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Use of G.hn in Industrial Applications

Summary

Power-line communication (PLC) provides a cost-effective way to enable digital transformation for traditional industrial businesses. This will trigger new business opportunities through satisfying specific requirements in terms of data rate, latency, reach of the communication, etc. Recommendation ITU-T G.9960/1, known as "G.hn" is a unified protocol for multi-media (power line, coax, twisted pair and plastic fiber), continuously evolving to expand its capability for industrial applications.

The technical paper "Use of G.hn for Industrial Applications" summarizes a set of industrial use cases (including Entrance Guard System of building, Smart lifting, Smart traffic light, Navigation lighting aid in airport and Charging station), where G.hn based PLC can be applied. Each use case is introduced by discussing the pain points and how the specific requirement can be addressed by G.hn based PLC technology.

It is believed that G.hn based PLC technology is a promising candidate for digital transformation in industry.

Keywords

G.hn, Power line communication, Industrial application.

Change Log

This document contains Version 1 of the ITU-T Technical Paper "Use of G.hn in Industrial Applications" agreed at the ITU-T Study Group 15 meeting held in Geneva, 27 January – 7 February 2020.

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Technical Paper: Use of G.hn in Industrial Applications

1 Scope

This technical paper summarizes a set of use cases for G.hn based PLC in industrial applications. Each use case is discussed by description and requirement for PLC technology. This document intends to provide guidance for G.hn based PLC technology to enter a new area beyond home network.

2 References

[ITU G.9960] Recommendation ITU-T G.9960 (2018), *Unified high-speed wire-line based home networking transceivers – System architecture and physical layer*

[ITU G.9961] Recommendation ITU-T G.9961 (2018), *Unified high-speed wireline-based home networking transceivers – Data link layer specification*

[Fortinet white paper] *Understanding IP Surveillance Camera Bandwidth* (2017)

3 Definitions and acronyms

3.1 Definitions

Term	Definition
RS-485	RS-485, also known as TIA-485(-A) or EIA-485, is a standard defining the electrical characteristics of drivers and receivers for use in serial communications systems.
Wi-Fi	A product branding of Wi-Fi alliance based on IEEE 802.11 specifications
Zigbee	A product branding of Zigbee alliance based on IEEE 802.15.4 specifications

3.2 Acronyms

AC	Alternating Current
CAN	Controller Area Network
DC	Direct Current
DLL	Data Link Layer
EP	End Point
GW	Gateway
IoT	Internet of Things
LTE	Long Term Evolution
MAC	Medium Access Control
P2MP	Point to Multi-point
P2P	Point to Point
PHY	Physical
PLC	Power Line Communication
QoS	Quality of Service
STP	Shielded Twisted Pair
UTP	Unshielded Twisted Pair

4 Introduction

With the evolving of digitalization in industry, new requirements are coming out on monitoring and controlling the components/devices engaging in the industrial process. This requires communication technologies to satisfy the needs for each specific application. The challenge is that it may require additional features defined in the current technology to fulfil the very diverse requirements. These include but not limit to large number of nodes, robust transmission with very few bits, extremely long distance reach, guaranteed latency, etc.

Current G.hn technology is able to work on different copper mediums (i.e. power line, twisted pair and coax cable), plastic optical fiber or visible light. Therefore, G.hn is promising to be the one to facilitate digital revolution in industry. This technical paper intends to collect use cases on use of G.hn in industrial applications, further guiding the development of the technology to fulfil the dedicated requirements.

