Bluetooth
SIGnal
The official newsletter of the Bluetooth Special Interest Group

Issue no.5, April 2000

Bluetooth™

The best innovative technology

Following its Best of Show Award at Comdex Fall '99, the Bluetooth™ wireless technology picked up two further honors at the CeBIT exhibition in Hanover at the end of February. The Best Innovation Award 1999/2000 was presented to representatives of the Bluetooth SIG by the German PC magazine PC Professionell. Ericsson also received an award from CHIP magazine for being the foremost individual company in promoting the Bluetooth wireless technology.

Unplugged enthusiasm

Evidence that several Bluetooth products are in the pipeline was obvious from the second Unplug Party that took place at the end of March in Monterey, California, with more than 250 participants.

It is unfortunate that many journalists and other Bluetooth observers interpret the secrecy surrounding these events as a cloak for interoperability problems that may occur between different Bluetooth devices. This is just not the case. Without confidentiality, companies developing Bluetooth products would not attend Unplug Parties because they do not want their intellectual property disclosed at a sensitive stage of product development. Without Unplug parties, the same companies would be deprived of valuable opportunities for testing the interoperability of their various prototype Bluetooth products.

The Best Innovation Award 1999/2000.

Revised Brand Book

With many Bluetooth consumer products nearing the launching pad, it is timely that the revised Bluetooth Brand Book is now available for marketing personnel. It can be downloaded as a pdf file from the members' site at: *www.bluetooth.com.*

As the Brand Book forms part of the Bluetooth Specification v 1.0, it must also be complied with in order for companies to use the Bluetooth names and marks on products and in marketing material.

The award presented to Ericsson by CHIP magazine.

The lure of Monte Carlo

The biggest SIG-sponsored event just around the corner is Bluetooth Congress 2000 being held in Monte Carlo between June 14-16. This is the world's largest open Bluetooth event this year, with more than 1000 delegates expected to attend. Two parallel streams will cover technical, application and marketing advances, and participants are also offered a choice between two pre-congress seminars on June 13: *Qualification and Approvals for Bluetooth Products* or *The Bluetooth Masterclass* led by the Bluetooth SIG. Vendor products can be seen in the showcase.

We hope to see many of your there.

The editor

In this issue:

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WPANs: creating standards for Bluetooth-IEEE

Issue 2 of the Bluetooth SIGnal [1] introduced the cooperative effort now underway between the IEEE [2] 802.15 Working Group and the Bluetooth SIG to derive an IEEE standard based upon the Bluetooth Specification Version 1.0.

This cooperative effort has resulted from a convergence of IEEE standards development activities previously underway within the IEEE coupled with the formation of the Bluetooth SIG in 1998 and its subsequent phenomenal growth under the leadership of the Bluetooth SIG promoter companies.

The IEEE 802.15 Working Group for Wireless Personal Area Networks (WPANs) is authorized to provide, in the IEEE 802 family, standards for low-complexity, low-power consumption wireless connectivity. The goal of Task Group1 (TG1) is to have a draft IEEE standard this summer. Full ratification and publication will occur early next year.

Peer Review

The jointly crafted IEEE 802.15 standard will provide checks and balances to the Bluetooth specification. As a result, the IEEE peer review process will achieve a key benefit to the Bluetooth community. For example, the first IEEE draft standard letter ballot [3] generated 1013 comments against the IEEE derivative work. Many of these comments referred directly to the Bluetooth Specification and were forwarded immediately to the Bluetooth SIG for review and disposition.

Another of the key benefits to the community is that this standard will add the Bluetooth Specification to the IEEE 802 family of standards.

The IEEE 802 LAN/MAN Standards Committee develops wired and wireless standards. IEEE 802 standards deal with the Physical and Data Link layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1: 1994).

Currently, IEEE 802 standards define eight types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives (see Figure). The most popular of these standards is IEEE 802.3, the Ethernet standard.

The Bluetooth SIG standards-making effort is based within the Wireless PANs (802.15), which is chartered to provide standards for different Usage Models based on wireless technology. It is expected to be a major growth area for IEEE 802 standards.

IEEE Outlook

Since the formation of the 802.15 WG in March 1999, there have been three projects authorized. The first is TG1, which is the Bluetooth-IEEE standards-making effort. The second project authorized is designated Task Group 2 (TG2) and the third project authorized is designated Task Group 3 (TG3).

