Smart Grid

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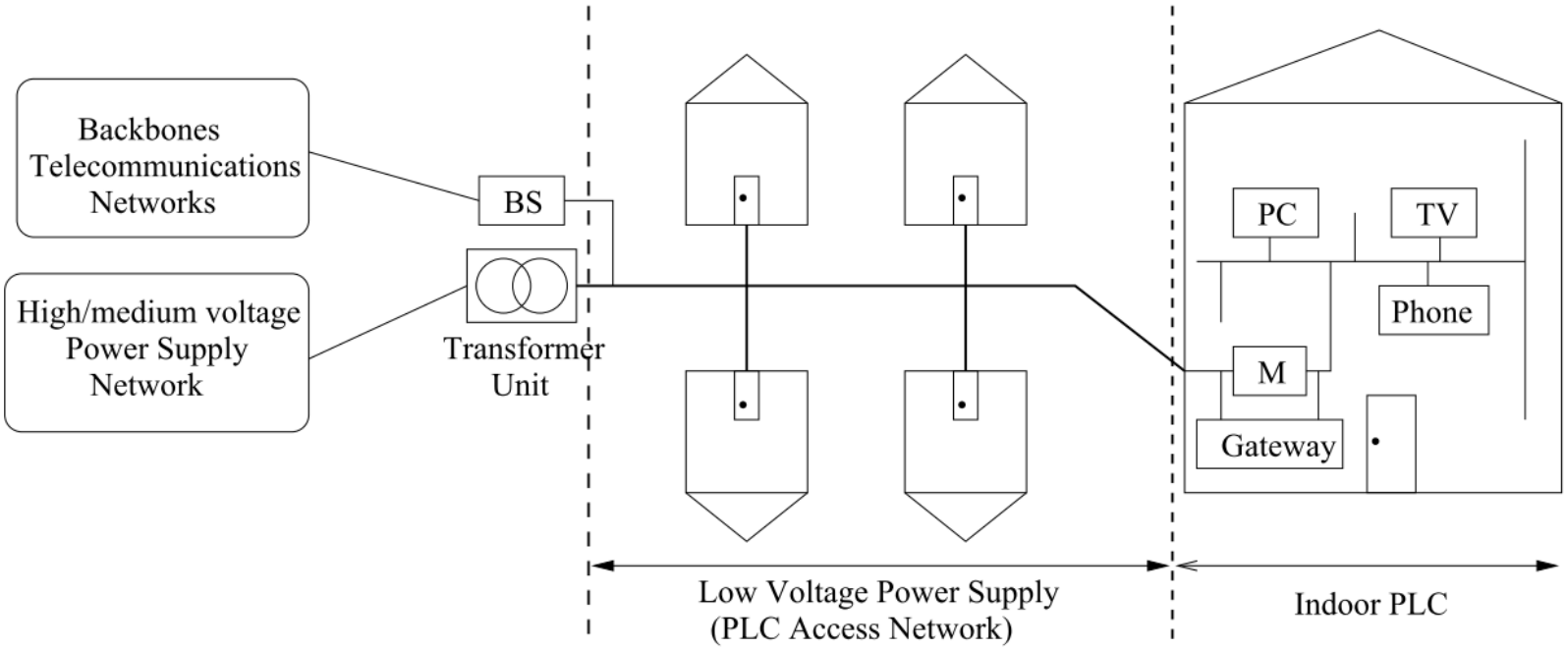
Contexte



What is interesting for us is the problem of data communication.

Plan

- Exiting solution for home communications
- PLC Channel
- PLC noise
- Problems to be solved
- Our futur activities

