Toll collection and speed monitoring system using RFID

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ABSTRACT *: Radio Frequency Identification (RFID) is an auto identification technology which uses Radio Frequencies (between 30 kHz and 2.5GHz) to identify objects remotely. The automated toll collection system using passive Radio Frequency Identification (RFID) tag emerges as a convincing solution to the manual toll collection method employed at tollgates. Time and efficiency are a matter of priority of present day. In order to overcome the major issues of vehicle congestion and time consumption RFID technology is used. RFID reader fixed at tollgate frame (or even a hand held reader at manual lane, in case RFID tagged vehicle enters manual toll paying lane) reads the tag attached to windshield of vehicle. The object detection sensor in the reader detects the approach of the incoming vehicle's tag and toll deduction takes place through a prepaid card assigned to the concerned RFID tag that belongs to the owners' account. This makes tollgate transaction more convenient for the public use. A system which does the job of detecting, billing and accounting for vehicles as they pass through a tollgate using RFID as the identification technology. The system is a great investment in the transport industry. It reduces the common hustles in accounting for the movement of goods from point to point. An RFID tag is programmed with information in the form of an Electronic Product Code (EPC), which can be read over a considerable distance so that its contents identify the vehicle and enhance a transaction to be undertaken with respect to the specific tag identity taking advantage of radio frequencies ability to travel longer ranges with better data capacities and high speed attained with maximum accuracy.*

Keywords – Electronic Toll Collection (ETC) , On board Unit (OBU) , Road side System (RBU) , Radio Frequency (RF) .

I. INTRODUCTION

There are two major types of electronic-toll-collection (ETC) systems currently used in the world, namely single lane and multilane free flow. It is well known that multilane free-flow systems represent much greater complexity than single-lane systems, but the former is more convenient for faster traffic throughput, especially in high-traffic-loading areas due to less restriction on vehicle passing speed. For communication between roadside units (RSU) and on board units (OBU) in ETC systems, there are several different media being utilized, such as 900-MHz, 2.4-GHz, and 5.8-GHz microwave based on dedicated short-range communication (DSRC), as well as 870-nm infrared. For ETC applications, a sufficient communication time interval is necessary to allow for the complete transfer of all the information between a roadside unit (RSU) and an on-board unit (OBU) while the vehicles are rapidly traveling through the communication region. However, for windshields with high infrared attenuation, the problem of severe shrinkage of the communication region is very serious [1], in particular, for vehicles at high speed.
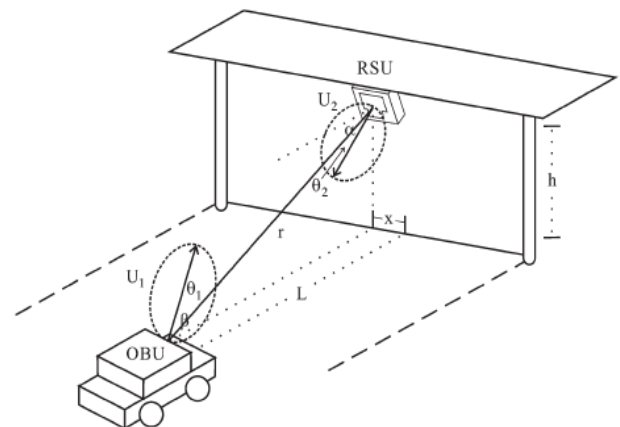
II. MODELING

Figure 1: Block Diagram of monitoring the vehicle

In figure 3, vehicle monitoring is shown. In order to simulate a complete ADS[2], we have to model the different

subsystems [3]. In this paper, we are only interested in the communication subsystem: the link between the microwave antennas at a gantry above the road (RSS) and the small patch antenna (OBU) in moving vehicles. Via this link, a certain fee that has to be paid for the passage is collected. When the vehicles are not equipped with an OBU, their license plate will be registered, which is a task of the other subsystems of the ADS (detection and registration). The other subsystems are out of the scope of this paper. A communication link for electronic payments has to be reliable. To prove the reliability of such a system, a detailed analysis of the occasional errors is needed. Large-scale simulations are well suited for this job. The aim of this paper is to find the right level of detail needed for such analysis.

III. SIGNAL STRENGTH RELATION

In ETC systems, the radiation power of the RSU is generally stronger than that of the OBU, so that the downlink communication region is much greater than that of the uplink. Hence, the capability of the uplink communication is crucial for data transmission. Therefore, we initially focus only on the uplink transmission. *A.Uplink Signal-Strength Relation* In a previous work, the uplink signal path under the single lane condition was analyzed [1]. The signal strength received by the RSU from the OBU emission can be described by Where $A0$ is the amplitude constant, $U1(\theta 1, \varphi 1)$ is the radiation pattern of the OBU, $U2(\theta 2, \varphi 2)$ is the receiving pattern of the RSU, and r is the distance between the OBU and the RSU. $U1$ and $U2$ are functions of the emitting direction $(\theta 1, \varphi 1)$ and the receiving direction $(\theta 2, \varphi 2)$, respectively, where $\theta 1, \varphi 1, \theta 2,$ and $\varphi 2$ are defined, following the conventional spherical polar coordinates (note that $\varphi 1$ and $\varphi 2$ are not displayed in this 2-D figure). For instance, for a typical infrared short-range communication system for the ETC applications previously discussed [1], where the half-intensity angle of the emitting module of OBU is $\Phi 1/2 = 24\circ,1$ the radiation pattern is calculated by $\cos^{7.5} \theta 1$, and the receiving pattern of RSU is a conventional cosine function calculated by $\cos \theta 2$, the relative signal strength received by the RSU and emitted from the OBU can be described by

