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Trasmissione di segnali a banda larga per mezzo di impianti elettrici

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Sommario

- 1) Cosa sono le PowerLine Communications
- 2) Cosa si può fare con le PLC
- 3) Confronto tra PLC e altre tecnologie concorrenti
- 4) La domotica con le PLC

Cosa sono le Power Line Communications

- La tecnologia **Power line communication** usa le linee elettriche di un appartamento, edificio, o rete di distribuzione esterna per trasmettere dati da un dispositivo ad un altro.
- Sotto opportune condizioni i dispositivi sono in grado di comunicare utilizzando l'infrastruttura pre esistente senza la necessità di cablaggio addizionale.
- Questo rende la tecnologia PLC potenzialmente conveniente rispetto alle tecnologie concorrenti.
- In ambiente domestico/residenziale è di fatto una tecnologia "plug and play".

Cosa sono le Power Line Communications

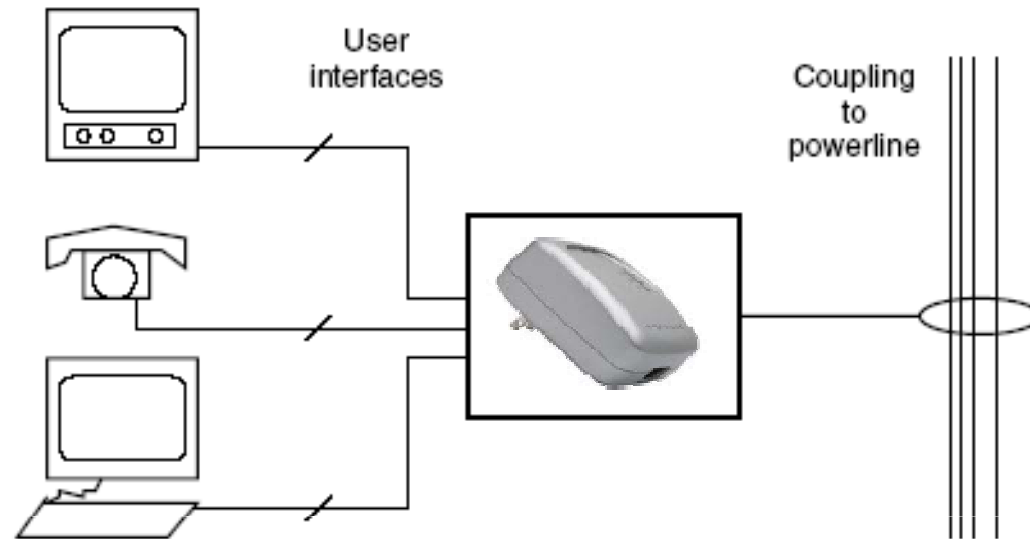
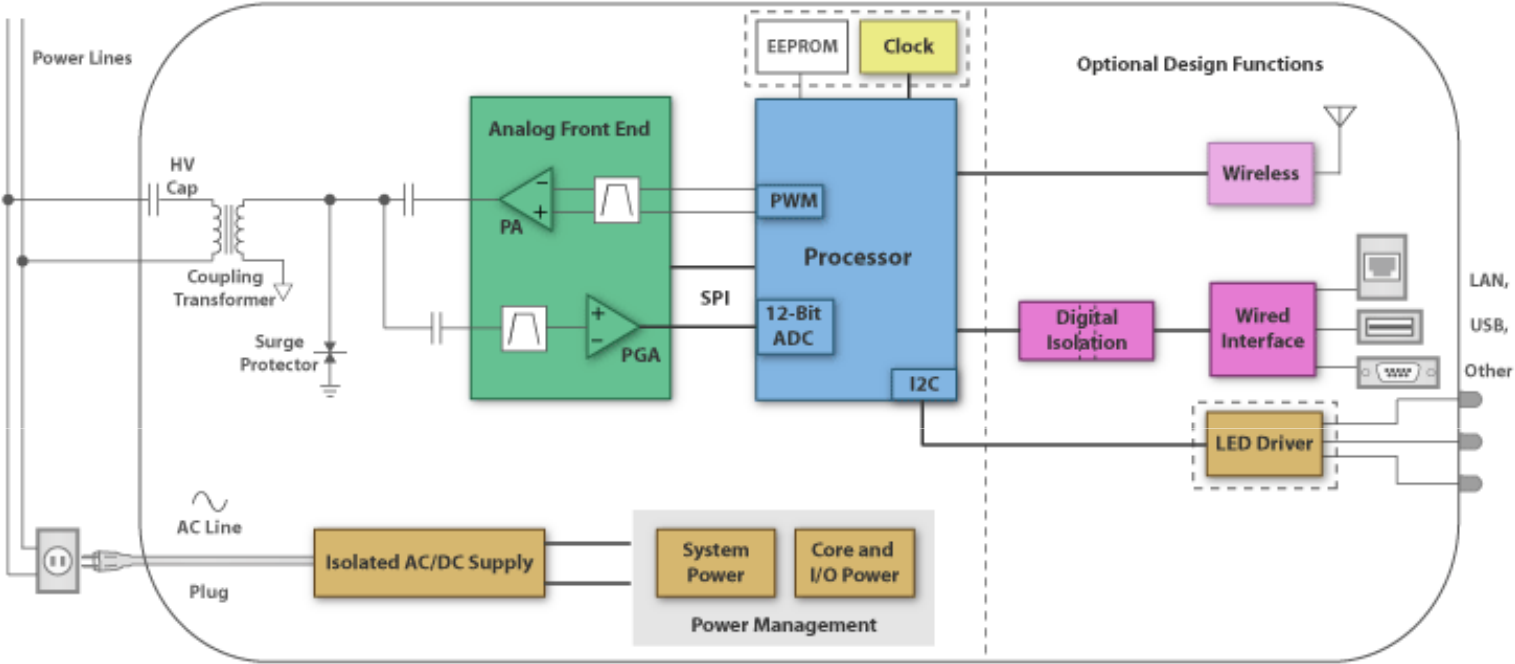


Figure 2.12 Functions of the PLC modem

Le informazioni che in genere vengono trasmesse e ricevute da un sistema PLC possono essere raggruppate nelle seguenti categorie:

- Dati
- Segnali telefonici, telecontrollo e teleprotezione
- Segnali a banda larga (P. Es internet, audio-video)