Data communication for smart grid

PLC Communications

- Cooperative, relaying, coding, …

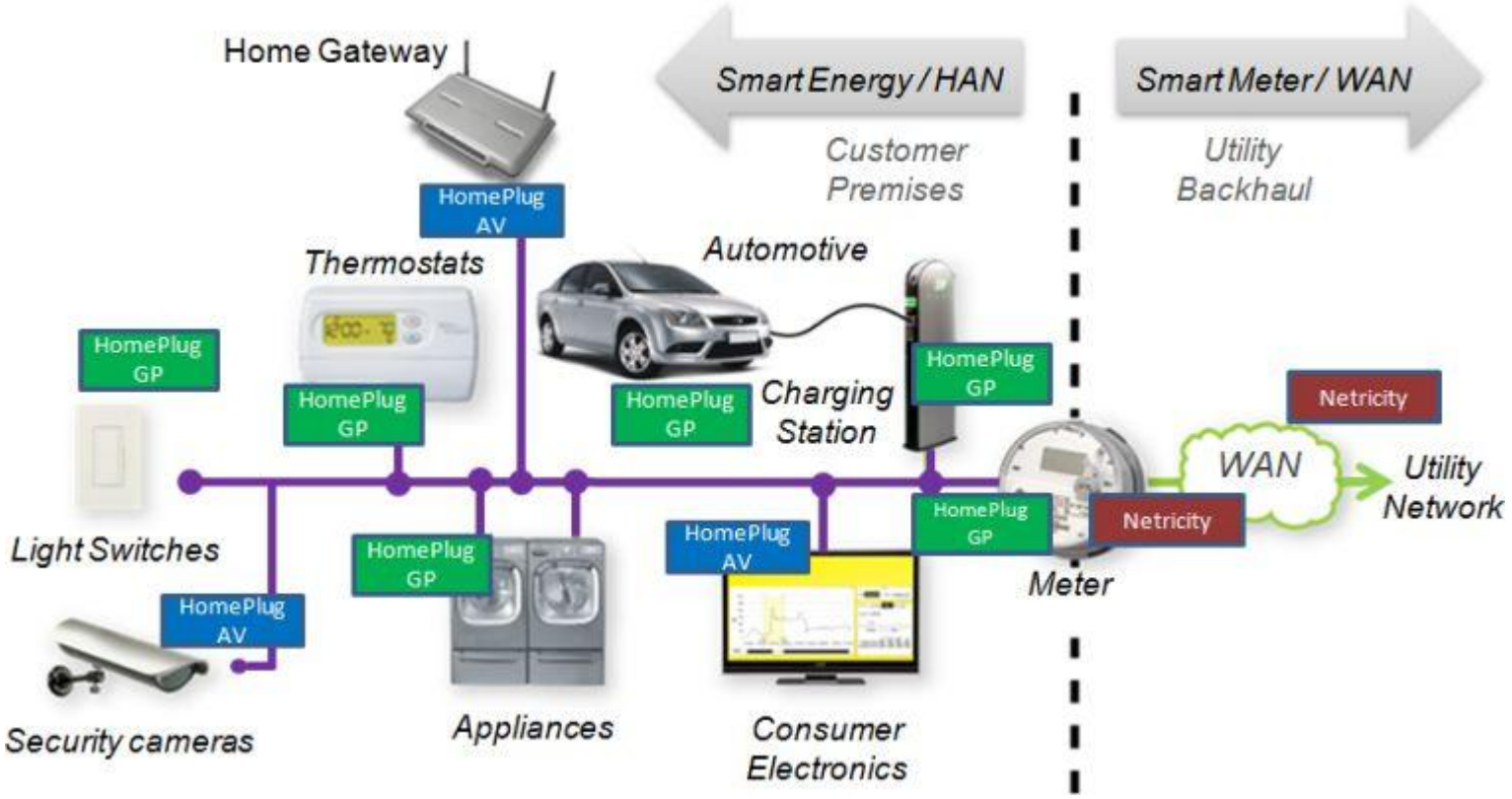
Wireless Communications

- Cooperative, Relaying, coding, …

Inhome/outdour

- Channel model, noise model, constraints, …

Existing practical solutions

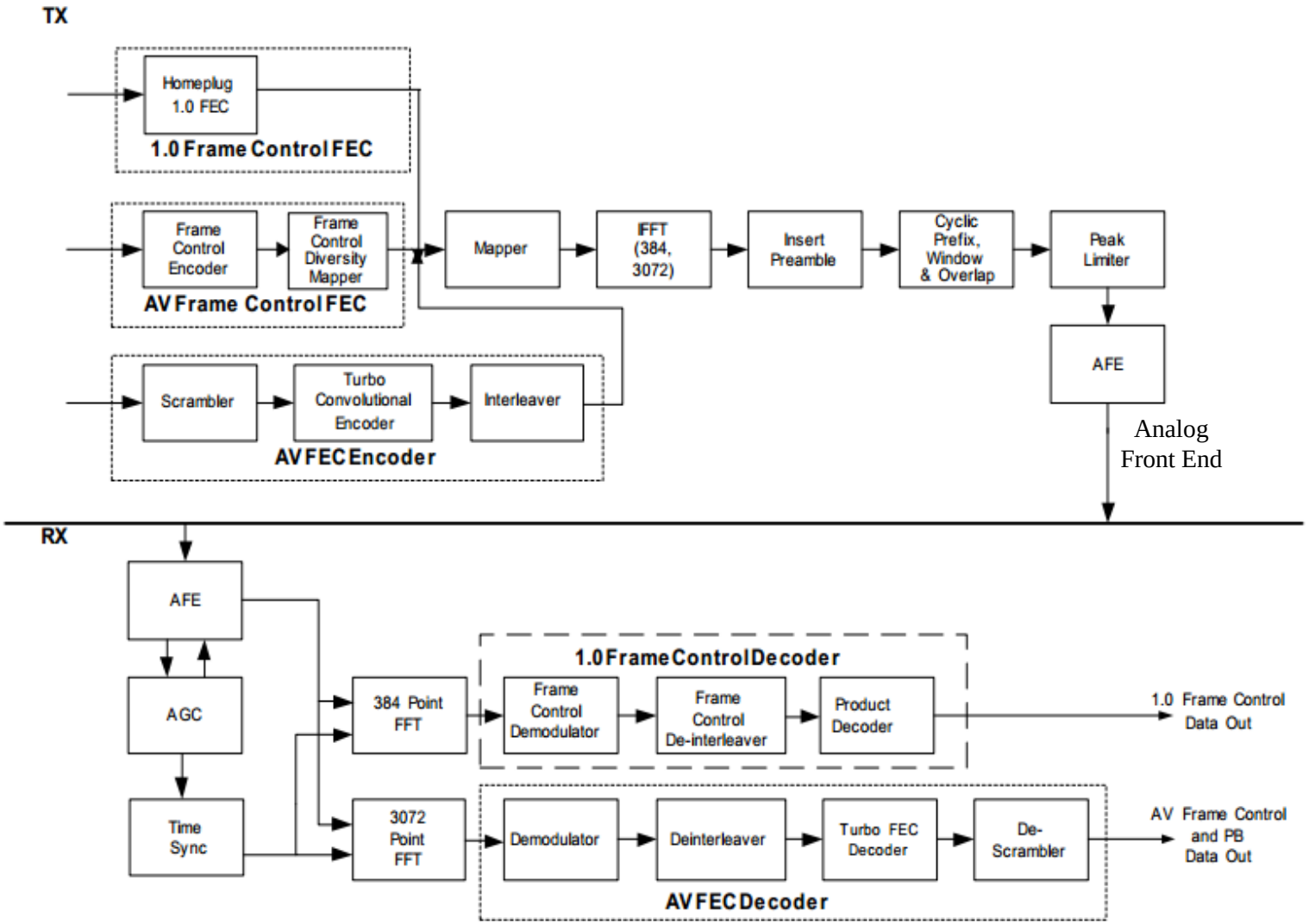


HPAV (HomePlug Power Alliance)
In home high capacity network

HPAV (HomePlug power Alliance)

- A power line network that is designed to run Ethernet over the existing electrical system and use AC wall outlets as connecting points.
- An alliance of 28 industrial firms including Broadcom, Cisco, Qualcomm, ST, Sony, Huawei, FranceTelecom.
- Standards
  - IEEE 1901.2010 - For High Speed Communication Devices (HomePlug AV)
    - 150 Mbps for video streaming OFDM modulation and the CSMA/CA access method used in wireless Ethernet (802.11)
  - IEEE P1901.2 - Netricity PLC: For Grid to Utility Meter and Long Range, Outside-the-Home Applications
    - Low frequency (less than 500kHz), Narrow band, adopted by ERDF en France
    - OFDM, DBPSK, DQPSK, D8PSK, optional BPSK, QPSK, 8PSK, 16 QAM, data rate < 500 kb/s, CSMA/CA mode
    - Reed-Solomon and convolutional coding
  - IEEE P1905 - For Hybrid Home Networks (multiple standard)
    - Sits on top of the MAC
    - Define a common data and control Service Access Point. Packets can arrive and be transmitted over any interface, regardless of the upper protocol layers or underlying network technology.

