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SCADA FOR REGULATING CONSUMER POWER CONSUMPTION

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ABSTRACT:
Every day, control systems are getting more advanced to ensure precise control and minimize errors. One common tool used in power system control and protection is SCADA. SCADA stands for Supervisory Control and Data Acquisition and is known for its ability to cover a large area. It's used in substations, transmission control, and maintenance tasks.

SCADA performs various tasks that help in achieving error-free systems, making it suitable for conventional electricity billing. These tasks are broken down into blocks like BCU, MTU, MMI, and DM, which are all connected in a Metropolitan Area Network (MAN). This network setup requires robust security measures to keep the system safe from unauthorized access.

SCADA, combined with newer technical concepts, brings a fresh perspective to multi-element systems. The paper aims to provide a comprehensive understanding of SCADA and its objectives.

INTRODUCTION TO SCADA:
SCADA is a technology that helps manage and control data in many different ways. It's become well-known for its ability to use smart computer systems. SCADA is a reliable system that ensures data is accurate and securely controlled with smart features.

SCADA IN POWER SYSTEMS:
The SCADA system helps electricity companies keep an eye on and manage their power distribution systems even from far away. For example, operators can use SCADA to control things like circuit breakers and transformers remotely.

In a central control room, important data like current, voltage, and the status of breakers are constantly sent and displayed. This gives operators a clear picture of the entire distribution network. SCADA also keeps track of distribution feeders at substations and can control various devices like switches and fuses.

This system makes it easier to manage things like voltage levels, read customers' meters, and adjust pricing based on the time of day. Overall, SCADA helps improve the reliability of power for consumers and saves money for the utility company.

The main characteristics of the system are:
1. Decisions are executed more quickly.
2. Manual errors and oversights are removed.
3. Periodic reports are generated for analyzing the performance of the power system.

TASKS OF SCADA:
Apart from the features mentioned earlier, there are specific tasks in SCADA that activate the entire control network. These tasks include:

1. Data collection:
This involves regularly gathering data from remote terminal units at the right frequency. Data collection also ensures that various scans start and finish within the expected timeframe.

2. Data transmission:
This refers to telemetry, where electronic equipment converts data from transducers into signals and sends them to the control room for computers to use.

3. Data monitoring:
Data monitoring involves regularly checking the status of data, such as the position of circuit breakers, switches, and fuses.

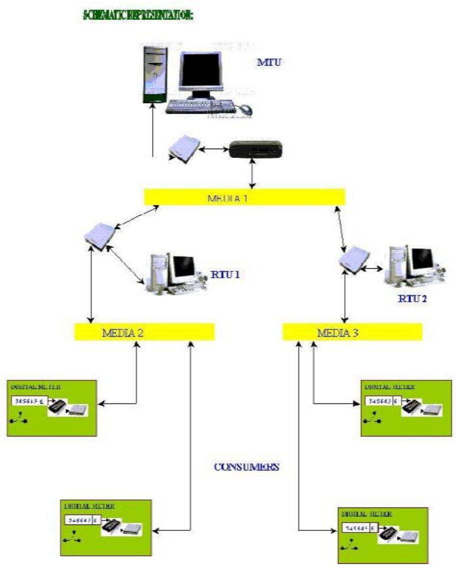
4. Man/Machine interface:
The Man/Machine interface acts as a link between the operator and the software/hardware used to control and monitor the power system.

APPLICATION OF SCADA IN ELECTRICITY BILLING:
The present capabilities of SCADA include offline processing with thorough handling of past data and strong processing ability. It swiftly responds with rapid data processing, enabling its application in electricity billing. Before examining SCADA's role in this task, it's essential to address significant uncertainties, which include:
- Possibilities of human errors.
- Occurrence of malpractices.
- Issues with tariff collection.
- Delays in tripping functions.
- Wastage of human resources.

