

Bluetooth™ in Automotive Diagnostics

by

Lars-Berno Fredriksson

KVASER AB, Sweden 010502

Abstract

The future market for Bluetooth units to be used in cars will be substantial and diagnostics is just one, essential but small, part of this market. A Bluetooth standard for diagnostics has to be developed in concert, not only with other expected car specific services as door locking, seat and mirror adjustments, hands-free calls, etc., but also car adoptions of common services for home and office. This will require a Vehicle Interface (VI) as an understructure, for scheduling available resources among the users. The work on the VI and standardized car services has started, but it is a difficult task and will take its time. Further, essential components fulfilling automotive temperature specification are still not at hand.

Although we will have to wait for a Bluetooth specification suitable for car applications, the work on car diagnostics using Bluetooth technology is making rapid progress. A straightforward concept is to use a Bluetooth link as a cable replacement in existing CAN solutions. This is a proprietary system that might not be regarded in the spirit of Bluetooth. However, it serves an immediate need as the currently used cable connections are expensive and fragile. The development of the “real” Bluetooth profiles and hardware for cars will surely benefit from simple “wire replacement” applications. The technology is new and car applications are in many aspects extreme. Valuable experience is gained in many design topics, e.g., the relation between casing/antenna/unit-placement and radio coverage as well as in interference, noise and bandwidth problems. Such experiences are essential inputs in the ongoing standardization work to make Bluetooth successful in cars, not only for diagnostics but also for general applications.

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Lars-Berno Fredriksson

KVASER AB, Sweden 010423

Introduction

The Bluetooth market for items used in cars will be substantial. People spend more and more time in their cars and expect to use this time in a positive way, either for work or for pleasure. The car will be an extension of home and office. We can foresee a most complex BT environment in the car with a high density of BT units requiring virtually all services offered at home and office plus vehicle specific services, e.g., car operations like door locking, seat adjustments, etc. as well as car diagnostics. It will take several years before we see the complete BT vehicle but the path to this goal will be passed in a stepwise manner. The first step in the infotainment area will be managing hands-free sets and within the vehicle specific area diagnostics.

Bluetooth Vehicle Architectures

Let us start with the BT vehicle architecture. To achieve the final goal, one hurdle is the available

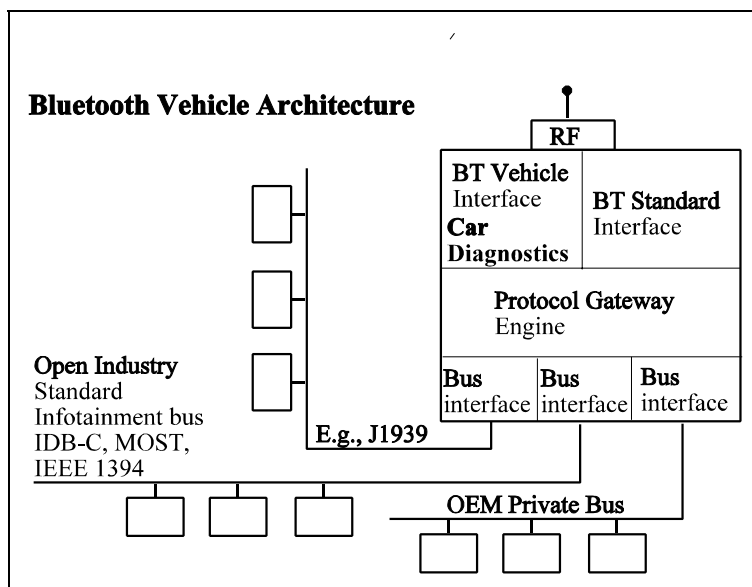


Fig. 1: Bluetooth Vehicle Architecture

bandwidth. We can assume that each person in a car will have four BT units which all can be either interfaced to the vehicle system or directly to other passenger BT units. We would then expect some twenty BT units within a small compartment, most of them working concurrently and asking for different vehicle services. This will end up in a complex scheduling task and the first attempt to solve the problem would be a single vehicle BT gateway.

The vehicle interface (VI) would take care of the service distribution within the car. Any incoming service request will be according to a BT protocol and then translated and distributed to the right internal bus in the vehicle. There are different

busses for different purposes, e.g., CAN high and low speed busses for vehicle related services, MOST for audio, IEEE 1394 and USB for PC, etc.

