Addressing the Digital Divide with IPv6-enabled Broadband Power Line Communications

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Definition

Power Line Communications (PLC) allows transmission of data over power lines. PLC is potentially the network with the deepest capillarity in the world, since power lines are almost ubiquitous.
IPv6 provides a package of highly scaleable enhancements to the Internet compared to the capabilities of the existing IPv4 protocol, which is today only sustained by Network Address Translation (NAT). NAT has unfortunately created unexpected barriers during the massive growth of the Internet, consequently breaking the initial end-to-end communications concept.

However, this massive IPv4 deployment happened mainly in rich countries, creating a digitally divided society. IPv6, associated with other scaleable technologies like PLC, is key to redressing the balance and alleviating the digital divide, enabling more people and entire countries to access information and knowledge, which in turn will allow them to benefit from the global economy, and create new knowledge and services.

Background

New access technologies, like PLC, that have been evaluated for some years, have failed to support the legacy Internet paradigm. These technologies now have a new opportunity with IPv6, because IPv6 will give value to their deployment.

Power Line Communications has been around since the 1930's but was never seriously thought of as a medium for communication due to its low speed, low functionality and high deployment cost. However, new modulation techniques supported by recent technological advances have finally enabled this medium to become a realistic and practical means of communication.

Recently, new technology has led to integrated circuits and modems entering the market, providing high speeds over power line infrastructure at reasonable and falling cost.

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http://the.honoluluadvertiser.com/article/2002/Nov/22/bz/bz01a.html

Relevant IETF RFCs

Over 50 RFCs have been published by different IETF Working Groups, including those directly implicated in the standardization of IPv6, but also some others. A new WG is being formed, Zerouter, that will facilitate the large scale deployment of networks, facilitating the autoconfiguration of the

Although several broadband PLC technologies have been successfully developed, there is no standard yet. Some vendors provide "low-speed" (up to 2 Mbps) data rates using single-carrier technologies (GMSK, CDMA). Some technologies are based on multicarrier modulations (OFDM) and offer higher data rates, notably a 45 Mbps OFDM PLC chipset, which is the highest data rate available at this time.

In December 2002, at least one PLC technology vendor announced that during the second half of 2003, a new generation of broadband PLC technology providing 200 Mbps of physical layer data rate would be available as a commercial product.

Technical Issues of PLC

The main advantage of PLC over other technologies is that no new cabling is required, as all the cables are already there. Every building, be it offices, apartments or houses, has the network already installed. This permits a computer, or any other kind of device, with a CPE card or adapter, to be plugged into any socket in any room and receive and send the signal. Therefore, no extra wires are required, neither in the house nor in the utility, and the user is not restricted to a few outlets in the house, as is usually the case. One may note that even if it is desired to use a wireless network within the building, this reduces to a simple matter of plugging the base station into any power socket.

PLC is mainly a "last half-mile" technology, but several electricity suppliers are using PLC in the medium voltage grid, in addition to their plans for using it in the low voltage grid for user access. Most of the electricity suppliers already have fiber or other infrastructures that provide data to the points that connect the medium voltage rings with the low voltage lines. These points are the medium to low voltage transformers.

In the worst case, the infrastructure needed to deliver power line to the customers is not more expensive than the equivalent core networks and Broadband Access Servers in the case of xDSL, with the advantage that the power grid has a higher penetration than the copper pair, and is subject to lower bit-rate errors, offering higher bandwidth.

The use of PLC technology as an access technology to deliver broadband capabilities has several key benefits, mainly related to the fact that power wires are already installed in any location where information could be delivered. We can foresee the tremendous impact on a wider spectrum of applications in existing infrastructure such as traffic lights, information panels, metering systems, to vending machines and of course for home devices at both, the customer end, and the ISP network itself.

