When the Network Is Everything

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Two major properties will characterize networks in the future. They will be ubiquitous; by default, everything will be connected to a network of some form and work in coordination with other devices, services, and network-enabled entities. And they will be invisible, always there and always in use; we will notice them only in those rare instances when they are not available.

Part of this ubiquity and invisibility will be brought about by networks being wireless, at least on their edges. Being part of a network will not require being wired into it, only being close by. Information transmission will occur through the ether when needed; the network you are connected to will be the network you are closest to. Wires will remain, but only in the parts of the network forming the interior of the network cloud and only because the wires allow greater speed and longer reach and require less energy.

Since we won't have to physically plug things into the network, we won't notice that things are actually on the network. For some classes of device, the connection to the network will make itself known (if we think about it at all) by localizing the information available to us through the device. What is shown on our display or heard from other devices will depend on where we are. Different merchants will bid for our business depending how close we are to their stores. Different maps will appear on our location devices, always centered on our current position.

These uses represent only a small fraction of the traffic over the network of the future. Most will be machine to machine, program to program, and service to service. While we might want to find out that our dishwasher is full (and then give a command to start the wash cycle) over the network, it is far more likely the manufacturer of the dishwasher would want to find out whether the water is heated correctly or that the machine's parts are wearing out. Our houses will not only talk to us but to the companies that supplied their components, ensuring they are working correctly, and, when they are not, they are serviced before they fail. Repair will be replaced with prognostics and dynamically scheduled maintenance.

A similar approach will yield fundamental changes in medical care. Rather than reacting to disease, networked sensors will allow our health to be monitored and preventive steps taken as needed. We won't need to worry whether our current symptoms are serious enough to require a trip to the doctor; the doctor (or, more likely, a computer receiving information from the sensors on, in, and near our bodies) will tell us when such a trip is needed.

The capabilities provided by such universal connectivity will be limited not by technology but by the social decisions such a network will require us to make. Universal connectivity will provide new levels of reliability, personal safety, and personal economic power. It will allow greater efficiencies in transactions, maintenance, and delivery of basic services. But it will also provide a means to gather information that makes the notion of personal privacy difficult to maintain, a degree of accessibility that makes uninterrupted time for thought and contemplation

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difficult to obtain, and opportunities for abuse, from both the government and the private sector, difficult to avoid or negate.

Unlike some who find the issue of privacy in the coming networked world technically, socially, legally, or politically straightforward, I have difficulty with the decision of where and when privacy must be maintained and where and when information should not be gathered. The kinds of information that will be available about any citizen in the networked world will be no different from the information available today; what will change is the ease with which the information can be gathered. Most moral issues do not depend on how easy it is to act immorally.

The big question, of course, is when this change will occur. I think it will happen in the near future, but exactly when is impossible to say. The technology for such a world has been coming into place over the past 20 years, including cheap processing power and memory, high-available bandwidth, wireless networking, and better power storage. The result is the networked equivalent of a supersaturated solution. There is no apparent change in such a solution, but when the first impurity around which a crystal can form is introduced, the crystal forms at seemingly magical speed.

The change to the ultra-networked world of ubiquitous computing will take place in the same discontinuous way. Those of us working on the enabling infrastructure will continue to pour the base ingredients into the socio-technical solution. Cellular phones will be more powerful. Networks will be self-assembling. Useful network services will be offered. Proximity networking will be understood. And as all this is happening, the world will proceed pretty much without change, with everyone predicting the change to ubiquitous networking at some time in the future. Then something will happen that precipitates the phase change. It might be a "killer app" for the network, the way spreadsheets suddenly made the PC a phenomenon almost as common as the telephone. It might be a better way to access the services being offered, the way Mosaic opened the Web to everyone on Earth. I suspect it will be something completely different and unexpected. If I knew what it was, I would be trying to build it today. But something will start the crystal; when it does, the transformation will be so radical and so complete, we will forget what life was like without such ubiquitous and invisible networks, just as we have forgotten what life was like before the Web.

Such a transformation may not happen for 5, 10, or 30 years. Or it may have happened between the time this article was written and the time it was published. When viewed in retrospect, the network-induced transformation will seem simple, inevitable, and obvious. Until it happens, we cannot know what it will be. We can only continue to pour our ingredients into the solution, waiting for the crystal to form. C

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