International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys. 9, No.6 (Nov-2020)

http://dx.doi.org/10.12785/ijcds/090609

Tracking and Controlling High-Speed Vehicles Via CQI in LTE-A Systems

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Received 23 Jan 2020, Revised 19 Oct. 2020, Accepted 24 Oct. 2020, Published 1 Nov. 2020

Abstract: One of the most serious problems facing the community around the world is car accidents. These accidents occur mainly due to the high-speed of vehicles. Thus, the paper aims to capture, track, and control high-speed vehicles using LTE-A mobile networks to avoid high-speed situations as well as decrease the number of accidents. The paper assumes that all vehicle drivers are now days carrying their mobiles that can be considered as mobile network user equipment (UE). This paper presents an innovative tracking and controlling high-speed vehicles in the LTE-A system that taking the advantages of Channel Quality Indicator (CQI) value mapped to the UE speed. The method can be accomplished by uploading the CQI index to the base station (BS), at the uplink, then the evolved node base station (eNB) sends an extra warning message at the downlink to initiate the radio frequency identifier (RFID) component fixed on the vehicle. The proposed scheme design assumes that the LTE networks have the all traffic speed for the covered area and to be activated when the speed is beyond the maximum speed. In that case, the RFID is activated and an alarm is switched on. Under now response, the RFID will activate the vehicle's traction control (TC), Engine Control Unit (ECU) and automatic brake system (ABS) to decrease the speed gradually. The proposed scheme was simulated using the system level-simulator (SLS) and the performance is depicted. The evaluations show that the CQI values are decreased meaningfully to 2 when the UE movement in the high-way increases to 150 km/h. Consequently, with the obtainability of CQI values at the LTE-A system, an immediate activity is completed to control the vehicle speed and warn the driver.

Keywords: High-Speed Vehicles, LTE-A, RFID, SINR-CQI, Mapping, Tracking.

1. Introduction

Generally, the vehicle speed can be observed by the driver on the dashboard, analog or digital, by tachometer which is an instrument measuring the rotation speed of the engine crank or transmission shaft. The speed gauge monitored on a calibrated analog dial, but digital displays are increasingly common. From the telemetry, monitoring, and communications perspective, the speed can be monitored by either video traffic cameras, radar, a global positioning system (GPS), or cellular sensors installed on the highway to monitor the traffic, collect data and record the speed [1].

Video traffic cameras give clear evidence for an over-speed vehicle but can be avoided by reducing the speed before passing its mounting places as the drivers know its places previously. Also, a huge number of cameras must be installed to provide enough coverage besides the monitoring, processing, and multiplexing. Video traffic cameras suffering from environmental conditions, mud, dust, fog, and damages. The cameras and recording systems may not be kept accurately. Moreover, the images, with high-speed vehicles, are not very high quality, so the monitor reading the vehicle's license plate might misread it and the punishment ticket will be sent to the wrong person.

Radar-based detectors are un-invasive and continuous-wave radars which are widely used for traffic, monitoring, management, and data collection. The installation schemes of radar-based detectors can be classified as forward-looking and roadside [1]. Radar-based speed measurement systems have many disadvantages.

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These radars cannot, some types, track or detect more than one vehicle moving in the same lane or moving at equal speed.

With the high development and wide application of GPS especially with vehicles, another form of speed detection and tracking was developed. The developed schemes use the vehicle positions to compute its speed by a Central Server (CS) computer. Road traffic in any modern city provided with many Road Side Units (RSU). The position of each vehicle periodically sent to RSU in the range. When the vehicle enters the RSU range, all RSUs receive the position and timing information of the vehicle and send these positions information to the CS. When the vehicle speed is beyond the limit, the CS sends the information to all RSUs within its range. These informed RSUs send warning messages to the vehicle and more actions are taken incorporation with the traffic police in case of more speed violation [2]. This method suffering from the delay in the processing time caused by GPS and CS [2].

The above-mentioned techniques and methods are low resistant for interference with other frequencies utilized for monitoring radars, terrains, and range limitation, whereas video cameras suffered from moisture, and accidents. Recent intelligent Transportation System (ITS) monitors the vehicle's speed on the road as well as assisted the vehicle drivers to avoid traffic jams and for travel times estimation [1].

Many developed techniques used for speed estimation, monitoring, and tracking vehicle from the signal sent from user equipment (UE) were mainly valuable since these technologies will not involve complex infrastructure costs or cameras and monitors on the highway [2]. Recent technique for speed assessment is limited to average speed values along RSUs with interference between UE's signal [3]. This motivation forms trends to encourage cellular network operators to enhance and improve the capacity of their systems. The system provides the UE to have high vertical handover flexibility from different cells, whereas the network confirms the required Quality of Service (QoS) [4]. Yet, if the UE’s movement data is available for the optimized network as well movement managing and tracking, the network achieves revision and ensure a continuous UE vertical handoff softly with effective sector or cell selection to enhance the performance and achieve the QoS [5]. The UE mobility tracking and management or mobility data can also be considered at mobility traffic with a capacity balancing, channel quality indicator (CQI) which is a four-bits used to identify the channel states and UE ability to create a better communications link for a UE with a specific QoS, feedback improvement, and packet scheduling (PS) [6-8]. PS is the key to 4G LTE systems for achieving improved spectral efficiency (SE) and enhanced throughput. PS is carefully involved in link adaptation (LA) which relates to setting the transmission parameters for the wireless connectivity to deal with fluctuations of the wireless connection state. CQI is a 4-bit that permitting three levels of modulation and different coding rates according to the CQI bits. Each CQI involves a related level of Signal plus interference to Noise Ratio (SINR) offered for a required Block Error Rate (BLER) which should be below or equal to 10 % [9-11].

