THE FINAL FRONTIERS OF NETWORKING, PART 1: HOME AT LAST
By Kevin Werbach

You wake up as the radio forecasts record high temperatures throughout the region. You look out the window, with relief, to see the sprinkler system automatically giving your garden an extra round of water. Still a bit sleepy, you pick up the tablet next to the bed and begin scrolling through your e-mail. A quick glance at the bottom of the screen shows that your daughter, still in her pajamas, is already chatting on the phone with a friend. You send a gentle reminder to her wireless phone’s text display that she should get dressed or she’ll miss the school bus. She writes back, a bit peeved, saying that the bus sent an instant message that it was running 15 minutes late today.

As you walk into the kitchen, there’s a message blinking on the dishwasher display. The power company is offering a $1 rebate for running a load of dishes now, rather than in the middle of the day when demand peaks. You push a button to accept and then pull a fresh carton of orange juice from the refrigerator. The supermarket delivered it yesterday to the lockbox outside your garage after the refrigerator noticed there was none left. You turn on the TV to watch the news. Just as an interesting segment on extra-terrestrial domain names begins, the phone rings. You push the save button on the remote, then click over to the call through the TV’s built-in speakerphone.

As you hang up, an alert on your screen says that Kleiner Perkins Davidow stock just hit your target price. You want to do more research on it over the weekend, so you bookmark the alert and send it to your PC along with the latest analyst report on the company. You forward the remaining e-mails to your office, as your watch/pager starts beeping to tell you it’s time to leave for work.

We may think we live in a wired world, but we’ve only begun to realize the potential of networking. Beyond the office and Internet-connected PCs in the home, connectivity is the exception rather than the rule. The positive externalities of networks, along with the rapidly decreasing cost of hardware, make it a safe bet that many of the non-networked laggards...
will eventually join the connected world. As always, with connectivity will come new applications and new usage patterns... not to mention new business opportunities for those able to catch the trend as it unfolds.

In this issue of **Release 1.0**, we examine efforts to bring networking to the home. In a future issue, we will consider other new venues for connectivity such as embedded devices and personal-area networks.

**Home networking: fad or inflection point?**

We have listed home networking in our coming-soon box since this spring. In the meantime, interest in the market has taken off, capped by reports declaring home networking the big story of this year's Comdex. There have been a plethora of product announcements and company launches. Why all the interest in what is still, at this point, a nonexistent market? Why now? And how real is the potential for home networking?

We believe networking in the home will happen in a big way, although it will be another couple of years before the market reaches critical mass. Nonetheless, it's important to evaluate this sector now because companies are making fundamental choices that will shape the way the market evolves. In most cases, consumers will deploy home networks initially as after-market additions to PCs and other machines they already own. Over time, service providers and hardware vendors will deliver home systems with networking capabilities built in.

**THE AGE OF UBIQUITOUS NETWORKS**

Computing is rapidly becoming a ubiquitous element of the industrialized world. Moore's Law means that computers at any given price become more powerful each year, but also that a given level of computing power becomes cheaper each year. As microprocessors become less expensive, they are being embedded into an ever-broader range of devices. The average US home today has dozens of microprocessors, running everything from the television and game machine to the microwave oven and refrigerator.

The value of those computing devices is limited so long as they can't talk to one another. The same benefits that make Internet connectivity a vital part of the PC experience today apply equally well to other (potentially) smart devices. Networking allows devices to respond to their surroundings and share information that they cannot acquire on their own. Networking also makes it possible to provide access to the same information in multiple places. Individuals use several rooms in their homes, in contrast to most offices, so there is value in making information more accessible by connecting devices in those different rooms. Several users in the same home may want simultaneous access to the printer or Internet connection, without having to order separate peripherals and phone lines for each computer (see page 6).

Some applications depend on networking from the beginning. A device next to your bed that gives you the day's weather prediction, so that you can wear the appropriate clothes, may be considered a computer or a souped-up alarm clock. However, it simply cannot work without some sort of connectivity to local weather data. (Next step: Hook it up to a stock-picking...
device in your closet.) A device that notifies you when your children's school bus is approaching similarly needs communications functionality.

As networks become ubiquitous and interconnected using Internet protocols, some interesting things happen. Today there is an imperfect relationship between the Internet and physical space. People go to places, whether the office, the study or a cyber-cafe, in order to connect to the Net. In a world of ubiquitous networks, especially as consumer access moves from dial-up to always-on, the Net is everywhere. Instead of where you are, the focus will be on what you want to do or who you are. The Net will supplement the physical world with a constant stream of information.

As we have seen in the enterprise, the Internet can provide a powerful return channel that enables new functionality across a wide range of market segments (see Release 1.0, 9-98 and 10-98). The key for these applications is that the Internet connection and client can be taken for granted, so that the server-based component need not carry the full load. Internet-connected homes today haven't yet reached this level. Most of them still use dial-up connections which limit the possibilities for always-on back-channel interactivity. And the connectivity stops at the Internet-accessible PC.

Home, home on the Net

Many of the next-generation home-networking applications bandied about today (our introductory fantasy included), sound as hokey as the home-automation visions of yesteryear. Let's try to sketch some more analytical visions of where things will go.

Networking took hold in the enterprise because it addressed immediate needs, like giving everyone access to a single printer or allowing employees to send documents from one machine to another. No one considered the potential of intranets for self-service human resources administration, Web-based collaboration, enterprise relationship management, or any of their other current uses. Many of the networked applications we take for granted today were not predicted beforehand.

A similar dynamic will occur in the home. The initial deployment of home networks will take place mostly in multiple-PC homes, to address relatively straightforward needs for shared access to Internet connections, files and printers. These functions, while supporting a reasonable revenue stream for hardware providers, won't change the nature of the home-computing experience. Over time, however, as home networks become more prevalent and performance increases, media-centric applications will become more significant. Finally, companies will start to build new applications that take home networks for granted.

One important category of applications will involve commerce. The business-to-business market is so different from the business-to-consumer environment in part because the former is far more heavily networked and data-rich. As home networks proliferate and cheap software adapts and migrates into the home, it becomes easier to imagine real-time monitoring of electricity usage, for example, or supermarkets that keep track of the inventory in your refrigerator. Supply-chain and yield-management algorithms designed for factories will make their way to your kitchen.
The need will have to convince consumers of the benefits and address the ever-present privacy and security issues, but the potential for win-win solutions gives them an incentive to do so.

On the consumer-to-consumer side, we'll start seeing family intranets and community extranets. Seeking a recommendation for a good local dermatologist? Interested in whether traffic is backed up along the route you take to work? Curious if anyone else in your apartment building is having the same problems with their daily newspaper delivery? Want your friends down the block to monitor the alarm system and cat food level in your home while you're on vacation? Networks can support all these transactions, far more efficiently than other mechanisms such as the telephone.

We're talking about an extension of online communities (see Release 1.0, 6-93 and 7-93) where the virtual complements the physical. The Net allows people with similar interests to interact outside the bounds of geography, but some activities require physical proximity. When networks in the home, the neighborhood and the rest of the world all run on IP, both kinds of interaction can be supported. Of course, sitting in front of a screen isn't a substitute for physical contact. Home networks will make it easier for parents to home-school their children, which may or may not be a good thing depending on your viewpoint. The social issues won't be easy, which is why it's worth thinking about them sooner rather than later.

