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Research Paper

SMART GRID APPLICATION IN NARROW BAND POWER LINE COMMUNICATION USING FULL DUPLEX

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This paper investigates performance of RoHC on IP traffic across Direct Line Communication. Channel provides performance analysis of data throughput and gains for a Smart Grid applications. Here we consider application such as tele-control and video surveillance which are perceived to be time critical. We propose a Qos negotiation algorithm that maximize bandwidth usage and provide low delay for busty Direct Line Communication channel. This will ensure a smooth and transparent data transmission between applications on Direct Line Communication channels. The purpose of our project is to monitor the smart grid status with the help of Power Line Communication. Here we are measuring the condition of grid like gas and temperature based on the requirements the device will operate. The overall measurement to monitor and control the smart grid and these information will be updated in server PC via Power Line Communication modem. Thus we may monitor the smart grid from anywhere.

Keywords: Smart grid, Power line, PLCC, RoHC, DLC

INTRODUCTION

Next generation of power grid is also known as smart grid in which it upgrading electricity distribution and management by two way communication. In which computational of smart grid is also possible. In computational we may estimate load estimation, control, efficiency, safety and reliability. But for this good communication network is required for detailed analysis of smart grid applications.

Thus for this smart grid communication the new technology is incorporated called as Power Line Communication. This PLC has many advantages. PLC allows all line powered devices in a electric grid to become a target as added value [2, 3, 4]. Every communication technologies uses PLC as its communication channel.

There are two technologies incorporates PLC. They are Broadband PLC (BPLC) and

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Narrow Band PLC (NBPLC) have been investigated by several projects to extend and improve their performance towards actualizing SG vision. BPLC which was initially developed to provide internet accesses to residential customers via the power line operates on HF/ VHF frequency band of 1.8-250 MHz While NBPLC operates in the CENELEC frequency band of 9 kHz-148.5 kHz in Europe; ARIB of 155 kHz-403 kHz in Japan and FCC band of 155 kHz-450 kHz in the United States of America. Both BPLC and NBPLC have roles to play in SG and deploying them as communication platform on the outdoor Low Voltage (LV), Medium Voltage (MV) and in-home part of the grid will depend on the channel characteristics [4]. For instance, BPLC has strong coupling effects as a result of its high frequency which may also help to mitigate line impedance, it will find application more in the in-home channels that are characterized by high frequency selectivity and low attenuation due to the high number of discontinuities and unmatched load. NB-PLC on the other hand, has low channel attenuation and can travel over the outdoor LV and MV channels. The growing interest in high data rate NBPLC operating in the CENELEC/FCC/ ARIB bands has led to initiatives by study groups and research bodies to develop NBPLC standards such as: iAd [14], Yitran [14], G3 PLC and PRIME [15], with High Data Rates (HDR). These technologies have gained industry support in Europe and have specified a HDR NBPLC solution based on Orthogonal Frequency Division Multiplexing (OFDM) with achievable data rates of over 100 kbps [2, 3, and 11]. Distribution Line carrier (DLC) is slightly different from other NBPLC and BPLC because it uses an extended frequency range of 9 kHz to 500 kHz and IP communication for utilities with achievable data rates of about 500 kbps [14]. The power line noise is time variant and cannot be represented by conventional models alone [5]. For example the sensitive indoor power-line channel is a frequency selective fading channel with time-varying characteristics.

SMART GRID APPLCATIONS ON DLC

The article defines a modular DLC architecture and a convergence layer that can efficiently and securely handle IP over PLC. The task of MAC protocols is to organize the access of multiple nodes to the PLC channel which is usually achieved by managing the accessible sections on the network provided by the multi access scheme. The application service or a packet requiring QoS in CSMA/CA MAC protocols go through a connection establishment procedure to ensure that the network, channel and station resources are available to support the connection. Connection requests can be initiated by either the application or convergence layer. The DLC protocol stack consists of a convergence layer which negotiates with the modem on behalf of the applications to know the required QoS that will ensure a smooth and transparent data transmission between nodes [1]. The QoS negotiation and resource reservation enhanced by the convergence layer allows an application to modify its requirements to available communication resources and “gracefully degrade” a service rather than completely cease to communicate should a node experience a poor channel [4]. The convergence layer uses three control planes to describe grouped interactions between different layers in the DLC node [3]. The management plane allows for configuration and control of parameters at each layer. The context plane manages the context of Packet Data Units (PDU) travelling over the signaling plane in terms of security and QoS. This is because several contexts may be realized from source to destination across the DLC network. While the signaling plane carries the IP PDUs that are destined to be transferred or have been received from the power line physical layer. It usually includes PDUs which represent both application data and context information. Throughput and latency are affected by channel noise and interference which results in high error rate values on the channel, for this reason the Council on Large Electric Systems (CIGRE) have defined bandwidth for grid critical application applications and IEC 60870 have set a residual error rates and latency for grid critical application.

