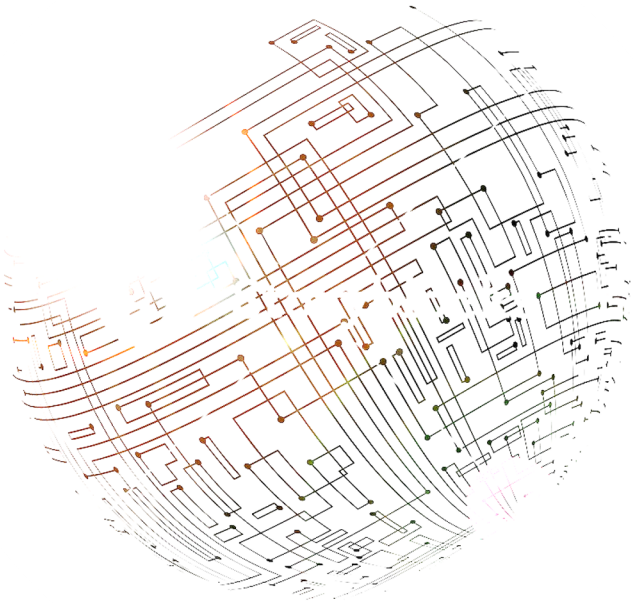

Verticross India Pvt. Ltd.

Meter Data Management System

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INTRODUCTION

In today's energy landscape, the efficient management of meter data is critical for utilities striving to optimize operations and enhance customer satisfaction. The Meter Data Management System (MDMS) serves as a cornerstone technology that enables utilities to effectively manage and process vast amounts of energy meter data. As the demand for accurate billing, efficient energy use, and enhanced service grows, MDMS has become an indispensable tool for utilities seeking to improve their overall performance and responsiveness to customer needs.

The complexity of managing data from various energy meters stems from the diverse types of meters deployed, including smart meters, and advanced metering infrastructure (AMI) systems. Each of these meter types generates a substantial volume of data, encompassing not only consumption readings but also real-time usage patterns, outage reports, and demand responses. As a result, the sheer volume and variety of data can be overwhelming, particularly when handled through manual processes. Inaccuracies in data entry, delays in processing, and inefficient workflows can lead to billing errors, dissatisfied customers, and lost revenue opportunities.

MDMS addresses these challenges by automating the collection, storage, and analysis of meter data. By centralizing data management, MDMS streamlines workflows and reduces thepotential for human error, thereby enhancing the reliability of billing and reporting.

Additionally, the system enables utilities to analyze energy consumption trends, identify peak usage times, and implement demand-side management strategies. This analytical capability not only aids in operational decision-making but also empowers utilities to engage with customers more effectively, offering tailored solutions that promote energy efficiency and sustainability.

Moreover, as the energy sector continues to evolve, with the integration of renewable energy sources and the push for smarter grids, the role of MDMS becomes even more critical. It supports utilities in navigating the complexities of modern energy systems, facilitating better data interoperability and enhancing collaboration with other energy management platforms. By leveraging MDMS, utilities can not only improve their internal operations but also contribute to broader energy goals, such as reducing carbon footprints and supporting the transition to a more sustainable energy future.

This inferences the Meter Data Management System is essential for utilities aiming to thrive in an increasingly data-driven environment. By automating data management processes and providing valuable insights, MDMS enhances operational efficiency, improves customer service, and supports the strategic objectives of utilities in the modern energy landscape. Asthe industry continues to advance, the importance of effective meter data management will only grow, positioning MDMS as a vital component of utility infrastructure.

This document elaborates on the functions and features of Verticross India Private Limited's indigenously designed and developed MDM application.

FUNCTIONS & FEATURES

1. Data Collection and Integration

- **Automated Data Retrieval**: MDMS automates the collection process, eliminating the need for manual data entry. This is achieved through advanced communication protocols that facilitate real-time data transfer from smart meters and mdas. Automation not only speeds up data collection but also minimizes human errors, ensuring more accurate records.
- **Interoperability**: The system is designed to work with various types of meters (e.g., smart, analog) and communication technologies (e.g., RF, PLC). This interoperability is crucial as utilities often operate mixed infrastructures, allowing for a seamless flow of data across different platforms.