Diagnostic information can be carried on different busses and today each of them has one or more protocols for diagnostics, all with language and manufacturer related flavors. There is an ongoing work to standardize a generic set of bus independent messages for diagnostics, the ISO/WD 14229. This will be used at the application level and a communication level will adapt the contents of messages to the respective transmission protocol. BT will be one of these in parallel with others, e.g., ISO 15765 for CAN.

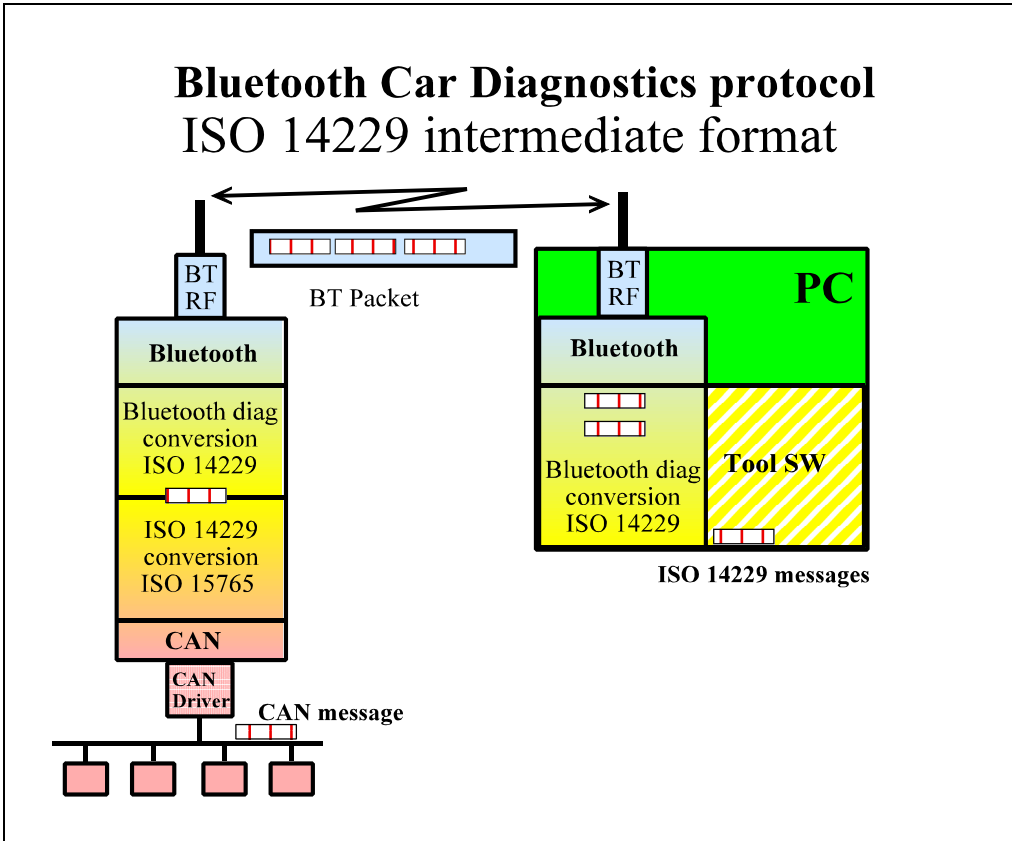


Fig. 2: A CAN-Bluetooth route for diagnostic messages

The ISO 14229 can then be used as an intermediate format in gateways between different communication systems. A CAN-Bluetooth route could then look as follows:

1. A PC application would generate a diagnostic service request according to the ISO 14229 standard
2. The request will be packeted into BT packets by the BT car diagnostics protocol firmware and transmitted.
3. The vehicle BT unit receives the packets and present the request to the gateway application as an ISO 14229 message

4. The Gateway application transforms into an ISO 15765 CAN message and transmits it on the CAN bus
5. The ECU receives it and responds with an ISO 15765 message
6. The Gateway application receives the CAN respond message and transforms it into an ISO 14229 respond message
7. The Gateway application turns the ISO 14229 message into a BT message and transmits it
8. The PC BT application receives the BT message and presents it to the diagnostic application as an ISO 14229 respond message