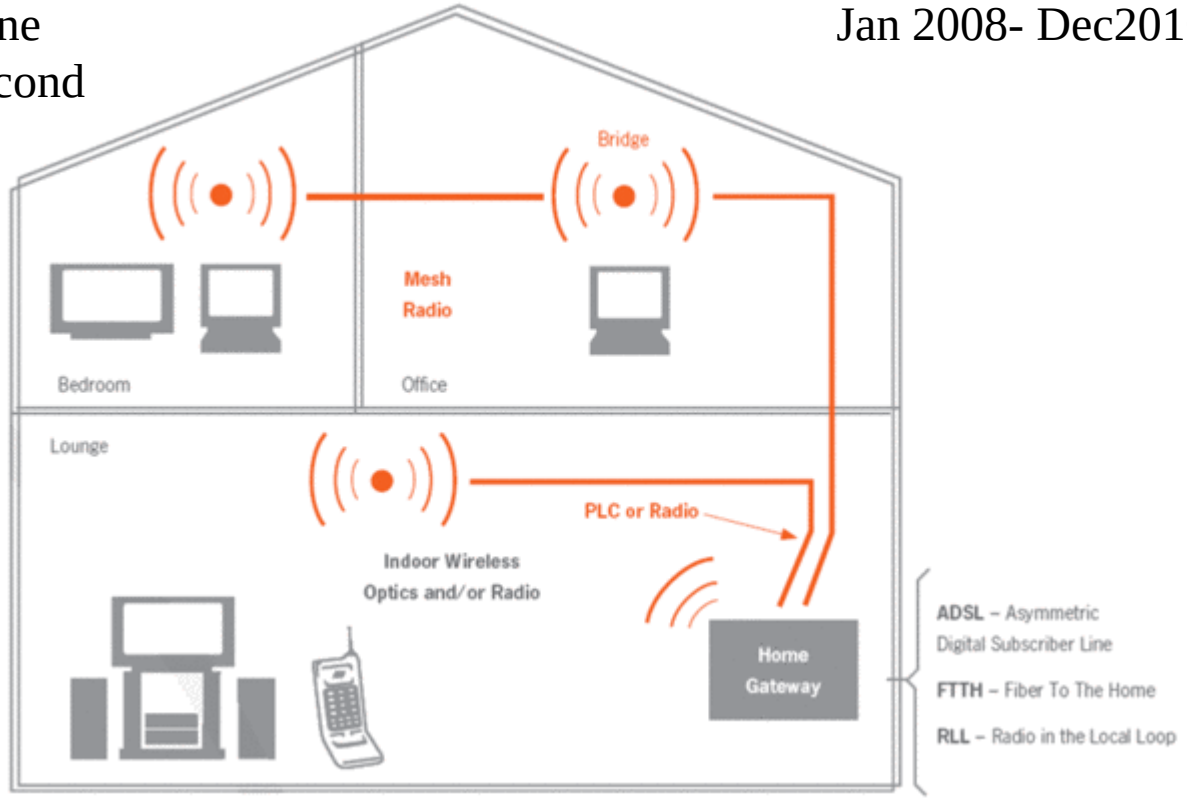
HPAV OFDM Transceiver



