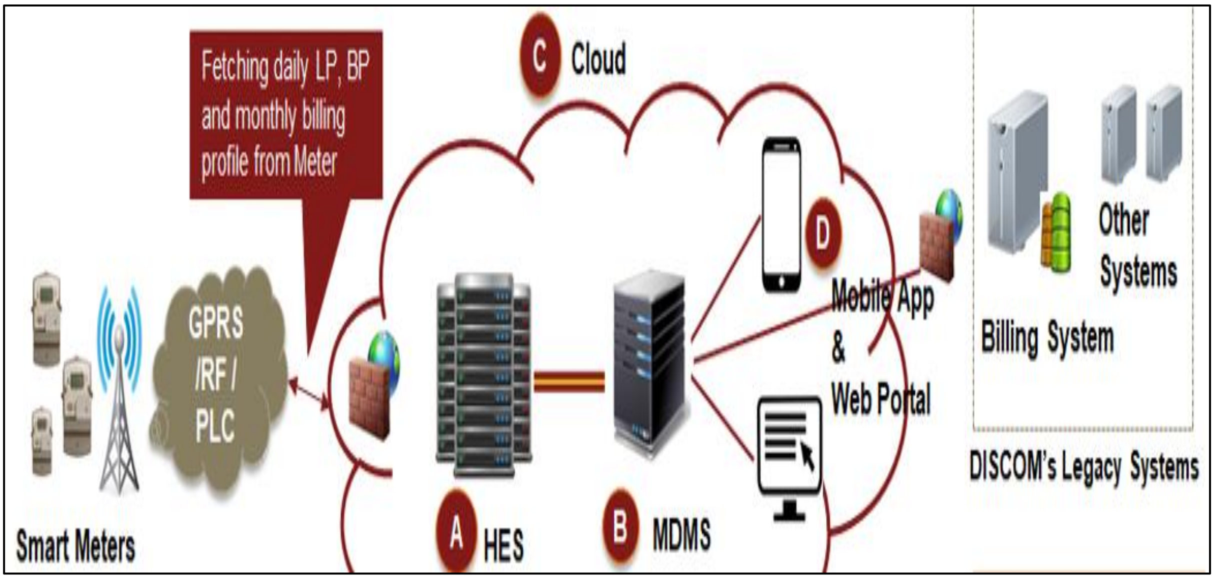
Guidelines for Standardization and Interoperability in AMI Systems for End to End Communication between Smart Meter, HES and MDM



MINISTRY OF POWER

Central Electricity Authority

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Contents

MOP OM for constitution of the Committee for Standardization and Interoperability of AMI layer

1 Background

Currently, in the RDSS projects, three (3) communication technologies viz RF/PLC/ Cellular are specified in the Indian Standards. Cellular communication can further be based on 4G/5G or NBIoT technology. In current scenario, most of the RF Mesh solutions are proprietary and there are multiple routing/ mesh protocols, security mechanisms etc. Similarly, with NBIoT, extra intelligence is added to increase the network performance. Also the HES used for communication based on above technologies, are generally separate and not unified, for reasons as under:

- All the above specified technology works on different mechanisms example RF and PLC requires intermediate NAN devices whereas cellular operates on direct WAN technology. Also, additional layers/ intelligence are required in certain communication technology to achieve reliable communication and higher performance.
- Cellular (4G/5G/NBIoT) - Smart meters & HES may directly communicate with meters in transparent mode using the DLMS protocol (as per IS 15959 Part 2 or Part 3 as applicable) or use WAN Adaptor.
- RF Mesh requires intermediate Gateways/ Data Concentrator Units (DCU) as per NAN communication methodology and some additional communication layers are used for data exchange between Smarts Meters & Gateways/ DCU's. Presently these additional layers are vendor specific solutions.
- PLC is not being used in the various RDSS projects. If the better solution comes up suitable for our electrical network, then there will be need to adopt standard based approach, along with use of unified HES.

In this context, a Committee was constituted by Ministry of Power for standardization and interoperability in AMI (Advanced Metering Infrastructure) under the chairmanship of Member (Power System) CEA with members from CEA/NSGM/IEEMA/Meter Manufacturers/Discoms/System Integrators/HES-MDM developers with DG CPRI as Member Secretary/Convenor of the Committee.

The deliverables for the Committee are as under:

i Identify the areas between meter and HES communication which are bottleneck for interoperability, mainly for RF and NBIoT communication technology.

ii Study the implementation challenges and propose solutions for unified HES and adoption of various standard layers for integration between Meter to HES and HES to MDMS

iii Identify the standard based approach for communication between Meters (based on RF Mesh or Cellular technology) and HES for making systems truly interoperable.

iv Deliberate and provide synopsis on developing plug and play type mechanism so as to have seamless integration between meter, HES and MDM of any make

v Finalize the other aspects of RF/ NBIoT solution for desired intelligence in the system.

vi Review the status of the standardization work of physical layer/ pin configuration of smart meter, which will have bearing on this TC report for various recommendation.

vii Submit report for finalization of actions and areas for further standardization work in BIS.

After the various meetings, the present Guidelines have been finalized by the above Committee constituted by Ministry of Power.

2 Executive Summary

The present Guidelines on AMI Interoperability are aligned to the specific deliverables of Phase A and phase B as below

1. Phase A - Unified HES – MDMS Interface Specification
2. Phase B – Pluggable Module Specification

1) **Phase A**: An initial and early solution that provides the main objective of ensuring a Unified HES with interoperability across its interfaces to the MDM above as well as to the Meter fleet across 2 broad categories of communication technologies
   a) Direct Cellular equipped meters
   b) RF Mesh equipped meters
      i) via an Aggregator provided by the **same Meter vendor**

   In this phase the meter communication module can be swapped if it is of the same communication technology (Cellular with Cellular or RF with RF) and if it is supplied **by the same supplier having same form factor and pin out configurations**.

2) **Phase B**: A secondary solution that separates the communication module at the meter end from the meter itself, while still providing a common secure enclosure. This is proposed to be achieved by standardizing an interface in the meter that can connect to a pluggable module that employ either of the communication technologies listed above (and with consideration for other communication technologies that may be found suitable in future). This standard is being designed under BIS ETD13 and will be specified there. The draft document is listed in the References section
   a) Direct Cellular Communication Module plugged into meters. The meters and the modules may be from different vendors
   b) RF Mesh Communication Modules plugged into meters. The meters and the modules may be from different vendors
      i) via an Aggregator provided by the **same Communication Module vendor**

The Guidelines aim to standardize the following:

1. A single Unified HES with standardized interfaces to the MDM and Meters / Aggregators. Such that different makes of HES that conform to this document may be used in an interoperable manner
2. For WAN Connected meters – this specification support two options
   a. Direct IS-15959 Parts1,2 and 3 for the application protocol between the Unified HES and Meters. **This option is to be mandatorily supported by the Unified HES as well as Meters**
   b. Through a WAN Adaptor - employing IEC61968-9 (plus additional message) - based interface to the HES
3. For RF and other NAN connected Meters through a NMS Adaptor - employing IEC61968-9 (plus additional message) - based interface to the HES
4. For upstream communication between Unified HES and MDMS – employing an IEC61968 based API

