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Title: G.hn: Technical Paper for BPL access in smart grid network

Purpose: Discussion

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Keywords: G.hn; BPL; Technical paper

Abstract: This contribution proposes to create technical paper on how to operate G.hn technology for BPL access in smart grid networks.

1 Discussion

1.1 The legacy of the energy system and the control of energy networks

In the past, the Energy system relied on central generation units. Consequently the Energy Network was built to meet the requirement for energy transport and energy distribution from the central generation sites to the regional and local customers.

Along with the energy network, the communication system for control was build up with the same structure in mind.

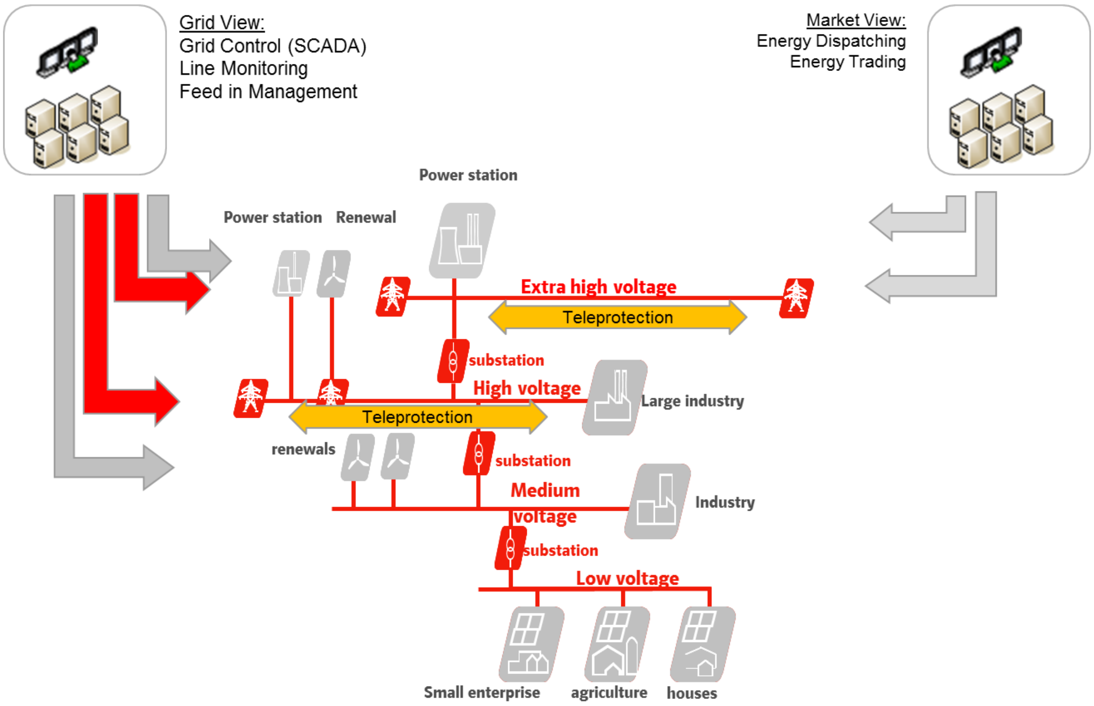

Figure 1: Energy Network Control today

1.2 Challenges for the energy system in the future

Due to the massive expansion of renewable energies, the requirements on the electricity grid are changing fundamentally. The increasing volatility and decentral energy generation increases the complexity and requires a higher flexibility of the networks, as well as an adapted control logic. The increased use of ICT will play a key role for the set-up of smart grids and the success. The electricity demand of all consumers has to be intelligently estimated/measured and forecasted. The generation and supply of the electricity will be dynamically controlled. This enables flexible business models and dynamic offers, which leads to changes in the consumer's consumption pattern.

The following megatrends will lead to a clear decentralization of the energy networks:

• The massive expansion of small-scale renewable energy sources
• Decentralization of energy production with high volatility
• The dynamic development of electro mobility
• The controllability of local consumers (e.g. heat pumps, night storage heater, V2G)
• The economic availability of local storage (battery, heat, cold)
• The implementation of climate change in Europe and the phasing-out of nuclear power in different member states (e.g. Germany)

So far centralized systems have used a few sensors and actuators for forecasting and operation of the grid. In the future decentralized systems at local level with a high degree of networking will determine the architecture. The aim is to optimize the local and regional energy distribution networks by implementing the dynamic control of producers, loads and storage in a way that they are in an energetic equilibrium. For this purpose, communication connections in local and regional structures with very low latency (short control time constants due to the lack of inertia of large machines in the energy system) are necessary. Direct interaction between loads and producers without using the core infrastructure of the communication network must also be ensured (Device 2 Device Communication). For this purpose, both mechanisms for peer to peer communication (unicast) as well as for mass communication (broadcast) will be used.