Cosa sono le Power Line Communications



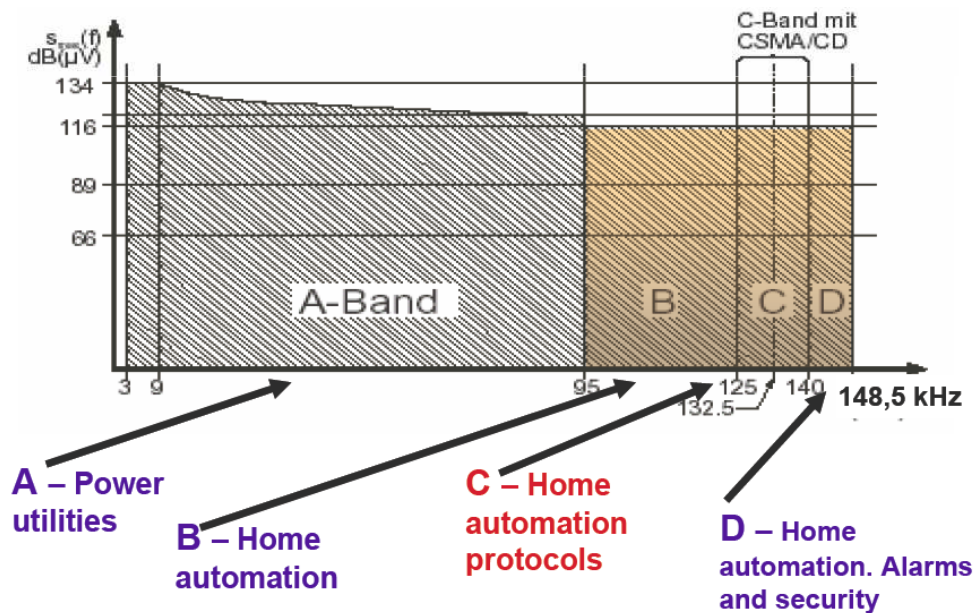
Cenni Storici

- First applications date back to early 1920s, on HV lines.
- The first standard is the European CENELEC EN 50065, which mandates the use of the frequency range 3-148.5 kHz (1991).
- The first commercial attempt to use PLC for last mile access dates back to 1997, when Nortel announced the NorWeb partnership with United Utilities (a UK power utility company)
 - Limited trials of broadband Internet access through power lines were conducted in Manchester and NorWeb prototypes were able to deliver data at rates around 1 Mbps.
 - Cost and commercial viability became questionable and the pilot project was terminated few years later in 1999.
- In the past few years, interest in the technology has picked up again and possible applications have multiplied.

Narrowband Power Line Communications

- Band A, to be used by power supply utilities (for energy related services).
- Bands B and C, provided for private usage (building and home automation).
- Narrowband PLC systems provide data rates up to a few thousand bits per second
- The maximum distance between two PLC modems can be up to 1 km. To overcome longer distances, it is necessary to apply a repeater technique.

CENELEC EN 50065

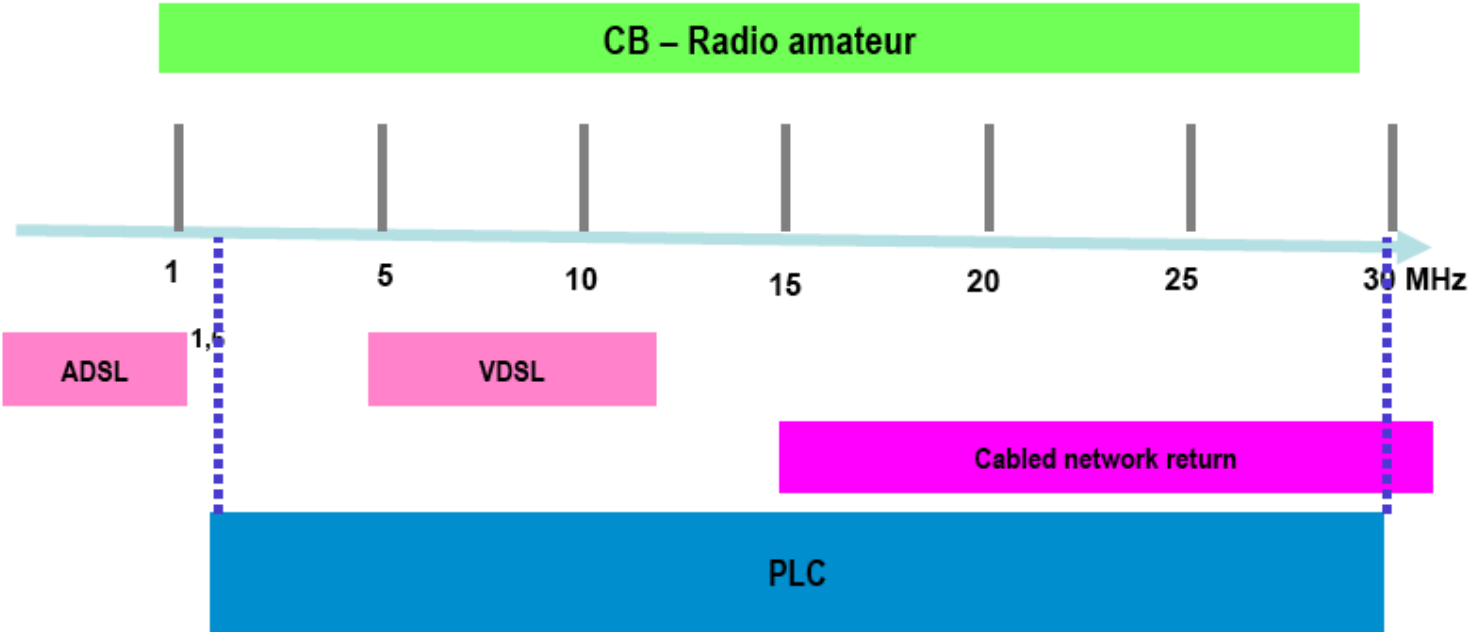


Broadband Power Line Communications

- For the realization of higher data rates, PLC transmission systems have to operate in a wider frequency spectrum (up to 30 MHz).
- However, there are no PLC standards that specify the operation of PLC systems out of the frequency bands defined by the CENELEC norm.
- **PLCForum**: international organization with the aim to unify and represent the interests of players engaged in PLC from all over the world.
- **HomePlug Powerline Alliance**: non profit corporation formed to provide a forum for the creation of open specifications for high speed home PLC.
- Higher data rates (up to 200 Mbps) and lower distance covered (order of hundred meters).