Hybrid automatic repeat request (HARQ) is a scheme or method for retransmission of unacknowledged packets, is consequently suitable and useful for QoS and performance enhancement. HARQ can be supposed as a scheme to manage or deal with the fluctuations in the instantaneous channel condition and its quality after re-transmission and well matches of LA and PS.

It is worth to be mentioned the presence of two issues with respect to UEs moving at high-speed. First, channel fluctuation is very fast. Fast fluctuation at the channel state at the increased fading rate formed by the UE moving at high speeds will produce high deviations of the immediate channel conditions every Transmission Time Interval (TTI). TTI, which is a main key universal mobile telecommunications system (UMTS) and other digital communication systems, related to the security of data from high-level layers into symbols or frames for transmission on wireless radio link-layer (RLL), which involves the duration of the transmission on the wireless radio-link. Second, transitions from the current evolved node base station (eNB) to the adjacent sector or other adjacent eNBs become more frequent for short inter-site and small cells, causing more recurrent handovers [4].

Many scheduling algorithms were developed to be used with the uplink of LTE systems. Round Robin (RR) is one of the most utilized scheduling schemes with the network whose target is to achieve high fairness. RR scheme distributes the resource blocks (RBs) equally to all UEs. The RR is appropriate for real-time (RT), services with steady information rate such as live video but it is unsuitable for non-real time (NRT), variable data rate services such as web browsing because distant UEs with low SNRs will dominate the cell’s use of resources [11]. Also, the best channel quality indicator (BCQI) scheme is another scheduling algorithm designed to allocates RBs to UEs and provides priority of access to UEs having the best channel states or high SNR. Utilizing the BCQI scheduling scheme will improve the system capacity among UEs without the consideration of fairness. In this strategy, UEs moving in the cell or located far from eNB have a low probability to get access to the common RBs [11]. Then, the Proportional Fair (PF) scheme is developed to utilize the orthogonal frequency division multiple access (OFDMA) abilities in time domain scheduling and frequency-time scheduling methods. PF scheme manages the tradeoff between the system throughput and data rate fairness. It enhances the fairness between UEs by selecting UEs with relatively fewer channel fluctuations [11].

Finally, the Maximum Throughput (MT) scheduler is a scheme that assigns RBs for UEs which have the highest SNR to send and detect high data rates, in turn, it maximizes the system throughput [11]. Each UE determines, at the downlink transmission, channel, and provides, at the uplink three parameters with feedback such as a CQI, precoding matrix indicator (PMI) for multi-input multi-output (MIMO) used to get the rank indicator (RI) for MIMO layers [8].

Simply, the CQI index depends on the detected Signal to Noise plus Interference Ratio (SINR) [9]. The higher bitrate can only be detected efficiently at higher SINR [10]. The CQI offers, at the uplink, the eNB the UE's channel state. This eNB, sequentially, deals with the CQI index detected on the uplink transmission to assign scheduled resources and adapts an appropriate, higher or lower, modulation and coding scheme (MCS) depending on the SINR which mapped into CQI bits [8].

In LTE systems, the UE speed can be estimated and determined with a mapping of each UE received SINRs into CQI bits at the uplink transmission to allocate the appropriate MCS [10]. The resource allocation is accomplished in RBs. Each RB consists of twelve subcarriers, each 15 kHz, that occupy a bandwidth of 180 kHz that comprises a time range to 0.5ms [5]. A sub-frame of 1 ms, consists of two RBs. The smallest resource is the Resource Element (RE) which comprises of a single sub-carrier through the OFDM symbol [5]. Each 1ms consists of 2 slots [5]. As mentioned before, the eNB collects the CQI index every TTI via the uplink. The eNB mapped the CQI to adjust Adaptive Modulation and Coding (AMC) with MCS to the UEs in the downlink. The CQI index is with a range that can offer speed estimation to the network for each UE mobility every TTI [11]. Therefore, an individual's vehicle's speed limits can be estimated and the scheme can track the UE mobility along the road whether the UE mobility is lower or higher the limits [11]. The proposed scheme can be synchronized with the mounted Automatic Brake System (ABS), Electronic Stability Program (ESP), and Traction Control (TC) of the vehicle if the driver is not responding to the precautions inevitably the vehicle's electronic buzz the crash will be avoided.

