Wiring Devices and Technologies in Home Environment

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Abstract

This paper reviews and compares technologies that home users can use to build their home networks. The focus of this review is on technologies that need no rewiring, i.e. they use existing wires or are wireless. The paper also discusses the topic from the users' point of view and tries to find out what are the main factors that might make a user prefer one technology over another?

KEYWORDS: home network, no-new-wires, wireless

1 Introduction

Home networks can be used for many different applications. Voice, video and data are often called the "triple play" services and together they seem to be the focus of the new home network technologies today. Users want, for example, to transfer video or music from one PC to another. At the same time, another user wants to make a VoIP phone call to his/her friend using the same network. And, of course, a broadband access to the Internet from all the devices connected to the home network is almost a must these days. These examples demonstrate that devices must be somehow interconnected by using some suitable technology or technologies. The available technologies vary and are limited in their own ways. For example, some technologies require serious home rewiring, others use existing wires at home or do not need wires at all. Therefore, a home user is in a predicament when it comes to choosing a wiring technology for his/her home.

Building a home network usually requires a physical infrastructure to which to connect the devices. Most people are reluctant to spend a lot of money on rewiring their homes, so a different approach is preferred. This was noticed already years ago by organizations and companies that make and develop devices and standards for networking. The development eventually led to a situation where many different working groups and standard specification proposals existed, as mentioned in [1, 2]. Many of these proposals, and even standards, have been abandoned later by their developers themselves or, more likely, vanished as a result of the poor success on the market. The main causes for these have been the lack of features or the technology has been outdated from the very beginning. Only the most capable ones have reached the point in which they are widely used or, at least, still exist.

The Ethernet, defined in the *IEEE 802.3* standard, has dominated the local-area network (LAN) market for a long time. It was developed mainly for corporate and enterprise networks, where the needed infrastructure, i.e. cabling, was already in place. Most homes, except for those built lately, might not have this infrastructure installed. Thus, they require the installation of cabling in order to be Ethernet ready. This can be a difficult and time consuming process, not to mention the high costs for building such an infrastructure. There are also other technologies, such as those mentioned in [1] Sec. 2, that need new wiring. This is a reason strong enough to search for more suitable solutions for home use.

This paper reviews and compares some of the most widely spread or promising home networking technologies that do not need any new wiring in the home. Sections 2 and 3 present no-new-wires and wireless technologies, respectively, and Section 4 compares these technologies based on various characteristics. The advantages and disadvantages of these technologies are viewed from the users' point of view in Section 5, to provide some insights why users might prefer a certain technology over another. Finally, section 6 sums up the findings.

2 No-New-Wires technologies

Many or most houses around the world have wiring already installed which "no-new-wires" technologies can use. At least electricity and phone cabling are available in most homes and, in addition, coaxial cabling for TV reception is common as well. These cablings provide a physical, already installed, infrastructure which can be used as a backbone of a home network. The following subsections introduce the most promising "no-new-wires" technologies.

2.1 HomePNA

HomePNA is a technology which uses existing phone-lines or coax cables to carry data [5]. It is defined by the Home Phoneline Networking Association and is an open standard recognized by the International Telecommunication Union (ITU).

The first generation, HomePNA v1.0, was capable of only 1 Mbit/s data rates. The second generation, HomePNA v2.0, did much better providing up to 10 Mbit/s. This was a reasonable bandwidth to support more demanding applications than normal Internet access, such as streaming video. In addition, the Quality-of-Service (QoS) aspects were taken into account in HomePNA v2.0, which provided 8 priority levels. By introducing QoS capabilities, HomePNA was able to provide something that the Ethernet had not been able to offer. The next generation, HomePNA v3.0, supported data rates up to 128 Mbit/s, and hence was enough for most needs in

the home environment. The first two generations supported data transfer only using phone-lines, but the third generation added support for coaxial cables as well.

