Insights from computational modeling and simulation towards promoting public health among African countries

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Abstract

One of the problems associated with some African countries is the increasing trend of road mortality as a result of road fatalities. This has been a major concern. The negative impacts of these on public health cannot be underestimated. An issue of concern is the high record of casualties being recorded on an annual basis as a result of over-speeding, overtaking at dangerous bends, alcohol influence and non-chalant attitude of drivers to driving. The aim of this research is to explore and adapt the knowledge of finite state algorithm, modeling and simulation to design and implement a novel prototype of an advanced traffic light system towards promoting public health among African countries. Here, we specify and built a model of an advanced wireless traffic control system, which will help complement existing traffic control systems among African countries. This prototype is named Advanced Wireless Traffic Control System (WPDTCS). We developed this model using an event-driven programming approach. The technical details of the model were based on knowledge adapted from the Finite State Automation Transition algorithm. It is expected that the AWTCS will promote the evolution of teaching in modeling, simulation, public safety by offering trainees an advanced pedagogical product. It will also permit to strengthen the collaboration of knowledge from the fields of Computer Science, Public health, and Electrical Engineering.

Keywords: public health, public safety, modelling , simulation, programming.

1. INTRODUCTION

Road accidents and fatalities among West African countries are as a result of inadequate and poor infrastructures, careless driver attitudes, vehicular factors and environmental factors ([1]; [2], [3], [4], [5]. However, a reduction in cases of vehicular collisions and road fatalities can be achieved with properly enhanced road signals and traffic systems.

The aim of this research is to explore and adapt the knowledge of algorithms, computational modeling and simulation, towards promoting public health and safety.

The objectives are to design, implement, and model the prototype of a wireless traffic control system suitable for a typical African environment.

Therefore, a programming and simulation approach has been adopted and a model adequately defined to depict the experimental reality of the use of this prototype.

This will go a long way to reduce the mortality rate recorded as a result of road-traffic accidents, thus prolonging the lives of more useful, intelligent, and productive citizens. The rate of environmental pollution will also be minimized. This will in turn improve the quality of health and life of the African citizens.

It is hoped that the deployment of this prototype on a large scale among African countries, will help reduce the rate of road fatalities.

This paper is organized as follows: review of relevant literature, methodology, results, discussion, conclusion and recommendation.

2. REVIEW OF RELEVANT LITERATURE

Previous works have been done in the area of simulation and modeling of digital traffic lights [6]; Cremer and Ludwig [7], developed a prototype version of traffic lights based on Boolean operations; Oluwagbemi implemented a simple model version of digital traffic lights for reducing road accidents on African roads, however, his model design does not address the issues of epileptic electricity supply and other related challenges presently confronting some African localities [8] and the model also lacked opportunity for alternative sources of energy. Albagul and colleagues [9] developed a sensor-based prototype of a digital traffic light system. A Fuzzy approach was used by Hoyer and Jumar [10] to model traffic lights. The knowledge of Petri nets was adopted by Huang and Su [11] in modeling and analyzing traffic control systems. A wireless mesh network for traffic control systems was implemented by Lan and colleagues [12]. Tubaishat and colleagues proposed the integration of wireless sensors networks into traffic systems [13]. Other works are reflected in the followings: [14], [15] [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27].

However, there are various limitations associated with some of these systems. These include: inability to adequately meet up with present day challenges confronting most African cities. With the improvements made in our model, it is expected that, if fully implemented as a fully-functional hardware, the quality of public health and safety will be enhanced among these countries.

3. METHODOLOGY

This model was designed and implemented using the .NET platform. This prototype is a representation of a digital, solar-powered, electric-powered and UPS-sustained traffic light controller.

The developmental process of the transition aspect of this prototype was implemented by adapting the knowledge and operations of Finite State Automation.

Timers were set to regulate each traffic light system. We later applied this model to different scenario within a T-traffic highway common in typical African countries.

3.1 ALGORITHM

Algorithm adopted for implementing time transitions in our model was the finite state automation algorithm.

