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Mobile Phone Networks for Communication in Feeder Automation

Several distribution utilities in India have taken up SCADA projects in the past decade. These projects involved the monitoring (and sometimes control) of the primary distribution network and substations (33/22/11kV). Encouraging operational benefits experienced from automating the primary network prompted utilities to raise the “automation intensity level” of their networks by automating the 11kV feeders. Feeder Automation is one of the key elements for efficient management of the power distribution networks, especially in rapidly growing metros and other bigger cities in India. Complex nature and size of urban distribution networks coupled with the issues related to urban growth makes wireless communication an attractive option. This paper discusses the use of mobile phone networks as an option for communication in Feeder Automation.

About the Author

Ranjeet Vaishnav has a B.E. in Electrical Engineering (1994) from BVM Engineering College, Sardar Patel University (Gujarat). He has over 13 years of experience in Control & Automation systems for Electric Utilities and for Plant Electrical Networks in the Oil & Gas industry. Ranjeet is with Tata Consultancy Services Limited and is working on power systems related initiatives. He is a member of IEEE and of The IET.

Prasanth Gopalakrishnan completed his Engineering degree in electronics and communication engineering from National Instititute of Technology, Calicut, India in 1995 and Master of Science degree in Electrical Engineering from Colorado State University, Fort Collins, USA in 1998. He worked with Robert Bosch India for a year, before founding KalkiTech in 1998. He has been with the company since its inception till now. His major areas of interest are high speed communications; standards based communication protocol for the energy industry and new communication architectures for remote applications.

Jose Thomas completed his Engineering in Instrumentation and Control engineering from Calicut University, India in 2000. He joined KalkiTech in 2000 and has been with KalkiTech since then in various capacities and currently heads the hardware and software products business. He invented and designed KalkiTech's patent pending Generic Protocol Conversion Engine. His major interest areas are control and automation, embedded systems and communication protocols.

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Introduction

Power distribution companies in India are working feverishly to improve the efficiency of their distribution networks. Rapid load growth, market restructuring & regulatory pressures and increasing expectations from customer, about quality and availability of the power supply, are driving utilities to look for innovative ways to improve the efficiency of the networks. By automating the network operations, utilities aim not only to enable remote monitoring and control but also to collect reliable data about the network performance. First steps were taken by several utilities when they deployed city-wide SCADA Systems (examples, Chennai, Hyderabad, Mumbai, New Delhi, Kolkata etc.) and automated the process of monitoring and control of their primary substations. The results achieved were encouraging. Need was then felt to automate the secondary network (the "feeder") which went outside the primary substations, in order to collect much finer details about the network operation, such as real-time data on the usage profiles of important customers, and to operate Normally Open Points (NOP) in the network to enable quick restoration.

The distribution networks in India are characterized by very high technical and commercial losses. The high technical losses can be attributed to inadequate investments in the network infrastructure - that resulted in unplanned extensions of the distribution lines, overloading of the transformers and conductors / cables and due to lack of adequate reactive power support. These are being addressed by various System Improvement / Strengthening Schemes. High commercial losses are largely due to poor metering efficiency, theft and pilferages and are a major concern for utilities. A system to automate the secondary feeders is seen as one of the ways of addressing these ills that plague the distribution networks.

The challenge in Feeder Automation lies in being able to reach all the relevant network elements and in being able to efficiently collect data and operate them remotely. The large spread of urban distribution networks coupled with other city infrastructure and difficulties associated with them makes it important that the communication option chosen is easy to deploy, is not prone to noise and does not call for any disturbance to any other infrastructure.

From the economics and speed of deployment perspectives, use of an existing communications network instead of deploying an entirely new infrastructure is the most attractive option. With the rapid growth of the Telecom sector in India, mobile telephone networks offer an attractive proposition for use in Feeder Automation.

Objectives of a Feeder Automation System

Feeder Automation systems are designed to meet the following objectives:

- Allow central monitoring of secondary network and substations of commercial & industrial customers.
- Enable quick response to outages and hasten supply restoration.
- Enable effective management of load between various feeders to avoid imbalance and overloading of feeders.

