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A Survey on Vehicle to Infrastructure Communication System

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Abstract: *Vehicle-to-Infrastructure (V2I) Communications for Safety is the wireless exchange of critical safety and operational data between vehicles and roadway infrastructure, intended primarily to avoid motor vehicle crashes. Vehicle-to-infrastructure (V2I) communication based on wireless local area network (WLAN) IEEE 802.11 standard technology can support user in-motion to achieve preferable Internet connectivity. This standard is created for urgent short message transmission.The IEEE 802.11 standard defines an infracture mode with at least one central access point connected to a wired network. In this paper we present an experimental study of IEEE802.11g using off-the-shelf devices in vehicle-to-infrastructure small scale scenario. In order to evaluate the V2I the type of communication in large scale scenario and intelligent transportation systems (ITS) will necessitate wireless vehicle-to-infrastructure (V2I) communica-tions. This wireless link can be implemented by several technolo-gies, such as digital broadcasting, cellular communication, or dedicated short range communication (DSRC) systems. Analyses of the coverage and capacity requirements are presented when each of the three systems are used to implement the V2I link*
Keywords: *Short Range Vehicle Network; 802.11g; wireless network; goodput; network performance; transport; mobile stations; auto traffic; vehicle speed*

I. Introduction

The demand for reduction of vehicular accidents, traffic congestions, transportation time, fuel consumption and environmental impact of road transport are essential area of research. Such vehicular communication systems are to be developed - vehicle to vehicle (V2V) in ad hoc mode and vehicle to infrastructure (V2I) with fixed nodes along the road. Wireless networking based on IEEE802.11 technology has recently become popular and broadly available at low-cost for home networking and free Wi-Fi or commercial hotspots. DSRC starting idea was to equip vehicular network nodes with off-the-shelf wireless technology such as IEEE802.11a. This technology is cost effective and has potential to grow and new versions were recently produced. The IEEE 802.11g standard promises to improve and extend most popular WLAN standards by significant increasing throughput and reach.

Nowadays dispositions of WLAN-based access technology are predominate to stationer indoor and outdoor users who are most slowly moving and in range limited. Despite the fact that the standard has been developed not for fast dynamic usage, nothing limits it to be evaluating for vehicular communication systems. Motivation is to understand the interaction between the vehicle speed and goodput of WLAN-based network.

Realizing field trials for goodput evaluation of vehicular wireless communication systems is very difficult and costly because many vehicles and communication equipments need to be involved, and also many experimenters need to be employed. Given such problems, it is highly desirable to obtain mathematical description of process with real data from small scale scenarios of practical measurement results and performance evaluations prior conducting field trials as it is made in this work.

This paper is constructed as follows: After introduction the problem in Section 1, Section 2 provides the performance of WLAN depending on number of active users. Then, in Section 3 provides the performance of WLAN depending on distance to access point and performance evolution of practical results. After then, in Section 4 WLAN goodput variations depending on vehicle speed and Doppler spread. In section 5 we discuss multiple standards used in V to I communication and further section 6 we will discuss implementation of wireless V to I infracture the several technologies used and their comparision & lastly conclusion.

Related Work:

In [1] the authors describe the various wireless links for V-I infrastructure communication systems. In [2] the authors discuss various 802.11 standards. In [5], the authors describe a multi-homed mobile access router (MAR) for on-the-move Internet access. MAR is capable of aggregating multiple wireless access links for seamless handoff, throughput improvement and fault tolerance. While MAR is capable of utilizing different wireless links, there lacks a comprehensive, user-policy driven interface selection mech-anism. Our interface selection algorithm fills that void. More broadly, our optimization framework is independent of the underlying mobility protocol and can be used for MAR or other systems using other mobility protocols such as Mobile IP

(MIP).

In [6], the authors investigate WiFi augmentation of 3G in mobile environments for data offloading. Data is transmitted on WiFi instead of 3G whenever WiFi and predicted future WiFi encounters can satisfy the delay requirement of the application; otherwise, data is transmitted on 3G only. This fixed interface selection strategy does not account for user preferences over different wireless link attributes. Our proposed in-terface selection algorithm addresses this deficiency and enables dynamic strategy selection. Other work on vertical handoff, such as [7]–[13] and references cited within, lacks user-specified preference input, or performs one-time optimization that fails to account for future AP encounters, or relies on fixed interface switching strategies.

Goodput variation depending on number of active users :

Goodput : The number of useful information bits, sent from source of information through the network to a certain destination, per unit of time. This useful information is a amount of data which exclude protocol overhead bits as well as retransmitted data packets. If a file is transferred, the goodput that the user experiences correspond to the file size in bits divided by the file transfer time. The goodput is lower than the throughput, which generally is lower than network access connection speed (the channel capacity or bandwidth).

