Wireless Communication Technologies for Vehicular Nodes: A Survey

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ABSTRACT

In many countries, road accidents are a leading cause of death as well as being financially draining to the authorities concerned. This problem can be alleviated by having a mechanism to enable exchange of safety related messages to road users in a timely manner. This has given rise to active research in identifying the best technology. Providing comfort and smooth driving experience is also propelling the need to support vehicular communication. These groups of applications present opposing paradigms whereby safety related messages must be exchanged in real-time and characterized by short bursts of traffic and satisfying these diverse criteria are challenging for wireless communications that is the backbone of vehicular communication. Additionally, vehicular nodes sometimes move at high speeds, presenting an added dimension to the complexities surrounding vehicular communication. This article attempts to show the many myriad wireless technologies that have been tossed about as the solution. Choosing the most suitable candidate has to take into account many aspects. This article guides stakeholders such as transport policy decision makers, vehicle makers, and spectrum allocator, to enable them to make a wise and informed decision regarding the right mechanism to use to support vehicular communication.

Keywords: Intra-Vehicle, Vehicle, Vehicle-to-Infrastructure, Vehicle-to-Vehicle, Wireless Communication

INTRODUCTION

Vehicular communications can be divided into three types, namely intra-vehicle communication (InV), vehicle to vehicle communication (V2V) and vehicle to infrastructure communication (V2I). Each category of vehicular communications presents unique challenges and constraints plus requirements making it difficult to find the best technology that can support each category well. In fact, this article will highlight among other things the fact that one glove fits all sizes scenario does not apply here. In depth analysis is provided in this article that compares each candidate technology for each communication group highlighting the differences as well as similarities in order to provide a complete picture of the candidate technologies. By
comparing technical characteristics of existing and current wireless technologies proposed for vehicular communication, this article proposes the most apt choice for supporting vehicular communication. This article is by no means complete but attempts to be as comprehensive as possible. The demands for providing efficient vehicular communication is driven by the urgency in reducing vehicle related accidents as well as ubiquitous computing mantra of providing connections anytime, anywhere, anyhow. As the requirements for vehicular applications are highly diverse, identifying the most suitable wireless technology that serves all needs will be a mammoth task. As such this article will also suggest the most suitable candidate technology for each communication group based on inherent technical characteristics and how well those characteristics can support applications unique to vehicular nodes. Therefore, the discussion and analysis provided in this article will shed some light in making that task easier for related policy makers and stakeholders. Car makers as well as authorities in charge of transportation have indicated that applications that enhances safety is a priority when building vehicles and designing transport policies (Gerla & Kleinrock, 2011). Therefore, future transportation planners and vehicle makers can use this article as a tool in making informed decisions regarding the future of intelligent transportation system.

INTRA-VEHICLE COMMUNICATION (INV)

InV refers to communication within the vehicle itself. The idea of using wireless networks for InV was first mooted as a substitution to wired vehicle because of wire length that can sometimes reach 4 km making the car substantially heavier and whereby the cost of installing and maintaining wires in vehicles maybe cost prohibitive (Ahmed et al., 2007). Modern vehicles that are equipped with increasing number of sensors need a communication mechanism that that is both lightweight and cost effective. Stringent requirements regarding latency as well as the high level of reliability expected from wireless sensor networks (WSN) deployed in vehicles makes it difficult to find a wireless technology that fits the bill. Research has been conducted as to the eligibility of three WPAN standards for this purpose, namely Bluetooth, ZigBEE and UWB. As the area of a car is contained, a WPAN standard seems like a logical choice. Inversely, the use of WLAN standard (IEEE 802.11x) for InV has been largely discredited by research done in (Ahmed et al., 2007) as having unnecessary overhead and was not designed by having vehicles as mobile nodes in mind, hence deemed as not suited for InV (Ahmed et al., 2007). Originally, Bluetooth (IEEE 802.15.1) was used as a communicating medium between the car’s hands free system and other Bluetooth devices can easily interconnect in a Bluetooth enabled car. Other more recent use of Bluetooth is as a medium to communicate with the car’s onboard diagnostics system. Bluetooth devices operate using a master and slave paradigm (Ferro & Fotorti, 2005) whereby the maximum number of slaves supported is seven (Kong, Zhang, & Ahmed, 2010). Incidentally, due to the increasing number of sensors deployed in cars, there is growing interest in implementing intravehicle wireless sensor network. More and more sensors are expected to be placed in vehicles i.e for tire pressure monitoring, parking assist, intelligent headlights and etc. The data collected by all these sensors needs to be processed and analyzed. Due to the constraints of supporting up to seven devices only, Bluetooth is not capable of supporting many sensors. Other standards that have been touted as possible candidates to provide InV are ZigBee (IEEE 802.15.4) and Ultra Wide Band (UWB/ IEEE 802.15.3) (Lee, Su, & Shen, 2007). UWB provides extremely wide bandwidth therefore rendering it less affected by narrowband interference (Richardson, Xiang, & Stark, 2006). UWB can provide bandwidth of up to 480 Mbps (Lee, Su, & Shen, 2007) and is also quite resilient against multi-path fading (Niu, Li, & Talty, 2009). Research done
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