Frequently Asked Questions

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General Information

What is HomeRF?

HomeRF (Home Radio Frequency) is wireless home networking – a way to connect PCs, peripherals, cordless phones, and many other consumer electronic devices so they can "talk" with each other to share resources and access to the Internet. Wireless home networking makes this possible without the expense and complexity associated with running wires.

In more technical terms, HomeRF is an open industry specification that defines how these devices share and communicate voice, data and streaming media in and around the home. HomeRF-compliant products operate in the license-free 2.4 GHz frequency band and utilize frequency-hopping spread spectrum RF technology for secure and robust wireless communications.

HomeRF extends the wireless LAN concept by blending technologies from several worldwide standards since none of them alone meet the market requirements of 'broadband' homes. Data networking technologies based on CSMA/CA protocols (essentially wireless Ethernet) are derived from the IEEE 802.11 and OpenAir standards, and cordless phone technologies based on TDMA are adapted from DECT. DECT is the Digitally Enhanced Cordless Telephone standard that is widely used across Europe, but it is not available in the Americas because it uses a frequency band that has been set-aside for other purposes. By combining these technologies using the license-free 2.4 GHz

frequencies that are available worldwide, HomeRF can become the global cordless phone standard, an exciting prospect for makers of phones.

What are the Key Messages?

1. HomeRF is designed for homes and small offices -- so interoperable products are Simple, Secure, Reliable, and Affordable.

2. HomeRF is ideally suited for broadband services -- with a unique ability to integrate voice, data and streaming.

3. HomeRF extends beyond wireless LAN -- with 10Mbps performance, cordless telephone support for up to 8 lines, quality-of-service support for media streaming including music and TV, and standardized roaming.

What is HomeRF's role in the Home Networking Market?

There are four basic types of home networks: (1) data networks that connect PCs; (2) communication networks that connect phones; (3) entertainment networks that connect TVs; stereos, and game consoles; and (4) control networks that tie in lighting, heating and cooling, security, and home automation.

The primary driver has been the Internet, falling PC prices, and multi-PC households. This has driven demand for data networks and attracted the large computer companies and organizations interested in e-commerce. A relatively new driver of home networking is broadband communications and integrated service bundles that add telephone and entertainment services including digital music and digital television.

Home Networking is a HOT market. Already, some 65% of US households have a PC, and some 22 million homes have more than one. By 2005, Analysts predict that over 46 million US households will use broadband connections to access the Internet, up from 10 million today, and 25 million home networks will be installed by 2004. With most families already paying $300 per year for Internet access, there's a need for products that let us share an Internet connection. And with broadband carriers starting to offer service bundles, there's a need to connect a wider variety of devices.

Internet services generate about $14 Billion per year today. (That assumes that 1/3 of us use a "free" access service and the rest pay an average monthly access fee of $25. AOL, MSN and CompuServe cost less but DSL and Cable modem services cost more. And 40M homes * $25 is over $14B.)

The market for home networking products that share the Internet connection and provide other benefits will reach $5 Billion in 2005, and the market for home gateways will reach another $5 Billion by then. These projections include the networking devices but not the PCs, information appliances, phones, peripherals, and consumer electronics that will surely grow at a faster rate because of home networking. We're looking at another $15 Billion for information appliances, for example. And the really big market, which is still a few years away, is the wide variety of new electronic services that home networking will enable.

Slowing the home networking market to date has been the cost and complexity of running wires. Since HomeRF solves that problem and meets other market requirements, it is the leading wireless home networking technology.

Access http://www.homerf.org/data/face_off/FaceOffHN_Market.pdf to view four charts further describing our view of the Home Networking market.

Who created HomeRF and why?

HomeRF was developed by the Home Radio Frequency Working Group (WG), which initially included five leading computer companies but has since expanded to about 70 companies made up of leaders across the PC, consumer electronics, networking, peripherals, communications, software, retail channel, home control, and semiconductor industries worldwide. This group was launched in March

1998 to promote the mass deployment of interoperable consumer devices that share and communicate voice, data and streaming media in and around the home without the complication and expense associated with running new wires.

The HomeRF WG is dedicated to developing wireless home networking products that are simple, secure, reliable and affordable to the consumer. At the beginning of 2001, it announced organizational changes to exploit new FCC regulations that allow increased transmission speeds and support additional device types, applications and services. And in the Fall of 2001, it announced for formation of a HomeRF European WG to focus on market differences in that geography.

What is the HomeRF Membership?

HomeRF membership is over 70 companies, made up of world leaders across several industries worldwide – including the PC industry, consumer electronics, networking, peripherals, communications, software, retail channel, home control and semiconductors. More information and a list of members are on our web site at http://www.homerf.org.

Why do companies like Siemens, Compaq, Motorola, National Semiconductor, and Proxim think it's important to be a part of the HomeRF organization?

These are the current HomeRF Promoter companies with the largest investment, and it is interesting to note that they are each heavily invested in other wireless technologies such as 802.11 and Bluetooth, as well as HomeRF. They know these separate markets have unique requirements and each technology has its best fit. But since these companies have their own reasons for investing so heavily in HomeRF, this is a question to ask them individually.

In general, the group feels that collaborating on similar specifications and enforcing a certification process to facilitate interoperable products that are simple, secure, reliable and affordable will drive growth in the wireless home networking market.

What are the Benefits of Wireless Home Networking?

Why do people choose wireless home networking and HomeRF? Let's first look at the alternatives, including Ethernet and phone-line networks.