SCADA prevents all blackouts in the traditional billing system. In this paper, we take a broad look at this topic. The system description is outlined as follows:

Taking into account the tasks of modern SCADA, we can categorize the SCADA billing system as follows:

- Data acquisition.
- Data transmission.
- Remote Terminal Unit.
- Master Terminal Unit
- Man Machine Interface.



SCHEMATIC REPRESENTATION

Data Acquisition:

At the consumer's location, necessary billing data is collected from the energy meter in the form of pulses. The digital meter is connected to a relay, micro-controller, and modem. Using a computational algorithm, the data is collected and sent to a central system. The algorithm depends on the meter's constant (revolutions per kilowatt-hour for electromechanical meters or pulses per kilowatt-hour). For example, if the meter constant is 1000 pulses per kilowatt-hour, the algorithm converts the data output to 100 pulses (0.1 kilowatt-hours). This process is carried out through micro-controller programming.

The data transmitted is of the following format:

ADDRESS WORD	UNITS

Address word -> refers to the consumer identification no.

Units -> refer to the no of units consumed at the time of request.

The data produced by the micro-controller cannot be transmitted directly. It is in the form of logic levels within the chip's circuitry. Therefore, a modem or data conditioning device is connected to the micro-controller. This allows the data to be transferred to a common medium, which is then connected to the Remote Terminal Unit (RTU) through any network setup, preferably a star network topology.

Data transmission:

Data transmission in SCADA billing is done in two ways,

- **Between consumers & RTU.**
- **Between RTU & MTU.**

Communication between RTU and Consumer:

The data from the consumer's meter circuit is sent to the RTU for updating purposes. Likewise, a command is sent from the RTU to the meter circuit. These transmissions occur through a common medium such as coaxial cable, optic fiber, or power line carrier.

Communication between MTU and RTU:

Data collected by the RTU is transferred to the MTU for further processing. Similarly, processed data is sent back to the RTU for billing purposes. This communication is established through server-client communication between the MTU and RTU. Routers are placed on the MTU side to enable high-speed communication with multiple RTUs. The accessories used may vary depending on the chosen communication medium.

NETWORKING TOPOLOGY:

The entire system operates on a Metropolitan Area Network (MAN), which combines two components. These two components can be extended between different regions:

- Between consumers and RTU
- Between RTU and MTU.

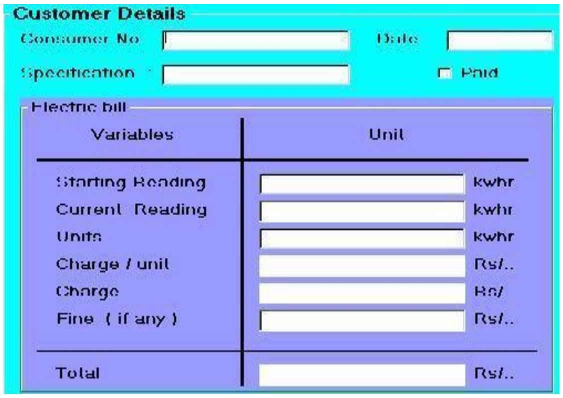
A suitable network topology for connecting consumers and RTU is the bus topology. This topology utilizes a single cable to link all consumers in the network, allowing for effective communication. This setup enables bidirectional communication.

Additionally, a star topology is utilized between RTU and MTU. In this configuration, each RTU is connected to a central controller known as the MTU. The connection between these two components is established using modems and routers.

REMOTE TERMINAL UNIT:

The SCADA system includes one or more computers with specific application software (referred to as the master station). These computers are connected to several remote terminal units (RTUs) placed at different locations through a communication system.

The RTUs are crucial in the system as they gather data, including readings from consumers' meters, and serve as zonal collection centers for billing. The data from consumers' meters is stored in their respective web pages on the RTUs.