This paper presents a tracking and controlling of high-speed vehicles via CQI in the LTE-A system to prevent car accidents. The proposed scenario unlike existing speed in the estimation, control, tracking technologies that it controls the speed and can track the mobility correctly by mapping CQI from UE's SINR for every UE, since the estimation is done every 10 msec. The target of the proposed scheme, which is an additional block to the mapping scheme that will be mentioned in section 3, is to adjust the reported mobility limit-based on the SINR-CQI mapped instantaneously the traffic control system and alert driver about the mobility limits. The paper shows how the proposed scheme can be realized and also shows the CQI values evaluated for diverse UE speeds and its estimation.

The paper is structured in the following way, the previous works related to vehicle speed are mentioned in section 2. Section 3 presents the proposed scheme for speed estimation. Section 4 explains the proposed tracking and control method. Finally, the paper presents the proposed scheme evaluation to assess the system and put the recommendation and conclusions in Section 5 and 6, respectively.

2. Related Works

This section, briefly, reviews many systems and schemes that use cellular network infrastructure on speed measurement. One of the most utilized methods is the received SNR determined at each eNB which estimates the UE's speed [11], where the authors presented two procedures for UE speed estimation. The first approach called; Spectral Analysis Method (SAM). While the second method named; Time-based Spectrum Spreading Method (TSSM). Though, for a UE moving in the cell at very low mobility, the measured SNR values fluctuates slightly as they were vastly correlated along with a wide duration. So, these methods failed to estimate the UE speed at high mobility. In [12], the author presented that the general mobility problem has been addressed by the Mobile Internet Protocol (MIP) with the switching domain to be MPLS. In [13], the author proposed an online scheme for UE mobility estimation in 4G-LTE systems focused on TSSM as it had low execution complexity. The proposed algorithm can permit the speed estimation to be done within 10 seconds and with an average speed assessment error of 15 km/h. In [14], the authors proposed a scheme that gets the speed data and feedbacks it via LTE adapter mounted in the car connected to the eNB. The authors in [15] evaluated the impact of communication and transmission range on network connectivity due to the high mobility of nodes in a mobile and wireless environment. The result obtained through derived mobility metrics and Rate Adaption (RA) shows that communication range has an impact on connectivity in a highly-mobile environment such as in vehicular communications. Authors in [16] proposed a scheme enabled to find out the vehicle's speed and send its data to the emergency center, with the respective international mobile subscriber identity (IMSI) number of UEs. The post-processor was achieved by a microprocessor (μp) that received the data submitted via GSM adapter giving it via the interface to the drive. While the authors in [17] used a robust adaptive sliding code control design for Unmanned Aerial Vehicle (UAV) trajectory tracking designed to control the attitude of the quadrotor. The paper reduced the chattering associated with the conventional sliding mode control (SMC), by implementing the adaptive fuzzy gain scheduling SMC technique (AFGS-SMC).

Accident's experience was reported to be a highly influential factor to make the drivers abstain from mobile phone use. Other solutions, as preferred by survey respondents, include; awareness campaigns through social media for awareness and use of accessories (Bluetooth, earphones, etc.) to avoid the handling of mobile phones [18].

To the best of our information, no paper or article proposes to estimates, track, and controls the high-speed vehicles utilize the CQI. This paper proposes a scheme based on the usage of the CQI mapping from the operative SINR for all UEs, which involves the mobility, to track the UE to control its high-speed when the car or UE exceeds the speed limit. The above methods, especially [11], which presents a scheme for speed estimation but suffering from measurement signal strength problem that is subject to the fast channel fluctuations with the effect of high-speed UEs, while the proposed scheme adapts the SNR-CQI mapping, every 10 msec., to the UE mobility and recognizes any variation in the channel state every TTI.

3. The Proposed Measurement Scheme

The CQI index variety offers a suggestion to the LTE network for the UE movement in the cell [10-11]. Therefore, an individual's vehicle's speed range will be provided and the vehicle's driver can be informed about the speed range, of the highway by receiving again the analyzed data at the radio frequency identification (RFID). The RFID exploits electromagnetic field to identifies and track the tags devoted to objects. An RFID tag consists of, a miniature radio transponder, a radio receiver and a transmitter. More details will be mentioned for RFID in the next item. In this paper, the proposed scheme block diagram, which composes of traditional SINR-CQI mapping and the additional blocks, is revealed in Figure 1. The system evaluates vehicle mobility using effective SINR to CQI mapping concerning the UE's driving the vehicle, or any user within it.