5 Use Cases

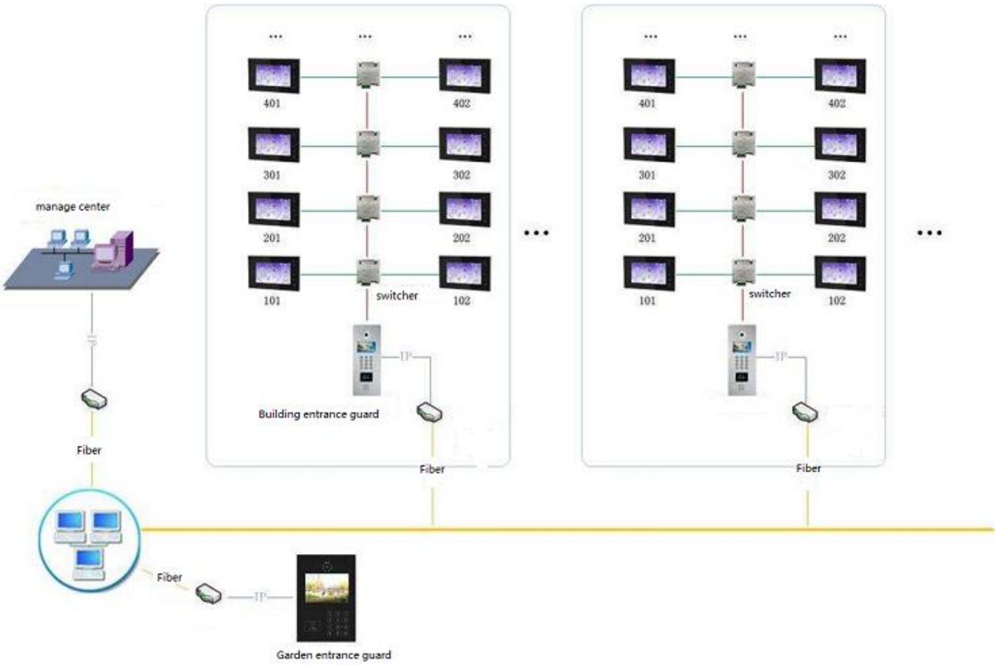
5.1 Use case 1: Entrance Guard System of building

5.1.1 Description

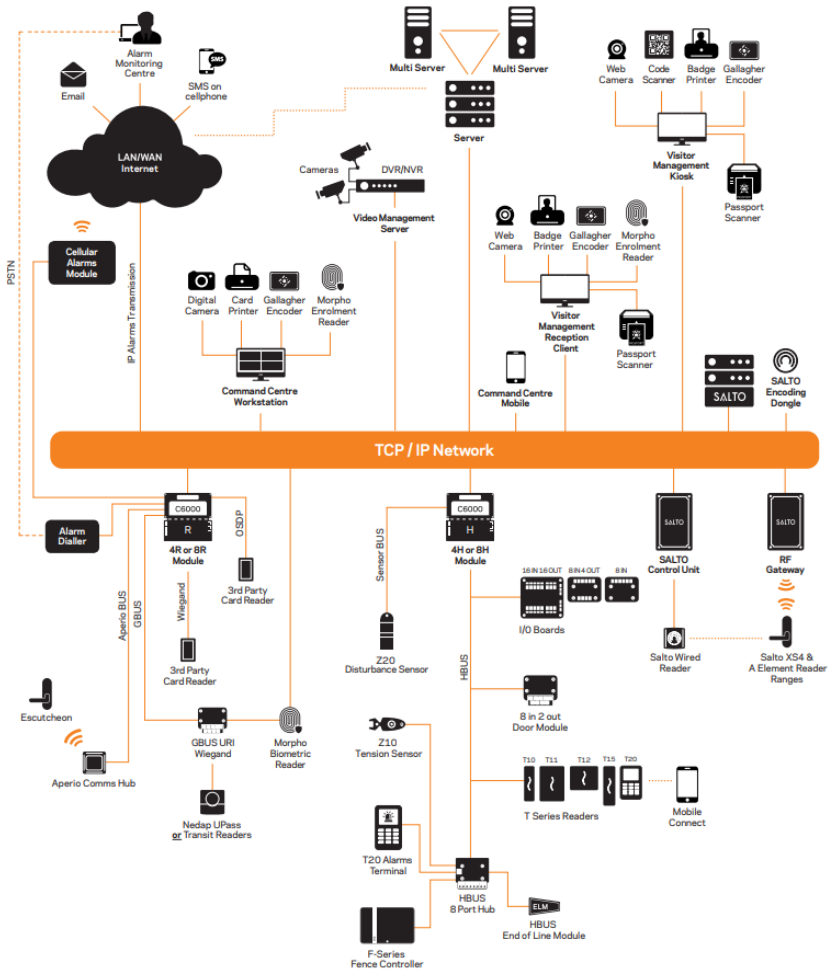
Entrance guard system provides access permission of visitor or resident to enter the building through voice or video identification. In general, visitor inputs the access code, such as room number, to initial the connection. Permission of door open is approved if the owner of the room identifies the visitor. In addition, smart building also provides coordination of building facilities to enable smart service. For example, before or after the permission is granted, the light can be turned on in the corridor and the elevator can be called for the visitors automatically.

To facilitate these smart connection in the building, the functioning building components should be connected. The basic communication service within this use case including voice, video, IoT command, etc.