Ethernet is the fastest, cheapest, and most reliable way to network your PCs, so we can recommend it when practical. For many people, installing Ethernet is as simple as stringing wires between the PCs in one room. But extending the network throughout the house adds complexity and cost. Even if you own your own home and can do anything you want to it, today's building codes require horizontal fire blocks between wall studs, making it hard to just drop wires down from the attic. And a 2-story home on a slab foundation makes wiring even more difficult. Sometimes it's just not possible to install the cabling required for Ethernet.

Another networking alternative uses your existing phone lines, with technology from a sister consortia called HomePHA (Home Phone-line Networking Alliance).

HomeRF lets you put PCs in places where there's no Ethernet or phone-line outlet, and some gateway products support bridging between HomeRF and Ethernet or HomePNA.

Often it's just easier or more convenient to go wireless. HomeRF offers the convenience of being mobile all around the home, and this benefit becomes more important as our products get smaller and run on battery power.

A PC with HomeRF can be used on the sofa while watching the ball game, at the kitchen table while eating breakfast, in the garage to access the online shop manual, or on the deck when it's just too nice to stay inside. Consumers have already demonstrated a willingness to pay more for the freedom of mobility. Cordless phones, for example, out-sell corded models by at least 2-to-1 even though the cost twice as much.

Because PC prices have fallen and most applications don't need the faster models, it's now feasible to buy several PCs – for the kitchen, the living room, and the bedrooms – not just one for the home

office. Instead of $3000 high-end models, you can buy three sub-$1000 models and network them. Share a printer in another room, or a phone line, or DSL or Cable modem. The higher monthly cost of broadband service (about $40/month) is much easier to justify if it is shared.

What is the importance of Simplicity?

Networking computers can be a daunting task. Unlike offices, consumer households don't have system administrators to configure, install, maintain and protect their networks; and running wires can be difficult to impossible. HomeRF is often the simplest way to network since there are no wires to run. PC Card and USB adapters are self-configuring, and most people find that the bundled software installs easily. Vendors are making their products increasingly easy to configure so that devices on the wireless network recognize each other.

Proxim's Symphony HomeRF products, for example, include software to simplify installation and setup, and Proxim includes a Location Switcher to make it easy to move a notebook PC between Ethernet networks in the office (or home office) and a HomeRF network for use on the sofa, kitchen table or patio. The HomeRF specification also defines a standard way to handle bridging between wireless networks and wired networks such as Ethernet and HomePNA.

What HomeRF Products are available?

Certified HomeRF products are available today from trusted consumer brands such as Compaq, Intel, Motorola, Proxim, Siemens and others through retail, online, and service provider channels. They come in a variety of form factors such as USB and PC Card adapters, residential gateways, and a growing variety of devices that use HomeRF design-in modules.

The community of HomeRF products is expanding beyond data networking and already includes TV set-top boxes, stereo accessories, Internet alarm clocks, and even a home robot. The first HomeRF cordless telephone handsets will be available in the first half of 2002 from Siemens, and the new HomeRF 2.0 specification is enabling entirely new types of products, applications, and services.

To learn more about HomeRF products, visit http://homerf.org/products/

Isn't HomeRF just Wireless Ethernet?

Think of HomeRF as a blend of wireless Ethernet, cordless telephony, and streaming media. Just as with Ethernet, it works in a building and can be used to connect your PCs to a broadband service provider through a cable modem, DSL modem, etc. Unlike Ethernet, it does not require that you run wires and gives you the convenience of being able to move about instead of being tied to an Ethernet port.

Although HomeRF has enough bandwidth for dialup and broadband services, it is not tied to a specific access service. If your home or small business is in an area covered by cable TV, chances are that your cable company also offers high-speed Internet access through a cable modem. If you are close enough to the telephone company's head-end, then you may be able to get high-speed ADSL service. Other broadband service choices include wireless cable (using LMDS or MMDS microwave radio technology), fixed-point PCS (similar to mobile phones but faster), and satellite (using Hughes' DirectPC service).

Why use HomeRF for Cordless Phones?

HomeRF voice support is progressing well. Siemens has demonstrated the first HomeRF voice call, and the company expects to introduce the first HomeRF cordless phone handsets in 1H 2002.

Only HomeRF supports multi-line toll-quality voice with all advanced calling features. HomeRF has a clear advantage for voice; Bluetooth is probably adequate for some voice applications; and 802.11 is at a distinct disadvantage.

Phone wiring in most U.S. homes (and the familiar RJ-11 jack) limits families to just two lines, but busy families and teleworkers often require more. Only HomeRF provides simultaneous support for up to 8 toll-quality voice connections, 8 prioritized streaming media sessions and multiple Internet and network resource connections at Broadband speeds. And HomeRF accomplishes this with excellent comparative ratings for low cost, small size, low power consumption, interference immunity, security and support for high network density.

Imagine Internet-enabled appliances that can receive phone calls, and cordless telephones that can interact with PC and Internet applications. Siemens is making this possible by integrating its DECT-based cordless phone technology with HomeRF's high-speed data and entertainment networking. Siemens is not alone in believing that HomeRF could become the worldwide cordless phone standard.

PCs can greatly enhance phone systems with capabilities such as universal inbox (for email, voice messages, pages, faxes, and short message services). And phones can become speech I/O devices for accessing PC and Internet applications. With a HomeRF handset, you can say "call Esther Cruz" and the PC can find the number in Microsoft Outlook and then initiate the call. And when you ask, "What is Siemens selling for?" text-to-speech software can tell you that it's time to buy.