Degrading a packet at the context layer will not only allow efficient delivery of packets to destination but also enable the packets to meet their latency requirements and reduce excess retransmissions in the network [1]. To test the DLC network performance for reliability and ability to meet the time-criticality of smart grid traffic; a measure of the average end to end packet delivery, RTT and reliability of the traffic in the network must be carried out for different characteristics of DLC channel.

Table 1: Time Critical Smart Grid Applications

Smart Grid Traffic	Data Rate Requirement	Latency	Criticality
AMI	10-100 kbps	2-15 s	Low
DR	14-100 kbps	500 ms	Medium
SCADA	1.8-9.6 kbps	0.5 s	High
Fault Detection		5 s	High
Video Surveillance	15-128 kbps	1 s	High

ROHC AND PERFORMANCE ON SMART GRID

IP headers added by respective layers in a communication system often exceed the length of payloads resulting in high overheads. The overhead will require significant amount of bandwidth, which is already scarce in NBPLC. It has a high compression efficiency and high robustness and also performs very well on channels with high BER and RTT. RoHC compression exploits the similarity in header fields sent over succession and makes a classification of these header fields in to static and dynamic [11]. The static field refers to the information which remains mostly constant during the life time of the stream, and dynamic header fields refer to information which may change but whose pattern may be known.

RoHC works in 3 stages:

1. Initialization and Refresh (IR) which identifies the protocols in the stream, marks the header fields patron and transmits the full header along with the RoHC header. RoHC header is computed based on the header field classification

2. First-Order (FO): During this stage only the static fields are compressed, the dynamic fields are transmitted along with the header

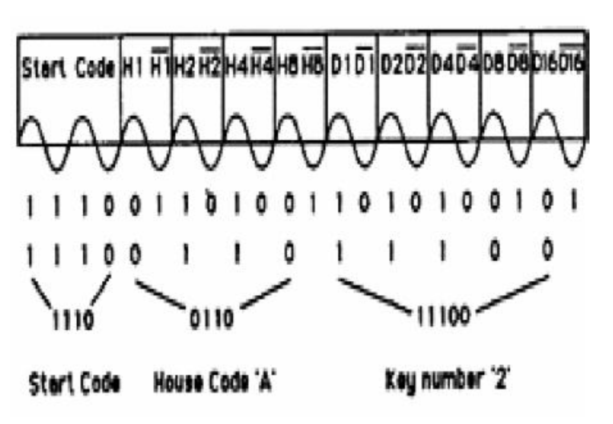
3. Second-Order (SO): The full RoHC compression is applied in this stage. This means all the static and dynamic fields are compressed and the fields decompressed the receiver.

RoHC also operates in 3 modes:

1. When packets are sent in only one direction from compressor to de-compressor it is known as Unidirectional Mode (U-Mode), it allows RoHC on links without a return path from decompressor to compressor;
2. Bidirectional Optimistic Mode (O-Mode) is similar to the U-Mode the only difference is that it uses feedback channel to send error recovery request and occasionally send acknowledgement of significant packets to the compressor, and
3. Bidirectional Reliable Mode (R-Mode) which is different from the previous two because it has more intensive usage of the feedback channel.

