Wireless Communication in Car

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Abstract—The evolution in mobile and wireless communication technology allows passengers and drivers in vehicles to use the Internet while they are on the road. Built-in equipment in cars or trucks can easily access travelling-related dynamic information, such as the current situation on the roads, weather forecasts, or information on local points of interests. However, personal information of the vehicle’s passengers — which could be also very useful for their travel — is usually distributed over various different devices, such as PDAs, PTAs, cellular phones, or laptops. Thus, this information is not easily accessible by the driver or the built-in equipment. In this paper, we envision future scenarios that might come up if those devices within a vehicle are able to communicate and interact with each other. Therefore, we discuss the characteristics of wireless infrastructure-based and ad-hoc networks for communication between mobile devices in vehicles in order to establish a local and integrated information system. Wireless communication systems are very interesting for communication in vehicles as the heterogeneity of devices bring a plethora of different plugs and interfaces for wired communication. We describe the Bluetooth de-facto standard in detail, which is one encouraging technology for those future scenarios. Bluetooth is a communication technology that is basically optimized for communication between small devices in mobile and wireless ad-hoc networks.

I. APPLICATIONS AND SCENARIOS

Within vehicles, we currently see the trend that several devices work together in an integrated fashion, resulting in new services as demonstrated by the following three examples:

• With the combined usage of the navigation unit and a RDS/TMC or DAB car radio supplementing traffic information, the driver can be guided to the desired destination by avoiding congested roads.

• Combining car radio and cellular phone, the car radio mutes the loudness and can be used for hands-free telephony. Note that this is a necessary and important feature for cars as drivers are not allowed to use their cellular phone while driving in most European countries.

• Together with the vehicle’s positioning system, a cellular phone can be used for on-demand emergency assistance. The system sends the position of a car having an accident and other information such as impact speed, airbag and engine status, etc. to a service center which organizes help for the driver.
II. COMMUNICATION TECHNOLOGIES

In general, two alternatives are conceivable for realizing wireless communication between mobile devices: infrastructure-based networks and ad-hoc networks. In order to deploy an infrastructure-based network, an access point (AP) must be set up within the car. The AP is usually integrated in the communication platform, which is the gateway to the Internet. Each device is connected to the AP and is able to exchange data with other mobile devices only via the AP. At the moment, there are several technologies for infrastructure-based wireless networks, e.g. IEEE 802.11 or DECT. However, this kind of network is not well adapted for communication between the devices in vehicles. First, the network must be configured, i.e. each device must receive a valid IP-Address. This could be achieved by manually configuring the network settings of each device or by using the dynamic host configuration protocol DHCP. Note that in the case of using DHCP, each networking device must be registered in the DHCP server which also results in manual administrative work. Second, infrastructure-based technologies are mainly optimized for local area networks with high bandwidths (e.g. up to 11 Mbit/s for IEEE 802.11) and, thus, waste the scarce energy resources of small devices. Additionally, the logic for controlling the hardware needs much space for the integrated circuit. Third, the hardware of current technologies is rather expensive or not available for many different types of mobile devices such as PDAs or mobile phones. Alternatively, ad-hoc networks seem to be well suited for communication within vehicles. Those networks do not rely on an infrastructure and can be set up quickly, as the mobile devices are able to organize the network themselves. Thus, ad-hoc networks provide the high flexibility that is needed for the scenarios described above. Communication can be realized via infrared light (using IrDA [6]) or via radio technology. Although IrDA is a very cheap and wide-spread technology, infrared light has several disadvantages: it allows only an establishment of peer-to-peer connections, it requires a line of sight between each device, and the communication characteristics depend mainly on the environmental situation. In contrast, radio communication does not have those limitations. Especially on lower frequencies, a direct line-of-sight is not needed for communication by providing relatively high data rates (up to 11 Mbit/s using, e.g., IEEE 802.11). An upcoming technology for radio communication is Blue-tooth [7], which addresses the specific requirements of mobile devices: it should be cheap (when available, about $3 per transmitter) and built-in in almost every electronic device, it is very robust against environmental influences, and it supports various kinds of communication scenarios, e.g., asynchronous data transfer or synchronous links for multimedia data. Currently, the first Bluetooth-enabled products are available, and lots of new products and services are announced by industry.