Another area where home networking will have profound effects is the convergence of computing and media. All the failed efforts in interactive television showed that convergence is not as simple as it seems. Getting richer digital content into the home through broadband access devices such as cable modems will solve part of the problem, but the next generation of applications will depend on how easy it is to manipulate that content inside the home. At some point camcorders will come with built-in networking chips so you can quickly send a video of your daughter's first steps to your parents, who will view it on their Net-connected TV (or if they are home you could conference them in live).

Home control will gradually move to the mass market. The same networks that zap movies across the house will also make it easy for anyone to have a home-security system, or to automate the watering of the garden. (Weeding will be tougher to automate!)

Of course, the great benefit of the Internet Protocol is that one networking infrastructure can support many unpredictable applications. Flexible home-networking platforms will create the biggest long-term market opportunity. Bob Frankston, who wrote the VisiCalc spreadsheet and later worked at Microsoft on home-networking and other projects, says the key is to use commodity hardware to create a market. In the early 1980s, companies bought Apple IIIs solely to run VisiCalc, but once they had the machines they could explore other uses. Similarly, Frankston sees shared Internet access as a way of getting connectivity into the home and enabling innovation at the application level.
PLAT FORMS FOR (IN-HOME) COMMUNICATION

So what exactly does the platform for these new applications look like?

Home networking means connecting various computing devices within the home. Those devices could be appliances (lights, toasters, security systems), personal computers, or consumer electronics (televisions, phones, game machines, video cameras). The connections between them will operate over several different physical channels. Home networks will incorporate Internet protocols; although they may not be designed primarily to connect to the Internet, in the end most of them will have that capability. After all, protocols are cheap.

What home networking isn't

Home networking, as we use the term, is a new concept. Many houses now contain networked devices, such as cable set-top boxes and PCs, but most of those devices can talk only to networks outside the home. Home automation products that control electrical outlets have been around for almost two decades, but have never represented much more than a niche business for hobbyists. Most consumers simply don't see much value in remotely controlling their light switches, and existing home-automation networks don't have sufficient data rates for sophisticated applications such as shared Internet access.

Home networks will look somewhat different from the Ethernet local-area networks (LANs) in most offices. A small number of high-end consumers, home-office denizens and telecommuters have Ethernets in their homes. However, the cost and complexity of such systems keeps penetration relatively low. Home networking systems are consumer products, and consumers don't have systems integrators or IS departments to deploy and maintain networks. In particular, Ethernet was designed to operate over special category 5 wiring, which is simple enough to install in an office but a huge barrier for the home market. Few home users will be willing or able to string new wiring, and the wires they do have (phone lines and electrical power lines) are of variable quality and configuration. To succeed, home networking products must be much more reliable and easier to use than what's in the office. As Dan Sweeney, business unit manager of Intel's home networking operation puts it, products must be "brain-dead simple" for consumers to use.

Home networks will also connect more than just PCs. Although PC-centric applications may drive the initial deployment of home networking, the greatest opportunity will be in melding networking with consumer electronics. The compact disk was the first mainstream digital media product, but with the arrival of DVD, digital cable set-top boxes and digital television, more and more of the content in the home will be in digital format.

Home networking should not be confused with broadband connectivity, although the arrival of high-speed connections such as digital subscriber line (DSL) and cable modems will certainly hasten the deployment of in-home networks. High-speed data connections affect the content that gets into the home, but by themselves they do nothing to communication within the home. Bringing a rich media experience to a single computer is one thing, but fostering communication between several devices will have an
even more profound effect. The much-heralded convergence of computing, communications and entertainment technologies will require connectivity between devices in each of those domains.

Why now?

Developments on both the demand and the supply side of the equation are reinforcing one another, and the most important technical elements are now in place.

The first driver is the prevalence of multiple-PC households. Although only half of homes in the US have PCs, 30 percent of those (15 million total) have more than one PC. The sub-$1,000 PC phenomenon has encouraged many first-time buyers to take the plunge, and it has also made it easier to justify a second machine for the kids or the grandparents. Intel estimates that by 2003 there will be 30 million US households, or about 25 percent of the total, with more than one computer. That doesn't even include the increasing number of homes in which someone brings home a laptop from work and needs to exchange data with a desktop machine. With the proliferation of appliances such as WebTV and digital cable set-top boxes, many homes will find themselves with computers in the living room that they would like to connect to the PC in the study. The same Intel study found that only 10 percent of multiple-PC homes (in other words, less than 2 percent of the total) had networks in place.

The second factor is the growth of the Internet, which links heterogeneous local networks. The Net brings connectivity into the home, but without in-home networks the benefits of that connectivity stop at a single PC. Users in all those multiple-PC homes are finding themselves contending for the single Net connection and wanting to share it. An Intel survey in February 1997 found that more than half of multiple-PC households rated home networking products as "highly appealing."

Broadband connectivity to the home will further accelerate the deployment of home networks. As users get a taste of office-style connection speeds, they will demand the same benefits they get from office LANs. Devices such as cable modems also provide a perfect point for a gateway between in-home and external networks. Companies such as Whistle that make easy-to-use thin servers for small offices intend to offer similar products for the home market once sufficient connectivity is in place.

Many companies are now developing technologies to meet the demand for home networks. Advances in data networking and the falling price of silicon have made it possible to offer far higher throughput under the constraints of the home environment than previous generation of home automation products. In addition to building products, home-networking vendors are also working together to develop standards for interoperability. These standards efforts, in particular the Home Phoneline Networking Alliance (HomePNA) and the Home Radio Frequency group (HomeRF), also help enhance awareness in the marketplace (see page 9).
THE BIG GUYS GET INVOLVED

The home-networking story is about more than innovative startup companies creating a new market. Today the leading pure-play home-networking companies, which we profile below, are all small technology companies. The development of the market, however, will depend on what the established PC and networking companies do.

Almost every major segment of the computer industry wants home networks to exist, although not always for the same reasons. Industry leaders such as Intel, Cisco and Microsoft need to find new markets for their products in order to sustain the revenue growth that their valuations (and their stock-option plans) demand. With PCs and LANs reaching saturation levels in the office, that means looking to the home. Companies competing against those giants realize their best hope is for disruptive change in the industry, like the shifts from mainframe to minicomputer to PC, that leaves previously dominant players stuck in a dwindling market. As the cost of processing falls, hardware vendors need to find new features that justify their pricing and preserve their margins.

Almost all the big names in consumer software and hardware, including Intel, IBM, Hewlett-Packard, AMD, 3Com and Microsoft, have launched significant home-networking initiatives. These companies are developing products of their own, but are also funding startups in the space and participating in standards efforts. Most of them are hedging their bets, supporting several different technologies. At some point most of the successful home-networking startups will likely be acquired. Most of those that remain will be relatively anonymous technology providers to larger players with the brand names and distribution networks to drive products into the residential channel. However, if our earlier statement about disruptive change holds true, one or two of the startups will break through to become new household names like Dell and Amazon.com.

Large companies will play several roles in the evolution of home networking. Some will develop technologies entirely in-house, but in most cases they will license building blocks from more focused technology providers. For example, Intel and AMD are both shipping home phoneline networking chips based on the HomePNA standard, which grew out of work by startup Tut Systems. 3Com has licensed Epigram’s phoneline networking technology, and Microsoft’s hardware division has licensed powerline networking technology from Intellon. Several of the smaller home-networking companies have roots in more established vendors, either as formal research groups or teams of employees who grasped an opportunity the parent company wasn’t in a position — financial or mental — to pursue.