HomeRF enables these capabilities even in the presence of severe interference and the handset range and voice quality is comparable to the best 2.4 GHz products on the market today. HomeRF is the only technology with support for all CLASS service features like call waiting, caller ID, forwarding to individual handsets, distinctive ringing, 911 breakthrough, etc. on an interoperable basis due to its DECT-based call stack.

Since HomeRF is derived from a blend of DECT (for TDMA voice networking) and IEEE 802.11 (for CSMA/CA data networking) and uses the globally available 2.4 GHz frequency band, it is the logical evolution of DECT and will benefit from DECT's large market and mature technology. Over 50 million DECT devices were sold in 2000, and by 2002 the installed base will be over 200 million. That's 10 times the size of the wireless LAN market, and the DECT technology is very mature, with semiconductors in their sixth generation and with chip sets selling for well under $10.

IEEE 802.11 variants fail completely to provide toll-quality voice services unless proprietary extensions are added (to date only for enterprise applications). Even with such extensions though, sending voice over 802.11 compares poorly in critical areas such as cost, size, power consumption, interference, security and support for high network density such as apartments. 802.11 has no mechanism to bound latency for voice, nor is there any existing industry infrastructure of cordless telephony technology that can be leveraged the way HomeRF can with DECT.

802.11 still is too focused on data networking for serious teleworkers at home, and radio interference can render it completely ineffective. HomeRF includes voice support because, while data traffic has far surpassed voice traffic across most phone systems, voice services are where the revenues are. Any service provider that believes multi-line, toll-quality voice is an essential ingredient of integrated services for the broadband Internet home network should have serious misgivings about deploying any of the 802.11 variants, especially interference prone 802.11b, because of the voice support issue alone.

Access http://homerf.org/data/press/FaceOff_Voice_Data.pdf to view 16 charts further describing HomeRF voice/data integration.

Is HomeRF compatible with the Siemens Gigaset?

The current Siemens Gigaset line, which uses WDCT technology, is not compatible with HomeRF but the cordless phones may be used in the same home without interfering. For a good resource on WDCT, visit http://www.siemens-wireless.com/about/resources/digcord.html.

WDCT (Worldwide Digital Cordless Telecommunications) is a term that Siemens uses to describe its Gigaset(TM) multi-handset phone system. Siemens derived WDCT from the European DECT phone standard and modified it for 2.4 GHz frequencies because the 1.9 GHz DECT frequencies require a license outside of Europe while the 2.4 GHz frequency band is available license-free worldwide.

As you may already know, Siemens offers a line of Gigaset phones that ranges from single-line single-handset models to multi-line multi-handset models. Their HomeRF phones planned for 1H 2002 timeframe will extend the high-end of the Gigaset line with the ability to support voice and data. The Siemens HomeRF phones will be multi-line models that are optimized for voice but with the ability to handle data.

Why use HomeRF for Entertainment Applications?

Only HomeRF supports multiple prioritized streaming media sessions independent of voice and data traffic on the network. While Bluetooth and Wi-Fi are adequate for some multimedia applications, HomeRF has a clear advantage.

HomeRF provides standardized quality-of-service support for prioritized streaming media sessions within the asynchronous data framework of the protocol. Such prioritized streaming media sessions are not immune from all radio channel impairments, but they are not affected in any way by network contention and the amount of asynchronous data traffic on the network. Note that by default two-way voice traffic in HomeRF has higher priority than streaming media.

HomeRF media streaming supports a full range of options including multi-cast, two-way (i.e. videoconferencing) and receive-only destinations. Up to 8 simultaneous sessions are allowed with typical applications such as MP3 headsets, remote Dolby Surround Sound speakers and MPEG4 video distribution to Internet appliances.

Both Bluetooth and Wi-Fi have the ability to support streaming applications, and a Bluetooth wireless MP3 headset is very believable. But multiple voice, streaming and broadband data connections operating simultaneously over Bluetooth is not feasible due to its limited bandwidth and MAC architecture.

Even though Wi-Fi has adequate bandwidth for many streaming applications, unpredictable and unacceptable results occur with network contention or interference. The IEEE 802.11e study group hopes to address the contention problem by changing the MAC layer and adding quality-of-service support as HomeRF and Bluetooth have done. They still must select from a half-dozen or so competing alternatives, and this decision is not expected until at least year-end 2001 with compliant products not expected until many months later. Deployment will be constrained by the understandable desire for complete backwards compatibility. In the interim, some companies are taking their own proprietary approach, but this leads to interoperability problems and dilutes the Wi-Fi "brand." While this may not be a serious problem for individual consumers buying a solution for a given application, it is a serious concern for service providers deploying broadband networks for the Internet home.

Wi-Fi lacks any support for latency-sensitive applications such as voice and is also seriously affected by interference. Imagine that you and your friends are listening to music or watching a movie, and then you answer a phone call with your 2.4 GHz cordless phone or decide to heat up pizza in the microwave oven (or your neighbor does this). With Wi-Fi, the entertainment experience can be destroyed by interference.

HomeRF uses hop-set adoption technology to sense interference within the band and learn to avoid it. At COMDEX Fall, HomeRF had a 20'x20' booth setup like a house – with a small living room, kitchen and boy's bedroom. Within that small space, we had five separate radio subnets to simulate high-density apartments. Even with all of that radio traffic, uniView was still able to sustain near-VCR quality in their video-on-demand demo using MPEG-4 video compression. HomeRF 2.0 further improves upon that experience.