The current HomePNA standard, HomePNA v3.1, was recently approved by the ITU. It is based on HomePNA v3.0, and is backwards compatible with the earlier HomePNA versions, i.e. v1.0 and v2.0. The new standard offers data transfer rates up to 320 Mbit/s and advanced QoS capabilities to ease the use of different applications. These applications are mainly voice, video and Internet services, often called the "triple play" services as mentioned earlier. Furthermore, the QoS is said to be "guaranteed". This means that jitter, latency and error rate for each stream are guaranteed to stay steady, thus providing a more satisfying user experience than most of the competing technologies. [5]

2.2 Multimedia over Coaxial Cables

Multimedia over Coaxial Cables (MoCA) [7] is a similar standard as the before mentioned HomePNA. The main difference is that MoCA uses only coaxial cables as its medium of transport. The specification is quite new, the alliance approved it in February 2006. The alliance itself is not old either, it was established in 2004. MoCA focuses on the "triple play" services similary as HomePNA.

The MoCA technology uses the unused bandwidth, i.e. frequencies, on a coaxial cable and thus does not interfere with other devices using the same medium [7]. MoCA promises data rates up to 270 Mbit/s on the physical layer. This implies MAC layer data rate of approximately 135 Mbit/s. An MPEG2 coded video-stream, used in digital TV sendings, requires bandwidth approximately from 1 to 19 Mbit/s. Therefore, the data rate of MoCA is enough to support multiple MPEG2 video streams simultaneously. In addition to TV streams, a user can transfer normal data, voice and gaming streams at the same time using the same coax medium. MoCA also provides robust QoS for each video stream [8].

2.3 Power-line technologies

Power-line network is probably the most available home network. The power-line as a medium of data transfer is challenging because it is a shared medium. Therefore, security has to be taken into account so that the data transferred in one home cannot be misused by the next door neighbour. In addition, the medium is used by other household devices that create interference to the network from time to time. A few competing specifications exist for transferring data using power-lines and this subsection presents two of them, namely HomePlug AV and UPA DHS. These two specifications are similar because of the same medium which they utilize.

HomePlug AV is a standard from the HomePlug Powerline Alliance. The standard, released in 2005, provides means to connect home devices together and to access the Internet. The home devices include, for example, TV, videos and set-top-boxes. This happens naturally via power-lines and power-outlets which exist in most homes today. HomePlug AV is backwards compatible with the earlier standard, namely HomePlug 1.0, which was released in 2001. HomePlug AV is capable of data rates up to 200 Mbit/s on the physical level. Therefore it can compete with, for example, HomePNA v3.1 and MoCA standards. HomePlug 1.0 provided a data rate of only 10 Mbit/s, which was adequate at that time. That said, HomePlug 1.0 is not capable of "triple play" services, but the HomePlug AV was designed with these services in mind. HomePlug AV provides security using 128bit AES encryption to ensure that the data streams cannot be eavesdropped. The QoS provided by HomePlug AV depends on the medium access technique used. HomePlug AV supports both TDMA and CSMA based access. With TDMA, QoS guarantees bandwidth reservation, high reliability and tight control of latency and jitter. On the other hand, the CSMA provides 4 priority levels which are enough for most needs. [9, 10]

The second standard presented here is the UPA DHS, formally Universal Powerline Association Digital Home Standard. As said, it is similar to the HomePlug AV standard providing means to transport "triple play" services. The DHS is capable of data rates up to 240 Mbit/s on the physical level and it supports advanced QoS with 8 priority levels for different types of data. In addition, the UPA DHS uses 3DES encryption to provide security on the power-line network. The DHS also provides another security mechanism. It uses a so called "Network Identifier" (NET-ID) to isolate traffic between different virtual networks. This means that only nodes using the same NET-ID are capable of communicating with each other. [11]

3 Wireless technologies

Wireless technologies can possibly provide an easier approach to home networking than the wired ones. Because there are no wires at all, the users are not restricted to a certain location or area in the home. However, most of these technologies have been developed for different purposes. For example, some technologies are intended for short and others for long distance networking. They differ in supported data rates as well. This section reviews the mature 802.11a/b/g standards, the promising 802.15.X family and the Bluetooth v2.0.

3.1 IEEE 802.11a/b/g

The IEEE 802.11x standards [12] are the most mature wireless technologies. This makes them the most widely used ones as well. They are used in many situations, including corporate, industrial, private and public environments. The 802.11a and 802.11b standards were released in 1999 and the 802.11g standard in 2003. Even though they all have their own characteristics, they are very similar in the end.

