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Mobile phones

Sensors and sensitivity

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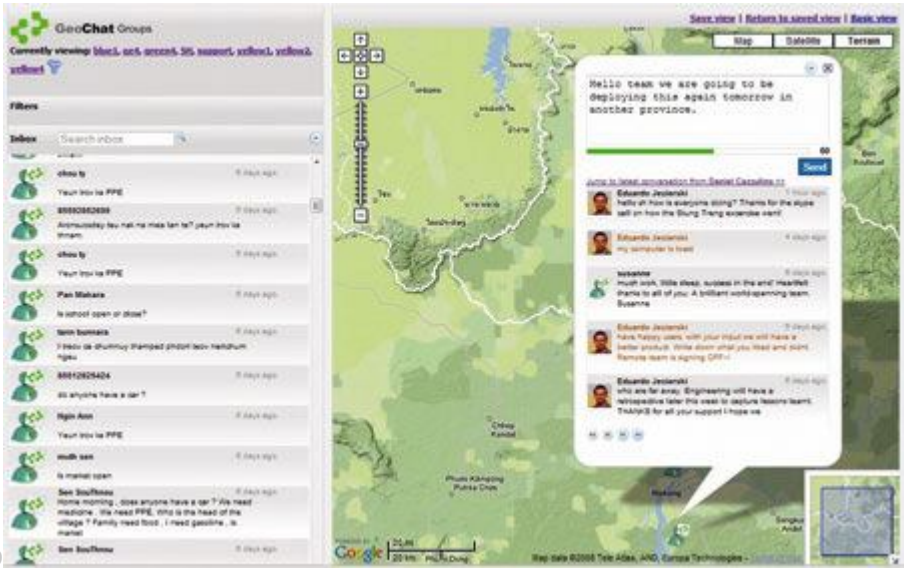
Data collection: Mobile phones provide new ways to gather information, both manually and automatically, over wide areas



InSTEDD

IF YOUR mobile phone could talk, it could reveal a great deal. Obviously it would know many of your innermost secrets, being privy to your calls and text messages, and possibly your e-mail and diary, too. It also knows where you have been, how you get to work, where you like to go for lunch, what time you got home, and where you like to go at the weekend. Now imagine being able to aggregate this sort of information from large numbers of phones. It would be possible to determine and analyse how people move around cities, how social groups interact, how quickly traffic is moving and even how diseases might spread. The world's 4 billion mobile phones could be turned into sensors on a global data-collection network.

They could also be used to gather data in more direct ways. Sensors inside phones, or attached to them, could gather information about temperature, humidity, noise level and so on. More straightforwardly, people can send information from their phones, by voice or text message, to a central repository. This can be a useful way to gather data quickly during a disaster-relief operation, for example, or when tracking the outbreak of a disease. Engineers, biologists, sociologists and aid-workers are now building systems that use handsets to sense, monitor and even predict population movements, environmental hazards and public-health threats.

A good example is InSTEDD (Innovative Support to Emergencies, Diseases and Disasters), a non-profit group based in California, which promotes the use of mobile phones to improve developing countries' ability to respond to disasters. Launched with seed money from Google's philanthropic arm and the Rockefeller Foundation in late 2007, it has just released a suite of open-source software to share, aggregate and analyse data from mobile phones. Its first test-bed is Cambodia, where health-workers can send text messages, containing observations and diagnoses, to a central number.

The sender's location is determined for each of the messages, which pop up as conversation threads on an interactive map that can be called up on the web. Clicking on this map allows text messages to be sent back to users in the field from the control centre. InSTEDD says this service, called GeoChat, enables "geospatial ground-truthing, as your mobile team works to confirm, refute, or update data".