To evaluate goodput of WLAN in stationary mode depends on a number of active users several experiments are made experimental results we derived the maximal goodput (18Mbps) of the network with one active user. The number of active users we increased one by one. We note that the average goodput values are depending on number of active users.

Goodput variation depending on distance to access point:

It is clear that wireless network goodput depends on distance to the access point. 802.11g standard uses OFDM and Complementary Code Keying (CCK) to support higher raw data rate "over the air" (up to 54 Mbps) and rate in MAC Layer (up to 25 Mbps). OFDM is a multi-carrier modulation which converts single high-rate bit stream to low-rate 64 parallel bit stream. Each sub-carrier can be modulated by binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), 16-symbol quadrature amplitude modulation (16QAM), 64-symbol quadrature amplitude modulation (64QAM). Wireless network goodput depends on which modulation is used.

There are three different goodput meanings. The first can be called overall, the second - conditional goodput and the third – individual goodput. In Fig 5a conditional goodput on 100 m distance from the access point for two users is 6 Mbps, but average individual goodput is only 3Mbps. Conditional goodput mean AP goodput when it serves a certain number of active users. Conditional goodput is less than overall, because AP is involved in the control process with some user stations. Overall goodput can be found when only one client connects to the AP and there are no overheads in the wireless network.

Short range vehicle network goodput depends on mobile station speed. It can be found experimentally using mobile station and IxChariot program. Experiments should be made at vehicle different speeds. Of course there should be more than one access point, because the vehicle will be in one access point zone for a short time on high speed. Wireless Distribution System (WDS) can connect some routers in one network without wires. There were used three routers in the experiment [3]. In Fig.6 shows the goodput dependence from different speeds of the vehicle. As WDS was used significant loss can be seen in left and right zones of the graph. Red point on the graph shows static results in different points of the route.

Theoretically and experimentally proved that IEEE 802.11g equipment with OFDM technology is insensitive against frequency shifting that cause power leakage between OFDM subcarriers on different vehicle speeds. But on the speed 75 km/h the signal can be dropped at all.

Various Standards used:

Wireless local networks are designed to support mobile computing in small areas such as building, park, airport, or office complex. The IEEE 802.11 standard defines an infrastructure mode, with at least one central access point connected to a wired network, and an *ad hoc* or *peer-to-peer* mode, in which a set of wireless stations communicate directly with one another without needing a central access point or wired network connection.The main attraction of WLANs is their flexibility. They can extend access to local area networks, such as corporate intranets, as well as support broadband access to the Internet—particularly at "hot spots," public venues where people tend to gather. WLANs can provide quick, easy wireless connectivity to computers, machinery, or systems in a local environment where a fixed communications infrastructure does not exist or where such access is not permitted. These hosts can be stationary, handheld, or even mounted on a moving vehicle.

Bandwidth considerations have thus far been secondary in WLAN design and implementation: The original 802.11 standard allowed a maximum channel bit rate of only 2 megabits per second, while the current 802.11b standard commonly known as Wi-Fi (for "wireless Fidelity")—supports an 11-Mbps maximum rate. However, the widespread deployment of 802.11a and 802.11g standards, which allow a bit rate of up to 54 Mbps, will pave the way for new types of mobile applications, including m-commerce transact

tions and location-based services.

As Table 1 shows, there are a number of IEEE 802.11 standards. One major problem is spectrum availability. The industrial, scientific, and medical (ISM) bands have always been the first choice, with 802.11, 802.11b, and the emerging 802.11g standard all sharing the 2.4-GHz radio band. However, because ISM frequencies are designated for unlicensed commercial use, users can experience significant interference in some locations from ambulances, police cars, taxicabs, and citizen's band radios as well as from other users and many household and office devices operating in ISM bands. The demand for higher bit rates has
led to the consideration of wider as well as less crowded bands for WLANs. IEEE 802.11 a for ex: uses 5 GHz band, but because all other working versions of 802.11 use the 2.4 GHz band, backward compatibility is an issue.

Dual band LAN adapters that allow access to both 802.11a and 802.11b are one possible solution but are not widespread. IEEE 802.11g, which is expected to become a standard later this year, will be somewhat compatible with 802.11b – it uses the same 2.4 GHz band and provides the igher bit rates of 802.11a but has a different ransmission method. Many vendors,including Apple, are already offering 802.11g-based systems.
The choice of spectrum likewise affects power equirements and range. For example, 802.11a signals would require significantly more power than
2.4-GHz WLANs to cover the same hot spot; using the same amount of power, they would need more access points, which may not be economically feasible for some carriers. Many physical layer enhancements—including coding, better antenna design, and energy-efficient LAN protocols—can
reduce, but not eliminate, power requirements at higher frequencies.