TG1 – Numerous meetings have been held over the past two years, "…however, significant progress towards the completion of the IEEE standard occurred during the February 25, 2000 face-2-face meeting between the Bluetooth-IEEE team in Copenhagen." said Tom Siep, IEEE P802.15.1 Editor-in-Chief. Again, the goal of TG1 is to publish an approved standard derived from the Bluetooth Specification early next year.

TG2 – This group will address the issue of coexistence between 802.15 and 802.11 wireless networks. The purpose of the TG2 is twofold. First, to develop a Coexistence Model quantifying the effect of the mutual interference of the two networks. Second, to develop a Recommended Practice to facilitate coexistence of 802.15 and 802.11 devices operating in a common environment. The target completion date for this project is March 2001.

TG3 – The latest addition to the IEEE 802.15 Working Group is the newly formed High-Rate Task Group, chartered to draft and publish a new standard for high-rate (20 Mbps or greater) WPANs. The new HR standard will provide for low-power, low-cost solutions addressing the needs of consumer digital imaging and multimedia applications. In addition, the new HR standard will provide compatibility with the TG1 specification. The process of reviewing responses to the formal Call for Applications and Proposals is expected to be completed in July 2000. The target completion date for this project is November 2001.

Mr. Ian Gifford, M/A-COM, Inc.
Mr. Bruce Kraemer, Intersil Corporation

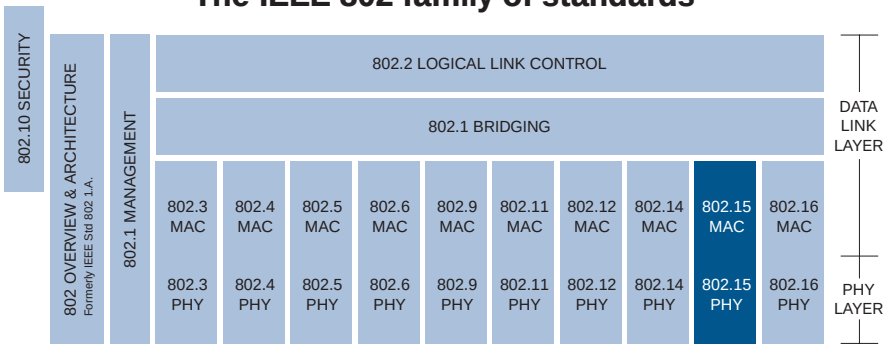
[1] Visit: *http://www.bluetooth.com*

[2] Visit: *http://www.ieee.org/about/whatis/*

[3] Ballots are a part of the standards process. Visit: *http://standards.ieee.org/resources/glance.html*

Visit: *http://grouper.ieee.org/groups/802/15/*

The IEEE 802 family of standards



The IEEE Wireless Personal Area Networks (WPANs) column will be a new feature in the Bluetooth SIGnal

The Bluetooth SIG and IEEE have decided to provide a recurring column on this joint standards-making effort to update the Bluetooth Adopters. These short columns will focus on the technical issues and progress of the standardization of the Bluetooth Technology.

Autonomy and robustness in Bluetooth radio IC design

As a specification for small form factor, low-cost, short-range radio links between mobile voice communications and computing devices, the Bluetooth wireless technology is anticipated to create a US $500 million chip market by 2004, according to market research firm Strategies Unlimited. Philsar Semiconductor defines the Bluetooth market according to Personal Wireless Connectivity (PWC) segments.

PWC is a wireless paradigm that allows for the network to be intuitively based on the end-user, providing an unparalleled degree of personal connectivity via wireless communications. Cellular handsets, accessories such as headsets, as well as notebook computers and personal digital assistants are just a few of the applications that the Bluetooth radio will integrate in piconets of PWC. The universal standard of connectivity that the Bluetooth wireless technology provides will drive the development and broad market acceptance of these and other PWC applications. Philsar believes that the key success factors of PWC are a high degree of user autonomy and robust performance.

Autonomy

Autonomy refers to the ability of a system to operate over an extended period of time without the need for servicing (recharging), as well as to the dual requirements of light weight and small size. For a Bluetooth radio, an extended period of operation implies a low current draw requirement from a battery, while the requirements for light weight and small size imply a high level of integration with very few external components.