Intel, 3Com and Microsoft have been particularly active in supporting the development of home networking technology. IBM also has a major effort around its Home Director product line, although initially directed at new construction (see page 18).

Intel

Intel’s Dan Sweeney helped start the chip giant’s networking group in 1990. Now in charge of Intel’s home-networking effort, he sees the same kind of opportunity for Intel to leverage its core strengths in manufac-
turing and microprocessor design to help create large, strategic new markets. Specifically, home networking will drive purchases of PCs and will foster the evolution of more consumer-oriented computing appliances. Intel wants to remain a leader in the post-PC world, so the company is getting in early and has already announced silicon for phoneline networks under the HomePNA standard (see page 9).

Like most of the big players, Intel is placing bets on several different home-networking technologies. The company is a member of both the HomePNA and the HomeRF working group, and has also invested in ShareWave (see page 19). Sweeney says that the Intel brand will be a major asset in driving adoption of home-networking technology. (The company has come a long way since the infamous Pentium bug uproar a few years back.)

3Com

3Com also sees home networking as complementary to its strengths. Home networking is all about connecting LANs to WANs, which is a big part of 3Com’s core business. 3Com's purchase of US Robotics gave it a substantial retail channel to go with its traditional expertise in network interface cards and access devices. US Robotics also brought with it the Palm Computing division, which provides interesting possibilities in the home networking space. As wireless connectivity is built into future Palm devices, imagine the handheld device serving as a souped-up remote control for home networks. Another connection is that several of the home-networking startups are run by former 3Com executives.

Vice president Rakefet Kasdin, who reports to ceo Eric Benhamou as an “executive in residence,” is helping to shape the company's home-networking strategy. Kasdin emphasizes that easy-to-use software will be a critical element of any successful home-networking solution. She says the Palm team, along with 3Com's experience building software that makes it easy to order ISDN service, give the company an edge in this area. Kasdin says 3Com is agnostic about the transport technology for home networking, but the company's initial activities have focused on phoneline solutions. In early November 3Com invested in Epigram, which is developing a 10-mbps phoneline networking technology. The company is talking with its PC OEMs about providing home-networking cards, most likely for the fall 1999 PC hardware cycle.

Microsoft

Microsoft has significant efforts underway in both software and hardware, although the company wouldn't talk on the record for this article. Home networking was among the featured topics at the Windows Hardware Engineering Conference last March, but Sun's Jini announcement seems to have galvanized the company's interest in the space. Microsoft has invested in both Tut and Sharewave, and has also licensed powerline networking technology from Intellon. The home version of Windows 2000 will include advanced drivers to support plug-and-play connections to in-home networking devices, as well as interfaces for home devices such as a telephone answering system. WebTV and Windows CE give Microsoft a presence in consumer hardware beyond the PC, and it doesn't take much imagination to see the possibilities for networking those systems with desktop machines.
Home-networking standards

Standards are important for any technology seeking a mass market. All the home-networking vendors recognize that at some point they will need to open up their technology to enable innovation and drive adoption. Any of the proprietary technologies could become a de facto standard, so long as it is widely licensed and the interfaces are open. Several multilateral standards efforts are also underway.

HomePNA

The Home Phoneline Networking Alliance (HomePNA) was formed in June to develop open standards for phoneline home networks. Founding members included 3Com, AMD, AT&T Wireless, Compaq, Epigram, Hewlett-Packard, IBM, Intel, Lucent, Rockwell and Tut. The group chose to use Tut's 1-mbps HomeRun technology as the basis for its initial standard, which is currently being finalized. A backwards-compatible 10-mbps version is planned for 1999. HomePNA devices will not require any new wiring and are designed to coexist with voice and DSL service. HomePNA is an independent effort, but the group intends to submit its specifications to the Institute of Electrical and Electronics Engineers (IEEE) and International Telecommunications Union (ITU) for formal adoption.

HomeRF

The HomeRF working group, established in March, now has over 40 members including Compaq, Hewlett-Packard, IBM, Intel, Microsoft, Ericsson, Motorola and Philips. The group is developing a standard for the Shared Wireless Access Protocol (SWAP) which will provide wireless home networking at 1 to 2 mbps over the 2.4-ghz unlicensed band. SWAP resembles the IEEE 802.11 standard for wireless LANs, with additional features to support voice communications to cordless phones. Version 0.95 of the HomeRF standard was released recently, and the group hopes to have final version by the end of the year.

Bluetooth

The Bluetooth Special Interest Group was founded in May by Ericsson, IBM, Intel, Nokia and Toshiba. It now has over 200 members (although Microsoft is a notable no-show), and it plans to release a specification for 2.4-ghz wireless networking in the second quarter of 1999. Bluetooth is intended to allow all sorts of short-range wireless devices (phones, pagers, PDAs, etc.) to interoperate with one another, rather than focusing specifically on home networks.

CEBus

Th Electronic Industries Association developed CEBus as a next-generation standard for home automation and control. CEBus may play a role if, as seems likely, consumers deploy home automation systems as adjuncts to their data-oriented home networks.
Networking technology has evolved a great deal since Bob Metcalfe developed Ethernet in 1973, especially in areas such as compression and wireless transmission. Vendors have also gained years of practical experience understanding what does and doesn't work. The lack of existing networking equipment in the home gives vendors an opportunity to start on a level playing field (tabula casa?). Alternate technologies that might make economic sense in the office if only Ethernet were not already available have no such competition in the home. Homes also in some ways are simpler environments. Bill Gates' mega-mansion aside, vendors need not worry about scaling to thousands of local devices and users.

The various home-networking companies have taken different approaches to the market. The following chart provides an overview of the technologies and providers; we profile these companies in greater detail below. (Note: The speed, price and availability numbers come from the companies themselves and aren't necessarily apples-to-apples comparisons, so take them with a grain of salt. Estimated prices are for standalone retail devices; your mileage may vary.) For comparison, we've also included two networking technologies that require new wiring: office-style Ethereants and Firewire (a standard for high-speed serial connections also referred to as IEEE 1394).