The 802.11b standard is probably the most commonly used. It has a maximum data rate of 11 Mbit/s on the physical level. The practical throughput on the application level is from 5 to 7 Mbit/s because of the CSMA/CA protocol overhead. The ’b’ standard operates at the 2.4 GHz frequency, which is free in most countries in the world. The typical operating range indoors is approximately 30 meters at the speed of 11 Mbit/s. The ’b’ standard has the capability to

scale back to lower data rates if the signal quality decreases. These lower data rates include 5.5, 2 and 1 Mbit/s and they use a different data encoding. Therefore, they are more resistant to signal attenuation and interferences. The 802.11b uses Complementary code keying (CCK) modulation technique on the physical level.

The 802.11g is the newest of these three standards. It is compatible with the 'b' standard and, in addition, it offers higher data rates. The maximum data rate is 54 Mbit/s but, in practice, the actual data rate is approximately 25 Mbit/s due to protocol overhead on the physical level. Additionally, the 802.11g uses a more sophisticated modulation scheme, namely orthogonal frequency-division multiplexing (OFDM), as opposed to CCK which is used in 802.11b. The 802.11g uses the 2.4 GHz band as well as the 'b' standard. Therefore, the operating range with the 'g' devices is almost the same as with the 'b' devices. The 'g' standard is capable of lowering its data rate in the similar way the 'b' standard. This way it can overcome signal attenuation and other interferences if needed. The 'g' standard can also revert to the 'b' standard if necessary.

The last standard presented here is the 802.11a. The major difference between 802.11a and the 802.11b and 802.11g is the different operating frequency. The 802.11a works on 5.0 GHz band, which is available in most countries as well as the 2.4 GHz band. The disadvantage of the 5.0 GHz band is that the signal is not as permeable as the 2.4 GHz signal. This means that the 802.11a is more prone to signal interference introduced by obstacles on the way. Furthermore, the 'a' standard is not compatible with the above two because of the different operating frequency. The operating range of 802.11a is about the same as with the 'b' and 'g' standards. The modulation which 802.11a uses is the same as 802.11g's, namely OFDM. In addition, 802.11a has the same data throughput as 802.11g (i.e., 54 Mbit/s) and it can be reduced to lower speeds if necessary.

3.2 IEEE 802.15

The IEEE 802.15 [14, 15] is a working group which develops standards for Personal Area Networks (PAN) and short distance wireless networks. The standards can be used to interconnect personal devices, such as mobile phones and PDAs, wirelessly with one another. IEEE 802.15 has five main task groups. The most relevant ones for this review are groups 1, 3 and 4, which are described below. These three groups define concrete standards for interconnecting devices, whereas groups 2 and 5 concentrate on coexistence of wireless networks and mesh networking, respectively.

Task group 1 has defined a standard derived from Bluetooth v1.1. This standard is named Wireless Personal Area Network standard (802.15.1). It was released in 2002 and updated in 2005. This standard covers wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs). Basically this standard is the same as Bluetooth v1.1 but it is ratified by IEEE. Bluetooth is covered more thoroughly in the section 3.3.

Task group 3 defines a specification for High Rate WPANs (802.15.3). The specification provides data rates from 11 to 55 Mbit/s and is intended to have low power consumption. In addition, the cost of the devices is supposed to be low. The specification uses the 2.4 GHz band to operate. This band is free and unlicensed in many countries. The maximum operating range of IEEE 802.15.3 is up to 70 meters, even though the standard is mainly supposed to be used in a personal operating range, which is approximately 10 meters. Furthermore, IEEE 802.15.3 provides QoS guarantees to data streams that need it, for example multimedia.

Task group 4 has defined a specification for a low data rate WPAN (802.15.4). The main focus of this group has been very low power consumption, which could provide months or even years of operation. IEEE 802.15.4 operates at 2.4 GHz (worldwide), 915 MHz (e.g., Europe) and 868 MHz (e.g., North America) bands and is capable of transferring data at 250, 40 and 20 kbit/s. This standard is mainly intended for different gadgets, such as remote controls, toys and home automation.

3.3 Bluetooth

Bluetooth [16] is designed to be a replacement technology for cables when connecting portable devices together. It is intended to be a low cost and low power solution to simultaneously handle data and voice communications. The first public version, namely Bluetooth v1.0, was published in 1999. The current standard is Bluetooth v2.0 which was presented in 2004.

