The Revolution At The Network's Edge

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Abstract

The edge is the new center, where overlapping options for content and connectivity converge on user devices. People-Ready? Human Network? These ad slogans reflect the truism that the technology world is expanding from its decades of focus on devices and services into the broader business of facilitating human interaction. While many device innovators and systems developers can see this emerging perspective, many carriers and network operators cannot. Perhaps this is because the emerging, human perspective is clear when we look from the edge of the network in, rather than from the inside of the network out. The outside-in, or edge perspective, reveals the way people actually use and value their technology, and subordinates the once-dominant power of the connectivity providers to the choice and control of the end user. The inside-out carrier's perspective puts the network ahead of the end user, and thinks of devices in terms of which may be attached and how they may be allowed to behave. (At this writing, Apple and AT&T were learning firsthand how hard it is to please end users with a new device while at the same time maintaining control over their use of it!).

Author Biography

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Dr. John Waclawsky joined Motorola in August of 2005 as the Software Architect for Motorola Software. He is also responsible for leading Motorola Software in concert with the Motorola Business Units, Labs and the Motorola Technology organization in constructing unified software architecture for seamless mobility useful across Motorola's business units for coordinated product and solution development. Waclawsky is consistently innovative and holds 38 US patents with over a dozen pending, was awarded IBM's top $150,000 suggestion award and has published more than thirty external technology papers and industry articles. Waclawsky holds a bachelor's degree in mathematics from Drexel University, a master's degree in computer and information sciences from the University of Pennsylvania, and a master's degree and Ph.D. in computer science from the University of Maryland.

TECH TRENDS

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John G. Waclawsky Ph.D.

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Today, the network edge—by which I mean the collection of devices, LANs and other end user technologies that connect to WAN infrastructures—is a communications world in transition from Plain Old Telephony Service (POTS) to a multidimensional, gadget-filled, user-oriented future featuring ubiquitous *Personal Area NetworkS using Pretty Amazing New Stuff*—or PANS to the second power, PANS^2. The devices we carry around with us and the unprecedented access they facilitate—access to information, to functions, and to one another— are changing fundamental patterns of human behavior.

Our daily activities, no matter what our trades or professions, as well our social interactions, are being colored, scheduled, even driven by the cell phones, music players, PDAs and other devices we routinely carry around with us. We are no longer tethered, as we once were in the old POTS days, and our untethered connectivity enhances our quality of living (and working), even as it shrinks the distances in our lives.

Let's take a look at how some of our fundamental patterns of human behavior have already started to change, how these changes are feeding into, and feeding upon our expanding choices in edge devices and connectivity, and where these converging social and technological trends are taking us. Along the way, we shall see that the revenue opportunities may be shifting away from the "inside-out" thinking carriers to the "outside-in" thinking innovators, but that the basic opportunities are right where they always have been—in delivering value to the end user.

Choices For The End User

Consider us older guys and gals. Because we grew up with expensive long distance calls and no email or Internet, our default behavior still tends to be mostly "offline." We periodically make phone calls, go online for information and check email. Our children, however, are growing up in a different world, and, for the most part, their default status is "always on." Kids go to bed with their mobile devices, texting their friends "good night;" and first thing in the morning, they call or text them "hello." Many can't remember ever being without a cell phone or portable computer.

We are in this world of "always-on" connectivity in large part due to the many advances in computing and networking technologies of the past few decades. These include:

- **More computing power for less cash**—As expressed in Moore's Law, the processing power, per dollar, of a microchip doubles every 24 months. A number of different fields of research could extend Moore's Law even further, including spin transistors, 3-D silicon, nano-technology and biochips. By the year 2020, microchips are forecast to be only about one atom thick.

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■ **Networks that get more valuable as they grow**—As expressed by Metcalfe's Law, the value of a network is proportional to the square of the number of nodes; so, as a network grows, the value of being connected to it grows exponentially. Implied, and experienced (although not expressed in Metcalfe's Law) is the related phenomenon that as the network grows, the cost per user remains the same or even drops.