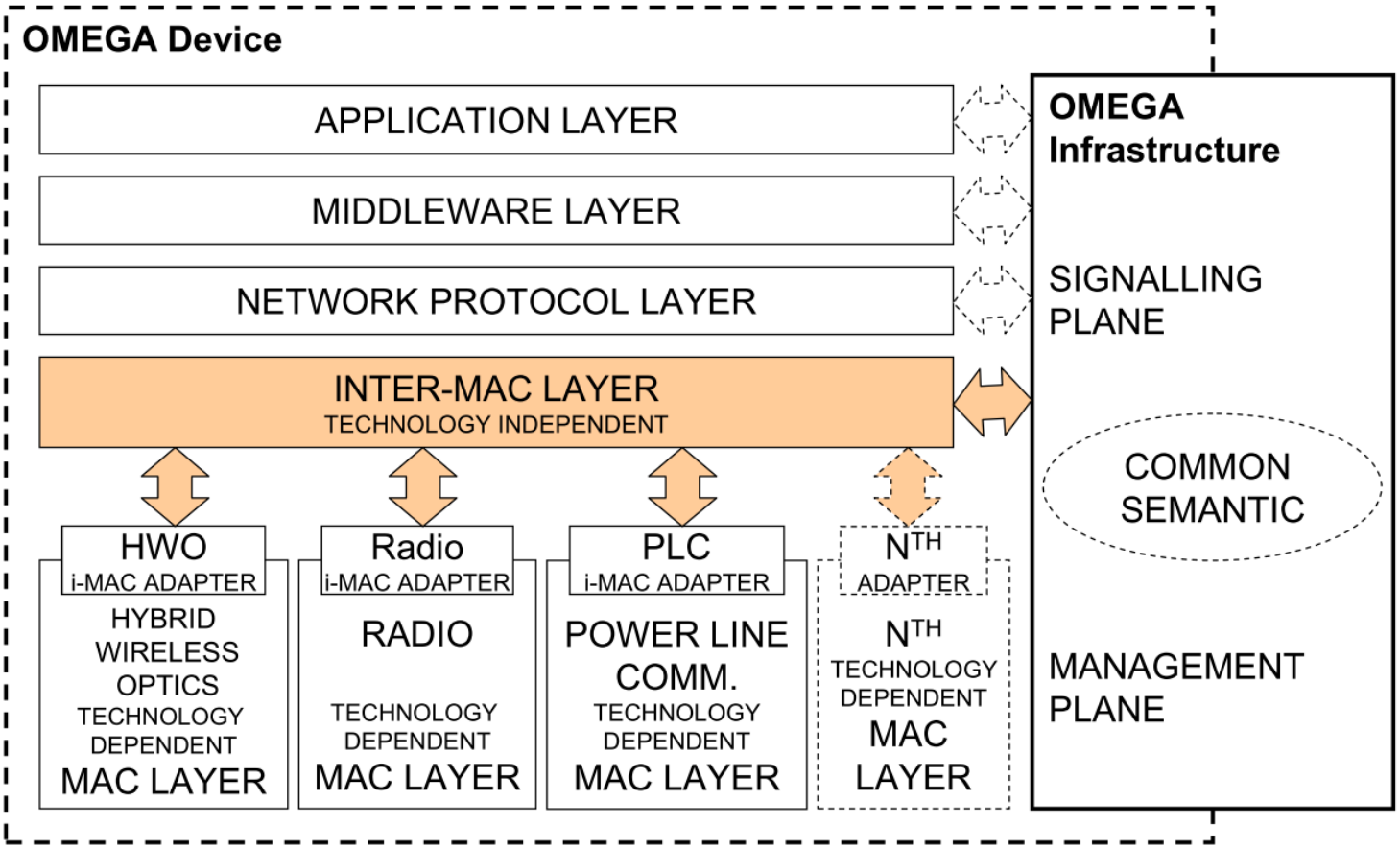
European project “Omega”

