G3-Alliance

Application Note

Unidirectional Smart Meter to User Device Communication over P2P-PLC

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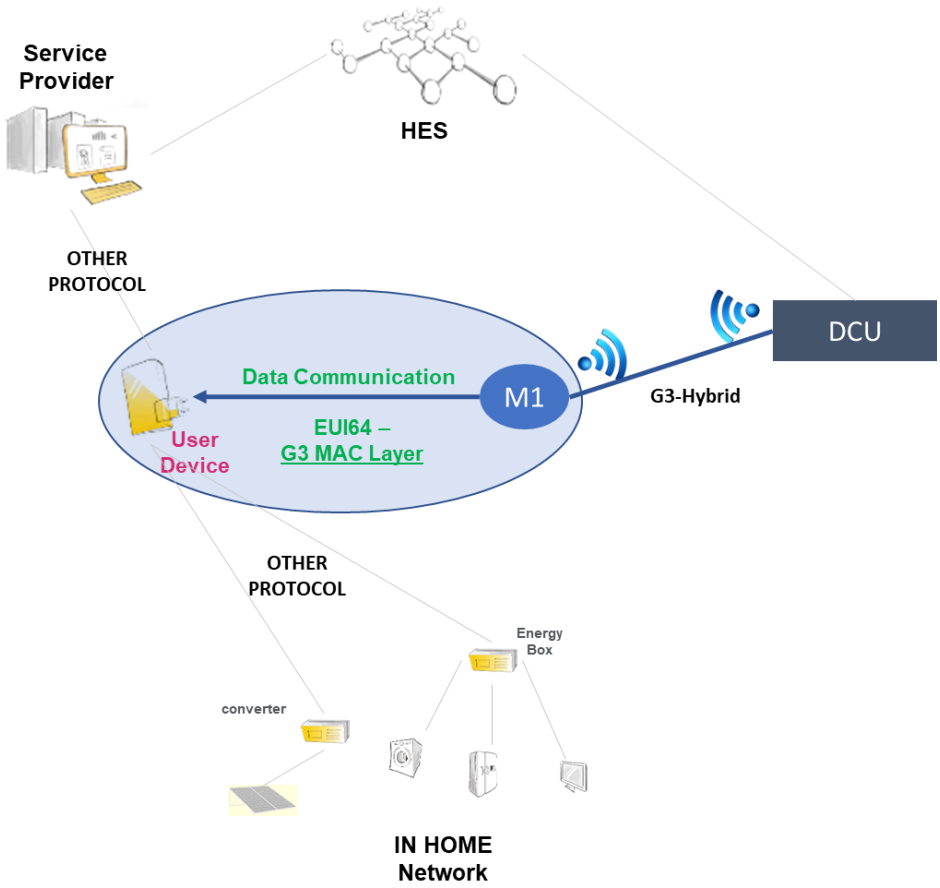
Executive Summary

This document describes a unidirectional data communication system from smart meters to user devices, which follows the standard smart meter architecture standardized by the Italian Electrotechnical Committee. The primary purpose is to provide in near real time, a subset of non-validated data to the customer or to an authorized person via a user device. The aim is to enable new opportunities and services related to awareness of consumption and energy efficiency.

This Application Note describes how unidirectional data communication can be realized between the smart meter and a User Device (UD) in a standard way over the P2P-PLC technology to help end-users and manufacturers in implementations and deployment.



About G3 Alliance Solutions

G3-Alliance solutions facilitate high-speed, highly reliable and long-range communication over the existing power grid (G3-PLC), possibly using additional radio communications (G3-Hybrid). These solutions' features and capabilities have been developed to address the difficult challenges of powerline communications. While earlier approaches were a step in the right direction, they fall short of meeting the technical and reliability requirements necessary in the hostile environment of the power grid.