$$S_u = 1000\frac{\cos^{7.5} \theta_1 \cos \theta_2}{r^2} \qquad (2)$$

Where we adopt an arbitrary scale (with $A0$ arbitrarily set to1000) [1]. For this arbitrary amplitude constant $A0= 1000$, the signal-strength threshold of this system can be determined by measurement [1] and was shown to be $Sth = 9$. With the aid of this signal-strength relation and the threshold, the performance of the system can successfully be analyzed [1]. The utilization of the $\cos n$ function, i.e., $\cos n$

θ, to calculate the radiation and receiving patterns is very effective.

IV. THE ARCHITECTURE

The fact that in both multilane-free-flow and single-lane ETC systems there are huge volumes of data in several simultaneous message traffic between RSUs and OBUs in all traffic lanes is without further discussion. In multilane-free-flow systems, the vehicle passing through the data-communication region in the ETC plaza may change travel lanes during data transmission between its OBU and the RSU on the previous travel lane. Because of this, the data transmission between the OBU and the RSU on the previous travel lane may very often be incomplete and must be performed consecutively by the RSU mounted on the current travel lane, into which the vehicle has entered. This is the main difference between multilane-free-flow and single-lane systems. Hence, the trajectories of moving vehicles passing through the data-communication region in the ETC plaza before, during, and after each data communication event are very important information for correctly performing ETC transactions in multilane free-flow systems. This is to say that besides the simultaneous data communication between RSUs and OBUs in all traffic lanes, we also need to track all vehicles passing through the toll-collection plaza like an active seeker in an advanced missile. The purpose of vehicle-trajectory tracking is to decide the timing for separating the whole data transmission into several segments so as to be able to communicate in contiguous traffic lanes consecutively, while the vehicles change traffic lanes. The technology of multi target tracking has been well developed in radar systems. An abundance of data-transmission techniques is also available. Now, we discuss the essence of this architecture, which combines frequency multiplexing and two techniques widely used in radar systems, including pulse ranging and fine target-direction determination.

A. Frequency Multiplexing and Wave Emission

The architecture for simultaneously performing multi target tracking and multi data communication between vehicles and the ETC system is based on the idea of using different carrier frequencies for different purposes. Fig. 2 shows an example of frequency multiplexing [9] for an appropriate frequency band arrangement among different traffic lanes. This figure illustrates that we use separate emitting antennas for each traffic lane, but only one common receiving antenna for collecting all return signals. The frequency bands utilized in different traffic lanes are distinguishable. There is a frequency discrepancy Δf between contiguous lanes. Furthermore, the carrier frequencies for target tracking and data transmission in each traffic lane are also different. The difference between them is δf.
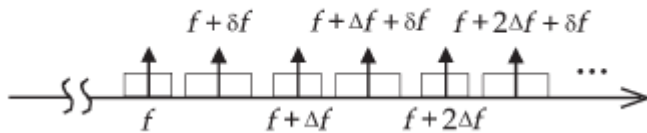
Figure 2:.Arrangement of frequency bands for simultaneously performing multitarget tracking and multidata communication in millimeter waves ETC systems.

CONCLUSION AND FUTURE WORK

The architecture presented in this paper describes a multi-free-flow of traffic using electronic-toll-collection (ETC) systems. The principle idea is that from the information of the trajectories of the vehicles passing through the ETC plaza, it has been made easy to decide the timing for separating the whole data transmission into segments so as to communicate in contiguous traffic lanes consecutively, while the vehicles change lanes. Another advantage of this architecture is that the millimetre wave range can provide a lane and it will be shown that no amount will be debited if the vehicle returns within 24 hrs. However, with such high resolution, we can also distinguish the signals reflected from different parts of a vehicle.

ACKNOWLEDGMENT

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very wide communication bandwidth to overcome the shortcoming of bandwidth deficiency present in the centimetre-wave range. Also the information regarding the vehicle and the account information also have been displayed at the receiver side. This architecture can be utilized for both active and passive on-board unit (OBU) systems, although for active systems, the circuitry of the OBU is more complicated. To realize this architecture, we allot different frequency bands to different traffic lanes, as well as to the different purposes of target tracking and data communication. With the aid of amplitude comparison and linear frequency modulation pulse compression, the target direction can be precisely determined and the resolution in the radial direction can be 40 cm. This needs a 400-MHz bandwidth for target tracking in each traffic lane. In addition to this, if we provide 90 MHz for data transmission and two 5-MHz guard bands, then the bandwidth required by each traffic lane is 500 MHz For a four-lane highway, we need a total of 2-GHz bandwidth, say, from 89 to 91 GHz. With a 40-cm resolution, it is not difficult to distinguish two cars closely in tandem Therefore, it is necessary to collect radar images of different types of vehicles by measurement in advance in this frequency range. This also shows that how a short message will be sent to the owner's mobile by using GSM regarding the amount detected for crossing a

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