The Philsar PH2401 addresses these issues with a highly integrated radio architecture that eliminates the use of high 1 dB compression point circuits such as the transmitter up-converter/filter. It also reduces the 1 dB compression point requirements for other circuits such as the image-reject down-converter, back-end filter stages, and ADCs. Further, the use of a low-power Silicon Germanium (SiGe) process results in a reduction in DC power consumption compared to other advertised solutions.

The elimination of the transmitter up-converter/filter is a consequence of the use of a delta-sigma fractional-N frequency synthesizer in place of a traditional modulator up-converter. By using two-point modulation with this synthesizer, 1 Mbps Gaussian FSK modulation is achieved with a 10 KHz loop bandwidth. This improves system performance by achieving superior phase-noise and spur levels.

The relaxed 1 dB compression point requirement for the receiver image-reject down-converter, back-end filter stages, and ADCs is a consequence of the use of complex filter/rapid AGC stages feeding a complex PLL demodulator. The complex filter stages possess a pass-band at the positive component of the center frequency of the IF, but strong attenuation at the negative component of the center frequency. This greatly relaxes the image-rejection requirement on the preceding down-converter. Further, since the filter stages are complex, the required number of cascaded filter stages is reduced by a factor of two. As a result, the back-end stages are not required to handle as high a level of signals as a receiver using twice as many stages of real filters.

Finally, the rapid AGC stages compensate for signal fluctuations resulting in a reduced dynamic range requirement for the ADCs, which also saves current.

The result of the various processes, circuit and architectural realizations is a five-fold reduction in DC power consumption compared to alternative solutions. This minimal DC power translates into a dramatic increase in operational time between battery recharges for the PH2401.

Robustness

Robustness refers to the ability of a system to operate in a non-ideal environment consisting of potentially many other signals (blockers) and experiencing deep fades.

Philsar's PH2401 addresses these issues with a highly flexible receiver architecture having interleaved filter and AGC stages, rapid AGC, excess gain availability, and gain-location management. The interleaved filters and AGC stages progressively attenuate adjacent-channel blockers while boosting the desired on-channel signal, without hitting the 1 dB compression point of any of the stages. The AGC allows operation through a rapidly fading channel, while the excess gain available allows operation within a fade. The gain-location management allows gain to be increased at the front-end stages to establish noise-figure when no blockers are present, or to be decreased to avoid compression when blockers are present.

The complex PLL demodulator allows the PH2401 receiver to operate robustly with remote transmitters that are operating off-frequency, or with an incorrect modulation index. In comparison, the PH2401 transmitter will never operate off-frequency or with an incorrect modulation frequency, since it is based on a delta-sigma fractional-N frequency synthesizer.

The result of the various architectural realizations is a Bluetooth transceiver that can operate in both a highly jammed and a rapidly fading environment. In particular, the PH2401 will operate reliably in the presence not of just one other blocker, but in the presence of many other simultaneous IMS emissions.

Conclusion

The promise of the Bluetooth wireless technology and PWC is going to be realized through the delivery of Real World

performance parameters that consumers have come to expect in existing point-to-point wireless communications. By their very nature, applications such as mobile handsets and headsets, as well as mobile computing, will require a high degree of user autonomy and robust performance. Central to the achievement of Bluetooth-based piconets is the delivery of both of these attributes at the silicon level. The Philsar Semiconductor PH2401 family provides a Bluetooth-specific architecture that provides ultralow power, thereby leading to a high level of user autonomy, as well as robust performance.