Discrete numbers of states can be found in finite state automation. The finite state machine was adopted to develop the timing aspect of our model because traffic light controller operates on a timer-driven cycle transitions. The finite state transition automation performs the following operations: sends events, receives events, starts timers, receive timers, makes decisions, arrives at a final state.

The next section contains the design phase of the proposed model of the wirelessly programmed digital traffic control system.

3.2 DESIGN PHASE OF THE PROPOSED WPDTCS ARCHITECTUREs

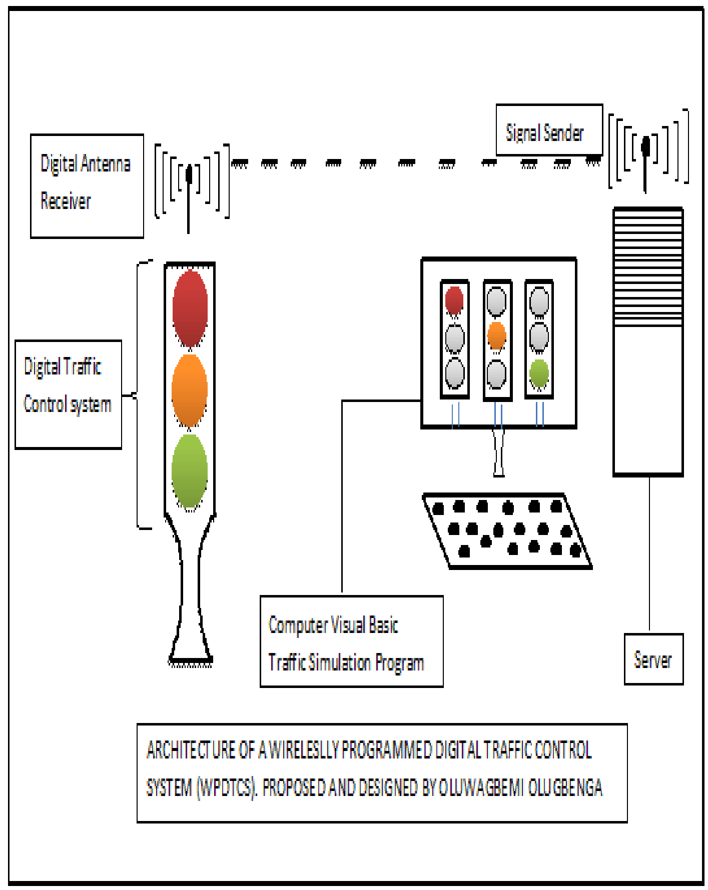


Fig.1. A Schematic Depiction of the WPDTCS model

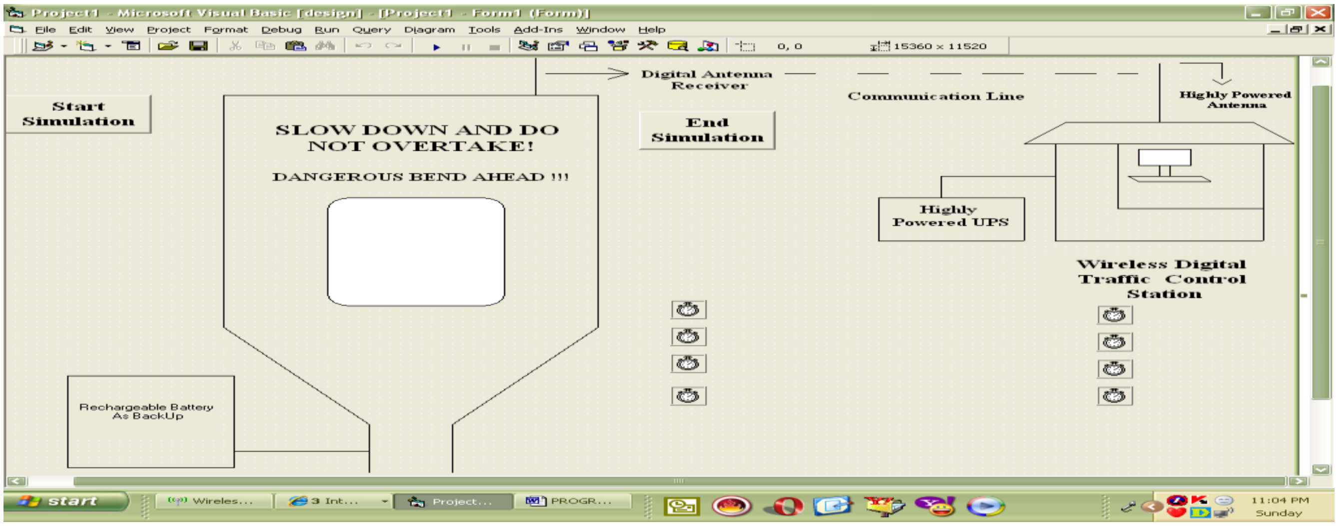


Fig.2