G3-PLC and G3-Hybrid are open international standards published by ITU: https://www.itu.int/rec/T-REC-G.9903

To help adopters properly integrate the G3-Alliance protocol stacks in products and systems we have developed a set of user guidelines. All user guidelines can be found on the G3-Alliance website: https://g3-alliance.com/technologies/specifications-user-guidelines-private/

For more information: visit www.g3-alliance.com

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1. Scope

This document addresses the high-level requirements for defining a G3 communication between smart meters and User Devices (UD). In the generic scenario, the UD is not always provided by the meter manufacturer or the Distribution System Operator (DSO) and can be acquired by third parties.

The smart meter is part of a G3 network and communicates with both PAN coordinator and UD, although the UD is not part of the aforementioned G3 network. Instead, the communication between the smart meter and the UD is done in a point-to-point fashion using MAC layer frames transmitted over the PLC medium.

2. Introduction

The primary purpose of unidirectional data communication from smart meters to user devices is to provide in near real time, a subset of non-validated data, available on the smart meter installed at the customer's premises, to the customer or an authorized person via a dedicated device (hereinafter called the **User Device** or UD). The aim is to enable new opportunities and services related to awareness of consumption and energy efficiency, such as for example new forms of supply, load modulation and home automation. In Italy, such a system known as “CHAIN-2” is part of the standard smart meter architecture and for which several use cases have been identified. These use cases can be grouped into the following categories:

- Awareness of consumption and production (for prosumer customers): providing information that can also be provided through the user interfaces of **smart appliances** (e.g. buzzer, display).
- Planning and control: providing information from the smart meter that is used to adjust the operating cycle and/or start time of smart appliances.
- Diagnostics: using information from the smart meter (voltage interruption, etc.) to have a diagnostic of smart appliances and to check for abnormality related to the operation of smart appliances.
- Market: providing information from the smart meter to support the implementation of innovative forms of contract that can be exploited by smart appliances (e.g. dynamic energy price, variable contractual power, prepaid consumption).
- Network services: providing information from the smart meter to enable smart appliances to provide services to the electricity grid.
- Specific additional use cases are required for the initialization of UD and their initial configuration.

A **smart appliance** is a device capable of exchanging information with other external entities and performing manually or automatically triggered actions also based on the data made available by the smart meter. For example, smart appliances can be integrated into home appliances, heat pumps, EV charging systems and smart plugs.

The use cases define for each data element, the periodicity and required latencies together with the possible trigger of an expected behaviour. To optimize the communication between the smart meter and the UD, different **service categories** have been defined, each of which is associated with sending of a specific subset of the data available.

3. Overall description

Given their domains of application, technical characteristics and related capabilities to provide a high level of flexibility regarding network architectures, G3 technologies represent a valid choice to enable PLC communications between the smart meter and the UD. The protocol stack is modular, allowing for different options at different layers. G3 may be used in a meshed configuration (typical architecture when deployed over a low voltage distribution network) or in a **point-to-point** configuration (P2P-PLC).

Since a UD must be associated to just one pre-defined meter, the point-to-point communication is the selected option for the communication between the two devices.

Figure 1 shows a G3 network, in which a pre-defined **G3-PLC or G3-Hybrid node** (M1), registered to an existing G3 PAN (for example using the G3-Hybrid technology), can communicate with a PAN

Coordinator (DCU) and with all the other nodes belonging to this G3 network. The smart meter can also establish a point-to-point communication with a **UD** (customer node not belonging to the aforementioned PAN). In turn, the UD may establish communication with a dedicated Head End System of the **Service Provider** (for instance, by the means of the customer's Internet connection) and to other devices (**smart appliances**) using dedicated communication protocols (out of the scope of this Application Note).

