Opening Bluetooth for Technical Tasks — Possibilities and Challenges for Automotive Applications

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Abstract

Bluetooth is on a good way to become an accepted standard for wireless connectivity in the fields of mobile telephone systems, office communication, multi media devices, and consumer electronics. Additionally there is a market for technical tasks like real time control, data acquisition, and monitoring where there is a need for wireless connectivity, too. Bluetooth seems to be a promising technical basis for such technical tasks for automotive applications, because of the technical performance, the high market penetration, and the potential for low cost solutions.

In this paper we want to discuss possibilities and necessary developments to set up wireless communication for automotive applications by the help of Bluetooth. To give an impression of this new and interesting market for technical systems with a wireless connectivity, recent trends of system architectures for control and communication as well as various applications are presented. Special requirements for the operation of wireless units in an automotive environment are discussed. Different issues of technical concepts to set up a wireless connection to a CAN bus network using Bluetooth are described. Some modifications for the standard Bluetooth protocol and chip-set required for automotive applications are discussed. If Bluetooth can be used for technical tasks like real time control, there may be an additional potential of up to hundred of million per year Bluetooth nodes within the vehicle manufacturer market.

Introduction

Starting in the market of mobile phones hard work has been done to specify, to develop, and to establish Bluetooth as a new standard solution for a radio based wireless communication. A big advantage – of course – is the wireless connectivity for mobile or portable devices. Therefore many activities started to make Bluetooth available for other products in similar fields of application. Examples for such Bluetooth applications are the networking of PCs and peripheral devices, multi-media devices, and portable products of consumer electronics. These Bluetooth devices, which are under development up to now, may be used in different environments: out door, at home, in the office, and inside vehicles. But there is a demand on wireless systems in other additional markets, too. An important example is the market for technical tasks like automatic control, monitoring, and data acquisition. Potential fields of application are the automotive industry and the wide range of automation industry (factory automation, building automation, medical device industry, ...) Compared to the applications mentioned above, the biggest benefit of a wireless connectivity for technical systems in vehicles is not portability but an increase in flexibility – especially during the phase of product design – and the replacement of cables. To set up wireless systems also for technical tasks is the motivation to discuss technical solutions on the basis of Bluetooth technology. Although modifications and further developments of the existing specification may be necessary, the technical performance, the high level of standardization, and the expected dissemination of Bluetooth make it an interesting technology. In this paper we want to focus on the potential of Bluetooth for technical tasks in the automotive industry, which is an important volume market.

General Trends and Requirements for Technical Tasks

For vehicles different developments are on the way to implement Bluetooth solutions for consumer oriented applications. These are mostly conventional Bluetooth applications for example for mobile phone, navigation system or different portable devices. The basis for these applications is the original specification of Bluetooth. Of course the behavior of a radio link inside a vehicle has to be studied carefully. Without neglecting this important field of application our intention in this paper is to focus on technical tasks for example for control or monitoring. For automotive applications this includes technical tasks inside the vehicle as well as during production, and during service. These technical tasks are basically concentrated on the product “vehicle” and the process of driving it.

The most important advantages of wireless technologies for technical tasks are more or less hidden to the vehicle customer. The benefit of such a solution is the increase in flexibility, modularity and reliability. Although the benefit cannot be experienced directly by customers it is nonetheless important for automotive industry. An overview of the most important technical advantages for the application of wireless systems in vehicles is shown in Fig. 1.