**Figure 1: Major home-networking technologies and providers**

<table>
<thead>
<tr>
<th>Players</th>
<th>Speed (mbps)</th>
<th>Price (per node)</th>
<th>Available</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phoneline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tut</td>
<td>1</td>
<td>N/A</td>
<td>Now</td>
<td>Phone jacks widely available, but not everywhere.</td>
</tr>
<tr>
<td>Epigram</td>
<td>10</td>
<td>$100</td>
<td>2Q 1999</td>
<td></td>
</tr>
<tr>
<td>Avio Digital</td>
<td>88</td>
<td>&lt;$10</td>
<td>3Q 1999</td>
<td></td>
</tr>
<tr>
<td><strong>Wireless</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ShareWave</td>
<td>4</td>
<td>$150</td>
<td>1Q/2Q 1999</td>
<td>Mobility a plus, but interference, fading and cost challenges.</td>
</tr>
<tr>
<td>Proxim</td>
<td>1.6</td>
<td>$100</td>
<td>Now</td>
<td></td>
</tr>
<tr>
<td>Alation</td>
<td>1</td>
<td>$85</td>
<td>Now</td>
<td></td>
</tr>
<tr>
<td>WebGear</td>
<td>.5</td>
<td>$85</td>
<td>Now</td>
<td></td>
</tr>
<tr>
<td><strong>Powerline</strong></td>
<td></td>
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<tr>
<td>Intelogis</td>
<td>.35</td>
<td>$80</td>
<td>Now</td>
<td>Ubiquitous, but major interference concerns.</td>
</tr>
<tr>
<td>Intellon</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Enikia</td>
<td>10</td>
<td>$100</td>
<td>1999</td>
<td></td>
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<tr>
<td><strong>Cable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peracom</td>
<td>100</td>
<td>$100</td>
<td>1Q 1999</td>
<td>High bandwidth, but lower penetration.</td>
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<tr>
<td><strong>Ethernet</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3Com, Cisco,</td>
<td>10-1000</td>
<td>$300</td>
<td>Now</td>
<td>Proven technology, but complex to deploy and requires new wires.</td>
</tr>
<tr>
<td>Intel, Nortel/Bay, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Firewire</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Consumer-</td>
<td>400</td>
<td>N/A</td>
<td>Now (but not for home networks)</td>
<td>Designed for peripherals and consumer electronics.</td>
</tr>
<tr>
<td>electronics</td>
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<tr>
<td>vendors; PC</td>
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<tr>
<td>OEMs</td>
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Home networks can run over several different physical platforms. A small number of homeowners have deployed category 5 wiring or even fiber optics, and some specialized companies such as DualStar in New York (see page 18) are working with developers to pre-wire new homes with office-style ca-
bling. However, these are very much the exception to the rule. For home networking to succeed, solutions will have to operate over existing facilities. Fortunately, virtually all US homes have two kinds of wiring—phonelines and electrical powerlines. Every home also has air capable of transmitting radio frequency (RF) wireless signals. In the US, over 60 percent of homes have coaxial cable TV connections. Companies are exploiting all of these with home-networking solutions.

**Phoneline**

Digital subscriber line (DSL) technology used for broadband access to the home has shown that twisted-pair copper wiring can support multi-megabit data rates. Virtually every US home is wired for telephone service, which means that users can deploy phoneline networking solutions without installing any new wires. Most phoneline technologies use a high-frequency signal to avoid interference with voice and DSL services running over the same wires. However, although phone jacks are prevalent throughout most of the world, many homes (especially outside the US) don't have jacks in every room. Moreover, in some countries regulatory requirements limit the kinds of devices that can be connected to the phone network.

The HomePNA standards effort (see page 9) has given phoneline home networking a big boost, as has the rollout of DSL services by major telcos. So far HomePNA has done a good job of bringing together the various forces within the industry; Avio Digital is the only phoneline provider committed to going in a different direction. Epigram CEO Jeff Thermond notes that most of the participants in HomePNA suffered through the debilitating 56 kbps modem standards battle, and want to avoid similar conflicts that could slow adoption of home networking. Given the support of major PC OEMs such as Compaq, Dell and HP, along with semiconductor producers such as Intel, AMD and Conexant (née Rockwell), it seems certain that phoneline providers will ship the greatest volume of home-networking systems in the next year.

**Wireless**

Wireless systems require radios, which tend to add cost. They also have to deal with interference, especially when they use less expensive unlicensed spectrum bands (see page 16). However, the same improvements in digital signal processing and error correction that have enhanced DSL performance also help drive up the performance of wireless packet-networking technologies. Wireless systems have the advantage of effectively ubiquitous coverage within a defined range, independent of phone jacks. In addition, wireless networks offer mobility, especially valuable for laptops, remote controls and PDAs (not to mention cars, bikes and lawn-mowers). Several companies including Proxim and RadioLAN have successfully deployed wireless office LANs in recent years, and similar technology is now moving to the home market. Proxim and Diamond Multimedia (a licensee of Alation) are already shipping. Startup WebGear is also selling a lower-speed product using the 900-mhz band, but faces an uphill climb against its higher-performance competitors.

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1 An Intel survey of 300 multiple-PC homes in May 1998 found an average of 4 to 5 phone jacks.
Even phoneline and powerline providers agree that there is a role for wireless in the home, because some applications require mobility. The open question is whether wireless systems will succeed as the primary platform. In addition to cost and interference challenges, standards battles may slow adoption of wireless. The current HomeRF and Bluetooth standards are incompatible; consumers won't be happy if their home networks go down when someone walks in with a Bluetooth wireless phone. The related IEEE 802.11 and IrDA standards for wireless Ethernet and infrared communications add to the potential confusion. Two of the most visible players, ShareWave and Diamond, are currently going the proprietary route, although they are members of the HomeRF working group. ShareWave and Alation (which provides the technology for the Diamond product), both emphasize they are committed to open products, but believe they can't wait for industry standards to emerge before addressing the market opportunity.

Powerline

Electrical outlets are more common in existing US homes than phone jacks, making powerline connections attractive as networking options. X-10 home automation systems have shown that powerline connections can transmit data reliably, albeit at low bit rates. Companies such as Adaptive Networks are working to scale up 19.2-kbps industrial automation technology for more bandwidth-intensive applications, but have not yet announced home-networking products.

The challenge for high-speed home-networking systems over powerlines is interference from other devices plugged into the electrical system. Blenders and other kitchen appliances generate particularly nasty power spikes, and every device plugged in attenuates the signal. Intel's Dan Sweeney says so far the company has not seen a powerline technology that works universally in the field because of variations in home wiring. However, providers such as Intelogis and Enikia (see pages 17 and 21) claim they have solved the interference challenges. Another company, Intellon, licensed its 1-mpbs technology to Microsoft in September, although neither company has announced products yet.

It's the applications, stupid

The most important issue for the evolution of home networking, however, is not hardware technology but applications. Each of the major application categories — PC resource sharing, media networking and new applications — places different requirements on the underlying networking platform. The products announced to date are all version 1.0 solutions, bound to mature and gain more functionality over time. The companies in the home-networking space have taken different approaches to the market based on their vision of how rapidly certain applications will emerge. Most providers have focused on the more concrete PC-centric applications, believing they can move to higher speeds and more media-oriented connections over time once they establish a position in the marketplace. A few companies, however, are betting that applications involving audio and video streams will take hold sooner rather than later.
Most of the first-generation home-networking products focus on connecting multiple PCs. After all, PC-to-PC networking is the model in the office, and PCs are designed to accept plug-in networking cards. There are several compelling reasons to connect multiple PCs once they have been deployed in the home. Intel's February 1997 survey of homes interested in a home-networking solution found that the leading applications mentioned were shared modem/Internet access (28 percent), printer sharing (27 percent), file sharing (15 percent) and multi-user games (8 percent). The 30 million multiple-PC homes in the US projected by the year 2003 present a major opportunity for companies to pursue. If just 20 percent of those homes buy home-networking products at an average cost of $200, the market will be over $1 billion.

Tut Systems

Tut Systems, which announced its HomeRun technology in June 1997, was the first to deliver phoneline home networking. Based in Pleasant Hill, California, Tut was founded in 1991 and now has 92 employees. The company has over $39 million in venture funding, with Microsoft, Compaq, AT&T Ventures and Itochu leading its most recent round.

Tut has built a portfolio of products around its FastCopper technology, which allows high-speed connections over ordinary phonelines. Tut's primary business is selling DSL products to carriers and Ethernet products to companies that want to extend WANs across corporate campuses. According to vp of marketing Craig Stouffer, Tut developed HomeRun almost by accident, and quickly realized it didn't have the retail presence needed for home networking to succeed. Tut therefore provided its 1-mbps home-networking technology as an open standard to the Home Phoneline Networking Alliance (see page 9).