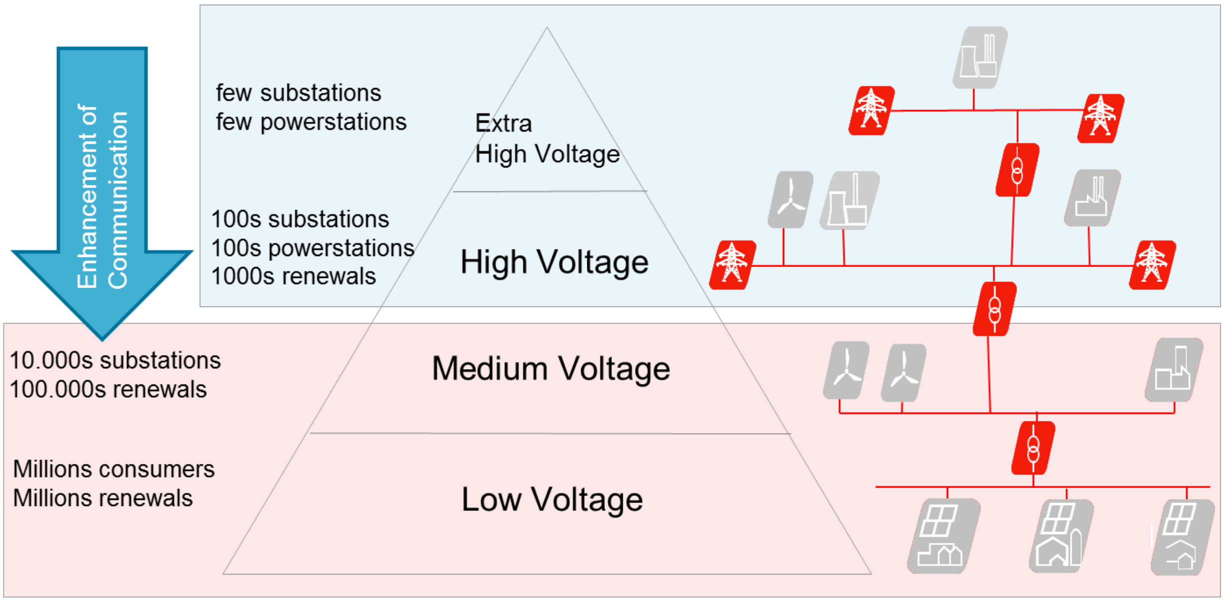

Figure 2: Challenge for communication in the future

Utilities have to enhance their telecommunication infrastructure into the medium – and low voltage networks. In parallel, the supervision and control of the energy networks have to be moved from a central to a decentral approach:

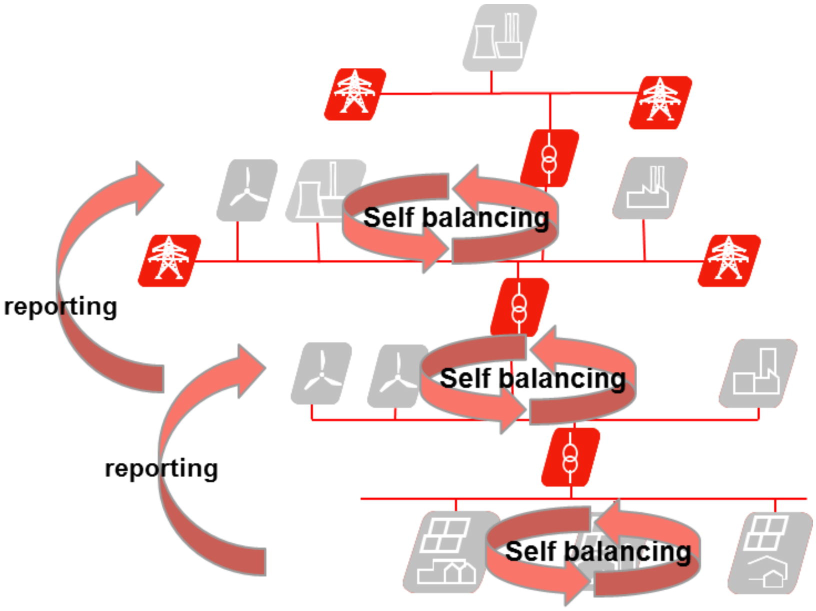

Figure 3: decentralised network balancing

Interaction between home automation systems, industrial control systems and local energy distribution networks