3 Abbreviation and Definitions

AMI	Advanced Metering Infrastructure
AMISP	Advanced Metering Infrastructure Service Provider
HES	Head End System
MDM	Meter Data Management
DLMS	Device Language Message Specification
REST	Representational State Transfer
CIM	Common Information Model
NMS	Network Management System
API	Application programming interface
WAN	Wide Area Network
NAN	Neighbourhood Area Network
JSON	JavaScript Object Notation
SOAP	Simple Object Access Protocol
XML	Extensible Markup Language
FTP	File Transfer Protocol
CMS	Cryptographic Message Syntax
PKCS#7	Public Key Cryptography Standards - Cryptographic Message Syntax

4 References

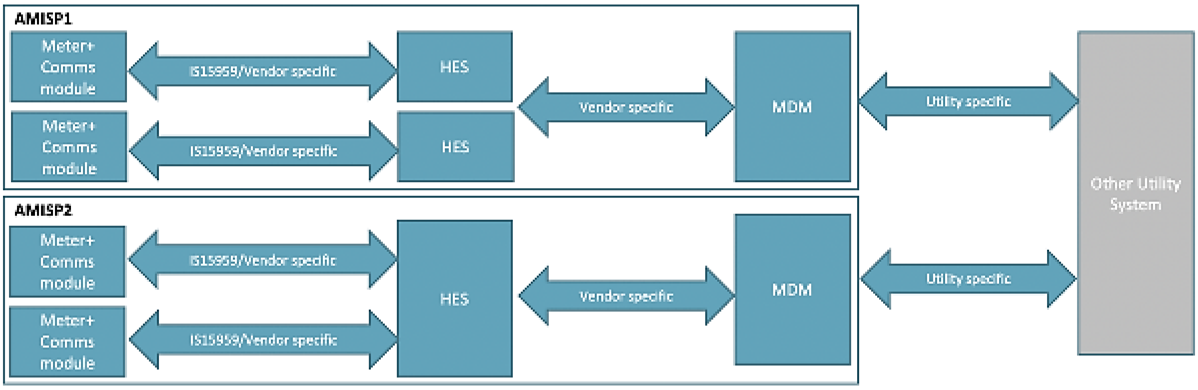
Sr No	Reference	Links
1.	IS 15959	https://www.bis.gov.in/
2.	DLMS documentation	https://www.dlms.com/dlms-cosem
3.	IEC 61968-9	https://webstore.iec.ch/en/publication/6204
4.	IEC 61968-100	https://webstore.iec.ch/en/publication/67766
5.	CMS/PKCS#7	RFC 5652 (https://datatracker.ietf.org/doc/html/rfc5652)
6.	Unified HES – NMS/WAN Adaptor Interface specification	HES-NMS-WAN adaptor-Interface v1.0.docx (sub-document)
7.	Unified HES – MDMS Interface Specification	HES-MDMS-Interface v1.0.docx (sub-document)
8.	Phase B – Pluggable Module Specification	Standard for Pluggable Communication Module v1.0.docx (sub-document)

5 AMISP Integration Architecture

These Guidelines only defines the integration between component under the scope of AMISP that is Meter, communication, HES and MDM. Integration of other utility system with MDM/HES is out of scope of the Guidelines.

5.1 AMISP Architecture - Existing implementations

Most of integration between the system components are based on bilateral agreement between the parties. Ultimate delivery of SLA is responsibility of AMISP. Below figure depicts the typical AMISP architecture model in the existing implementations



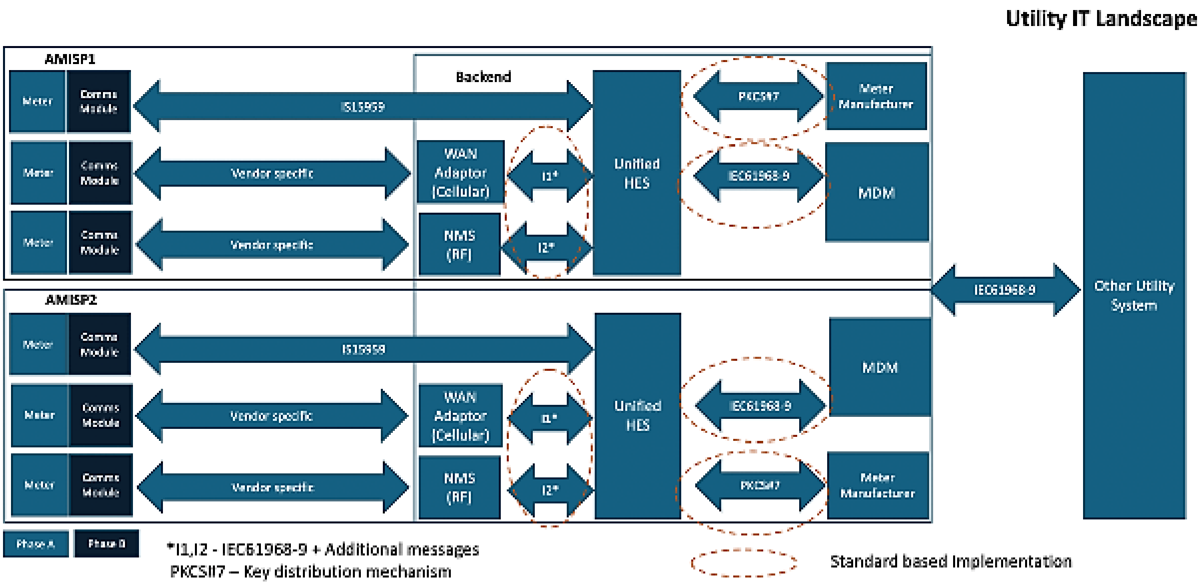
5.2 AMISP Architecture – Proposed

Though existing architecture provide the functional need of utility from AMI and puts accountability on AMISP to deliver AMI functions as per SLA this is a black box approach with following challenges for AMISP on ecosystem as whole

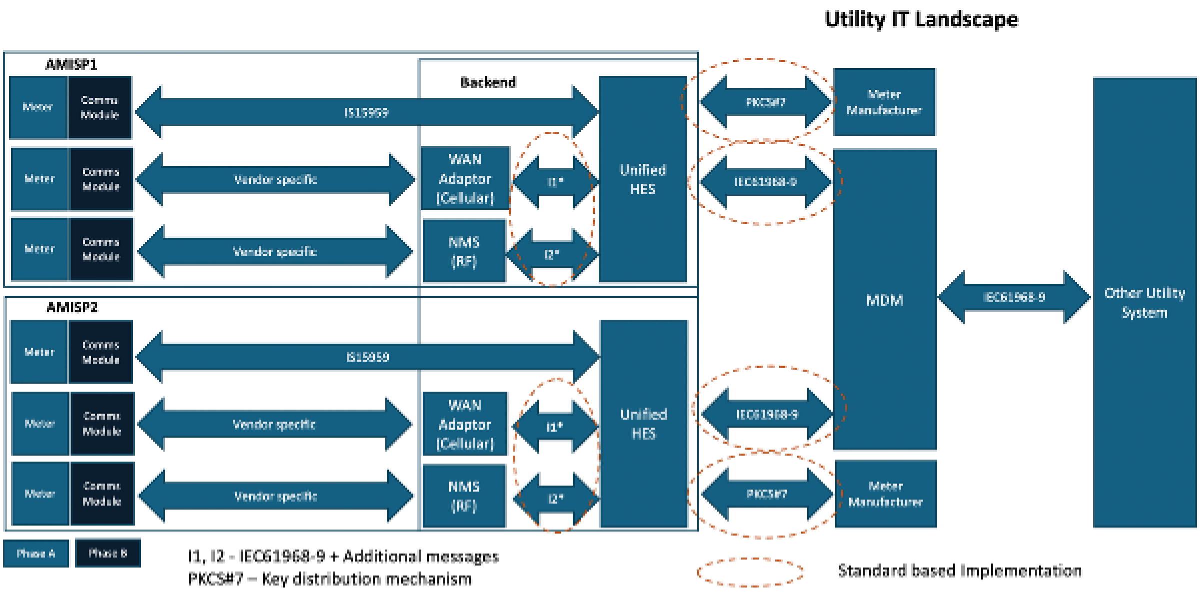
1. Lack of interoperability between the system component make it difficult to add new partners or development vendors.
2. Additional cost due to duplication of components
3. Create entry barrier for new participants

Below two architecture options are proposed as alternate solutions for AMISP integration architecture to overcome the challenges and keep the accountability of data delivery based SLA with AMISP.