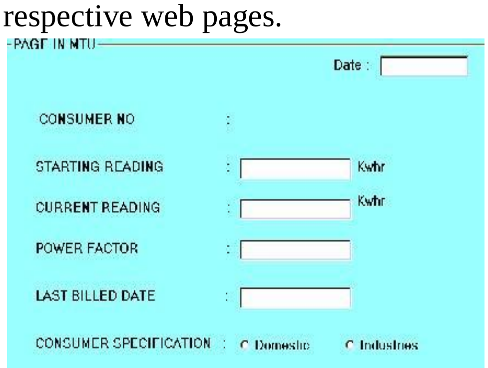
On the web page, various fields relate to data acquisition. For example, the starting and current readings store consumer data, while the units, charge, and fine fields store data results from the MTU. The "paid" field registers consumer payments.

When tasks such as remote control and monitoring are added to the RTU, it is also referred to as the Bay control unit. Modem interfacing devices are added as needed for communication.

MASTER TERMINAL UNIT:

The MTU collects data from the RTUs for further processing. The collected data undergo processing depending on the application software installed in the MTU, which is typically developed using high-level languages like C or C++.

Data collection from the RTUs follows a priority table, determined by an algorithm in the router. This algorithm may prioritize RTUs based on factors like shortest distance. Based on this prioritization, the MTU selects the primary RTU, and consumer details are updated on their respective web pages.



It's worth noting that the web page layout in the MTU differs from that in the RTU.

As a result, the designated RTU is chosen, and consumer information is refreshed on their web pages. The layout of the web page in an MTU varies from that in an RTU.
The programming algorithm operates based on the data retrieved from the fields. The algorithm can be simplified into the following steps:
- Selecting the primary RTU from the router's priority table.
- Updating the data.
- Processing the data.
- Calculating the number of units.
- First check: Limit selection and determination of charge per unit.
- Calculating charges.
- Second check: Assessing power factor.
- Calculating penalties.
- Third check: Evaluating the last billed date.
- Imposing fines if the date is after the due date.
- Calculating the total charge.
- Dispatching the data.

MAN/MACHINE INTERFACE:
The MMI enables the RTU operator to disconnect the consumer's power supply if they fail to pay the bill by the due date. This action is triggered by the status of the 'paid' field on the consumer's web page. An internal timer is set to the number of days for bill payment. On the final day, the status of the 'paid' field is checked, and the appropriate command word is sent to the consumer's meter. The command word follows a specific format.

111011	**000000**

Where:
111011: address word representing the consumer.
000000: command word to the tripping unit in the meter.
In this scenario, the command word is used to restore the consumer's power supply. Alternatively, a different code can be employed to deactivate the supply.
Security measures for SCADA:
Implementing robust security policies is increasingly crucial in today's corporate networks. To begin, organizations should establish comprehensive security protocols and ensure that their SCADA networks adhere to these standards. Failure to do so not only exposes the company to cyber attacks but may also result in legal consequences.

Steps required to secure the SCADA network include:
- Establishing a security policy
- Securing the SCADA network and its operating environment
- Ensuring the security of the SCADA application
- Detecting unauthorized intrusions

- Regulating physical access to the SCADA network.

These objectives can be achieved through the implementation of the following security measures:
- Firewalls
- Virtual private networks (VPNs)
- Demilitarized zones (DMZs)
- Authentication protocols

FUTURE TRENDS IN SCADA:

SCADA is an impressive control concept applicable to extensive networks of elements. Additionally, SCADA's integration with intelligent database processors enhances processes such as search, retrieval, and updating. Moreover, SCADA incorporating artificial intelligence and embedded systems can facilitate automatic power monitoring, network restoration, load compensation in distribution, and real-time control. Furthermore, IT-enabled SCADA systems offer increased operational efficiency and ensure the security of power system networks.

CONCLUSION:

The journey towards the new era has already begun from a foundational standpoint. SCADA, coupled with computational intelligence, is poised to revolutionize the field. This transformation is initiated through our paper. With practical considerations and thorough qualitative and quantitative analysis, these advancements can be effectively implemented in practical settings.

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