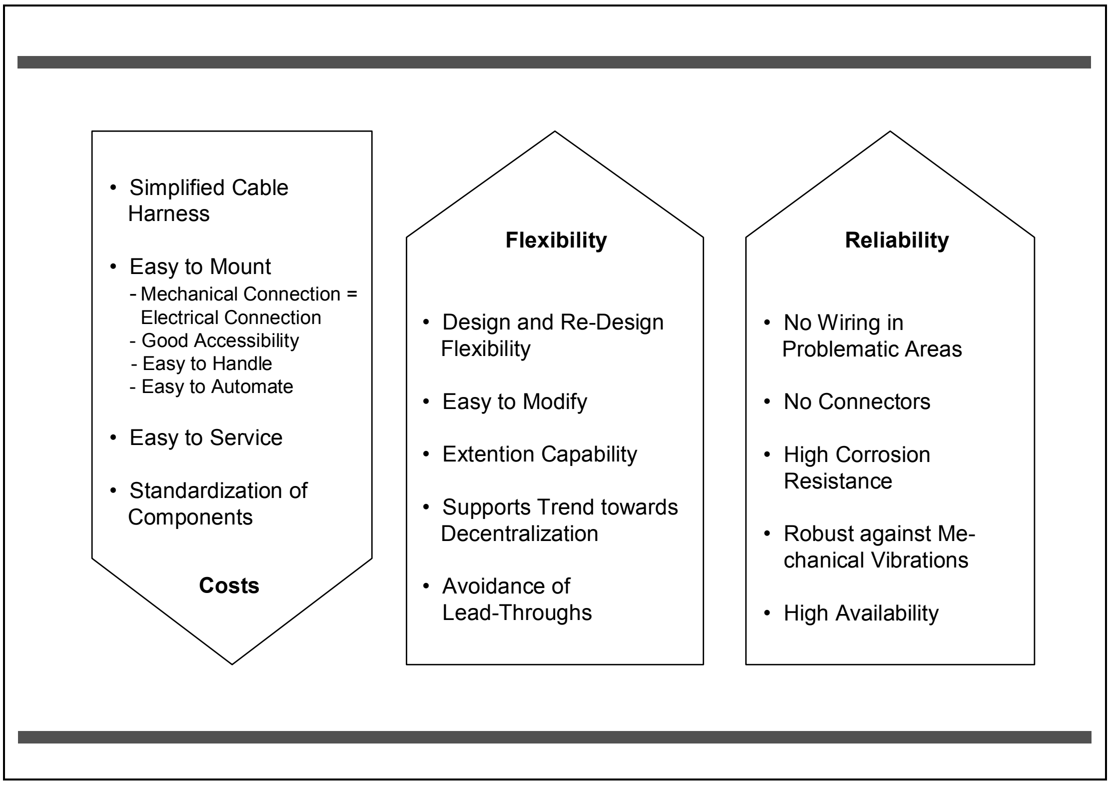

Fig. 1: Advantages and benefit of wireless systems for technical tasks

For several years a major trend in vehicle development has been the increasing number of electrical and electronic systems. Many of these systems have been introduced to offer innovations to the customer by an increase in functionality, comfort, and safety. Another reason is the partial replacement of mechanical components by electrical components or their integration into mechatronic systems. On a more technical level some other major trends are as follows:

- extended automation and increasing number of control tasks (process level and system/component/ level)
- increasing number of monitoring and diagnostic tasks
- increasing number of variants (variety)
- increasing degree of decentralization
- increasing demand for communication between several control units as well as between sensor/actuator units and control units
- increasing degree of system integration (e.g. mechatronics).

Using conventional technologies only, these trends cause increasing difficulties. Some of the biggest problems are as follows:

- increasing number of wires and complexity of harness

- increasing number of connectors/pins
- increase of malfunctions due to connector failures
- high cost in case of design modifications
- high cost for assembly, service, and repair

A development strategy aimed at the introduction of wireless systems for automotive applications really fits to the described technological trends. The discussion about wireless systems – which in general include technologies for the transmission of data and electrical power – is focused here on wireless communication using Bluetooth technology.

Well known technical solutions to overcome the problems of increased complexity of wiring consist in the introduction of bus systems for networking or the use of wireless communication techniques. Today most vehicle manufacturers are using bus systems in their design of a control architecture. Especially CAN is an established bus for a wide range of applications. In many vehicles different communication technologies are used in parallel. There are still a lot of wires for direct point to point connections for single components. CAN buses with different specifications and performance levels are used for different applications (e.g. control of aggregates or vehicle dynamics) and/or in specific areas of the vehicle (e.g. engine compartment or interior/cabin). Other important aspects of the communication architecture are topology, hierarchical structure, and connections between different subnetworks/subsystems.

An additional trend is the increasing data processing capability and performance of the field level components, for example sensors and actuators. Together with new technologies for wireless communication like Bluetooth this may drive future developments with mutual influences on field devices and controllers as well as communication systems. These trends may result in a new generation of a system architecture with a more decentralized and distributed structure of intelligent devices and a lower hierarchy. It is obvious, that such a development will influence and change organization and protocols for communication, too.

Specific Requirements for Automotive Applications

One has to be aware right at the beginning of a development that the envisaged products in the field of wireless systems have to meet the requirements of vehicles. Especially the environmental conditions, the data volume and the requirements for real time communication are different from those in the field of telephones or office communication.

Operational requirements, especially for wireless communication, are:

- full functionality
- operation with several but a limited number of units
- fully reliable communication (data security, data integrity, and authentication
- data volume (short messages)

– response time and cycle time for communication (real time performance)
– electromagnetic compatibility (EMC)
    + inside and outside the vehicle
    + for human beings and technical systems
– characteristics of onboard vehicle power supply (voltage, tolerances)
– worldwide certification.

The most important requirements concerning environmental conditions are temperature range, humidity, corrosion resistance, and resistance against mechanical vibrations and dirt/pollution. Further requirements are: operation in a limited area or within short distances (see EMC), easy-to-mount capability, low volume, low weight, compatibility with materials of surrounding parts, and design to cost.

For many automotive applications wireless systems could be the right answer to overcome some of the described difficulties. Probably not all the devices in a vehicle will communicate by means of wireless technologies in future. But an important progress may be achieved by the combination of bus communication using CAN with wireless communication using a modified Bluetooth technology.

Communication inside vehicles for control and monitoring tasks

There is a wide field of potential applications for wireless communication for control and monitoring tasks inside a vehicle and in defined surroundings of a vehicle. Regarding these applications it may be helpful to distinguish different systems, different levels of control, and different phases of the product life cycle, for example development process, manufacturing and customer use. For this description the terms “single units” and “subsystems” of a vehicle are used. Examples of such single units and subsystems inside vehicles are shown in Fig. 2.

Single units are components at the field level which are more or less intelligent. In case of vehicles such single units are control units, devices for man-machine interfaces, sensor units, actuator units, lights, switches, and the like. On a higher control level there are several subsystems. Such subsystems may include several single units, especially sensor/actuator units and possibly a control unit and a local bus or network.

Additionally single units and subsystems can be distinguished by regarding the degree of freedom of motion during operation. There are subsystems without any degree of freedom of motion, for example engine, transmission, power train, suspension system, body control, brake, dash board, and roof module. For other subsystems or single units (e.g. door, sliding door, bonnet, seat, wheel/tire, steering module) a degree of freedom of motion is essential for operation. Especially for this group of subsystems it is important to design a simple interface (separation point) between the vehicle and the movable system.