■ **Bandwidth that grows even faster than computing power**—Social pundit George Gilder gained notoriety in the late 90s with his "Laws of the Telecosm," one of which is "Gilder's Law," which states that "bandwidth grows at least three times faster than computer capacity." DSL and cable modems today routinely reach 500 kbps or more, 3G wireless is approaching this and optical media rates in carrier backbones continue to climb. The price per bit also keeps falling, so that many expect the marginal cost of communication eventually will tend to $0. WiMAX continues the progress in this area, since it is capable of offering transfer rates that are anywhere from two to 10 times faster than 3G but only use half as much radio spectrum.

The kids are just fine with the results of these three "laws"—many, inexpensive devices with which they can maintain near-constant connectivity to their friends—but, as shown in Figure 1, many adult end users have to work hard to make informed and intelligent use of all these connectivity options.

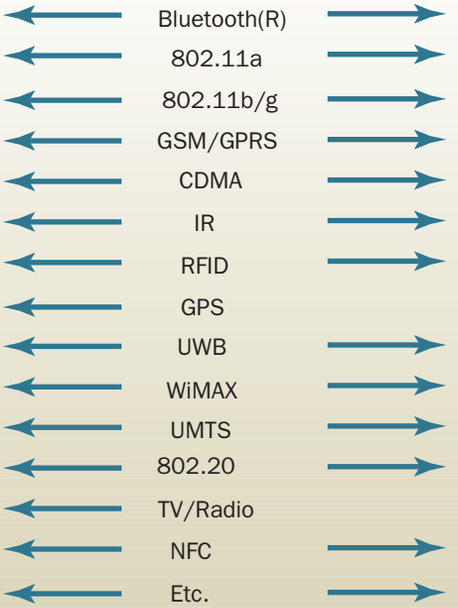
In effect, the end-user has become the convergence point. He or she decides whether to use one device or the other, one network or the other, based on a range of factors. Maybe it's a quick call home on the cell phone, a text message to the teenager, an important business discussion over a landline, a fax of a document, an email to the team, or surfing from the coffee shop for theatre tickets. The various operators of the services that the end user accesses can't possibly know how his or her context and connectivity choices will change through the day.

At the end of the day, our end user comes home, and enters another world that is also being transformed (albeit more slowly) by wireless technologies. In the home, peer-to-peer and *ad hoc* networks, using connectivity options such as Bluetooth, MANET and 802.11 for example, will soon allow him/her to connect to things within his/her general proximity. This means that s/he can control the temperature based on where s/he is located. Maybe the air conditioning goes down in one room and comes up in another, just as the lights do as s/he moves around. Many expect content to eventually follow you around the home, too (see "The World of Short Distances," p. 32).

Think this way for just a little while, and you begin to see almost endless opportunities for the environment to become aware of end-user presence and to serve the end user in new ways that will likely result in new business opportunities. Consider these additional examples, from the realm of surveillance and remote actuators: fire alarms and extinguishers (not only in buildings, but also in parking lots, tunnels etc.), cameras in public/private areas, acoustic detectors, silent burglar alarms, remote control of railway crossings and bridges, speed detectors/cameras, chemical sensors (gas sniffers), water intrusion/flooding detectors, stress and elongation meters on various

Our children are comfortable with many devices, and with "always on" connectivity to their friends

FIGURE 1 What Does The End User See?



The overall trend is toward connecting people, gadgets and content in new ways

buildings, bridges and other public works, unmanned door-contacts and entry authentication units, parking meters, city clocks, electronic billboards, elevators, bus stop arrival boards, vending machines, advertisement to in-shop TV-screens …and the list goes on and on.

But back to the home—have you seen the Samsung or LG refrigerators with Internet connectivity on the door? Do you want one? Maybe not, but I'll bet you know someone who does, or who at least thinks it's cool. Consider things like DVD players, digital cameras, one or more laptops, MP3 players, PDAs, etc. People love their gadgets—in their house, or on their person, or in their transportation vehicles.