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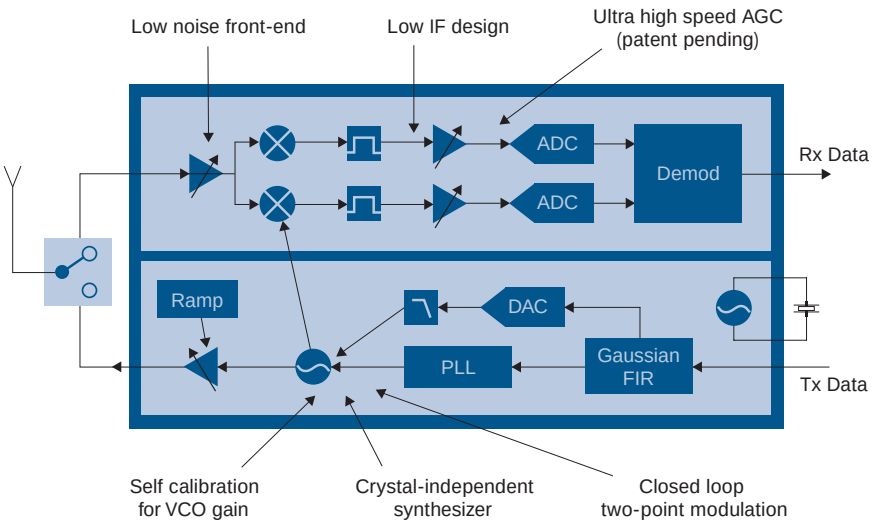

The Philsar PH2401 single-chip radio provides Bluetooth-specific architecture.

Qualification test equipment

A series of steps must be completed before test and measurement equipment manufacturers can develop the testing systems required for the qualification of Bluetooth products. First, an informal prose version of the test specifications is written in English based on the Bluetooth Core Specifications. This informal version is then translated into the formal test specification. The formal language is Tree and Tabular Combined Notation (TTCN) standardized for communication systems by the International Standards Organization (ISO).

At present, nine test and measurement companies – all Adopter companies – have access to the informal prose version. If they want to go further and develop test systems, they have to purchase the TTCN code from the Special Interest Group via Ericsson. The executable test suites then have to be developed by the test and measurement companies.

Key to the categories

Category	Test case level	Description
A	Validated and commercially available	This test case is fully validated and commercially available. The test case is mandatory and has to be performed at a recognized BQTF*
B	Declaration with evidence	The test case has to be performed and a declaration with evidence is required. The instructions given in the test specifications has to be followed. If the test case does not follow the instructions in the test spec, it has to specify how the test was carried out.
C	Declaration without evidence	
D	Informative	A prelimilary test case with no official qualification value. The purpose of this status is to inform any manufacturer about an upcoming test case.

* Bluetooth Qualification Test Facility

One company, Rohde & Schwarz of Munich, is now developing test equipment for use in the qualification process, and interim solutions have been received from them for qualifying the radio part of the core specifications. Ericsson Mobile Communication AB has such a RF test system, TS8960, installed in Lund, Sweden.

Compliance Testing

The Test Specifications together with the Test Case Reference List (TCRL) define the tests a product manufacturer has to successfully pass to qualify a product. The test specifications are divided into the following areas:

- Radio frequency qualification testing
- Protocol conformance testing
- Profile conformance testing
- Profile interoperability testing

The Qualification requirements will evolve based on the availability and maturity of test cases as well as the measurement equipment. The evolution and current level of requirements will be tracked through the TCRL.

Different Test Categories

A key to the tables contained in the TCRL is given on page 6, and a key to the different categories given in the tables is shown to the right. The 51-page TCRL can be downloaded as a pdf file from the member site at *www.bluetooth.com.* (After member login, click on "Documents" in the Short Cuts column, click on "Test Specification" at the next level, and then finally scroll down to the bottom of the page to access Test Case Reference List.)

For category A, Bluetooth products can only be tested on validated and commercially available qualification test equipment. For category B and C, Bluetooth products can be tested using standard test equipment. "Blue Units"[1] can only be used for category B and C until a conformance test system exists.

As regards part of the qualification of protocols, Blue Unit interoperability tests were available for these at the end of March 2000 at approved test facilities, which may be affiliated with a product manufacturer or be independent. Final qualification solutions for protocols and profiles are expected to be in the hands of approved test facilities during September 2000.

At the time of going to press, there were no commercially Bluetooth products on the market, only development kits or prototype products used for testing and demonstration purposes.

Apart from qualification test equipment, certain test and measurement companies are now developing one-box RF testers, sniffers, and protocol and profile analyzers, intended to be used in the R&D, production and field service of Bluetooth devices. As expectations of Bluetooth-certified products are so high and the financial commitment is so great, the qualification of Bluetooth devices must be strictly regulated and controlled to ensure full interoperability.

[1] Previously called Golden Units. See articles on the Bluetooth Qualification Program published in the first two issues of the Bluetooth SIGnal newsletter.