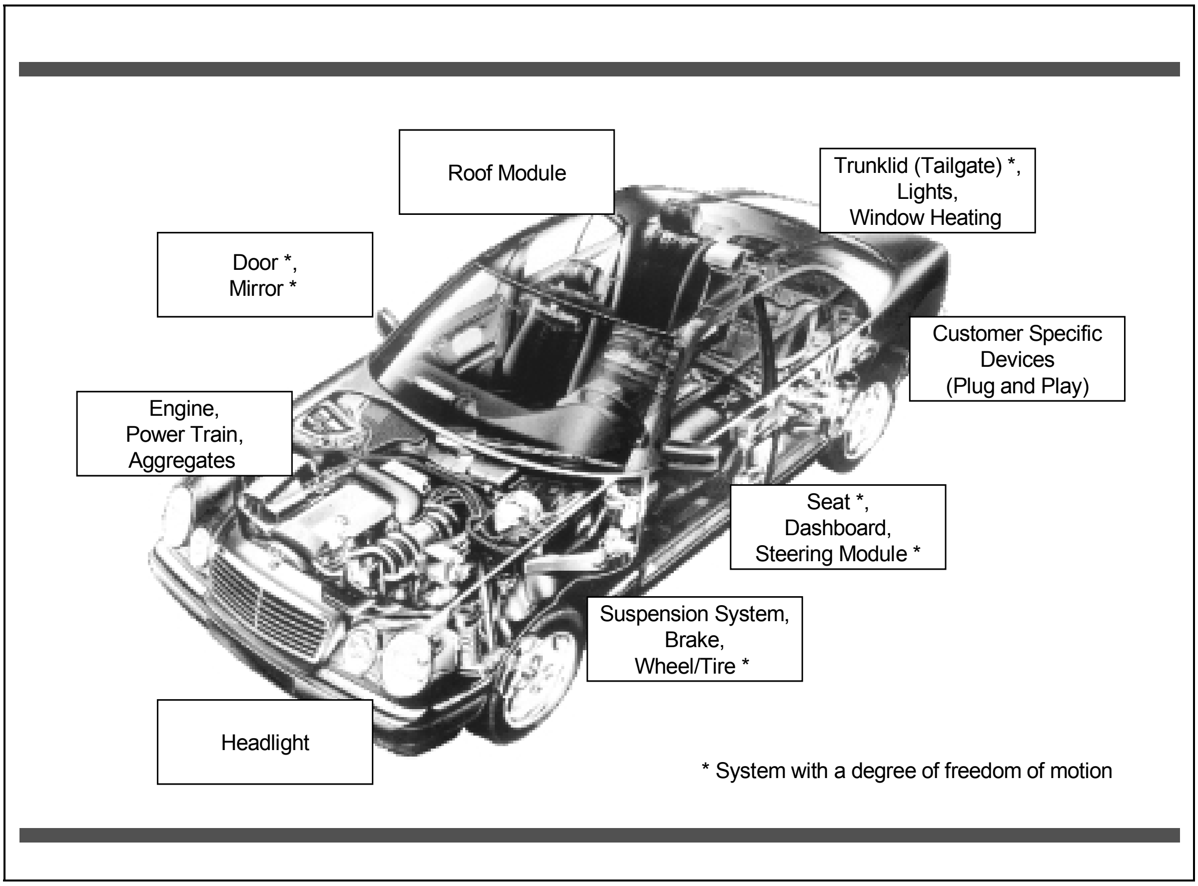

Fig. 2: Potential applications for wireless systems

This can be realized by using wireless technologies for the transmission of data and electrical power. Based on such a construction a door – for example – can be finally mounted only by fixing the mechanical parts of the interface (separation point) and without any handling of cables or connectors. By the help of wireless technologies it is possible to develop modular subsystems which are electrically autonomous. Such modular subsystems can be completely pre-assembled and tested in parallel to the assembly of the vehicle. The handling of these modules during testing and assembly is much easier, because no handling of wires and connectors is necessary. A wireless interface also increases the potential of automated assembly for these systems. For service, maintenance, and repair wireless interfaces are advantageous with respect to disassembly and assembly of such systems.

Another application for wireless systems are the flexible installation of customer specific devices (plug and play), for example a special display unit. Using a radio link for wireless communication would increase the flexibility with respect to the packaging of electronic units and the mechanical design. Other possibilities – especially for trucks – are to send load relevant data (status information, weight) from a sensor unit on the trailer to a base station in the truck cabin via a wireless data link. For other devices like portable computers for special tasks (electronic logbook) and portable operating units a wireless connection to a control unit in the cabin would be an advantage.

Communication during production

Using wireless communication between the product and the automation system of the production line could open a way to completely new functions in the production process. Such a product can be a vehicle or a complex aggregate like an engine, transmission or drive train. Depending on the step in the process – for example during final assembly of a vehicle – the vehicle controller and controllers of the production line are able to exchange status information both about the product and the process. Additionally data for testing or diagnosis may be sent from the vehicle to the production line. Wireless communication can also be used to download vehicle specific software from a production controller to the vehicle. In such a vision the intelligent vehicle which is equipped with a wireless communication link to the production line represents an active system in the overall production process. Of course in such a production environment a power supply for the systems inside the vehicle is necessary.

Communication during service

Potential applications during service can easily be derived from the scenario for the production process described above. Wireless communication between the vehicle and a computer of the service station can be used to exchange status information and service specific information. This step may be supported by a preceding data exchange using telecommunication. Wireless communication in combination with a mobile service computer offers optimum flexibility to the service personnel. The mobile computer is connected to the computer of the service station as well as to the vehicle controller. During service all single units and subsystems of the vehicle are checked, functions are adjusted, and new sets of parameters or new versions of software are downloaded to the vehicle if necessary.