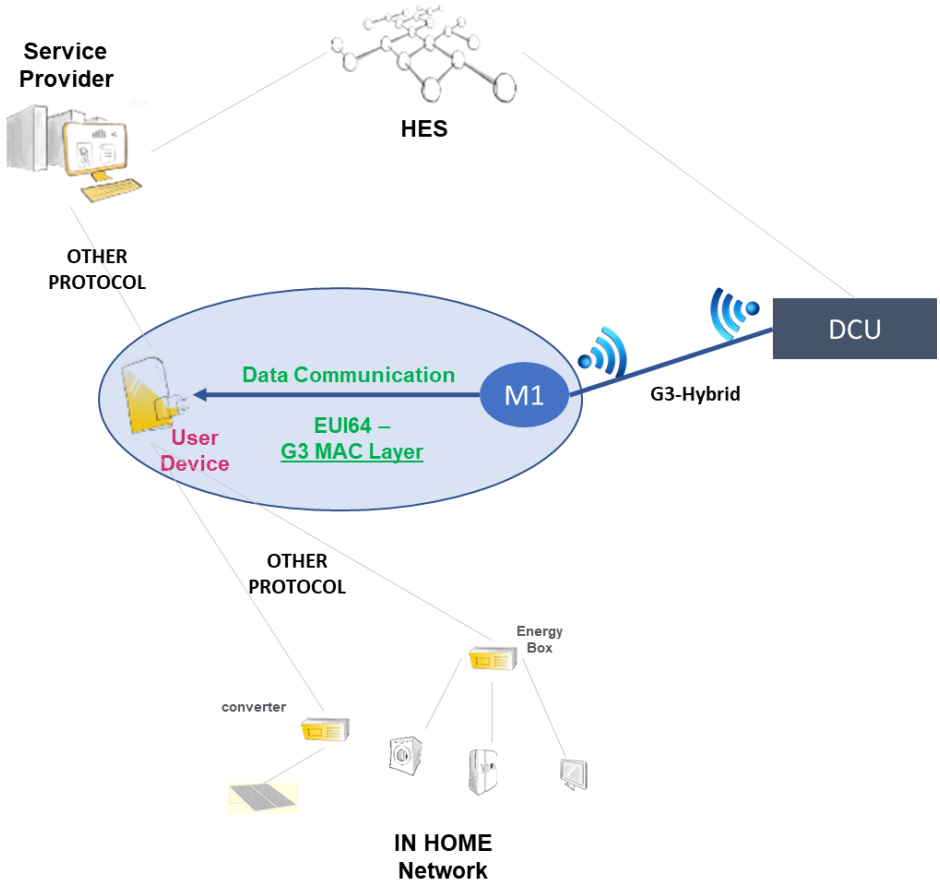

Figure 1 : Reference architecture

The establishment of the point-to-point communication of the smart meter to the UD falls under the responsibility of the DSO. For this purpose, the smart meter needs be aware of the unique address of the UD.

In the following sections, reference will be made to the architecture described in Figure 1.

4. Technical Use Cases

This section describes the "technical use cases" enabling unidirectional communication to cover all application use cases introduced in §2.

4.1. UC1: Installation, Activation of the Service and Configuration of the User Device

During the initial "installation, activation of the service and configuration of the UD" phase, the end customer or Service Provider shall provide all information required to correctly establish the communication with smart meter M1 to the DSO:

- UD EUI-64 MAC Address
- Applicative cryptographic keys (If required)
- Transmission medium bandplan (CENELEC A, FCC, etc.)
- Smart meter M1 identifier

Note : if applicable, the end customer or Service Provider shall provide the service class (definition is out of the scope of this Application Note, but it gives an indication of the characteristics of the data to be transmitted to the UD : content, frequency, etc.) to the DSO, as it is responsible to configure smart meter M1 accordingly.

Once configured, the smart meter M1 establishes the communication channel with the UD.

4.2. UC2: Unidirectional Data Communication

Once the communication channel is established, smart meter M1 sends data to the UD by the means of applicative data frames, which description is not in the scope of this Application Note. The UD's capabilities are restricted to receive data from smart meter M1 and to acknowledge (ACK) reception of this data.

The content, transmission frequency or ACK policy are at the discretion of smart meter M1's application layer. The transmission of ACK frames is enabled or disabled by configuring appropriate TXOptions of the MCPS-DATA.request primitive invoked for the transmission of the applicative data.

