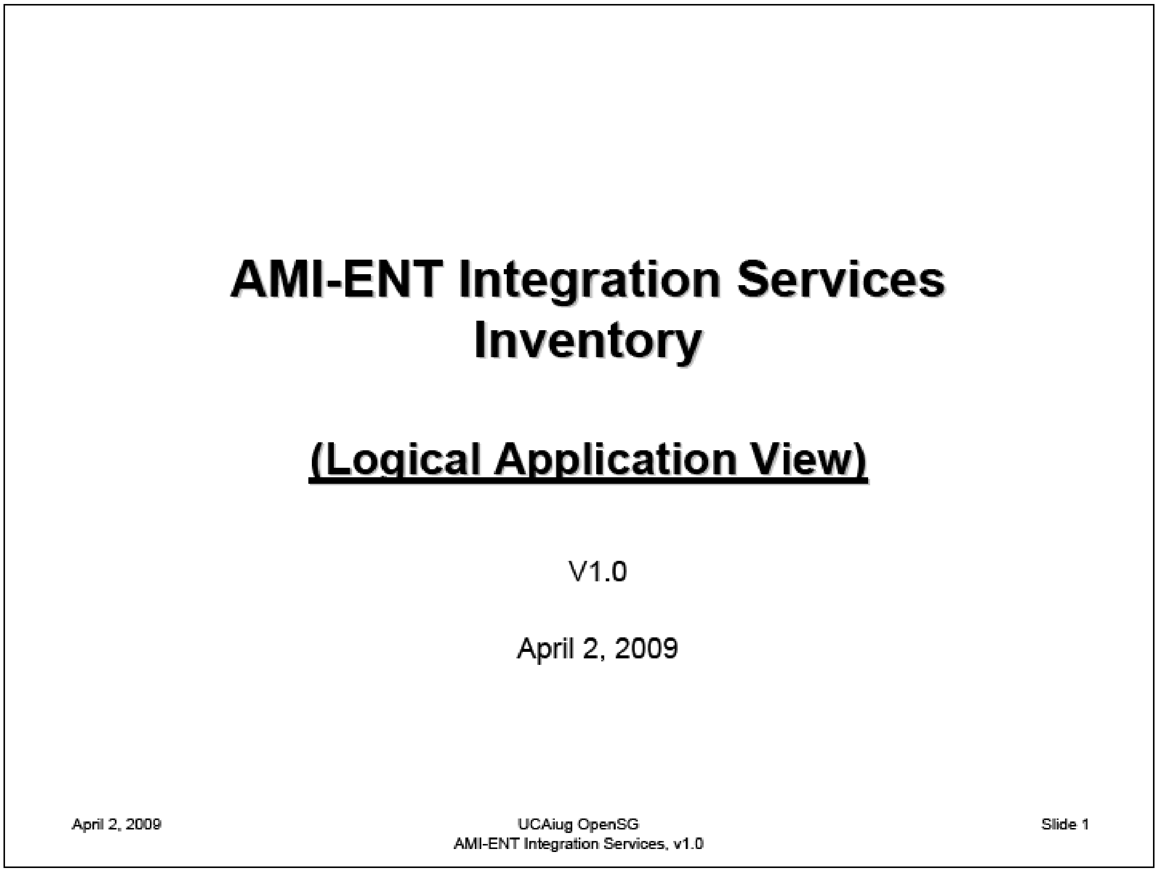


Figure 8. Example of services that are provided or consumed by customer information management.

For complete list of diagrams, please refer to this document. (Double click the picture below to open the document).


AMI-ENT Integration Services Inventory
(Logical Application View)
V1.0
April 2, 2009
April 2, 2009
UCAiug OpenSG
AMI-ENT Integration Services, v1.0
Slide 1

3.4 AMI-ENT Data Architecture View

Based on AMI ENT use cases, four semantic model views are provided:

- Meter Reading and Event
- Asset and Customer Information
- End Device Control and Token
- Outage Record and Work Order

The published XML Schemas for AMI-ENT services have the detailed attributes and data types associated with each of the entities listed in the diagrams below.