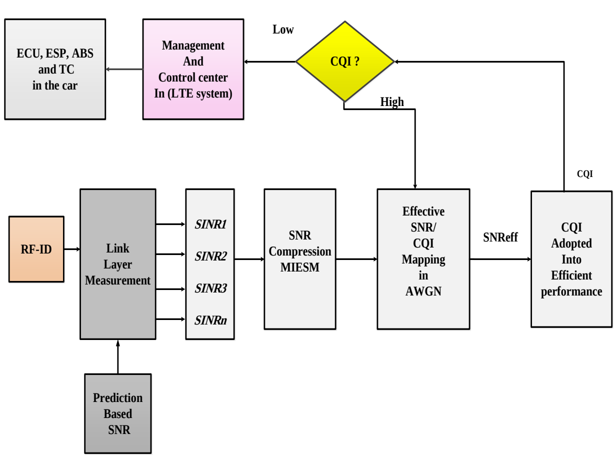

Figure 1. The proposed system for SINR-CQI

Then, the UE sends the data, via uplink to the eNB, about the channel state. The eNB maps the CQI from the effective SINR to adapt the MCS at the downlink transmission to the UE. The eNB can determine the UE speed. In the meantime, the system will inform the traffic management administration, via the LTE system, if any vehicle exceeds the limit via SMS service. The eNB, directly, feeds back a control signal through the proposed method, after determining by speed comparison with the CQI index to the Engine Control Unit (ECU), ESP, ABS and TC circuits to control the speed.

To highlight the main feature of our proposed scheme it is important to focus on the tracking of the UE and controlling the vehicle speed, as a feedback action. The proposed system integrates two techniques; mapping scheme of SINR into CQI index and RFID knowledge in LTE systems by speed estimation, vehicle or UE tracking, and control systems.

The proposed scheme started via two main parallel operations:

- This operation starts by spreading the detection range of the RFID module by adding a short-range wireless ability to the RFID reader. The RFID reader is a built-in wireless receiver to emit data, the speed information, to LTE systems [20]. The RFID reader performs as a sensor node: the vehicle identifier (ID) was built-in as data. The car ID is the vehicle type, brand, model, color, and owner name. This information is sent to the eNB via the LTE uplink transmission mobility sensor, mounted as an ordinary tachometer sensor for vehicle speed measurement and transmits this data to LTE systems [20].
- The next procedure is performed inevitably by mapping the CQI value from the effective SNR by the UE in the vehicle, or any passenger having his own UE in the vehicle, by the eNB of the uplink LTE system, which sends the AMC via downlink transmission to the UE to assign the allocated bitrate according to the scheduling algorithm mapping by the CQI bits.

When the UE's speed reaches over limits, the system transmits a control data to the modules; ABS, ECU, TC, and ESP, installed in the vehicle, to decrease the speed by controlling the ABS system and a beep alarm to warn the UE that the vehicle's speed exceeds the limit allowed by the traffic management authority. Again, as shown in Figure 1, the proposed scheme includes the three main parts:

A. *Basic Radio Frequency Identifier (RFID) Module*

The RFID tag consists of a miniature radio transponder, a radio receiver, and transmitter. When the receiver triggered by an electromagnetic pulse from a nearby RFID reader, the tag sends data, usually an identifying unique manufactory number, back to the reader. There are two types of tags; Passive tags, which are powered by power from the RFID reader's harvesting the radio waves. Active tags, which are powered by a battery and thus can be read at a greater range from the RFID reader; up to hundreds of meters. RFID tags are utilized in most recent industries.

For example, an RFID tag mounted in the vehicles during production, which can be used to track the assembly process. Most basic RFID modules consist of an RFID reader which exchanges permanent vehicle ID, and vehicle speed, from the linked antenna.

The RFID module switches this data to be recovered in real-time to maintain certain application requirements. Data stored in the tag will provide the data vital related to vehicle ID programmed during production in factory automation. This information can be pasted by a micro-computer to the RFID tag [20]. A tachometer sensor mounted in the vehicle alerts data to its ECU module.

B. The Traditional Scheme

The mapping scheme of effective SNR into CQI is the traditional LTE scheme as revealed in Figure 1. This system consists of a link-layer block that measures each UE SINR every TTI and via mutual information effective SINR metric (MIESM) algorithm converted the SINR to effective SNR. Next, each effective SNR is mapped into its CQI index. The modification to the traditional scheme is the comparator. Each CQI is fed to the comparator. The comparator compares the threshold value of the CQI. When the comparator output is low, the CQI bits level is low, the comparator feedbacks the CQI bits to the Managements and Control Center (MCC) to allows alarm signal to be sent to the ABS, ESP, and ECU.

C. CQI Measurements

LTE systems, basically, every TTI, consider the mapping of effective SNR to CQI to select the MCS according to the channel condition and determine the allocated shared resources to assign scheduling algorithm. The channel state may regularly vary across the downlink bands (frequency fading channel). To make this known, the eNB configures the UE to report the CQI in three aperiodic diverse approaches:

1) Wide-band report: which reflecting the normal channel state across the complete system BW with an only CQI value. Even with a single CQI index provided for the entire BW, the PMI reported a frequency selective channel, which is found by dividing the downlink BW into equal width of a number of sub-bands. Each sub-band comprises a set of consecutive RBs. Each sub-band will allocate a range from four to eight RBs, according to the entire BW. For transmission schemes that supported spatial multiplexing (SM), the PMI and the CQI are determined to assume the RI.

2) UE-selected reports: each UE selects and reports the best sub-band selected one CQI which reflects the instantaneous channel state over the selected many sub-bands organized with a single wideband CQI reflects the instantaneous channel state over the full, downlink, BW.

