

Airport of the future: tracking people and packages

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A passenger-sensing, self-organising unified network to track the location of every passenger and bag in the terminal will feature in future airports.

It's not much fun sitting in an airport waiting for a plane. But might it be less of a chore if you could download your in-flight films in the departure lounge? Might you even pay for the service? If you find that airport bars usually serve the best antidotes to tedium, would you be glad to know that a nearby display can detect your presence, prompt you when your gate number changes and provide clear directions to it at drinking-up-and-boarding time?

Welcome, then, to the airport of the future, brought to you by a passenger-sensing, self-organising network. It's being developed by scientists from the University of Cambridge, University College London, and the University of Leeds. The idea is to tidy up the tangle of wired and wireless networks used in most modern airports by installing a single infrastructure that can handle GSM, 3G, Wi-Fi and RFID communications, as well as locating every person and piece of baggage in the building.

Over the past three years, the researchers have devised a simple but elegant scheme based on a tree-like structure of low-cost, multimode fibre-optic cables threaded through the airport walls and connected to multiple wideband radio-over-fibre antennas dotted around the airport buildings. Because the antennas can receive and transmit frequencies from VHF radio to WiMax, many types of radio-based communication service can be piped around the buildings on the fibre at once. All the signals are concentrated at one of two computer rooms (duplicated for security) that house all the servers and networking equipment, including cellular phone basestations, Wi-Fi access points and RFID readers. Airport-wide services can be upgraded just by changing the central hardware.

TINA - The intelligent networked airport

This ambitious EPSRC-funded project is known as The Intelligent Networked Airport (TINA), and its industrial partners include Arup, BAA, Boeing, Laing O'Rourke, Motorola, Red-M, Tyco and Zinwave. These partners provide feedback about what it will take for the technologies to be successful in the real world - their main interest being asset tracking and security.

"For instance, can we solve problems like bags being in one place but the passenger not showing up, or a passenger being on an airplane and not knowing where their bags are?" asks Jon Crowcroft, Marconi professor of communications systems at the Cambridge University Computer Laboratory.

Organising a building's network infrastructure in this way could also create opportunities for airport operators to generate money.

"In an airport environment, where in-building communications systems [such as Wi-Fi] are often used to generate revenue for the airport operator, the adoption of such a technology could lead to some interesting innovation with regard to the commercial models under which airports operate," says Justin Trevan, a consultant at the communications division of Arup - an engineering consultancy well known for its work on airports, including Heathrow's Terminal 5 and Dubai International Airport.

RFID tracking

To track people and assets, researchers are looking at both active and passive RFID tags, locating the active tags by comparing the different time delays of the transmitted signals as they arrive at neighbouring antenna units, which are typically positioned tens of metres apart.

"If we have three antenna cells, we have two pairs of time delays and that is sufficient to locate a tag in two dimensions. For a three-dimensional location, we need at least four cells but in most cases, people aren't bothered about height," says Paul Brennan, UCL's professor of microwave electronics, who is working on the active tags.

Brennan's latest measurements of a 2.4GHz prototype tag with 1mW output show a location accuracy of 1m with a resolution of around 4m. The resolution might seem limited but in a cell with a radius of 10 to 20m, it's possible to uniquely identify and locate

2,000 tags even though some of the responses would overlap, he claims.

Being battery-powered and expensive, active RFID tags would only be suitable where they could be re-used and recharged, such as when issued to members of staff or applied to airport vehicles. In contrast, passive RFID tags could be printed cheaply on disposable paper boarding cards or luggage labels, given to every passenger and attached to each of their bags. In Hong Kong airport, luggage is already labelled with bar-coded passive RFID tags that are read (by conventional short-range means) with two antennas placed either side of the luggage conveyor belt.

Zinwave application

A 'long-range' passive RFID sensing scheme is novel and technically difficult. Passive tags send a signal when they receive enough power from an antenna, and can then be located using received signal strength indicator (RSSI) algorithms. But, owing to the complex multi-path environment of a busy airport, fading and nulls mean that the signal strength is likely to bear only a weak relation to distance.