3.4.1 Meter Reading and Event View

This view is a center piece of AMI data architecture on meter reading and events. The key classes are MeterAsset and EndDeviceEvent/MeterSystemEvent. It provides a data structure for constructing the following messages:

- MeterReading
- MeterReadingSchedule
- MeterSystemEvent
- MeterStatus
- ScheduledEvent
- ServiceToken
- BillingDeterminant
- EndDeviceEvent
- ActivityRecord

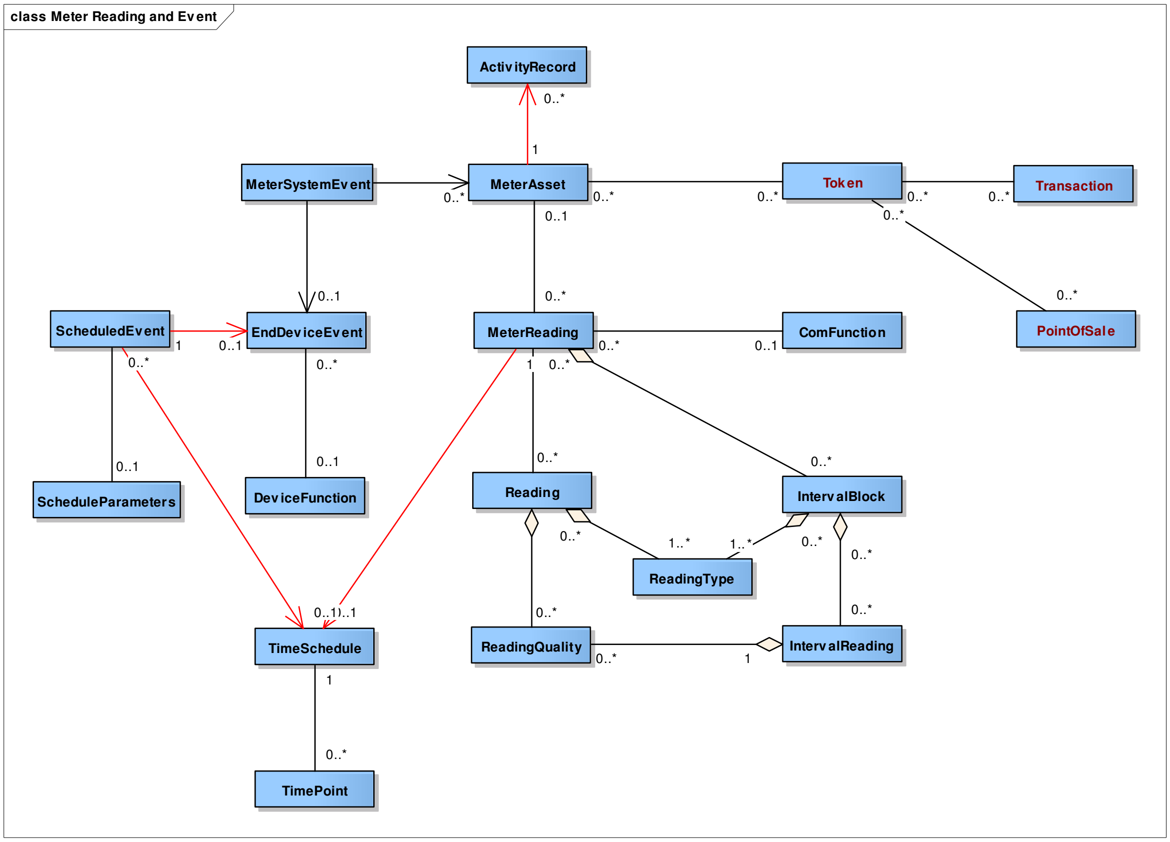


Figure 9. Class relationship diagram representing the meter reading and related events.

3.4.2 Asset and Customer Information View

This view contains asset and customer related information. The key class is EndDeviceAsset which has 3 major children: MeterAsset, ComMediaAsset and HANAsset. EndDeviceAsset can have a list of DeviceFunction via a relationship between Asset and AssetFunction. An EndDeviceAsset has a related ServiceLocation which typically has a list of ServiceDeliveryPoint and a particular Address. CustomerAccount and CustomerData are associated with MeterAsset in this view.