How does HomeRF benefit Home Gateways and Broadband Services?

First let's describe what a gateway is. It's a device that connects an access service, such as DSL or cable, to one or more home networks. Simple gateways let multiple PCs share an Internet connection, but more advanced models also support the delivery of bundled services and the distribution of those services throughout the home to various access devices.

It's safe to say that ALL of the access providers – for telephone, TV cable, satellite TV, etc. – are migrating their analog networks to digital. Digital is far cheaper, more reliable, and has the ability to carry any kind of information that can be put into digital format.

That means a telephone company can start offering Internet services and video-on-demand, while a cable company can offer phone services. Over the next few years, they all plan to deliver integrated services that include local, long-distance and mobile phone, Internet, TV, digital radio, security monitoring, etc. These services will come in a bundle with a single monthly bill that's less than if you bought these services separately. 'Interesting. 'Competitive. And it's already starting.

It is with this perspective that analysts predict that within 10 years every US home (or at least 90% of them) will have at least one home gateway. What a great opportunity for products that support HomeRF!

HomeRF is ideally suited for these broadband services because of its unique ability to blend voice, data, and streaming media. HomeRF has the ability to give cable services a way to reach cordless telephone handsets, and it gives DSL services a way to reach TVs and stereos.

All of this is why TV set-top box companies like Motorola, Scientific-Atlanta, Arris, Pace Micro Technology, and uniView, as well as gateway manufacturers 2Wire, Cayman Systems, Compaq, and Proxim all include support for HomeRF.

NOTE: Because of the huge potential in broadband services, the HomeRF Working Group is establishing a Broadband Service Provider advisory council to help advise us how to best serve their needs.

Access http://homerf.org/data/press/FaceOff_Gateways_Broadband.pdf to view 9 charts further describing our view of the Broadband Gateways market.

What is the HomeRF Future Roadmap?

HomeRF products hit the market in 2000 with 1.6 Mbps performance, which is over-kill for sharing a phone line and a great match for DSL and Cable modems. As expected, nearly all of the early products were PC related and supported data applications.

HomeRF 2.0 with 10 Mbps performance in 2001 will support for more phone lines (up from 4 to 8), new features designed for digital music and standard definition TV, and even roaming. Products to watch for include the first HomeRF cordless phones, Web tablets, more music devices, as well as increased use in home gateways. Since HomeRF 2.0 will be compatible with today's HomeRF products, the roadmap is evolutionary. HomeRF 2.0 exploits an FCC rule change that authorizes the use of wide-band frequency-hopping technology.

A proposed FCC rule change to allow digital modulation techniques such as OFDM (Orthogonal Frequency Division Multiplexing) is expected to allow considerably faster speeds. The HomeRF technical team is already working on HomeRF 3.0, with performance expected to exceed 40 Mbps in 2002 and with 100 Mbps performance possible soon after.

Access http://homerf.org/data/press/FaceOff_Future_Roadmap.pdf to view 3 charts further describing our technology roadmap.

How has Intel's shifts to 802.11 affected HomeRF?

Intel quietly announced that their next generation products would be based on 802.11b instead of HomeRF due their limited resources and inability to support both standards during these tough economic times. Intel, which helped form the HomeRF Working Group and has been a long time supporter, will continue as a member, and will continue selling its high-demand AnyPoint wireless home networking products, which are based on HomeRF.

Intel has an acute understanding of the benefits HomeRF brings to the broadband Internet home, so we are especially sad that they are unable to offer next-generation HomeRF products. Their decision

has indeed tarnished public opinion of HomeRF and its future prospects, but the technology continues to be right for the broadband Internet home.

HomeRF gained the dominant market position in wireless home networking because it was designed from the start for consumers so certified products are Simple, Secure, Reliable, Affordable and Interoperable. 802.11 gained market share as prices for 11 Mbps products fell close to that of HomeRF, but HomeRF is ready for a come-back. HomeRF is ideally suited for broadband services because of its unique ability to integrate voice, data and streaming. HomeRF 2.0 extends home networking with 10Mbps performance, cordless phone support of 8 lines, streaming media support of 8 sessions, and standardized roaming. HomeRF 2.0 products started shipping in October 2001.

HomeRF voice support is progressing well; Siemens demonstrated the first HomeRF voice call; and the company expects to introduce the first HomeRF cordless phone handsets by mid-year 2002.

The community of HomeRF members and products continues to grow, and many companies hope to fill the void that Intel is leaving by their decision to not offer second-generation products.

Has HomeRF lost or gained Market Momentum?

HomeRF has lost momentum but is far from dead, as 802.11 advocates may claim. Rather than worry about HomeRF, one could argue that 802.11b is on the verge of being obsolete due to the more robust and much faster 802.11a products shipping by the end of 2001 and the 802.11g products shipping in 2002. With uncertainties in the 802.11 road map, companies making 802.11b products could shift to next generation HomeRF products once the technology proves itself in the market.

HomeRF gained the dominant market position in wireless home networking because it was designed from the start for consumers so certified products are simple, secure, reliable, affordable and interoperable. HomeRF 2.0 extends that home networking lead with 10Mbps performance, more phone lines, improved streaming support, and standardizedroaming. And because of its unique ability to integrate voice, data and streaming, HomeRF is ideally suited for the broadband services that will drive home networking technologies. HomeRF 2.0 products started shipping in October 2001.