However, Sithamparanathan Sabesan, Michael Crisp, Richard Penty and Ian White at the University of Cambridge's department of engineering, have found a way to reduce the fading and improve the accuracy of RSSI techniques, using an optimised Zinwave radio-over-fibre hub with multiple antennas.

They've demonstrated the error-free identification of a passive tag over a 20m × 6m area with three transmitting antennas fed by the optimised hub. The RFID tag was an Atmel device that returns a back-scattered signal with a 120KHz offset in response to a carrier frequency of between 860MHz and 960MHz, using phase-shift keyed modulation to send data at rates of 60kbit/s.

"The first challenge was getting the range up to 20m. The second, which we're still working on, is the resolution at that range. We've got the location accuracy down to around 2m, but we'd like to do better," said Professor White, head of photonics research in the electrical division of the department of engineering at Cambridge.

Andy Bell, chief technology officer at Zinwave, is intrigued by this use of the Zinwave equipment.

"Passive RFID needs a large share of the available power in order to get tags to respond," he says. "Because our system shares the power across a number of services, if one of the applications is using more power, there is less for everybody else. But the Cambridge team has come up with some quite cute techniques to improve the efficiency of the position location by overdriving our system without distorting the normal signals."

"The passive RFID operates in a very narrow band and so you can get away with quite poor distortion characteristics. This means you can overdrive it, as long as you limit its effect on the other signals that need to be carried."

Tracking every single passenger anywhere in the building all the time may not be feasible with passive RFID tags. But the technology could indicate if a passenger has moved from one space to another, maybe from a lounge to a bar, which is enough to target a message to a nearby display, page them, or send someone to find them.

"People in airports move around a lot so it's a bit like satellite navigation in your car. Even if you lose the signal going under a bridge or past tall buildings, it picks it up again later and that's good enough most of the time," said Crowcroft.

Network architecture specifications

The basic TINA network architecture is being designed to support a terminal with typically 1,000 fixed and 500 mobile video cameras (demanding 10Gbit/s of bandwidth); 500 displays (10Gbit/s); 500 biometric scanners (10Gbit/s); private and public fixed and wireless LAN (20Gbit/s); cellular services (10Gbit/s); TETRA and private radio (500Mbit/s); as well as passive RFID (300Gbit/s) and active RFID (5Gbit/s). These figures, which include projections for future demand, are based on input from BAA and other companies involved with the network installations in Heathrow Terminals 4 and 5.

All the elements of the network architecture are being simulated using a software model based on Heathrow Terminal 4, developed by Professor Jaafar Elmirghani, chair in communication networks and systems, and his team at the University of Leeds. The software tool can model and simulate passenger flow, radio propagation delays, optimum antenna position, and bandwidth requirements to give a top-down picture of how the network might perform under various circumstances. In this way, designers can better understand how the flow of people in indoor spaces, traffic demands and energy consumption constraints might influence different architectures.

Dividing the total bandwidth budget up into chunks by bringing traffic back over separate fibres from each lounge, gate or bar should help manage the overall demand. But one of the key observations in the research so far has been the high ratio of peak to average data rate that occurs when groups of passengers descend on certain areas and make intensive use of laptops and phones.

"Part of the problem is the 'flash crowds' effect, and part of it is the future scenarios we are modelling where people are accessing video, perhaps because airlines are making on-board entertainment available to passengers waiting in the lounges. We found the data rate could increase up to several 100Mbit/s per basestation, whereas a current Wi-Fi base--station is only about 50Mbit/s," says Elmirghani.

To accommodate these waves of passenger activity, Elmirghani and his team have come up with a neat load-sharing scheme using repeaters or relay nodes.

"The repeaters trigger when a basestation starts to reach its maximum capability and they divert some of the communications to basestations attached to empty neighbouring cells, as a way of balancing the network load throughout the airport," he says.

From a mobile phone operator's point of view, it would also be useful to balance the load across different air interfaces to ensure that Wi-Fi isn't clogged with traffic, say, at the same time as a 3.5G connection sits idle. So part of the project involves building these self-organising elements into handsets and basestations and simulating the results, adding further features such as user preferences in terms of battery life versus achievable data rate, or cost per bit versus performance.

