‘Broadband for All’ using the Power Grid

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Extended Abstract

Introduction

With liberalization of telecom sector and introduction of IP networks and services, number of service providers has been increased multifold, bringing lot of benefits to the customers in terms of services and cost. However, the ‘broadband for all’ concept is still not achieved. The main bottleneck in providing such services to reach the users is to have appropriate access networks to their premises. Urban areas are quite well covered by using the copper wires from the incumbent operators, whereas the semi-urban and rural areas are not so well covered since the business case is not so appealing.

It is beyond any doubt that the telecommunication infrastructure is a dominating driving factor in improving the economy of a country. All national governments are therefore promoting alternate access network technologies to provision broadband services to their citizens.

The power grid (the electricity supply networks) reaches almost 100% of the population in developed and most of the developing countries. Broadband over Power Lines (BPL) exploit this ubiquitous presence to provide broadband services to sub-urban and rural areas. By using the available power transmission and distribution infrastructure the CAPEX costs are reduced since only appropriate system level developments have to be done to reach the customers, independent of their location.

Broadband power-line communications has to overcome several technical challenges. The transmit power spectral density has to be low in order to ensure that the generated electromagnetic radiation is conforming to the limits defined by the regulators. There are other users in the frequency spectrum employed (military, radios, radio amateurs) and the allocated frequency bands to these users has to be notched.

The market for Broadband over Power Line is taking off, particularly in the United States, where a large number of trials and first commercial deployments are ongoing. The European market is lagging. The BPL equipment deployed seems not to meet the expectations of the utilities. Regulatory uncertainties allow at this time no economies of scale resulting in not very competitive service offerings.

There are good reasons for believing that this situation will change: A consortium of SMEs has been formed to develop new generation of power-line communication system solving the technical challenges mentioned above. Their project proposal ‘ POWERNET’ has been accepted by the European Commission research framework and obtained partial funding for developing new generation of ‘Cognitive Broadband over Power Line (CBPL)’ system.

New Solution in the Horizon: The New Approach

Most of the PLC equipment on the market is using a master-slave approach. Thereby, the master has to reach all slaves in order to allow them to register. The slave has to ask the master for transmission permission. The transmit power spectral density of the master must be high enough to reach the most distant slave. High transmit power leads to high electromagnetic radiation. If an additional master is needed, the new master equipment has to be synchronized to the master equipment is operation otherwise they will interfere with each other, resulting in a poor communication quality.

The new approach meets the following technical challenges**:**

1. The power grid infrastructure (its topology) has been optimised for energy distribution (load sharing) and must be taken into account.
2. When the path loss is substantial and the resulting SNR at the receiver is poor, communication is jeopardized. Communication must be possible under very poor SNR conditions.
3. There are other users in the employed frequency band and they should not experience interferences.
4. The electromagnetic radiation limits of the regulatory restrict the use of high transmit power spectral density.
5. To be competitive with other broadband access technologies, high aggregate data rate communication must be achieved.

Unique and Crucial Features

The new, Cognitive Broadband over Power Line (CBPL) technology uses peer-to-peer communication. To establish communication with another CBPL modem, the transmitting CBPL modem uses a distributed neighborhood list. This list has been forwarded to him during the joining by neighbor CBPL modems and is updated at regular intervals.

The developed CBPL technology is meeting the above mentioned technical challenges of communication over the power grid. The new approach has the following unmet features:

- It uses low transmit power spectral density allowing to meet the limits of electromagnetic radiation given by the regulatory.
- It guarantees reachability by achieving communications even at high path loss (at very low SNR)
- It has a flexible frequency management allowing to efficiently sculpture the allocated frequency bands and to ensure coexistence with the other users of the radio spectrum
- It has a high aggregate data rate (up to 300 Mbps)

The latency (the access time) is also considerably reduced compared to master-slave equipment, since transmission is immediate. Collision avoidance is achieved by listening on the channel before transmitting. In case the channel is occupied, a default channel is selected. The receiving CBPL modem will inform the initiating CBPL modem about the path loss and either to confirm the channel employed or propose another.