3) Configuration report: where the network configured and report a set of sub-bands the UE should create its reports for. Each UE reports one wideband CQI reflecting the instantaneous channel state across the entire BW and single CQI index per organized sub-band. The sub-band size, as mentioned before, depends on the downlink BW within the range of (4-8) RBs.

The UE selects many sub-bands having the best CQI scheduling algorithm, the reporting their locations, together with a single CQI index. As mentioned before, in sub-section 3-B, the mapping of SINR into CQI done in four steps: the SINR link-layer measurement, then the measurement of effective SNR. Next, the quantization of SNR values to discrete CQI values. Finally, the system reporting the CQI index into effective performance.

4. The Proposed Speed Tracking and Controlling System

The proposed scheme, as presented in our previous article [19], for speed tracking only. While the proposed scheme for tracking and controlling the vehicle is composed of two steps as follows:

- The system measures the CQI index for all UEs and uploads it as a feedback signal via the uplink to the eNB. The eNB assigns the allocated RBs to adopt the MCS that each UE can handle. This method proposes that as the UE moved in the cell with very low-speed will uplink a high SINR and will map a high CQI. This means that if the UE is very close to the eNB, the eNB will assign higher MCS to the UE. If the CQI index is low, the adopted MCS is low and the related speed estimated is high.
- Next, the system transmits a signal to control and decrease the vehicle's speed. Every TTI, the network receives the CQI index, which gives an indication that the CQI value becomes high, which means the speed is reduced to a low-speed. The system informs the eNB about the instantaneous channel state to stop controlling the vehicle's speed.

Conversely, if the CQI index is logically low, which means that either the UE speed is too high, the UE channel is suffering from fading, or is far from the eNB. At that time, the speed trace produced by the proposed scheme will provide a tracking facility to the system to track the UE on the highway since every UE mapped the SNR into the CQI index at each TTI. This means that speed monitoring can be available to track the UE or the vehicle and control the over-limit speed.

For example, if $CQI_A = (CQI_1, CQI_2 ...CQI_M)$ is a CQIs value extracted every TTI for all UEs, each eNB will produce a matrix of CQIs. This matrix has a [TTIs x M] elements.

The simulation duration is run for 5000 TTIs (5000x 10 msec. will be 5 seconds), while M is the number of UEs moving in the cell at different speeds. These matrices, which give a trace for speed for all UEs, enable the eNB to decides for sending a control signal to the UE to reduce the speed when the CQI index descending.

Figure 2 shows the simple road plan of many vehicles, on the mentioned highway. All UEs send the CQI values to the nearest eNB every TTI. Figure 2 shows the layout when each UE sends its CQI every TTI to the associated eNB.

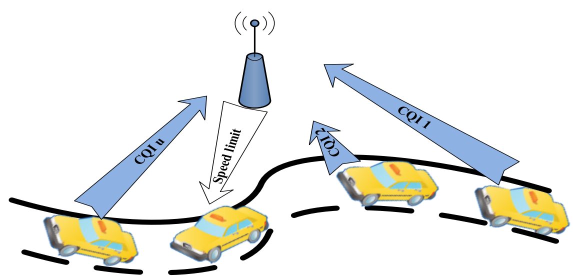

Figure 2. The vehicles layout on the road.

The proposed scheme will share the following registers, as indicated in Figure 3:

- The control and management register; this register will responsible for the entire system management and setting.
- The built-in register for speed limits determination for each UE. This register will save the threshold for the speed limits suitable to the speed road path limits.
- A recorder register; this register is set to have responsibility, every TTI, to save the updating of CQI indexes for all UEs moving in the cell.
- A database registers for UE record: This register can be used to configure the driver and to issue a violation ticket. A copy of this ticket will also be sent to the police center.
- A dynamic register; this register alerts, immediately, the over-limit speed report to the over speed to control the UE's speed.

