Intelligent Infrastructure Futures

Tagging, sensors and data collection

We are increasingly surrounded by computing devices that are changing the way we live our lives. In future, devices will be embedded in everyday objects and connected to the Internet over wireless networks. The impact of this 'pervasive computing' on an intelligent infrastructure system could be at least as great as the mobile phone and the Internet.

Pervasive computing is already beginning to penetrate the transport sector, through the use of radio frequency identification (RFID) tags to monitor the transit of goods along the supply chain and through ever more sophisticated in-vehicle systems for command, control and communications.

RFID replaces bar codes as a way of tracking goods. A typical RFID system consists of a host computer, a reader and a number of tags or transponders. The electronic reader interrogates the tags by sending out a radio signal then collecting and storing data returned by the tags.

RFID tags offer advantages over barcodes – tags can hold more data that can be read at greater distances and several tags can be read at the same time. Some tags can even monitor their environment – for example, the Container Security Initiative of the US Customs Service which is intended to help to increase security for containerized cargo shipped to the United States.

Privacy issues

Privacy issues have already affected the use of RFID, with Benetton withdrawing its systems after consumer protests. While individuals worry about the privacy implications of tagging, businesses that use them are concerned about information security.

RFID tags are the forerunners of a succession of ever smaller and more capable wireless sensor devices, collectively known as motes, or smartdust. The ultimate aim is to implement a mote that fits into a volume of one cubic millimetre.

Sensor devices will autonomously form networks to achieve common goals while tolerating individual failures and changing patterns of ad-hoc communication. They will forward each other's information and act as bridges to the roadside infrastructure. Each device will contain a microprocessor, a two-way radio link and sensors to measure, for example, light levels, temperature, pollution or a vehicle's movement.

Tagging and sensors are part of a wider environment which includes mobile telephony. However, even new 3G networks will never provide sufficient bandwidth to support truly pervasive computing due to the high cost of infrastructure and the limited capabilities of embedded devices.

The always-on model of 3G networks will be extended through the incorporation of 'WiFi' to provide 4G networks with a national reach. Any future IIS will probably use 4G networks to connect to a deployed infrastructure and the Internet.

A further link in the technology chain of pervasive computing could be the Mobile Ad-hoc NETwork (MANET), a collection of mobile computing devices co-operating to form a dynamic network with no fixed infrastructure. In MANETs, devices can access the Internet even where there is no direct wireless connection between the device and an Internet access point. In a MANET, computing nodes themselves become an integral part of the communications infrastructure, forwarding each other's data and bypassing traditional network operators.

Networks are of limited value with nothing to communicate. Sensors are the "eyes, ears, noses and taste buds" of pervasive computing. Large pervasive networks of simple sensor devices will gather and communicate information about their environment.

One technology attracting increasing attention is that of biosensors. Researchers are investigating the use of biosensors in medicine, to monitor air quality and analyse emissions, and to detect chemical and biological agents.

The way ahead

Processing data from networks of large numbers of autonomous connected devices poses new technical problems. Traditional techniques work well enough for tens, or even hundreds, of connected devices, but will not work when numbers reach many thousands. The key challenge is to devise systems that deal not with individual sensors but that can abstract the desired information about the environment from a distributed network of sensors.

This Research Brief is based on the Research Review written by Dr Alan Tully for the Foresight Project on Intelligent Infrastructure Systems. Series editors Professors Phil Blythe, Glenn Lyons, Will Stewart and John Urry. Editor Michael Kenward.

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