Tut still earns direct and indirect licensing revenues from HomeRun-based devices, although the royalty rates are relatively low to encourage widespread adoption of the technology. The company believes it can be most effective selling equipment that enables high-speed connections into homes and multiple dwelling units (MDUs) if multiple providers can build end-user devices that extend those network connections within the home. As Stouffer puts it, "home networking improves the end-customer's value proposition for high-speed access." Tut recently announced a line of products designed for MDUs, such as apartments, hotels and dormitories. Most DSL technologies have difficulty in such environments, due to the amount of inside wiring the connection must traverse. Tut's latest products also function in garden-style apartment buildings, which involve particularly long cable runs.

Tut believes the 1-mbps HomePNA systems based on Tut's HomeRun technology will catch on quickly because of their low price points. PC vendors that are putting networking or broadband connections into their machines will be able to include HomePNA functionality without any significant impact on margins. Stouffer sees higher-speed phoneline products available towards the end of 1999 but at a price premium, so that both 1-mbps and 10-mbps devices will coexist for some time.
Epigram was incorporated in May 1996 with a vision of melding the best aspects of Ethernet and modem technology. Ethernet is a proven networking solution with a huge installed base, but it doesn't operate over existing home wiring. Epigram set out to design an Ethernet-based technology that would deliver high-speed connectivity over such noisy channels. The 46-employee Sunnyvale, California, company has so far raised $13 million in two financing rounds led by Mohr Davidow and Benchmark Capital, and it is currently completing a third round comprising an additional $15 million. President and ceo Jeff Thermond joined last summer from 3Com.

Epigram announced a 10-mbps phoneline networking technology in November, and it has signed licensing agreements with 3Com, Texas Instruments and Netgear (a subsidiary of Nortel that sells networking hardware for the small-office/home-office market). Epigram is a founding member of HomePNA; its technology is backward-compatible with the 1-mbps HomePNA standard and is under consideration as the foundation for the forthcoming 10-mbps standard. Epigram is an ingredient provider, rather than a systems vendor like Tut. In addition to marketing its own chipsets, the company plans to license its technology for application in residential gateway devices, set-top boxes and other hardware.

Thermond is bullish about the market potential for home networking in the next year. According to Thermond, “the PC OEM community is absolutely galvanized on this topic as a new source of revenue growth.” Major PC vendors recognize that they can increase their gross margins significantly by bundling DSL or cable modems and serving as portals to broadband ISPs. Home-networking chipsets that allow users to share those broadband pipes with other machines are a natural supplement to this strategy. Thermond expects significant deployment of PCs and add-in cards with home-networking capability by June 1999. He says that home-networking products will have to cost less than $100 for the market to take off, but is confident Epigram’s chipsets will support those price points.

Epigram expects to have silicon compatible with the HomePNA standard in production by April, and plans to demonstrate a 100 mbps version by the end of 1999. Thermond says that shared Internet access will be the initial killer application, but sees intriguing possibilities for multimedia networking down the road. In fact, Epigram’s high-speed technology may allow it to straddle the PC- and media-centric camps. At Comdex Epigram demoed cable, DVD and direct-broadcast satellite signals running over its system between PCs and consumer-electronics devices. Down the road, Epigram-based phoneline connections could serve as a backbone for Firewire devices, overcoming Firewire's distance and wiring requirements.

Epigram is focused on phoneline solutions initially because of the high level of demand from PC vendors and the momentum behind HomePNA. Thermond says that because of cost and interference issues with other technologies phoneline will be the dominant platform over the next 1 to 2 years. However, he emphasizes that “we are not a phoneline-networking company; we are a home-networking company.” Epigram has demonstrated its technology running Internet and video applications over powerlines in the lab, and the company also intends to develop wireless versions.
Although Epigram is primarily interested in the home, the company sees small business as an important secondary market. Ethernet LANs are too expensive and too complicated for most small businesses and home offices (see Release 1.0, 7/8-98). Home-networking solutions, which address both of those issues, should therefore appeal to this sector as well. Epigram believes it is well positioned to reach the small-business market through its relationships with 3Com and Netgear. At 10 mbps, Epigram provides the same speed as traditional Ethernet LANs.

Proxim

Proxim, based in Mountain View, California, has been developing wireless products for nearly 15 years. It released its first 2.4-ghz wireless LAN product in 1994, and it is currently one of the leading providers of such systems to hospitals, financial exchanges and other corporate customers.

According to vp of sales and marketing Brian Button, Proxim saw an opportunity to provide a lower-cost version of its wireless LAN technology to the small-office and home market. Market research showed a high level of demand for shared Internet access, files and peripherals among multiple PCs in the home. Proxim was able to drive down the price of its wireless LAN technology because home networks don't need the same scalability and features as their corporate counterparts.

Proxim began shipping its Symphony home-networking product in late September. Symphony offers data rates of up to 1.6 mbps over distances up to 150 feet, using frequency-hopping spread-spectrum technology over the 2.4-ghz band. Proxim was one of the original members of the HomeRF group. Its product does not yet comply with the still-developing HomeRF specification, but the company plans fully compliant versions next year.

Button says the company's experience building wireless LANs gives it an edge over new home-networking competitors. The fact that demanding customers rely on Proxim's wireless technology is an "existence proof," he says, of the reliability of the company's products. He points out that despite the large number of home-networking announcements, only a handful of companies have actually shipped products. He believes that there will be a shakeout by this time next year. Although companies such as Epigram and ShareWave have generated a great deal of attention because of their faster data rates, Button is confident that for PC-to-PC networking applications 1 mbps is largely sufficient.

Alation

Alation Systems of Redwood City, California, was founded in February 1997 but only launched publicly in November of this year. Most of the company's founders came from the Presario group at Compaq, where they noticed that an increasing number of households had more than one PC. The trend in the last year towards consumer PCs at $1,000 or less now leads many consumers to buy second computers for their children, and others simply keep older machines when they upgrade to new models.

Cto Paul Beard most recently designed mobile data systems as an architect at Norand Corporation. He was also an avid hobbyist builder of radio-
controlled boats and other devices, and that wireless expertise went into
the design of the Alation system.

Alation is initially bringing its HomeCast Open Protocol (HOP) technology
to market on an OEM basis, with Diamond Multimedia as the first licensee.
Alation, like Proxim, uses spread-spectrum technology over the 2.4-ghz
band. However, the company feels that the HomeRF standard will result in
systems that are too expensive and subject to fading, so it is going its
own way. The company hopes to make HOP a de facto standard and is
licensing it in multiple forms including full products, chips and refer-
ence designs. Alation says HOP devices will sell for less than $100 per
PC, because the system uses software to handle many of the functions that
traditionally required more expensive radio hardware.

2.4 is the place to be

Wireless communications systems can use two kinds of spectrum:
licensed or unlicensed. Most commercial wireless systems, including
virtually all cellular and personal communications service (PCS) net-
works, operate over licensed bands. Because companies gain exclusive
rights over licensed spectrum (through auctions, lotteries or hear-
ings), they can avoid interference from other devices. The flipside
is that licensed spectrum is expensive, and the lower number of users
also pushes up the cost of radios.

Companies have shied away from using unlicensed spectrum for commer-
cial voice and data communications because of concerns about inter-
ference. However, spread-spectrum technology originally developed by
the military makes it possible for many different devices to share
the same band with limited interference. Companies such as Metricom
have used the 900-mhz unlicensed band to build citywide wireless net-
works, but only deliver 28.8 kbps of bandwidth.