Requirements for a successful development process

A successful development requires a good understanding of the envisaged product, the steps of the development process, and the different partners in this process. At first some issues of product design for wireless units are discussed.

The flexibility of wireless communication combined with low cost of standard products could lead to significant innovations for the networking of control units and other intelligent devices. That means, that it is not sufficient to concentrate development only on wireless communication interfaces. For the design of a wireless application unit (wireless subsystem, wireless single unit) it is necessary to consider the system architecture as well as the hardware and software. This is true for the application part and for the interfaces of such an application unit. Fig. 3 shows the general architecture of wireless application units, equipped with wireless information and power transmission. The wireless sensor unit is connected

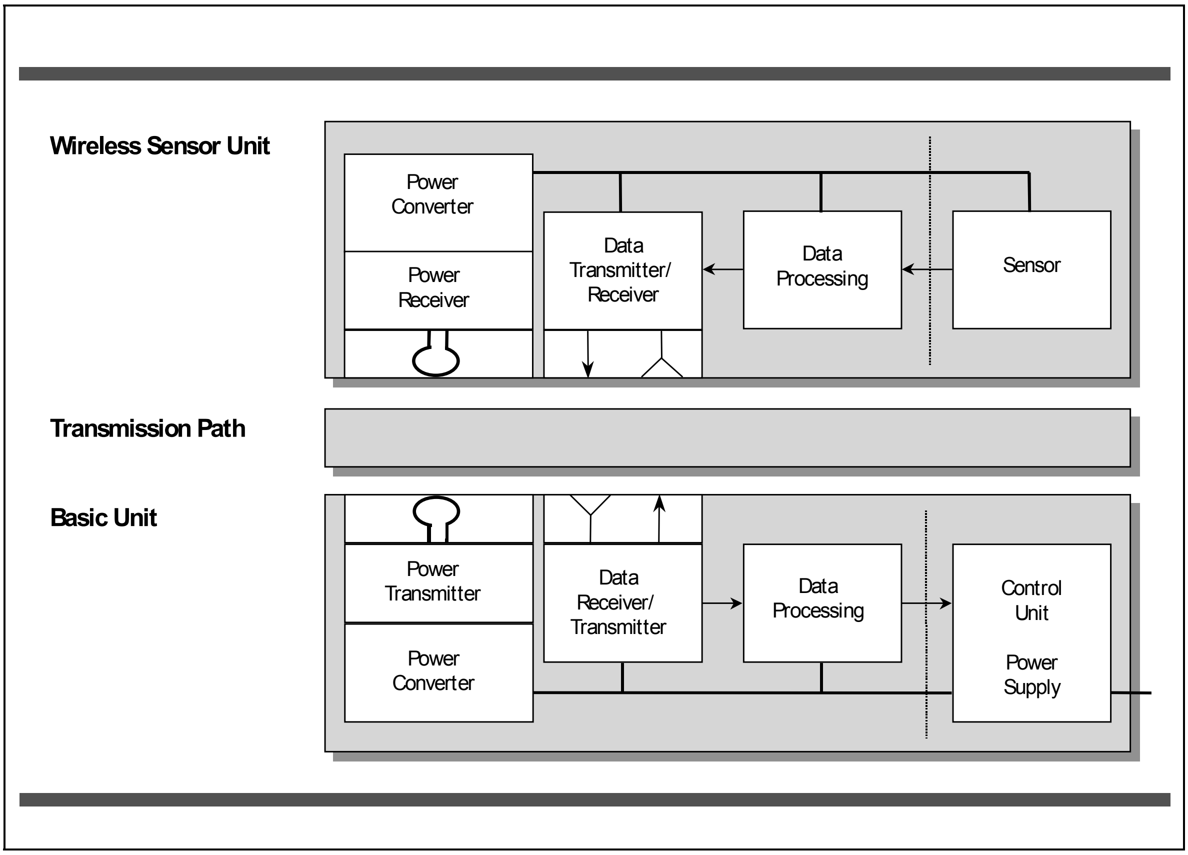

Fig. 3: Architecture of a wireless application unit with information and power transmission

to the wireless basic unit, which includes the control unit. These units are given as an example. The design of other wireless units (single units, subsystems) can be derived from this architecture.

In comparison to other wireless communication interfaces such as radio modules based on IEEE 802.11, telemetry modules, transponders, or other inductive systems Bluetooth seems to be a promising technical concept to meet the requirements described above. But several development steps are still necessary to set up wireless systems for automotive applications. It should be possible to realize a short reaction time for real time communication. There is a strong demand for a short settling time for system start up and after system brake down. A reliable connectivity is necessary anytime and anywhere, but only exclusively for a well defined number of devices. For the described technical tasks voice services are not needed. But perhaps it may be possible to increase the number of devices in a pico net. The discussion of these issues may lead to some modifications of Bluetooth protocol and software. Another issue is the integration of hardware and software for the Bluetooth interface and the technical system. Very important is the design of the radio antenna. Especially wave propagation in an automotive environment has to be investigated, because of the influences of reflections, shadowing, and multipath propagation.

Another design criterion is important regarding the feasibility of wireless application units (controller, sensor, actuator, subsystem) for automotive applications. It is the potential of standardization for such units. On the one hand standardization opens the chance to reduce the number of variants of a given component. The goal is to make such units applicable both for different applications within one vehicle and for different vehicles. On the other hand standardization is a possibility to reduce product cost. This is an important issue, because in general an electronic component for a wireless transmission unit is more expensive than a cable.