- Allow monitoring of end-point voltage profiles and thus the quality of power supplied to customers.
- Collect accurate data from the network and calculate performance matrices – CAIDI and CAIFI.
- Collect line loading patterns and network element performance data for better informed planning and maintenance.

Available Mobile Communication Technologies

Communication network is the most critical aspect of Feeder Automation. The available mobile phone communications technologies and their relevance are described below:

GPRS

GPRS stands for “General Packet Radio Service” which is a packet data bearer service for wireless communication over GSM (Global System for Mobile). It uses a packet radio principle for transferring user data between GSM mobile stations and thereby it reserves the radio resources only when there is data to be transmitted. GPRS works on Frequency Division Multiplexing where a user is assigned with one pair of uplink and downlink frequency channels. This is combined with time domain statistical multiplexing, i.e. packet mode communication, which makes it possible for several users to share the same frequency channel.

GPRS allows IP-based applications to run on a GSM network. The data speeds can range from 9.6 kbps (using one radio time slot) to 115 kbps (which can be achieved by amalgamating 8 time slots).

GPRS is different from GSM. GSM is based on circuit switching technology whereas GPRS introduces packet switching technology over GSM. Another important difference is that GPRS offers higher bandwidth and thus higher data speeds. Packet switching rather than circuit switching ensures higher radio spectrum efficiency as network resources and bandwidth are used only when data is transmitted over the network even though the connection is “always on.” Also, the running charges for GPRS networks is lower since the billing is based on amount of data transfer and not on “call time.”

CDMA

CDMA or “Code Division Multi-Access,” is the other competing technology for mobile communications that is available in India. It is different from GPRS in that it neither assigns a particular time slot for each user nor it splits the frequency among the users. CDMA allows all the users to use the entire frequency spectrum for all the time. This is achieved by “spreading.” Each group of users uses a shared code and many such codes occupy same channel. Only users associated with a particular code can understand each other. In CDMA, there are 64 Walsh codes available that provide 64 logical channels whereas in GPRS, 8 channels (Time Slots) are available per carrier.

Suitability of GPRS & CDMA as a Communication Option for Feeder Automation

GPRS and CDMA mobile networks make it easier to integrate with other IP based protocols such as TCP/IP, X.25, etc. When the Internet Protocol (IP) service is used within a CDMA or GSM-GPRS network, it can provide:

- An “always on” connection between the Master Station and the RTU
- High throughput of up to 100kbps
- Low latency; typically less than 1 second
- Extremely high security: when used with advanced encryption (security aspects are discussed separately)
- Cost-effective communication option as the billing is on the amount of data transfer rather than on “call-times”

System Architecture & Design Considerations

System Architecture

The Feeder Automation system architecture using mobile phone networks for communication are shown below. The architectures using GPRS and CDMA are presented. It is worthwhile to notice that with both technologies, the system architectures are the same with the only difference being the set-up within the Network Operations Center of the telecom service provider – which is transparent to the utility using the telecom network.

The architecture envisages network elements and consumer substations on the secondary distribution network being remotely monitored and controlled with RTUs communicating over a mobile phone network using IEC 60870-5-104 protocol.