Automating the reporting of titbits from remote clinics has already had a profound impact, says Eric Rasmussen, InSTEDD's chief executive. Instead of recording information on scraps of paper, which would sometimes take days to reach higher-ups and trigger an alarm, the cycle-time has been reduced to days or even hours. GeoChat has been officially adopted by the six countries which share a border in the Mekong Basin, including Myanmar and Yunnan province in China, establishing a flow of real-time disease data from villages in the region to each country's health ministry. Authorities can then choose to share this information with international bodies such as America's Centres for Disease Control and Prevention (CDC) or the World Health Organisation. The aim is to enable a quick response to any outbreak of avian flu, cholera, malaria or dengue fever. InSTEDD is helping aid organisations and government agencies deploy its free tools in other countries, including Bangladesh, Peru and Tanzania.

An alternative approach is to gather information passively from mobile phones, without any user intervention. Alex Pentland, a computer scientist at the Massachusetts Institute of Technology, dreams of "X-raying entire organisations, cities and countries" by collecting data in two ways. First, some handsets can capture information about individuals, such as their activity levels or even their gait, using built-in motion sensors. (Modern handsets use these sensors to work out whether to display information in landscape or portrait format.) Second, information from mobile-network operators, which keep track of handsets in order to pass them smoothly from one network cell to another, can provide a high-level view of how people move around. Dr Pentland's algorithms can even cluster information from thousands of phones to divide people into "tribes" of like-minded folk. He calls this "reality mining".

Nokia

Following the crowd

Sense Networks, a company co-founded by Dr Pentland, wants to use the predictions derived from tracking mobile phones not only for commercial purposes—to produce real-time maps showing the most popular nightlife venues in a particular city, for example—but also for the public good. The company's charitable foundation is working with Vodafone, a big mobile operator, the CDC and other collaborators to build an early-warning system for modelling and predicting the spread of tuberculosis in South Africa.

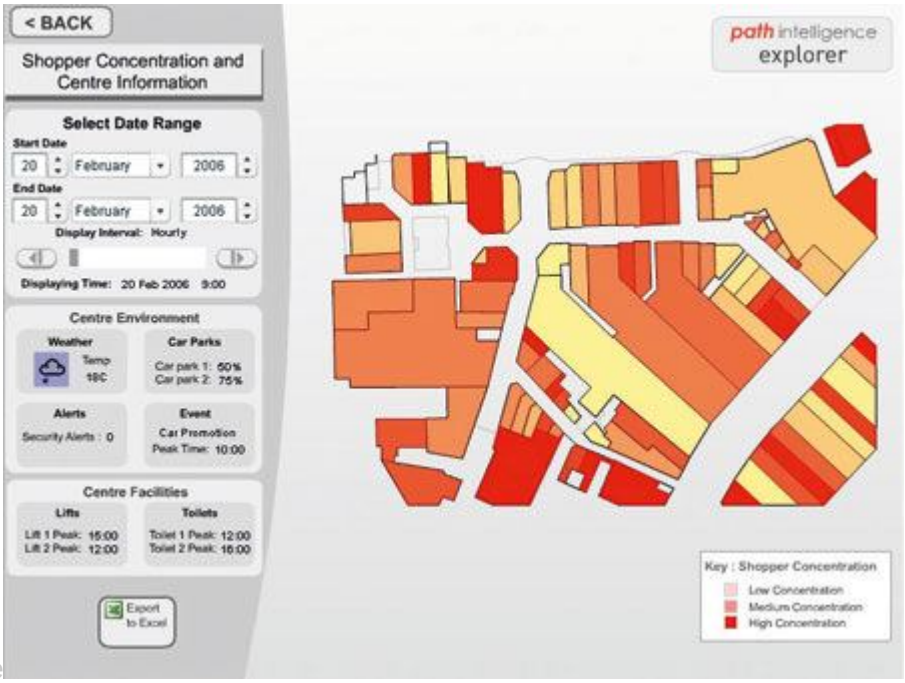
As a first step, Sense plans to collect positional information from a control group of infected patients being treated at Helen Joseph Hospital in Johannesburg who would have to volunteer to participate in the scheme. Dr Pentland and his colleagues will then be able to determine which neighbourhoods these patients frequent, and their commuting patterns between them. They hope this will then enable them to work out the characteristics of typical TB patients, so that they can then spot potentially infected people in the wider population. How public-health officials will use this information has yet to be decided: people who are thought to be infected could be contacted by text message and asked to visit a doctor, for example.

