INTERCAI
MONDIALE

Bluetooth as a 3G Enabler

The next generation of cellular telephony provided by the evolution of existing digital systems (GPRS, EDGE and HSCSD) or through the development of new ones (UMTS / IMT 2000) will offer the user greater flexibility and capability than ever before. This paper describes how Bluetooth, a new short range communications device, will open up a host of new applications that will extend the role of the mobile phone far beyond today's conventional phone service. In fact, it may be true to say that the commercial viability of the new developments is only likely to be realised if Bluetooth is successful in delivering the applications that will create the anticipated "datawave".

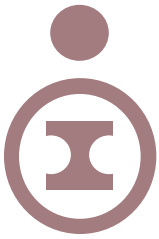
What is Bluetooth?

Bluetooth is a de-facto open standard for short range digital radio. It is designed to operate in the unlicensed ISM (Industrial, Scientific, Medical applications) band which is generally available in most parts of the world (see table below). The specification includes air interface protocols to allow several Bluetooth applications to intercommunicate simultaneously, and to overcome external sources of interference such as domestic and commercial microwave ovens. The short range referred to above is defined as up to 10m in normal operation although greater range/penetration can be achieved through higher output powers under some circumstances.

The aim of the promoters of Bluetooth is to enable the intercommunication of just about any piece of apparatus with any other (where this is appropriate of course!) and consequently one of the main constraints on the design must be cost. When the Infra Red Interface, common on mobile phones and PCs today, was conceived it was appreciated that to persuade equipment manufacturers to implement this interface, the cost of implementation had to be low. The target cost, set at $5, was achieved and more than 90% of portable PCs and an increasing number of mobile phones now have an IR interface built-in.

A sophisticated radio interface is more complicated (and more flexible) than the IR interface and therefore more expensive. The price target of $10 per unit however seems to be realistic especially if all our homes will eventually have half a dozen or so Bluetooth equipped items operating in them, driving quantities to very high numbers.

AREA	FREQUENCY BAND (GHz)	BLUETOOTH CHANNELS
USA, Europe and most other countries	2.400 – 2.4835	79
Spain	2.445 – 2.475	23
France	2.4465 – 2.4835	23



In addition to cost, size matters. With ever-decreasing form factors and weight, any new addition to a piece of electronic apparatus must be small, light and consume minimum power from the host system or separate battery. The Bluetooth implementation is feasible in a very small footprint comprising a single chip and associated RF components, and should be relatively easy to install in anticipated applications. Its low output power and sophisticated power conservation design, ensures minimum power consumption.

Bluetooth has the potential for impacting many areas, including applications that would have been inconceivable a few years ago e.g. a fridge-freezer telling a microwave oven what ingredients are available, allowing the microwave to suggest menu options! However, one particular area where Bluetooth will have a significant impact is in the support of other wireless delivery mechanisms such as cellular telephony. While national networks are suited to delivering communication on the move or wireless to any location, purely local interconnection is better handled by a local communication system.

To deliver telephony based services from one undefined location to another, and to distribute the services and functions at those locations, requires a hybrid solution, at the core of which is a cellular handset with an in-built Bluetooth transceiver.

The Next Generation

Cellular telephones today are just that; telephones, primarily intended for speech and not particularly good at delivering data. Enhancements to existing 2nd generation systems (so called 2.5G), will allow data to be carried much more easily and at higher rates (typically between 28.8kbps and 64kbps, though higher rates are possible), and where required, as packets rather than circuit switched. The next generation of cellular telephony (3G) known globally as IMT 2000 and in Europe as UMTS (Universal Mobile Telephone System), has been *designed* to carry packet data, and speech is simply treated as a particular data application. 3G systems will give the end user flexibility in the traffic channel, delivering multiple services with differing bandwidth requirements, simultaneously if needed. Data rates of up to several hundred kbps will be readily available to the terminal (being able to do so much, the end user device is no longer just a mobile phone, and will be referred to as a terminal for the remainder of this paper). It is expected that the 2.5G developments will be available in the short term, certainly within the same period that Bluetooth will make its debut. This paper will show how Bluetooth will support enhanced 2nd generation as well as 3G systems in the delivery of a wide range of services.