My point is this: Just because you or I can't see any reason to connect things does NOT mean that someone else can't find a cool application or a market advantage in connecting them.

What is the obvious technology trend here? It's

The World of Short Distances

The world of short distances is not just about talking on the phone and receiving services; it is also about experiences, and local proximity will clearly be part of the mix for having great user experiences. For example, we (or our personal devices, on our behalf) will need to communicate with a great many sensors in the home to control our environments in optimal ways.

Ubiquitous availability of short distance wireless connectivity will also drive new social interactions through chance encounters in clubs, restaurants, at a football game, or on the beach or subway. The trend is clear: The end-user at the edge has the possibility of doing lots of interesting things with an edge device that can handle direct proximity communications.

When you look from the core of the network out to the edge, and you don't consider the end users, you miss the end users' perspective, and the developing "worlds" of short distances. To better understand this perspective look first at your immediate environment and then outward to ever-more globally distributed networks (Figure 2a).

Handling all these proximity interactions efficiently and economically can't be about "dipping into the core" for billed-by-the-dip types of services. To support such services, today's core-focused networking model would have to be changed significantly.

On the other hand, if we begin with development for small environments, then we could replicate that solution for lots of other similar groups, and scale it up to larger "worlds." As shown at the bottom of Figure 2a, our connectivity options may come to look like a sea of overlapping networks—some "worlds" will be quite large, but the majority will be very small and at the edge.

In effect, the edge will become the center of the networking universe, because it will converge, at the end user's devices, a huge number of overlapping physical and logical connectivity options□

FIGURE 2a The Network World Of Short Distances

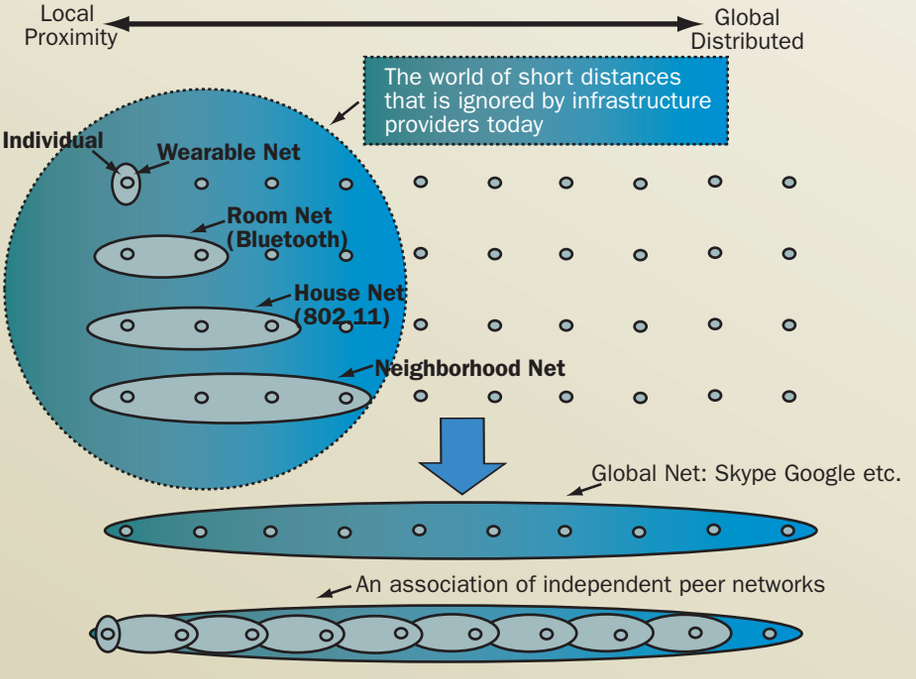
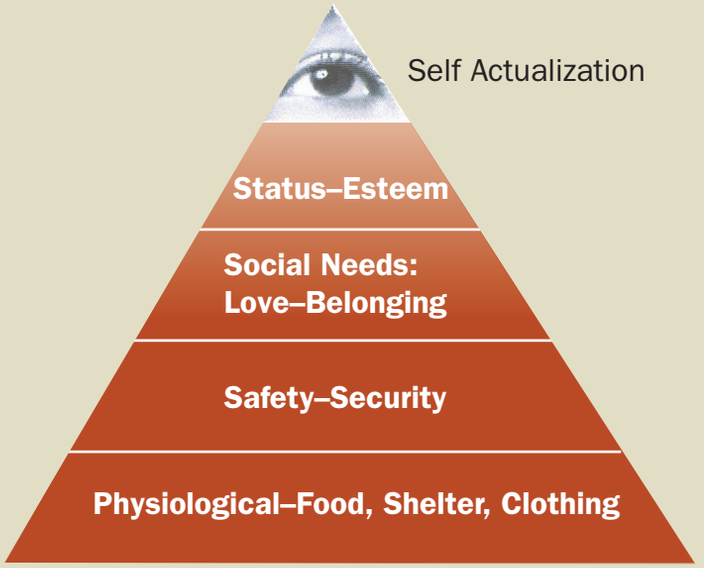


