From the Editor in Chief

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When Disaster Strikes

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Earthquakes, hurricanes, fires, toxic spills, and terrorist attacks are examples of natural and man-made calamities that are a tragic fact of life. Emergency personnel such as firemen, paramedics, and police officers who arrive on the scene immediately after the event are referred to as *first responders*. Their primary goals are to find and rescue survivors and to prevent damage from spreading. Their work is greatly hampered by damage to local infrastructure such as electric, gas, water, and phone lines and wireless base stations. Maps and building plans might be of limited use because of upheaval to local terrain and the collapse of buildings. First responders are also under extreme time pressure, because many injured victims might not survive long without medical assistance.

Can pervasive computing technologies help? Even modest improvements in basic capabilities such as vision, navigation, and communication have the potential to be of great help to first responders. What specific forms might such help take in the future?

A HYPOTHETICAL SCENARIO

In the April–June 2003 issue of *IEEE Pervasive Computing*, we published an excerpt from *IT Roadmap to a Geospatial Future*, a US National Research Council report.[1] That excerpt, "Challenges in Location-Aware Computing,"[2] presented a futuristic example from the report of how technologies relevant to pervasive computing might help in disaster recovery:

A devastating earthquake, "the Big One," has hit downtown San Francisco. A huge complex of skyscrapers built on reclaimed land has caved in. It is feared that thousands of people are trapped in the rubble. Emergency personnel have little time in which to rescue them. Although cranes and heavy earthmoving equipment have been put in place with amazing speed, it is not clear how the excavation should proceed. With unstable interior spaces and broken gas and electric lines, it is not clear how to excavate in a way that is fast yet will not further injure survivors. Time is ticking away and with it, hopes for survival.

With few options left, the disaster-relief director decides to use an experimental, robot-based, just-in-time 3D mapping capability that was developed after the 11 September 2001 World Trade Center calamity. Thousands of small mobile robots ("mapants") burrow into the rubble. Each robot is equipped with location-sensing ability as well as visual, toxic-gas, and other sensors. The key to the speed of the just-in-time mapping application is the enormous parallelism made possible by the huge number of mapants. To conserve energy and enable communication through the rubble (which has large concentrations of steel), the robots use ad hoc wireless communication to share data with one another and with high-powered computers located outside the rubble. The computers perform planning tasks and assist the mapants with compute-intensive tasks such as image recognition and visualization of the map as it is constructed.

Although early trials of this approach have been promising, it still is considered highly experimental. This is its first use in a real-world event. After an initial planning phase, the mapants are let loose. Each has its own mission but also is cognizant that this is a team effort. The thousands of mapants organize themselves according to the planned strategy, burrowing and climbing as needed. They possess sufficient autonomy to handle unexpected situations. Once a mapant has reached a designated region, it explores that region and reports on what it senses. The input from these mapants is combined to produce a 3D map showing (with centimeter accuracy) the location of potential survivors, fires, dangerous gases, and other critical information. Human experts monitor the mapants' progress, review early maps, direct the robots to areas of interest, evaluate dangers, and select strategies for mapping refinements. As they finish mapping the

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Published by the IEEE CS and IEEE ComSoc ■ 1536-1268/04/$20.00 © 2004 IEEE

rubble's top layers, the mapants move deeper, and excavation of the just-mapped region begins. Within 48 hours, many survivors are rescued who might have perished were it not for the mapants' assistance.

In presenting this scenario, the authors fully recognize it is currently science fiction. At the same time, they observe that the rudiments of many necessary component technologies for the scenario are already available. They explain that the challenge will be to improve the technologies substantially and to integrate them to attain the desired levels of accuracy, speed, and usability. Examples of specific technical challenges include

- Engineering small, energy-efficient autonomous mobile robots
- Planning and coordinating robot diffusion
- Enabling high-precision location sensing without a supporting infrastructure
- Deploying wireless communication through steel-filled rubble
- Performing real-time analysis and integration of distributed sensor data
- Conducting real-time map construction and refinement
- Designing map-based user interfaces for coordination and control

IN THIS ISSUE

Fortunately, pervasive computing work for less ambitious scenarios is under way that may soon bear fruit. We present three such efforts in this issue.

The first article, "Sensor Networks for Emergency Response: Challenges and Opportunities," describes a sensor network architecture that can be used for patient triage, where medical personnel must make quick decisions on which patients most urgently need medical attention. The next article, "Robot and Sensor Networks for First Responders," describes a pervasive sensing capability for firefighters, and the final article, "Computers in Police Cruisers," reports on deploying a speech-based integrated computing system in police vehicles. Although the use of pervasive computing technologies in first response is still in its infancy, we are likely to see substantial growth in this area in the coming decade—the opportunities are many and the rewards high. P

REFERENCES

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2. C.A. Patterson, R.R. Muntz, and C.M. Pancake, "Challenges in Location-Aware Computing," *IEEE Pervasive Computing*, vol. 2, no. 2, 2003, pp. 80–89.