Important for the successful development is a good and efficient partnership between all suppliers in the supply chain and the end user. Considering Bluetooth as a new technology for various automotive applications suppliers are manufacturers of communication interfaces (based on Bluetooth) as well as manufacturers of sensors, actuators, and controllers. Other important suppliers are system integrators. The vehicle manufacturers are the end users in this chain.

On the way to the market of wireless communication systems for automotive applications the development of manufacturer specific solutions has to be avoided. According to the trend towards open system architectures with open communication structures it is necessary to develop wireless units with the characteristic of inter-operability. Therefore discussions about development strategies, standardization, and worldwide certification have to be established between all partners.

Architectures

As we have seen in the previous part of the presentation, the future use of radio communication in cars spans over a wide range of applications from simple slow, neither time critical nor safety critical ones, to highspeed, time and safety critical ones. Bluetooth will cover a big part of this market, thanks to its flexibility and good real time performance.

The general trend today in vehicle developments is to carry an increasing number of information and control messages via serial busses. For technical information and machine control, the CAN (Controller Area Network) bus is dominating and this technology is developing rapidly. Thanks to the bus technology, the cable harness and amount of connectors can be reduced to a great extent. However, for many applications it would be nice to have a wireless connection to the CAN bus. This is a prime target for the Bluetooth technology and I will limit my presentation to discuss such applications.

CAN/Bluetooth basics

CAN was developed to be a base for a highly reliable communication via a twisted pair of wires that could be applied from very simple tasks to advanced real time control. To achieve this goal, it is based on the principle that every node in a system simultaneously checks each bit transmitted on the bus. By this principle a row of problems like buss access, collision detection, data consistency, etc. are solved in an elegant way. However, the condition that every node should see the same bit at the same time requires a controlled wave propagation time. This is easily achieved in a wired system but hard to achieve in a wireless system. Therefore, any wireless transmissions in CAN systems have to be made via gateways and Bluetooth offers the best possibilities for this task among the available radio standards.

The service CAN offers can be summarized as correctly transceiving useful bit packages of a length from 11 up to 93 bits to all connected nodes at a bit rate from 10 Kbit/s up to 1 Mbit/s. As CAN only supports the low levels of a protocol, a Higher Layer Protocol (HLP) is always needed to form a complete protocol. In practice, every car or truck manufacturer has a proprietary one although SAE has defined one called J1939. More details about CAN can be found at http://www.kvaser.com/archive/edu/.

Some comparisons:

	CAN	Bluetooth	
Raw bit rate (bit/s)	10k - 1M	1M	+
Useful bit rate (bit/s) protected	2k - 581k (at 1Mbit/s)	64k, 723k	+
Packet length (overhead not included)	0 - 8 bytes plus 11 or 29 bits	10, 20, 30 bytes (SCO) 17, 27, 29, 121, 183, 224, 339 bytes (ACL)	+
Basic Transmission Method	Broadcast	Point-to-Point via Master	–
Addressing Method	Message Identifier	Source-Destination	–

From the comparison above it can be seen that there is a good match between the bit rates and that some Bluetooth packets seem to be suitable for transporting CAN messages. There is a mismatch in the transmission and addressing methods. This indicates that a CAN/Bluetooth gateway lends itself to a point-to-point cable stretcher but not to a network replacement. In fig. 4 below, we have a CAN/Bluetooth

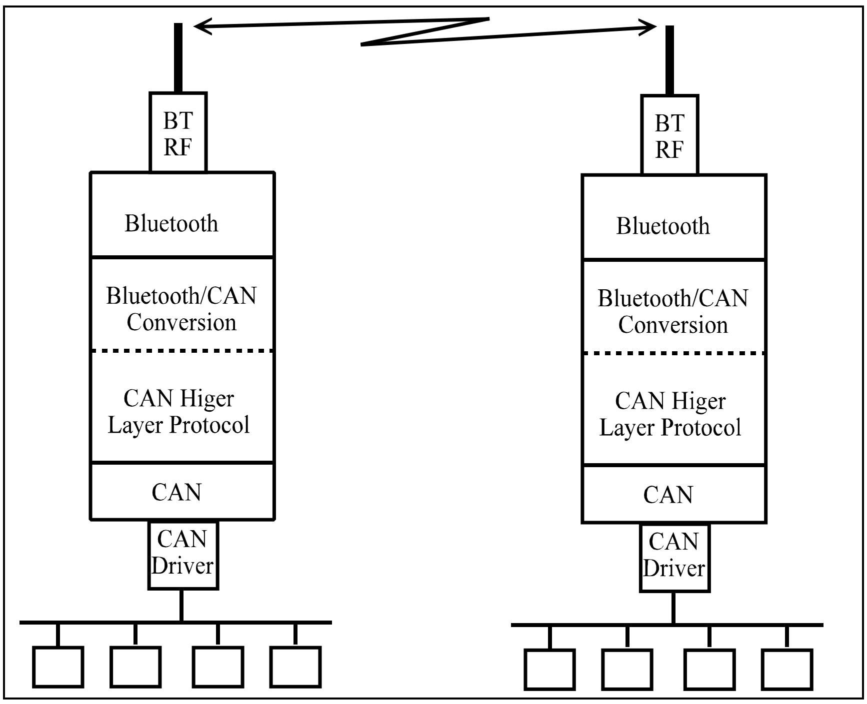

Fig. 4: Simple CAN/Bluetooth link

gateway used as a cable stretcher. The CAN network is divided into two separate networks and the inherent data consistency feature in CAN is then lost. A message in the left part is accepted by all nodes before it is transmitted to the right side. The nodes on the right side will get the message later and it might even be corrupted .The CAN higher layer protocol has to be adjusted to take care of this problem .As the error checking in CAN is made in a bit-by-bit fashion, it makes no sense to use this for the wireless transmission. The CAN message is picked up in the gateway node and warped up in a Bluetooth protected package. The Bluetooth protection will replace the CAN protection mechanisms and thus most of the CAN overhead is deleted when a message is wrapped up into a Bluetooth message. The CAN overhead will be recreated by the CAN Controller when it is transmitted on the other side. The optimum Bluetooth package type to be used is depending on the transmission rate, direction and allowed latency time of the CAN messages. This has also to be solved by the CAN higher layer protocol.