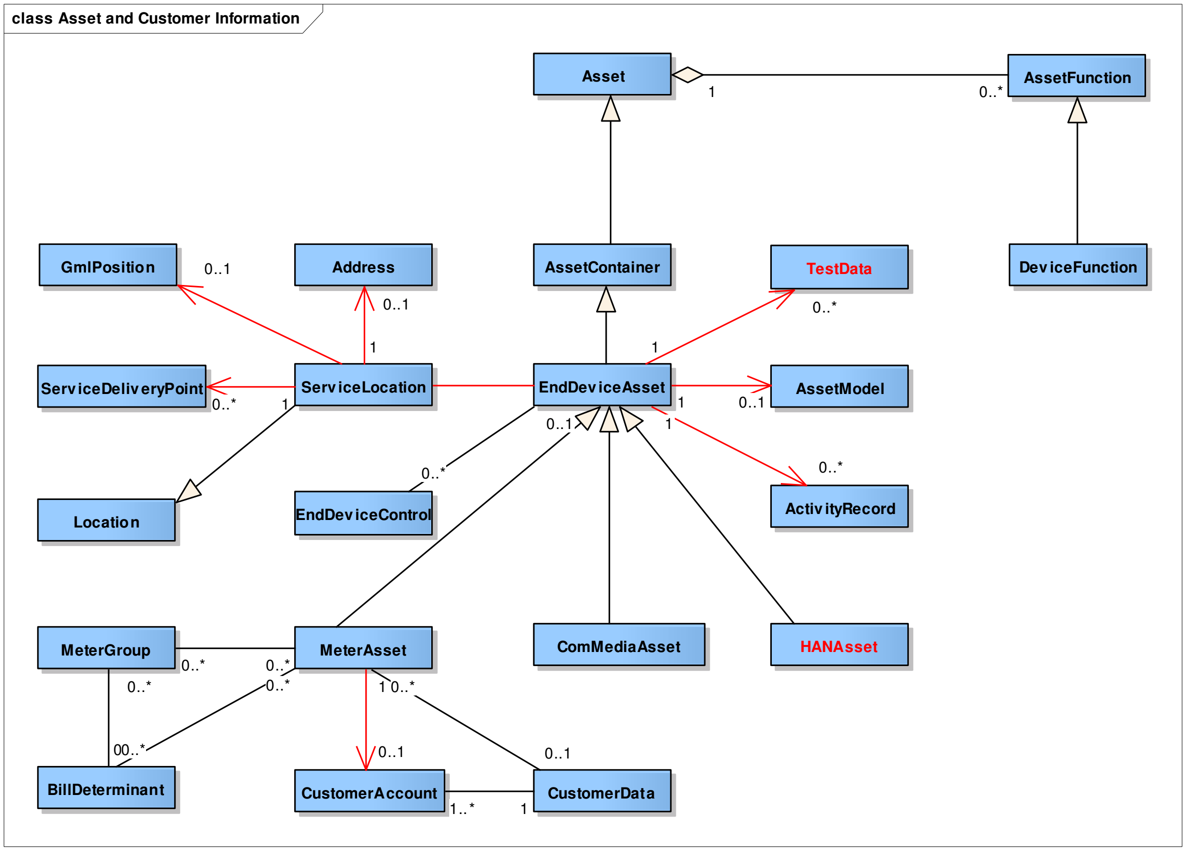


Figure 10. Class relationship diagram showing reflecting the asset and customer information.

Based on this view, the following messages are defined and posted at SmartGridiPedia:

- EndDeviceAsset
- MeterAsset
- HANAsset
- ComMediaAsset
- MeterAssetConfig
- EndDeviceFirmware

3.4.3 End Device Control View

This view focuses on end device control. The key relationship in this view is the association between EndDeviceAsset and EndDeviceControl. Two device functions are included: LoadMgmtFunction and ConnectDisconnectFunction.