The IEEE 802.11 standard allowed three different ways to transmit data over the wireless channel—frequency hopping spread spectrum (FHSS), digital sequence spread spectrum (DSSS), and infrared—but other versions have focused on a single method of transmission. For example, 802.11b only allows DSSS, while 802.11a uses orthogonal frequency division multiplexing (OFDM), a technique that uses up to 52 carriers to transmit data from a single source to achieve a 54-Mbps channel bit rate.

In addition to multiple 802.11 stan-dards, there are other standards for WLANs such as the European Hiper-LAN2. Although designed for similar environments, these standards differ in frequency, bit rates, power require-ments, and coverage.

Various Transmission Technologies:

The problem of ensuring timely and reliable communication amongst vehicles and infrastructure elements remains a central issue in the development of V2I systems. In order to imple-ment this link, various wireless transmission technologies can be deployed, either in isolation or as a complimentary mix of multiple, coexisting technologies. In this work we explore the feasibility of V2I communication based on the three major classes of wireless transmission technologies that are currently considered for ITS, namely:

- Digital Broadcasting: Digital Video Broadcasting-Handheld (DVB-H),
- Cellular systems: Universal Mobile Telecommunications System (UMTS), and
- Dedicated Short Range Communications (DSRC): Wire-less Access for Vehicular Environments (WAVE).

Table 1. IEEE 802.11 WLAN standards.

Standard	Spectrum	Maximum physical rate	Layer 3 data rate	Transmission	Compatible With	Major disadvantage	Major advantage(s)
802.11	2.4 GHz	2 Mbps	1.2 Mbps	FHSS/DSSS	None	Limited bit rate	Higher range
802.11a	5.0 GHz	54 Mbps	32 Mbps	OFDM	None	Smallest range of all 802.11 standards	Higher bit rate in less-crowded Spectrum
802.11b	2.4 GHz	11 Mbps	6-7 Mbps	DSSS	802.11	Bit rate too low for many emerging applications	Widely deployed; higher range
802.11g	2.4 GHz	54 Mbps	32 Mbps	OFDM	802.11/ 802.11b	Limited number of colocated WLANs due to narrow Spectrum	Higher bit rate in 2.4-GHz spectrum higher range than 802.11a

The results we present for DVB-H are in fact general and apply equally well to any digital broadcasting systems.

The deployment of any of these technologies requires pre-cise parameterization of the wireless system in question (e.g. density and location of roadside units, power levels, spectrum allocation, etc.), in order to balance meeting the requirements
of the V2I system with minimizing the rollout and operational costs. Hence, estimating the requirements of the V2I system, both in terms of coverage and capacity, is a critical step in its deployment.

Comparative Analysis:

1) **Multiple Standards**
2) **Capacitive Analysis for three technologies :**

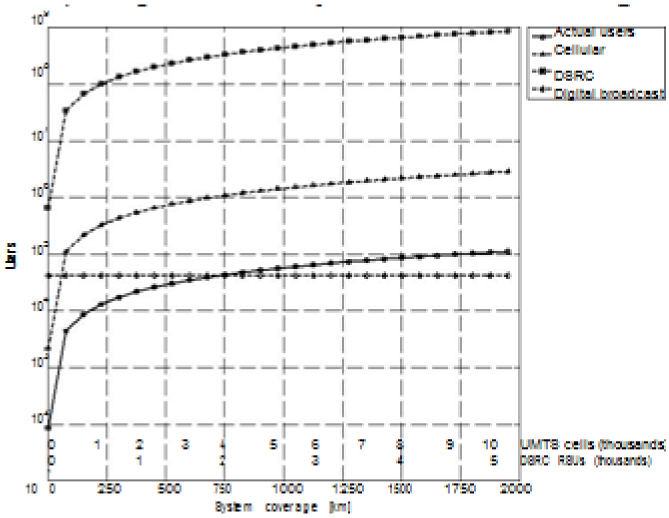

Fig. 11

The three presented systems – namely digital broadcast, cellular, and DSRC systems – each have different limitation s which need to be considered in designing the proposed ded-icated V2I link. Each of these systems has been shown to be either capacity or coverage limited. A summary of these results is given in Table XIII.

For capacity limited systems, the critical design parameter will be the number of users in the system and in the local segment, so that the ability of the system to simultaneously support all the users with all the services within the required time limits can be achieved. For coverage limited systems, the critical design factor will be the range achieved by the infrastructure, so that sufficient coverage can be achieved .