Expected performance for a gateway is shown below:

Expected performance in an undisturbed environment						
Package type	Number of full CAN messages 1 Mbit/s		Max Latency time (ms)	% of CAN bandwidth		Direction
	Std	Ext		Std	Ext	
HV1 (SCO)	1	0	1.25	11	0	Bidirectional
HV2 (SCO)	2	1	5	5	3	Bidirectional
DM1 (ACL)	1	1	1.25	11	14	Bidirectional
DH1 (ACL)	2	2	1.25	22	28	Bidirectional
DM3 (ACL)	12	10	2.5	67	67	One-way
DH3 (ACL)	19	15	2.5	100	100	One-way
DM5 (ACL)	23	19	3.75	85	82	One-way
DH5 (ACL)	36	29	3.75	133	126	One-way

The figures above can be seen as a rough estimation of the performance. The packet type to be used is depending on the nature of the communication and the environment. The performance can be increased by compression of the CAN messages when it is wrapped up into Bluetooth packets. The final performance depends on the CAN higher layer protocol. Currently no CAN higher layer protocol supports Bluetooth, but at least CAN Kingdom will soon have a Bluetooth support.

Applications

There are basically three types of applications:

– Open connection to a Human-Machine Interface

– Proprietary connection to an HMI

– Proprietary Machine-Machine connections

Open HMI connection

This type of connection will probably use standard Bluetooth equipment. An obvious application would be for legislated emission control tools (On/Board Diagnostics OBD) but this will take some years to happen. Legislative and standards committee work tend to move slowly. The architectural requirements are simple and straight forward: A point-to-point connection with no real-time or safety demands.

Proprietary HMI connection

The first applications on the market will be based on proprietary HMI connections. The car node will be specified and produced for each car manufacturer, but the HMI will, in most cases, be based on high volume Bluetooth laptops or palmtops. The first applications will be non-time critical as diagnostics, code downloads, etc. and safety issues will be taken care of by the CAN higher layer protocol. Gradually we will see more time critical applications appear.

Proprietary Machine/Machine connections

An example on Machine/Machine connections is shown below. Flexible cables in cars are often a source of problems. Electronic units in the steering wheel, the doors, the seats, the roof are all candidates for Bluetooth technology. Already today, most cars have more than one CAN network and the trend is that the car of tomorrow will have five or six CAN networks, all connected to each other by gateways. Some of these connections might be Bluetooth links. A connection between CAN systems in the front and the back of the car, as well as standalone units, is shown in fig. 5.

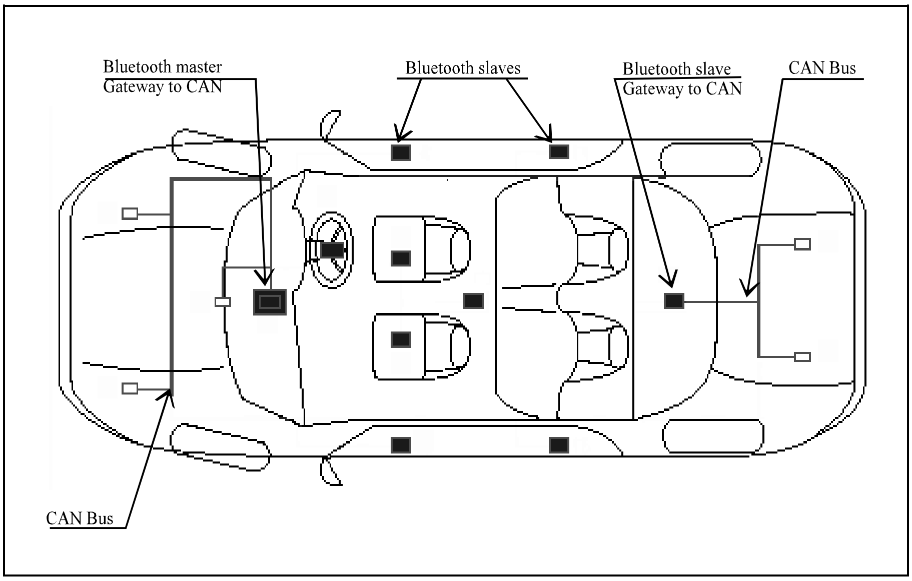

Fig. 5: Machine-Machine connections in a car

A further application for Bluetooth is in instruments. Dashboards could be easily customized if the instruments are designed as units with an LCD and a Bluetooth module. In this case we have very short distances, from a few centimeters up to say 50 cm.