2. Data Storage and Management

- **Centralized Database**: MDMS provides a centralized repository for storing meter data, making it easier for utilities to access and manage information. A single database reduces data silos, ensuring that all stakeholders have access to consistent information.
- **Scalability**: As utilities expand and adopt more advanced metering technologies, MDMS can scale to accommodate increased data loads. This scalability ensures that the system remains effective as the number of connected devices and data volume grows.

3. Data Validation and Quality Assurance

- **Validation Rules**: MDMS includes customizable validation rules that check for data accuracy and completeness. For instance, it can compare current readings against historical data to identify anomalies, such as sudden spikes in usage, which may indicate equipment malfunctions or fraudulent activity.
- **Error Detection**: The system can automatically flag discrepancies, enabling quick investigations. This proactive approach helps maintain data integrity and reliability, which is crucial for accurate billing and reporting.

4. Reporting and Analytics

- **Comprehensive Reporting Tools**: MDMS provides utilities with customizable reporting capabilities, allowing them to generate detailed reports on consumption trends, peak demand periods, and other metrics. These reports can inform operational decisions and help identify areas for improvement.

- **Advanced Analytics**: The analytics features of MDMS can forecast energy usage based on historical data, identify trends, and analyze customer behavior. This information is invaluable for demand-side management strategies, enabling utilities to better align supply with demand.

5. Billing and Revenue Management

- **Automated Billing Processes**: By utilizing real-time meter readings, MDMS automates the billing cycle, reducing the risk of errors associated with manual billing practices. Accurate and timely billing enhances cash flow and customer satisfaction.
- **Customer Account Management**: MDMS supports efficient management of customer accounts, allowing utilities to easily track payments, handle inquiries, and make adjustments as needed. This streamlined process contributes to better customer service and improved retention rates.

6. Customer Engagement and Support

- **Self-Service Portals**: Many MDMS solutions include self-service portals where customers can view their consumption data, billing history, and payment status. This transparency fosters trust and empowers customers to manage their energy usage proactively.
- **Usage Alerts and Notifications**: The system can send automated alerts to customers about unusual consumption patterns or upcoming payment deadlines. These notifications help customers stay informed and engaged with their energy usage, promoting energy conservation.

7. Outage Management and Response

- **Real-Time Monitoring**: MDMS enables real-time monitoring of meter data, allowing utilities to quickly detect outages or service interruptions. This capability is essential for timely response and restoration efforts.
- **Data for Outage Analysis**: The system provides valuable data that can be analyzed to understand outage patterns, enabling utilities to improve their response strategies and reduce downtime.