It has been shown that digital broadcast systems are not coverage limited, but are severely capacity limited. For a given bandwidth which has been assigned to the dedicated V2I link, the system can support up to a certain critical number of users, and no further rollout of infrastructure can alleviate this situation. This is not the case with cellular and DSRC systems.

We have also shown that the UMTS DCH scheme imposes a severe limit on the sustainable number of users. In high density areas, i.e. traffic jam scenarios, the cell coverage is strictly limited by the capacity requirements, where up to 8 bi-sectorial cells would be required per segment. It was also shown that the UMTS MBMS scheme greatly mitigates such a problem by means of a real multicast/broadcast transmission. Notably, we did not consider the uplink capacity in our analysis. In theory the uplink capacity eventually saturates due to acknowledgement packets from an increasing number of users. However, due to the fact that only a limited number of services requires acknowledgement packets, and that these packets are only a few bits long, the uplink saturation point is far from reachable in the given scenarios.

Finally, it has also been shown that DSRC systems are coverage limited, where up to 4 RSUs would be required to provide complete coverage in the given scenarios. It should be
noted that under these conditions, the deployed DSRC system has ample capacity to support both a growing number of users and a growing complexity of future services.

An illustration of how each of the three system types scales with the growing size of the overall system is shown in Figure 11. The system coverage, i.e. the length of road network covered by the system, is shown on the horizontal axis, as measured in kilometers. On the verticals axis, the number of users is plotted for each curve.

Firstly, the curve labeled *Actual users* shows how many users will in fact be present in the system, given the parameter values shown in Table XIV, representing traffic flowing freel y and uniformly through all the segments in the system. For a detailed description of each parameter, see Section III-A.

The curve labeled *Digital broadcast* represents the maxi-mum number of users that can be supported by a digital broadcast

System	Limitation
Digital broadcast	Capacity (available bandwidth)
UMTS DCH	Capacity (8 cells/segment)
UMTS MBMS	Capacity (Uplink eventually saturates)
DSRC	Coverage (4 RSUs/segment)

TABLE XIII
SUMMARY OF COVERAGE AND CAPACITY LIMITATIONS

Parameter	Value
Segment length **l**	1500 m
Number of lanes **m**	6
Speed **v**	80 km/h
Occupancy **o**	0.5
Number of services **n**	8
Length of a vehicle L_{VEH}	7.5 m
Following tempo $T_{F\ OL}$	2 s
Fundamental data volume **b**	400 bits
Service activity **a**	(0.02, 0.03, 0.03, 0.07, 1, 1, 1, 1)
Update period **P**	7 s

TABLE XIV
PARAMETER VALUES FOR THE CROSS -SYSTEM COMPARISON

systems using the same parameters given in Table XIV and assuming the data rate available to this system is 10 Mbps. As shown in Section III-B, the number of supported users does not grow with any rollout of new infrastructure and hence does not scale with the system coverage. It can immediately be noted that this digital broadcast system saturates at the coverage of approximately 750 km, and at larger system sizes cannot support all the existing users.

Using the same parameter values in Table XIV, the number of users that can be supported by a UMTS DCH system, with 8 bi-sectional cells per segment, is represented by the curve labeled *Cellular* in Figure 11. Although the UMTS DCH system is capacity limited, and hence designed to support the actual number of users present in the system, its curve is more than one order of magnitude higher than that of the actual users. This is due to the fact that the system must be over-designed, to support high stress situations (accident, traffic jam) in any of its segments.

Finally, the curve labeled *DSRC* represents the number of users that can be supported by a DSRC system with 4 RSUs per segment. It can easily be noted that this curve exceeds the number of actual users in the system greatly, by almost 4 orders of magnitude. This is due to the fact that DSRC systems are coverage limited, and not capacity limited, as was shown in Table XIII. In other words, the design of this system is governed by providing adequate spatial coverage and provides ample capacity which can be exploited by future additional services on the dedicated V2I link.

II. Conclusion :

In this paper have been analyzed the data communication performance of user in vehicles to obtain Internet connectivity. In particular, the measurements indicate that the goodput in the short range vehicle network is dependent of many factors: (1) number of active users; (2) the distance between vehicle and roadside wireless access point;

(3) velocity of active user. Realizing of large scale field tests for evaluation of short range vehicular network is very difficult and costly, because many vehicle and communication equipment need to be rented or procured. This model is able to quantify the impact auto traffic parameters on the goodput of short range vehicular network.

Analyses of the coverage and capacity requirements of digital broadcasting, cellular, and DSRC systems for the implementation of V2I communications have been presented. Digital broadcasting systems have been shown to be inherently capacity limited and not to scale appropriately. In every case, such V2I systems have been shown to scale well and be capacity limited. A direct quantitative comparison has also been presented, showing the scaling behavior of all three types of systems with the number of users and geographical coverage.