Broadband Power Line Communications

**Work in progress: CENELEC SC205A WG10
up to 30 MHz**



Cosa si può fare con le PLC – Energy related services

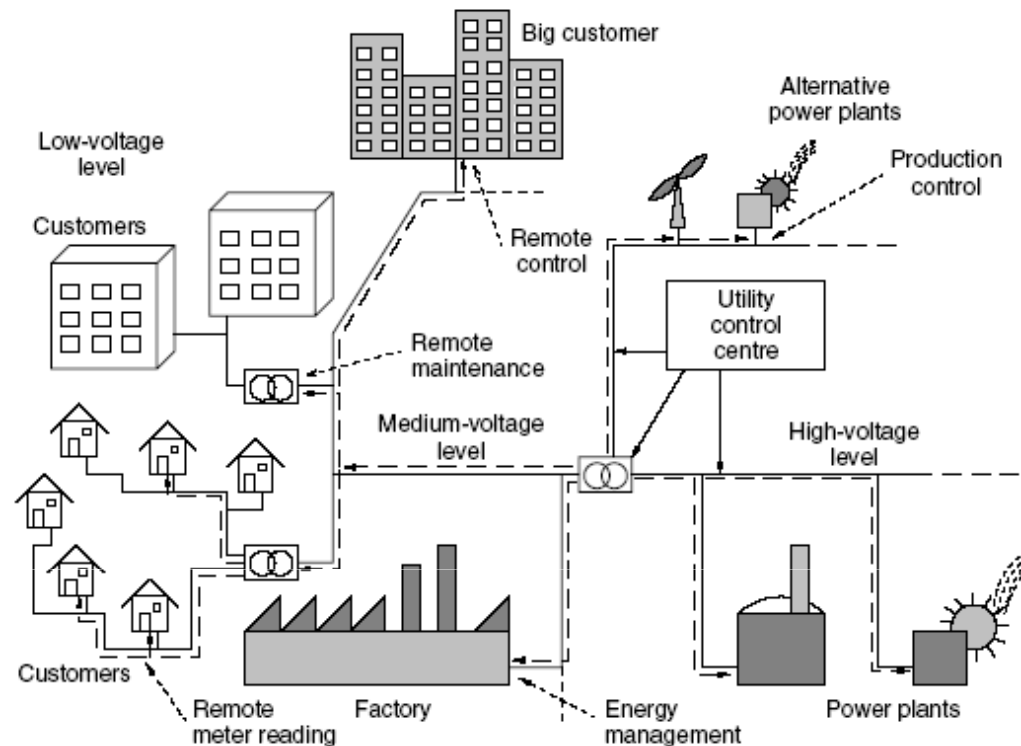


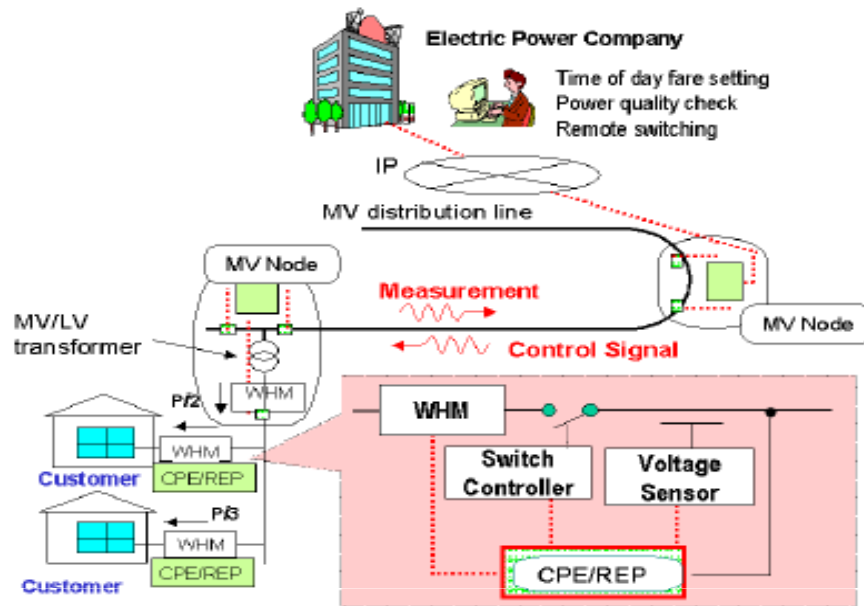
Figure 2.9 General structure of a PLC system used for energy-related services

A power utility can use PLC to realize internal communications between its control center and different devices, ensuring remote control functions, without building extra telecommunications network or buying network resources at a network provider.

Cosa si può fare con le PLC – Energy related services

- PLC can be used for **remote reading** of a customer's meter units, which additionally saves cost on the personnel needed for manual meter reading.
- Finally, PLC can also be used by the utilities for **dynamic pricing** (e.g. depending on the day time, total energy offer, etc.), as well as for **observation and control** of energy consumption and production.
- Lately utilities have been trying to integrate an increasing number of small power plants (small hydroelectric power stations, wind plants, and so on). However, the small power plants are not completely reliable and their power production varies depending on the current weather conditions. Therefore, the regions that are supplied by the small plants should also be supplied from other sources if necessary. For this purpose, the utilities need a **permanent communication** between their system entities, which can be at least partly realized by PLC as well.

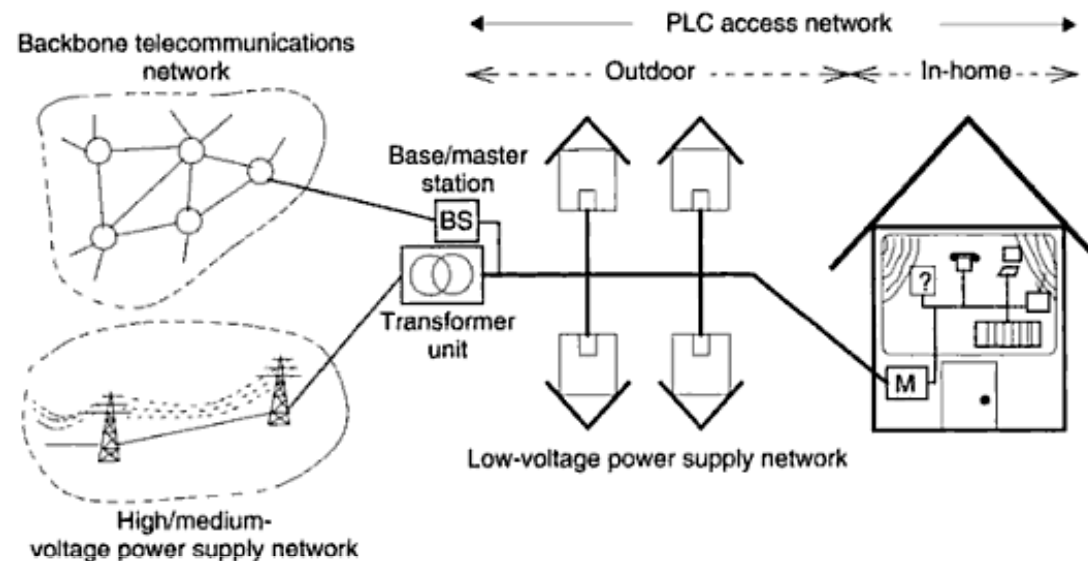
Cosa si può fare con le PLC – Smart Grids



- Today existing and planned implementations of smart grids provide a wide range of features including the PLC technology.
- **Automated Meter Reading** and **Automated Meter Management** via PLC.
- In cooperation with **Consumer Premise Equipment** and **Repeaters**, **WebHost Manager** controls the flow of MV level powers.

- **Load Adjustment**: the load reduction by even a small portion of the clients may resolve the problem of fast-varying loads.
- **Demand Response Support**: enables generators and loads to automatically interact in real time, coordinating the demand to flatten power demand spikes.
- **Distributed Power Generation**: allows individual loads to fit their generation directly to their load making them independent from grid power failures.