Several years ago, Apple petitioned the FCC to set aside a new block
of higher-frequency spectrum for unlicensed wireless data networks,
and the FCC eventually created the unlicensed National Information
Infrastructure (U-NII) band at 5 ghz for this purpose. However, U-
NII has significant power limitations and other constraints that have
hindered its adoption so far.

The 2.4-ghz industrial-scientific-medical (ISM) frequency band is
sometimes referred to as the junk band due to the wide variety of
existing uses. 2.4 ghz turns out to have excellent properties for
high-speed wireless home LANs. As a bonus this band is unlicensed
not only in the US but in most of the world. Consequently, every one
of the wireless home-networking technologies mentioned in this issue
(except WebGear, which only offers 300-500 kbps of throughput) uses
2.4 ghz.

Vice president of marketing David Atlas believes Alation has a year to
capture a leading position in the market. He sees Proxim as the primary
competition, arguing that ShareWave’s emphasis on high-end media appli-
cations (see page 19) is too early for the market. Alation believes that
PC-to-PC applications will drive home networking over the next two years,
with consumer electronics vendors entering the market in force during or after 2000. The company is therefore pursuing a range of distribution partners beginning with peripheral OEMs followed by PC OEMs, vendors of broadband access devices such as digital subscriber line and cable modems, network providers such as ISPs and telcos, and ultimately consumer-electronics companies.

The Diamond deal gives Alation a significant retail presence and a brand to push its HOP technology. The arrangement has already provided a substantial revenue boost for the small company, allowing it to bring its technology to market without venture financing and to achieve profitability this year. To succeed as a standard, however, the company will have to sign up enough partners to make HOP a significant presence on retail shelves and to crowd out other players.

Intelogis

Intelogis, headquartered in Draper, Utah, originated as the NEST (Novell Embedded Systems Technology) group at Novell. Novell launched NEST in 1993 to develop technology for ubiquitous connectivity for embedded devices. In 1995, the company acquired a technology for sending RF signals over powerlines, which it sought to develop for commercial products. The team was prescient, but the pre-Schmidt parent company saw its proprietary NetWare network operating system, rather than open Internet-based protocols, as the core platform. As Novell struggled in its attempted frontal challenge to Microsoft, the NEST project languished. The group was spun off as Intelogis in January 1997 and purchased by local investor Justin Reber. Novell retained a minority interest, and the 30-employee company has since raised two rounds of venture funding led by utility companies, Nth Power and Pacificorp.

Intelogis' FSK (frequency shift key) modulation technology uses a transceiver to send data down particular frequencies on existing electrical wiring. Vice president of marketing Robert Bauer, who joined the company from 3Com a year ago in preparation for the commercial launch, says that Intelogis provides the lowest-cost and most reliable method for networking the home. The company was issued a patent on its technology in October 1998. It released its Passport product, offering powerline networking at 350 kbps, in July of this year.

Bauer says Intelogis felt being first to market was important in the increasingly crowded home-networking space, and therefore it didn't wait for higher speeds before launching. He points out that only a handful of the announced home-networking technologies are actually shipping. In the long run, however, Bauer expects that distributed access to broadband content will be the killer app for home networking. Intelogis is working on a next-generation product for the fourth quarter of 1999 capable of speeds as high as 2 mbps and offering greater reliability.

Intelogis acknowledges that some individual outlets may not support adequate signal strength to transmit data effectively. The company bundles a power strip to filter out potential interference from some older computers plugged into the same outlet for power, and it plans to build this functionality into its next-generation devices. Bauer believes that consumers
will become increasingly comfortable with powerline networking as they realize that they have always depended on electrical outlets.

Intelogis is currently in discussions with potential partners for its technology. The company is talking both to service providers that could install Passport along with their broadband service offerings, and to hardware companies that could incorporate Intelogis-designed chipsets into their products.

MEDIA NETWORKING

Sooner or later, home networks will move from PCs to other digital devices. The companies we've discussed so far think the shift will happen later, although they realize they will have to increase the bandwidth of their technologies over time. After all, the market research shows that printer and modem sharing are where the demand is today.

But what if the market for PC-centric applications is limited to the early adopters (a.k.a. geeks)? The issue isn't whether all the multiple-PC homes would see some value in home networking; it's whether they are willing to purchase and install a system. For example, few consumers will spend $200 to share a color printer when they can buy a second printer for the same amount. There is clearly a market today for PC-centric home-networking solutions, but in chasing that opportunity companies run the risk of missing a much bigger second wave. With the exception of Epigram, the providers focusing on PC connectivity currently offer systems in the range of 1 mbps. This bandwidth is sufficient for sharing printers and dial-up Internet connections, but becomes a limitation for broadband and multimedia applications.

If the market moves directly to media-centric home networks, the PC-centric technology providers may be leapfrogged. Four companies that are betting on the near-term viability of multimedia applications are ShareWave, Avio Digital, Enikia and Peracom.

ShareWave

ShareWave founder and vp of marketing Bob Bennett states that “our focus is on developing ingredient technologies for multimedia digital wireless home networks.” The company plans to provide chips, reference designs and other components to manufacturers with retail distribution who will build products using the ShareWave technology.

Three of the four founders came from Intel's consumer products group. At Intel, they engaged in extensive research on the use of technology in homes, and they concluded that there were significant unaddressed opportunities in home networking. ShareWave believes that in the near future, people will want tools that make it easier to interact with digital content throughout the home, and therefore it has designed its technology with an emphasis on multimedia rather than PC-connectivity applications.2

2 Although it is not the company's primary focus, ShareWave will also support PC-to-PC networking. It recently released a reference platform called Osprey for 4-mbps wireless connections between PCs.
Since its founding in 1996, the company, based in El Dorado Hills, California, has raised $42.5 million in venture financing from investors including Intel, Microsoft, Cisco, Philips, Paul Allen's Vulcan Ventures and Ameritech. ShareWave also lured Jim Schraith, former general manager of Compaq's North American division, to be CEO, and it has grown rapidly to 95 employees. Clearly, ShareWave is a company many large players in the industry want to see succeed. If its vision of a media-rich networked home becomes a reality, consumers will buy many more pieces of hardware, with the market for networking expanding well beyond the two-PC platform.

There is already a significant amount of digital content delivered to today's homes, and with DVD and eventually digital television that will only increase. Digital consumer content is typically delivered through stand-alone appliance-type devices; given the heterogeneous nature of the media streams and user experience, it's unlikely that one device, especially the PC, will be the universal interface. Bennett believes that "you've got to let the appliances play their natural role," and use wireless networking to send data to the appropriate device at the appropriate time.

But can the company deliver on its technology promise? ShareWave originally planned to offer standalone networking products in 1998. It has since pushed out the release date for OEM retail products to the first half of 1999, but says chipsets and software are available now. The first announced ShareWave-based device is the Philips Ambi, a PC/TV hybrid announced at Comdex. The Ambi is essentially a TV that can serve as a large-screen monitor for any PC using a ShareWave wireless connection.

ShareWave has focused on wireless connectivity because it provides mobility and universal coverage within a defined area. However, Bennett acknowledges that some home connectivity will operate over wired networks, and that vendors such as ShareWave will eventually have to provide bridges between different platforms.

The current ShareWave system has a raw bandwidth of 4 mbps, operating over the unlicensed 2.4-ghz band. However, ShareWave uses a specially designed wavelet-based compression algorithm called Network Adaptive Multimedia Image that the company claims provides effective throughput of 120 mbps. This allows the system to handle full-motion digital video streams. ShareWave plans to increase the raw throughput to 11 mbps next year, and ultimately to over 30 mbps. Bennett says that wireless LANs are increasingly closing the bandwidth and pricing gap with their wired counterparts, as compression and other functions are moved from software to hardware.