With such broad capabilities, it will be tempting to use the 2.5 and 3G systems to support every new application (and many old ones too). Vending machines calling for supplies, cars sending service requirements to the garage, cordless phones, communicating with personal data assistants (PDAs), wireless LANS (Local Area Networks) etc.; all these applications could be supported directly by 2.5/3G. Each of the above devices would need to be equipped with an expensive transceiver, and base stations would have to have sufficient capacity to carry the traffic with an appropriate blocking level. However some of the traffic will be purely local; LANs, PDAs and groups of vending machines, only require intermittent communication beyond the local area. Domestic machines such as televisions, VCRs, PCs and even kitchen machines could usefully inter-communicate, with little or no requirement to access the world beyond the home.

Bluetooth, through its flexibility and ultimately low cost, can provide all the local interconnection, plus a gateway to the national networks when this is required. While there are other solutions already available that could conceivably provide similar local service support, they are less flexible, have specific shortcomings or are more expensive than a Bluetooth solution. See table overleaf:

Cordless phone systems need contact with national networks and 3G systems can offer a combined national/cordless service. However additional handsets (or headsets) are also used to provide intercom functionality, and while a national network could directly offer support for this, it would be inefficient and uneconomic to provide the capability for two people in close proximity, to communicate this way.

TECHNOLOGY	MAX BANDWIDTH	COMMENTS
Bluetooth	1Mbps (gross rate)	Packet oriented for data applications, max full duplex data rate is 432kbps, arranged as 64 kbps channels for speech
DECT	144Kbps	Primarily designed as voice service, not packet, expensive (typically $100 for a handset and home base station)
IR	4Mbps	Very cheap (now around $1 to $2 per installation, low range (~1m) and line of sight only

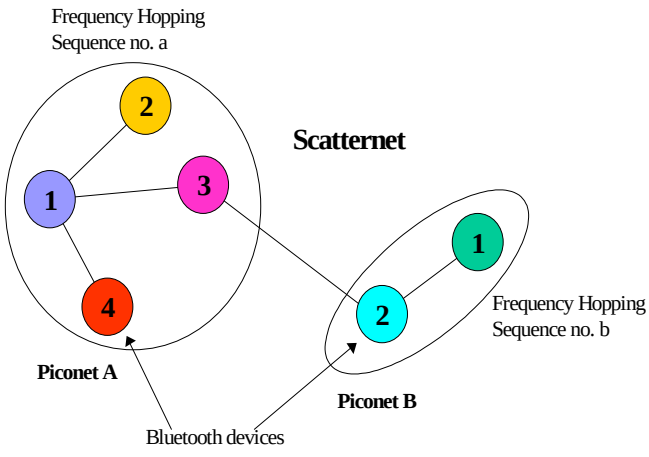
This last example brings us to the real issue of whether advanced systems should be expected to support every new service directly. RF spectrum is a limited resource, with increasing demands being placed upon it. It must be deployed efficiently and used in appropriate ways to ensure maximum use from each MHz. To do this in a wide area scenario, 3G utilises expensive technology and the base stations and terminals themselves are consequently expensive ($100s for the terminals $10,000s for the base stations). A home intercom system or even a wireless LAN system cannot justify this kind of infrastructure expenditure.

Bluetooth can provide interconnection for local devices

Bluetooth is able to simultaneously interconnect up to 8 transceivers in a "piconet" over a short range. Each Bluetooth transceiver costs the same (~$10) and there is no requirement for any infrastructure (see diagram). The simultaneous connectivity limit of 8 devices may seem to be a serious constraint, however several piconets can operate in close proximity and Bluetooth devices can rapidly move from one piconet to another. In fact Bluetooth devices need only remain a member of a piconet for the period of time required to complete a communication transaction. So devices can join and leave a local piconet frequently, effectively overcoming the 8-device constraint.

In the diagram, there are two interconnected piconets forming a scatternet. They are able to operate within the vicinity of each other because they are using different hopping sequences, reducing mutual interference to an acceptable level. In this way it is possible to have several small groups of Bluetooth devices communicating with each other in the same area, particularly useful at a conference for example where individuals may be comparing notes while the main discussion points are being broadcast to all.

Devices communicating using Bluetooth can transmit and receive up to 1Mbps, though in reality to allow multiple applications to simultaneously communicate, data rates will be somewhat lower than this. Bluetooth devices that are not currently part of a piconet, are constantly "listening" for other Bluetooth devices, and when they are close enough to become part of a piconet, they identify themselves so that other devices can communicate with them if required. An example would be a Bluetooth equipped printer and notebook PC. When the PC comes into range of the printer (arriving at the office for example), the printer makes itself known to the PC so that if and when the user wishes to print a document, the two devices can immediately begin the data transfer. Meanwhile other PCs will have joined the piconet so that they too can use the printer when required.