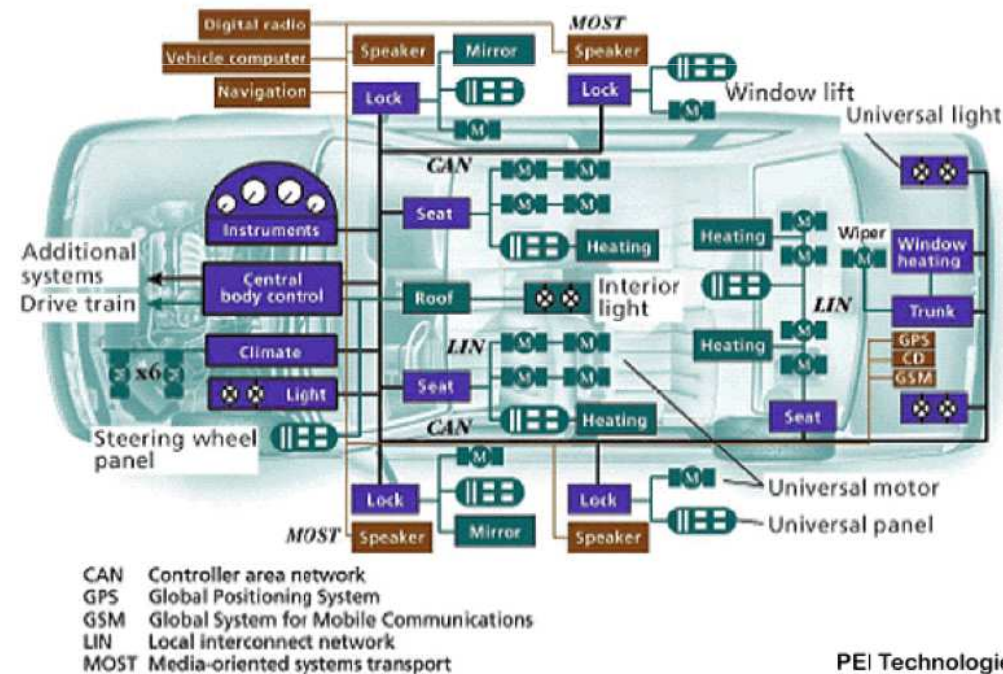
Cosa si può fare con le PLC – Last Mile



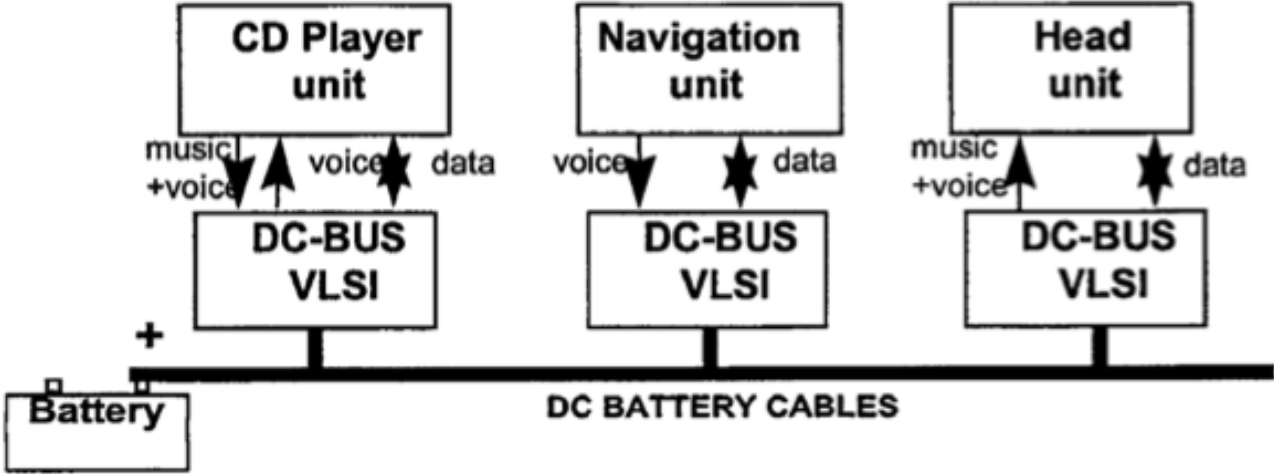
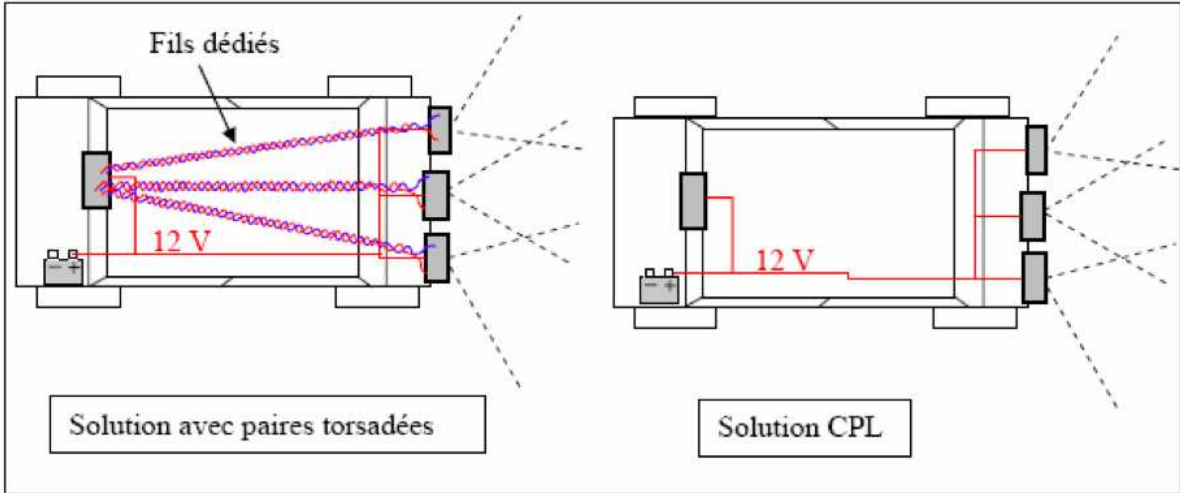
- PLC can be used for the so-called “last mile” communication networks.
- The PLC access networks are connected to the backbone communication networks via a base/master station placed within the transformer unit.
- The PLC subscribers are connected to the network via a PLC modem placed in the electrical power meter unit.

