Co-operative Wireless Neighborhood Networks

Antti J Tuominen
Helsinki University of Technology
Telecommunications Software and Multimedia Laboratory
Antti.Tuominen@tml.hut.fi

Abstract

Use of wireless technology to provide connectivity to residential networks is growing fast. When wired network is too expensive, or otherwise infeasible to build, wireless radio technologies are the solution of choice. In many regions people have started to build co-operative neighborhood networks (sometimes called SNAN or Suburban Neighborhood Area Network) on their own utilizing wireless technologies and ad hoc networking.

Neighborhood networks are usually connected to the Internet with a shared connection. A group of people pay for a single leased line which is then shared with the houses participating in the network. This paper takes a look at the technology and solutions behind these networks, how they are used today, and how they might be used in the future. The paper discusses the benefits and drawbacks of connection sharing and how different technologies may be used in parallel.

1 Introduction

Always-on Internet connectivity is fast becoming a commonplace, and new residential buildings are almost always already equipped with high speed enabled network wiring. Connectionless technologies like xDSL enable always-on Internet connectivity to households at a reasonable price.

Parallel to the growth of wired residential networks, wireless network technologies are becoming more and more affordable replacement for wired networks. Especially IEEE 802.11b hardware is readily available for reasonable price, and for others, e.g. 802.11a and HiperLAN2, are promised in the near future. In residential areas where wired network is not an option, due to high price or other factors, wireless LANs are picking up fast. In urban and sub-urban areas people are using this technology to connect neighborhoods in a community owned and operated high speed wireless network.

In addition to connecting neighboring households together in a high speed wireless local area network, these LANs are connected to the Internet usually using some broadband wired technology. Entry level technology in use today for shared Internet connection is ISDN, next steps are ADSL, SDSL and all the way to optical fiber leased lines, depending on how much people are willing to spend.

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2 Internet connection sharing

In urban areas many coffee houses today are providing WLAN Internet access to their customers as a complementary service. Recently, in the US, this idea has been taken up by some network enthusiasts, who have started to offer free Internet access to anyone via a private WLAN access point connected to the Internet. Doing this does not usually cost anything extra to the person, since most ISP agreements are on a flat monthly fee basis. Such networks are called Neighborhood Area Networks, or short NANs.

This paper is deals with sharing connectivity in a local closed group of people, not with anyone happening to be passing by. However, from a technological point of view there is little or no difference whom the connection is shared with.

2.1 Connection sharing

Simple connection sharing is technically very easy to set up. Larger more complex setups require expertise on the area. Sharing the Internet connection in a neighborhood has many benefits for the user. On the service provider side benefits may be harder to find. ISP sentiments and impact is discussed later in section 2.2.

Pros of connection sharing:

- low cost

  With flat rate agreements connection sharing is obviously very cheap. Getting a large bandwidth leased line may prove cheaper in some cases than having separate service agreements for every individual.

- better utilization

  With just one user traffic is often bursty. This is especially true with web browsing. Connection sharing would lead to better utilization of the available bandwidth.

- ability to use shared caches

  When a group of people share the connection, it is possible to use a shared cache server. With traffic based billing, this can amount to considerable savings. Shared caches are further discussed in section 5.2.3.

Cons:

- currently must NAT

  Current situation is that ISPs will usually give either a single permanent IP address or a dynamic IP address (using DHCP) to an end-user. To be able to share a connection like this, access router must do network address translation (NAT), which means that true end-to-end connectivity is lost. In the future, IPv6 can alleviate this, since ISPs should give a network prefix instead of single address to even individual customers.

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- requires technical knowledge

  Setting up connection sharing requires technical knowledge about networking. This is probably not a serious problem, since usually people setting up neighborhood networks have this kind of knowledge anyway.

2.2 Impact on ISPs

From ISP point of view connection sharing may not be very desirable. An ISP should have a service tailored for connection sharing to be able to profit from it. Many ISPs today offer a flat monthly rate, that is in no way connected to the amount of traffic.

There is a new trend of setting up private WLAN access points and sharing free Internet connectivity to anyone that happens to be passing by. Many ISPs are outraged by this and are saying it is a violation of the service agreement.[4] Though this is slightly different situation, the bottom line is still the same. When connecting a community network to the Internet, it is a good idea to openly discuss the situation with the ISP to avoid any legal problems.