5.2.2 Option 1 – Unified HES and MDM at AMISP level



5.2.3 Option 2 Unified HES at AMISP level and MDM at Utility Level



NOTE: A third alternate architecture option is discussed in Annexure B – which is however deferred due to the reasons mentioned in the annexure

5.3 Key architecture points are defined below

1. Phase A

a. All Meters must support IS 15959

b. Cellular communication module shall have ability to be configured in transparent mode. RF Mesh communication may choose to support transparent mode for IS 15959 based communications between HES and Meter.

c. Unified HES must support meter reading and control messages on IS15959
d. Unified HES must support offline reading of meters in case of no connectivity to meet SLA.
e. Unified HES should support integration with WAN adaptor or NMS with
    i. IEC 61968-9 for meter reading and control messages
    ii. Defined additional message format for network optimization, keys change, firmware upgrade on top of IEC 61968 framework
f. Unified HES should follow IEC 61968-9 for interface with MDM

2. **Phase B**
    a. Pluggable communication module in meter by defining hardware/mechanical parameter.
    b. RF providing transparent channel for reading over IS15959

3. Other related work is specified in section 9 Future Work

5.4 System components

1. Meter – Electrical meter which collect and control various electrical parameter and communicate with HES/Adaptors via communication modules
2. Communication module – It facilitates communication between Meter and HES/Adaptors for the given communication media.
3. WAN Adaptor – For cellular network it facilitates configuration of communication module to optimise performance, additional manufacturer specific innovative features for additional functionality, performance optimization and distributed intelligence.
4. NMS – For RF network it facilitates management of RF network, implement distributed intelligence to best use the underlying RF technology to communicate with meter and HES.
5. Unified HES - Unified HES do meter reading and send control messages to meters directly or via adaptor/NMS. It should facilitate to measure and monitor the SLA defined for interaction with Meters. Generally speaking, AMI system will comprise of Meter, communication module, WAN adaptor, NMS and Unified HES.
6. MDM – MDM system interacts with other utility system and HES to implement business process required for meter reading and control.

5.5 Interface framework

1. Should use message patterns and message defined in IEC 61968-100 for request-response and notification. For details refer the Verbs defined in IEC 61968-100 for each message pattern.
2. IEC 61968-100 only define message transport on SOAP API and JMS. Other transport can be used but not defined. It is proposed to add RESTAPI and any other message bus should also be allowed.
3. IEC 61968-100 only define message encoding schema for XML. However, it will be useful to have JSON encoding as most of modern application use JSON. This is listed as future work in section 10
4. Should use message format of IEC 61968-9 for meter reading and control. For details refer Class and noun defined for meter reading and control in IEC 61968-9
5. Additional messages are defined in this document for comms adapter and MDM.
6. Parameter code for reading types should refer the Reading type defined in IEC 61968-9.

5.6 Interfaces

1. Meter-Unified HES – When communication module is in transparent mode Unified HES can directly interact with Meter over IS 15959.
2. WAN Adaptor-Unified HES – When Unified HES need to use features provided by WAN adaptor it can use
   a. IEC 61968-9 for meter reading and control messages
   b. Additional classes required for WAN adaptor – Unified HES are defined in HES-NMS-WAN Adaptor interface document.
3. NMS-Unified HES – Unified HES should support
   a. IEC 61968-9 for meter reading and control messages
   b. Additional classes required for NMS – Unified HES are defined in HES-NMS-WAN Adaptor interface document
4. Unified HES-MDM - Should use message format of IEC 61968-9 for Meter Reading and Control messages.
5. Meter Manufacturer-Unified HES – Meter manufacturers should use Key file (as per format defined in Section 6.1 - Key file format) to transfer meters keys and firmware securely to Unified HES.
6. MDM-Other Utility systems – Recommended to use IEC 61968-9

6 Key Management

6.1 Key file format

Key files should follow below mentioned format. Fields for key files are defined below.

Field	Field Type	Remark
DeviceKeys	List of Device	Root
Device	Object	Repeat for each device
DeviceType	Enumerated type	Field under Device
DeviceID	String	Field under Device
Keys	List of Keys	Field under Device
Key	Object	Repeat for each Key
KeyType	Enumerated type	Field under Key
KeyValue	String	Field under Key

XML file example is given in Section 10.2 – Key File Structure, though any serialization can be use by bilateral agreement.

6.2 Key file distribution

Key file distribution should use PKCS#7. PKCS#7 is a standard for Cryptographic Message Syntax (CMS) that describes a general syntax for data that might have cryptography applied to it. PKCS#7 can be used to transfer signed data and message.

6.3 Key management recommendations

Below are recommendations for Key management. Key file format should be as per defined format

1. Meter keys file must be distributed to unified HES following PKCS#7. Meter manufacturer and Unified HES provider should share organization verified certificate issued by trusted 3rd parties.
2. Once keys are received it is the responsibility of Unified HES to securely manage or change the keys.
3. Unified HES must support key rotation or changing strategy and mechanism
4. Network devices keys in case of RF should be managed by NMS and security of keys will lie with NMS.

7 Unified HES for Firmware Upgrade

Below are recommendations for Unified HES to take care of variability across vendors for meter firmware upgrade

1. Should support PKCS#7 for transfer of meter firmware image from firmware vendor to HES.
2. There can be more than one firmware image and sequence of transferring image must be ensured.
3. During image transfer to meter, block size should be negotiated as it can be different based on capability of underlying network and meter.
4. Many a times if previous version is not upgraded in meter new version cannot be downloaded. This has to be supported by the HES

8 Interoperability Scenarios

Below table demonstrate how interoperability scenarios are addressed

Sr No	Scenario	Recommendation
1.	Integrating new meter vendor on cellular	• Directly read meters over IS15959. • Integrate with WAN adaptor in case interested to use additional features.
2.	Integrating new meter vendor on RF	Integrate with NMS
3.	Replacing meter of different communication media	Use appropriate method i.e. direct, adaptor or NMS
4.	Migrating for RF to cellular, cellular to RF or RF to different RF but meter remaining same.	Possible only after Phase B
5.	Integrating new AMISP	Based on the commercial agreement with Utility and existing AMISP it can integrate with existing Unified HES

9 Future Work

Following actions are required to enable industry to implement the approach defined in this document. It will be useful to do these action in close coordination with IEC 61968 Committee using the process and techniques used by them

Sr No	Action	Remark
1.	Define REST API based message transport which can be later proposed as addition to IEC 61968-100	**Mandatory** requirement as currently defined SOAP API and JMS are obsolete technology
2.	Define JSON schema for class/noun defined in IEC 61968-9	**Optional** as XML schema and object definition as available in IEC 61968-9. However, this can be taken up as an optimization in future
3.	Detailing of additional classes for communication adapter to Unified HES	**Mandatory** as IEC 61968-9 does define object for collecting topology and network diagnostic data of communication module and gateway
4.	Communication module firmware image upgrade to be specified in IS15959	**Mandatory** as this is a required feature
5.	Data Push and Communication parameter configuration being defined in BIS Committee for Smart meter. This is to be added in IS15959	**Optional** – this will help to optimize HES performance and bandwidth usage in restricted networks

10 Annexure A – Informative

10.1 The Common Information Model and IEC 61968-9

The Common Information Model, or CIM, developed originally by a company called Unified Information. The CIM was intended to facilitate the computer-based exchange of information about the configuration and status of an electrical network.