Cosa si può fare con le PLC - Automotive

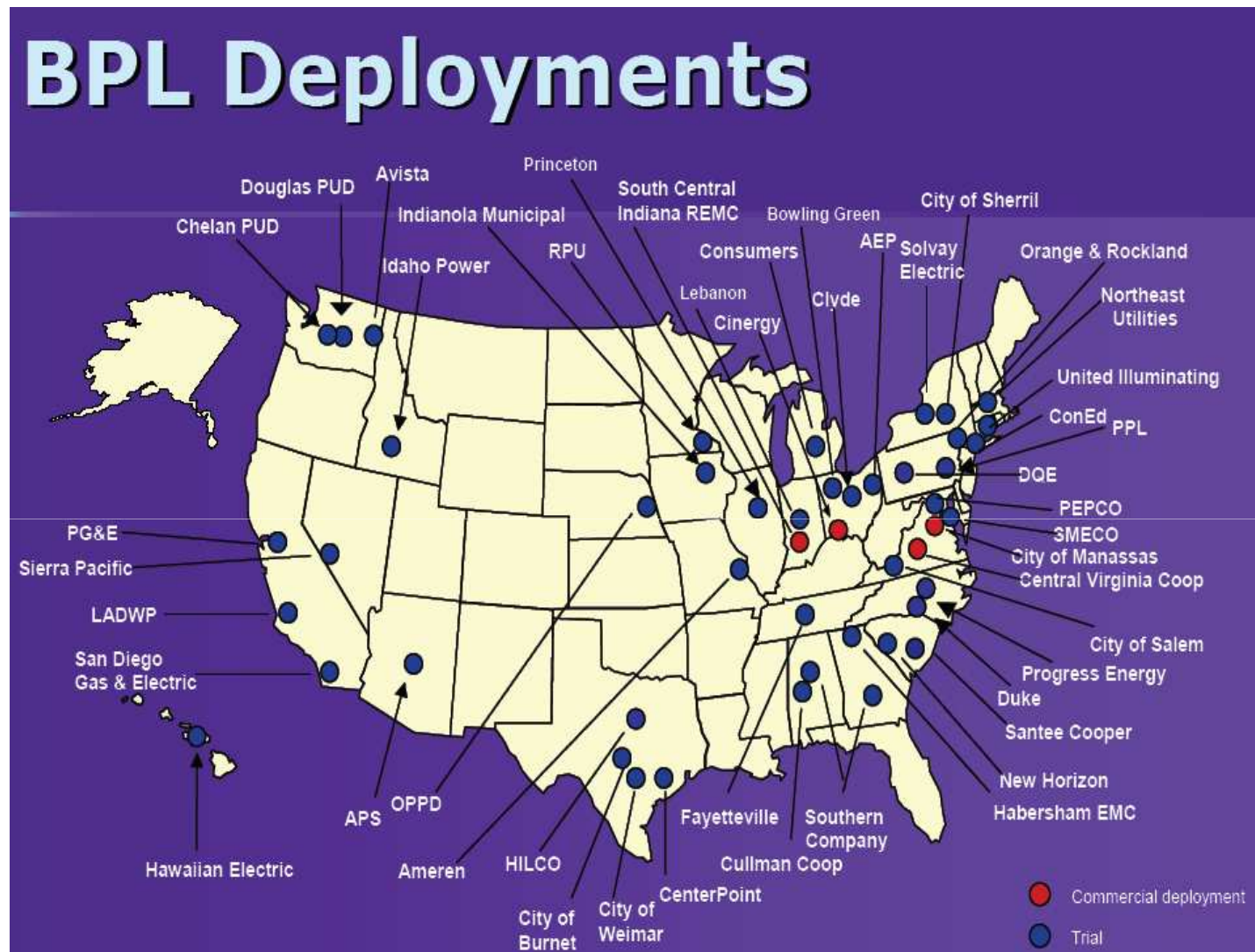
- In any vehicle (from automobiles to ships, from aircraft to space vehicles), separate cabling is used to establish the PHY of a local command and control network.
- The in-vehicle power distribution network may well perform double-duty, as an infrastructure supporting both power delivery and broadband digital connectivity.
- Weight, space and cost savings (aircraft, auto).



Cosa si può fare con le PLC - Automotive



La diffusione delle PLC



BPL project and trials in the US

La diffusione delle PLC

Country (Area)		State of power distribution lines	State of PLC penetration
Europe	Spain	Each MV/LV transformer supplies power to about 300 homes. The percentage of underground distribution lines is high.	Electrical power companies ENDESA and Iberdrola began commercial service in 2003.
	France		Electrical power company EDF is conducting testing.
	United Kingdom		Electrical power company SSE began access-type service.
	Germany		Electrical power company PPC is providing a commercial access-type service.
North America		Each MV/LV transformer services 5 to 10 households.	Now that the FCC has declared the policy for promoting Internet access by power lines, PLC penetration is expected to accelerate down the road.
South America		Power is supplied from overhead LV distribution lines.	In Chile and Mexico, trials are underway.
Asia	Singapore and Malaysia	Mainly Underground distribution lines. There are many high rises and office buildings.	Trials are in progress.
	China	Underground power lines in big cities, but overhead distribution lines are used in all other areas.	A demonstration trial is being conducted in Beijing, involving some 2,000 households.
	Hong Kong	Underground distribution lines. There are many high rises and office buildings.	Practical service is being provided to high rises, hotels, etc.
	South Korea	More of the same situation as Japan	The Radio Law, similar to the corresponding one in Japan, was relaxed.
Japan		Both high-voltage (medium-voltage by international standards) and low-voltage distribution lines are predominantly of the overhead type. In urban areas, underground cables are used.	By the Radio Law and its work-execution regulations (ministerial ordinance), use is only permitted of equipment designed to use frequency bands from 10 to 450 kHz. With effect from January 26 of 2004, the ministerial ordinance was revised to permit the performance of experiments with technology to reduce the leakage of electrical fields in the 2-to-30-MHz range.

(From ADVANCE, March 2005)

La diffusione delle PLC

- The world's largest smart meter deployment was undertaken by Enel, with over 27 million customers. Over a 5 year period beginning in 2000 and ending in 2005 Enel deployed smart meters to its entire customer base.
- These meters have integrated bi-directional communications, advanced power measurement and management capabilities, an integrated, software-controllable disconnect switch, and an all solid-state design.
- They communicate over low voltage power to data concentrators at which point they communicate via IP to Enel's enterprise servers.



La domotica e le Power Line Communications

- Building/home automation.
- PLC-based automation systems are realized without the installation of additional communications networks.
- No need of additional cables, hence cost reduction.

