Online Live Street Watch Application Supported by LTE-A

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ABSTRACT
The online applications for street information have gained much popularity and wide use recently. The growing data rate of cellular services at affordable cost is supporting such applications. The Long Term Evolution (LTE) and its later version, LTE-Advanced (LTE-A) are now the most promising technologies for the cellular services. The street information, presently available online for general users, is either limited or not presented in enough user-friendly way. In this paper, we discuss a user-friendly approach for an application that provides online live view of the streets disseminating a lot of information. We analyze the potential usefulness of this application. We consider the use of LTE-A to upload video data from traffic cameras for the application. We propose a method to configure less frequent transmission of cell measurement reports in LTE-A in order to save wireless resources and power during this video data upload.

Keywords
Map view, Street view, LTE-A

1. INTRODUCTION
A good number of applications exist today to disseminate information about streets. This can primarily help decide the route for transport and thus, can save cost and time. However, most of the present applications primarily provide street locations with little information about the conditions of the streets. In practice, the current street conditions, especially in urban areas, can be pivotal in the decision for route. Considering the requirement of current and detailed information, a live view of the streets using traffic cameras, can be most useful. A convenient way to receive the street information can be online access from a website. Only a few websites so far provides live street view and their approaches are not enough user-friendly [1]. In this paper, we suggest the use of a user-friendly method for an application, particularly suitable as a mobile app, which offers online web access for live view of the major parts of the streets and highways. The application is termed online live street watch (OLSW) in this paper. The OLSW uses a 2D map view as the web interface from where the user can open up live view by clicking a point on the street. As the serving network infrastructure to support video data upload for OLSW, we select LTE-Advanced (LTE-A) in the description but any high speed wireless network can be employed. LTE and LTE-A are the latest steps in the evolution of cellular services and their underlying advanced technologies enable them to provide high data rate at affordable costs [2].

For street information, the most popular application is now Google map, which covers the geographical map of around 220 countries and over 15,000 cities. It contains the information of more than 100 million places [3]. Google street view, incorporated with Google map, gives panoramic view of the streets. Using GPS based location information, Google map can provide voice guided directions for navigation, which can be used for walking, biking or driving. There are also OpenStreetMap, Bing maps, MapQuest, Mapline, Wikimapia, Apple maps and Umap as popular applications for street information and some of them are available only in particular areas. Some websites indicates accidents and similar incidents in the streets [4], [5]. Some websites provide still images from traffic cameras at different times of the day [6]. However, the information from these applications is usually limited and the user may not get a complete idea at the moment when he is taking a decision. The OLSW overcomes this limitation by allowing the user to watch live view of the street.

There are various technologies, except traffic cameras, to collect street traffic information. The microwave sensors and magnetic loop detectors are two of the common technologies for monitoring streets [7]. However, they are required to be installed in a lane under the road surface using a labor intensive earth work. It also causes the disruption of traffic flow. These limitations have been overcome in some recent nonintrusive traffic monitoring technologies. The road traffic can be determined using a microphone array detecting the sound waves generated by the road vehicles. From the detected signals, the speed and density of vehicles on the road are determined using a correlation based algorithm [8]. The high resolution radars can also be used to monitor the road traffic. But the radar radiates probing beam on to the lane and it must be ensured that they do not cause interferences with other existing applications. Also, the installation cost of radar makes in unreasonable for deployment in many countries. Besides, laser, infrared and ultrasound can be used to detect the road traffic but for the best performance, the devices need to be mounted over the lane on some structure. In monitoring road traffic, radio frequency identification (RFID), global positioning system (GPS), intelligent traffic monitoring using MANET are also used [9]. The OLSW uses traffic cameras, which provide much more information compared to all these aforementioned technologies. The video data from traffic cameras is uploaded wirelessly for convenience. The installation of traffic cameras is neither too expensive nor disruptive on the traffic. There has already been installation of traffic cameras in thousands of places around the world, especially, for the purpose of constant surveillance. Most of these present traffic cameras are placed atop traffic signals along busy roads and at busy intersections of the highway.

The OLSW uses any suitable vision based image processing technique to interpret data and determine traffic density, average speed of the vehicles and various incidents in the streets. [7] shows that the vision based image processing gives more accurate data in less cost compared to the sensor based image processing. From the color image captured from the camera, a gray image with low gray scale can be derived to reduce the computation time. There are several kinds of algorithms to quantify the texture feature of image and a convenient method is gray level co-occurrence matrix (GLCM) [10]. The computer vision method may be chosen as the vision based image processing technology as it can determine the number, mean speed and dimension of the vehicles. The moving objects are extracted from the scene by means of a frame differencing algorithm and texture information based on grey scale intensity. The shadows are removed from the foreground objects using top hat transformations and morphological operators. Finally, the objects are tracked in a Kalman filtering process, and the position, dimension, distance and speed of moving vehicles are determined. [11] provides a method for accurately counting the number of vehicles based on computer vision and thus, the estimation of traffic density can be reliable, albeit the speed estimation is not very reliable.