In 1993, the Control Center Application Programming Interface (CCAPI) Task Force, a working group sponsored by Electric Power Research Institute (EPRI), took over responsibility for the CIM with the goal of making it an international standard. The CIM was submitted to the International Electrotechnical Commission in 1996 and became an official standard in 2001.

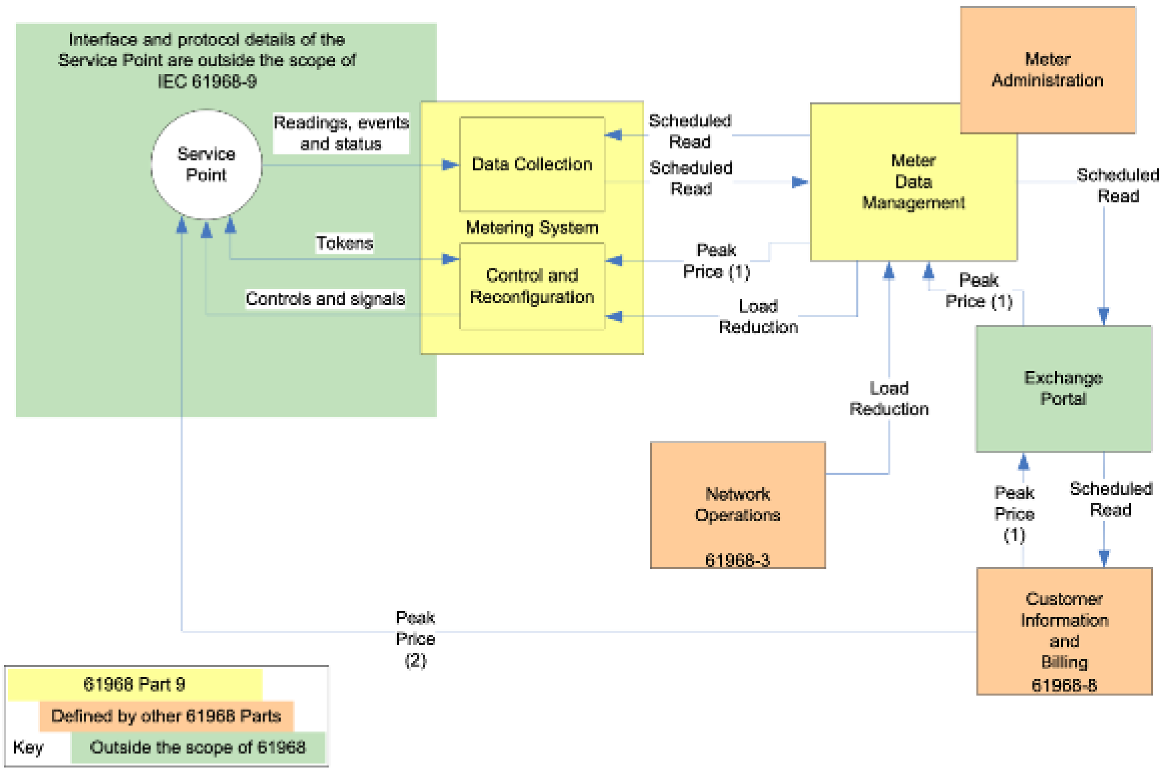
The CIM is currently maintained as a UML model. It defines a common vocabulary and object model for many aspects of the electric power industry. The central package within the CIM is the 'wires model', which describes the basic components used to transport electricity. The CIM can be used to derive 'design artifacts' (e.g. XML Schema, RDF Schema) as needed for the integration of related application software.

Post formal adoption in 2001, the CIM has been enhanced over the years to provide more extensive modelling in the metering domain and coverage for metering of gas and water in addition to electricity.

Responsibility for the CIM today rests with Working Groups 13 (Energy Management System Application Program Interface) and 14 (System Interfaces for Distribution Management) of the IEC's Technical Committee 57 (Power Systems Management and Associated Information Exchange).

WG 14 is also responsible for the IEC 61968 series of standards that extend the CIM to meet the needs of electrical distribution, where related applications include distribution management systems, outage management systems, planning, metering, work management, geographic information systems, asset management, customer information systems and enterprise resource planning. Part 9 of the IEC61968 standard, referred to as IEC 61968-9, specifically addresses interfaces for meter reading and control. The 1st Edition of IEC 61968-9 was formally approved as an International Standard in August of 2009. The content for the 2nd Edition id IEC 61968-9 was frozen in early 2011 and forms the basis for the v2.0 revisions of the CIM-Compliant interfaces

Below diagram is taken from IEC 61968-9 document as normative reference to show part relevant to AMISP. Details should be referred from supported version of IEC 61968-9



Key IEC 61968-9 Interfaces relevant for the scope are meter reading and control messages as below. Detail of each interface request and response can be referred in IEC 61968-9 document.

Business functions	Business sub-functions	Abstract components
Meter reading and control (MR)	Metering system (MS)	Data collection
		End point controls
		End point reconfiguration
		Disconnect/reconnect
		Demand reset
		On request read
		Point of sale
		Outage detection and restoration verification
		Power reliability and quality events
		Metering system events
	Meter maintenance and asset management	End point install, configure, remove, repair, disconnect, reconnect
		End point asset history
		End point reconfiguration
		Special read
		Meter service request
		Tariffs
	Meter data management (MDM)	Meter data repository
		Usage history
		Validation, estimation and editing
		Customer billing data
		End device controls and events
	Demand response (DR)	Real-time pricing
		Emergency reductions
		Economic reductions
		Program registration
	Load management (LM)	Load analysis
		Load control
		Demand response
		Performance measurements
		Risk management

IEC61968 CIM also specified additional data models as below. However, these are not considered in the scope of this Interoperability Report

- Customer Information Systems/Billing
  - Consumption readings
  - Interval readings
  - On demand readings
  - Demand reset o Remote disconnect
- Outage Management Systems
  - Current power status
  - Outage/Restoration events
  - Event filtering and throttling

- Network Management/Monitoring Systems
    - Event monitoring
    - Network and meter level
    - System administration via utility network operations center