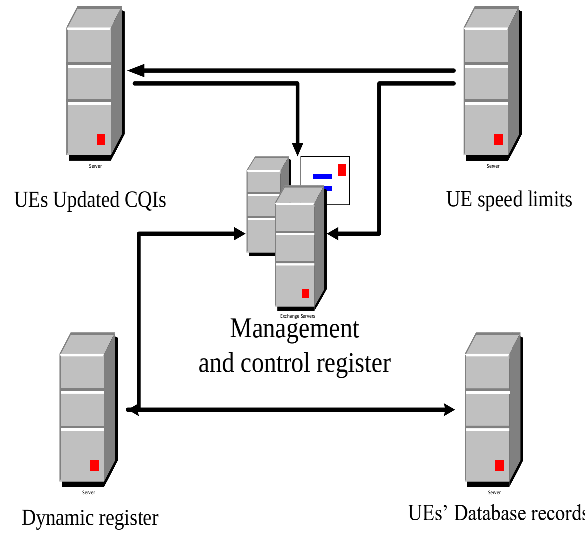

Figure 3. The system registers

5. SIMULATION SETTING AND EVALUATION

To validate, authenticate, and evaluate the proposed scheme, along linear area in a rural location is considered for a wide range that extends from the low mobility to Vehicular channel schemes. The system setting of the main parameters and simulate the proposed scheme by Vienna system-level simulator (SLS) [21]. The Vienna LTE SLS is utilized to accomplish the proposed scenario. The Vienna LTE SLS is applied in object-oriented MATLAB, which is made as an open-source available for download under an academic use license. Its rich set of features and easy adaptability including huge studies on energy-efficient cell-coordination schemes, handover schemes in self-optimizing networks (SON), and resource allocation or packet scheduling (PS) techniques for small cell, femtocell, networks as well as for device to device (D2D) communications. The LTE SLS complements an already freely-available LTE link-level simulator (LLS). This combination permits for detailed simulation of both the physical-layer procedures to analyze LL related issues and SL simulation where the physical layer was abstracted from LL result and network performance is performed.

The proposed scheme layout is composed of five eNBs with transmission mode using Single Input Single Output (SISO)/Open Loop Spatial Multiplexing (OLSM) scheme for covering a long linear rural area, in which ten UEs moved in the cell at different mobility, low and high-speed, and distributed in a random method. To show the advantage of the proposed scheme, the simulator is started and the result is evaluated utilizing the graphical user interface (GUI) which shows the UEs performance with the BCQI algorithm to discriminate between the UEs mobilities with variable high-speeds in the uplink using SLS [21].

As mentioned before, the model supposition setup consists of five cells, each cell composed of three-sectors with ten UEs having average SNRs ranging from -25 to

40 dB moving in the cell at a range of speed 70, 100, 125 or 150 km/h. The distance left between vehicles is proposed to be randomly distributed in the high-speed road, as race road. Although the LTE systems standard supposed the UE considered to move at speed up 350 km/h, this paper proposed that the UEs move in the cell at 150 km/h has the maximum speed due to most vehicles' standard. On the other hand, the evaluations for extreme limits for the simulation may not be configured or satisfied.

In this paper, we consider the uplink delay is neglected, 0 TTI, as the delay caused by fading or multi-path does not exist, hence the area is proposed to be a rural and open area, no shadowing, no reflection, and no scattering which mean neglected uplink delay. The best scheduler chosen for our proposed scheme simulation is the BCQI algorithm as SNR, for each UE, is the main parameter that will be determined and mapped into the CQI index to estimate and control the UE speed accurately. The main setting parameters of the UE mobility simulation are tabulated in Table I.

TABLE I. MAIN PARAMETERS USED IN THE SIMULATION

Parameters	Data
Carrier frequency	2GHz
System BW	1.4 MHz
Number of RBs	12
Transmission and Reception mode	SISO-OLSM
Inter-site inter distance to eNB	1500 meters
Number of users /cells	10 UEs
UE speed km/h	(70, 150)
Channel type	VehB, VehA
Packet Scheduling	BCQI
Time of simulation	5000 TTI

The eNB creates a matrix for every UE to be used for speed trace and eNB sends a control signal to ABS via the system to reduce the speed when the CQI index is down. The proposed scheme adopts that the UEs are moving in the cell as follows:

a) UEs 1, 2, and 3 are UEs moving in the cell at an average speed of 70 km/h.

b) UEs 4, 5, and 6 are UEs moving in the cell at average speed 100km/h.

c) UEs 7 and 8 are UEs moving in the cell at average speed 125 km/h.

d) UEs 9 and 10 are UEs moving in the cell at an average speed of 150 km/h.

In this simulation configuration, the UE's speed was the only parameter that chooses to evaluate the fading and fast channel fluctuation of UE mobility on CQI every TTI to track very fast UEs. The eNB transmits a control signal to the UE, which alerts the UE immediately, via the RFID, a warning and control signal to reduce the speed. The proposed scheme supposes that each UE sends its CQI to the eNB however the size of the vehicles as the system considers the received SNR while the radar system depends on vehicle radar cross-section of the target.

The extracted evaluation depicts the traces for CQIs with time. Figure 4 shows the CQI with time for a UE moving in the cell at 70 km/h. The figure described that the CQI ranges for UE 2 are between 6-8. In Figure 5, the GUI depicts the CQI values with time for UE moving in the cell at 100 km/h. Figure 5 described that the CQI range for UE5 is between 4-5. Figure 6 shows the CQI with time for a UE moving in the cell at speed 125 km/h. The figure described that the CQI ranges for UE 8 are between 3-4. Figure 7 shows the CQI with time for a UE moving in the cell at speed 150 km/h. The figure described that the CQI ranges for UE 8 are between 2-3.

To assess the whole evaluation, Figure 8 depicts the entire CQIs versus time for all UEs moving in the cells and sectors at different speeds. The CQI indexes related to the UE's speed and the variances for each speed are tabulated in Table II. The evaluation and table II show that for UE moving at high-speed map very low CQI and the UE moving in the cell at low-speed map high CQI. Table II indicates the mean and variance fluctuation for CQIs for UEs moving at different speeds, feedback eNB to decide among UEs low range of CQIs at high-speed. The proposed scheme decides to control and then reduce the speed of UE 9 and UE 10.