The community of HomeRF members and products continues to grow. HomeRF voice support is progressing well; Siemens demonstrated the first HomeRF voice call; and the company expects to introduce the first HomeRF cordless phone handsets by mid-year 2002.

Access http://homerf.org/data/press/FaceOff_Momentum.pdf to view 5 charts further describing HomeRF market success and momentum.

Where can I get More Information?

Visit our Web site at www.homerf.org for more information, including a technical white paper that compares various wireless technologies for the broadband Internet home as well as additional papers on quality-of-service, RF interference, and wireless security.

Market Positioning with Bluetooth and 802.11b

The home and the enterprise have completely different application, range, cost, speed, interference, and security needs. Products designed for one environment don't always work well in the other. We believe there's room for both kinds of products, just as there are people who drive different types of cars and not everyone needs a van, truck or bus.

Access http://homerf.org/data/press/FaceOff_Positioning.pdf to view four charts further describing the positioning of HomeRF, Bluetooth and 802.11b.

What are the Applications?

Home and enterprise application needs are different, and teleworkers often require both. Enterprises that have deployed wireless networks (and they are not as wide-spread as hyped) have done so for data applications such as e-mail and Internet access. HomeRF goes beyond just data and uniquely supports consumer needs for voice, data, and streaming media at home. These applications are also important to broadband service providers, and we believe that broadband will drive home networking standards, not centralized enterprise IT decisions.

What is the Range?

Often the simplest way to compare wireless networks it to look at the coverage area. Mobile phone networks include overlapping cells that cover a wide area (WAN) – large portions of cities and countries. Enterprise networks such as IEEE 802.11b cover only a local area (LAN) – multi-story office building or campus. HomeRF is a smaller LAN – the space of a house. And finally, Bluetooth covers a personal area (PAN) – the space of a room.

Wi-Fi has excellent range characteristics for pristine, interference-free environments while HomeRF has good full-home coverage even under severe interference. Both HomeRF and Wi-Fi have enough range for the broadband Internet home.

For range-critical applications like cordless telephony, HomeRF is equal to or better than the best 2.4 GHz products on the market today. And the HomeRF range advantage is magnified in high network density or severe interference environments.

Bluetooth can also have adequate interference-free range for most residential applications when the "high power" devices are deployed. But most analysts expect mainly "low power" Bluetooth devices with room-size coverage to be deployed in mobile phones and PDAs. Thus most consumers will likely either associate Bluetooth with single room usage or be frustrated when mixing the two classes of devices. For this reason, Bluetooth is seen to be at a disadvantage when comparing range.

What is the Cost?

HomeRF meets typical consumer price points of about $100 per PC node, and HomeRF doesn't need a separate access point that can add to the cost. Just $200 connects two PCs and $400 connects four. One of the PCs can act as a gateway and share its modem with the others, but some people don't like leaving the PC powered on all of the time, or they would rather a separate device and not a Windows PC provide firewall security. It that case, they may choose a home gateway with built-in firewall security.

Proxim's Symphony-HRF Cordless Gateway lists for just $199. Compaq's iPAQ Connection Point, which adds bridging between HomePNA and Ethernet, costs a bit more. In general, we're seeing tremendous support for HomeRF among home gateway manufacturers.

Lower complexity gives HomeRF and Bluetooth a Cost advantage over Wi-Fi. HomeRF and Bluetooth are simpler technologies than any of the popular 802.11 variants. "Simpler" means fewer and/or less demanding RF semiconductor chips and passive components as well as less complex digital base-band chips. Although generalizations are dangerous, it appears that for the next few years that equivalent product volumes of HomeRF and Bluetooth should have an advantage of about

a factor of two in bill of materials (BOM) cost over any 802.11 systems. This point is shown visually when the cover is removed from popular HomeRF PC Card adapters and the chip count is compared with that of 802.11 cards. To see the photos, visit http://homerf.org/data/press/FaceOff_Cost.pdf.

802.11 advocates dispute the magnitude of this cost difference and the implications for broadband deployment. They point out that the retail pricing of network interface cards (NICs) does not show the same magnitude difference as the BOM cost and in some cases can point to subsidized retail prices that match that of HomeRF. However, this is mainly due to margin compression on the 802.11b suppliers in the face of HomeRF (and pending 802.11a) competitive pressure.

The key for pervasive presence in a networking technology standard with consumers, as clearly recognized by both HomeRF and Bluetooth, is that the technology must get built-in to pivotal devices. For the broadband Internet home, this means broadband gateways, Internet appliances and cordless telephones. For this to occur, cost is always of paramount importance, and every cost "tier" (whether $50, $30, $20, $10, etc.) gets a given new technology built-in to ever increasing percentages of these pivotal devices. HomeRF and Bluetooth will always get to these important cost tiers ahead of 802.11 variants and thus on this basis alone enjoy a significant advantage for becoming the de facto choice for wireless networking of the broadband Internet home.

What is the Data Rate & Throughput?

HomeRF has 10 Mb/s peak data rate in 2001 products with sufficient range for most residential applications. The data rate backs off to 5 Mb/s or lower if needed to extend the range or communicate with current HomeRF products that have a peak rate of 1.6 Mb/s.

Consumers should feel comfortable that their original HomeRF products will work with the newer HomeRF products. The 1.6 Mb/s performance of these original products is up to 30 times faster than dial-up modems and a good match for DSL and cable modems, and HomeRF 2.0 is designed to enable entirely new product categories, applications, and services with a focus on entertainment – digital music, video and games.