Avio Digital

Microsoft co-founder Paul Allen created Interval Research in 1992 to explore emerging technologies, some of which could be spun off into for-profit companies. The first two spinoffs, Electric Planet and Purple Moon (a presenter at the last PC Forum), develop interactive content for children. The largest research project at Interval, however, was an effort called Trio targeted at a different market: home networking. After three years of research and development, Avio Digital was formed in July 1998 to bring to market a high-speed home networking technology called MediaWire. The company, which has funding from Interval and Allen's Vulcan Ventures, recently named Philips executive Eugene Van Bergen as its CEO, effective
in January. It is currently exploring partnerships and licensing arrangements to market its technology. Avio expects retail distribution of MediaWire beginning the second half of 1999.

According to acting vice president of engineering Don Burtis, MediaWire is a totally new networking technology designed from the ground up to handle digital audio and video. Avio’s researchers started with the notion that digital media devices are beginning to penetrate the home, including DVD, digital television, CD players and digital cable set-top boxes. They designed a system to network all those devices and make it easy and affordable to transmit digital content anywhere in a home.

Unlike virtually every other home-networking product under development, MediaWire is not packet-based. Packet-switching makes sense for data and computer-centric applications, which can tolerate small delays and gain efficiencies by aggregating many bursty data streams. High-fidelity digital audio and video, by contrast, cannot handle any significant delay, because the loss of packets to congestion will degrade the quality of the signal. MediaWire addresses this challenge by giving each stream a time assignment, and synchronizing both the relative transmission of an individual stream and the absolute timing of multiple streams. A five-channel digital surround-sound system therefore comes out perfectly synchronized.

Avio claims to be able to deliver an effective bandwidth of 88 mbps (44 mbps full-duplex) over ordinary telephone lines, with a range of over 100 feet between devices. That allows the system to support 16 audio channels, four full-screen video channels, eight phone lines and over 3 mbps of TCP/IP data simultaneously. The poor and uneven quality of in-home telephone wiring has been a major problem for phone-based networking technologies, but Avio claims its proprietary technology works over existing wiring reliably.

Unlike HomePNA, however, MediaWire devices won't necessarily plug into existing phone jacks. Avio's literature says that in "whole-house installations, the existing telephone wiring can often be used," but many users will need to run new wires. MediaWire is also incompatible with ordinary analog voice service on a wire. Consumers will need new digital phones or analog-to-digital converters to use the same jacks for voice and MediaWire applications, in contrast to other phoneline approaches that segregate the voice and data channels.

Burtis believes that consumers will buy products without necessarily thinking of home networking as a separate category. He points out that connecting stereo speakers to a receiver is a form of networking, but one consumers take for granted. Avio sees initial applications such as making it easier to support surround sound or DVD content in multiple rooms. The company expects its technology to be incorporated into devices for only a minimal increase in cost, in the single digits in dollar terms. At that point, the convenience of connecting up various devices becomes sufficient to justify consumer purchases... he figures.
If you build it, they will network

Running new wiring in existing homes may not be appealing to most consumers, but the cost of deploying high-speed “structured wiring” in new construction is relatively insignificant. One company pursuing this market is IBM. IBM is training builders, developers and home system integrators to install the wiring along with network controller devices that serve as the hub of house-wide networks. IBM also sells Home Director software to manage appliances in networked homes, and it is looking to provide services that tie together local businesses and community organizations with networked homes. Andrew Hayden of IBM’s home-networking group says the company is talking to most of the major builders in the country and anticipates signing several contracts shortly. IBM is a member of both the HomePNA and HomeRF standards efforts, but it believes those approaches are not inconsistent with deploying structured wiring in new construction.

While IBM works with large developers, DualStar Communications has been creating home networks one building at a time since 1995. The New York company is a subsidiary of an electrical and heating/ventilation/air conditioning contractor. It offers phone service, satellite TV and high-speed Internet access in addition to in-home networks. DualStar initially focused on new construction, but it is also talking with developers and co-op boards in several existing buildings. The company surveys residents to determine the business case for various services; vp of marketing Land Grant says there is particular interest in home networks from members of the financial industry with home offices. For home or building-area networks, the company sends out technicians to run category 5 wire and also to help with installation details such as IP addressing for multiple PCs.

Enikia

Enikia, based in Piscataway, New Jersey, was founded in 1997 by Andreas Typaldos, Dinos Manis and Bob Dillon. Manis, who teaches computer networking at the New Jersey Institute of Technology, had been studying pow- erline home automation systems for a decade. He saw an opportunity to develop a new technology that would provide much higher bandwidth than existing solutions, and took the idea to Typaldos, a high-school friend of his from Greece. Typaldos, now chairman of Enikia, was the founder/ceo of software vendor Computron before starting his own technology consulting firm. Dillon, a former student of Manis who most recently worked for computer-telephony vendor Dialogic, came aboard to handle marketing.

Enikia believes most home-networking companies are missing the greatest opportunity because they come from a computer-centric background. Dillon says competitors generally see home networking as “a simple transplantation of enterprise networking phenomena onto the consumer.” In other words, these companies believe applications such as printer and file sharing that drove adoption of networking in the office will also be the keys to the home market. As Dillon points out, however, consumers may not see the value proposition for such functions, for the same reason that most of them still have VCRs flashing 12:00. Mainstream consumers may see bene-
fits from printer sharing, but how many of them will go to the trouble of buying and installing add-on home-networking kits?

Enikia believes that service providers, such as telephone and cable companies, will be the primary drivers of home networking to the mass market. In the short run (roughly the next two years), home networking will cater primarily to technology-savvy do-it-yourselfers, but eventually Enikia sees home-networking applications as part of integrated service packages involving voice and broadband Internet access. Dillon points to AT&T's plans to use its acquisition of TCI to deliver integrated voice and data services, and Sprint's Integrated On-demand Network (ION) announcement (see Release 1.0, 6-98), as evidence that carriers are moving this way.

An important element of Enikia's service-provider focus is a belief that only service providers can deliver the ease of use that the mass market demands. Dillon says that "Silicon Valley has a conception of operations beginning and ending at Fry's," but that home-networking vendors will need to be able to deliver services independent of the hardware distribution channel. For example, wireless carriers can activate customer accounts remotely, without having to sell the phones themselves. Enikia, unlike its competitors, is building its technology from the beginning to support similar business models.

Dillon says that "in the home there is going to be a heterogeneous environment, because no one technology solves everyone's problem." He sees wireless technology as complementary to home backbone networks running over either powerlines or phonelines, and believes the greater ubiquity of powerline connection will give it the edge.

Enikia's technology currently operates at 10 mbps, much faster than alternate powerline solutions, and the company believes it can increase the bandwidth well beyond that over time. Dillon says Enikia benefited from attacking the problem of powerline networking without preconceptions, rather than trying to scale up low-speed systems designed for home automation. The company's engineers, most of whom came from the wireless and satellite industry, studied dozens of homes to understand the dynamics of powerline networks in the field. The system uses proprietary transmission technology, but employs an Ethernet transceiver so that eventually the interfaces could become standardized through the IEEE.

