INTEGRATED SYSTEM FOR REMOTE METER READING AND CONTROL OF MV AND LV NETWORKS

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INTRODUCTION

Acea Distribuzione, electricity distributor in Rome - Italy, for 1.5 million clients, with Landis+Gyr and BTicino as suppliers, has developed a computerized control system, named “AceaTEM”, which integrates the functions typical of an automatic meter reading application, with those required to perform supervisory control of medium and low voltage electricity networks.

The basic concept of this approach has been considering the electricity meters as remote control terminals, allowing the acquisition of information, measurements and data related to both network operation and commercial management of clients.

The paper describes the system and its components, gives an overview of the system functions, pointing out some innovative features, highlights the expected benefits and summarizes the initial operation experience.

SYSTEM DESIGN APPROACH

The system has been designed for electricity and other concurrent network services (public lighting, water, gas, heating), with the following basic functions and objectives:

- operation of a multi-service process with innovative performances for network operation and commercial management
- monitoring of network operation and certifiable assessment of service quality
- two way data transmission on a multilevel communication network
- data exchanges with peripheral devices
- control of peripheral devices
- application of time-of-use tariffs
- messaging
- connection with legacy computer systems for billing and network operation
- reduction of costs of network operation and metering
- improved communication with the clients for service information and commercial management
- data traffic accounting
- software downloading on peripherals
- remote management of meters and supply contract transactions, without access to the user premises

As far as electricity is concerned, the scope of the system is remote control of MV and LV networks and automatic meter management.

ARCHITECTURE OF THE SYSTEM

The architecture of the system, shown in Figure 1, outlines the components and their place in the chain going from the central computers, down to the electricity meter and a companion information terminal named “Acea Link”.

The system uses communication gateways, installed in the MV/LV substations, which manage the data transmission to and from the meters, by power line carrier (PLC) over the low voltage lines and provide the connection to a control centre, using an IP protocol, over public or private telephone networks.

The connection of the information terminal to the meter is performed via PLC on the client’s main.

Control of the electricity distribution network

Control of the distribution network is carried out by exploiting the data exchange capacity of the concentrator, by installing devices to monitor the passage of fault currents on the substation MV feeder lines and voltage detectors to signal the tripping of circuit breakers or fuses on the outgoing LV lines.
This solution overcomes the lack of auxiliary contacts on the LV circuit breakers and allows detection of blowing of individual fuses. In this way telecontrol operators can rapidly locate MV faults and be alerted on low voltage faults, without waiting for clients calling. Also other supervisory plant operation information (access and fire alarms, protections, switching equipment etc.) can be acquired and transmitted.

Network operation functions include emergency load shedding by supply cut off on groups of LV clients, individually selectable, by a suitable configuration of their meter software. The meter in the substation registers the energy supplied to the LV network and the transformer load curve. The load curve of the transformer enables to check its correct operation. It is therefore possible to make energy balances with the readings of the connected meters and determine losses and possible irregular consumptions. Meters and concentrators can be accessed locally by suitably protected interfaces and hand held terminals.

The “plug and play” feature

Loading of newly installed meters into the system database is carried out by an automatic “plug and play” process. Also the transfer of LV meters from an MV/LV transformer to another, in the event of changes of the network connection schemes, is registered automatically. This feature allows installation when network maps are not available and provides updated connection schemes.

Commercial management

The commercial management application package includes:
- Remote meter reading with assigned timing
- Remote changing of tariffs
- Time-of-use tariffs programmable for day, week, month and season
- Remote assignment of power demand limits
- Remote activation and interruption of supply
- Management of prepayment
- Detection of irregular consumptions and tampering on the meters and concentrators
- Connection with contact centre and Internet portal, to improve access and information services to clients (for example demand curves to select the best supply contract)

CONTROL CENTRE

The control center (Fig. 2) is based on an open hardware architecture, easily scalable and flexible for future additions, using the following commercial equipment:
- a duplicated management server, housing the application software and the alarms handler
- a duplicated data collection server
- one gateway server interfacing the control centre to the external commercial management system and another interfacing the telecontrol system
- a firewall with an unlimited client number
- one router
- 3 operator workstations
- one high capacity tape cassette backup unit

Fig. 2 Structure of the control centre

Software

The standard software platform consists of the following commercial packages
- UNIX and Microsoft Windows operation systems
- Data Base
- Network Management and security packages
- Application Server software
- Cluster configuration software
- File System
- Back up and dump data protector

The application software is completely modular and is organized into a layer managing services, a layer of “clients” which implement the services and a middle layer interfacing the two. This approach makes the control centre easily scalable and flexible for future additions.
A library of the communication protocols used by peripheral equipment allows to support different types of equipment, simply loading the corresponding protocols.