Bluetooth operates at the 2.4 GHz band which is unlicensed and freely available in many countries. The operating range on the band depends on the class of the Bluetooth device. Three classes exist for Bluetooth devices. Class 3 devices can operate at the maximum distance of 1 meter, whereas Class 2 devices' operating range is up to 10 meters. In addition, Class 1 devices can support distances up to 100 meters, but they are intended mainly for industrial use. The longer use range is provided with the use of higher transmission power. The Class 2 is the most common one used in various mobile devices with 2.5 mW transmission power.

The Bluetooth v2.0 provides data transmissions at the speed of 1 Mbit/s. In certain cases, using enhanced data rate (EDR), it is capable of 2 to 3 Mbit/s speeds. Earlier versions of Bluetooth were able to speeds up to 1 Mbit/s, therefore the new standard is faster than its predecessors using the EDR mode. Bluetooth v2.0 is backwards compatible with the earlier Bluetooth v1.X standards, thus providing interoperability with older mobile devices. In addtion, QoS is supported to provide better service for applications needing it.

4 Technology comparison

All technologies reviewed in sections 2 and 3 have a set of unique features because all of them have been developed for slightly different purposes. Therefore, comparing them must be done in such a way that these purposes are taken into account. The situation is that these technologies will co-exist in modern homes. The question is whether they can?

Table 1 and Table 2 sum up the characteristics of the no-new-wires and wireless technologies, respectively. It is easy

Technology	Medium	Network	Data rate, Mbit/s	QoS	Security
HomePNA	Twisted pair or coaxial	Phone-line or Cable TV	≤ 320	Guaranteed for each stream	Not needed with phone-lines. Cheap physical isolation with coaxial.
MoCA	Coaxial	Cable TV	≤ 270	For each video stream	Cheap physical isolation + encryption
HomePlug AV	Copper	Power line	≤ 200	Guaranteed with TDMA, 4 priority levels with CSMA	128bit AES encryption
UPA DHS	Copper	Power line	≤ 240	8 priority levels	3DES encryption + "Network Identifier"

Table 1: Comparison of no-new-wires technologies

Technology	Frequency band, GHz	Range	Data rate, Mbit/s	Power cons.	QoS	Security
802.11a	5	up to 300 m	≤ 54	medium-high	No	Data encryption
802.11b	2.4	up to 300 m	≤ 11	medium	No	Data encryption
802.11g	2.4	up to 300 m	≤ 54	medium-high	No	Data encryption
802.15.3	2.4	up to 70 m	≤ 55	medium	Yes	Data encryption
802.15.4	2.4, 0.915, 0.868	up to 10 m	≤ 0.250	very low	No	Access control and data encryption
Bluetooth v2.0	2.4	up to 10 m	≤ 3	very low	Yes	Authentication and data encryption

Table 2: Comparison of wireless technologies [4]

to see that there are similarities in many cases, but also different features exist. The selection between these technologies is not easy to make and a user must consider what features he/she needs before making the decision.

All the no-new-wires technologies share a common purpose of use; they are meant to be used as a home wide network, carrying the "triple play" services, i.e. voice, video and data. This means that these three technologies must support QoS to ensure, for example, smooth video playback. In addition, the technologies must provide a reasonable amount of bandwidth to carry many types of data simultaneously. The long time LAN market leader, namely Ethernet, has enough bandwidth but lacks QoS features by default. Therefore, it is not an optimal choice for home networks. All the no-new-wires technologies presented in this paper have enough bandwidth to offer for home network needs and they all support QoS. HomePNA promises guaranteed jitter, latency and error rate for each stream individually and MoCA promises similar QoS support, at least for each video stream [8]. The power-line technologies have advanced QoS support as well. The HomePlug AV has two different QoS schemes, depending on the access method used. With TDMA, HomePlug AV can guarantee bandwidth, latency and jitter and with CSMA it supports four priority levels. Meanwhile, the UPA DHS supports eight priority levels.

All the no-new-wires technologies presented share their medium with other devices or technologies. For example, the coaxial cabling is used to carry TV signals and the power-line network is used by all devices that need electricity. This brings up some issues to consideration. Firstly, because other devices or technologies exist on the same physical network, the technologies must cope with at least some interference. With phone-lines and coaxial cables this problem is small, because the frequency bands of the phone and TV are known and, therefore, can be avoided. The interference is a bigger problem with power-lines. That said, the situation is that all the connected devices create noise which can affect the performance of the home network. In addition, the problem is time-varying because different devices are used at different times. Secondly, the shared medium causes security issues. With coaxial and power-lines physical isolation or data encryption are needed to prevent eavesdropping and data misuse. Phone-lines are an exception because they are not shared and hence the data streams do not necessarily need any methods of protecting.