RoHC on DLC Model

RoHC is integrated with DLC convergence layer to allow control and management of compression gain based on channel conditions and QoS parameters requested by the transmitting DLC application. RoHC ratios will offer adaptive control for the convergence layer to ensure maximum reliability and efficiency of DLC application over the network. Figure 2 illustrates the impact of RoHC on UDP/IP and ICMP packets for payload sizes ranging from 25-1024 bytes. It compares the size of the UDP packets and ICMP packets before and after RoHC. The RoHC performance compression rate is calculated for different payload sizes and presented in Figure 3. Performance compression rate on ICMP packet is constant since the payload size is the same all through. The performance rate is higher when the ratio of payload size to header is lower. This is a good indication of the significance of RoHC in smart grid because



most of the control and monitoring packets have small payload, the headers added to the packets will exceed the length of the payload, most of the time.

Data traffic over SG system are estimated based on a set of assumptions and power grid topology such as the granularity of sending intervals and the number of events to be monitored in [2] and [8] for smart metering and AMR. The data traffic supported by UDP/IP are mostly voice traffic using the Real-Time Transport Protocol (RTP), multicast traffic and broadcast traffic while TCP/IP can support most of the unicast traffic types. When deploying DLC for smart grid communication it is important to take in to consideration that traffic flow will comprise of periodic data and random data coexisting together. It is however required to keep the overhead to its minimum in order to efficiently utilize the available bandwidth in DLC network.

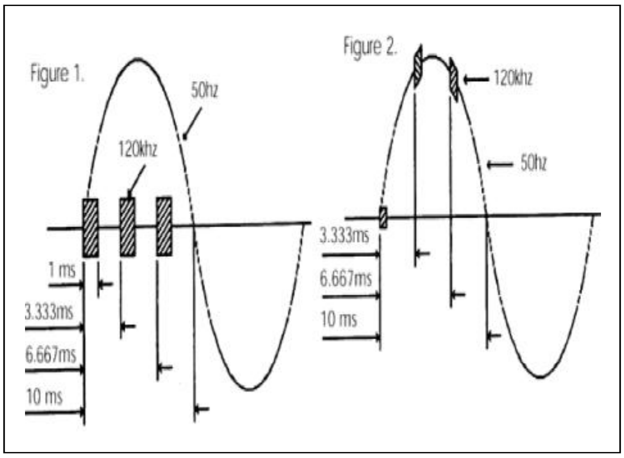
DUPLEX OPERATIONS ON PLC

A duplex communication system is a point-to-point system composed of two connected devices that can communicate with one other in both directions. There are two types of duplex communications they are (1) Full Duplex, (2) Half Duplex.

Duplex communications are employed in many communication systems either to allow for a communication link between two connected parties.

Half Duplex (HDX) systems provides communication in both directions but only one at a time. Typically, once a party begins receiving signal, it must wait for the transmitter to stop transmitting, before replying. Such example for walkie-talkie. A good analogy for a half-duplex system would be a one lane road with traffic controllers at each end. Traffic can flow in both directions, but only one direction at a time, regulated by controllers.

Full Duplex (FDX) allows communication both directions, and unlike half-duplex allows this to happen simultaneously. Land line telephone network are full duplex, since they allow both callers to speak and heard at the same time, with the transmission from four two wires being achieved by hybrid telephone line. Full duplex has many advantages like time not wasted, no frames need to be retransmitted, and no algorithm. Full duplexing can be done in Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD). All communications exchanges in DF-1 half-duplex protocol are initiated by the host, in this case the Comm-Master. The remote cannot initiate any exchange with the host nor can the remote directly address or communicate with another remote.



Full-duplex protocol is a multi-drop protocol used for communication between one master and one or more slave devices. The Comm-Master is the master device and the slave devices are Allen-Bradley (or compatible) modules that have DF-1 slave mode capability. The Comm-Master can communicate with from 1 to 254 stations on a single communication link.

Word offset 0 is used for 2 functions: Byte #0 is used to define the Allen-Bradley Data Highway address of the interface module that is connected to the Comm-Master. This address is typically 118 but may be assigned to other values depending on the final system configuration. The address of the data highway interface module is used as the file address when reading or writing data to a PLC-5 system. The interface module can be assigned any address from 1 thru 778. Byte # 1 is used to define the number of RTU Polling Tables that are defined in the system. The Comm-Master will use this number to determine the number of Polling Table Entries to read.

The Polling tables start immediately following the end of the configuration table header section. The polling tables are contiguous, one immediately following the other. Each Polling table is 20 words long. There is a polling table for each poll message that the Comm-Master is required to send.

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