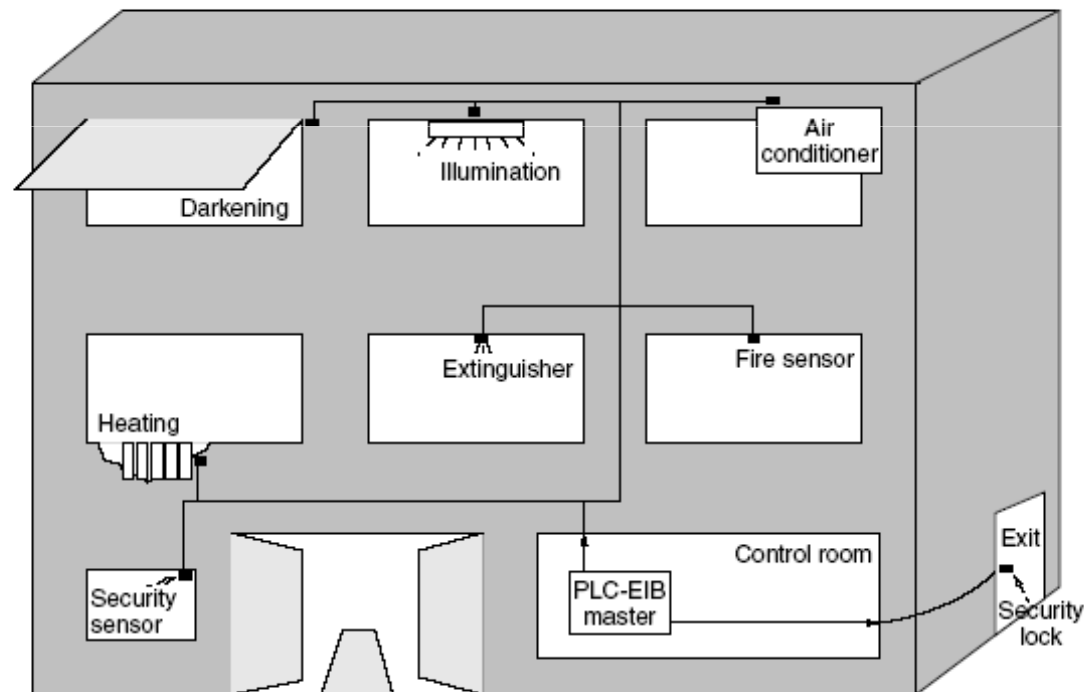
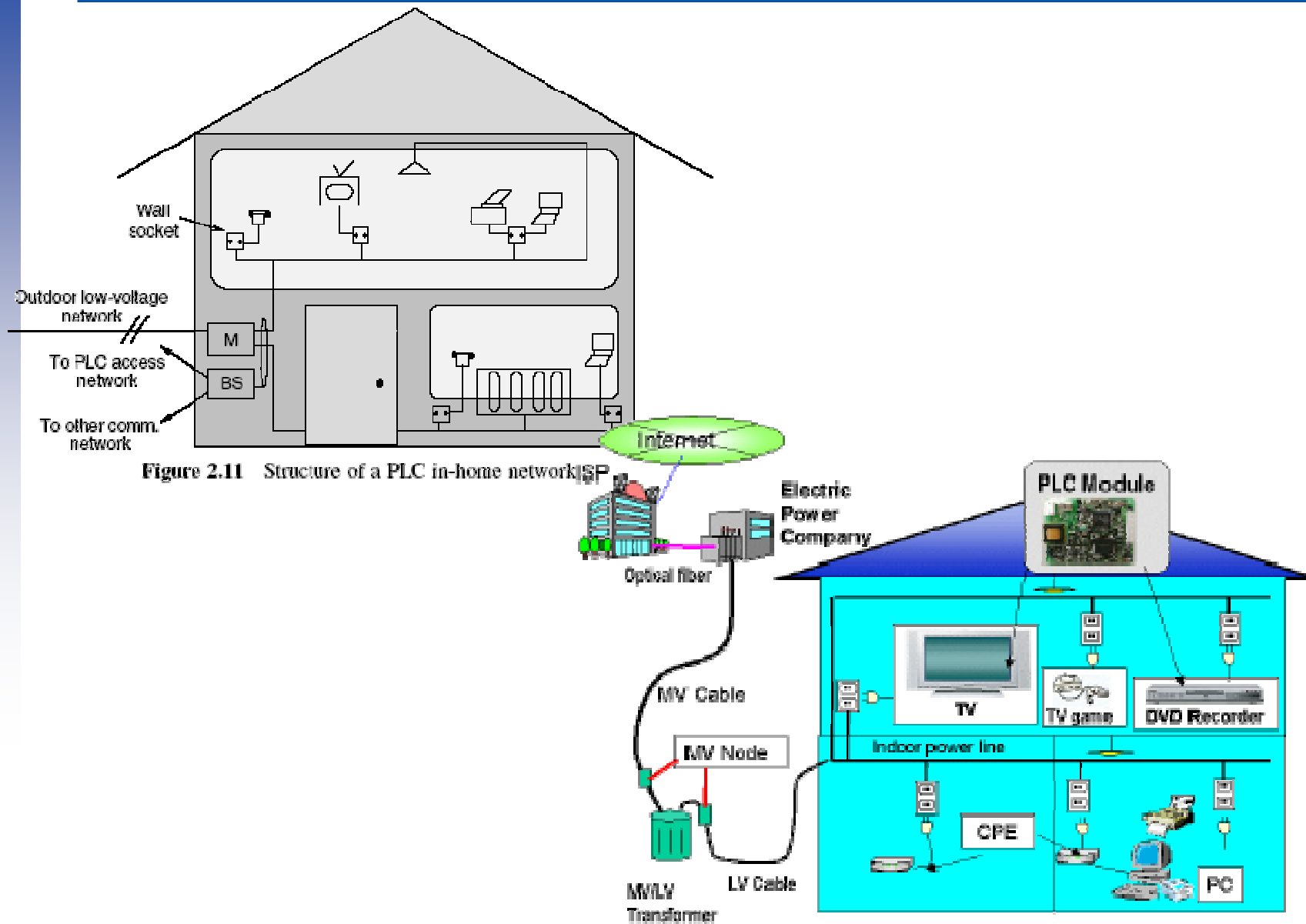


Figure 2.8 Structure of an automation system using narrowband PLC

La domotica e le Power Line Communications

- Control of various devices that are connected to the internal electrical installation (such as illumination, heating, air-conditioning, elevators...)
- Centralized control of various building systems (windows and door control).
- Security tasks (observance, sensor interconnection...)
- PLC-based automation systems are not only used in large buildings but they are also very often present in private households for the realization of similar automation tasks (home automation). In this case, several authors talk about so-called *smart homes*.

La domotica e le Power Line Communications

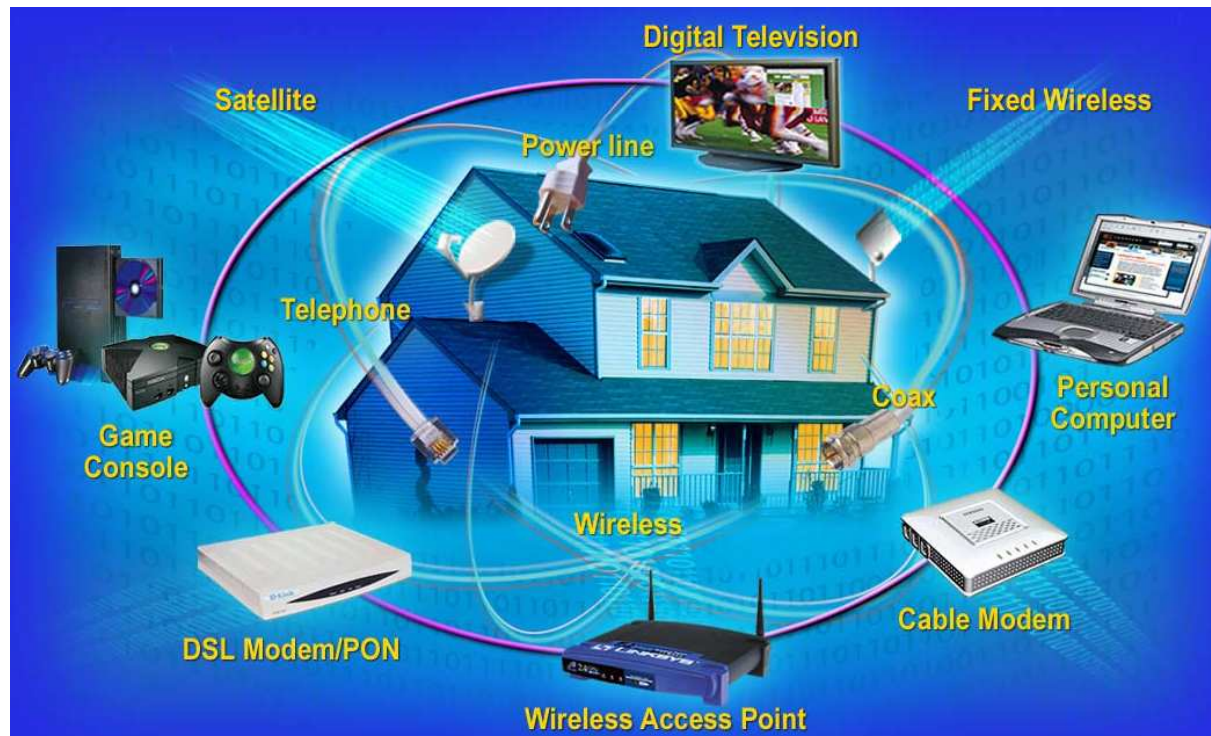


La domotica e le Power Line Communications

- PLC makes possible the realization of **local networks** within houses, which connect some typical devices existing in private homes: telephones, computers, printers, video devices, and so on. The laying of new communications cables at high cost is avoided.
- Therefore, in-home PLC technology seems to be a reasonable solution for the realization of such networks with a large number of end devices, *especially within older houses and buildings that do not have an appropriate internal communication infrastructure.*
- A remote controlled in-home PLC system is very comfortable for the realization of various automation functions (e.g. security, energy management)

La domotica e le Power Line Communications

- Also, **connection of an in-home PLC network to a WAN** communication system allows the usage of numerous telecommunications services from each electrical socket within a house.
- An in-home PLC network can be connected to the access networks provided by different network operators as well. Thus, the users of the in-home network can also profit from the liberalized telecommunications market.