Figure 1 shows the concept of Entrance Guard System of building. The gate controller in the front door of the building usually has a physical connection with control panel in each resident's room, leading to a logical topology of P2MP. Nowadays, to implement the connection, additional wire (STP or UTP) are indispensable to be deployed and floor switchers are necessary. Specifically, to provide video identification will require extremely high deployment complexity based on coax or Ethernet cable to construct the network. To implement the connection between sensors and the gate, RS 485 protocol or other private protocols are adopted and additional wires are required.



a） Building entrance guard scenario



b） Multiple entrance guards connection scenarios

Figure 1 Entrance Guard System

5.1.2 Requirements of the use case

To re-use the power line resource that provides power to control panel and entrance guard system, PLC can be a potential and better way to connect all the in-home control panels and entrance guard system. The use case requires:

1. Support enough number of nodes: apartment (typical 20 floors with 15 rooms per floor) is a typical scenario in city centre. It is necessary to maintain more than 300 connections for this individual building.

   NOTE: more nodes/connection may be required depending on the building construction.

2. Support communication over a loop length of larger than 20*3 = 60 m.

   NOTE: 3 meter is the typical height between the floor and ceiling.

3. Support real-time speech and face-to-face video streaming.

4. Support dedicated EP getting on line as required by the system

5.2 Use case 2: Smart lifting

5.2.1 Description

Downlink static/real-time advertising and uplink video streaming are the two basic services that exist in the car of lift. To facilitate communication between control room in the roof of the building and lift car for advertisement broadcasting and video backhaul, wireless access technologies (Wi-Fi/LTE) are used as one of the solutions in the current deployment. However, the unexpected interference within the building causes significant instability in Wi-Fi communication. Moreover, the operator could not suffer from operating cost by using LTE to do real-time downlink/uplink video streaming. It is well known that travelling cable provides power support and dedicated robust communication channels for control command and information exchange. Therefore, it is potential to reuse the power line in travelling cable to provide broadband and robust broadband data transmission.

Figure 2 shows a typical application of PLC in lift scenario. The topology of link is a simple P2P structure and data rate is expected to be less than 30 Mbps, potentially servicing for multiple HD video cameras.

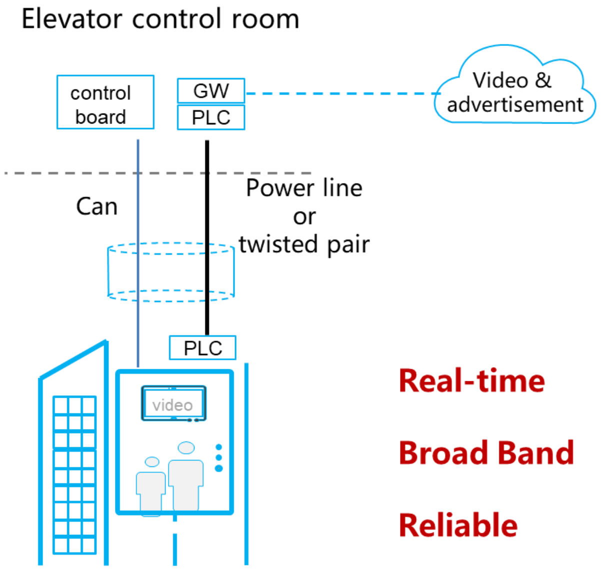


Figure 2 PLC usage of smart lifting

5.2.2 Requirements of the use case

To re-use the travelling cable to deliver the video service, PLC needs to provide:

1. Best effort on P2P transmission. This requires the improvement of the MAC efficiency by reducing any possible redundancy.
2. Noise mitigation should be consider to improve performance. It is found that noise is strong in both ends of the connection. As shown in Figure 3, strong noise shows up in the frequency band from DC to 20 MHz, which is the golden spectrum for baseband signal transmission of PLC. This noise greatly deteriorates the performance. In addition, the noise is non-stationary and keeps changing during the movement of the lift car.