10.2 Key file structure example

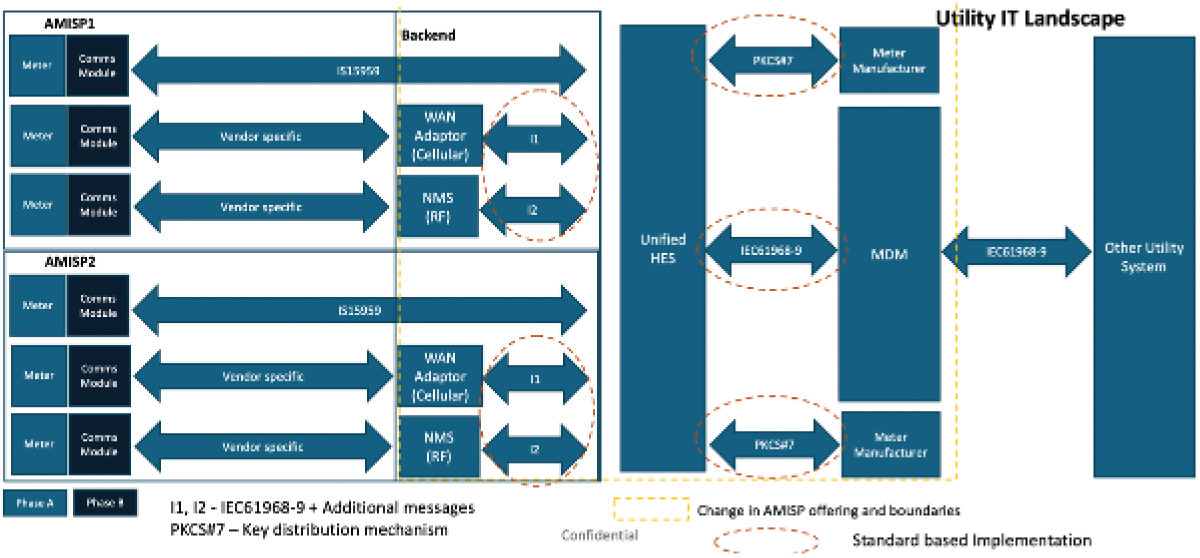
(Refer section 6 for the structure)


```xml
<?xml version="1.0" encoding="UTF-8"?>

<DeviceKeys>
  <Device>
    <DeviceType>Meter</DeviceType>
    <DeviceID>Meter123</DeviceID>
    <Keys>
      <Key>
        <KeyType>HLSKey</KeyType>
        <KeyValue>ABC123XYZ</KeyValue>
        <Description>High level security (HLS) key </Description>
      </Key>
      <Key>
        <KeyType>LLSKey</KeyType>
        <KeyValue>DEF123XYZ</KeyValue>
        <Description>High level security (HLS) key </Description>
      </Key>
    </Keys>
  </Device>
  <Device>
    <DeviceType>Meter</DeviceType>
    <DeviceID>Meter123</DeviceID>
    <Keys>
      <Key>
        <KeyType>HLSKey</KeyType>
        <KeyValue>ABC123XYZ</KeyValue>
        <Description>High level security (HLS) key </Description>
      </Key>
      <Key>
        <KeyType>LLSKey</KeyType>
        <KeyValue>DEF123XYZ</KeyValue>
        <Description>High level security (HLS) key </Description>
      </Key>
      <Key>
        <KeyType>TLSCert</KeyType>
        <KeyValue>Meter123.pem</KeyValue>
        <Description>TLS certificate file </Description>
      </Key>
    </Keys>
  </Device>
</DeviceKeys>
```


11 Annexure B: Alternate Architecture option

The option to have a Unified HES in Utility scope that can be utilized by subsequent AMISP projects was discussed in the panel. This is technically feasible following the interfaces and standards defined in this document. However, this option is not immediately recommended due to non-technical feasibility reasons as described in this annexure. This option is considered as violating core principles of SLA based data delivery for which AMISP concepts was introduced.



Below table list the comparison of options

S. No.	Criteria	Option 1	Option 2
1	Data delivery based SLA for AMISP	Aligned with the requirement. As AMISPs will select its partners so they are responsible for data delivery and meet SLAs as per Utility contract.	This requires re-defining the existing AMISP SLA boundaries, which shall be quite challenging – what will come in scope of AMISP and what will come in scope of Utility; and requires, re-structuring of the well-developed and established SBD document. In addition to it, ensuring end-to-end stack accountability will be a key challenge.
2	Integration Type	Standard based integration, accountability resides with AMISP	Standard based integration, however, no single entity accountability can be defined.
3	Performance and Scalability requirements	Responsibility of AMISP as it owns end-to-end stack	Defining ownership of performance shall be a challenge.
4	Handling of Offline meter readings	AMISP is responsible to collect meter data	No clear ownership of offline meter reading.
5	New Meter Contracts	Will depend on the techno-commercial agreement between AMISP and Utility.	Will depend on the techno-commercial agreement between AMISP and Utility.
6	Testing Framework	To be defined during the subsequent stage. AMISP shall be responsible for testing & compliance with its own on-boarded partners.	To be defined during the subsequent stage. Difficult to ensure testing and compliance accountability scope.
7	Ownership	AMISP owns the end-to-end stack and its maintenance.	Who will own the development, maintenance, and upgrade of Unified HES along with its 100% compatibility with deployed smart meters.
8	Backward Compatibility	Difficult as existing contracts are already under execution, and will have performance accountability issues. Hence, not recommended.	

HES-MDMS Interface

Contents

1. Introduction

Systems and applications that interface with the MDMS using CIM-compliant messages fall into two categories:

- Back Office Systems, which can include, but are not limited to, Customer Information Systems, Outage Management Systems, Asset Management Systems, Service Order Systems, Outage Planning Systems and the like.
- AMI and other meter data acquisition systems that are responsible for communicating with, obtaining data from, and controlling meters and Home Area Network (HAN) devices, and managing the technical nuances of the metering system network. These are commonly referred to as Metering Systems or Head End Systems.

MDMS complies with International Standard IEC 61968-9 and the IEC Common Information Model, or CIM. Interfaces that comply with IEC 61968-9 are said to be CIM-compliant. This specification defines a common set of CIM-compliant messages for use by both Back Office and Head End Systems, providing an unprecedented level of flexibility and ease of integration with the MDMS.

Information describing the use of these messages to support specific business scenarios and to describe the conventions for population of the mandatory and optional elements of the CIM-compliant messages is contained in a set of ancillary specifications referred to as CIM-Compliant Messaging Guidelines.

2. Intended Users

This document is intended for use by utility personnel, AMI Head End System and Back Office System vendors, and system integrators responsible for the integration of systems and applications with the MDMS.

It is directed in particular to business analysts, developers, testers, integrators, and business users. It may also be useful for systems and operations personnel who must understand how the interfaces function once they are implemented.

3. Interface Details

The scope of this document is restricted to interactions between HES and MDMS.

- **Device Provisioning from MDMS to HES**

The purpose of this interface is to allow MDMS to inform HES about various updates, including meter and module installations, removals, logical disconnects, rate schedule changes, and other significant alterations related to meter, module, location, account, and customer data within the client utility system.

Once devices are provisioned in MDMS, they are communicated to the Head End System to ensure synchronization between the CIS, MDMS, and HES concerning device information. This information can be passed via XMLs or files.

Refer Annexure for the CIM standard

- **Readings**

Readings can be pushed from HES to MDMS via scheduled jobs. The reads can be received either via XMLs or file. MDMS can request for reads from HES via On Demand readings. These requests can be register reads or interval data reads.

✓ **Readings from HES to MDMS**

a. Register/Cumulative Read from HES to MDMS. HES sends cumulative reads to MDMS at the end of day which is the total meter reading. MDMS calculates daily usage from this read and stores.
b. Interval Usage from HES to MDMS. HES sends interval data multiple times a day to MDMS.