3 NAN and SNAN

3.1 General

Term Neighborhood Area Network, or NAN, was coined in the Internet primarily to mean providing free Internet access to anyone using cheap wireless communication technology. Suburban Neighborhood Area Network refers to a privately built and operated community network. SNAN connects a community of people together, provides local services and Internet access.[5]

3.2 Ideology

Some NAN enthusiasts claim that Internet access should be free for everyone. Also some see WLAN networks as an alternative to the 3G mobile networks.[11] SNAN, however, is ideologically somewhat different. Basic idea is to provide low cost, high speed network connectivity to a (usually) closed group of people, in a manner of co-operation and mutual benefit.

3.3 Demand

Demand for high speed networks is growing fast. At the moment the cost may be prohibitive. Therefore, if a neighborhood already has the technical expertise to build a fast network on its own, it is certainly an attractive alternative. More and more people want to be able to access the Internet and without waiting for long connection setup times and waiting the content on slow dial-up lines. Also, people are finding new ways to utilize such networks.

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New services demand more of the connection. Modern web pages for example, use graphics, animation, audio and video clips, which are annoyingly slow if not unusable on slow links. While every building is not yet connected to a high speed network, people are not waiting for someone else to do and are doing it by themselves.

3.4 Benefits

A comparative cost study has been conducted at the George Mason University. The study concludes that with relatively high initial cost it is possible to set up high speed Internet connectivity to a group of people at the monthly cost of a single dial-up line. However, cost of labor is not included in this study.[3]

When a group of people build a network on their own, they own the infrastructure. This gives much more freedom and flexibility. On the other hand, there is no help desk, no company to take the blame if things don't go as smoothly as thought. This is the trade-off, when using voluntary labor. [3] suggests that network administration might charge other participants for the service to cover own costs or even to make profit.

4 NAN technology

This section shortly describes link technologies available (or soon available) used for building Neighborhood Area Networks. It also describes parallel use of different link technologies.

4.1 Wireless technologies

Several different wireless technologies are nowadays available to the consumer. Different technologies are available in different parts of the world.

4.1.1 802.11b (WaveLAN)

The predominant technology used in todays SNANs (and NANs) is the IEEE 802.11b.[6] Hardware is relatively inexpensive and readily available. Installation and use does not require much special expertise. 802.11b operates at 2.4 GHz band with speeds from 1 Mbps to 11 Mbps. 802.11b is available everywhere in the world.

4.1.2 802.11a, HiperLAN2

IEEE 802.11a is the successor of 802.11b. 802.11a operates on 5 GHz band and offers speeds up to 54 Mbps. It has the same media access control as 802.11b. At this time, 802.11a hardware is not available.

European Telecommunications Standards Institute (ETSI) is promoting HiperLAN2[8] as an alternative to 802.11a. HiperLAN2 uses 5 GHz band and offers speeds from 6 Mbps to

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54 Mbps. As 802.11a, HiperLAN2 hardware should be available in the near future. In the US, 5 GHz band has been reserved for 802.11a devices by FCC, which suggests that since HiperLAN2 uses the same band, it will only be available in Europe. As a consequence, ETSI might do similarly in Europe, and allow only HiperLAN2 devices.

4.1.3 Nokia Roof-top

Nokia Roof-top is a product for building wireless community networks [9]. It is mainly aimed at service providers and is quite expensive. However, it has a few interesting properties. Roof-top nodes are able to use both 2.4 GHz or 5 GHz unlicensed bands. Roof-top uses a proprietary ad hoc routing protocol to dynamically alter routes, if for any reason a current route is broken. Each transceiver has a line of sight to three other stations creating a routing mesh. At 2.4 GHz and 5 GHz frequencies, waves are easily absorbed by for example rain, or any other obstacles between transceivers, which makes dynamic routing important.

4.2 Heterogeneous environments

Since there are several wired and wireless technologies available, it is conceivable that various technologies are used in parallel. Further, wired and wireless may be mixed. For example, a house might have 802.11b for connecting computers to the network and a HiperLAN2 for inter-house connections.

Some houses might be connected with wired network and others using 802.11b. Packets can be delivered as long as there is one (or more) nodes that support both technologies and can act as bridges. This is true for any number of technologies in the same network. Even using both connections simultaneously is possible. A node could select which ever connection is better and route packets over it.

5 SNAN Services

This section describes what SNANs are used for and what kind of services are or could be available in SNANs. The amount of local services obviously depend on the community and the amount of time, effort and knowledge they have for setting up services, that people want to use.

5.1 Internet access

The primary reason for SNANs usually is providing a group of people easy and cheap Internet connectivity. Shared Internet access and benefits of sharing are discussed in more depth in Section 2.

