Road Safety: Adoption of ICT for Tracking Vehicles' Over-speeding in Tanzania

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ABSTRACT
The number of road incidents which result to deaths, injury, disabilities and loss of property is frightening. In Tanzania, the major contributor of road accidents is human factor which account for 74% in 2010. Vehicles' over-speeding is named to be one of the accelerating factors to the increase of road casualties. The existing measures to limit over-speeding has not shown major contribution to the road safety as there are only countable inspection points with speed radar guns as a way to limit over-speeding. This paper discusses the adoption of ICT for tracking vehicles and proposes the model for tracking in real time vehicles' over-speeding in Tanzania.

General Terms
ICT for Development.

Keywords
Over-speeding, ICT and road safety, GPS, GSM, Satellite.

1. INTRODUCTION
In Tanzania, road transport is the most commonly used by the majority of citizens. Road transportation has emerged to be the easiest option in moving goods and travellers. Despite the important role played by road transport, the sector has encountered a number of challenges emanating from road accidents. Statistics shows that while developing countries own only 32% of the world's vehicles, they account for 75% of annual accident fatalities [1]. The Road Safety situation in Tanzania has been deteriorating. During the period between 2000 and 2008, the number of road crashes increased by 42 percent (from approximately 14,500 to 20,600) whereby; the number of injuries had gone up by 27 percent and number of people killed had increased by 67 percent [2]. Road accidents have resulted to numerous consequences including deaths, injuries, disabilities and loss of properties, both of which accelerate to poverty in the country. The death of the most productive member exerts a devastating impact to the families, pushing many into poverty with long lasting effect to their children and their community at large [3]. There is a need of technological interventions in escalating road safety and diminishing number of people who die from road accidents each year and loss of potential. Road traffic injuries are now the 9th leading cause of death worldwide. Without new and improved interventions, road traffic injuries are expected to become the 5th leading cause of death globally by 2030 [4]. Recent statistics show that more than 100 people die in road traffic crashes per 10,000 vehicles in Tanzania and Ghana, compared to the 1.7 fatalities per 10,000 vehicles in the US. The fatalities will nearly double in two decades between 2000 and 2020 if major action is not undertaken [3].

Road accidents are attributed by the number of factors which could be grouped into three major categories: human, vehicle and road infrastructures. This paper is focusing on the causes related to human, speeding in particular. Speeding is a contributing factor in more than 25% of all traffic crashes in Dar-es-Salam in Tanzania between 1999 and 2001 [3]. Table 1 illustrates the major causes of road crashes in Tanzania and their percentage of contribution in the year 2000 to 2005 and 2010.

Table 1: Major causes to road crashes

Causes of Road crashes	**Contributory percentage (%)**	
	2000 - 2005	2010
Human factors	77	74
Including careless driving	54	57
Over-speeding	8	9
Improper overtaking	7	8
Drink and Drive	3	0
Overloading	4	na
Mechanical factors	16	12
Road conditions	7	14
TOTAL	100	100

Source: A performance audit report on the management of traffic inspections and speed limits in Tanzania (2012).

Over-speeding may result to loose of control of the vehicle and give a driver no time to make precise decisions. The crash impact due to higher speeding is more destructive and therefore increases the severity of the damage. From Table 1, despite of the fact that human factors are the major contributors to road incidents, yet they receive less priority in inspection. Table 2 illustrates percentage of priority that each cause of road crashes received in the year 2010.

As per Table 2, the inspection emphasizes that has been put by the responsible entities is bit scaring. Much of priority is focused to other factors which contribute very less to road casualties. One among other factors that results into this uneven prioritization of vehicles inspection and monitoring is lack of human resources and speed tracking tools (such as, speed radar guns). The analysis showed that most districts did not have a radar gun or breathe analyzer [2]. However, even with enough supply of speed radar guns, it is still challenging to have promising number of traffic inspection points all over the trunk roads across regions in the country. In this aspect there is a need for technological intervention that will ensure constant tracking of vehicles' speed in transit.

Table 2: Risk for road crash against priority in inspection for 2010

Causes of Road crashes	Relative risk for road crash (%)	Relative weight in inspections (%)
Human factors	74	17
Including careless driving	57	4
Over-speeding	9	4
Improper overtaking	8	0
Drink and Drive	0	1
Overloading	na	8
Mechanical factors	12	14
Road conditions	14	4
Other factors	0	65
TOTAL	100	100

Source: A performance audit report on the management of traffic inspections and speed limits in Tanzania (2012).

2. RELATED WORKS

Without new safety measures, all road users may be exposed to ever greater risk as the volumes of traffic increase, especially when different types of motor vehicle, some travelling at high speeds, share roads with each other and with pedestrians and cyclists. From the perspective of pedestrians and cyclists, mixing them with motor vehicles capable of travelling at high speeds is the most important road safety problem [5].