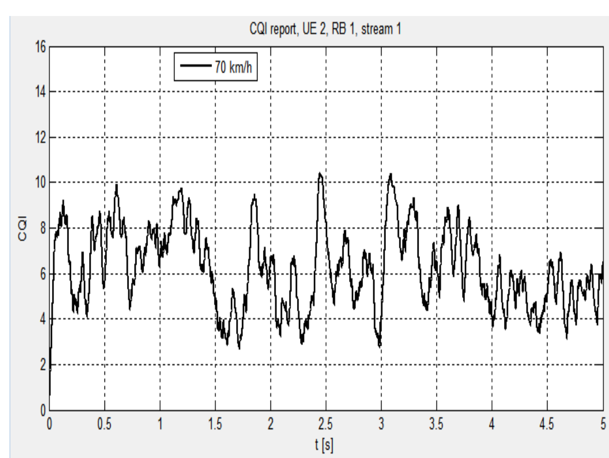

Figure 4. The UE CQI moving in the cell at 70 km/h

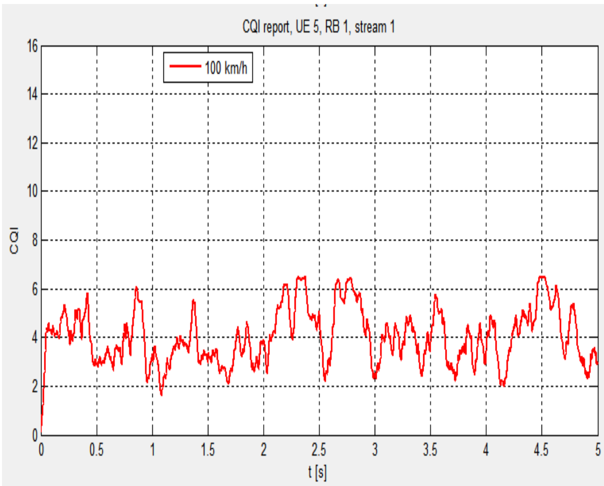

Figure 5. The UE CQI moving in the cell at 100 km/h

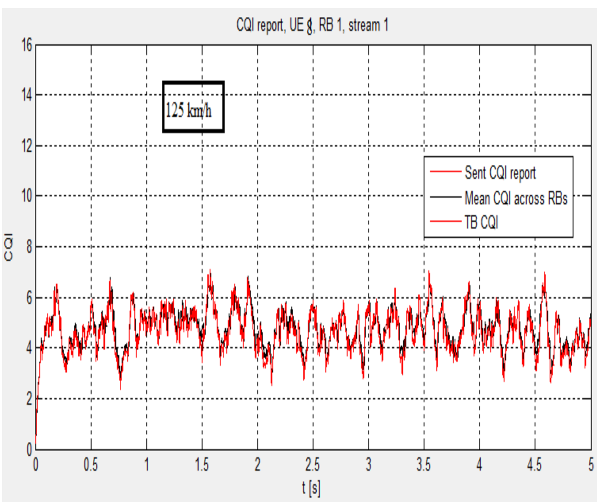

Figure 6. The UE CQI moving in the cell at 125 km/h.

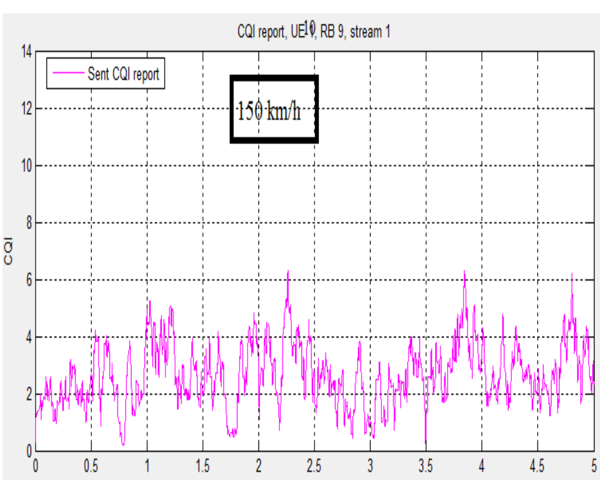

Figure 7. The UE CQI moving in the cell at 150 km/h.

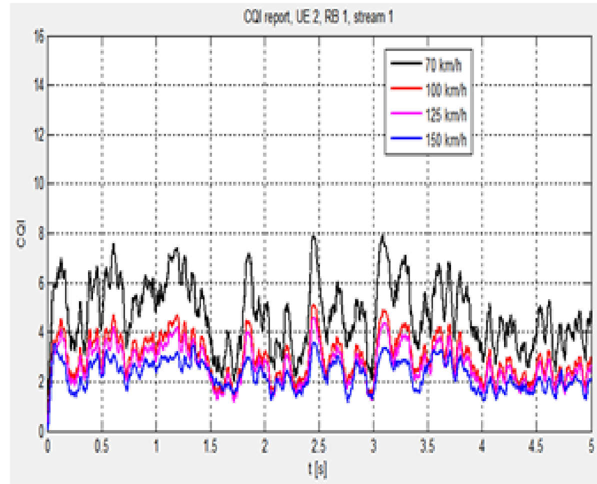

Figure 8. The UEs CQIs moving in the cell at speeds 70, 100, 125, and 150 km/h

TABLE II. UEs SPEED WITH CQI

UEs	UE speed km/h	Mean (CQI)	Variance
1, 2, and 3	70	8	6
4, 5, and 6	100	5	3
7 and 8	125	4	2
9 and 10	150	3	1