Key to the CBPL technology is the cognitive (adaptive) approach (inbuilt intelligence on the topology and any changes of the transfer function of the electric line.

To ensure that there are no interferences in the frequency bands allocated to other users, a multi-carrier modulation (MCM) technique based on Digital Filter Banks (DFB) is employed allowing switching off these frequency bands. Since the transmit power leakage in the allocated frequency bands must be low, the sub-carriers used in MCM must have high stop-band attenuation. This excludes the use of OFDM modulation.

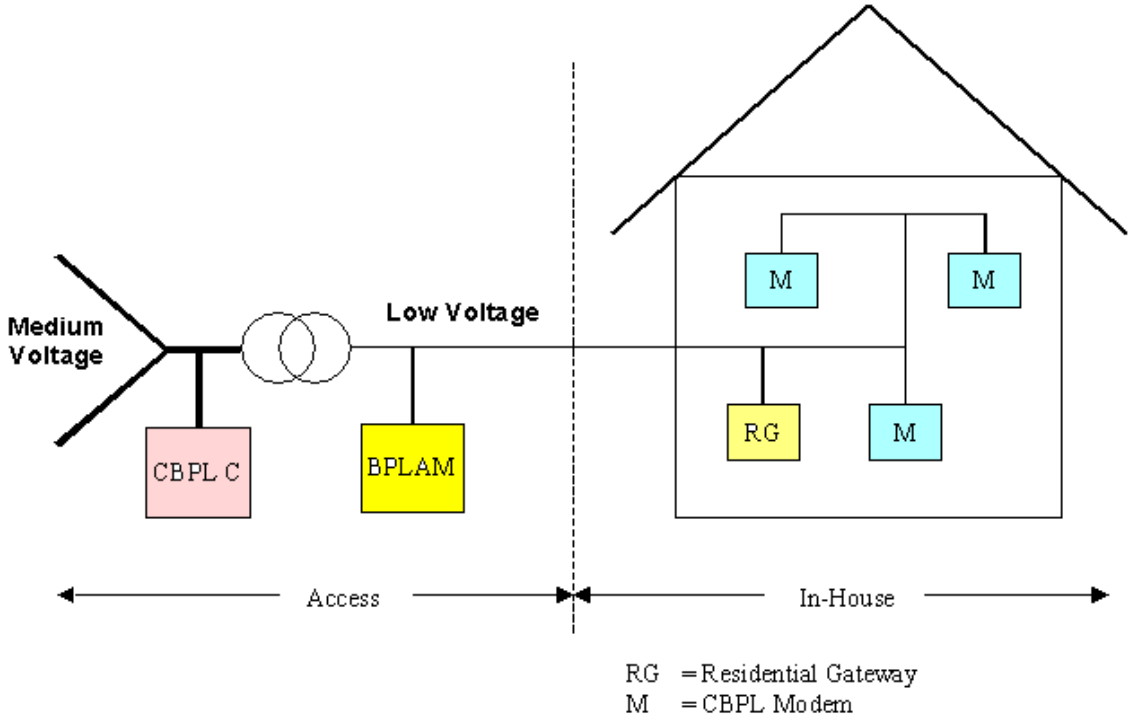
In order to be able to establish a low rate communication between the sending modem and the called modem, both must be able to synchronize even at 0 dB SNR. This is required in order to exchange handshake messages that will have as a result to change the channel used for example.

Architecture of the CBPL network

As shown in the above figure, the CBPL technology is to be used in both the access and in-house networks.

The following types of CBPL equipment will be developed for the Access CBPL network: Communicator for the medium voltage, BPLAM (access multiplexer) Range Extender, and Residential Gateway for the low voltage distribution,.

Two CBPL modems (CBPL_USB and CBPL_WiFi) will be developed for In-house CBPL network.



Conclusions

The EU project POWERNET has started with ambitious goal to achieve “Broadband for All” over the power grid in sub-urban and rural areas. A completely new approach has been taken to meet the technical challenges. The design of CBPL system is in progress and we will have the first results of field trials which will be presented during the conference