Ethernet extension: moose protocol

A network of this kind needs to work independent of the protocols being sent over it, as well as being able to handle a vast number of devices. While Ethernet is a good base, it's not very scalable because it makes heavy use of broadcast techniques when handling packets sent to unknown addresses. On large networks, this broadcast traffic may even exceed the capacity of individual edge links.

In addition, Ethernet switch technology is currently unable to manage the number of addresses involved.

One innovation in this project is an extension to Ethernet, developed by Jon Crowcroft and Malcolm Scott of Cambridge University's Computer Laboratory, which enables Ethernet switches to handle many more addresses. MOOSE (for Multi-level Origin-Organised Scalable Ethernet) is a modified switch that performs in-place rewriting of the source MAC address in Ethernet frames entering the network. The replacement MAC address is hierarchical, which means switches are no longer required to maintain an address database for the entire network. This also makes it easier to implement shortest-path routing.

Arup's Trevan has been particularly impressed by the MOOSE protocol, being a network designer himself.

"Potentially it provides a whole new way of approaching network design. It might even turn out to be the biggest result of the project, even though it was developed as an enabler," he notes.

The TINA researchers successfully demonstrated the different elements of the system in the lab at the end of last year. The project ends in around six months, when a planned larger-scale demonstration will integrate the various hardware elements into a converged "departure gate of the future", as well involving some applications (see below). The next step would be to try the technology out on a larger test site, maybe at small airport terminal with a few gates.

Further information:

<http://intelligentairport.org.uk/>

www.technovelgy.com/ct/Technology-Article.asp

www.rfidjournal.com/article/view/275/1/1

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In-Building Wireless in Healthcare

Provision of enhanced in-building wireless services to increase efficiency and reduce costs

The Challenge

With the increasingly ageing, growing global population set to push medical resources to the limit over the next two decades, there is intensifying pressure on the healthcare industry to look at new and dynamic ways to boost efficiency. Many leading healthcare providers are now embracing wireless technology and in-building wireless coverage as part of the solution to improving efficiency and communication.

Wireless services may include:

Wireless Medical Technology Services (WMTS)

Wireless medical technology has made huge strides in the last few years and continues to gain pace. As well as providing increased comfort and mobility to patients, wireless medical telemetry devices allow healthcare organisations to manage resources more effectively and ultimately improve medical efficiency and practices. These medical services include:

- Ambulatory vital signs monitoring
- Wireless cardiogram sensors
- Radio Frequency Identification technology (RFID) with real time presence
- Internet Protocol (IP) over WLAN-based communications systems

Commercial cellular communications

The emergence of pioneering, new mobile applications has dramatically increased the mobility and expectations of healthcare professionals, patients and their families for ubiquitous coverage wherever they may be on the healthcare campus.

Public Safety Communications

Healthcare providers have the need and very often the regulatory requirement, to improve the provision of wireless services in their facilities. This is most apparent in the area of public safety. In recent years, ensuring the safety of emergency service personnel entering a building in their day to day work and in emergency or disaster situations has become critical. These services are required throughout the facility, not just in A&E or the main entry points.

The Benefits of Enhanced Wireless Coverage

Improved wireless coverage across the healthcare facility brings many advantages in patient care and efficiency:

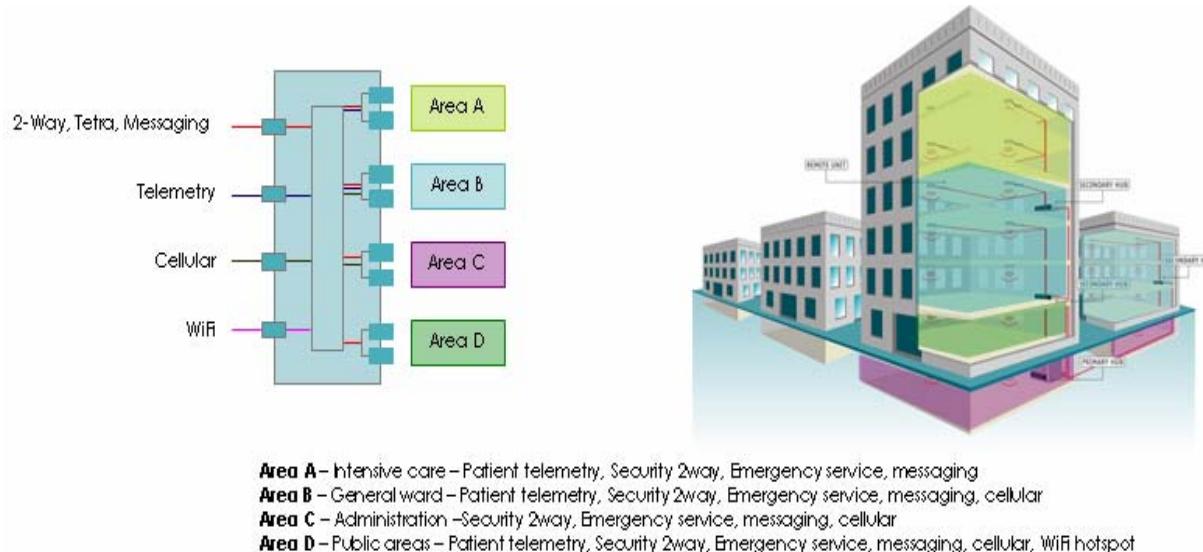
- A wire free patient bedside with continuous patient monitoring and mobility
- Improved crash response times
- Improved communication between Doctors, nursing and administration staff as well as patients and their families
- Cellphones operate on reduced power and minimise any interference "The selection of a proper maximum power class reduces significantly the risk of (EMI) Electro Magnetic Interference" (Source: **Electromagnetic Interference To Infusion Pumps From GSM Mobile Phones** Calcagnini,G.; Bartolini,P.; Floris,M.; Triventi,M.; Cianfanelli,P; Scavino,G.; Proietti,L.; Barbaro,V. Engineering in Medicine and Biology Society, 2004. IEMBS apes;04. 26th Annual International Conference of the IEEE; © 2004 IEEE.)
- Police, fire, and paramedic wireless service available throughout the hospital
- No paging and messaging blackspots
- Secure environment through ubiquitous public safety coverage
- WMTS provision for all wireless technology services
- Reduction of operational costs through optimisation of your IT expenditure
- Selective streaming of services to certain areas within the building or campus

How can you, as a healthcare provider, effectively integrate your specialist wireless needs with coverage for commercial and public safety wireless?

The Solution

The healthcare campus brings its own unique set of challenges for the provision of reliable wireless coverage. Different materials such as steel and tinted glass, cause in-building penetration of RF signals to weaken resulting in reduced data rates and even complete loss of signal. Without comprehensive, reliable and unified coverage, the healthcare facility is at risk from poor signal, and black spots which could lead to dangerous lapses in patient monitoring and communication systems.

Zinwave's unique 3000 Wideband Active Distributed Antenna System (DAS) removes many of the traditional issues and considerations associated with delivering multiple RF services in buildings. In addition, services can easily be routed to the areas of the building where they are required.



Some of the key benefits are detailed below:

Wideband Supports any services and technology between 136MHz to 2700MHz

Solution design Self-calibrate and auto-configure features simplify design and deployment

Low component count Just four components supports any mix of services

Lowest cost per square meter The single hardware platform ensures significant savings over traditional solutions

Summary...

There are many exciting advances in wireless medical technology and emerging mobile applications that could significantly increase efficiency in healthcare without the need for sacrificing patient care or heavy financial outlay. However, in order to take advantage of these groundbreaking new developments, it is essential that there is ubiquitous, reliable in-building wireless coverage in place. Zinwave, as a member of American Hospitals Association (AHA), is committed to providing active DAS coverage to healthcare facilities and working in partnership with the healthcare provider to help maximize efficiency and communications in the healthcare sector.