It may first appear that the continuous wireless transfer of huge video data to support live views may be too expensive to hinder the implementation of OLSW. But the rapidly growing data rate of cellular communication system can make the implementation of OLSW viable in many countries now and in the rest of the countries in near future. In this paper, we assume that the cellular communication system uses LTE-Advanced, which will potentially offer high data rate at easily affordable costs.

The remainder of this paper is organized as follows. Section 2 explains the features of the OLSW application. Section 3 describes the services that can be offered by OLSW. Section 4 proposes how LTE-A can be configured with less frequent cell measurement reporting for video data upload for OLSW. Finally, some concluding remarks are provided in Section 5.

2. PROPOSED APPLICATION MODEL

The proposed model for OLSW application sends the video data continuously from the traffic cameras to a data storage server as well as a data processing server. This can be conveniently performed using a high speed cellular network. As shown in Fig. 1, the video data will be routed to internet cloud via the radio access network (RAN) and core network (CN) of the cellular network. The arrows in this figure indicate the directions of data flow. The data storage and data processing servers receive the video data via an internet service provider (ISP). These servers will forward necessary data to the web server, which is accessed by the UEs. The data processing server picks images from the video data and performs vision based image processing using one of the available techniques to determine traffic density and average speed of the vehicles.

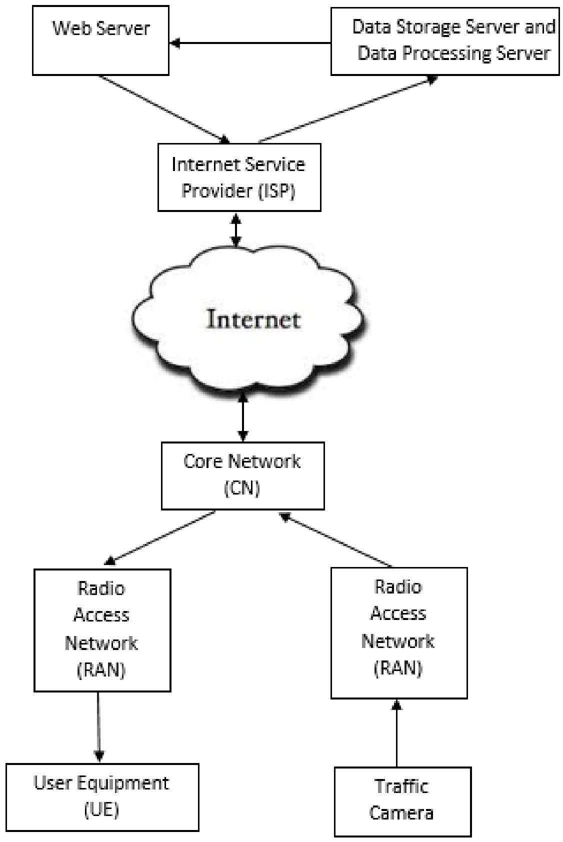

Fig 1: Block Diagram Indicating Data Flow among Different Entities for OLSW

The video data will be available online for users for live view. In the first website interface, a user finds a 2D map view of the area similar to what Google map and similar other applications provide. The parts of the streets for which video data are available, will be marked with arrows of different colors. When the user clicks a point from those parts of the streets, a live view will appear in a small window at a corner. The window for live view can be optionally extended to a full screen view. The traffic density is quantized and different colors are chosen for different threshold values of traffic density. The map view of the first web interface will have its streets marked with arrows of different colors according to the traffic directions and densities. This interface will also display average speed of the vehicles next to the streets. This will help the user get a quick idea about the street conditions at the early interface. Fig. 2-5 exemplifies the application interfaces. Fig. 3-5 shows the street views at different times of the day and the traffic density was small, medium and large at these different times. The street at Board Bazar, Gazipur-1704, Bangladesh, is used in Fig. 3-5.

The data processing server uses vision based image processing to determine various road incidents, in addition to traffic density and speed of the vehicles. Besides, news centers can be connected to the data processing server and provide information on the incidents. The incidents can include:

i. road accident,
ii. roadwork,
iii. public procession,
iv. public meeting,
v. violence and sabotage,
vi. Police cordon, etc.