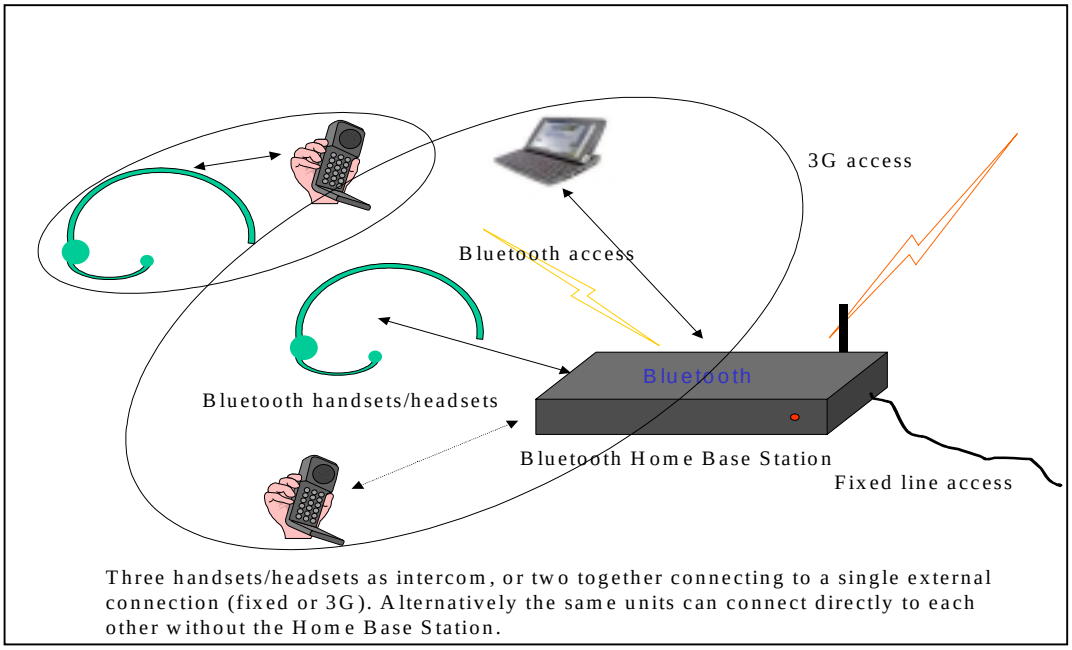


Support for the "Multi-Media" terminal

3G terminals will provide access to many different forms of information and communication such as web browsing, e-mail transmission and reception, video (slow scan for video phone type connections, and higher quality for short video clips and still pictures) and of course voice, making them true multi-media terminals. Voice will remain a major form of communication for humans and this is recognised in the Bluetooth specifications by providing specific support for high quality (64Kbps) speech channels. With the ability to support packet data as well as speech (and at the same time if required), Bluetooth can provide full local support for these multi-media applications.

Bluetooth transceivers can support multiple data connections and up to three voice connections simultaneously providing the functionality for a three handset cordless multi-media/intercom system. The diagram above shows three terminals in voice intercom mode (one of which is a full multi-media terminal) and the alternative of two terminals in a conference speech connection with an outside connection. The limit of three interconnected terminals applies specifically to speech, the limit for the number of terminals exchanging data (web connections, e-mail and video depending upon bit rate requirements) would be the upper limit of 8 per piconet.

A Bluetooth enabled Home Base Station would provide the interconnection for the local Bluetooth equipped terminals and also for telephone "line" (may be a 3G terminal) connection. When an external connection is required only two local handsets can participate in voice connections. The Home Base Station forms a gateway between the home environment and national networks and services. Any two handsets can connect to each other of course without the Home Base Station unit, making the whole arrangement very flexible.



Three handsets/headsets as intercom, or two together connecting to a single external connection (fixed or 3G). Alternatively the same units can connect directly to each other without the Home Base Station.

This example highlights the complementary functionality of Bluetooth and 3G cellular systems. The 3G system is used to deliver a "trunk" connection to a specific location and Bluetooth is used as final delivery and local network connection. This will considerably reduce the "unnecessary" traffic on the 3G network, creating a cost-effective solution for the convergence of fixed and mobile services and as a by-product, keep RF interference, to a minimum.

Possible 3G Support Applications

The following examples demonstrate how 3G and Bluetooth could work together, providing local intercommunication as well as wide area connectivity in a wide range of applications. These are not definitive and by no means exhaustive, but aim to show how complementary standards can work together to provide a greater level of service than either could achieve separately.

