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An Evolution Toward a Programmable Universe

By LARRY SMARR

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Larry Smarr

Over the next 10 years, the physical world will become ever more overlaid with devices for sending and receiving information.

Already billions of processors are embedded in our smartphones, cars, appliances and buildings and the environment. These sensors can send out streams of data about their surroundings, and more and more it is anonymously transmitted to remote data centers — the "clouds" of Google, Amazon, Microsoft, Yahoo and Apple.

From these vast clouds, the companies can power apps that are "spatially aware." For instance, Google Maps now draws on data in the cloud to sample the location and movement of cellphones in cars, producing a real-time picture of traffic congestion.
Smart electric grids are measuring our homes' use of power; active people are tracking their heart rates; and hundreds of millions of us are uploading geo-tagged data to Flickr, Yelp, Facebook and Google Plus. As we look 10 years ahead, the fastest supercomputer (the "exascale" machine) will be composed of one billion processors, and the clouds will most likely grow to this scale as well, creating a distributed planetary computer of enormous power.

Such computational power, co-located with the gigantic storage that holds the data from all the incoming data streams, will enable faster-than-real-time simulations of many aspects of our physical world. As Mike Liebhold and his colleagues at the Institute for the Future have discussed, computing will have evolved from merely sensing local information to analyzing it to being able to control it. In this evolution, the world gradually becomes programmable.

At the California Institute for Telecommunications and Information Technology, we are using this vision to better understand the coming digital transformation of health, energy, environment and culture. We are experimenting with sensors to monitor electricity use in homes, buildings and data centers; the data can then be analyzed and used to control lighting, heating, cooling, appliances and computers to make them more energy-efficient.

It is logical that the analysis of traffic data, coupled with in-car radar and autopilot electronics, will enable software control of large numbers of robot-driven electric cars. Since buildings and transportation are major sources of greenhouse gas emissions, the sensor-aware planetary computer can be a crucial factor in reducing our carbon footprints.

The same principle applies to our bodies. I wear sensors to measure my steps, caloric burn and sleep patterns, while heart patients can wear sensors that wirelessly notify their doctors of life-threatening conditions. People will soon be able to have their genetic code and medical imaging stored in the cloud, along with charts of vital signs and detailed nutritional analysis of everything they consume.

Using this data, the planetary computer will be able to build a computational model of your body and compare your sensor stream with millions of others. Besides providing early detection of internal changes that could lead to disease, cloud-powered voice-recognition wellness coaches could provide continual personalized support on lifestyle choices, potentially staving off disease and making health care affordable for everyone.

Finally, in culture, the fine-grain streaming provided by Twitter, Facebook and Google Plus enables us to map out phenomena using “human sensors.”

For instance, a vast power failure occurred in Southern California in September; within minutes we could tell from the locations of Twitter messages saying “my power just went out” that it was widespread, long before the official announcement. Similarly, Twitter feeds from large geographic areas have been analyzed to create dynamic “social mood” or “political anger” maps, like the Google traffic maps constructed from GPS feeds.

Conceivably, the coupling of the sensor and human streams with planetary computing power will make it possible to create “social forecasts.” For good or evil, it seems inevitable that individuals, corporations, political leaders and intelligence agencies will come to use planetary computer models of social behavior to inject content into the global attention stream at just the right moment, hoping to steer the social dynamics to a desired outcome.

With the continuing exponential increase in the power of the planetary computer, one has to wonder whether we stand at the beginning of what Isaac Asimov’s “Foundation” series, more

than 60 years ago, called “psychohistory.” His visionary genius Hari Seldon believed that statistical forecasting of human society’s actions would be possible with data from enough people throughout the galaxy.

In the next several decades, we will have a glimpse of whether something similar can emerge on planet Earth.

Larry Smarr is the founding director of Calit2.