To implement these local energy networks, a seamless interaction between the power distribution network and the control systems of industry (SmartFactory) and houses (SmartHome) is indispensable. Only in this way it will be possible to establish a regional balance between energy consumption and energy production without having a loss in the supply quality of the electrical energy. Both the Smart Home and the SmartFactory or SmartBuilding rely on the robust, fast, cost-effective and secure exchange of a large amount of data. The main applications in the field of energy data, monitoring of energy consumption and performance vary between a data granularity of 1Hz up to 1kHz in average). These data must be exchanged between potential market participants via the communication infrastructure locally or regionally. In particular, with the requirements of virtual power plants as well as load control (demand side management), these data have to be available in near real-time. The requirement on the availability of the communication networks includes not only coverage but also the availability of the service in buildings (deep indoor coverage). In addition to this, combinations with other services such as building security and comfort are making latency increasingly important.

These overall requirements, particularly in the case of end users, are concurrent with the low cost requirements, both in terms of the cost of the infrastructure and the cost of the transmitted data. This is only way to realize a comprehensive use of a Broadband Powerline System in the end customer business.

1.3 Blackstart from islanded local energy networks

As a result from moving generation, storage and demand into the distribution networks, the concept of blackstarting (start of the energy network after a blackout) has to be adapted.

The megatrend decarbonisation will lead to a shutdown of fossil generation in the extra high voltage and high voltage networks. Moreover, the shutdown of nuclear generation in different European member states will increase the lack of big generation facilities. The only option for blackstarting the energy network will be to make use of the renewal generation and decentral energy storage in the distribution networks.

As a consequence, it must be possible to operate local and regional energy networks independently from the transmission network.

The coordination and balancing of these local energy networks will only be possible, when all participants communicate with one another and have a communication with a local control instance. Moreover, market mechanisms have to be postponed in a case of islanded operation.

The local communication has to be available, even when the backbone –network of the telecommunication provider is not available.

Broadband Powerline Systems, with the functionality should facilitate this approach.