✓ **On Demand Readings from MDMS to HES**

The configuration for On Demand Reads is:

- Register Reads (daily, billing or instantaneous)
- Load Profile Reads
- Ping (Health check)

Refer Annexure for the CIM standard

- **Events from HES to MDMS**

End device event messages are designed to convey changes in the state of an end device, either by the end device itself or by a proxy on behalf of an end device.

Any such change needs to be communicated to MDMS so that relevant action can be taken. These events can be received either via XMLs or file.

Refer Annexure for the CIM standard

- **End Device Controls**

End Device Controls are a type of request message defined in the IEC CIM standard.

It is employed whenever a control command needs to be sent to an End Device in an AMI system.

✓ **End device control from MDMS to HES**

- Demand Reset
- Load control (Power Connect, Power Disconnect)
- Prepayment to post payment and vice-versa
- Meter change out

- Cancellation request (removal of meter)
- Meter Re-programming

Refer Annexure for the CIM standard

4. Definitions and Acronyms

Term	Definition or Explanation
Advanced Metering Infrastructure (AMI)	Communications hardware and software and associated system and data management software that creates a network between advanced meters and utility business systems which allows collection and distribution of information to customers and other parties such as competitive retail suppliers, in addition to the utility itself
AMI Head End System	The server / application portion of an AMI System (as defined elsewhere in this table) that communicates on one side with AMI Network Equipment and AMI-enabled End Points and on the other side with Enterprise Systems such as an MDMS.
CIM	Common Information Model; Standard developed by the electric power industry that has been officially adopted by the International Electrotechnical Commission (IEC) and that aims to allow application software to exchange information about the configuration and status of an electrical network. The CIM and associated standards also provide limited support for gas and water commodities and networks.
CIM-compliant	A term signifying compliance with the IEC Common Information Model. For purposes of this specification, CIM-compliant also signifies compliance with the IEC 61968-9 Standard.
End Device Control	A command sent to an End Device with the intent of creating a change in state of the End Device or causing the End Device to perform an action.
End Device Event	An event, typically involving a change of state, which is detected and reported by or with respect to an End Device.
End Point	A generic term used to indicate a Usage Point or the device (meter) associated with the Usage Point.
Enterprise System	A system in the utility enterprise that is communicating with the MDMS or other Enterprise Systems. Examples include, but are not limited to, Metering Systems (which can be AMI Head End Systems), Customer Information Systems, Outage Management Systems, Asset Management Systems, and Work Management Systems.

Head End System (HES)	The server / application portion of a Metering System (as defined elsewhere in this table) that communicates on one side with Metering System Network Equipment and End Points and on the other side with Enterprise Systems such as an MDMS.
MDMS	Meter Data Management System; a system that acts as a digital nerve center for a utility's AMI system. An MDMS provides data brokering and validation capabilities for device provisioning, reading and metrology data acquisition, and command and control of utility meters and other related devices.
Meter	Physical asset that performs the metering role of the Usage Point. Used for measuring consumption and detection of events.
Meter Exchange	A business operation that involves the removal of one Meter and the installation of another meter at a Usage Point.
Metering System (MS)	An IEC term for meter data acquisition system typically consisting of meters, communications infrastructure and a server that controls the system and serves as a point of integration with utility Back Office Systems. Metering Systems are not necessarily AMI systems. For example, handheld reading systems and MV-90 systems, in addition to AMI Systems, are considered Metering Systems.
XML	eXtensible Markup Language, a method of organizing data so that individual data items are delimited by descriptive tags. (see http://www.w3.org/XML/)
XSD	XML Schema Definition

Annexure

Refer IEC TR 61968-900 for normative reference and payload

Use case	Section	Description
(Meter Config) Create Device Configuration and Provisioning	8.3.2	Depending on the scenario, a given create, change, or delete request may cause several reply messages can be generated.
On Demand Meter Read Request and Response	3.3.2	Used for sending commands (from MDMS to HES) and returning the corresponding data or status information (from HES to MDMS)
Unsolicited Meter Reads	6.6	A HES may also send unsolicited meter reads to a MDMS
Unsolicited Event Message	3.3.4	An unsolictited event message is similar to a response message in that it is used to send data from HES to MDMS
EndDeviceControl	7.3	Meter control requests are used, among other things, to instruct the meter to reset itself, to connect the power or to disconnect the power

HES-NMS-WAN Adaptor Interface

Contents

1. Introduction

Systems and applications that interface with the HES using CIM-compliant messages fall into two categories:

- Back Office Systems, which can include, but are not limited to, Customer Information Systems, Outage Management Systems, Asset Management Systems, Service Order Systems, Outage Planning Systems and the like.
- AMI and other meter data acquisition systems that are responsible for communicating with, obtaining data from, and controlling meters and Field Area Network (FAN) devices, and managing the technical nuances of the metering system network. These are commonly referred to as Network Management System.

HES complies with International Standard IEC 61968-9 and the IEC Common Information Model, or CIM. Interfaces that comply with IEC 61968-9 are said to be CIM-compliant. This specification defines a common set of CIM-compliant messages for use by both Back Office and Network Management Systems, providing an unprecedented level of flexibility and ease of integration with the HES.

Information describing the use of these messages to support specific business scenarios and to describe the conventions for population of the mandatory and optional elements of the CIM-compliant messages is contained in a set of ancillary specifications referred to as CIM-Compliant Messaging Guidelines.

2. Intended Users

This document is intended for use by utility personnel, AMI Network Management System, and Head End System, and system integrators responsible for the integration of systems and applications with the HES and NMS.

It is directed in particular to business analysts, developers, testers, integrators, and business users. It may also be useful for systems and operations personnel who must understand how the interfaces function once they are implemented.

3. Interface Details

The scope of this document is restricted to interactions between Unified HES and NMS/WAN Adaptor.

3.1 WAN Adaptor – Unified HES

Below are additional classes required in IEC 61968-9 for capturing communication related information from WAN adaptor

Class/Noun	Description
CommsModuleReading	This class have similar structure as of Meter Reading class but parameters are for Communication module This class to keep diagnostic data of communication module will contain interval profile for signal strength, disconnection count, unregistered duration, BTS change count etc.
CommModuleConfig	This is existing class in IEC61968-9 which can be extended to set/get additional parameter like randomization period, retry interval, threshold network signal for event generation and tune the connection retry logics

3.2 NMS -Unified HES

Below are additional classes required in IEC 61968-9 for capturing network topology and communication related information from NMS

Class/Noun	Description
CommunicationNetworkTopology	This class provides extensive network topology details, featuring a visual tree structure of the network layout. It includes key fields such as MAC Address, IP Address, Serial Number, Latitude, Longitude, Gateway IP Address, Signal Quality, Active Network Interface, Colour Code, Zone Code, Battery Percentage, Battery Health, Network Level, Connected Devices Count, and Max Network Depth. These elements offer a thorough view of each device's status and connectivity within the network.
CommsModuleReading	This class have similar structure as of Meter Reading class but parameters are for Communication module and gateway. This class to keep diagnostic data of communication module will contain interval profile for , Signal Quality, Active Network Interface, Colour Code, Zone Code, Battery Percentage, Battery Health, Network Level, Connected Devices Count.
CommsModuleConnectionStatus	This class provides the device connection status, indicating whether a device is connected to the network or not. It includes real-time data on signal quality and active network interfaces.