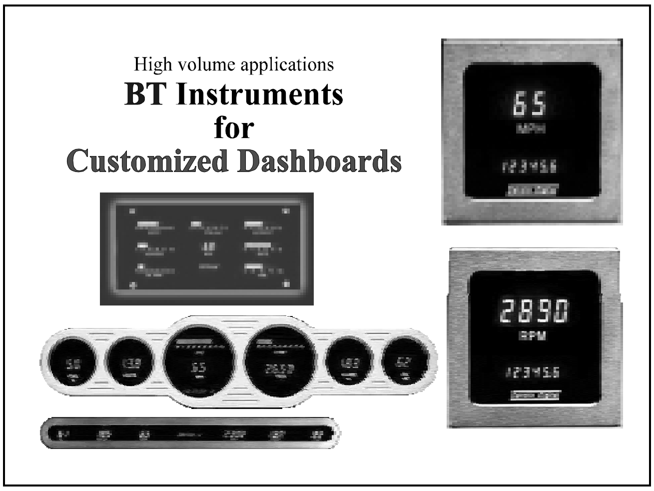

Fig. 6: Bluetooth instruments for dashboards

The cases above can be handled by standard Bluetooth piconets, although the limit of seven slaves might be a drawback. However, the connections are predefined and no node in the system will ever take part in any other Bluetooth communication. On the contrary, this communication should interfere as little as possible with any other Bluetooth application in the car compartment. Antenna arrangements and output power have to be fine-tuned to the application.

The applications shown are not time critical for Bluetooth, but time critical applications, integrated with CAN systems, can be envisaged as well. There will be a need for simplified MAC layers providing only a subset of the Bluetooth standard, optimized for integration into advanced CAN networks. As CAN soon will support TDMA networks, there will be a need to synchronize the clocks in the CAN and Bluetooth nodes. Perhaps we will see a new protocol for Machine/Machine applications based on a combined CAN/Bluetooth technology.

Connection establishment

In the connection establishment, there is a great difference between the “ordinary” Bluetooth concept and the requirements for technical automotive applications. The main applications for Bluetooth is to connect standard devices like mobile phones, PCs, printers, keyboards etc. to ad hoc networks. In most cases, the manufacturer of such items can leave it to the end user to decide which items should be connected and how they transfer messages. For automotive applications, it is a bit different. A connected device must not interfere with the ordinary CAN traffic in an unpredicted way. A disturbed CAN traffic in the control system of a vehicle may lead to a severe accident.

As an example of a common application, we will study a Bluetooth connection between a service tool and the control system of a vehicle. Today service tools are connected directly to the CAN network of the vehicle by a cable, so in this case the Bluetooth link would be a pure cable replacement. However, the physical cable is a safeguard against unwanted connections. When you are driving your vehicle, you can be sure that no one can manipulate the CAN system but f the connection is wireless, someone just being in the vicinity of your vehicle might have the possibility to interact with the control system of the vehicle. This cannot be tolerated.

With a wired connection, you are always sure that you are connected to the right vehicle. That is not obviously the case with a radio connection when there are several vehicles nearby. So we have to solve at least two problems:

- The vehicle has to be in control of the CAN bus traffic
- The service tool has to establish connection with the right vehicle

Bluetooth has got several means to solve the problem but, as several solutions is at hand, most probably each car or truck manufacturer would develop a proprietary solution. Another way to solve the problem, that might be generally accepted, is to establish a connection in two steps. First a simple Bluetooth point-to-point connection is made independently of CAN. When this is successfully done, CAN messages are wrapped up in Bluetooth messages and a second handshaking is made on the CAN level. The Bluetooth connection can then be treated as a transparent layer in the communication. Any authentication or safety problems are solved at the CAN level. A suitable architecture is shown in fig.7.

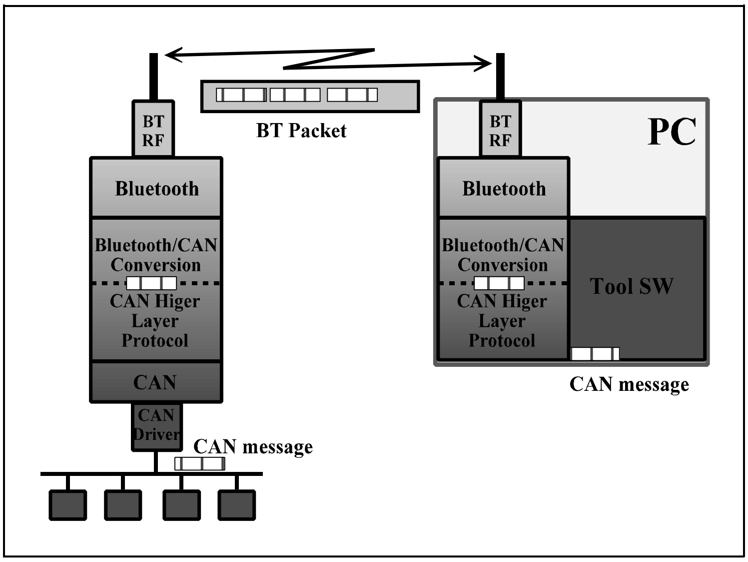

Fig. 7: Architecture of a connection between a CAN tool and a CAN system via a Bluetooth link

The steps could be as follows:

1. The Bluetooth software (BT-SW) in the tool initiates an inquiry
2. The BT-SW in the Bluetooth/CAN gateways in cars within reach responds to the inquiry
3. The tool presents any Bluetooth units within reach to the operator

   The user-friendly names appears on the screen, e.g., as brand of the vehicle and its registration plate number

4. The operator selects the car

5. The tool and the vehicle establish a paired connection

The steps 1 - 5 above are made entirely at the Bluetooth level

6. The BT-SW in the selected vehicle makes a “Connection Request” to the CAN-SW in the gateway
7. The CAN-SW transmits a CAN message “BT connection request” on the CAN bus
8. The system ECU on the CAN bus responds with a CAN message that any authorized tool will understand. This is very much the same as a tool directly connected to the can bus would receive.
9. The CAN-SW in the gateway picks up the CAN message and forward it to the BT-SW
10. The BT-SW wraps it up into a Bluetooth message and transmits it
11. The tool receives the message, the BT-SW unwraps the CAN message and hands it over to the CAN-SW.
12. The CAN-SW responds to the received message by another CAN message according to the CAN higher layer protocol used and hands it over to the BT-SW.
13. The BT-SW wraps it up into a BT message and transmits it to the gateway.
14. The CAN communication can now proceed via the Bluetooth link that acts fully transparently.