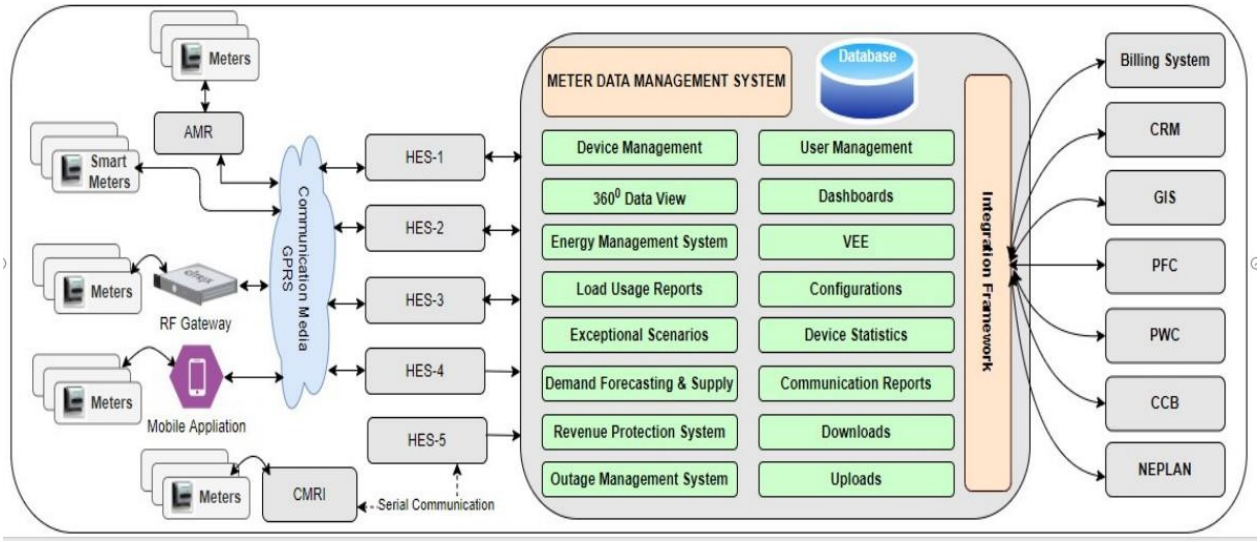
8. Regulatory Compliance and Security

- **Compliance Reporting**: MDMS assists utilities in generating reports required for regulatory compliance, such as emissions reporting or energy efficiency assessments. These reports ensure that utilities meet industry standards and avoid potential penalties.
- **Data Security**: Robust security features protect sensitive customer data from unauthorized access and cyber threats. MDMS employs encryption, access controls, and audit logs to safeguard data integrity and confidentiality.

9. Integration with Other Systems

- **Smart Grid Compatibility**: MDMS integrates seamlessly with other smart grid technologies, enhancing the overall performance and reliability of energy systems. This integration facilitates better grid management and supports the deployment of renewable energy sources.
- **Third-Party Application Support**: The system can interface with other software solutions, such as customer relationship management (CRM) and enterprise resource planning (ERP) systems. This compatibility allows for a holistic approach to utility management, ensuring that all functions are aligned and efficient.

ARCHITECTURE



The data management and integration system for smart meters follows a structured workflow beginning with data collection from remote devices, progressing through Head-End Systems (HES), central management in the Meter Data Management System (MDMS), and integrating with various third-party systems. Remote smart meters capture data on metrics like consumption, voltage, and current, utilizing methods such as RF Gateway, Mobile Application, CMRI, or AMR. These meters transmit data over GPRS to HES units (HES1, HES2), where it is pre-processed to ensure compatibility and data integrity before being sent to the MDMS.

The MDMS acts as a central hub for device configuration, data validation, analysis, and reporting. Key modules in MDMS support functions like Device Management (for configurations and firmware updates) and User Management (for access control), with a 360° Dashboard providing comprehensive views of device statuses, usage, and alerts. The system's Energy Management module analyzes consumption patterns for efficiency insights, while VEE (Validation, Estimation, and Editing) ensures data accuracy by identifying and correcting anomalies. Load Usage Reports give peak consumption analytics, while Demand Forecasting & Supply assists in planning, and the Outage Management System monitors outages to support timely response. Other modules, such as Communication Reports and Revenue Protection, help track connectivity, device health, and prevent revenue loss due to potential tampering.

Processed data is then integrated with third-party systems. The Billing System uses this data to bill customers accurately, CRM synchronizes it for customer service, and GIS provides a spatial view to aid field maintenance. Additional systems like Power Factor Control (PFC), Customer Care and Billing (CCB), and NEPLAN further optimize power factor management, network planning, and customer services. The MDMS thus completes an end-to-end smart meter data management and operational solution.

MDMS also serves as a central data repository, supporting storage, retrieval, and analysis of data from various meters (Feeders, Distribution Transformers, and Consumers). It ensures compliance with CEA guidelines for AMI and accommodates both raw and validated data in defined formats for further integration with upstream systems, such as billing, customer care, and load analysis. To support future

needs, MDMS enables integration with smart grid functionalities like Distribution Transformer Health Monitoring and self-healing systems, ensuring adaptability for evolving utility requirements.