It may not always be possible to identify the incidents automatically and manual intervention can sometimes be necessary. The map view of OLSW indicates the incidents in the streets using different symbols. The color of the symbol indicates whether the road is partially or fully blocked because of the particular incident. Some of these indications can be especially helpful when there are some security concerns.

Fig 2: First Web Interface for OLSW Showing Arrows and Symbols on the Map View

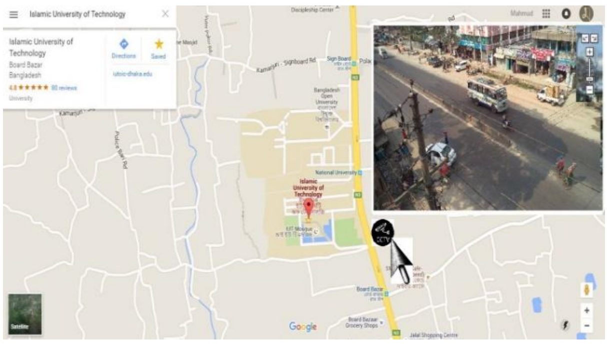

Fig 3: OLSW Interface with Low Traffic Density

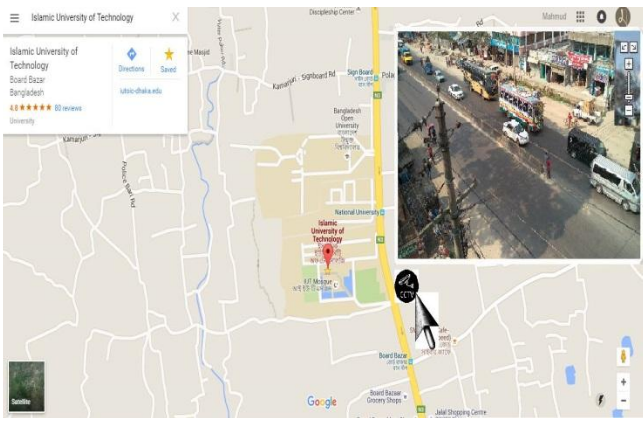

Fig 4: OLSW Interface with Medium Traffic Density

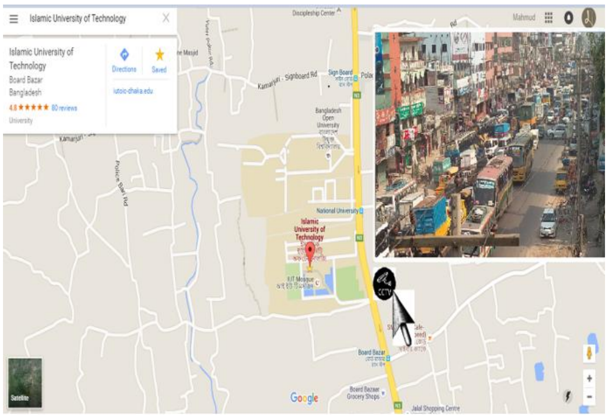

Fig 5: OLSW Interface with High Traffic Density

The uploaded video data will be stored in a data storage server. This can allow the user to view the streets in times past. The user can specify the date and time and then the web interface will start playing the recorded video of the street view from that moment showing the progress in time alongside.

A customer premises equipment (CPE) needs to be installed along with the camera to upload the video data. Since this is an installation at a fixed location, the CPE can use highly directional antennas pointing to the base station. The installation of CPE and camera involves a good amount of investment. Therefore, depending on the priority of locations, the deployment of CPE and camera can gradually expand in the course of time. The deployment may first take only arterial roads into account, especially, covering the intersection of the major arterials with the urban freeways. Then the deployment can gradually cover selected areas of major streets and highways, for example, the signalized intersections around selected downtown areas and near the shopping malls, exhibition places, hospitals, airports, sports venues, etc. In time, the deployment can even cover less important areas of the streets.

The position of the installed camera must be selected such that the view is not obstructed by the tree, canopy, adjacent buildings or other overhead structures. The higher the camera is mounted above the ground, the greater is the likelihood of wider camera view. It is often preferable for the camera to be mounted at the height of at 12m to 18m (40 ft. to 60 ft.) in order to provide a bird's eye view of the overall traffic [12]. Optionally, the camera can keep changing its direction slowly so that a single camera can be used to cover a wide range of view. The cameras must not capture restricted zones or private areas.

3. USEFULNESS OF OLSW APPLICATION

The OLSW can potentially render manifold services and we derive some of these services below.

1. The primary use of OLSW will be to enable a user to select less crowded routes or routes free from any road blocks or other problems so that he can travel faster and more conveniently.
2. The selection of less crowded routes will help distribute the vehicles more uniformly among the streets. This can minimize traffic congestions in the streets and highways. Also, the traffic management will be easier and more effective.