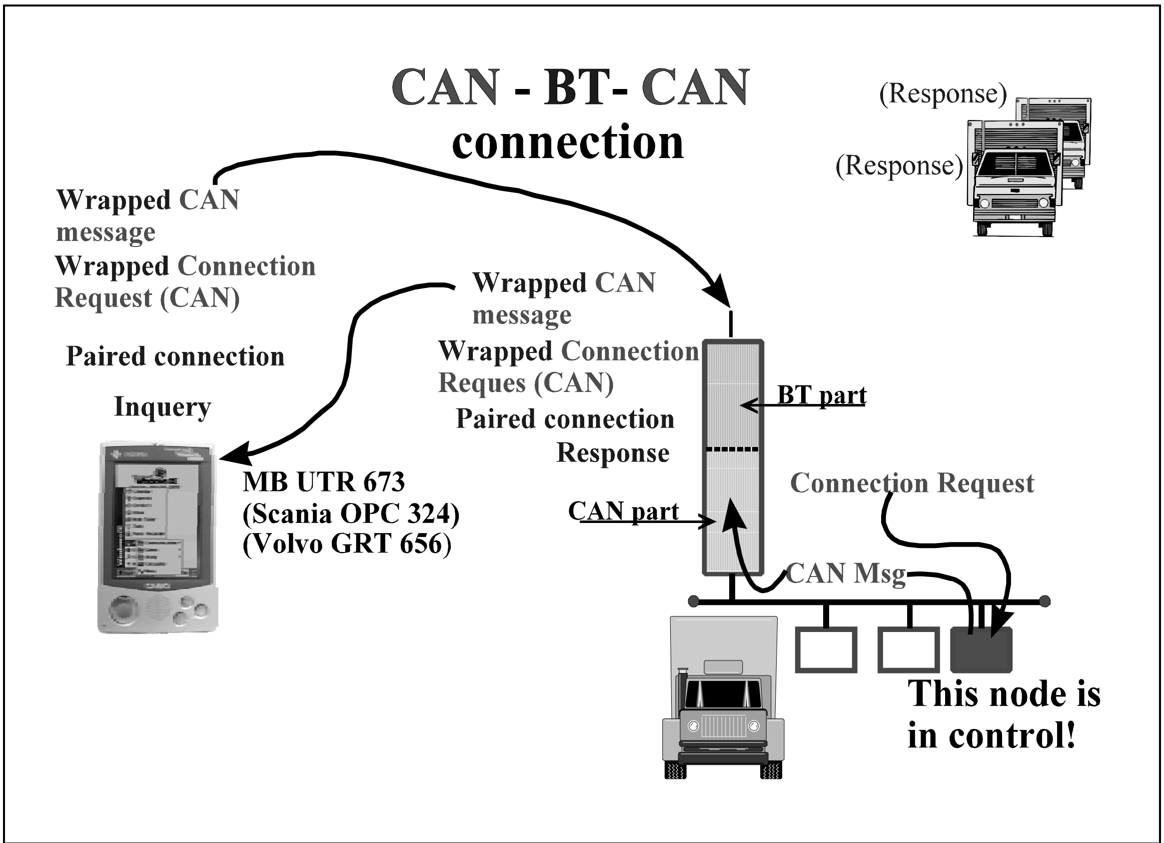

Fig. 8: Connection establishment between a tool and a CAN system in a truck

With a procedure like this, we have established a simple but safe Bluetooth link between a service tool and a vehicle. The system ECU in the vehicle is in total control of the CAN-SW in the gateway and the gateway is then acting as a guard against any unauthorized CAN traffic via Bluetooth. As most service tools are based upon PC platforms, it will be a simple task to adjust the software to support a wireless connection. A standardized Bluetooth profile based on the presented sequence would be very useful, not only for service tools but for other equipments that would be temporarily connected to different vehicles.

Conclusion

Three important aspects have to be evaluated before a decision is made to start with Bluetooth developments for the automotive market. These are the potential market, an estimation of the cost of wireless systems, and the appropriate time to start development. Some figures should give an impression of the additional market for Bluetooth nodes:

One BT station per vehicle:	about 50 million per year
BT for N subsystems per vehicle:	about Nx50 million per year
BT for single units in vehicles:	about 10xNx50 million per year.

The figure of about 50 million vehicles per year includes passenger cars and commercial vehicles. The potential number of Bluetooth nodes per vehicles depends on the different level of application. The number of up to several hundred million Bluetooth nodes seems to be a challenge, which is worth to be discussed for suppliers and end users. The first implementations of one Bluetooth station per vehicle will be driven by the success of Bluetooth in the consumer area. The vehicle customer would like to have the same services available in the vehicle as he is used to at home or office. However, the Bluetooth technology has a much bigger potential in machine-machine communication in vehicles. These applications require further developments. Considering the duration of product development and the perspective of cost reduction for Bluetooth in the next years it seems to be the right decision to start developments now.

Further information

Further information about CAN and the use of Bluetooth in connection with CAN can be found at
http://www.kvaser.se/can/index.htm
http://www.kvaser.se/can/info/interart/index.htm