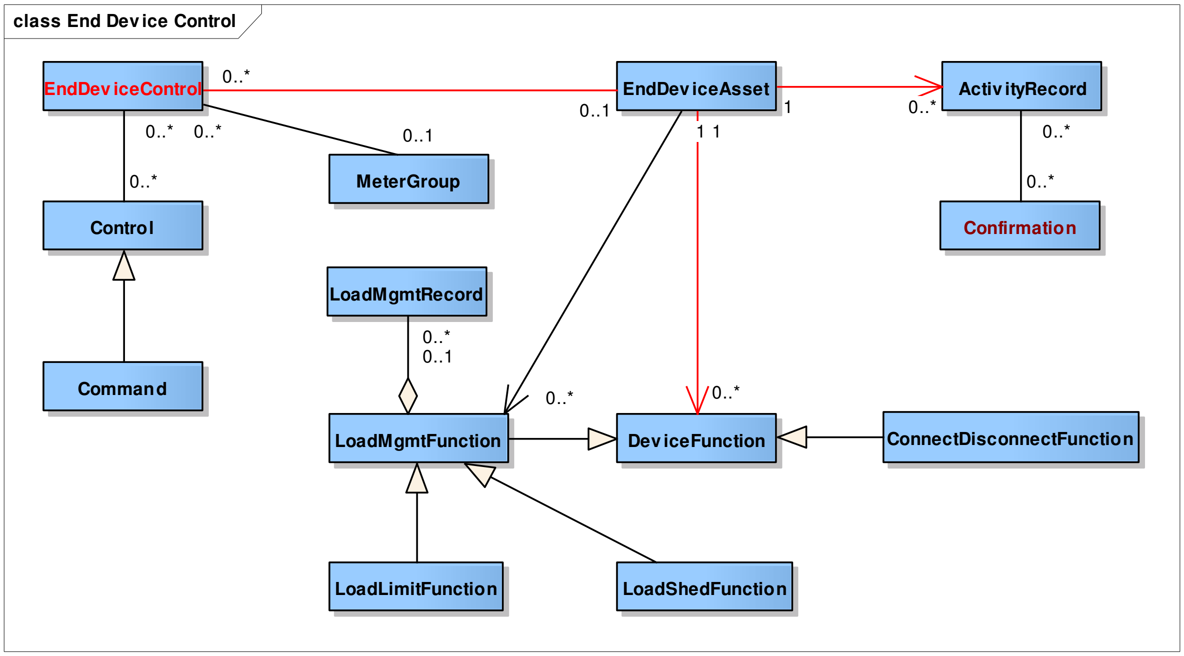


Figure 11. Class relationship diagram reflecting the end device control related objects.

Based on this view, the following messages are defined and posted at SmartGridiPedia.org:

- ConnectDisconnect
- HeadEndCommand
- CommonConfirmation
- LoadControlCommand

3.4.4 Outage Record and Work Order

This view is mainly used for outage management and work order management in AMI domain. It provides a data structure for the following messages:

- OutageRecord
- MeterServcieOrder
- WorkOrder

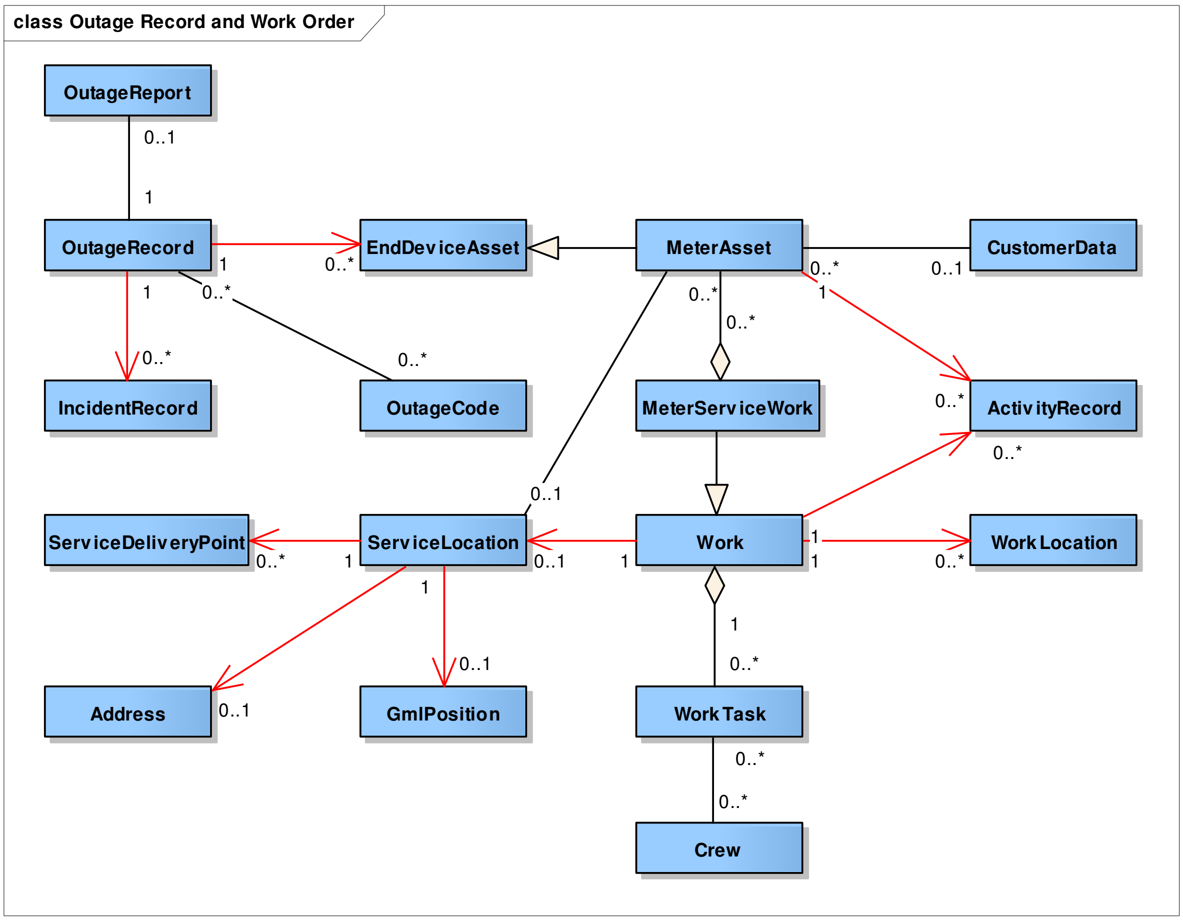


Figure 12. Class relationship diagram showing the outage and work order objects.