Path Intelligence, a British firm, is applying a similar approach to answer more commercial questions. Its FootPath system aggregates and analyses signals picked up from mobile phones as people move through a particular area. The results can be used by planners to optimise the flow of pedestrians through railway stations and airports or to guide the layout of shopping centres. It can determine, for example, whether customers who visit a given shop also visit a rival shop. The same passive method can be used to figure out where best to locate emergency exits, and even to locate clusters of survivors after a disaster.

But some people find the idea of having their movements tracked in this way unsettling, even when the data are anonymised and aggregated. And knowing someone's position is not enough on its own to determine whether they carry a disease or would be interested in going to a particular nightclub. So the best approach may be to combine voluntary (but potentially unreliable) contributions

that are submitted manually with automated data capture that does not require user intervention, but may not capture the whole picture. A good example is the study of well-water contamination in Bangladesh conducted by Andrew Gelman, a statistician at Columbia University. His project combined readings from remote water-sensors with queries and data which villagers keyed into their mobile phones.

On a grander scale, InSTEDD's Dr Rasmussen is trying to stitch together a global network, tentatively dubbed Archangel, to combine all manner of data sources, from satellite imagery and seismic sensors to field-workers texting from refugee camps. A first glimpse of what such a network would look like is pachube.com, an experimental web-service launched in 2007 by Usman Haque, an architect based in London. He aims to patch together sensors and people into a "conversant ecosystem" of devices, buildings and environments.



Path Intelligence

Watching while you shop

Some computer scientists look forward to the day when mobile phones and sensors can provide a central nervous system for the entire planet. An abundance of sensors, they believe, will lead to two things. First, the amount of data will increase, allowing scientists to build more realistic models. Alessandro Vespignani of Indiana University compares the current state of affairs to weather forecasting a century ago, before satellites had provided meteorologists with the data to build and optimise mathematical models. When it comes to problems such as tracking and predicting the spread of diseases and other environmental hazards, he argues, scientists can never get enough data.

The human touch

Second, once people are able to contribute data to research projects from their mobile phones, it could provide an ideal way to broaden public involvement in

scientific activities. This would be the next logical step after the popularity of web-based participation in scientific research, from folding proteins to categorising photographs of galaxies. Eric Paulos, a computer scientist at Carnegie Mellon University in Pittsburgh, predicts the rise of “citizen scientists” able to measure and sample their surroundings wherever they go. When people can report mundane variables such as the level of traffic noise in their street or the degree of air pollution at the bus stop, he argues, their outlook on science changes. “People develop a relationship with and a sense of ownership over the data,” he says. He foresees amateur experts being driven by a new sense of volunteerism, the 21st-century equivalent of cleaning up the neighbourhood park. Nokia has even designed a prototype handset with environmental sensors (see article).

Dr Paulos has already equipped street sweepers in San Francisco and taxis in Accra, the capital of Ghana, with sensors to measure pollution levels, which he then used to create a map of each city’s environmental landscape. He plans to do the same with cyclists in Pittsburgh. Graduate students in his newly created Living Environments Lab have loaded households with sensors to sample tap water and indoor-air quality. Results are uploaded to a website where participants can compare them with other people’s contributions.

The technology is probably the easy part, however. For global networks of mobile sensors to provide useful insights, technology firms, governments, aid organisations and individuals will have to find ways to address concerns over privacy, accuracy, ownership and sovereignty. Only if they do so will it be possible to tap the gold mine of information inside the world’s billions of mobile phones.