Road safety measures can be categorized as user related measures, training and education, traffic law, incentive, enforcement and vehicle related measures [6]. ICT can be adopted to increase road safety through addressing education, enforcement and vehicle engineering. [7] Suggested the use of ICT in education and enforcement. Education, sensitization or awareness campaigns about the consequences of not complying with road safety regulations are vital in influencing road user behavior and also change people's attitude. Further contended that, tackling enforcement with ICT can make enforcement more effective. The Police force can be provided with instant information which they can use to track road abusers, and discipline them appropriately [7].

Angela-Aida *et al.* [8] contend that, ICT allows road users and vehicles to be managed based on real-time road status information. [9] proposed the application that uses the power of smart phones in delivering real time information pertaining the events happening on the major roads. They synchronized web application with the mobile application, both of which share the same database. The most important thing is that user can send his information through application about conditions on the road where he is and to choose event, which is the reason he is in the crowed (road works, traffic accidents). Users use mobile and web application for monitoring and informing about traffic problems that they meet [9]. In addition to that, the application is equipped with map to locate the location with the reported road incident. The introduction of ICT into traffic systems will contribute to reducing of gas emissions, traffic accidents, save the time and money [9].

The GPS based system for tracking in real time the school transportation to avoid over-speeding and reckless driving was proposed by [10]. The system is modelled to track school buses which are fitted with GPS tracker of which send the information to school via GSM network and monitoring station. The proposed approach provides an overview of the GPS technology adoption and how it can be employed in over speeding detections with auto email and short messaging (SMS) alerts [10]. The adoption will be a major step forward for the Kenyan Government geared towards the reduction of road accidents attributed to over speeding and reckless driving [10].

In Tanzania, there have been a number of technological interventions towards the effort in addressing road incidents. In 1995, a computerized accident recording and analysis program so called MAAP5 was put in use. However, MAAP5 was declined to be used in 1999. Moreover, Tanzania Police Force partnering with other entities undertook the project to develop Road Traffic Accidents (RTA) information system (RTAIS) and Web-based RTA Database (RTAD) to ensure reliable availability of accidents data in the country. An efficient data collection system and a well maintained and accessible database are important prerequisites for the work to identify road safety problems, to categorise them and quantify them before measures are planned [11]. In 2013, the government through her Traffic Police Chief, pledged the implementation of the system of which among other features will help monitor careless drivers especially those who are driving whilst operating hand held gadgets such as phones and electronic pads. The system will first be applied for upcountry buses that are more blamed for over-speeding. The advanced technology will greatly reduce road accidents [12].

3. PROPOSED MODEL

This paper is focusing in proposing a model for tracking vehicles over-speeding in Tanzania, upcountry buses in particular. The proposed system will constantly track buses in real time and update the central database. The system will promptly pop up warning messages in case of over-speeding for appropriate action. Analysed data from the central database could be used as the evidence in case of traffic case prosecution. The system will allow for easy tracking of drivers with a habit of over-speeding and therefore appropriate disciplinary action could be taken against them, such as ceasing of their driving license. The proposed system will make use of the potential of Global Positioning System (GPS), Global Positioning Satellites and Global System for Mobile communications (GSM) Technology in delivering its services. Many researchers have proposed the use of cutting edge technologies to serve the target of vehicle tracking. These technologies include: Communication, GPS, GIS, Remote Control, server systems and others [13]. GSM and GPS based vehicle location and tracking system will provide

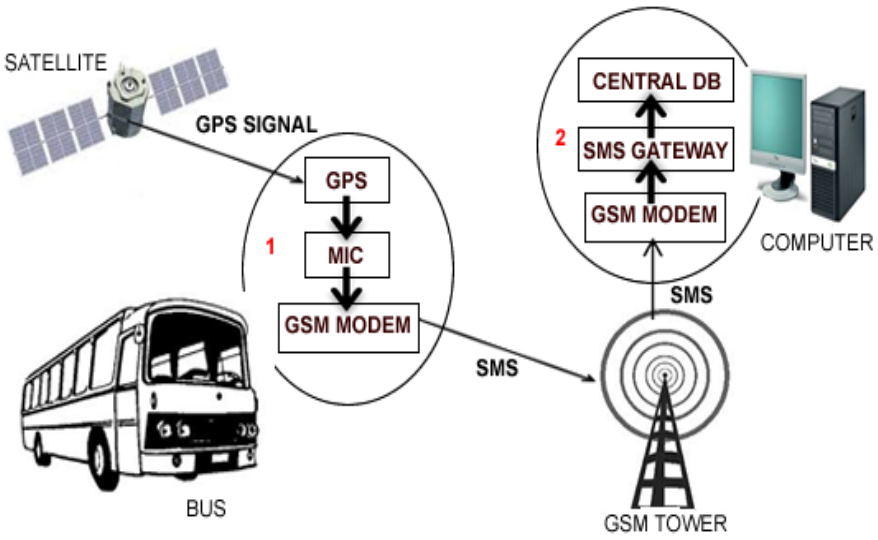

Figure 1: Proposed system architecture

effective, real time vehicle location, mapping and reporting this information value and add by improving the level of service provided [14].