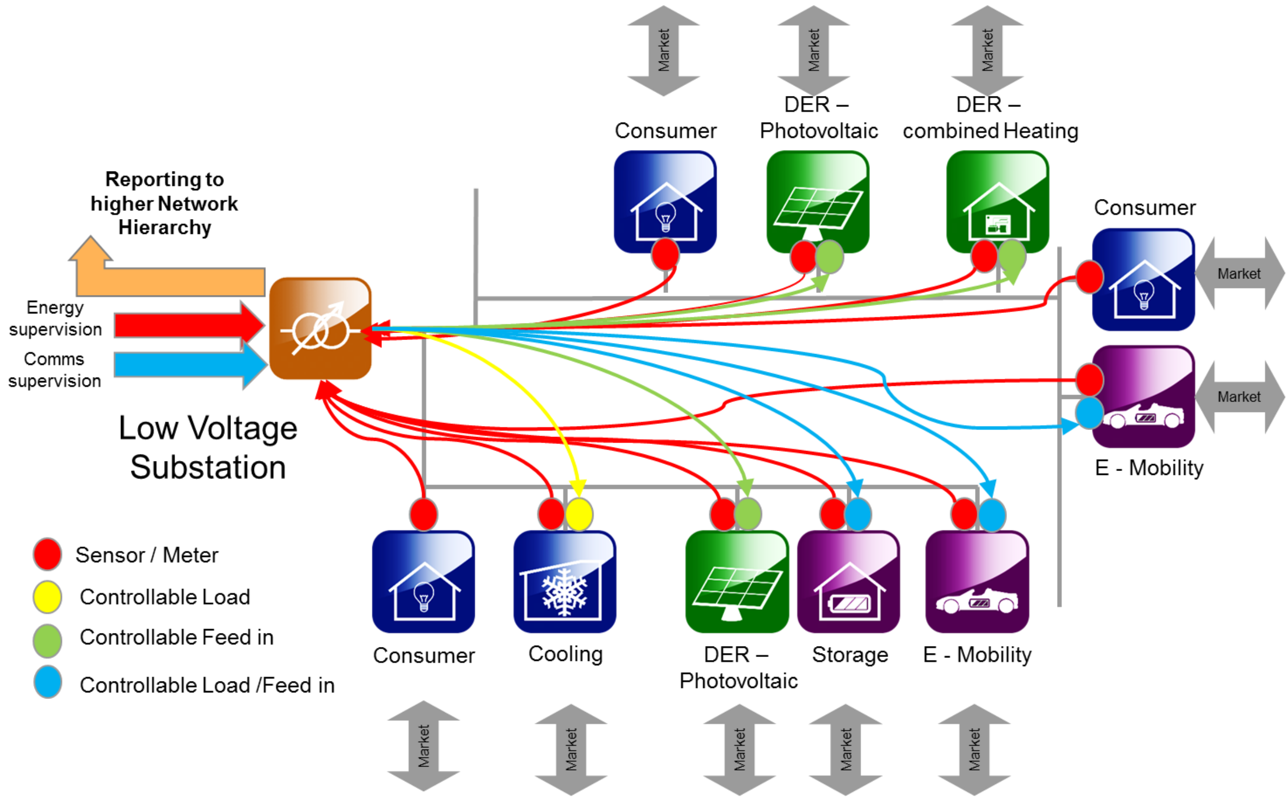

Figure 4: Local energy network

1.4 Architecture for the smart grid and smart meter communication network in Germany

Based on a requirement definition, the reference architecture for smart metering and smart grid was generated. As a result of coverage investigation of public LTE networks (average coverage not more than 60% of the smart meters), the only option for connecting smart meters was making use of a combination of public LTE and Broadband Powerline Systems:

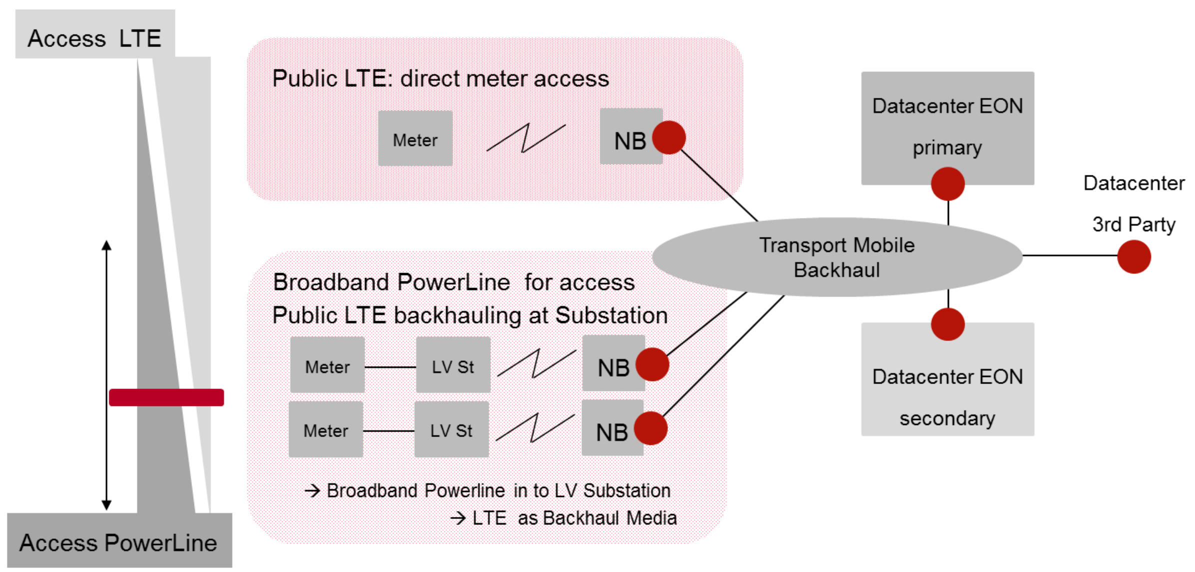

Figure 5: Technology mix for smart metering

In addition, the operation for the network and the application was split into 2 entities:

- The WAN - Network Operator
- The Application Provider

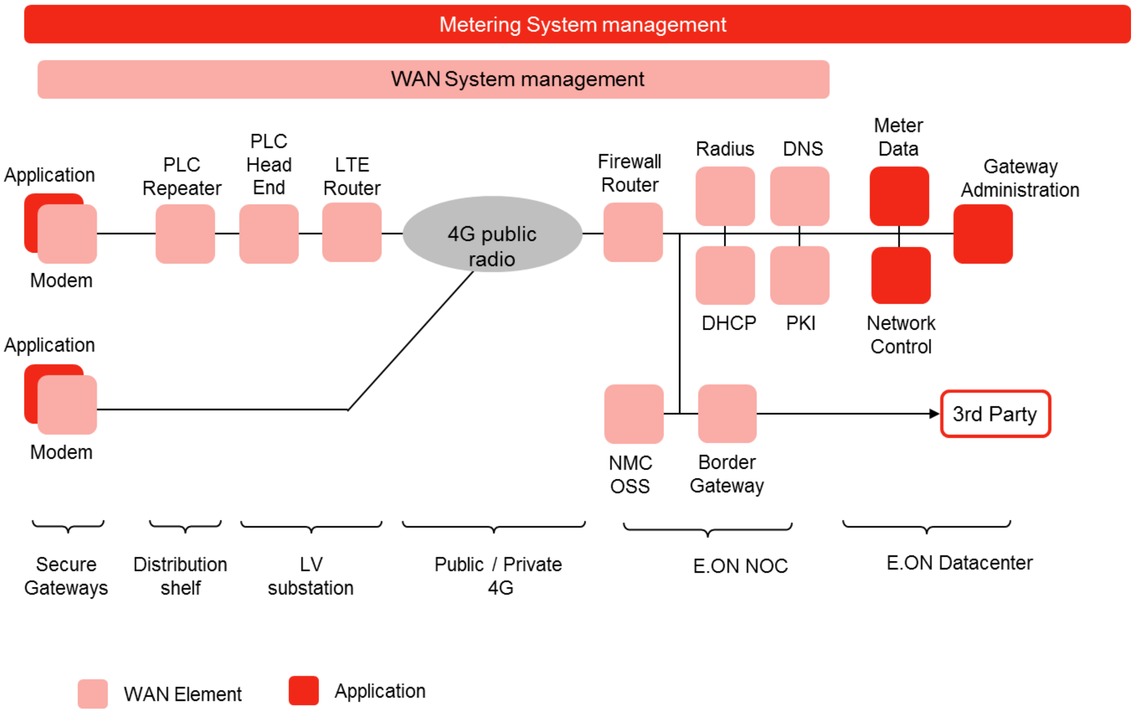

Figure 6: Operational Model

1.5 Requirements on a Broadband Power line System

Attached there are some typical requirements on a broadband power line system

- Physical and MAC – Layer
  - OFDM Modulation
  - MIMO if feasible
  - Up to 1000 nodes
  - Coexistence to narrowband PLC Systems PRIME, meters and more, G3
  - Coexistence to broadband PLC Systems according to IEEE 1901 and G.hn
  - Notching of aeronautical, broadcasting and HAM spectrum range
  - Spectrum Range 2 MHz … 30 MHz (adjustable to 2MHz … 12 MHz)
  - Compliant to EN 50561-1, CISPR I PT/PLT CD 89 and CD 257
  - Adjustable transmission power (max -50dBm/Hz) and reception gain

- Network Layer
  - Cluster hopping (different head end systems)
  - Mesh or tree shaped operation
  - Ethernet Interfaces
  - min. 16 VLAN
  - Provisioning of e-Tree (root to CPE) and e-LAN (peer too peer) topology
  - Multicast and Broadcast (Layer2 and Layer3)
  - AES 256 encryption on physical layer
  - automatic topology building
  - multi repeater functionality

- Application Layer
  - Device Authentication based on RADIUS / EAP-TLS
  - Encryption of management access based on SNMP V3
  - Use of X.509 certificates for management access and encryption
  - Full IPv6 and IPv4 support (DHCP, SLAAC, IGMP)

- Management Layer
  - Common MIB and network management integration (at least 1 NMS for infrastructure and 1 common NMS for CPE)
  - Authentication and authorization of management access based on X.509 certificates
  - Automatic deployment features (zero touch deployment)

2 Proposal

2.1 Scope

The scope of this document, is the utilization of G.hn in Smart Grid networks, and serves the purpose of ways to define, deploy and configure a network with a variety of G.hn devices.

The scope of the technical paper should cover Physical and MAC layers, as mentioned in section 1.5.

2.2 Use of G.hn as BPL access for smart grid network

2.3 BPL network concept

2.3.1 Concept

Editors' note: Description of the concept

2.3.2 Use cases and architectures

Editors' note: Description of the use cases and architectures

2.4 BPL network characteristics

Editor´s note: Characteristics of the system. What are the main assumptions we can make and how to adopt the G.hn technology

2.5 G.hn as a suitable technology for BPL network

Editor´s note: Why G.hn technology is well suited for the selected architectures. What are the implications of deploying G.hn ?

2.5.1 PHY layer

Editor´s note: Advantages of the G.hn PHY layer in BPL networks

2.5.2 DLL Layer

Editor´s note: Advantages of the G.hn DLL layer in BPL networks

2.5.3 Management layer

Editor´s note: Advantages of the G.hn Management layer in BPL networks

3 Summary

Item Number	Status	Item Description	Reference(s)
(new)	Open	Should Q18/15 develop a Technical Paper on the use of ITU-T G.hn technologies as a BPL Access technology for Smart Grid networks?	This contribution

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