Target : Home access network with a speed of one Gigabit per second

Omega, IP in ICT (FP7), Jan 2008- Dec2010



Technology independent MAC layer



PLC channel

Noise

- Impulsive, periodic, colored, etc

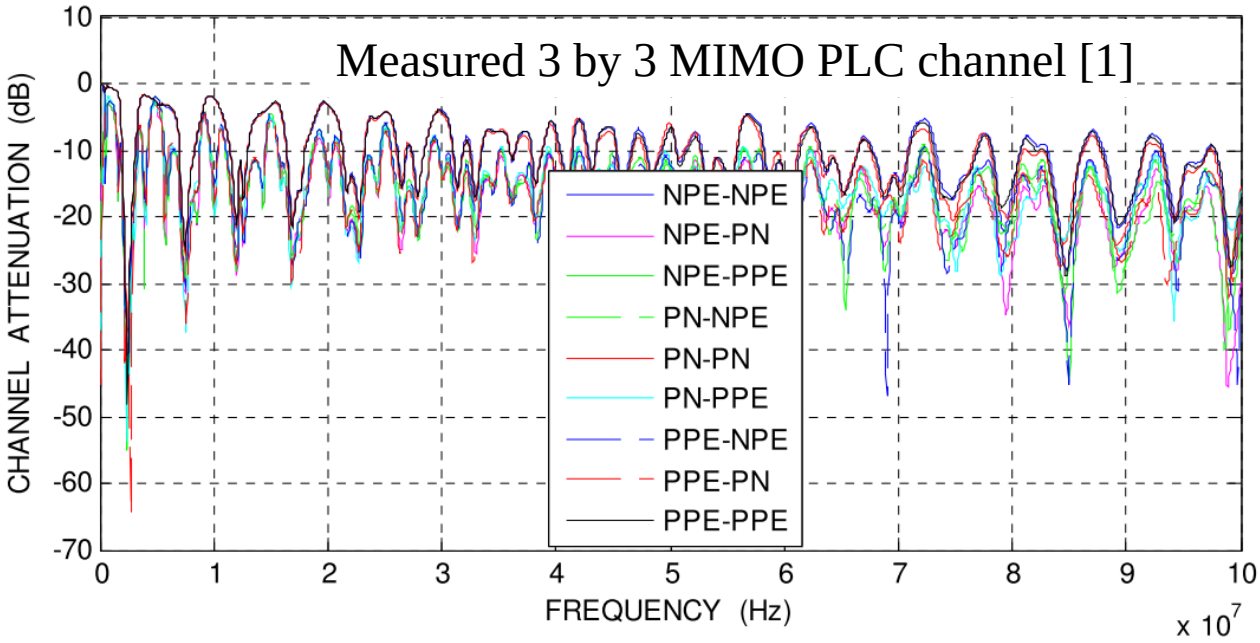
Transfer function

- Frequency selective, slow time varying

SISO/MIMO

- With earth, a 3x3 MIMO is possible
- Highly correlated channels

PLC Channel

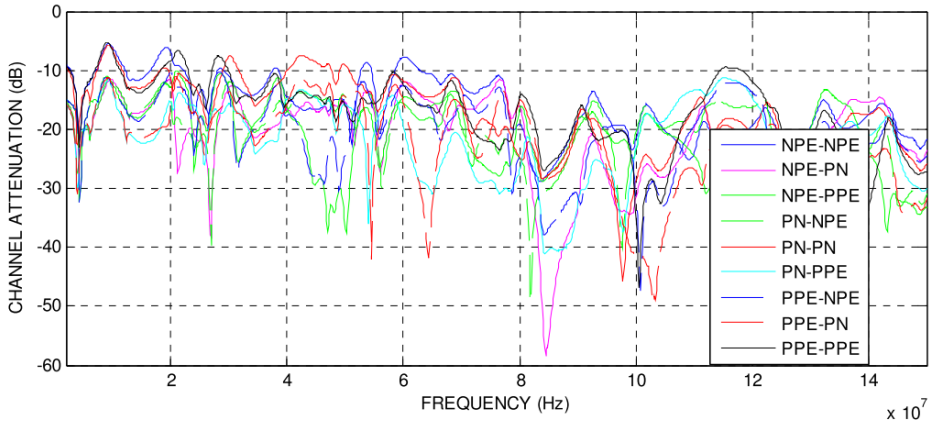


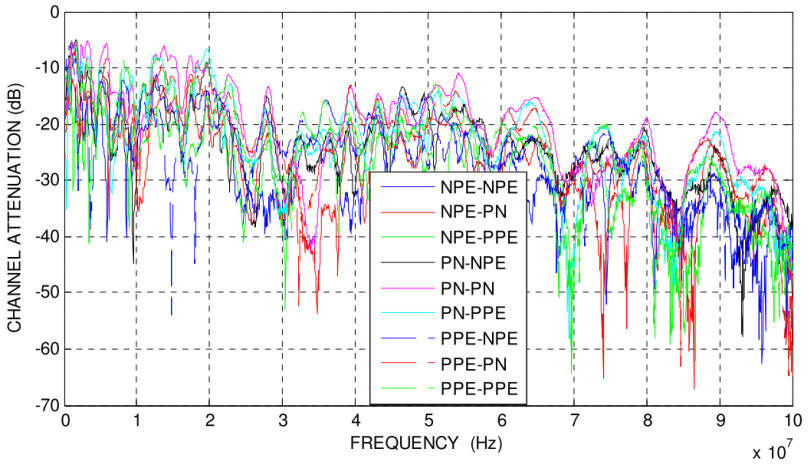
- The loss is not proportional to the distance
- The loss is not proportional to the frequency
- The channels are frequency selective
- The channels are correlated
- The channel are not fast fading

- The diversity advantage cannot be fully exploited.
- Relaying can help
- Channel estimation is devised
- OFDM modulation is recommended
- Network coding is quite possible

PLC Channel

- Channel Transfer Function depends extremely on the electric network configuration
- Same measurements in two different configurations