CommModuleConfig	This is existing class in IEC61968-9 which can be extended to set/get additional parameter like randomization period, retry interval, threshold network signal for event generation and tune the connection retry logics

4. Definitions and Acronyms

Term	Definition or Explanation
Advanced Metering Infrastructure (AMI)	Communications hardware and software and associated system and data management software that creates a network between advanced meters and utility business systems which allows collection and distribution of information to customers and other parties such as competitive retail suppliers, in addition to the utility itself
AMI Head End System	The server / application portion of an AMI System (as defined elsewhere in this table) that communicates on one side with AMI Network Equipment and AMI-enabled End Points and on the other side with Enterprise Systems such as an MDMS.
CIM	Common Information Model; Standard developed by the electric power industry that has been officially adopted by the International Electrotechnical Commission (IEC) and that aims to allow application software to exchange information about the configuration and status of an electrical network. The CIM and associated standards also provide limited support for gas and water commodities and networks.
CIM-compliant	A term signifying compliance with the IEC Common Information Model. For purposes of this specification, CIM-compliant also signifies compliance with the IEC 61968-9 Standard.
Configuration Event	A Configuration Event occurs whenever any transaction within the scope of this Guideline is executed. The CIM ConfigurationEvent class is used to specify the start and end effectivity dates/times of the transaction as well as other business information concerning the transaction.
Daily Reads	For purposed of this Guideline, Daily Reads refers to meter readings that are provided whether or not an account is due to be billed. Contrast with Off-Cycle reads and On-Cycle Reads (as defined elsewhere in this table).
End Device Control	A command sent to an End Device with the intent of creating a change in state of the End Device or causing the End Device to perform an action.

End Device Event	An event, typically involving a change of state, which is detected and reported by or with respect to an End Device.
End Point	A generic term used to indicate a Usage Point or the device (meter) associated with the Usage Point.
Enterprise System	A system in the utility enterprise that is communicating with the MDMS or other Enterprise Systems. Examples include, but are not limited to, Metering Systems (which can be AMI Head End Systems), Customer Information Systems, Outage Management Systems, Asset Management Systems, and Work Management Systems. (See also Back Office System).
Head End System (HES)	The server / application portion of a Metering System (as defined elsewhere in this table) that communicates on one side with Metering System Network Equipment and End Points and on the other side with Enterprise Systems such as an MDMS.
MDMS	Meter Data Management System; a system that acts as a digital nerve center for a utility's AMI system. An MDMS provides data brokering and validation capabilities for device provisioning, reading and metrology data acquisition, and command and control of utility meters and other related devices.
Meter	Physical asset that performs the metering role of the Usage Point. Used for measuring consumption and detection of events.
Meter Exchange	A business operation that involves the removal of one Meter and the installation of another meter at a Usage Point.
Metering System (MS)	An IEC term for meter data acquisition system typically consisting of meters, communications infrastructure and a server that controls the system and serves as a point of integration with utility Back Office Systems. Metering Systems are not necessarily AMI systems. For example, handheld reading systems and MV-90 systems, in addition to AMI Systems, are considered Metering Systems.
XML	eXtensible Markup Language, a method of organizing data so that individual data items are delimited by descriptive tags. (see http://www.w3.org/XML/)
XSD	XML Schema Definition

5. Annexure: Message formats definition

5.1 Network Topologies details request response format

(Sample format – Informative)

Request from HES to NMS


```
<RequestMessage xmlns="http://iec.ch/TC57/2011/schema/message">
<Header>
<Verb>get</Verb>
<Noun>NetworkTopologies</Noun>
<Timestamp>2012-10-02T14:16:09Z</Timestamp>
<MessageID>f4cef283-9a3d-40f3-a3b2-48aa6088ad80</MessageID>
<CorrelationID>facb121a-b46e-4deb-8188-68a4cbde6746</CorrelationID>
<Comment>simple network topology request</Comment>
</Header>
<Request>
<GetNetworkTopologies>
<DCU>
<Names>
<name>dcu1</name>
</Names>
</DCU>
<TimeSchedule>
<scheduleInterval>
<end>2013-07-25T09:40:00Z</end>
<start>2013-07-25T09:35:00Z</start>
</scheduleInterval>
</TimeSchedule>
</GetNetworkTopologies>
</Request>
</RequestMessage>
```


Response from NMS to HES


```
<ResponseMessage xmlns="http://iec.ch/TC57/2011/schema/message">
<Header>
<Verb>reply</Verb>
<Noun>NetworkTopologies</Noun>
<Timestamp>2012-10-03T13:08:15Z</Timestamp>
<MessageID>eed4dac0-c3a5-432a-a9b2-e7c481a9c029</MessageID>
<CorrelationID>facb121a-b46e-4deb-8188-68a4cbde6746</CorrelationID>
<Comment>response to a simple get network topology request</Comment>
</Header>
<Reply>
<Result>OK</Result>
<Error>
<code>0.0</code>
<level>INFORM</level>
</Error>
</Reply>
<Payload>
<NetworkTopologies>
<NetworkTopology>
<DCU>
<Names>
<name>dcu1</name>
</Names>
</DCU>
<Details>
<dcu>
<deviceId>60b647fffe2057c3</deviceId>
<parentId />
<deviceLabel>DCU</deviceLabel>
<nodeInformation>
<macAddress>60:b6:47:ff:fe:20:57:c3</macAddress>
<ipAddress>2401:4900:1cbc:37fc:62b6:47ff:fe20:57c3</ipAddress>
<serialNumber>dcu:fe:20:57:c3</serialNumber>
```

<latitude>23.11745834350586</latitude>
<longitude>72.56900024414062</longitude>
<gatewayIpAddress>2401:4900:1cbc:37fc:2c93:f3ff:fed2:c57c</gatewayIpAddress>
<signalQuality>65</signalQuality>
<activeNetworkInterface>eth0</activeNetworkInterface>
<colorCode>#FDD36A</colorCode>
<zoneCode>BLR</zoneCode>
<batteryPercentage>99</batteryPercentage>
<batteryHealth>91</batteryHealth>
<networkLevel>0</networkLevel>
<connectedDevicesCount>2</connectedDevicesCount>
<maxNetworkDepth>2</maxNetworkDepth>
</nodeInformation>
<childDevices>
<childDevice>
<deviceId>ff47b6600e2c20fe</deviceId>
<parentId>60b647fffe2057c3</parentId>
<deviceLabel>NIC</deviceLabel>
<nodeInformation>
<macAddress>ff:47:b6:60:0e:2c:20:fe</macAddress>
<ipAddress>2401:4900:1cbc:37fc:fd47:b660:0e2c:20fe</ipAddress>
<serialNumber>nic:0e:2c:20:fe</serialNumber>
<gatewayIpAddress>2401:4900:1cbc:37fc:2c93:f3ff:fed2:c57c</gatewayIpAddress>
<signalQuality>17</signalQuality>
<colorCode>#609966</colorCode>
<zoneCode>BLR</zoneCode>
<latitude>23.12479782104492</latitude>
<longitude>72.56394958496094</longitude>
<networkLevel>1</networkLevel>
<connectedDevicesCount>1</connectedDevicesCount>
</nodeInformation>
<childDevices>
<childDevice>
<deviceId>ff47b660cb2720fe</deviceId>
<parentId>ff47b6600e2c20fe</parentId>
<deviceLabel>NIC</deviceLabel>
<nodeInformation>
<macAddress>ff:47:b6:60:cb:27:20:fe</macAddress>
<ipAddress>2401:4900:1cbc:37fc:fd47:b660:cb27:20fe</ipAddress>
<serialNumber>nic:cb:27:20:fe</serialNumber>
<gatewayIpAddress>2401:4900:1cbc:37fc:2c93:f3ff:fed2:c57c</gatewayIpAddress>
<signalQuality>17</signalQuality>
<colorCode>#609966</colorCode>
<zoneCode>BLR</zoneCode>
<latitude>23.130199432373047</latitude>
<longitude>72.56542205810547</longitude>
<networkLevel>2</networkLevel>
<connectedDevicesCount>0</connectedDevicesCount>
</nodeInformation>
</childDevice>
</childDevices>
</childDevice>
</childDevices>
</dcu>
</Details>
</NetworkTopology>
</NetworkTopologies>
</Payload>
</ResponseMessage>