The proposed scheme for speed estimation, track, and control can be suggested for the current LTE system since this method permits the network to determine the speed for any UE, every TTI, as well as it allows the system to track any UE as long as the UE in the connected state. From Table II, and Figures 4-7, it is clear that the proposed system captures the speed and track the UE speed. Moreover, the system can also recognize the user's speed when some users have the same CQI. The idea is the system measures the CQI every TTI which means that no two users have the same CQI at that TTI. This assures that the proposed system can record the speed every 10msec for each vehicle in any city. The availability of the speed at the city traffic police means all drivers must be aware of their speed since it is computerized and recorded as conducted in airplanes black box. Moreover, having such speed allows the system designer to design and implement a real-time kit for alarm and speed control in any vehicle. This will validate the proposed system and can be recommended for future use. However, this needs agreement and system specification between the countries' traffic police and mobile network operators to install this system in all vehicles in the country. It is worth mentioning here that there is research has been conducted and can be adopted for real-time speed controller design and implementation.

Comparison has been conducted in Table III between the proposed LTE method and other methods, GPS, camera, and RSU is obtained. The results show that the proposed scheme is better than any other since the lowest delay is achieved. Generally, the most important issue that the proposed scheme provides is the ability to capture, track and record speed vehicles in the whole country traffic whereas the other systems cannot provide these features. This, of course, need a server at any city traffic police to be installed together with the system controller in the vehicles by an authorized agent. One of the most serious aspects that have been drawn attention for such research that most of the drivers specifically in our countries are unaware of speed and pay attention for speed for places where radars or cameras are installed. Moreover, the GPS, tracking radar and monitoring traffic camera systems unsuccessful to distinguish between moving vehicles on the highway lanes at identical speeds. LTE systems can measure the UE speed by mapping its SNR into the CQI index. Compared to other technology, LTE needs not to relay the measured vehicle speed from the camera, GPS, or radar monitor to the monitoring and tracking system which will cause delay, about 300ms compared to 20ms in the LTE-A system [9]. The error caused by the tracking radar system, used for speed measurement, was approximately 5km/h for a single vehicle, phase shift and need to mount hardware circuits and complex software to solve this problem; such as filters, DSP, and fast Fourier transform (FFT). The cameras system, too, needs to switch among monitors to discriminate against many over-limit speed vehicles.

Finally, it is worth mentioning that with the advancement in mobile communication and increasing the data rate of mobile services, the bandwidth limitation can avoid or reduced. Furthermore, the inclusion of mobile services with the tracking and mobile speed control will allow other mobile applications to be embedded in the tracking and control system.

TABLE III. COMPARISON BETWEEN LTE, GPS, AND CAMERAS [1, 2, 9]

Systems	Advantage	Disadvantage
LTE	Very low delay	Limited BW
GPS	Delay 100-200 ms	Delay 100-200 ms
Cameras	Immediate record	Delay 300 ms
RSU	Internet-connected	Dust or damaged
Radar	Can detect many targets	Error 5km/h

6. CONCLUSIONS

In this paper, a new scheme for vehicle speed estimation, tracking, and control have been proposed and implemented using CQI and UE speed mapping in the LTE-A mobile system. The scheme has been validated via the implementation of the system using the Vienna system-level simulator. The results of the simulation provide the evaluation of the CQI for UEs moving in the cell at different speeds which were extracted from the SNR-CQI mapping for each UE every TTI. The proposed scheme also has the capability to track UE's speed, every TTI, in order to control the violated vehicles and to prevent potential accidents. The simulation evaluations showed a range of CQI values every TTI depicted for each UE moving in the cell. The estimated UE speed is mapped to the range of the CQI. This validates the proposed scheme objective. Comparison with other speed tracking has shown that the proposed scheme can accurately estimate and track speed in the whole country traffic with the capability of recording the data. Furthermore, the proposed scheme can discriminate between all UEs moving on the highway at different speeds as the BS receives, every TTI, the CQI index. The lower values of CQI for each UE received at the eNB will send an emergency warning message to the UE and an immediate signal via downlink to enable the RFID that sends an immediate control signal to the equipped Engine Control Unit (ECU) and the automatic brake system (ABS) to reduce and control the vehicle's speed. Finally, as a recommendation and for the RFID implementation an agreement is required between country traffic police and mobile network operators. Furthermore, the proposed method can be modified to the developed 5G systems. The scheme can use a mounted wireless sensor network (WSN) as wireless transmitters and receivers with autonomous driving systems. In this aspect, the proposed scheme can be used with artificial intelligence (AI) in future trends of controlling smart cars.

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