For further information on Rohde & Schwarz visit: *http//www.bluetooth.rsd.de/*

Test equipment developed by Rohde & Schwarz for use in qualifying the radio part of the Bluetooth Core Specifications.

Key to the Tables of the Test Case Reference List

Table	Contents
A–E	Part A: RF Conformance – Provisional
A	Part A: RF Conformance
B	Part B: BB Conformance
C	Part C: LM Conformance
D	Part D: L2CAP Conformance
E	Part E: SDP Conformance
K1	Part K:1 GAP Conformance
K2	Part K:2 SDAP Interoperability
K3	Part K:3 Cordless Interoperability
K4	Part K:4 Intercom Interoperability
K5	Part K:5 Serial Port Profile Conformance
K6	Part K:6 Headset Interoperability
K7	Part K:7 DUN Interoperability
K8	Part K:8 FAX Interoperability
K9	Part K:9 LAN Access Interoperability
K10	K10 Not used
K11	K11 Part K:11 Object Push Profile Interoperability
K12	K12 Part K:12 File Transfer Profile Interoperability
K13	K13 Part K:13 Synchronization Profile Interoperability
Keys	Keys for the Change Notes
Tplat	Keys for the Test Platform

The power of profiles

Interoperability between Bluetooth devices covers three main levels:

- **Radio level** – to ensure that devices can contact each other.
- **Protocol level** – to ensure that devices can talk to each other.
- **Usage level** – to ensure that devices can execute mutual applications and satisfy end-user expectations.

These interoperability levels are covered by profiles, which can be defined as specifications of how to use a set of base standards to achieve interoperability by: reducing options and setting parameter ranges in base standards; by specifying the order in which procedures from different base standards are combined; and by defining a common user experience.

The Bluetooth Profiles

International standardized profiles for Open Systems Interconnection (OSI) are specified in document ISO/IEC TR 1000. OSI is a reference model that defines standards for communicating between systems manufactured by two different companies. OSI standards consist of seven protocol layers used to perform different functions in data communications. The first four layers comprise transport profiles, relay profiles L3-L3, and layers 5-7 comprise application profiles for interchange format and representation.

The base standards forthe Bluetooth profiles are:

- The basic stack – baseband, LMP, L2CAP.
- Higher layer protocols – RFCOMM, TCS-BIN, SDP, etc.
- Adapted protocols – TCP/IP, OBEX, WAP, etc.
- Usage models.

When involved in radio communication according to a Blueooth profile, each device assumes one of the roles specified in a profile, such as gateway or voice terminal, network access point or data terminal, headset or audio server, OBEX client or server.

Usage models describe the prime Bluetooth applications and intended devices, whereas profiles specify how the interoperability solution for the functions described in the usage models should be provided using Bluetooth protocols. The relationship between usage models and profiles can be seen in Figure 1.

Profiles based on the Specification of the Bluetooth System release 1.0 can be divided into five groups – Generic Access, Transport, Telephony, Object Exchange and LAN Access. These are discussed further below. The Bluetooth profile family tree is presented in Figure 2 on the next page.

General Access Profile (GAP)

The GAP defines common modes and procedures used in all other profiles and thereby represents the minimum conformance requirements for Bluetooth devices. It ensures that all Bluetooth