F. No. 14/01/2022-UR&SI-II-Part(1)(E-257881)
Government of India
Ministry of Power
****

Shram Shakti Bhawan, Rafi Marg
New Delhi, Date: 04th June, 2024

ORDER

Subject: Constitution of the Committee for Standardization and interoperability of AMI layers.

The project of Advanced Metering Infrastructure (AMI), along with installation of smart meters, is being implemented under RDSS, across the States. Although, the Indian Standard for Smart Meter (IS-16444 part 1 & 2) has been in force in the country, the physical and functional standards are yet to be established. it has been, accordingly, decided to standardize various layers of AMI system so as to reduce vendor specific solutions in AMI chain, to achieve higher level of cross system communication and to achieve higher degree of inter- operability for ease of integration at all levels (Meter to HES and HES to MDMS) thus allowing for utilization of a unified HES solution.

2. In order to standardize the various layers of AMI chain, a committee is, hereby, being constituted with the following composition:

S. No.	Name	Designation and Organization	Committee
1.	Sh A K Rajput	Member (PS) CEA & Chairman of BIS- LITD 10 working group	Chairman
2.	Shri Atul Kumar Bali	Director, NSGM	Member
3.	Shri Vivek Goel	Chief Engineer (DP & T), CEA	Member
4.	Shri Rakesh Kumar	Managing Director, APDCL	Member
5.	Shri Gajanan S. Kale	CEO, TPDDL	Member
6.	Shri Vinoo Warrier	VP Comms Solution, Kalkitech	Member
7.	Shri Rameshwar Dubey	Director– Landis + Gyr	Member
8.	Shri Aashish Gaur	Chief Manager, Genus Power Infrastructure Limited	Member
9.	Shri R S Rathore	CTO, Genus Power Infrastructure Limited	Member

contd...

10.	Shri Deepak Nimare	Vice President, Cyanconnode	Member
11.	Shri Mahesh Oni	Technical Solution Architect, Wirepas	Member
12.	Shri B. A. Sawale	Director General, CPRI & Chairman, Sectional Committee-BIS	Member Secretary

3. The **deliverables for the committee** is as under:

i. Identify the areas between meter and HES communication which are bottleneck for inter-operability, mainly for RF and NBIoT communication technology.

ii. Study the implementation challenges and propose solutions for unified HES and adoption of various standard layers for integration between Meter to HES and HES to MDMS

iii. Identify the standard based approach for communication between Meters (based on RF Mesh or Cellular technology) and HES for making systems truly interoperable.

iv. Deliberate and provide synopsis on developing plug and play type mechanism so as to have seamless integration between meter, HES and MDM of any make

v. Finalize the other aspects of RF/ NBIoT solution for desired intelligence in the system.

vi. Review the status of the standardization work of physical layer/ pin configuration of smart meter, which will have bearing on this TC report for various recommendation.

vii. Submit report for finalization of actions and areas for further standardization work in BIS.

4. A background note is being enclosed at **Annexure-A**. The committee may co-opt the new members as per their requirement. The committee shall draft the specifications/ regulations/ guidelines for standardization of various AMI layers interoperability and would submit its report along with details of further course of action required for implementation of standardization, within a period of 2 months time.

5. This is issued with the approval of competent authority.

Encl. as above.

04/06/2024

(Jamiruddin Ansari)
Deputy Secretary to the Govt. of India
Tel: 011-23352913

To,
All the members of the committee
Copy to:

PPS to Secretary (Power)/ PSO to Joint Secretary (Distribution)

Annexure-A

Background Note

Currently, in the RDSS projects, three (3) communication technologies viz RF/PLC/ Cellular are specified in the specifications. Cellular communication can further be based on 4G or NBIoT technology. In current scenario, most of the RF Mesh solutions are proprietary and there are multiple routing/ mesh protocols, security mechanisms etc. Similarly, with NBIoT, extra intelligence is added to increase the network performance. Also the HES used for communication based on above technologies are generally separate and not unified, for reasons as under:

- All the above specified technology works on different mechanisms example RF and PLC requires intermediate NAN devices whereas cellular operates on direct WAN technology. Also, additional layers/ intelligence required in certain communication technology to achieve reliable communication and higher performance.
- 4G cellular is easier to integrate, as Smart meters & HES directly communicate with each other in transparent mode using the DLMS protocol (as per IS 15959 Part 2 or 3 as applicable) in WAN communication methodology.
- RF Mesh requires intermediate Gateways/ Data Concentrator Units (DCU) as per NAN communication methodology and some additional communication layers are used for data exchange between Smarts Meters & Gateways/ DCU's. Presently these additional layers are vendor specific solutions.
- In NBIoT two approaches exist, one is similar to 4G cellular communication where the devices are always connected or ON and communication is transparent. In other approach, the modules are first woken up through some commands and go in sleep after a fixed time. This is done to reduce live devices for better utilization of narrow band for communication.
- PLC is not being used in the various RDSS projects. If the better solution comes up suitable for our electrical network, then there will be need to adopt standard based approach, along with use of unified HES.

F. No. 14/01/2022-UR&SI-II-Part(1)(E-257881)
Government of India
Ministry of Power
*****

Shram Shakti Bhawan, Rafi Marg
New Delhi, Date: 26th June, 2024

ORDER

Subject: Constitution of the Committee for Standardization and interoperability of AMI layers.

In continuation to this Ministry's order dated 04.06.2024 on the subject cited above, following members are, hereby, also added in the Committee for Standardization and interoperability of AMI layers :

S. No.	Name	Designation and Organization	Committee
1.	Mr. Jaideep Mukerjee	Vice – President, Secure Meters Ltd.	Member
2.	Mr. Sundeep Tandon	Vice – President, HPL Electric	Member
3.	Mr. Amarjeet Panesar	General Manager, Schneider Electric	Member
4.	Mr. Vipin K Mishra	Vice–President, Capital Power	Member
5.	Ms. Charu Mathur	Director General,IEEMA	Member
6.	Mr. Chetan Bundela	Executive Director, Torrent Power	Member
7.	Mr. Ravi Sharma	Sr. Vice President (Energy) , Montecarlo Ltd.	Member

2. The other terms and deliverables of the committee shall remain the same.

3. This is issued with the approval of competent authority.

Encl. as above.

26/06/2024

(Jamiruddin Ansari)
Deputy Secretary to the Govt. of India
Tel: 011-23352913

To,

All the members of the committee

Copy to:

PPS to Secretary (Power)/ PSO to Joint Secretary (Distribution)