Second generation HomeRF devices being deployed starting in October 2001 have peak data rates of 10 Mb/s and the same low cost structure as today's first generation products. This corresponds to peak TCP/IP throughput of around 5 Mb/s (~25 times faster than Bluetooth). In the same timeframe, 802.11b devices with similar peak data rates and throughputs will also be approaching consumer price points. Thus for 2001 deployment it seems that both technologies are on par when comparing these factors alone. The real advantage of HomeRF is in its cordless phone and multimedia streaming support, and this is especially important to broadband carriers.

Access http://homerf.org/data/press/FaceOff_Positioning.pdf to view 3 charts that show how HomeRF outperforms Wi-Fi over distance and with interference in co-located networks.

What about Interference & Reliability?

HomeRF has intelligent hopping algorithms that detect wideband, static interference from microwave ovens, cordless phones, baby monitors or other wireless LAN systems. Once detected, the HomeRF hop set adapts so no two consecutive hops occur within this interference range. This means with high probability that a packet lost due to interference will get through when it retries on the next hop. While this is powerful for data, it is especially powerful for HomeRF's native voice service, which includes a retry mechanism for lost voice packets. The result is extremely low bit error rates for the voice service with low latency.

At COMDEX Fall, HomeRF had a 20'x20' booth setup like a house – with a small living room, kitchen and boy's bedroom. Within that small space, we had five separate radio subnets to simulate nearby apartments, and still uniView was able to sustain near-VCR quality in their video-on-demand demo using MPEG-4 video compression.

Homes are often riddled with interfering devices, and we have already heard of one executive of a large telephone company who was surprised during a recent installation of 802.11b in his home. While he was not too surprised that performance was very sensitive to where the equipment was

placed, to his dismay his wireless network seemed to completely shut down suddenly when his daughter was talking on her 2.4 GHz cordless phone in the other room. You see, Wi-Fi is very sensitive to interference from cordless phones, microwave ovens, next door neighbors, and… Bluetooth devices. Ouch!

There haven't been many interfering devices in businesses, but Bluetooth is gaining popularity rapidly, and this will soon change. Bluetooth's effect on Wi-Fi can be severe at times, so Ford Motor Company took the drastic step of banning Bluetooth from its Deerborne, Michigan facility.

Not all of the controversy regarding the effects of unwanted interference on 802.11b is fair and justified. For asynchronous data communications, most users won't notice a 10-50% data throughput reduction that might occur with interference. The bigger problem is that severe fluctuations in latency under interference hurts streaming media applications and kills toll-quality voice calls. Note that 802.11a is "immune" from interference problems today only because its 5 GHz bands are virtually unoccupied. In the long run it faces the same severe issues as 802.11b does today, although mitigated somewhat by the additional channels available at 5 GHz.

A white paper describing Interference Immunity in 2.4 GHz Wireless LANs can be found at http://www.homerf.org/data/tech/hrf_interference_immun_wp.pdf.

How does HomeRF address Security?

Although any network has its vulnerabilities, HomeRF is more secure than Bluetooth or 802.11.

Security is a real concern for consumers with regards to wireless communications. Analog cordless phones, analog cell phones and CB radios have trained them to see wireless as easy to eavesdrop. With digital authentication and encryption, it is easy to deny the casual eavesdropper, and all three standards accomplish this adequately.

While none of these systems can truly defend against attack by a professional eavesdropper (like the CIA) with unlimited resources, there are still clear and important differences between the different technologies. As researches at the University of California at Berkeley and at the University of Maryland have shown recently, any 802.11 compliant device can demodulate MAC layer bits to allow the attacker to work offline and break the password. Furthermore, a compliant device can easily be put into a mode where it joins a network without permission and either searches for network traffic and resources or sends packets to aid in breaking the relatively weak "WEP" encryption. In fact, a compliant 802.11 device can also be used to insert unauthorized encrypted packets into the wireless network or even the backbone wired network, all without knowledge of the encryption key. For 802.11, mass denials of service attacks are possible with remote and legal equipment.

In contrast, HomeRF was designed from the beginning to provide much better security for consumers who, unlike IT managers in the enterprise, are not likely to run upper layer security measures over their wireless network.

The defects highlighted for 802.11 simply are not present in HomeRF. HomeRF adds a 24-bit network ID, 128-bit data encryption (versus 40 bits for 802.11) and other security features to its digital frequency-hopping spread spectrum technology, which was first developed for the US Military to keep enemies from jamming our radio transmissions or eavesdropping on them.

To tap into HomeRF's pseudo-random frequency-hopping technology would require custom hardware like a radio-scanner used by the CIA. Individuals caught with this equipment would be suspected of foul play, thus increasing their chances of being prosecuted. And even if they can learn the hopping pattern, they must still contend with a network ID and 128-bit encryption.

A white paper comparing wireless security of HomeRF and 802.11 can be found at www.homerf.org/data/tech/security_comparison.pdf.

How does HomeRF achieve low Power Consumption?

HomeRF and Bluetooth, by nature of their modulation techniques and radio transceiver requirements, have somewhat lower power consumption in active transmit or receive modes than any of the 802.11

variants. However, in "standby" mode where a device is attached to a network but not actively transmitting or receiving, the differences between HomeRF and Bluetooth versus 802.11 can be extreme (by a factor of 10-100). For enterprise applications such as networking desktop PCs or even laptops that often connect to AC power, power consumption has not been a major factor. But for small, light and personal information or communication appliances in the broadband Internet home, low power consumption especially in standby mode is of paramount importance.