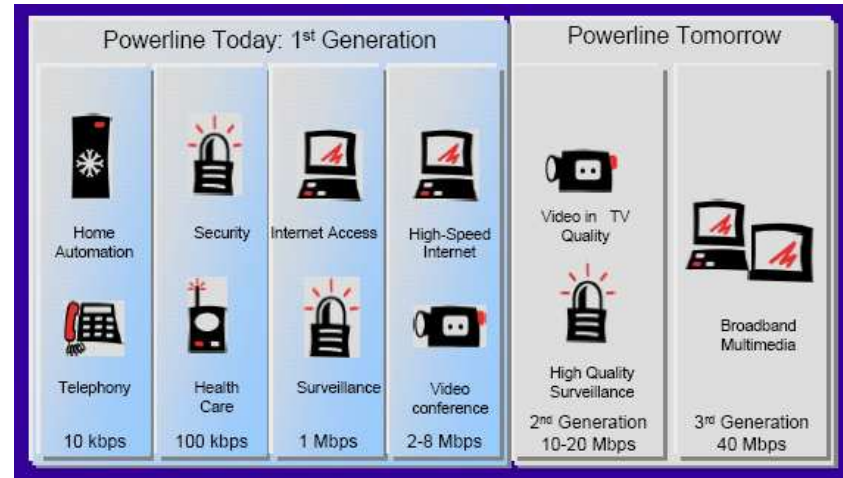


La domotica e le Power Line Communications

Application App. Rate Mbps	Scenario 1 Two Person family		Scenario 2 Six-person family with small children		Scenario 3 Six-person family with small children & teenagers	
	Qty	App. Rate Mbps	Qty	App. Rate Mbps	Qty	App. Rate Mbps
HDTV Home Theater @ 22-27.8	1	22 - 27.8	1	22 - 27.8	1	22 - 27.8
SDTV @ 3 - 7	1	3 - 7	3	9 - 21	2	6 - 14
Home Theater Audio @ 5.4	1	5.4	1	5.4	1	5.4
CD Audio @ 0.8 x 2					3	4.8
Phone- VoIP @ $(.064 + .016) \times 2 = .160$	2	0.16	2	0.16	3	0.24
IP Data @ 2	2	4	2	4	5	10
Total	6	34.5 - 44.4	9	40.6 - 58.4	15	48.4 - 62.2

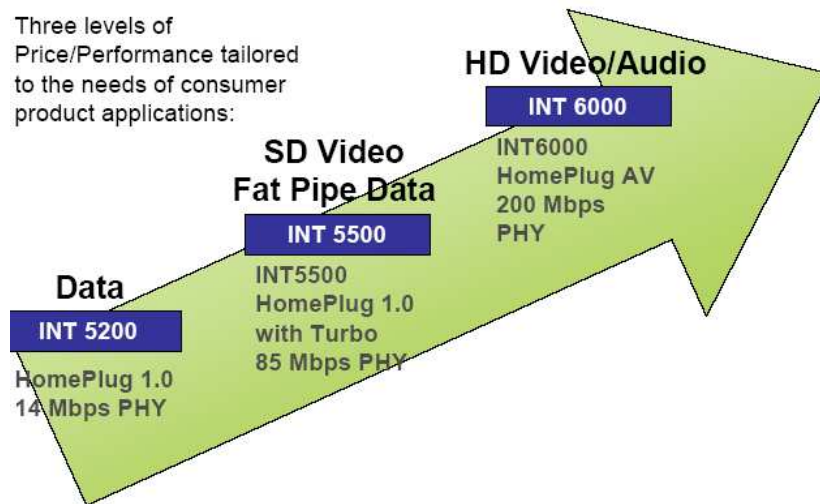
Esempio di pianificazione della banda necessaria in una rete domestica

La domotica e le Power Line Communications



PLC forum 2003

Three levels of Price/Performance tailored to the needs of consumer product applications:



Confronto tra PLC e tecnologie concorrenti

Solutions for the Digital Home

Network Comparisons: At-a-glance			
	Special Wires	Wireless	Powerline
Pros	- dedicated connection	- nodes available almost everywhere	- inexpensive - built-in encryption for security - many nodes available - single standard
Cons	- needs new wires - difficult to add nodes - expensive to retrofit	- added cost to devices - older hardware needs adapter - no single standard - possible security issues	- not ideal for handheld devices

HomePlug

Strengths

- **Simplicity**
- **Whole Home Coverage**
- Superior Security
- Quality of Service

Limitation

- No mobility

Wireless

Strengths

- **Mobility**
- Multiple RF Channels Available
- Market Penetration
- Throughput (802.11a/g)

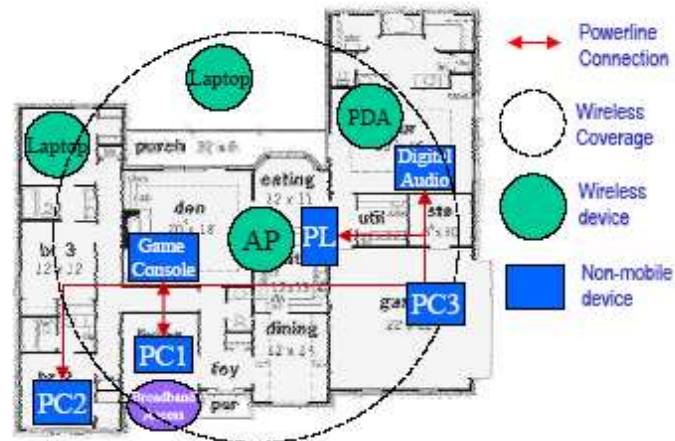
Limitations

- Coverage drop-off
- No Quality of Service differentiation
- Lack of Security

- Simple, reliable connectivity is essential to content delivery
- Wireless alone is not enough, especially for entertainment
 - Range limitations
 - Security concerns
 - Difficulty for most consumers to set up for AV content delivery
 - Why use valuable Wi-Fi bandwidth for fixed devices?
- Wireline solutions are also required

Confronto tra PLC e tecnologie concorrenti

Medium	Standard	Actual Throughput	Guaranteed QoS	No new wires	Multi-sourced	Whole House Coverage
CAT5	Ethernet (1G)	✓ ✓	-	✗	✓	✗
Phoneline	HomePNA 3.0	✓	✓	-	✗	-
Coax	MoCA	✓	✓	-	✗	✗
Powerline	HomePlug AV	✓	✓	✓	✓	✓