The system is designed for scalability, capable of handling over two million meters while maintaining performance standards. The MDMS allows selective data retention or archival to manage storage effectively, adapting to the Utility's data retention policies. This flexible, scalable architecture ensures robust support for both current and future operational requirements.

Dashboards

MDMS Supports following dashboards which provides users the summary details of entire solution:

Device Summary:

- Present Day Communication
- Last 1 Week Communication
- Signal Strength of Installation Points
- Load Curve in MW of the selected hierarchy (default is the previous day)
- Transient & Sustained Monthly Summary
- Exceptional Scenarios

Live Status:

- Textual & Graphical Reports of nodes communicating in the last 30 minutes

Industrial Feeders:

- Present Day Communication
- Load Curve in MW of the previous day
- Transient & Sustained Monthly Summary
- Exceptional Scenarios
- Live Load Graphical & Textual Reports of present-day load for the entire utility
- Group A, B, and C Feeder Summary

Device Management

The software maintains the geographic / administrative / regional hierarchy of a utility's control area, i.e., the tree hierarchy of zones, circles, divisions, subdivisions, and substations constituting a utility. The software also maintains the electrical network topology, i.e., substations, feeders, transformers, and HT consumers.

Both the regional hierarchy and topology would be specific to the Indian context and flexible enough to account for different voltage levels in Indian substation and distribution networks e.g., 66/33/22/11/ 0.4 KV and maintain associations between various metering nodes.
The software allows addition of virtual metering nodes and associate the same to the regional hierarchy / network topology. Navigation to any level of the regional hierarchy / network topology would be simple and intuitive via drill-down mechanism.

360 Degree Data View

MDMS facilitates 360 data view of each meter which covers below following profiles,• **Instantaneous (Phasor Diagram):**

- Displays all electrical parameters in both textual and graphical reports.
- Parameters include:
    - Phase Currents
    - Phase Voltages
    - Powers
    - Power Factors
    - Frequency

Energy Readings:

- Generates reports of cumulative readings for:
    - Active Energy
    - Apparent Energy
    - Reactive Energy Lag
    - Reactive Energy Lead
- Maximum demand parameters can be viewed through reports.

Time-of-Day (TOD) Analysis:

- TOD of energies and maximum demands can be viewed based on meter configuration.

Readings:

- Present and historical readings can be viewed and exported.

Load Profile Data:

- Supported parameters and the number of days' data uploaded by HES can be viewed in the application as per the meter firmware design.
- Supported parameters include:
    - Phase Voltages
    - Phase Currents
    - Active Energy
    - Apparent Energy
    - Reactive Energy Lag
    - Reactive Energy Lead

Daily Profiles Data:

- Daily energies at the zeroth hour can be viewed in the report.

Meter Events:

- Entire meter event log can be viewed based on the selected date range.

ENERGY MANAGEMENT SYSTEM

MDMS maintains each meter's active energy, apparent energy, reactive energy lag, reactive energy lead and maximum demand of all the present and previous billing histories.
Energy Input Report: This report provides consumption, demand, and power factor of the selected month.
Daily Energy Input Report: This report provides consumption of the installation point day wise of the selected month.
EA – Report Monthly: This report provides the initial & final readings of the month, consumption and assessed units. If any of the meter's data is not available, then there is a provision to enter the readings manually from the application.
Bus Bar Losses: This report displays the loss of substation.