HomeRF achieves low standby power by exploiting the properties of a central controller and the extremely fast synchronization properties of its PHY layer. Bluetooth is solving a much more difficult problem than HomeRF in this respect. "Unconscious connectivity" in ad hoc networks means that extremely clever algorithms and very fast hopping are needed to minimize power consumption and keep connection latencies acceptable simultaneously.

Does HomeRF have benefits in Size & Form Factor?

Lower complexity enables HomeRF and Bluetooth to fit in handheld appliances, and low standby power extends the battery life of these devices. This, plus the fact that HomeRF supports integrated voice, data and streaming, makes the technology ideal for embedded applications in a variety of appliances. As early as COMDEX Fall in November 2000, Proxim showed how HomeRF fits into small spaces by introducing the world's smallest WLAN form factor – its Compact Flash HomeRF Card. This card is especially well suited for handheld computers and PDAs, essentially turning them into wireless Web tablets that operate at broadband speeds and use your existing Internet service provider instead of requiring separate and expensive services such as Ricochet.

The most popular 802.11 NIC form factor by far is the PC Card (or PCMCIA card). This is more than adequate for the enterprise market where the laptop PC is the dominant mobile device. The discussion of form factor is somewhat analogous to cost. It is not that 802.11 can never reach any given form factor, just that HomeRF and Bluetooth can always get there sooner. This provides yet another advantage for getting "built-in" to those pivotal devices in the broadband Internet home.

Only recently has Intersil announced the ability to put 802.11b into Compact Flash and Mini-PCI form factors. Intersil's new Prism 2.5 chipset has 4 integrated circuits, which is still twice as many as required for HomeRF, and we don't believe the new Prism chips yet ship in quantity.

Are there any Network Topology advantages (Host/Client & Peer-Peer)?

Only HomeRF supports simultaneous host/client and peer-peer operation. Bluetooth is inherently a point-multipoint system. It is effectively host/client except that in Bluetooth the host position is not fixed in advance. Although this doesn't make Bluetooth "broken" for home networking, it is definitely not the most efficient use of bandwidth, which is scarce with Bluetooth to begin with.

802.11 variants can operate in either host/client (via the point coordination function or PCF) or peer-peer (via the distributed coordination function or DCF), but not both modes simultaneously. To date, all 802.11b products aimed at homes operate in DCF mode. To improve power consumption and/or introduce proprietary streaming media, PCF is preferable though more complex and expensive to implement.

Another IEEE study group, 802.11e, is actively debating PCF versus DCF for proposed MAC changes in the standard so streaming media can be better supported. One major barrier is how 802.11 handles roaming in the enterprise. Ironically, HomeRF has actually solved this problem completely in its second-generation specification that allows simultaneous host/client, peer-peer and roaming.

Access http://homerf.org/data/press/FaceOff_NW Topology.pdf to view 5 charts that further describe HomeRF's unique architecture.

Can HomeRF Roam into Public Places?

The good thing about mobile devices is that they can move around. While most of the interesting devices within the broadband Internet home will logically stay within the home and its vicinity, a few will roam far. For those devices that do roam, such as a laptop computer or PDA, being able to use the same wireless NIC is desirable. HomeRF, Bluetooth and 802.11 all have stories for roaming outside the home, and none is perfect.

Bluetooth has both the best vision for roaming and the least current reality. The whole premise of Bluetooth is "unconscious connectivity anywhere, anytime." If Bluetooth indeed does get built-in to every cell phone, a true platform for roaming outside the home, the vision can become a powerful reality.

802.11 has the most over-hyped story about roaming by far. In fact, 802.11 advocates trying to enter the home networking market have made this issue their central theme. They argue that all corporate employees will have as manifest destiny an 802.11 NIC in their laptop PCs so that when they take their laptops home, one node in the home network is already paid for. Nice argument – but it falls apart upon closer scrutiny.

Actual penetration of 802.11 into corporate offices or educational campuses is non-existent compared to Ethernet (which by this argument should be the runaway standard for home networking). Also, only a fraction of corporate laptops actually go home on a regular basis. It is simply inconceivable that service providers would base their long-term wireless home networking strategy on this tiny user segment and their narrow application. Furthermore, 802.11b is on the verge of being obsolete for mainstream enterprise deployment due to the more robust and much faster 802.11a products shipping by the end of 2001.

HomeRF has the least understood roaming story. In reality, many first-generation HomeRF products can roam outside the home today onto the more than 50,000 OpenAir networks in enterprises, educational and healthcare campuses, hotels, and airports.

The second-generation HomeRF specification adds support for low-cost roaming of HomeRF devices independent of OpenAir. And finally, by 4Q 2002 combination HomeRF/Bluetooth devices are expected to be commonly available. This will combine the rich capabilities of HomeRF and the projected pervasiveness of Bluetooth for operation outside the home.

Instead of enterprise network technologies moving down-market into homes as suggested by 802.11 advocates, there is considerable evidence that consumer technologies more easily move up-market. There are many examples of important technologies that started first in homes and then moved into offices: the PC sound card, CD and DVD drives, color printers, digital cameras, DSL and cable modems, peer networking, sales force automation, the PC itself, Microsoft Windows, mobile phones, and even sales force automation software. In fact, it's hard to find any technology that came into homes from the enterprise.

Can HomeRF scale into High-Density Environments and work in Apartments?