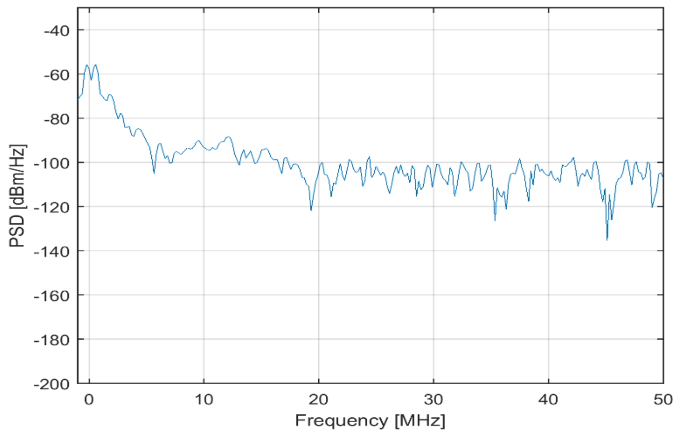


Figure 3 An example of analysis of the noise spectrum

3. QoS guaranteed video streaming: real-time video streaming is the key service in smart lift.

5.3 Use case 3: Smart traffic light

5.3.1 Description

Smart traffic light system intends to provide a central control of the traffic flow and relevant smart terminals, including traffic light, count-down device, etc. The existing solution utilizes additional CAN BUS wire to facilitate such controls. This leads to extra cost of copper wires and its deployment, which also makes headend a larger size and a complex design. Moreover, a powering system is embedded in smart traffic light system to supply power for all the active terminals. Therefore, power line could be re-used as infrastructure for power transfer and communication. This use case describes a possibility to use PLC technology to collect information from smart terminals and further control them.

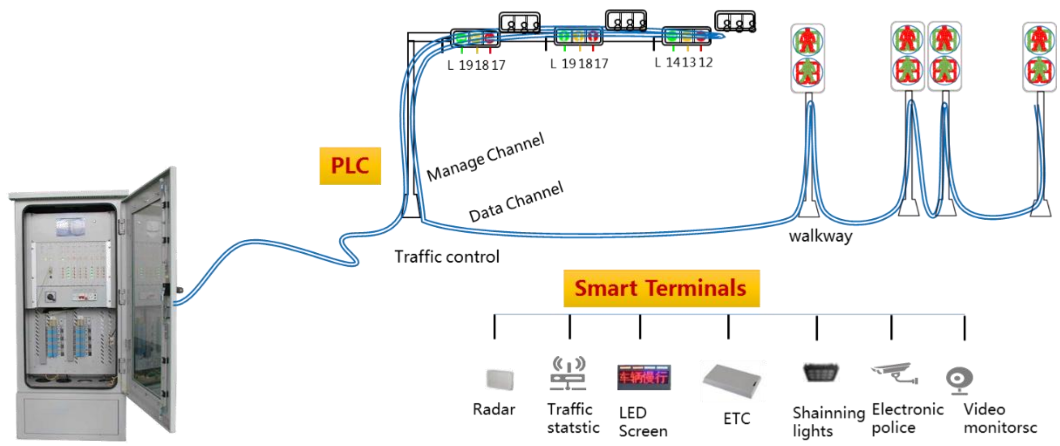


Figure 4 PLC usage of smart traffic

5.3.2 Requirements of the use case

To re-used the power infrastructure to facilitate communication between central control system and smart terminals, PLC needs to satisfy:

1. Necessary bandwidth for information collection and terminal control.
2. Capability to support enough number of nodes with low data rate communication.
3. The PLC network should support broadcast transmission to improve efficiency.
4. For count-down service, RTT and jitter should be lower than 200 ms.

5.4 Use case 4: Navigation lighting aid in airport

5.4.1 Description

Airport lighting is a standardized pattern of lights for identifying key locations or route in the airport. It helps the pilot locate and define the runway and airport environment. Airport lighting such as runway edge lights, in-pavement lights, and sequence flashing lights, is not continuous at airports with minimal traffic in order to save money when not in use. Furthermore, navigation car sometimes is used to guide approaching fly to a target gate. It is expected a cost-effective solution to realize smart control of airport lighting.

The lighting system in a large airport normally has a loop length for several km or even more than 10 km. The lights are cascaded with a special power cable, which is normally shielded to protect radiation leakage and buried in the land. This infrastructure can be re-used to convey PLC signals by using appropriate signal coupler. Compared to deploy new cable, such as optical fiber, PLC technology provides an easy establishment of the communication system by modifying light module in the wells.

5.4.2 Requirements of the use case

To re-used the lighting power infrastructure to facilitate communication between air traffic control tower/flight service station and the lights, PLC needs to satisfy:

1. Up to 15 km long distance communication. Except the wire attenuation, additional attenuation may generated by cable aging, transformer, connecting components, etc., shown in Figure 5.
2. Since there will be hundreds of lights in one specific long loop, appropriate number of relay hops needs to be supported.
3. Navigation function requires “real-time” control target lights turned on/off. The reaction time (between the control command sent and successfully received the command) should be limited to a certain level, i.e., the round-trip delay including the jitter of the successful communication is less than 400ms.