The wireless technologies presented in this paper are limited in bandwith when compared with the the no-new-wires technologies. The 802.11a, 802.11g and 802.15.3 have most potential with their over 50 Mbit/s data rates. These technologies are mainly purposed for data transmissions and, for example, web browsing where data rates do not need to be so high. The Bluetooth v2.0 is used to connect mobile and other portable devices together and to transfer voice and small amounts of data between them. This is why the data

rate of Bluetooth is much lower than with other standards presented in this paper. The 802.15.4 is intended for similar purposes as Bluetooth and it is very limited in data rates as well. For the same reasons, the operating ranges vary between these technologies. The 802.11 standards are capable of up to 300 meters of operating range with the downside of lowering data rates. The 802.15.3 comes in the second place with its up to 70 meters of operating range. Although having a quite long operating range, the 802.15.3 is intended to be used within 10 meters from the device it is connected to. This is the case with Bluetooth and 802.15.4 as well.

The 802.11 standards have been used for a long time in corporate networks and in the past few years they have become common in homes as well. The 802.11 standards are the most mature standards reviewed in this paper and they are used widely. The downside of these standards is the lack of QoS. This is also because of the different purpose of use than with the no-new-wires technologies. The newer standards, namely 802.15.3 and Bluetooth both support QoS. The 802.15.3 provides QoS for data streams that need it, for example, multimedia. Bluetooth has similar capabilities to control bandwidth, jitter and latency.

Air is a shared medium as well as coaxial and power-lines. A long operating range increases the chances of an attacker to eavesdrop the data. With the coaxial cable it is possible to physically isolate one home from another whereas the wireless networks do not allow this. Therefore, the only option is to use encryption. All the reviewed wireless technologies are able to use encryption. For example, the 802.11 standards can use Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA) and Wi-Fi Protected Access 2 (WPA2). The WEP is the most unsecured method of these three. The WEP is easy to crack and so many programs exist for breaking the encryption. The WPA was developed to address the known weaknesses of the WEP standard. The WPA is a subset of the *802.11i* standard because the standard was not ready in 2003 when a new encryption method was needed. The newest and the strongest of these three standards, namely WPA2, is based on the full *802.11i* standard. The WPA2 uses a stronger encryption method, called Advanced Encryption Standard (AES), to provide better security than WEP and WPA. The WEP and WPA both use RC4 as their encryption method. Although these encryption methods exist, there are still wireless home networks which use no encryption what so ever. The most common reason for this is the fact that users might not have the knowledge to enable the encryption. The other reasons might be the total unconcern for the possibility of missuse of the home network, or the network is intentionally left open to everyone. [13]

The question whether these technologies can co-exist has not been answered yet. This question is not so easy to answer. The technologies with different mediums can co-exist for sure, but if two or more use the same medium the situation can be different. This brings up another question. Is there any sense to use different technologies on the same medium? Is there any reason to use, for example, HomePNA on coax and MoCA in the same house? This might be the case in a larger apartment building where multiple homes are interconnected with the same cable network. Instead, for a single home, this scenario is not so feasible. It is possible that in this case the two technologies could affect each others performances, but is it enough to completely disable one or both of them? It is hard to say, but in the author's opinion it is not possible. The situation is the same with wireless technologies. Almost all of the presented technologies use the 2.4 GHz frequency band, so it is possible that the different devices and technologies interfere with one another. In addition, microwave ovens use the same 2.4 GHz band and they might affect the performance of these wireless technologies as well. In the end, the fact of the matter is that all the presented technologies are designed to work and co-exist with other technologies. Although there might be occasional interferences, it is not a matter of concern, at least, in the author's opinion.

5 What users prefer?

A user with little knowledge on home networks has very different requirements for a home network than an advanced user. The normal user prefers most of all simplicity in installation and in usage. In addition, the price of the home network is a critical factor as well.