3.1 The potential of GPS and GSM

The proposed system is anticipated to make use of GPS and Satellites in determining the speed at which the bus is moving. GPS is considered powerful in speed measurement. Very high accuracy in the average speed measurement can be achieved today providing that sufficiently large number of suitable GPS instruments is used to measure the speed. GPS Doppler tracking data from multiple satellites provides a very accurate and very easy way of measuring average speeds [15].

In Tanzania, GSM network coverage has rocketed at a very surprising rate. Tanzania Communications Regulatory Authority estimates that 75-80% of the population has access to a mobile phone. This extended GSM network coverage will allow for smooth use of GSM modems by the proposed system in relaying data (speed and bus location) as Short Messaging Service (SMS) to a central database. A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone [14].

3.2 Proposed system architecture

As shown in Figure 1, the proposed system can be broken down into two major parts; 1. Data Processing Unit (DPU) and 2. Data Repository Unit (DRU). DPU as a complete electronic gadget will be mounted in a bus. DPU consists of GPS, MIC (Microcontroller chip) and GSM Modem. With the help of satellite dishes, GPS is solely for tracking bus's speed and location. Data (bus's speed and location) from GPS is sent to GSM modem by the microcontroller chip imbedded in DPU. The GSM modem in DPU will send the data supplied to it as SMS via GSM network to the receiving end, DRU. DRU is not an electronic gadget per say, this is just the collection of hardware and software tools installed in a dedicated computer for receiving and analysing data. DRU is composed of GSM modem, SMS gateway and Central Database. GSM modem in DRU is used for receiving data sent from GSM modem in DPU. The received data will be sent to a central database for repository via SMS gateway. The central database is built with capacity to analyse data and provide user tailored reports. The central database as a complete web application is powered to receive user settings such as maximum speed allowed in a particular location. These pre-defined settings allow for determination of over-speeding. Moreover, the GSM modem in DRU is capable of sending information or warnings generated by the central database to the intended recipients such as bus owners and the closest traffic inspection point to the location of incidence for further action.

4. RESULTS AND DISCUSSION

The existing approach of tracking over-speeding by using speed radar guns is not efficient as it is only instituted to only accessible locations. The used speed radar guns are only for reading a speed of one vehicle at a time and no records which are kept and therefore it is not possible to track the speeding records of a particular vehicle. In the same line, it is difficult to trace the driving behavior of a particular driver. The proposed model is anticipated to offer an improved solution in tracking buses' over-speeding in trunk roads in real time despite of the geographical locations. If the proposed model will be implemented it is expected to improve transparency and accountability and therefore strengthening road safety. Proposed model offers prompt warnings for immediate actions and provide forensic evidence that will facilitate prosecutions. Figure 2 depicts prospective users' assessment (in %) of the proposed model.

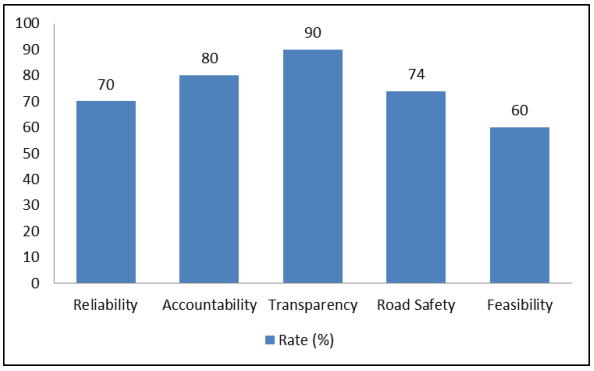

Figure 2: Prospective users' assessment

Prospective users' opinions in rating the practicability of the proposed model were reviewed and analyzed. In summary, the results showed that, the proposed model's advantages would overweigh that of the existing approach. Few parameters were used for assessing proposed model to see whether it will improve; Reliability, Accountability, Transparency, Road Safety and how feasible would the solution be.

5. CONCLUSION

Reducing road accidents is inevitable, for better performance the existing measures should be supplemented by more sophisticated ways. One among other parameters to ensure road safety is through limiting vehicle speeding. The proposed model for tracking vehicle's over-speeding delivers an ability to track buses in real time. The system is constantly updating the law enforcers (traffic policies) on what is going on in the roads and take promptly action in case of misbehaving. The successful implementation of this model is anticipated to offer positive results and contributes to road safety considerably.

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