Chapter 39
Seamless Communication to Mobile Devices in Vehicular Wireless Networks

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ABSTRACT

Vehicular networks are deployed as hybrid networks, which consist of a cooperation of different radio access networks. Seamless communication in vehicular networks relies on proper network planning and thorough dimensioning of network protocols. Both are assessed and verified by simulation. In transportation networks, the location of the mobile devices and their pattern of movement are very important. Therefore, different mobility models suited to vehicles in transportation networks are introduced. Then, the need for location information is exemplified. Mobility models and location play an important role in the verification of handover protocols. One hybrid handover protocol is given in detail. It provides low handover latency with additional mutual authentication to allow the transfer from one radio access network to another while maintaining the network's built-in security standard. This protocol is easily extensible to include a broad variety of networks.

VEHICULAR WIRELESS NETWORKS

Wireless networks for vehicular communication and communication in transportation systems attract interest from different stakeholders for several reasons. Operators want to establish a new market, governmental authorities want to provide roadside assistance and active traffic management, and transportation authorities look for better fleet management and cost reduction. The different interests of the different stakeholders result in sometimes contradictory constraints. At the same time, high investment costs prevent the simultaneous installation of different redundant wireless networks as well as the setup of a complete new network. Most likely, existing networks will be used wherever possible.

From the different interests described above, very different requirements arise. Among them are reliability and availability, kind and amount of data to be transmitted, frequency and tolerable delay of transmission, needed security level, speed,

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mobility profile of the devices and cost (cf. chapter Communication Networks for Transportation Systems). Nevertheless, some requirements are mandatory for any vehicular communication. As the mobile devices (MDs) move fast, they will change network access points (NAPs) frequently. Therefore call setup and handover have to take place with a very small delay. Handover is the unnoticeable forwarding of a call from one network access point to a neighbouring network access point due to movement of the mobile device. The call setup needs to be finished before the mobile device leaves the coverage area of the network access point. The handover needs to be even faster, as it has to take place while the mobile device is in the overlapping coverage area of two network access points.

Besides, many of the intended services, such as e.g., roadside assistance, deal with sensitive data, e.g. road condition, traffic light status, position for fleet management and emergency assistance. These data must be protected against malicious attackers. Privacy, confidentiality, availability, and integrity are major concerns when designing the security mechanisms. The system needs information from the vehicles about road, traffic and vehicle condition while at best the mobile device should not be traceable. Thus, the systems shall provide security mechanisms, e.g., encryption and integrity protection. In addition, the access to the network should be restricted to avoid man-in-the-middle attacks. This can be done by authentication. Furthermore, some of the scenarios may require a certain data rate or a certain quality of coverage. Also, the accounting has to be taken into consideration if the network will not consist of closed user groups only. This also requires authentication to attribute the call to the correct bill.

These requirements have to be taken into account in the planning stage of the network already. As the networks are far too large to be set-up in a real-life test bed, simulation plays a major role in mobile communication network planning. The planning is aided by simulation-based planning tools, which are based on radio propagation models, mobility models, traffic data and others. The vehicular environment in transportation systems needs special simulation models to cope with the new requirements, e.g., higher speed, track-bounded movement, data protection. These models can be used to evaluate new protocols that aim for low delay and latency.

Vehicular traffic scenarios have challenges arising from the varying driving speeds, traffic patterns, and driving environments. This multitude of different movement options must be modelled. Vehicular networks will be infrastructure based when including a road side unit (RSU). Nevertheless, for seamless connectivity mobile devices or on board units (OBUs) may also form ad-hoc networks. The combination of these two types of networks has to be reflected in the planning tool. Areas where no infrastructure coverage exists may still be sufficiently covered by ad-hoc networks, depending on the traffic density. In contrast to other mobile networks, these ad-hoc and infrastructure networks provide ample computational and power resources as they are vehicle-based. Especially, this extends the range of the ad-hoc spots and has to be reflected in the ad-hoc propagation models.

Compared to infrastructure networks, additional security and scalability issues arise when wireless communication occurs directly between vehicles, ad-hoc. The hybrid structure of the network which consists of several different radio access networks (RANs), poses new authentication challenges. The security of vehicular networks can be crucial. Life-critical information must not be inserted or modified by a malicious attacker. The system must be able to determine the liability of users while still maintaining their privacy. These problems are difficult to solve because of the large network size, its hybrid structure, the high speed of the vehicles, their relative geographic position, and the randomness of the connectivity between them.