3.5 AMI-ENT Technical Architecture View

Given a large variety of integration technologies that exist in the market place and in the utility enterprises, it would be up to each utility to implement the AMI-ENT systems requirements specification that fit with their chosen technology infrastructure and architecture goals. However, regardless of the technologies, the following architectural issues are important and needs to be addressed when it comes to achieving interoperability.

3.5.1 Service Patterns

Service naming standards are important to achieve a level of "plug & play" at the run time environment. It implies the semantics of the service and its operations.

The AMI-ENT services naming convention has the following rules:

- **Information Object –** Collection of entities to describe an object in a business context.
- **Service Name –** Service naming convention follows the information object in a business process for an interface definition.
- **Operation Name –** Operation name indicates a specific action that will be performed to the Information Object. This is a list of operation naming patterns utilizing IEC 61989 verbs (See IEC61968-1 Specification for details):
  - The following verbs are used for service/operation provided by the master system that owns the Information Object to entertain the request for the specified action implied by the verb.
    - **Create**
    - **Change**
    - **Cancel**
    - **Close**
    - **Delete**
  - The following verbs are used for service/operation provided by systems that are interested in receiving the Information Object as the result of the specified action implied by the verb. This can be invoked by the master system or an intermediary to supply the Information Object.
    - **Created**
    - **Changed**
    - **Closed**
    - **Canceled**
    - **Deleted**
  - The following verbs are used for query type services provided by the master system of the Information Object.
    - **Get**
    - **Show**
    - **Reply**
  - The following verbs are not used within AMI-ENT.
    - **Subscribe**
    - **Unsubscribe**

3.5.2 Intra-system vs. Inter-system

Inter-system interaction is defined as integration (exchange of information/event or execution of service) between systems that are owned by different business entities. Intra-system interaction is defined as those between systems that are owned by the same business entity.

Following is a table comparing how intra-system and inter-system integration differ as to the level of implementation needed to achieve the listed requirements.

GridWise Interoperability Context Setting Framework – Cross Cutting Issues	Requirements	Intra-System	Inter-System
Shared Meaning of Content	**Precise and declarative Service Definition**	Same	Same
Shared Meaning of Content	**Precise and semantically consistent schema/payload definition**	Same	Same
Transaction and State management; Time synchronization and sequencing.	**Service interaction (choreography)**	Can be achieved through process/service orchestration implemented in an ESB or at end points between consumer and provider.	Without a central mechanism to implement process/service orchestration, services that require complex iteration may need to implement choreography in a secure and reliable manner.
Resource Identification	**Reference data and ID (identifier) management and cross reference, including naming standards.**	Although master data management is desirable, most utilities still duplicate master (reference) data and their key identifiers. It is possible to leverage the verbs pattern listed above to implement a master data ID management for a given domain.	It would not be scalable and sustainable if some form of master data management is not implemented for B2B integration services. Smart Grid and DR processes will require participating businesses to share and understand supply and demand resources that connect to the delivery networks across the entire chain of energy delivery.
Logging and Auditing	**Error handling, management and monitoring**	Standard fault operation and schema.	Much more standardized and meaningful error handling and tie with SLAs and operational procedures.
Security and Privacy	**Security management**	There will be at least three security zones: utility operations, utility enterprise, and utility edge systems.	B2B interaction will be at least in par with the utility edge security requirements.

GridWise Interoperability Context Setting Framework – Cross Cutting Issues	Requirements	Intra-System	Inter-System
System preservation; Quality of Service.	**Service Level Agreements (SLA) on performance, availability, scalability, etc.**	Yes, but often loosely defined and implemented.	Much more formal and measured, and may be subject to regulatory oversight and reporting.
Discovery and configuration; System Evolution and Scalability	**Service management and governance**	Yes, but could be gradually implemented.	Must be in place fully to manage change and evolution of requirements.

3.5.3 Service Aggregation

Services can be defined and standardized at different levels:

1. Services that represent an entire business process that often involve multiple systems and/or multiple organizations.
2. Services that represent a complex and composite business function that often involve multiple systems.
3. Services that represent a unit of work that often involve one system.