FIGURE 3 Maslow's Hierarchy Of Needs



not about minutes of usage and kilobytes of data services for everyone on the planet. It's about connecting people—along with all their gadgets, information and content—in an increasing number of physical and logical ways. That is the foundation of a great opportunity to create value and satisfy end users in new ways.

Technology Meets Maslow

Technology is also helping us to adapt to living in this sea of connectivity, by increasing our ability to satisfy fundamental human needs, such as belonging to a group, sharing our lives with a number of peer communities, and further enhancing our ability to be socially connected. Take a look at Maslow's hierarchy of needs, shown in Figure 3 (Maslow's pyramid).

Today our computers, cell phones and PDAs already help us to meet our needs on all these levels. You can satisfy basic needs by ordering a pizza, checking on your dry cleaning or making a hotel reservation. When my daughters go out, they take a cell phone, not just to stay connected with their friends, but also for security. If my car is in an accident that causes the airbag to deploy, the car automatically calls 911 and reports my location by GPS coordinates.

Moving up the hierarchy, from safety and security to social needs, people have used phones, computers and PDAs for years to stay connected with friends and loved ones, as well as to break the ice with new acquaintances, ask for a date, be "cool" and to find and become part of new communities. In today's younger generation, however, network devices and their usage are no longer just about talking on the phone; they are about belonging and self-actualization.

Even older people enjoy sending emails and IMs around to share links to the websites they find which feature quirky, fun, beautiful or entertaining content. Sharing with your peers the music and videos that you like is a big part of demonstrating who you are as an individual (status and esteem) but your recommendations also make you a viral content and advertising distribution vehicle. This social aspect makes content distribution even more important and valuable. When users share and recommend, they are saying these are my tastes, this is relevant to my community of interest, this is who I am.

Self-expression and sharing are important and growing social Web trends

While individualism and anonymity rule the Internet today, sharing and self-expression also is growing as more individuals, young and old, use the Net to create and join in new forms of community. Social applications are here today—including MySpace, YouTube, Second Life and many others—and, as the Internet develops into a social fabric, devices at the edge are evolving to allow the dynamic formation of a wide variety of networks to meet social needs. Membership will range from an individual and his/her buddy, to a bridge club, to an alumni association or even larger groups of people (see "Leveraging the Edge," p. 34).

Business people could also benefit from this social trend of joining (and leaving) groups. For example, client programs installed on hotel guests' edge devices at check-in or beforehand could automatically add the hotel operator, front desk, housekeeping, etc. to your phone book and/or IM buddy list when you check in, and delete these references when you leave. The net result is that you and the hotel are better connected; you can more easily express your needs and the hotel can serve you better.

