CLOUD-BASED HEAD-END SYSTEM FOR AUTOMATED METERING INFRASTRUCTURE (AMI)

TECHNICAL FIELD OF THE UTILITY MODEL

The present utility model relates generally to a cloud-based head-end system and, more specifically, to an Automated Metering Infrastructure (AMI) that utilizes Smart Meters for collecting, processing, storing, and analyzing metering data.

BACKGROUND OF THE UTILITY MODEL

Conventional head-end systems for AMI often rely on on-premises infrastructure composed of physical servers and proprietary hardware, which can be costly, rigid, and prone to performance bottlenecks or failures. These systems typically require extensive maintenance and present scalability challenges, limiting their suitability for growing smart grid deployments.

With the evolution of cloud computing and network virtualization technologies, cloud-based solutions offer a more scalable, resilient, and cost-efficient alternative. However, existing cloud-based implementations often fall short in providing end-to-end compliance with regulatory standards and ensuring secure, bidirectional communication with smart meters in geographically dispersed locations.

This utility model addresses these challenges by providing a cloud-based head-end system specifically designed for the needs of AMI, compliant with the energy regulations of the Philippines, while ensuring high availability, secure data transmission, and advanced analytics.

SUMMARY OF THE UTILITY MODEL

The disclosed utility model provides a cloud-based head-end system that virtualizes key components of AMI including:

- Virtualized Data Acquisition and Ingestion from smart meters over diverse communication protocols;
- Real-Time Data Processing and Analytics including validation and anomaly detection;
- Scalable and Secure Storage for historical data;

- Encryption-Based Data Transmission Framework for secure communication;
- Standards Compliance, particularly with the Energy Regulatory Commission (ERC) of the Philippines.

This model supports bi-directional communication for tasks such as remote meter control and firmware updates, and offers robust access control and advanced monitoring tools.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

Figure 1 shows the System Architecture of the System;

Figure 2 shows the AMI Head-End Communication Architecture; and

Figure 3 shows the cloud-based head-end system for AMI.

DETAILED DESCRIPTION

The present utility model relates to a cloud-based head-end system for Automated Metering Infrastructure (AMI), herein referred to as system 100. **Figure 1** shows the system architecture, wherein said system 100 enables secure, real-time data acquisition, processing, and analysis from a plurality of smart meters deployed across a utility network.

The system 100 comprises the following key modules:

The data acquisition module 110 is configured to interface with a plurality of smart meters 101. It supports communication protocols such as:

- Radio Frequency (RF)
- Programmable Logic Controller (PLC)
- Cellular (e.g., LTE)
- Low-Power, Wide Area Networking (LoRaWAN)

This module 110 receives raw metering data from the smart meters 101, which normalizes into a standardized format for downstream processing. The cloud processing engine 120 is operatively connected to the data acquisition module 110 and performs:

- Real-time data validation using a validation sub-module 121, which compares incoming data against predefined operational thresholds.

- Anomaly detection and analytics using an analytics sub-module 122, which employs predictive algorithms to identify irregularities and forecast energy consumption patterns based on historical data.
- Utility billing system integration 123 for accurate and automated billing.

The storage and data management system 130 is operatively connected to the cloud processing engine 120. It includes a distributed cloud-based storage architecture 131 designed to:

- Scale as data volume increases.
- Provide redundancy through automatic replication and failover mechanisms 132.
- Ensure compliance with local data retention regulations.

It further includes a metadata indexing system 133 that allows efficient querying, retrieval, and reporting of historical metering data, aligned with Philippine regulatory requirements.

The AMI Network Communication Module 140 provides bidirectional communication between smart meters 101 and cloud servers.

It ensures:

- Secure transmission via end-to-end encryption protocols 141 such as Transport Layer Security (TLS) or Advanced Encryption Standard (AES).
- Support for firmware-over-the-air (FOTA) updates 142 and remote service commands 143 issued from the cloud processing engine 120 to the smart meters 101.

The Security and Access Control Module 150 is operatively connected to all other components. It enforces:

- Role-based access control (RBAC) 151 to restrict user privileges.
- Activity logging 152 for user operations and system events.
- Data protection 153 mechanisms compliant with the Philippine Data Privacy Act and related legislation.

The Monitoring and Analytics Module 160 is integrated with both the processing engine 120 and storage system 130, the monitoring and analytics module 160 generates:

- Real-time operational dashboards 161 showing meter status and communication quality.

- Performance reports 162 including network latency, signal quality, and data integrity.
- Consumption analytics 163 derived from real-time and historical data to provide actionable insights to utilities and consumers.

Figures 2 and 3 illustrate the cloud-based head-end system for AMI, wherein a Smart Meter 101 captures energy usage data and supports communication protocols like RF, PLC, Cellular (4G LTE), and LoRaWAN. A Data Acquisition Module 110 interfaces with smart meters via multiple protocols and normalizes incoming data for cloud processing. A Cellular Communication Infrastructure 120 or Telecom towers (e.g., Smart, Globe) relay metering data over 4G LTE to the internet. An AMI Network Communication Module 140 ensures bidirectional communication between smart meters and cloud systems with secure data transfer. Said Module 140 uses TLS or AES encryption, supports FOTA updates and remote meter control. An Internet Data Transmission 145 that transmits normalized and encrypted metering data to the cloud over standard IP-based networks. A Cloud Processing Engine 150 that performs real-time data validation, detects anomalies, and integrates with utility billing systems. Said Engine 150 further includes: (1) a Validation Sub-module 151 that compares real-time readings to operational thresholds. (2) Analytics Sub-module 152 that uses predictive algorithms for anomaly detection and forecasting. A Storage & Data Management System 160 and Security & Access Control Module 170 that Ensures user authentication, role-based access, logging, and compliance with local data privacy laws. A Monitoring & Analytics Module 180 that provides real-time dashboards, consumption analytics, and system health insights via user interface.

Operational Flow Summary:

1. Smart meters 101 send raw consumption data via RF, PLC, Cellular, or LoRaWAN to the data acquisition module 110.
2. Data is normalized and passed to the cloud processing engine 120 for validation 121, anomaly detection 122, and billing integration 123.
3. Validated data is stored in the distributed storage system 130, with support for high availability 132 and indexed querying 133.
4. The communication module 140 manages encrypted, secure interactions 141 with the meters, including remote commands 143 and firmware updates 142.
5. All user interactions and system processes are governed by the security module 150 through access control 151, logging 152, and legal compliance 153.

6. Insights and reports are continuously generated by the analytics module 160 to assist in operational decision-making and customer engagement.

Advantages of the System

- Supports multiple communication protocols to accommodate heterogeneous meter deployments.
- Provides secure, real-time data validation and analytics.
- Ensures regulatory compliance with Philippine data and energy guidelines.
- Scalable and resilient cloud storage and processing architecture.
- Enhances utility efficiency through remote management and intelligent insights.