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About the Author

Jordi Palet is CEO/CTO of Consulintel, a Spanish leading consultancy/integration company in IPv6 Research, Development and Innovation. Jordi accounts with over 20 years of experience in R&D, management, marketing and sales. He is coordinating and participating in several European projects (http://www.euro6ix.org, http://www.6link.org, http://www.ist-ipv6.org,

networking and industrial automation.

The prime objective is to provide self-configuring systems to customers, and from that point, all the rest of the network will be automatically configured, including all the different levels of devices up to the end user CPE. Such auto-configuration is not foreseen in IPv4.

As the number of users and devices connected to Power Lines increases by orders of magnitude, it becomes clear that we cannot satisfy the demand using IPv4/NAT, at least not without enormous administrative complexity. A much larger address space is needed to provide end-to-end connectivity in a simple manner and to allow new applications and services to work in a transparent manner.
Also, if we agree with the premise that the supply of bandwidth is never enough and that next generation applications are by default bandwidth-hungry, the end-users and their applications will always demand more of the same. We need to cater for this challenge appropriately. Especially considering streaming video and audio applications, this means that multicast is a must and needs to be efficiently provided in PLC networks. Finally, the different kinds of traffic flows (video vs. audio vs. email, for example) will require different qualities of service in the network.

Thus we see a number of respects in which today's best-effort IPv4 network is ill matched to a future widespread deployment of PLC connectivity.

Electro-Magnetic Radiation Issues
Earlier PLC systems such as the one developed by Nor.Web in the UK emitted a high level of radio noise in the 1-30 MHz bandwidth. This resulted in conflicts with the British government's Radio Agency, when it disrupted radio signals from the BBC World Service. The Department of Trade and Industry (UK) subsequently made it impossible to use PLC in the UK and contributed to the withdrawal of Nor.Web from the business.

Learning from the failures of Nor.Web approach, second generation PLC technologies are using techniques like OFDM, which substantially reduce the potential of interference to radio users, thanks to a decrease in transmitted power spectral density. The OFDM modulation spreads the signal over a very wide bandwidth, thus reducing the amount on power injected at a single frequency. Field trials of PLC technologies carried out during the last 2 years in Europe (Spain, Italy, Germany), North America, South America (Chile, Brazil) and Asia (Singapore) have shown that interference with radio users is no

http://www.eurov6.org, http://www.ipv6tf-sc.org, http://www.6qm.org), towards the global deployment of IPv6. Jordi participates in the EC and Spanish IPv6 Task Force, and is also education, awareness, public relations and promotion co-chair at the IPv6 Forum and member of the Technical Directorate. He is the organizer of the next Madrid 2003 Global IPv6 Summit (http://www.ipv6-es.com), after the two previous very successful events in 2001 and 2002.

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longer a problem for PLC.

The same technique explains why current PLC technology does not affect other appliances in the home. In fact, vendors like LG and Samsung released several products for home automation, using PLC.

Synergy with IPv6

Firstly, IPv6 provides a set of autoconfiguration mechanisms for routers and hosts, so that even today it is possible to simply "plug and play" on a home network.

In addition, IPv6 will ease rapid deployment of PLC networks, as new protocols like router zero-configuration and automatic prefix delegation become available and are implemented. ADSL networks taking full advantage of these IPv6 facilities have already verified them, and it is expected that other broadband technologies will do so as well.

Clearly, the almost unlimited address space of IPv6 is needed to provide end-to-end connectivity and allow new applications and services to work in a transparent manner across PLC networks at massive scale (imagine every power socket in Beijing or Mumbai becoming an Internet access point!).

New Quality of Service models should emerge with IPv6's Flow Label, to provide better flow classification than IPv4, although this is still experimental and under standardization in the IETF.

IPv6 facilitates network management by eliminating much manual configuration and private address administration, and consequently makes it easier and therefore cheaper to deploy new networks. This is also valid for the existing access networks, but they would require an initial "transition" or an integration investment to fully benefit from IPv6; PLC has the chance to start out with IPv6.