In the future, such social networks are likely to form and go away as people come and go. There are two main points here: First that everyone and their devices will be communicating all the time; and second, that a lot of interesting things can happen when end users collaborate and form communities of interests.

So we have a growing social use of networks, a variety of devices and network technologies that can be used for these new purposes, and a generation coming of age that will be prepared to use them, by virtue of their childhood habituation to constant connectivity via their cell phones, laptops and PDAs. Now let's consider some of the imped-

Hollywood says it hates file sharing—but it used to hate VCRs, too

Leveraging The Edge

One person's spam is another's source of information. Even ads can be valuable, if they are targeted to the specific communities who have an interest in what is being offered. The emerging Web-based communities of interest are ideal for such targeted advertising. The question becomes: How do I integrate advertisers into the webs of relationships that are springing up at the network edge?

For example, say that most of the members of my online motorcycle club own Hondas. I would think that Honda would be interested in being a trusted member of my community of interest, because we are people who use their products and are very likely to buy more equipment and products that Honda sells.

Perhaps network providers could actively encourage the formation of these online communities of interest and, as a result, become a conduit for targeted advertising. If there were enough advertising revenue, perhaps the operators wouldn't even have to charge the communities anything because the operators would be, in effect, selling access to this community to the advertisers. Perhaps the advertiser also would use this opportunity to bring real information to the community, not "just" advertising but perhaps links or widgets for motorcycle-related parts and services.

Of course, there is a lot of technology that has to come together and a lot of mindset changing that has to take place for such trends to develop. On the other hand, there are people all over the planet who are already looking at these opportunities, technologies and challenges from the perspectives of peer-to-peer, social networking, identity/reputation management and advertising.

Remember how the motion picture industry reacted to the first VCR? Hollywood predicted it would doom the industry and fought it to the Supreme Court. But now they love the VCR, because they make a ton of money with it. When their business model changed to embrace the new technology, that's when they made even more money.

Today, many edge devices are being used to replace the VCR, and the content providers say they hate file sharing. If the past is prologue, however, they will come to love it, because edge networking will lower their marketing and distribution costs. It will also enable more people to get access to their content and to the associated advertising (or, I should say, information).

Radio stations are already monitoring download statistics (both from legal and illegal sites) to determine what they should be playing to keep listeners tuned in. Advertisers and infrastructure providers will soon see that they can have better consumer relationships and get more effective advertising to a better targeted audience (like my motorcycle club) much more cheaply than ever before, if they are willing to help leverage the trends with the largest growth: creating content, connecting socially and sharing□

iments to these developments, and how they could be addressed.

New Challenges: Reputation And Trust

Look again at communities of interest and notice that, when privacy or money is at stake, they are commonly called "circles of trust." If you don't know a new participant, how do you measure their reputation, or determine if they can be trusted? These issues of trust and reputation are among the most critical in these new social usages of the Net.

Something like a person's Whuffie—the ephemeral, reputation-based currency of Cory Doctorow's sci-fi novel, *Down and Out in the Magic Kingdom*—is a general measurement of his or her overall reputation. It is lost and gained according to other participant's judgments of the person's favorable or unfavorable actions. You'd be more likely to do business with someone who has a good rating than someone who doesn't. Success is measured not monetarily, but by what money really represents—your personal capital with your friends and neighbors.

Although Whuffie was never intended for real-world implementation, many community-oriented websites are built around Whuffie-like concepts of reputation management, such as Slashdot's karma system or eBay's feedback ratings. Currency systems similar to Whuffie include Local Exchange Trading Systems (LETS, in which goods and services can be traded without printed currency) and the Ripple monetary honor system.

A related and very significant challenge for networking environments of all sizes is promoting "good" behavior and stopping or reducing "bad" behavior. If you look at issues like behavior and reputation from the "inside-out" standpoint—that is, what could you charge for services on the network that might help with these matters—you can see how the idea of walled gardens came naturally to network operators, and you can also see how antithetical that is to the way people are actually using social networking today.