3. Because the video data of the street views are stored, this data can later be used by the law enforcement agencies for various purposes as shown next.
   i. When there has been any crime or misconduct in the streets, proper information about the misdeed can be derived and the criminals can be identified.
   ii. When a criminal has fled, the recorded video data may help track the criminal.
   iii. In the cases when children or aged people have been lost, the recorded video data may help track them.
   iv. In the cases when a person has been kidnapped, the recorded video data may help track the kidnappers.
   v. When there has been any car accident, the recorded video data may help determine who is at fault in the accident and resolve arguments.
   vi. Speeding drivers can be identified more easily. Plenty of surveillance cameras are already in use very successfully for this purpose [13].
   vii. Drunk drivers can be identified more easily.
4. The live view can convey the information of road accidents faster and in better detail. Consequently, proper actions can be taken quicker to save lives.
5. The live view can convey the information of violence and sabotage in the streets faster and in better detail. Consequently, the relevant authorities can take proper actions quicker to save lives and properties. Besides, general people can avoid routes along these streets.
6. Detailed information of traffic flow patterns, traffic events, speed of the vehicles, and so forth, are made available to traffic management authorities, city planners and drivers. This can potentially help in many ways, for example, to improve road safety, improve traffic control and even develop new capabilities for intelligent vehicles.

4. PROPOSED MEASUREMENT REPORTING CONFIGURATION IN LTE-A FOR UPLINK DATA TRANSFER

We assume that the CPE installed with the camera for OLSW uses LTE-Advanced for video data upload. This uplink data transfer uses a communication between devices and a server without the need for human interaction, and thus, it is a Machine-to-Machine (M2M) communication. LTE-A is expected and widely acknowledged as the main enabler for the widespread emergence of M2M systems. For efficient M2M communication, there has been a growing need to develop new UE categories in LTE-A. Consequently, a new UE category has been developed meeting the requirements of general M2M communication and it is referred to as UE category 0, or simply UE cat 0. The cost of the modem for this UE category 0 is approximately 40-50% of regular LTE devices. The peak data rate for the UE category 0 is reduced to 1 Mbps, which is sufficient for video data upload. It can operate in half duplex mode, which is suitable for video data upload while saving cost and power [14]. Thus, the UE category 0 mostly matches the CPE requirements for video data upload for OLSW. However, for CPEs at fixed locations, it is possible to enhance the performance defining a new UE category, which can be a little modified form of UE category 0. It may be noted that M2M communication is defining LTE-A as one of the main platforms for the Internet of Things (IoT) [14]. But there will be many different types of requirements in data transfer for IoT. So, we propose that multiple UE categories with different configurations should be defined to support the forthcoming various M2M communications and one of these UE categories should meet the requirements of CPEs at fixed locations as required for video data upload for OLSW. We assume that our proposed category for OLSW is UE category X. The UE category X performs cell measurement reporting as described below.

In LTE-A, the UE performs measurements of the radio link quality of serving and neighbor cells and sends measurement reports to the network. The network considers the radio link quality reported and makes the decision for handover. In the RRC_CONNECTED state, in a measurement period of 200 msec, the CPE or the UE performs measurements of at least 8 identified intra-frequency cells when no measurement gaps are activated [15]. The UE sends the measurement reports to the eNodeB and the interval between consecutive measurement reports is configured by the eNodeB using ReportInterval field on a layer 3 message. The value of ReportInterval field can range from 120 ms to 1 hour. The measurement reporting consumes wireless resources and power as well.

For UEs at fixed locations, the handover is not usual. Thus, the cell measurements and its reporting will be of no use unless there is a major change in the network infrastructure or in the multipath environment. Therefore, for low-to-zero mobility devices with M2M communication, less frequent cell measurements is already under consideration to reduce power consumption [16]. Thus, the measurement period for UE category X can be made much larger than 200 msec and we suggest that this is performed to save wireless resources and power. We propose that the eNodeB additionally sends a ReportIntervalFactor field on the layer 3 message. The UE category X uses an interval between consecutive measurement reports equal to the product of ReportInterval and ReportIntervalFactor. Evidently, this will allow to conveniently adjust an increased interval between reporting for the UE category X and thus, save some wireless resources and power during video data upload for OLSW.

5. CONCLUSION

The OLSW application can be of great use especially, for city dwellers. The service can range from the daily commutes to the bulk business transport. However, the deployment and maintenance for OLSW requires a good amount of investment. Therefore, local government or welfare organizations can step forward to implement OLSW. The implementation project may also be public-private partnership (PPP). The proposed method to configure less frequent cell measurement reporting in LTE-A can potentially save wireless resources and power during the video data for OLSW.

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