The 20-person company is currently privately funded by chairman Typaldos. It is seeking venture investments from companies such as networking vendors who could also provide distribution or other strategic relationships. Enikia is currently talking to potential partners and anticipates that products incorporating its technology will be available next year.

Peracom

Coaxial cable is the dark-horse candidate as a transport medium for home networking, primarily because of its limited penetration. Though it reaches into many homes (70 percent), it is not much deployed within them outside rooms with televisions, which may not be the ones with computers. On the plus side, coax provides far greater raw bandwidth than any other widely available home-networking medium. Coax is run to every room in most new construction, and the early adopters for home networking will
likely have more cable-connected TVs than the average. If home networking does take off as a means of sending video streams within the home, cable companies may exploit the wiring they have already deployed.

Peracom Networks, based in Research Triangle Park, North Carolina, was founded in 1997 as a subsidiary of Accton, a large Taiwanese manufacturer of network interface cards. Peracom currently sells universal serial bus (USB) networking hubs, but in late March it plans to launch a home networking product called HomeConnex. Peracom has been spun off as an independent private company, but the Accton connection gives it a stronger manufacturing and distribution base than the typical hardware startup.

HomeConnex consists of software, a wireless remote, a hub that keeps the in-home network traffic separate from the incoming cable TV signals and boxes to connect either PCs or video sources to the home network. To receive content from another device, the user simply selects a channel on the remote. The connector boxes also include an infra-red receiver, which means a wireless mouse or other devices such as remote controls, game-machine controllers, or even laptops with IrDA-compliant infra-red transmitters can be taken from room to room and used with whatever device is displaying the relevant video stream.

Peracom initially plans to sell HomeConnex kits through retail outlets such as high-end audio/video stores, with typical pricing between $200 and $400 depending on the number of connections. The company will also offer professional installation as an option through partners. Peracom is also talking with builders about installing HomeConnex in new homes or in conjunction with security and home-automation systems.

Like ShareWave, Peracom sees a market for home entertainment networks rather than just connections between PCs. Peracom's system will support up to 16 simultaneous video sources. Product manager Steve McConaughey foresees applications such as viewing video content from existing VCRs, DVD decks and game stations in other rooms in the house, shifting direct broadcast satellite entertainment content to other TVs, turning video cameras into remote baby monitors and using DVD-ROM drives in PCs or laptops to play movies on televisions or home-theater systems. McConaughey believes many of the same customers who purchase HomePNA systems for shared Internet access will also be interested in HomeConnex to network entertainment devices throughout the home.

Peracom's vision of home networking centers on the convergence of the PC and the TV. This is not a new idea: It was at the heart of the interactive television and video dialtone efforts of the early 1990s, and products such as the Gateway Destination. Those efforts flopped because the systems were too expensive for the value they provided. In the meantime, video-capture cards in PCs have multiplied, and the prices of digital cameras have plummeted. And slowly but surely, broadband connectivity and interactive video over cable networks are being rolled out. Peracom believes networking, rather than integration of PC and TV functionality into a single device, will make convergence happen.

If ShareWave and Avio can deliver on their promises, Peracom will face a significant challenge due to the limited penetration of coax compared to wireless and phoneline technologies. On the other hand, McConaughey says
Peracom is not wedded to coax for data networking and would build USB adapters to phoneline or other home-networking products if there is sufficient demand.

**Plumbing issues**

Price is not the only barrier to massive deployment of home networking. Home users don't have technical staffs to install and troubleshoot their networks, which means that any successful system must be far simpler and more reliable than the norm in the enterprise. The home-networking providers described in this issue all offer plug-and-play connections, so that users need not configure arcane parameters such as DHCP for each new device added to the network. New technologies that make it simpler for devices other than PCs to talk to one another, such as Sun's Jini, are synergistic with platforms that enable physical connectivity between those devices.

Standards will be important for the evolution of home-networking as a mass-market phenomenon. Different systems will have to interoperate, including technologies that run over different physical connections such as phoneline and wireless, so that consumers can easily connect devices they purchase from many different vendors. Companies such as 3Com and Compaq that build retail products may actually implement this level of interoperability, rather than home-networking providers agreeing on a technical standard.

As the number of connected devices in the home increases, mundane issues such as addressing will be increasingly significant. The current version of the Internet Protocol would not support a separate IP address for each device. IPv6, which provides a much larger address space, will take time to roll out, but will be important to the evolution of home networks. Bob Frankston believes that vendors could sell IPv6 devices for use inside the home, and use address translation devices to connect to IPv4 networks outside.

**MARKET EVOLUTION**

Despite all the interest in home networking, the market won't start to take off before mid-1999. We've already seen something of a backlash in the past month, as people realize that home-networking announcements are different from deployment. Surveys of consumer interest are different from actual purchases. None of the competitors in this space, with the possible exception of Tut, has any kind of track record of working products. The home presents a different environment from the office, both from a technical standpoint and in terms of the level of pain users are willing to endure to get their hardware working.

Even if the products work, it will take time for home-networking equipment to penetrate the marketplace. Home-networking applications are still at the early-adopter stage, and it will take time for mainstream consumers to justify (or rationalize) investment in the necessary equipment. The profusion of companies and technologies in this space will also lead to con-
fusion until winners emerge. Major vendors such as Intel and 3Com will continue to hedge their bets and support a variety of technologies until it becomes clear which way the market is likely to go. When that happens, and vendors of PCs, modems and other devices begin to incorporate home-networking capability as a default, sales will accelerate. Van Baker of Dataquest predicts over 17 million home-networking nodes in nearly 8 million US homes by 2003, and he expects that estimate to increase based on recent announcements about digital cable set-top box deployment.

Home networking benefits from the same externalities as other network businesses. The value of these systems will increase as consumers own more connected devices. At some point, we will reach a critical mass of connectivity that provides sufficient incentives for other companies to build new applications dependent on home networks. With all the forces pushing for connectivity inside the home, we have no doubt that a vast market will eventually emerge.

**COMING SOON**

- Wireless and embedded networking.
- Search and meaning.
- The Net swallows the phone network.
- Living on the Web.
- And much more... (If you know of any good examples of the categories listed above, please let us know.)
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Correction

Release 1.0 Calendar

1999

January 6-9  Consumer Electronics Show - Las Vegas, NV. See the latest gadgets with 100,000 of your best friends. To register call (703) 907-7605; fax, (703) 907-7692; e-mail cesinfo@eia.org.


February 7-10  #Demo 99 - Indian Wells, CA. Chris Shipley picks the hot startups. Call Alexa Hanes (650) 286-2730; e-mail alexa@demo.com; www.demo.com.


February 9-12  Milia ‘99 - Cannes, France. The international content market for interactive media. Contact Barney Bernhard, (212) 689-4220; fax, (212) 689-4348; e-mail infomilia-us@compuserve.com; www.milia.com.


March 6-9  SPA/IIA Spring Symposium - Los Angeles, CA. Issues critical to the future of software and information providers. Contact Anika Valentine, (202) 452-1600 x339; fax, (202) 785-3649; avalentine@spa.org.

March 21-24  *#PC Forum - Scottsdale, AZ. Sponsored by EDventure Holdings. You read the newsletter; now meet the players. Call Daphne Kis, (212) 924-8800; fax, (212) 924-0240; daphne@edventure.com; www.edventure.com.


* Events Esther plans to attend.
# Events Kevin plans to attend.

Lack of a symbol is no indication of lack of merit.
The full, current calendar is available on our Website (www.edventure.com).

Please let us know about other events we should include. - Mari Katsunuma
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