An advantage of this solution is that it is generic. The applications do not get involved with the communication. A disadvantage is that the applications have no control of timing as this is inherently depending on the communication layer. Further drawbacks are:

- Lack of accepted standards. ISO/WD 14229 is still in working draft status and the parallel work in the BT SIG has just started.
- There are some open issues to be solved:
 - Should several diagnostic tools be supported in parallel?
 - What priority should a diagnostic tool have in comparison with other services as phone calls, audio, etc.?
 - A standardized connection method has to be developed, not only for diagnostics but for all other services. Different services will require different levels of access control and security.
- The BT Vehicle node will be very complex, handling not only vehicle specific tasks as a set of control commands for locks, mirrors, seats, etc. plus diagnostics but also the administration of substantial set of services related to home and office. The Vehicle Interface has to have RTOS qualities.

The development of a BT standard subset for vehicles is a tremendous task, but there are no reasons not to believe that the combined forces of BT SIG and AMI-C will succeed in due time. They are backed not only by the leading car, telecom, chip and PC companies, forming the strongest industrial consortium in history, but also by small high-tech niche companies like Kvaser, contributing with peak competence in different areas.

A short time alternative

Most car diagnostic today is done via CAN. A laptop diagnostic tool is connected to the selected CAN bus in the car. Due to high realtime demands, most advanced diagnostic PC tools communicate with the CAN bus via a PCMCIA slot. This solution has some drawbacks:

- The PCMCIA connector is fragile
- The CANbus connector is most often at the wrong place, making the use cumbersome
- The PCMCIA board is expensive

Thus, a wireless connection would be highly appreciated.

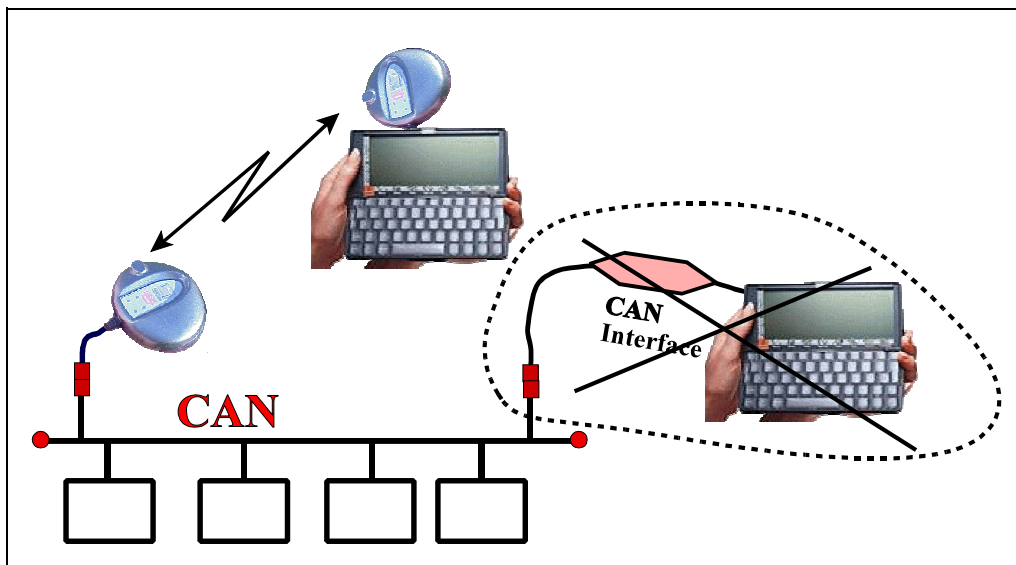


Fig. 3: Current CAN diagnostic tool connection substituted by Bluetooth cable replacement.

While waiting for a generic BT solution, Kvaser has chosen to adopt a cable replacement architecture. Here, we are using existing CAN based diagnostic applications. Bluetooth is used for establishing a connection between the diagnostic tool and the targeted vehicle system. Currently the Kvaser device only supports the Generic Access Profile and each pair has a bonded link. This means that they respond on inquiries by their Bluetooth address but nothing more happens. As there is no Bluetooth profile or service defined for neither car diagnostics nor CAN messages, there is nothing else to do. That is also why we have made the “real” connection very simple: After powering up, the master unit starts paging for the slave unit. After powering up, the slave unit just waits to be paged. Once the connection is established, the Bluetooth link will be transparent for CAN messages. The CAN messages are picked up from the bus and wrapped up into Bluetooth packets on the transmitting side. On the receiving side they are unwrapped and presented as CAN messages again.