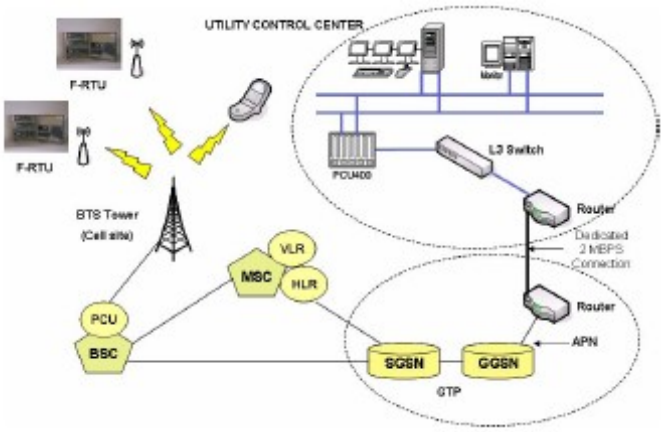

Fig.1. System Architecture using GPRS

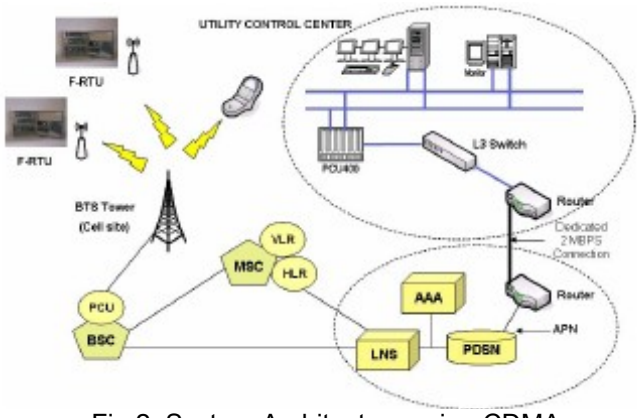

Fig.2. System Architecture using CDMA

Salient Points

- GPRS or CDMA modems are used at the remote (RTU) end. The modems are assigned an IP address by which they are identified on the network.
- A TCP/IP network is established by connecting the Master Station to the core switches of the telecom service provider. This is a point-to-point direct link that can be achieved by establishing the leased line connection between the telecom company network operating center (NOC) and the utility operations control center.
- A private network of IP addresses is created. The IP addresses assigned to the modems are fixed IP addresses and are in a “private range” and hence not available to the external world.
- The RTUs get connected to the telecom network by dialing into the network core using AT commands. Once the connection is established, the Master Station and the RTUs establish an “always on” link between them over the telecom network.

Important Design Considerations

- The Feeder Automation system is required to be configured to connect to the RTUs over an IP based protocol with the remote site having fixed IP addresses (IEC 60870-5-104 protocol is commonly used in India, DNP3.0-IP is also an option). The IEC 60870-5-104 channels are then created with the fixed IP of the remote as the connection parameter. The overall system is designed to report any important event detected at the remote site via an “unsolicited response”. This ensures that only relevant traffic is maintained on the network and ensures fast updating of data at the workstations.
- The RTU communication interfaces are configured to auto-dial onto the telecom network and to remain connected and available on the GPRS/CDMA network. The RTU is configured for a defined number of automatic reconnection attempts in case of a communication failure.
- IEC-60870-5-104 protocol defines timing parameters for monitoring network connection, protection against loss and duplication of message frames. Test messages are sent between Master Station and each RTU, within a preconfigured time interval, in case no other information exchange

happens between them. This helps to monitor connection. In case of “time out” for a test message acknowledgement, the connection is closed and re-attempted again.

Security Concerns Addressed

The security issues of using public network are addressed by the following means:

- The network is totally private and the fixed IP addresses are not available to normal users on Internet.
- The interface to the Master Station is situated within a fire-wall and inside the utility network.
- The access is configured in such a way that no incoming connections are allowed. Only outward connections from the Master Station network, through the utility fire-wall, are allowed.
- The RTU accepts connection from only pre-configured IP address and rest of the requests are ignored;

The above measures make it virtually impossible for anybody to hack into the network or carry out a denial of service attack.

Conclusions

- The techno-commercial feasibility of using mobile phone networks for Feeder Automation is established. Major utilities in India have conducted pilots and have gone ahead with mass-deployments.
- One of the major advantages of using public mobile phone networks is that utilities are not required to make a huge investment in deploying the communication infrastructure and nor are the required to invest in the continuous network monitoring, maintenance and upgrade of the same.
- The mobile phone networks include several security aspects such as encryption, VPN, firewalls, static IP, passwords etc. which are adequate for any Feeder Automation application.
- Use of this communication can also be explored for other applications such as AMR as well as for other industries such as water supply networks.

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Contact us

eru.pmo@tcs.com