So far, services defined for AMI-ENT has been at the third level to drive system to system level interoperability. As the third level services become mature and stable, there will be opportunity and need to define higher level services. Services patterns at the higher levels will also potentially introduce new verbs at the service/operation levels.

3.5.4 Master Data Management

Master data management is a concept and practice growing out of the need for controlling the quality, consistency and proliferation of reference data that are used across utility business applications. It is also very necessary to achieve SOA and interoperability goals. While utilities are moving towards master data management, challenges remain due to a large number of legacy and COTS systems. With the increasing need for information and process integration with other businesses, the master data that need to support these processes will have to be managed across multiple enterprises.

For the purpose of AMI-ENT and Smart Grid, the master data management requirements need to address the following issues:

1. What constitute a Master Data?
2. What is the meta-model for master data?
3. What is the ID naming and design standard for master data?
4. What is the ownership and governance model for master data?
5. What is the recommended patterns and architecture to implement Master Data Management?
6. What are the security requirements for master data management across business boundaries?

3.5.5 Complex Event Processing

As utility operation move towards tighter integration with communication and information technologies in more real time terms, there will be need for complex event processing. According to Wikipedia, Complex Event Processing, or CEP, is primarily an event processing concept that deals with the task of processing multiple events with the goal of identifying the meaningful events within the event cloud. CEP employs techniques such as detection of complex patterns of many events, event correlation and abstraction, event hierarchies, and relationships between events such as causality, membership, and timing, and event-driven processes. This is also tightly linked to the notion of Operational Intelligence (OI), which focuses on providing real-time monitoring of business processes and activities as they are executed within computer systems, and in assisting in optimizing these activities and processes by identifying and detecting situations that correspond to interruptions and bottlenecks.

For example, the use of AMI technology for revenue protection (energy theft detection) is an interesting use case of applying CEP concepts. With many meter events coming from AMI meters that may indicate tampering, these events will need to be correlated with other events that may be happening with the same meters (service orders, etc.). The analysis of usage patterns overlaid with the weather patterns will help determine if an investigation order is warranted. As future DR programs and dynamic pricing schemas get implemented, complex event processing will play an important role in enabling grid operators and dispatchers get much needed help from computers to indentify and correlate events, so that they can focus on important information to act upon in a timely manner.

3.5.6 Governance

Utilities adopting Service Oriented Architecture (SOA) in the enterprise need to develop a governance framework early on in a SOA initiative. Utilities with a mature IT Governance and/or Enterprise

Architecture Governance can leverage their existing process and will require less effort establishing the right processes for SOA governance. On the other hand, organizations with less mature IT or EA governance processes will require significant effort to put into place the processes needed to develop a SOA governance framework. Much of the work used for the SOA governance framework can be leveraged to help drive and improve IT and/or EA governance strategies.

Projects like Advance Metering Infrastructure (AMI) that have large integration requirements are bringing SOA into the enterprise. Developing a Service Life-Cycle and a framework for governance around the different cycles will lead to a successful SOA implementation, resulting in reusable business services. The Service Life-Cycle includes Portfolio Management, Service Interface Design, Service Implementation and IT Operations Management. Processes for adding, modifying and retiring the inventory of services and the alignment with other portfolios, needs to be part of the portfolio management process. In addition, because services may span across different business domains, determining ownership of each service will be included in the service portfolio management process. Proper Interface Service Design will result in service reuse, taxonomy for a service repository and improved data quality. Minimally, a governance framework for this cycle is needed, due to its impact on the Service Life-Cycle.

Some utilities engaging in Smart Grid enablement projects are establishing Enterprise Information Management (EIM) strategies, standards, and reference architectures to insure the Interface Design cycle results in consistent, actionable, service interfaces. The Service Implementation cycle consists of many components and complex environments. Strict processes that provide consistency during the implementation are necessary. Furthermore, because SOA environments have many moving parts and are complex, test strategies need to include the support for a mixture of technology platforms, system domains and automation. Because business services may be tied to critical business processes and a single service will be used by multiple applications, control and monitoring the technical delivery and exceptions of the service is required. IT operations are leveraging ITIL version 2 and 3 framework to improve IT process and move toward a Service Oriented Organization. Technology vendors have created products that can help automate the implementation and IT operational governance processes to insure consistent design patterns, security, monitoring and service level reporting. However, many of these products are immature and standards and policies still need to be defined. Most organizations have a delivery cycle for application development.

SOA governance for future Smart Grid needs takes an even more important role as utilities will have to integrate more with other businesses in real time. SOA requires a similar delivery cycle, but introduces some new changes, which include a service portfolio, service interface design, and technology platforms. Adapting these changes will require the organization to change and learn new processes and technologies.