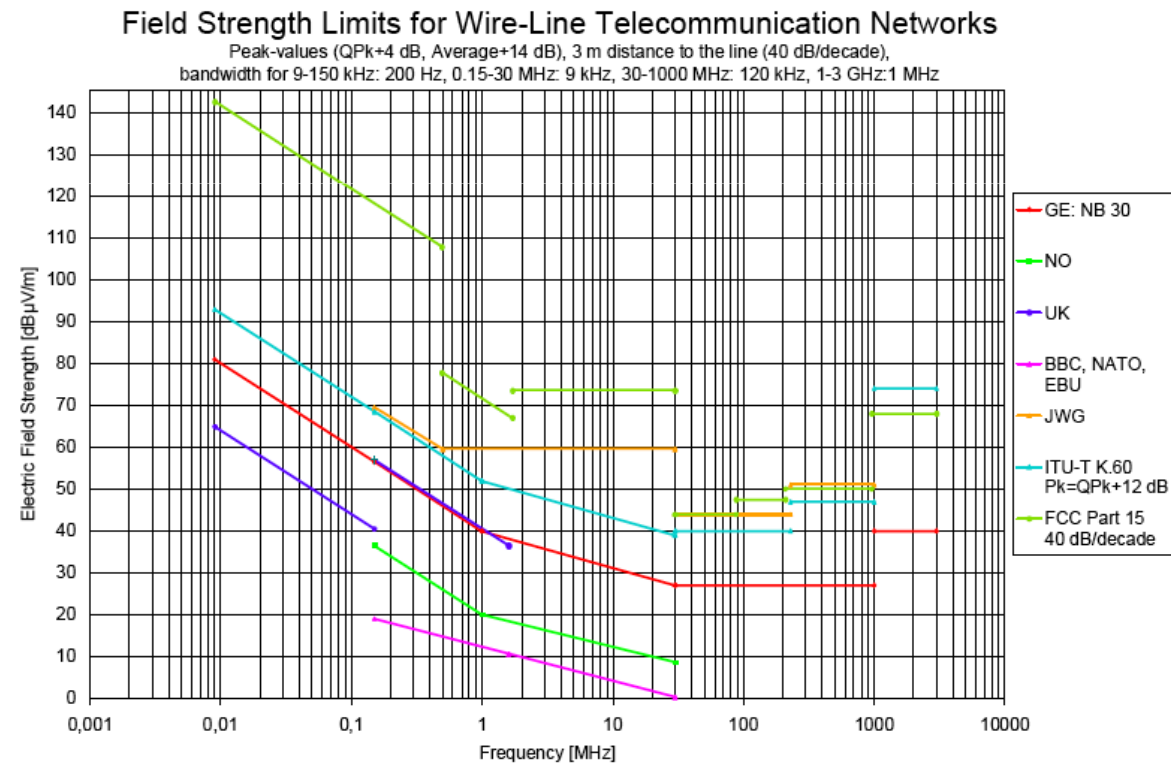
Confronto tra PLC e tecnologie concorrenti

- Simple and reliable
 - Easy to set up and use; very low return rates and service calls
 - Proven globally by service providers and consumers
- Only technology that meets requirements for AV/CE applications and PC/CE convergence
 - Reliable bandwidth with whole house coverage and robust QoS
 - Maximum ubiquity: High number of convenient outlets, no new wiring
- Useful in primary and hybrid network applications
 - Dual networks: Powerline for fixed devices; wireless for mobility
 - Backbone network for WiFi and UWB

La diffusione delle PLC - Problematiche

EMC constraints:

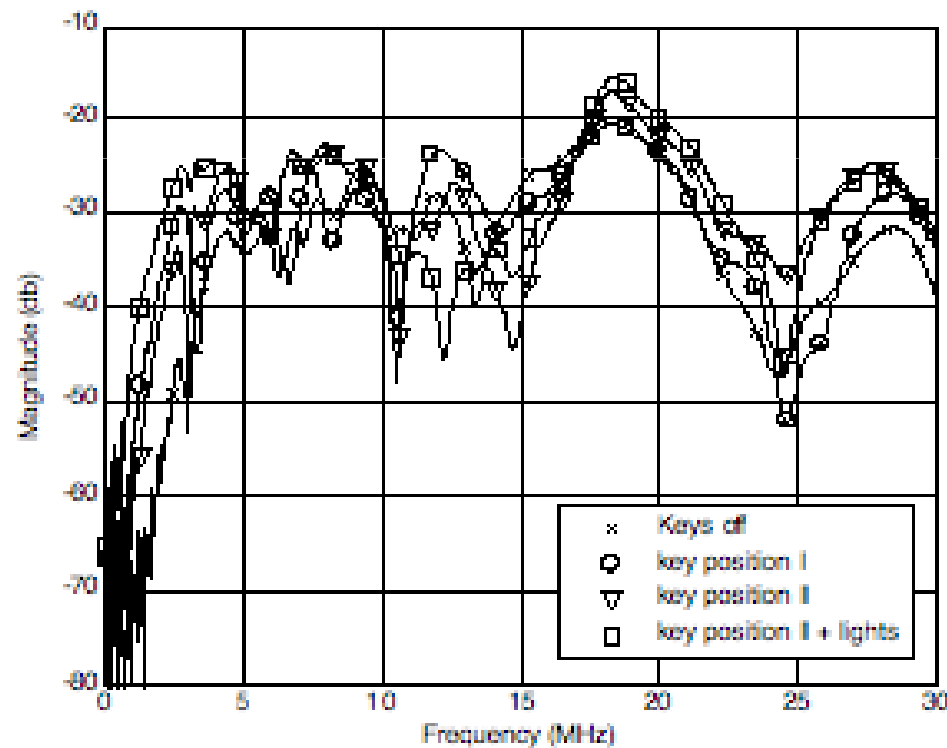
- Currently, there are different guidelines related to emission limits for PLC in different countries; however, some entities have issued regulations and guidelines with the aim of ensuring EMC between high-frequency radio transmission and PLC installations.



La diffusione delle PLC - Problematiche

Channel variation:

- The channel varies with time because of topology changes, load changes, cyclostationary variations.
- Need of real time channel estimation.



Compatibility of different PLC systems

- Coexistence between PLC systems of different suppliers
- Coexistence of the PLC access system and different indoor systems.
- Possible solutions are
 - Filtering
 - Frequency separations
 - Adaptive frequency allocations (smart modems for smart grids)

Conclusioni: pros

- PLC is a less known technology which can be economically convenient if compared to other well established solutions.
- They can be easily integrated with other technologies in order to find the most suitable solution.
- PLCs as the enabler for truly *pervasive* and *ad-hoc* networks: Just look around... power is everywhere.
 - Traffic lights, lamp posts, etc. can easily become network node.
 - Smart grid applications, better mains utilization and monitoring.

Conclusioni: cons

- PLC technology is still “young” and evolving
- Do we really need another access solution?
- Is there a solid business case?
- Lack of standardization and interoperability of products
- Not everybody convinced of the technology
 - Electromagnetic compatibility issues
 - Necessity of hybrid infrastructures, between PLC-based networks and existing wireless/fiber/copper-based ones