The Home Network

In a typical family home there are various forms of entertainment (television/VCR, Hi-Fi etc), several different sources of topical information (papers, magazines television guides) and functional items particularly in the kitchen (oven, microwave, fridge/freezer central heating). While these groups of items are today in no way associated with each other, with Bluetooth equipped devices a loose association can be imagined, and the control and access of these items can be centred on the user wherever he is.

Imagine a simple data pad (we'll call it the βpad, short for btpad or Bluetooth pad) with the form factor of a paper back book only a few millimetres thick. It has limited functionality of its own and consequently requires little memory, but it has a Bluetooth transceiver and a touch screen display. It is light, slim and with an advanced icon driven menu, easy to use.

The proliferation of Infra Red (IR) remote controls will be a thing of the past. The βpad will not only control all the entertainment devices, but will be able to control new ones, as yet unbought, too.

The βpad can also connect to the PC, physically located elsewhere (still in the briefcase perhaps). With this connection the βpad becomes a remote terminal and via the 3G terminal the PC connects to the internet for latest news, views, interviews with the stars and television programming information. Using the on-line TV guide, dragging the programme of choice onto the TV or VCR icon will select the programme or record it.

Bluetooth equipped kitchen equipment will permit remote control of, say, the central heating or perhaps turning the oven on (and selecting the temperature of course). This would be more useful if it can also be done remotely from the house. The βpad would detect that it was not close to any of the usual household items, and look instead for the 3G terminal. Through this it would call a 3G/Bluetooth gateway at home (the Home Base Station mentioned earlier), and regain access to all the household appliances:

- The fridge can be interrogated, and its contents revealed, from the shops, or while compiling the on-line shopping list
- The house temperature will be controlled to personal preference before arriving home
- The Utility Operative can be monitored via security cameras and his identity card checked, while the door is unlocked permitting him to read the meters
- And despite getting home late, that favourite TV programme is not missed, but recorded

Bluetooth and 3G together will enable people to be more fully in control of their lives, wherever they are.

Vending machines in shopping mall

All the automatic vending machines within a confined area can, through a Bluetooth access system, be connected to a central vending machine administration unit, that in turn uses a 3G access system to call for maintenance or supplies. Minor problems can be relayed to the Mall technician directly through his Bluetooth communicator. Pricing changes can be sent from central administration and locally "broadcast" to all Bluetooth vending machines.

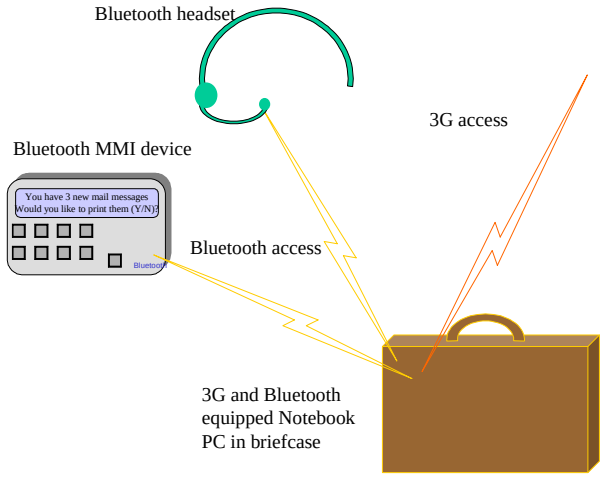
E-mail delivery to the PC

3G terminals will be able to handle several channels simultaneously (e.g. voice, fax and data each requiring different channel characteristics and speeds). With predictions of terminal penetration being very high (every member of the population above the age of 12 in a few years), the PC itself does not have to be a 3G terminal in order to receive e-mails on the move. A Bluetooth/3G terminal can receive e-mail as a data transmission and forward it, via Bluetooth to the PC (assuming it is within close proximity). When the reception is complete, the PC can notify the user via Bluetooth and a short message to his mobile terminal that he has e-mail, and if an item is urgent, this fact can be forwarded too. This concept allows the 3G terminal to be the local "headend" for a variety of applications that are locally interconnected via Bluetooth. If for example, such an e-mail was received while waiting for a train or plane, the user could approach a Bluetooth services booth (example new commercial enterprise for business travellers). Here, for a fee chargeable to his charge/credit card or e-Wallet, he can instruct his PC to print the e-mails of interest (using his 3G/Bluetooth terminal to control it, leaving the PC in the briefcase).