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5.2 Routing

Routing is the cornerstone of internetworking. Current SNANs usually have very simple routing, between the local network and the Internet. A very simple SNAN could have only one wireless access point which is connected to an ADSL router or similar. This access point can serve computers with WLAN cards and directed antennas in several houses.

On a larger SNAN with several access points, all *leaf nodes* are not connected to the access point that connects to the Internet. In this case, access points must act as intermediate nodes (routers) and forward packets toward the root access point. To allow this either static routing or a routing protocol is needed. Using a routing protocol allows more dynamic configurations.

Though a SNAN is mostly static, a dynamic routing protocol, like protocols defined in the IETF MANET (Mobile Ad-hoc Networking) working group, may be desirable.[2] In radio networks, links are not as reliable as in wired networks, and links may fail for a number of reasons for short periods of time.

If for whatever reason a route is lost, the routing protocol instantly discovers a working route, if one exists. This approach requires a *mesh network* topology.[1] Each node can hear several others simultaneously. In case connection to one is lost, packets may be rerouted via still reachable nodes. Also this allows two nodes to communicate peer-to-peer if they can reach each other directly, and there is no need to go through the root router.

5.2.1 Web services

In a neighborhood network it may be conceivable to have local services. Services like neighborhood bulletin boards, web-based jumble sale service, etc. are easily set up using free software.

5.2.2 Security and Firewalls

In a co-operative network, it may be sufficient to use a shared firewall. All connections to the SNAN go through a single firewall, so individual nodes are easier to secure from attacks from the Internet. This benefits in less maintenance for individuals and better security for the whole SNAN.

Wireless networking however, opens up to attacks from a node that is near enough to connect to the wireless network directly. IEEE 802.11b has WEP security feature, which protects against unauthorized access to the network and against listening. This or some other access control technique must be applied to protect against unauthorized network access.

5.2.3 Caches and proxies

Using a shared cache reduces the need for outside traffic. Shared caches with many users are much more effective than individual user level caches. It is common that several people in a group are interested in the same subjects. Using caching allows the data to be retrieved once and storing it in an intermediate proxy for other users.

When using a traffic based payment model, caching makes most sense. Minimizing outside traffic by using local copies also minimizes the amount of money paid to the ISP. If certain sites are accessed constantly by a number of users, one might even consider mirroring portions of these sites.

5.3 Applications

When a community owns the infrastructure, local high speed services can be used virtually free. For example, within a SNAN people could use IP telephony instead of regular telephones for voice communications. If there is need for surveillance cameras, these can be easily connected to the network. Also, on children's playgrounds network connected "nannycams" could be installed for parents to look over their children while indoors.

5.3.1 Broadband services

Audio and video services are becoming more popular. Also other real-time services requiring broadband connectivity will soon be available.

6 Future of SNANs

New buildings are usually equipped with CAT5/6 cabling allowing high speed networking. At least in urban areas, it should be easy to get a shared leased line for an apartment building, making SNAN solutions unnecessary. Old buildings and sub-urban areas, on the other hand, are potential for SNAN solutions.

6.1 Growth

Main growth area for SNANs will probably be already built areas, where no network exists. Other area could be places where networking is extremely costly or otherwise impossible. New buildings are often built with network wiring and are sometimes even already connected to a wired community networks.

6.2 New applications

SNAN community network allows many applications of which some might be special to SNAN. New applications may appear when people use SNANs and think of new ways to utilize the network.

Areas where outdoor wireless connectivity is available could be used to support mobility. For example, you could walk around the neighborhood with a PDA and never lose connec-

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tion to the network. For true mobility, a mobility management protocols such as Mobile IP[10] and Mobile IPv6[7] must be used.

7 Conclusion

High speed wireless networks are providing a viable alternative to wired residential networks in built urban areas as well as sub-urban areas. Using wireless technology to connect neighboring houses in a neighborhood area network, and sharing broadband always-on Internet connectivity, has a lot of advantages over wiring every house separately, most obvious being the cost savings.

Small neighborhood networks are easy to setup and maintain. The amount of expertise needed, however, grows rapidly when the number of connecting houses increase. With only a few nodes, static routing suffices, but for larger networks use of a routing protocol is necessary.

While future may bring wired network to every household, SNANs are probably not just a passing fad. Future computers are envisioned to be very mobile. Wireless community networks enable the use of mobile wireless devices with the same infrastructure that is used to connect buildings. Communities with already built SNANs may take full advantage of mobility and mobile services when available.

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