Load Usage Reports

Hourly Load Reports:

- Based on:
  - Currents
  - kVAh
  - Power Factor (PF)

Peak Load Reports:

- Monthly peak load data

Load Curve Reports:

- Based on load profile data for active energy
- Graphical report of the load curve for the last year

Load Factor:

- Reports on load factor calculations and trends

EXCEPTIONAL SCENARIOS

Exceptional scenarios provide users to quickly get the details of the installation points where abnormalities are noticed and take corrective actions.
Based on the energy histories, meter events and instantaneous data, MDMS derives following exception scenarios:

- High/Low Usage Consumption
- Events Log Exceptions:
  - Not Yet Restored
  - Restored after 10 Minutes
- Instant Based Events
- Potential Missing Current
- Missing Potential Imbalance
- Low Power Factor (PF)
- Low Voltage

USER MANAGEMENT

MDMS contains User Management module through which role-based access can be assigned

to the users. User can create role and while creating user this role is to be assigned to the users.
Role can be created to any of the hierarchy level, list of reports which can be accessed and actions like add, edit, delete, and view so that user created with this role gets access to those specific features.

DEMAND FORECASTING & SUPPLY DETAILS

Demand Forecasting: MDMS forecasts the demand of next month based on the recent demand of the installation point. Using this forecasting demand utility can take the necessary actions to maintain the load.
Power Supply Details: MDMS provides a report with supply hours and consumption of each quarter of the day as below: Supply Hours and Consumption.
00:00 to 06:00
06:00 to 12:00
12:00 to 18:00
18:00 to 24:00

REVENUE PROTECTION SYSTEM

MDMS performs analysis on load profile and derive the energy saved due to proper maintenance of 1-Ph and 3-Ph power supply. Daily & Monthly Supply hours reports can be generated and downloaded from MDMS solution.
Summary reports of nodes in which abnormalities are noticed are generated which provides information to the users to take corrective actions. Below reports of abnormalities gets generated:

- Zero Consumption
- Zero Consumption in Recent Months
- Consumption < 100 kWh in Last Six Months
- Negative Consumption
- High Consumption
- Low Consumption
- Time-of-Day (TOD) Consumption (kWh)

OUTAGE MANAGEMENT SYSTEM

As part of OMS, MDMS performs analytics on the outage information of meter data and generates below reports which helps Utility to monitor the power supply pattern.
Following reports gets generated as per
the hierarchy selection:

- Average Supply Hours of a Month
- Monthly Reliability Index
- Transient & Sustained Outages of the Selected Date Range
- Supply Deviation of Agricultural Feeders (Daily

VEE (VALIDATE, ESTIMATE AND EDIT)

MDMS performs below validations checks on all the types of data profiles and generate summary reports.

- Meter RTC Spike
- kVARh Sum Check
- High/Low Consumption
- Zero Consumption
- Negative Consumption
- Time-of-Day (TOD) Consumption
- Time Tolerance

CONFIGURATION MANAGEMENT & ONDEMAND

MDMS invokes the API published by HES and exchange the command to accomplish any of the below activities:

OnDemand Data Collection

- **On-Demand Data Collection Write Operations:**
  - Real-Time Clock
  - Load Profile Integration Period
  - Day Profile Integration Period
  - Demand Integration Period
  - Limiter
  - Prepaid/Post-paid Mode Change
  - Uni/Bidirectional Mode Change
  - Single Action Schedule for Billing Dates Activity Calendar
- **Execute Operations (Smart Meter):**
  - Connect
  - Disconnect
  - Activity Calendar
  - MD Reset

PREPAID FUNCTIONALITY

As part of prepaid functionality below features are covered:
Instant Push (64 Association): Acquires instant push at regular intervals and captures below parameters:

- Voltage
- Current

- Active Energy
- Maximum Demand (KW, KVA)
- Tamper Count
- Billing Count
- Disconnect Control

Additional Features:

- **Revised Balance:**
  - Derived after applying slab rates to the calculated consumption.
- **Monthly Transactions:**
  - Provision to view transactions related to connect and disconnect operations for smart meters.
- **Slab Rates:**
  - Applicable to the calculated consumption for billing purposes.

Smart Meter Alerts

Alerts Data (64 Association): When an event occurs in smart meter, an alerts get uploaded to HES and HES integrates the data with MDMS.