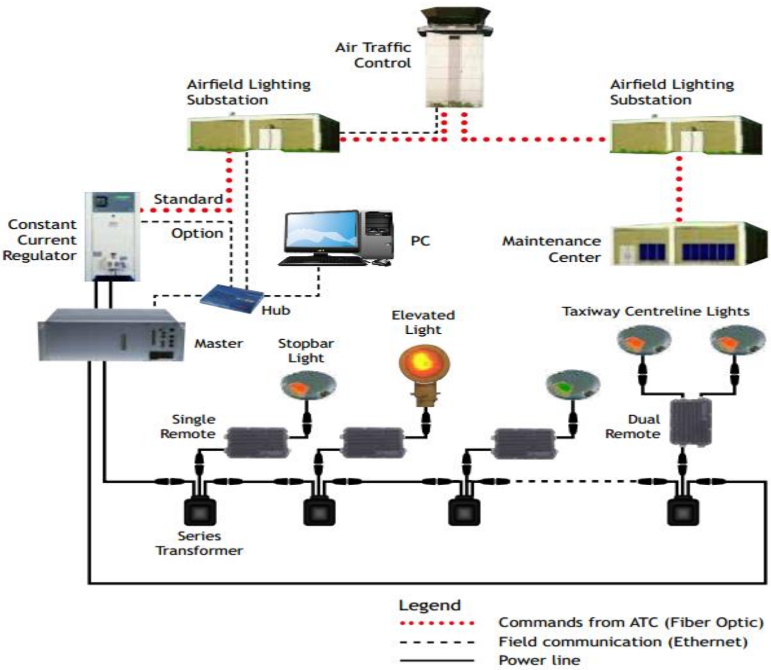


Figure 5 PLC usage of smart navigation lights in airport

4. Crosstalk avoidance is necessary in some loops. Collocated cables of different loops exist in some distance starting from running out of the lighting center. The PLC system running on different loops needs to coordinate each other to overcome crosstalk effect (i.e. FEXT or NEXT).

5.5 Use case 5: Charging station

5.5.1 Description

As required by the government to reduce carbon dioxide in the future, industry of electrical vehicle grows rapidly in the past a few years. The facilities of charging stations are then built up to match the needs for using electrical cars. This brings new business on providing ease of utilization of these stations, including fast payment for customers, and easy query, operation and station management for facility operator. Therefore, communication among charging stations, cars, edge service center and cloud control center are necessary. For the local communication, wireline technologies such as

PLC, Ethernet, and RS485, and wireless technologies such as zigbee, Wi-Fi and LTE are considered.

However, charging stations are normally installed in the underground garage, at the roadside or alongside the wall. For most of cases of underground garage scenario, due to the obstacle (i.e. wall), wireless way required complex deployment, additional backhaul facility and power source. As can be seen, electric system is embedded in charging stations system to supply power. Therefore, power line could be re-used as infrastructure for transmit information. This use case describes a possibility to use PLC technology to control and manage charging station facility.

5.5.2 Requirements of the use case

To re-use the charging stations power line infrastructure to enable communication among different components in the charging system, PLC needs to satisfy:

1. Capability to maintain the links up to 200 nodes;
2. Up to 700m long distance communication for one hop and 1500m for two hops;
3. Based on the communication distance, 2Mbps data rate should be supported.

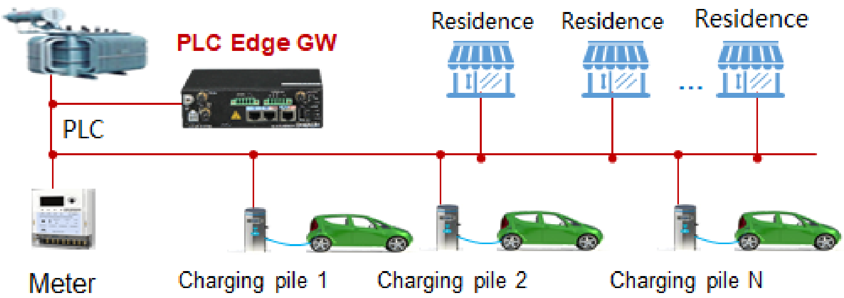


Figure 6 PLC application in charging station scenario

6 Summary

Power line communication (PLC) technique provides a cost-effective way to enable digital service for traditional industrial business. This will trigger new business opportunities through satisfying specific requirements in terms of bandwidth, latency, reach of the communication, etc. ITU-T G.hn recommendation is a promising candidate, currently continuous evolving to expand its capability for industrial applications.