III. BLUETOOTH

Bluetooth offers two basic service types: a synchronous connection-oriented link and an asynchronous connectionless link. SCO (Synchronous Connection-Oriented Link):

- SCOs are symmetrical, circuit-switched point-to-point connections with a data rate of 64 kbit/s, which is achieved by reserving timeslots at fixed intervals. For reliability, no forward error correction (FEC), 2/3 FEC, or 1/3 FEC can be dynamically selected (the 1/3 FEC is as strong as the FEC for the packet header and triples the amount of data). This type of connection can be used for, e.g., telephony services.

- ACL (Asynchronous Connectionless Link): Data applications typically require asymmetrical packet-switched point-to-multipoint links. Data rates in this mode are either up to 432.6 kbit/s for symmetrical links or up to 721.0 kbit/s (57.6 kbit/s in the other direction) for asymmetrical links. Bluetooth can support a single ACL, three SCOS, or one ACL and one SCO at the same time.
IV. APPLICATION PROFILES

Although the core standard of Bluetooth covers the technical aspects of communication, the Bluetooth Consortium thought about typical user scenarios for deploying Bluetooth technology. Their work is published in a separate document and comprises 13 application profiles.

- Generic Access Profile: This profile defines generic procedures for discovering Bluetooth devices and link management aspects of the connection to other Bluetooth devices. It also defines procedures for different security levels. Thus, this profile is needed for forming and organizing piconets and scatternets by finding other Bluetooth devices within the communication range.

- Service Discovery Application Profile: This profile defines the features and procedures to discover services provided from (other) Bluetooth devices and retrieve any desired available information pertinent to these services. Using this profile, a Bluetooth device can expose its capabilities to other devices, such as a dial-up networking functionality.

- Cordless Telephony Profile: The so-called 3-in-1 phone use case is supported by this profile. It covers the features and procedures that are required for interoperability between different units active for those devices. 3-in-1 phones provide a solution for three modes of operation to cellular phones: First, Bluetooth can be used as a short-range bearer for accessing telephony services in fixed networks via a base station. I.e., the user can use the cheaper fixed network for telephony instead of the expensive cellular infrastructure. Second, Bluetooth can be also applied to set up calls between two terminals (e.g., for wireless telephony) in small office environments. Third, Bluetooth enabled devices can access supplementary services provided by the external network.

- Intercom Profile: The Intercom Profile defines the requirements for Bluetooth devices necessary for supporting the intercommunication functionality within 3-in-1 phones.

- Serial Port Profile: This profile defines the requirements for Bluetooth devices necessary for setting up and maintaining a connection between two devices.

- Headset Profile: In order to support headsets, this profile defines the requirements for Bluetooth devices that are necessary for this scenario.

- Dial-up Networking Profile: This profile defines the requirements for Bluetooth devices necessary for the support of dial-up networking functionality. This allows mobile users to connect to a modem of their Internet Service Providers (ISPs).

- Object Push Profile: This profile specifies the application requirements for Bluetooth devices necessary for exchanging objects (e.g., vCards) to other devices.

- Fax Profile: Fax functionality of Bluetooth devices is covered by this profile.

- LAN Access Profile: Devices supporting this profile will be able to access local area networks. First, the LAN access Profile defines how Bluetooth-enabled devices can access the services of a LAN using PPP. Second, it shows how the same PPP mechanisms are used to form a network consisting of two Bluetooth-enabled devices.

- Generic Object Exchange Profile: This profile defines the requirements for Bluetooth devices necessary for exchanging various types of objects, such as vCards (business cards objects) or vCal (calendar objects). File Transfer Profile: This application-level profile defines the application requirements for Bluetooth devices necessary for transferring files from one device to other devices.

- Synchronization Profile: This profile defines the requirements for Bluetooth devices necessary supporting the synchronization of applications, such as PIM data (Personal Information Manager, e.g. schedules, phone books, address lists, memos, task lists, etc.).

V. CONCLUSIONS

The trend of integrating new services in vehicles increases rapidly. Meanwhile, car radios have evolved to small communication centers, offering dynamic route guidance, access to Internet services, or on-board emergency assistance. As mobile devices become more and more popular, users wish to integrate them into their vehicles, as those devices also contain information useful for traveling. In order to enable those devices to communicate with each other, we showed that ad-hoc networks based on wireless technology are very interesting, as they are organize and configure them. Bluetooth is one of the emerging communication technologies for realizing ad-hoc networks – not only within vehicles – and it will help that the vision of mobile information centers on the road will become true.

REFERENCES