5. Requirements

5.1. Smart Meter Requirements

- Smart meter M1 implements the P2P-PLC protocol stack
- Smart meter M1 shall be able to send P2P-PLC frames to the UD
- Smart meter M1 shall be able to receive P2P-PLC acknowledgements (ACK MAC frames) from the UD
- Smart meter M1 data shall be transmitting using "normal" channel access priority
- Smart meter M1 shall transmit data without any encryption at MAC level, considering that the UD operates outside the DSO's G3 network. Encryption at application layer is outside the scope of this Application Note.

5.2. UD Requirements

- The UD implements the P2P-PLC protocol stack
- The UD operates outside the DSO's G3 network
- The UD shall be able to receive P2P-PLC frames from the smart meter M1 after association (see §4.1)
- The UD shall be able to send P2P-PLC acknowledgements (ACK MAC frames) to the smart meter M1 upon successful reception of data frames
- The UD shall discard any frames received by a smart meter different from the one it is associated with (smart meter M1).

6. Technical solution

Point-to-point communication is enabled by the P2P-PLC technology, consisting of the sole use of G3-PLC PHY and MAC layers as depicted in Figure 2.

In addition:

- EUI-64 MAC addresses are used for both source and destination addressing schemes.
- Smart meter M1 and UD are aware of each other's EUI-64 MAC addresses.
- Communication between smart meter M1 and the UD is unidirectional (from M1 to UD), as shown in Figure 3.