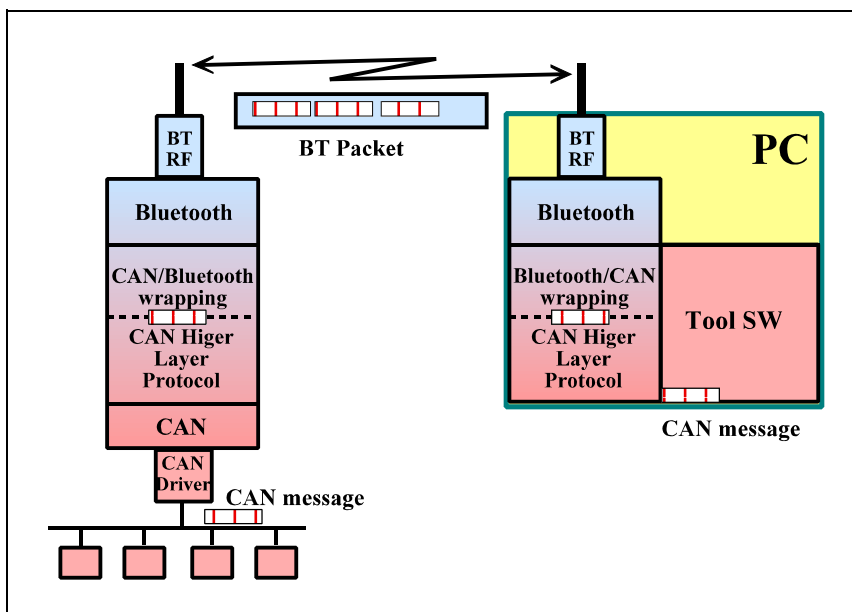


Fig. 4: Cable replacement architecture of a connection between a CAN tool and a CAN system via a Bluetooth link

For the time being, this simple solution is quite sufficient. It allows us and our customers to gain practical experience of Bluetooth communication, and this is urgently needed. The current version is deliberately made rather big in order to minimize antenna and positioning problems. We have also a smaller version that can be equipped with either an internal or an external antenna.

Some practical experience:



Fig. 5: WaveCAN unit for testing and evaluation of Bluetooth/CAN properties

- With the design shown in fig. 5 and 1mW output power, we have measured a range of 10m, 15m, 40m and 80m respectively with four different antennas of the same type, all “look alike,” and designed for the 2.45 GHz band, by just changing the antennas.
- When using a standard Bluetooth baseband protocol implementation, expect a low net data throughput, a considerable latency and jitter.
- A Bluetooth connection can be very reliable and insensitive to noise.
- Temperature range can be a problem. Already 50°C can be challenging.



Fig. 6: A smaller version of the WaveCAN concept

- Antenna design and the surroundings around the Bluetooth unit are often critical for range and coverage. The smaller unit, the more sensitive.

Due to the lack of high temperature RF components, this solution is mainly feasible for development work. It is used when testing cars and in the workshop for collecting data as well as a testing platform for future Bluetooth applications in cars. It serves well for these purposes.

What is in the crystal ball?

Although the hype is in Infotainment, most probably the first Bluetooth car applications will be within diagnostics. The first generation will be proprietary solutions for the factory, integrated with the production system. The technology for this is already available. The second generation will be a similar solution for service workshops with one detachable unit connected to the bus in the car and the other unit a laptop or a PDA. The third generation will be the first one we will see in serial produced cars. By then we have both a Bluetooth standard for diagnostics and components according to automotive specifications.

Summary

- There will be a Bluetooth standard for car diagnostics, but it will take some time
- There will be components for automotive temperature range, but it will take some time
- The first car diagnostic applications will be proprietary for development use in cars and workshops followed by us at car production lines
- The industry will gain a lot of experience from these first applications. Such experience is urgently needed for a success of Bluetooth in cars at the end of the day