HomeRF and Bluetooth are more scalable than 802.11b for high-density residential applications. Both have the advantage of supporting many independent channels while 802.11b has only 3.

The IEEE 802.11 committee focused on the needs of a large enterprise deployment, just as 802.3 (Ethernet) had done before them. Here the goal was to maximize overall system throughput, not that of an individual user or "cell" of users. Thus 802.11 devices defer to or shut down in the presence of any other active 802.11 devices detectable anywhere on their physical channel. This is true even if the device belongs to another private network in another apartment or building so far away that the signal strength is so low that it would not impede local connectivity.

This self-interference greatly limits the ability to scale 802.11 networks to urban environments where independent network density is high. The problem is especially acute for latency-sensitive applications like voice and streaming media. And while the approach taken by 802.11 makes perfect sense to enterprise IT managers, consumers see things very differently. They do not accept that it is

"OK" to sacrifice their specific application such as a toll-quality voice call or streaming session to the greater good of maximizing overall wireless network throughput in their neighborhood.

Consider the following graphic example: House A has an Internet appliance several feet away from a residential gateway that is streaming MPEG4 video to it. Elsewhere in the neighborhood, House B has exactly the same scenario going with a different video. Because broadband Internet is so popular in this neighborhood and this service provider chose to deploy 802.11b, both independent networks for Houses A and B are on the same physical channel. Unfortunately for these customers, one or both of the streaming sessions will be stopped to wait for the other, even though both have signals easily strong enough to overcome the effects of the distant interference. So, these consumers suffer and this service provider will not maximize its revenue.

For HomeRF, this scenario would have a much different outcome. If the signal strength is strong as it is in this example, both sets of transmissions would go through successfully even in the much more unlikely case of coincident physical channel.

HomeRF enables graceful degradation when separate wireless networks are deployed in high-density apartments and can even benefit offices or public places that want to support more users. HomeRF supports up to 15 overlapping networks while Wi-Fi only supports 3. Actual performance in these environments, however, is a complicated combination of geometry, network traffic, power levels, and many other factors. Still, we believe that a frequency hopping physical layer is much more appropriate for the case of multiple, uncoordinated networks than is a frequency static physical layer.

As a concrete example, there are many independent frequency-hopping networks on the floor of the Chicago stock exchange. We believe that it would not have been possible to deploy so many networks in the same place without the use of frequency hopping.

How well is HomeRF Selling (Sales Volumes)?

HomeRF, which once claimed 45% of the no- new-wires (phone-line, power-line, and wireless) home networking market and over 90% of the wireless home networking market, lost market share in 2001 to the momentum of 802.11b, but HomeRF is ready for a come-back with second generation HomeRF 2.0 technology.

WECA, the organization charged with pushing Wi-Fi into all possible markets, published press releases saying that Wi-Fi products are now selling in retail channels, that their prices have come down, and that Wi-Fi dominates retail sales. But it is not clear what products are purchased for homes versus small businesses, schools, commercial offices, or industry vertical applications. While it is reasonable to assume that some Wi-Fi products are being sold into homes, we believe that HomeRF continues to enjoy a respectable market share in this segment that will increase with HomeRF 2.0. That's because HomeRF was designed from the beginning for consumer households (to be simple, secure, reliable and affordable) and is ideal for broadband Internet homes (by integrating data, voice and entertainment).

How does HomeRF compare with Bluetooth?

The Bluetooth specification has much in common with the first generation PHY layer of HomeRF but the MAC layer is considerably different. This reflects the emphasis of the Bluetooth SIG (Special Interest Group) on solving very different connectivity problems than those undertaken by either HomeRF or IEEE 802.11. The Bluetooth MAC layer is entirely time division multiple access (TDMA) based. Bluetooth can thus carry either voice or low rate data connections. With a peak data rate of only 1 Mb/s, the central focus of the Bluetooth SIG is achieving unconscious connectivity in a cable replacement paradigm.

The main driving application for Bluetooth is connecting mobile phones to hands-free accessories and information appliances, where long battery life is a requirement. Early usage scenarios included wireless telephone headsets for driving in Europe where it's against the law to hold a mobile phone while driving. With an Ericsson Bluetooth headset, you can just say "answer" when the phone rings, instead of fumbling through your purse or briefcase. Others scenarios have the phone accessing a

large contact list in your PDA or PC, or having your PC connect to the Internet through a mobile phone. These compelling applications cause analysts to predict that Bluetooth will be found in a billion mobile phones worldwide, over the next several years. Surely many of those phones will be used in homes and offices.

Other Bluetooth scenarios that are more home-like include replacing cables for PC peripherals, digital cameras, and MP3 players. And while Bluetooth makes a good wire replacement, it makes a poor home network or LAN. That's the design sweet spot of HomeRF. In fact, the Bluetooth SIG does not position its technology as a networking technology at all, much less as the ideal solution for networking the broadband Internet home. However, the Bluetooth SIG is a very large organization (membership is free) and some members have been vocal about extending Bluetooth into home wireless networking applications.

Bluetooth and HomeRF do not work together, but because they use similar frequency-hopping spread-spectrum technologies, they don't interfere with each other as much as Bluetooth and 802.11b. Liaison work between the HomeRF Working Group and the Bluetooth SIG hopes to find ways to enable future interoperability.

Access http://homerf.org/data/press/FaceOff_Positioning.pdf to view four charts further describing the positioning of HomeRF, Bluetooth and 802.11b.