The application software is implemented in the "clients" mentioned before and consists of the following components:
- Final client manager
- Electricity network manager
- Service quality manager
- Peripheral equipment manager
- Legacy systems interfaces

**Communication protocols**

The control Centre implements the following different communication protocols:
- Proprietary protocol on TCP/IP socket, toward concentrators and meters
- FTP for data transfer with concentrators
- a commercial standard for alarms and access to concentrator memories
- a commercial communication security protocol
- HTTP for data exchange with the telecontrol system
- XML for data transfer toward legacy systems.

**User profiles**

The following user profiles have been implemented: Administrator, Configurator, Supervisor, Operator, Remote Supervisor and Remote Operator.

**DATA CONCENTRATORS**

The data concentrators (Fig. 3) perform the following functions, by a continuous polling of peripherals:
- Acquisition of meter status (self diagnostics and operation information)
- Daily acquisition of billing data
- Daily acquisition of service continuity and voltage quality
- Daily acquisition of load curves
- Acquisition of digital signals in the substation (voltage on LV lines, MV fault current detectors, alarms)
- Monitoring of communication quality
- Communication with peripherals by narrow band Power Line Carrier and with the control centre via radio networks GSM or GPRS, and public phone lines.

The electronic meters developed for the system (Fig. 4) measure energy and power in four quadrants, so that they are fully bidirectional, a feature which can be useful for clients owning generators (for instance photovoltaic panels).

Accuracy is 1 % for active energy and power and 2 % for reactive.

The protection of the LV network at the meter level, is performed by a single type of circuit breaker, sized for the maximum load (63 Amps), integrated into the meter assembly, equipped with thermal and magnetic overcurrent tripping.
An additional protection function has been integrated into the measurement circuit of the electronic meter. This innovative feature ensures fast tripping of the breaker for overcurrents lower than the magnetic threshold, in order to protect also the user outgoing lines with a section not compatible with the circuit breaker magnetic setting. As an option, the single phase meter can be equipped with a motor, allowing a client to remotely reclose, with proper safety controls, the circuit breaker integrated into the meter, using the Acea Link terminal. This option is meant for clients with a meter installed outside their premises.

A DIALOG TOOL

Users can be offered the ACEA Link display (Fig.5), which:
- is connected to the meter via two-way PLC communication
- can be plugged into any indoor mains socket
- displays consumption, service and billing information, including hourly load curves
- can remotely close the circuit breaker of an outdoor meter equipped with the motor option
- communicates with the control centre to receive messages
- alerts the client when their load exceeds a given limit, in time to reduce it and prevent tripping of the meter breaker
- supports prepayment

Fig.5 AceaLink Terminal

EXPECTED BENEFITS

The evaluation of possible benefits brought by the described system, depends on the specific situation of the concerned utility and cannot be completely generalized. The most significant are listed below:

- Reduction of billing cost: readings will be performed remotely by the system and without tipping errors
- Reduction of client management cost: the system allows the remote execution of disconnection, connection, variation of subscribed power, change of tariff and so on
- Reduction of frauds: it will be possible to eliminate irregular consumption by abusive connections and meter tampering
- Increased billing revenues: higher accuracy and stability
- Reduction of investments: no need to substitute obsolete meters and possibility of selling recovered meters
- Reduction of contact centre traffic: billing information will be available to clients on the Acea Link Terminal; billing will be made on the actual readings, eliminating calls by the clients to communicate readings
- Reduction of verification activities: energy balances for each MV/LV transformer, self diagnostics and anti-tampering on the meters, will help to detect anomalies
- Reduction of fault localisation times: the use of MV fault indicators and of voltage detectors on the LV lines, will shorten appreciably the time necessary to locate a fault
- Reduction of investments for telecontrol of MV/LV substations: MV fault current detectors are interfaced with the concentrators, thus sparing the related power supply and communication facilities
- Increased operation efficiency: a faster fault selection will decrease the duration of interruptions
- Automatic identification of the transformer-meter connection: the plug and play process will supply the information without labour costs and the information can be used to generate and update network maps

IMPLEMENTATION OF THE SYSTEM

The deployment of the system has been started with field trials on some thousand meters and is now being performed for a first batch of 40 thousand meters, which will be completed at the end of march 2005. The first results are quite positive, in particular for the aspect of the performance of the PLC communication, which shows that 98 % of the meters are accessed by more than 60 % of the time and only a 2 % need additional trials. After a final assessment of the system performance on the 40 thousand meters, the installation will be carried out at a rate of about 300 thousand meters per year, until the total population of 1.5 million meters and 13 thousand concentrators will be installed and in operation.

CONCLUSIONS

The AceaTEM system has been conceived to be a versatile management and control tool, applicable to a variety of network services, even concurrent, depending on the total population of different meters to be connected. For the electricity supply service, it combines control of MV and LV networks operation with remote meter management and client information services. Many novel functional features have been identified and provided, by a thorough design analysis, aiming to achieve as many synergies and benefits as possible.