For the users, it is not about money; it is about reputation and identity and fulfilling social needs. That doesn't mean operators, or others, couldn't

make money by addressing reputation, security and identity issues, it just means they will more likely succeed by doing this at the edge, with end user cooperation—not with services created and controlled in the core network layer.

Once trust and reputation and identity issues are addressed—and, no doubt, they will be—the edge-centric trends we have discussed above will take off even more quickly. Social networking will include having a lot of proximity interactions when you are en route to meet your friends—in a car, traveling to a party, the beach or to meet at a bar, coffee shop or restaurant.

When we are close to each other, Bluetooth, 802.11, Near Field Communications (NFC) and other *ad hoc* proximity networks will give us more opportunities to share our stuff. When we are home, we will be using local connectivity to load up our iPod with selections from our music library, etc. In short, as I said at the outset, the revolution at the edge is really about personal area networks using pretty amazing new stuff–PANS[2].

Let The Edge Get Smarter

Connecting everyone and all their gadgets together in an increasing number of physical and logical ways is the foundation of a truly staggering opportunity. Keep in mind that many, if not most, of the data flows will occur between devices at the edge of the network, inside their small-distance "worlds," and that there will be a decreasing need for "inside-out" type services from the core.

In a future that consists of hundreds of billions of edge devices with radios, the opportunity for infrastructure builders will entail providing some order to this growing diversity at the edge. Yet centrally controlling and servicing hundreds of billions of smart devices seems impossible.

I doubt that any scalable, reliable means of centralized management and control could be created that is also innovation-friendly, cost effective and able to keep up with changing technology and usage trends. The logical and physical complexity of the infrastructure that will be required to control all this precludes it, given all the variables that are in play.

Instead, the industry should let the edge get smarter, and focus its own efforts on repurposing the infrastructure to try to bring order to what's going on at the edge. For example, you might want a short access control list in your home or proximity network, filtering who is and isn't allowed to interact over which ports or interfaces, etc. Security could be at the device-level, provided by the network operator or left to chance for people who don't care—consider the number of open WiFi access points.

Identity also could be handled easiest locally or in a small community of interest. But as the community of interest gets larger (e.g., an alumni association) then it might be best handled by an identity service that someone could offer.

At the end of the day, a large variety of networks will form. Many will be large enough that someone will have to worry about identity management, persistent storage, security, administrative services, billing services, maintenance, etc. These larger networks are opportunity arenas for infrastructure providers, but some things can be done easiest and best locally.

Conclusion

The gradual transition away from a total core networking environment to a more distributed one has already begun. The core won't just go away, however, and distributed environments will continue to augment the core before, eventually, replacing it. People will make varied choices, evolving over time. Older folks may continue to hang onto a business model that works for them, but if service providers count on "old–folk" inertia to keep their business models viable, and if they don't evolve that model toward the tastes of younger users, then when the older folk die off, or change to embrace new alternatives, those service providers will go out of business.

In time, broadband access will be available anywhere and at anytime. The challenge for future network providers will be, "how do I keep my networking edge communities happy and productive and socially connected doing cool new things?" Not "how do I control what each individual subscriber does?"

It's really all about how a network infrastructure can help satisfy Maslow's hierarchy of needs as connectivity options continually increase. We need to get beyond thinking about minutes and services, and instead contemplate how the industry can offer the foundation functions or enabling mechanisms for a world of millions and perhaps even billions of overlapping edge networking environments over numerous physical transports.

The critical questions for innovators, systems folk and network operators alike are these: How do I supply whatever would help the end user to belong to a group and share their lives with members of peer communities? How do I make it easy, automatic and routine for individuals to get information, participate in commerce, social interaction and everything else that an individual seeks on a daily basis?

In answering these questions, I believe we will find that substantial new opportunities will present themselves□

Companies Mentioned In This Article

LG Electronics (www.lge.com)
Samsung (www.samsung.com)

Reputation, identity and security issues will be addressed at the edge, and with end-user cooperation

Motorola, Inc.
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