DOWNLOADS

MDM has facility to download and save reports in various forms like Excel, CSV, PDF:
Device Summary: Status of each device and its hierarchy mapping gets displayed. Using this report, user can plan rectification activity or if there is any meter issue noticed corrective action can be taken accordingly. In this report source of data also gets displayed.
Master Data: User can download total master data available in MDMS for further analysis.
MIOS files of meter data integrated from HES solution can be downloaded for further analysis.
Raw Data files uploads through MRI/Mobile App can be downloaded.

INTEGRATIONS

After verifications of data, MDMS integrates any of the meter data profiles like billing determinants, load profile, daily profile, and event log. MDMS integrates exchanges data with any of the below formats:

- MIOS File
- JSON Integration through Web Services
- CSV

MDMS Integrated with below external modules as per the requirements of the clients:

- CRM - Customer Relationship Management
- GIS - Geographic Information System
- PFC - Power Finance Corporation
- PWC - Price waterhouseCoopers

- Billing System
- NEPLAN - Network Planning Software
- CC&B - Customer Care and Billing

KEY COMPONENTS

Data Storage Layer:

- Database Management System: Uses a secure relational database to store meter data and historical consumption records.
- Data Archiving: Efficiently manages historical data, allowing for easy retrieval and analysis without affecting performance.

Data Processing Layer:

- Data Ingestion Module: Receives data from the HES in real time, processing and validating it for accuracy.
- Data Validation Engine: Checks the integrity of data using set rules and flags any issues for review.
- Data Transformation Module: Converts raw data into a standardized format for easier analysis.

Analytics and Reporting Layer:

- Business Intelligence Tools: Allows utilities to generate reports on usage patterns and performance indicators.

User Interface:

- Web-Based Dashboard: Provides an easy interface for staff to access data and generate reports.
- Mobile Access: Ensures users can access important data on their mobile devices.

Integration Layer:

- API Interfaces: Supports integration with AMR devices, HES, and other systems for smooth data exchange.
- Third-Party Integration: Connects with external applications for extended functionality.

Security Layer:

- Data Encryption: Protects sensitive data during transfer and storage using strong encryption methods.
- Access Control: Implements role-based access to ensure that only authorized personnel can access or modify information.

Maintenance and Support:

- Monitoring Tools: Continuously checks system performance to quickly identify issues.
- Helpdesk Support: Provides user assistance and troubleshooting through a dedicated helpdesk.

TECHNICAL SPECIFICATIONS

(Prerequisite)

Database Technology: Uses SQL-based relational databases (like MySQL or PostgreSQL) for effective data management.
Server Architecture: Can be deployed on cloud or on-premises servers with load balancing for reliability.
Programming Languages: Built using Java, Python, or .NET for backend; HTML, CSS, and JavaScript for the frontend.
Operating System Compatibility: Works with various operating systems (Windows, Linux) for flexible deployment.

Application/wWeb Server

- **Processor:** 16 vCPU
- **RAM:** 256 GB
- **Storage:** 1 TB (for backup of data from HES solutions)
- **Operating System:** Windows Server 2019 Standard Edition

Database Server

- **Processor:** 16 vCPU
- **RAM:** 64 GB
- **Storage:** 500 GB (initial storage, increasing by 500 GB annually)
- **Operating System:** CentOS Linux 7

BENIFITS

• **Accuracy**: MDMS helps collect and store meter data correctly, minimizing mistakes.
• **Better Reports**: It makes it easy to generate detailed reports on energy use and trends.
• **Efficiency**: Automating data handling saves time and reduces manual work.
• **Real-Time Monitoring**: Utilities can see data as it comes in, allowing quick responses to issues.
• **Customer Service**: Better data access means utilities can provide clearer bills and usage information to customers.
• **Compliance**: MDMS helps utilities meet regulatory standards by keeping accurate records.
• **Growth**: It can easily handle more data as the number of meters increases.
• **Integration**: MDMS works well with other utility systems for a complete view of operations.
• **Forecasting**: It can analyze data to predict future demand and optimize resources.
• **Cost Savings**: By improving efficiency and accuracy, MDMS can save money in the long run.