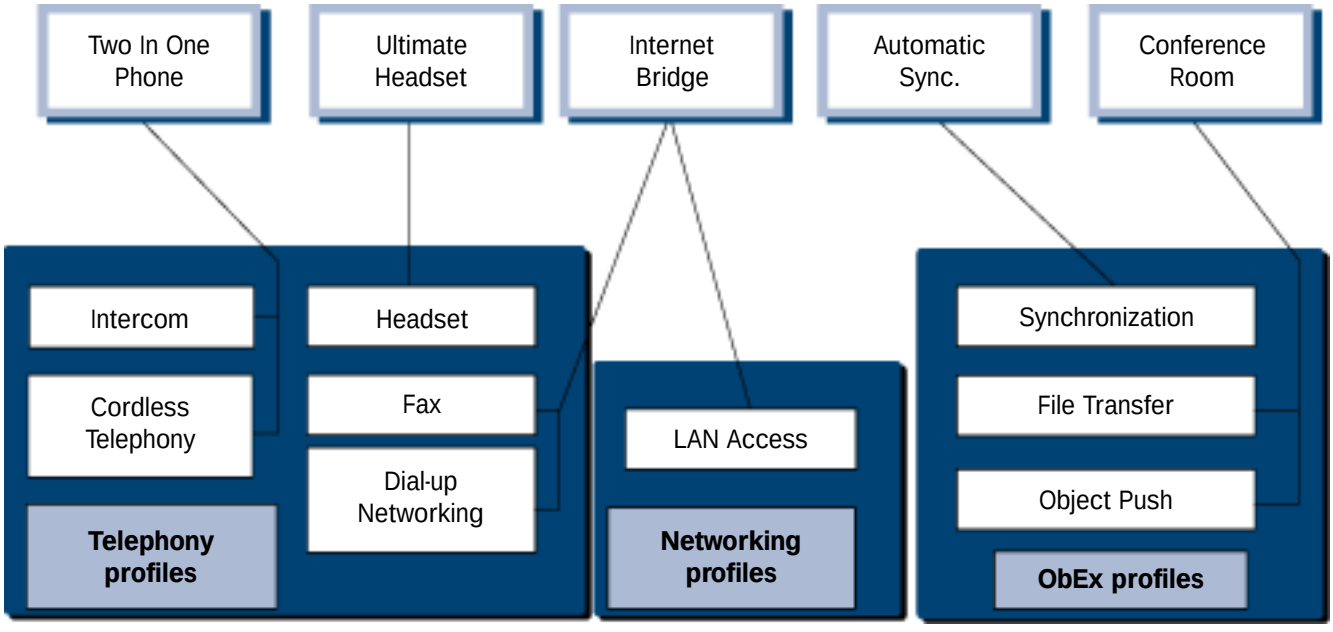

Fig. 1 The relationship between usage models and profiles.

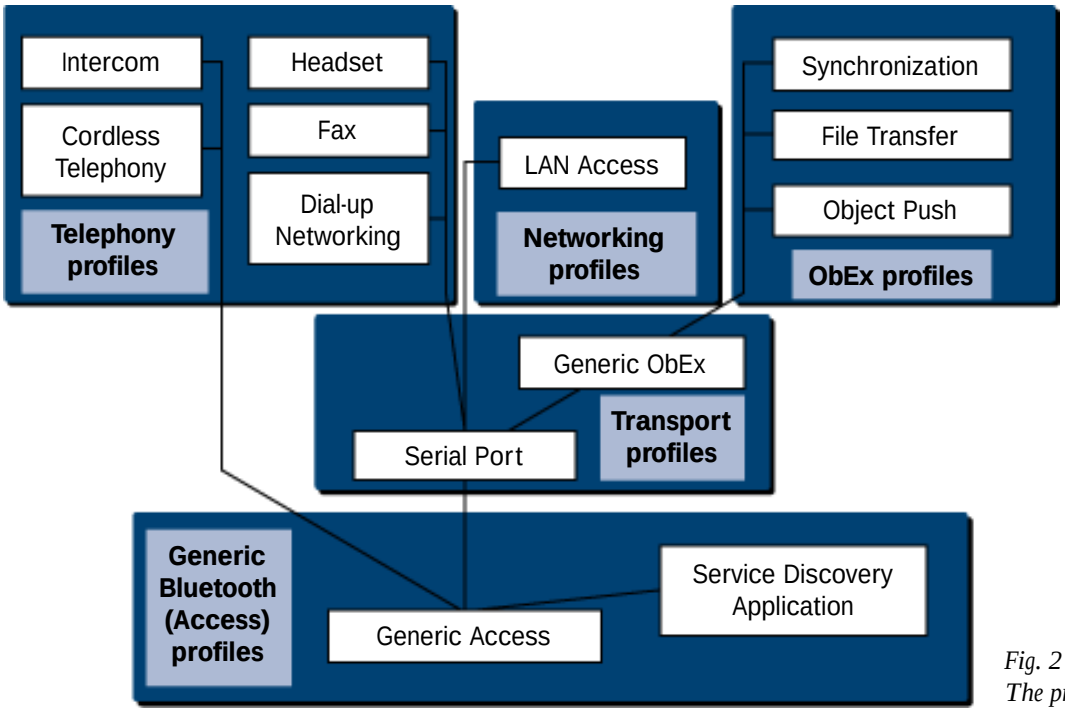

Fig. 2
The profile family tree.

devices can establish contact with each other independent of the application profiles supported. The following functions make up the GAP:

- User interface (UI) requirements
- Modes
- Security aspects
- Idle mode procedures
- Establishment procedures
- Service discovery application

UI requirements
For all Bluetooth devices the same terms shall be used for the basic parameters and procedures, and all parameters shall be presented on the UI in the same format and coding.