4. Appendices

4.1 Terms and Definitions

This subsection provides the definitions of all terms required to properly interpret the UtilityAMI AMI-ENT SRS.

Term	Definition
Advanced Metering	Technology which allows two way communications between the utility and the meter. This communication enables the ability to analyze energy consumption resulting in more efficient demand response systems.
Advanced Metering Infrastructure (AMI)	The infrastructure built around advanced metering allowing the utility and consumer to communicate in real time with respect to energy consumption. Based on the information collected the utility is able to obtain an accurate reading of demands, while consumers are able to modify their usage to save energy.
Automated Meter Reading	Automated meter reading is a subcategory of AMI which allows for communication devices to transfer data from a meter to the utility or from a meter to the data management provider.
Business Service Provider	Software delivered over the Internet as web services. The platform for integrating these web services is the enterprise service bus.
Business Intelligence	A term describing the extraction and presentation of data to provide business value.
Daily Consumption	The amount of energy a customer uses in a 24 hour period. This information is used to drive business intelligence solutions.
Demand Billing	The energy demand of a customer upon which billing is calculated. This is often based on peak demand or some other demand related measurement.
Demand Interval	The interval of time between demand queries to the meter. This is typically in 15, 30, and 60 minute intervals
Demand Response	An agreement between customer and utility that states that the customer agrees to allow the utility to manage their energy consumption when the utility deems necessary. Often times this result in the utility increasing or reducing energy distribution based on supply based metrics. Demand response mechanisms typical operate in on or off whereas dynamic response mechanisms may passively curtail energy usage as the mechanism senses stress on the grid.
Distributed Generation	Electricity generation from small energy sources allowing for more efficient energy distribution. This approach allows for energy to be generated closer to the source of the consumption which reduces the distance the generated energy has to travel.
Energy Data Acquisition	Obtaining meter data by way of handheld devices. Essentially a non automated meter reading typically administered by a utility worker.
Energy Data Management	Analyzing meter data for consumption by backend systems. Often times these back end systems will measure load, calculate demand response, billing intervals, etc.
Enterprise Resource Planning	Integrating all back and front office data and process into one unified enterprise system.
ESB	Enterprise Service Bus. The ESB provides the features necessary for a service oriented architecture implementation by providing a place to host all of the web services.

Term	Definition
IEC	The International Electrotechnical Commission (IEC). The IEC TC57 maintains an electric utility focused information model called CIM (Common information model).
IEC 61968	International standards for Energy Distribution Managements Systems, respectively, specify a Common Information Model (CIM) for utility data exchange, Applications Programming Interfaces (API) for application integration (GID), and XML messaging standards.
Load Shedding	Reducing a customer's demand in order to maintain integrity of the grid. Load shedding in utility operations, is monitoring electric usage continuously (usually by automated instrumentation) and shutting down certain pre-arranged electric loads or devices if a certain upper threshold of electric usage is approached.
Logical Data Model	A representation of an organization's data based upon entities and attributes of those entities. A logical data model is often a logical representation of a business' integration or business requirements.
Meter Bus (M-bus)	Allows for the interconnecting of many different utility measuring units (i.e. gas, electric, water, etc.) The M-Bus acts as the central station for these different utilities to communicate with.
Meter Data Management	A system for storing, processing, consuming and analyzing large quantities of meter data.
Real Time Metering	Meter readings taken almost in real time to allow for adjustments to be made as the energy market fluctuates.
Smart Grid	The term smart grid represents the digital upgrade of our distribution and long distance transmission grid allowing for increased energy efficiency as well as a boost in optimization of current systems.
SLA	Service Level Agreement: the part of a service contract where the level of the services are agreed upon between two systems.
Smart Meters	Meters with extra functionality that allow for more accurate and useful meter readings. This extra functionality allows the meter to collect usage data and transmit this data back to the utility over a network.
SOA	Service oriented architecture – The concept of grouping business functionality around business processes. These services are than packaged as interoperable services. A SOA architecture allows for the transmission of data between multiple systems as they participate in multiple business processes.
SOAP	Simple Object Access Protocol (XML protocol) – A protocol for exchanging xml messages for web services in a service oriented architecture implementation.
Supervisory Control and Data Acquisition (SCADA)	SCADA systems monitor and control the electric power generation, transmission, and distribution.
UML	Unified Modeling Language is a general purpose modeling language commonly used for object/data modeling.
WSDL	Web Services Description Language is an xml format used to describe web services and the messages that interface with the web services.
XML	Extensible Markup Language – general purpose markup language for creating custom mark-up languages.
XSD	A description describing a specific xml document focusing primarily on the restraints and structure of that xml document.