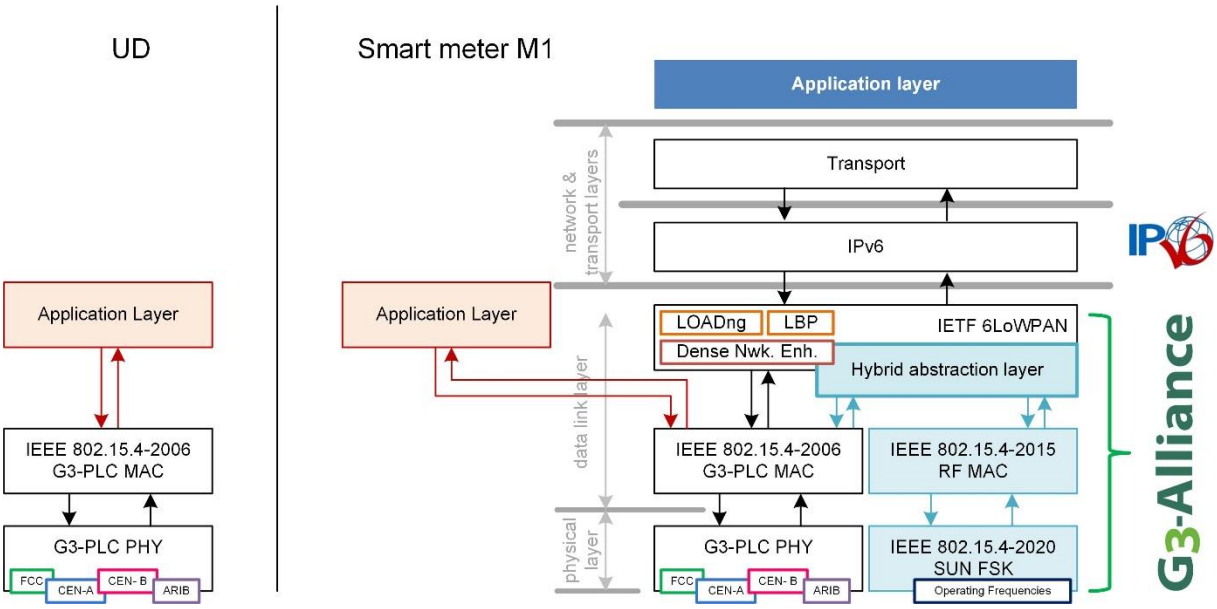

Figure 2 : UD and smart meter M1 protocol stacks

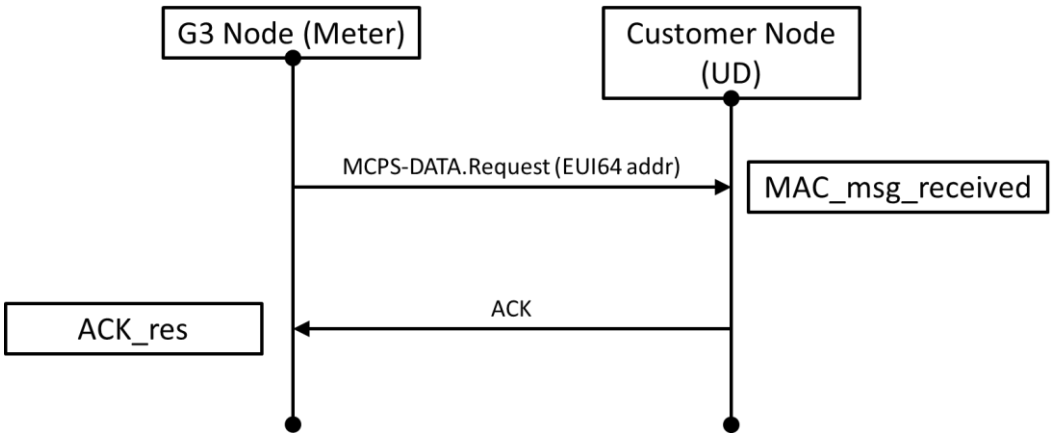

Figure 3 : Typical smart meter M1 to UD point-to-point communication flow chart

The following example illustrates unidirectional communications between smart meter M1 and the UD.

- Data communication between smart meter M1 and the UD takes place at MAC level in point-to-point mode:
  - Smart meter M1 sends a “MCPS-DATA.request” to the UD without any encryption at MAC level
  - UD sends an acknowledgement to M1 for confirming the correct reception of the MAC frame
- The modulation selected for the data communication is only ROBO; TMR messages are not used and will not be exchanged between smart meter M1 and UD.

Typically, smart meter M1’s application layer would invoke “MCPS-DATA.request” as follows (see [1], §9.3.11.1) :

- SrcAddrMode: 0x03 (EUI-64)
- DstAddrMode: 0x03 (EUI-64)
- DstPANId: 0xFFFF
- DstAddr: EUI-64 of the UD
- msduLength: application-dependant

- msdu: application-dependant
- msduHandle: application-dependant
- TxOptions: 0b001 (ACK requested) or 0b000 (no ACK)
- SecurityLevel: 0x00
- KeyIdMode: 0x01 (default)
- KeySource: not used
- KeyIndex: 0x00
- QualityOfService: 0x00 (Normal priority)

7. Technical Background

7.1. Advantages of Communications at MAC Layer in P2P-PLC

The communication at MAC layer allows to:

- Avoid the increase of devices to be managed by the DCU and the DSO's Head End System.
- Avoid the joining procedure between the UD and the DCU including the maintenance of connectivity (involved the routing protocol and related overhead): the UD is not a leaf node which joins a G3 network, but it connects directly with smart meter M1.

7.2. Advantages of Unidirectional Communications

The communications between smart meter M1 and the UD are unidirectional. However, to improve reliability and channel performance, optional use of MAC acknowledgements (ACK) allows smart meter M1 to identify the successful reception of an applicative frame by the UD. The option to request an ACK is always managed by smart meter M1, while the UD simply generated the ACK if requested.

The main reason for unidirectional communications is to limit the increase of network traffic and prevent external devices to influence smart meters' normal operation.

8. Abbreviations

ARIB	Association of Radio Industries and Businesses
CENELEC	European Committee for Electrotechnical Standardization
FCC	Federal Communications Commission
ITU	International Telecommunication Union
MAC	Medium Access Control
PAN	Personal Area Network
PLC	Power Line Communications
UD	User Device

9. References

[1] G3-PLC Alliance – G3-PLC Specifications – CENELEC – ARIB – FCC – revision (2022-final): Narrowband OFDM PLC Specifications for G3-PLC Networks – 2022