Thus, IPv6 seems to be the best way to make Power Line Communications installations scaleable and self-configuring, allowing us to exploit the benefits of both technologies working together.

Action rather than words

One strategic project called 6POWER (http://www.6power.org/), a European Union co-funded project, takes into consideration all of these aspects, adapting and integrating products, applications and services that enable IPv6 and related protocols over Power Line, and running trials needed to validate the technology and its real benefits with end-users. This project is researching, developing and exploiting several next generation technologies, mainly IPv6

and PLC, but also QoS and multicast together with broadband, specifically to explore the synergy between PLC and IPv6. Built-in protocols supported by IPv6, like security and mobility, will be also used and several applications that could be deployed in real PLC installations will be ported. Consider for example home networking applications, surveillance and alarms, being deployed in a much easier way than ever before. They need end-to-end connectivity strengthened with security.

Fully addressing the Digital Divide?

Many estimates can be made of the objective extent of the digital divide, both within the population of rich countries, and between the rich and poor worlds. Sources such as the Caida project (http://www.caida.org) and United Nations studies suggest that the US has about a 60% share of existing Internet resources, Europe a further 20%, with the other rich countries taking at least half the rest. The distribution is much more skewed than for telephony, and certainly more skewed than for electricity distribution, which is available at least in the permanent buildings of almost every city in the world. While it is true that some countries have low electricity coverage, and that PLC is not the solution for the entire digital divide problem, it has the potential to vastly extend Internet coverage without additional "last mile" cabling.

For instance, in China there are 9 phones for every 100 inhabitants (low copper/phone penetration), but 32.1 TVs (better electricity coverage. http://www.cyberschoolbus.un.org/infonation/info.asp?theme=tec&id1=156&id2=724&id3=999&id4=999&id5=999). In contrast, in Spain, there are 41 phones and 40.7 TVs per 100 people. Thus, in an emerging economy like China (20% of the global population) the electricity network penetration is very high (about the same as in Spain) although the telephone coverage (teledensity) is quite low. The effect of using the electricity network for communications would be to substantially enhance the teledensity.

In countries with little cabled infrastructure, we can expect that governments and international organizations willing to invest will much prefer to provide electricity (and data) first, than just telephone coverage. Indeed, by adding Voice over IP to PLC, one can avoid dedicated telephone cabling completely.

Implications

The main message of this briefing, and the vision of the 6POWER project, is that PLC combined with IPv6 can contribute significantly to ensuring affordable, scaleable broadband access and the deployment of Internet access for all, helping to repair the worldwide digital divide.

The benefit, from the end-user point of view, is quite clear. Broadband PLC with IPv6 and QoS could provide the means for new service providers (electricity suppliers) to enter a difficult market, increasing the user perception of the "quality of the service" and either increasing competition or saving the massive cost of dedicated communications cabling. The end-user is the major beneficiary of these technologies that will help to repair the digital divide and open the Internet for a new and perhaps unexpected growth curve.

In addition, PLC technology with IPv6 could open new avenues and very affordable solutions to ease deployment of 3G (and beyond) networks as well as for WiFi networks where every Base Station or Access Point needs a power supply.

For the end-user, Internet access will become cheaper and quite easy to connect and configure.

In contrast, the kind of massive, worldwide deployment described above is unlikely to succeed if inhibited by the practical disadvantages of limited IPv4 address space, and by the administrative costs of address translation, private addressing, and manual configuration.

ISOC Position

ISOC's motto is "Internet is for Everyone". This could be facilitated by the usage of Power Line Technologies and IPv6.

Addressing the Digital Divide has always been one of ISOC's goals. With over 3 billion end-users worldwide, electricity networks form the most ubiquitous utility on this planet, and can only grow. Using them to extend immediate access to the Internet and to become the second largest communications infrastructure in the world, within reach of all and without extra infrastructure costs, just makes sense.