Term	Definition
Utility Sub Metering	An implementation that allows for a multi tenant property to bill tenants for individual energy usage. This is most commonly implemented in apartments and condominiums.

CIM Term	Definition
ActivityRecord	Records activity for an Asset, Location, Document, PowerSystemResource, Organization or ErpContact (e.g., operator, market participant, etc.) at a point in time. An activity may be for an event that has already occurred or for a planned activity. The PowerSystemResource relationship records events regarding the logical function being provided by the resource in the electrical network (independent of the particular asset providing the function). The Asset relationship records history about the particular equipment, independent of where it is currently being used in the electrical network. The Location relationship records events associated with the geographical location. The Customer relationship records history regarding the customer independent of the logical network or particular assets being used to serve the customer.
ConnectDisconnectFunction	A function that will disconnect or reconnect the customer's load under defined conditions.
DeviceFunction	A function performed by a device such as a meter, communication equipment, controllers, etc.
ElectricMeteringFunction	Functionality performed by an electric meter.
EndDeviceAsset	This type of AssetContainer performs one or more EndDevice functions. One type of EndDeviceAsset is a Meter Asset which can perform metering, load management, connect/disconnect, accounting functions, etc. Some EndDeviceAssets, such as ones monitoring and controlling air conditioner, refrigerator, pool pumps may be connected to a MeterAsset. All EndDeviceAssets may have communication capability defined by the associated ComFunction(s). An EndDeviceAsset may be owned by a consumer, a service provider, utility or otherwise.
EndDeviceEvent	A meter event is used to convey events that are detected by a meter.
GasMeteringFunction	Functionality performed by a gas meter.
IntervalBlock	Used within a MeterReading to identify a time sequence of Readings of the same ReadingType.
IntervalReading	Data captured at regular intervals of time. Interval data could be captured as incremental data, absolute data, or relative data. The source for the data is usually a tariff quantity or an engineering quantity. Data is typically captured in time-tagged, uniform, fixed-length intervals of 5, 10, 15, 30, or 60 minutes. Interval Data is sometimes also called "Interval Data Readings" (IDR).
IntSchedAgreement	A type of agreement that provides the default method by which interchange schedules are to be integrated to obtain hourly energy schedules for accounting.
IrregularIntervalSchedule	The schedule has TimePoints where the time between them varies.
LoadLimitFunction	A kind of LoadMgmtFunction that limits the customer load to a given value.
LoadMgmtFunction	A collective function at an end device that manages the customer load.

CIM Term	Definition
LoadShedFunction	A kind of LoadMgmtFunction that sheds a part of the customer load.
Location	The place, scene, or point of something where someone or something has been, is, and/or will be at a given moment in time. It may be the spatial location of an actual or planned structure or set of point-oriented structures (as a substation, structure, building, town, etc.), which may be defined as a point or polygon. It may also be the path of a underground or overhead conductor.
Meter	This is generic logical meter object.
MeterAsset	The physical asset that performs the metering role of the ServiceDeliveryPoint. Used for measuring consumption and detection of events.
MeterAssetModel	Documentation for a type of a meter asset of a particular product model made by a manufacturer (Organisation). These types of meters are used to measure power consumption. There are typically many instances of an asset associated with a single asset model.
MeteringFunctionConfiguration	The configuration of data for a given meter functions.
MeterReading	Used to convey quantities that are measured by a meter.
MeterReadingPurpose	The purpose of the meter reading, such as initial reading, final reading, peridic reading, demand reading, etc. This information is often used to distinguish final and initial readings when there is a tenancy change at a service location.
MeterServiceWork	Used to manage work involving meters.
MeterTypeAsset	Documentation for a generic meter that may be used for design purposes. Rather than being associated with CustomerMeter, it is associated with EnergyConsumer as it may be used for many applications, such as tie line metering, in addition to customer metering.
Reading	Used to convey a specific value measured by a meter or other asset. Each Reading is associated with a specific ReadingType.
ReadingQuality	The quality of a specific reading. Note that more than one Quality may be applicable to a given Reading Value. This field is not necessary unless problems or unusual conditions occur because Quality for each Reading Value is assumed to be 'Good' unless stated here otherwise.
ReadingType	Used to identify the type of data that is conveyed by a specific Reading.
ServiceDeliveryPoint	There can be multiple service points at a single ServiceLocation, each one identified as a ServiceDeliveryPoint. They deliver service in accordance with a CustomerAgreement.