The e-Wallet

Many people believe that the mobile phone can become the portal of first choice to the e-commerce world. At present however a separate Smart Card is required to hold electronic cash -

no-one wants to remove their SIM from the phone in order have it read by a Point of Sale terminal. Bluetooth of course will allow the SIM (which now becomes a multi-function Smart Card) to be read while it remains in the phone. With 100 Kbyte Smart Cards on the horizon we can foresee our mobile phones becoming the main repository for our cash, health info, personal preferences, season tickets, etc. etc. The wide area cellular world will be one of the main routes for updating it.



The Underground Train

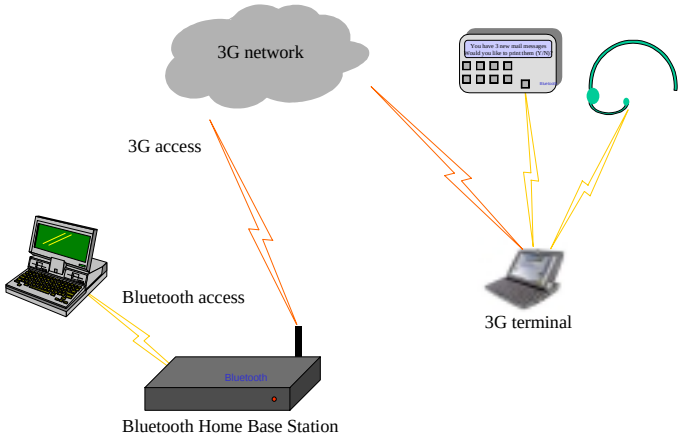
Underground facilities suffer from "poor" coverage on cellular systems. Many underground rail operators are overcoming this by installing systems designed to provide driver and station staff with a reliable communication network. Systems such as TETRA (TErrestrial Trunked RAdio) provide sufficient capacity that there is spare to carry some passenger traffic too. Carriages equipped with Bluetooth transceivers would provide a gateway between the train TETRA system and the user's 3G/Bluetooth terminal, and the TETRA system would provide the gateway to the surface public networks. For the convenience of other passengers, not all carriages would be enabled for support of voice over Bluetooth (though the use of Bluetooth for broadcasting timetable information, advertising etc. could be available in all carriages).

The Bluetooth Headset

The 3G/Bluetooth terminal mentioned in the above example does not in fact need to be in the user's hand or pocket during most of the noted transactions. The user will have a Bluetooth headset (a product already announced by Ericsson) allowing him to leave the terminal in his briefcase too. This may provide voice control/recognition functionality, removing most of the need for a keyboard or display on the 3G terminal.

These suggestions may raise the question as to where the terminal (3G) in fact should reside. Much of the functionality delivered by 3G systems will be directed towards a data terminal device such as a PC or palm top computer and it may be logical to build the 3G terminal into it. With an external (Bluetooth) headset, there would be nothing to hold, though a simple MMI (Man Machine Interface) device to allow dialling and displaying of short messages (connected to the main terminal by Bluetooth of course) may be required. If this could be made credit card sized it becomes a small version of the βpad discussed above and may well replace the handset/terminal as we know it.

Alternatively, as has been suggested previously in this paper, the PC and 3G terminal may be physically separate devices while being functionally connected when in close proximity to each other. This perhaps offers greater flexibility (it wouldn't be necessary to carry a PC everywhere simply to make and receive calls), while losing none of the functionality of the combined device. In some cases it may even be



possible to leave the PC at home connected to the Home Base Station (via Bluetooth), and retrieve data from it directly to the βpad using Bluetooth and 3G together.

In conclusion

Bluetooth is set to be a communication standard, which through its small size, considerable functionality and flexibility and very low cost, will find its way into many modern devices, offering control and information easily and simply. The new generation of cellular telephony systems while offering national coverage and mobility could never provide a cost effective interconnection of so many devices, but coupled with Bluetooth, localised groups of equipment can be interconnected wherever they are and wherever they're going. Bluetooth will thus extend the reach and scope of cellular systems well beyond today's horizons.

Chris Angell
Consultant with Intercai Mondiale

Intercai Mondiale Ltd
Regatta House
Marlow
Bucks. SL7 1AB
UK

Tel: +44 (0) 1628 478470
Fax: +44 (0) 1628 478472

e-mail: chris_angell@intercai.co.uk

http://www.intercai.co.uk/