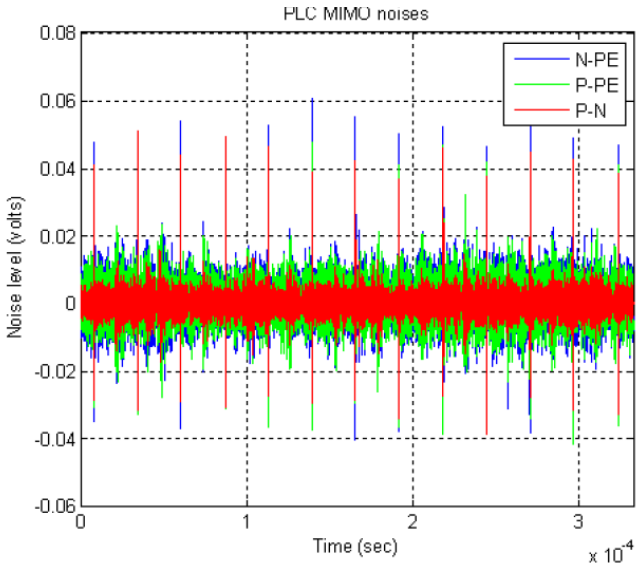


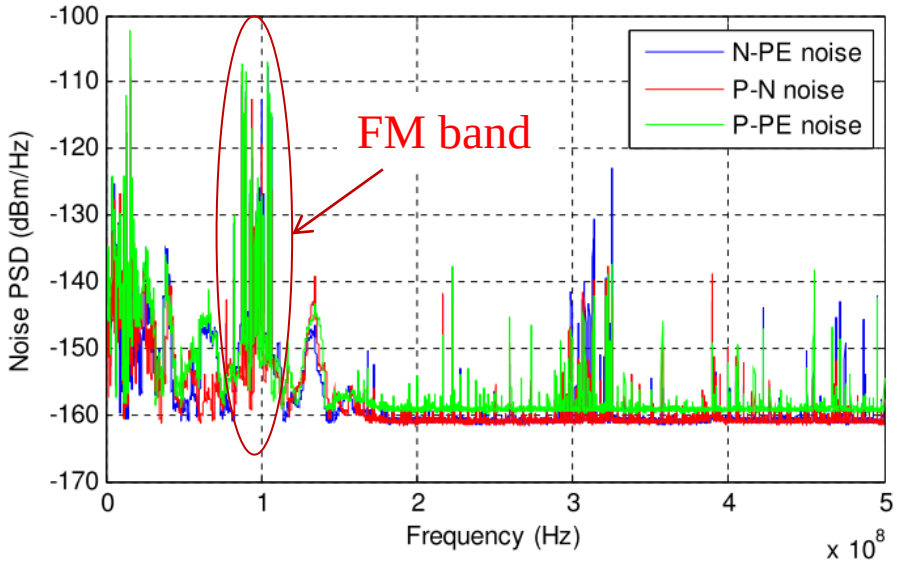
PLC noise

- Colored background noise, stronger at low frequency. Its PSD varies with time very slowly.
- Narrow-band noise, mostly sinusoidal due to broadcast stations
- Periodic impulsive noise with a repetition rate of 50 to 200 kHz (due to switched power supplies)
- Periodic impulsive noise synchronous to the main frequency (50 or 100 Hz)
- Impulsive noise due to the switching transients in the network; Il can be very high with respect to the background noise and with durations up to a few millisecond.

Noise measurements

- Measured noise in-home PLC network





Time diversity can be considered to avoid the impulsive noise.
Erasure channel so the corresponding code should be used (network coding, relaying, rateless coding, …)

Problems to be solved

- A very high pic of throughput can be obtained
- However, the rate can be drop very fast depending on the electrical configuration of the network
- Multiuser environment
- Multi rate/multi priority environment
- Multi standard network

Our proposed activities

- Realization of a test bench for PLC communications and measurements using the on-the-shelve equipment
- Developing coding schemes including network coding, rateless coding to enhance the throughput and QoS
- Hardware implementation and testing of the algorithms
- Relaying/routing techniques including relay assignment algorithms developed previously in the lab
- Diversity

Activities and funding

- A Master student working on PLC communications (April-July 2012)
- A PhD student (Oct 2012-Sept 2015)
- Answering to European/French/Regional calls

References

1. Rehan Heshmat, « Caractérisation et modélisation du canal et du bruit pour les réseaux CPL MIMO domestiques », PhD Dissertation, Télécom Bretagne, 2012
2. Gaëtan NDO, « Etude et Optimisation de Techniques de Réduction de Bruit Impulsif pour transmissions Haut Débit sur Lignes à Courants Porteurs en Contexte Résidentiel », Télécom Bretange, 2010