Modes
There are three modes:
Discoverability – non-discoverable, limited discoverable and general discov-erable.
Connectability – non-connectable and connectable.
Pairable modes – non-pairable and pairable.

Security aspects
Authentication based on a secret key derived from an entered Bluetooth security code, or based on an existing secret key. The security modes comprise service level enforced security or link level enforced security.

Idle mode procedures
These comprise limited and general inquiry, name discovery, device discovery based on inquiry and name discovery, and pairing involving the creation of a common link key.

Establishments

- Link: paging, …, Imp_setup_complete
- Channel: L2CAP_ConnectReq, …, L2CAP_ConnectRsp
- Connection: application dependent
- Additional link/channel/connection: independent of first connection

Service discovery application
The service discovery profile defines the protocols and procedures that shall be used by a service discovery application on a device to locate services in other Bluetooth-certified devices using the Bluetooth service discovery protocol (SDP). With regard to this profile, the service discovery application is a specific user-initiated application.

Transport Profiles

These profiles include specifications for serial port application profiles and legacy applications, as well as for generic object exchange (OBEX) application profiles and the exchange any type of specified object.

Telephony Profiles

Two types of profiles are involved, one based on telephony control (TCS) and the other based on the serial port (AT commands). Telephony control covers cordless telephony for residential systems, and intercom applications such as walkie-talkie and local telephony. Serial port applications cover dial-up networking (cordless modem), faxing, and headsets (audio and call control from a device with limited UI).

Object Exchange Profiles

Object push profiles are used to push, pull and exchange single objects, file transfer profiles effect the exchange of larger objects and files, and synchronization profiles enable synchronization of contacts and calendars between personal computers and mobile electronic devices.

LAN Access

The LAN access profile with the point-to-point protocol (PPP) is used in personal computers to access a LAN via a cordless network access point.

Online technical introduction to the Bluetooth wireless technology

Customer demand for more and more information about the Bluetooth wireless technology has prompted Ericsson to develop a web-based learning course entitled *Bluetooth: A Technical Introduction.*

This 3-4 hour online course provides a technical overview and a comprehensive introduction to the Bluetooth wireless technology. It focuses on architecture, the air interface and radio specification.

Bluetooth: A Technical Introduction contains the following modules:

- Course Introduction
- Technical Features & Architecture
- Topology
- Physical Channels and Links
- Packet Formats and Packet Types
- Logical Channels
- Timing & Synchronization
- Access Procedures
- System Operation
- Security
- Course Summary
- Course Quiz

Self-paced learning

The course is aimed at individuals, both inside and outside of the telecom and datacom industries, who want to keep up to date with emerging technologies. It is suitable for marketing personnel who require an introduction to the Bluetooth wireless technology, and to business developers who are deciding whether to include the technology in product plans.

The web-based course is interactive, self-paced and accessible from a personal computer. Subscribers will be allocated a password to a Bluetooth web address. For companies with multiple users, a site license is available with discount rates.

For further information on this course, contact Maeve Bourke by e-mail at: Maeve.Bourke@eei.ericsson.se or by telephone on +353 1 2072545. Alternatively browse the Bluetooth website: *http://www.ericsson.se/bluetooth*

Share your experience

In Bluetooth SIGnal we would like to present stories on how SIG members are applying (or intend to apply) the Bluetooth technology to their own products. Therefore if you think that you have an interesting application story to tell, including the challenges involved and how you are meeting them, contact us at *bluetooth@pyramid.se*.We also welcome suggestions for articles from readers.

COMING UP

April 17–20
Comdex Spring 2000, Chicago

April 25–27
WinHEC 2000, New Orleans

June 6–9
CommunicAsia, Singapore

June 13–16
Bluetooth 2000, Monte Carlo

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