Home users are mostly novices when it comes to building a home network. As mentioned in [2, 3], the consumers, i.e. novice home users, do not want a home network; they want the things a home network can do. A novice user could not care less about whether his/her home network uses air, coaxial cables or phone-lines as its medium. If the home network does what it is needed for, for example, connects PCs together and to the Internet or allows the distribution of music and video, the consumer is satisfied. The only thing to think about is whether the technology can satisfy a user when looking at its specifications. The technology must have enough bandwidth to offer and it must be reliable and easy to maintain. From the technologies reviewed in this paper, the no-new-wires solutions have higher data rates. However, the wireless technologies are sufficient for most usage, including file sharing and web browsing. In addition, all of the reviewed technologies are not meant for high bandwidth multimedia streams. The Bluetooth and 802.15.4 are intended for low rate data, which can include voice in the case of Bluetooth. Video and other data transfer needing higher bandwidth must be transferred using some other technology. The reliability issue is hard to conclude based on a mere literature review, but the wired solutions have been mentioned to be more reliable [17].

The price of the devices needed to build a home network might be the most significant factor when choosing a particular technology. What has been seen is that the wireless components are more expensive than the wired ones [8] and this of course rises the prices of the devices as well. In addition, when thinking of building a network using some of the 802.11 standards, an access point must be bought in order to take full advantage of the network. Of course, the network can be ad-hoc, but it can be formed only between two 802.11x devices at a time. In the end, users tend to want the cheapest solutions possible, and the wired choices might just be a bit cheaper when compared to the wireless ones.

In the past, the home networks have been like a hobby to technical enthusiasts who have had the knowledge to build

them. Nowadays, however, the installation must be easy for the novice user as well. This saves time and money when the need for outside help to install the home network is minimized. The no-new-wires solutions provide this by using existing cables for the physical medium. There is no need for new wires, only the devices must be connected to the medium and the network is usable. The wireless technologies presented are not difficult to install either. For example, the mature 802.11 technologies require the installation of an access point and in some cases a network card to a computer. The cost of new wires is avoided by using any of the reviewed technologies in this paper.

The location of use is also worth thinking about. The technologies requiring cables, in this case the no-new-wires technologies, are a little limited. The outlets' positions in home define the places in which the devices connected to the particular network can be used. Obviously, the wireless technologies are not limited to a certain location in the house. Of course, the wireless technologies suffer from "blind spots". They are places in which the signal is so low due to obstacles that the technology cannot be used. A smarter placement of the access point can make things better at least in the case of the 802.11 technologies.

6 Conclusions

This paper reviewed no-new-wires and wireless solutions for home usage. The focus of this review was on technologies that do not need any new wiring in home. Furthermore, the paper compared the technologies using various characteristics and collected the data in tables for easy comparison. At the moment, all the reviewed no-new-wires technologies are good choises for home networks because of their high data rates and QoS supports. A good alternative on the wireless side is the 802.15.3 because of its QoS support. The data rates of the reviewed wireless solutions are out of the competition of the ones on the wired side. The most mature technologies, namely the IEEE 802.11 standards, are proven and widely used when compared to the other standards presented in this paper. To prove their capabilities, the no-new-wires technologies have been deployed to test use in many places [5, 6, 18].

In the future, all these reviewed technologies will be used concurrently. One such scenario might be that a wired technology, such as the HomePNA, is used to provide the backbone of the home network. Several access points might be connected to this backbone to provide wireless connectivity to mobile and other devices capable of wireless networking. The "triple play" services, i.e. voice, video and data, will play a major role in the future as well. As mentioned, the no-new-wires technologies were designed to provide the necessary means to transfer these services. This might be an advantage when a user is choosing a home network technology.

The wireless technologies are older when compared to the no-new-wires solutions. However, the wireless world is developing as well. At least *IEEE 802.11n* and *Bluetooth v3.0* are being developed presently to compete with the more advanced, wired or wireless, technologies.

Looking at the topic from the users' point of view brought up a few important issues. The ease of installation is a must as was mentioned earlier. This reduces the cost of the home network, which might just be the most important factor when choosing a home network technology. As with all the reviewed technologies, the cost for pulling new cables into the home is avoided which also reduces the cost of the home network. In addition, maintaining the network must be easy as well. The main point is that users want the services the home network can provide. They do not care about the technology underneath.

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