This new architecture Figure 2. is a typical architecture of a WTCS. It shows a traffic control system based on Wireless Technology, which is being controlled from a Traffic Control Base station, by using highly powered transmitting devices both from the base station and on individual traffic control stand. This particular design will help to reduce the speed of on –coming vehicles as they approach a dangerous bend ahead, and it will also prevent them from over-taking the vehicle directly in front of them, thus averting road-traffic accidents and injuries.

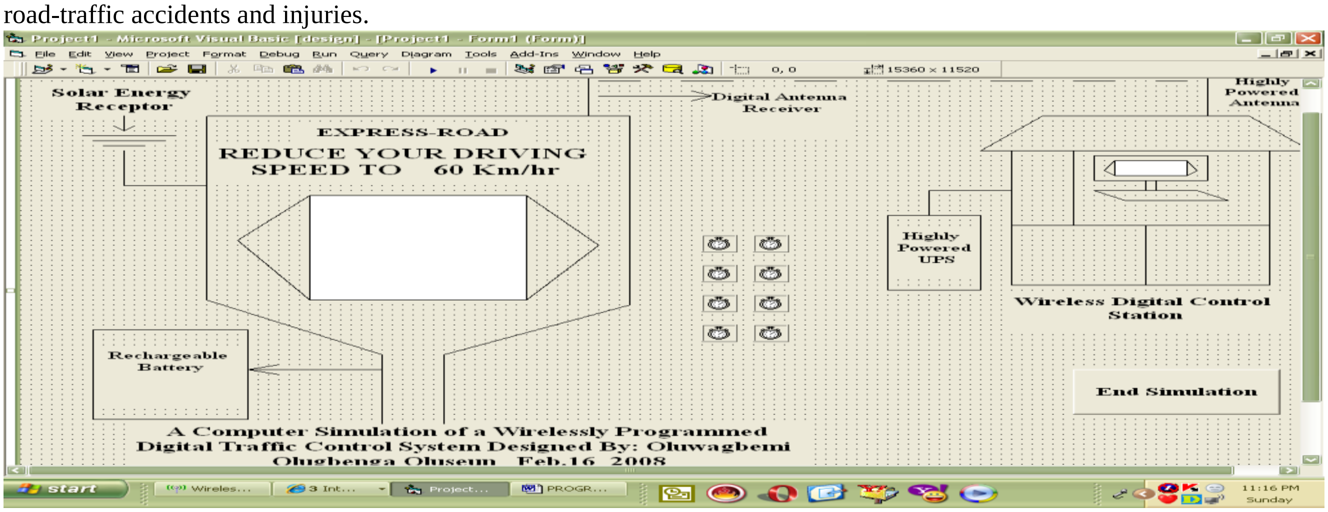


Fig.3

The architecture in Fig.3, which is the second design in the implementation of a viable wireless traffic control system technology here, helps to reduce the speeds of vehicles on African, Asian and European express-roads, thus reducing the rate of road-traffic accidents and injuries.

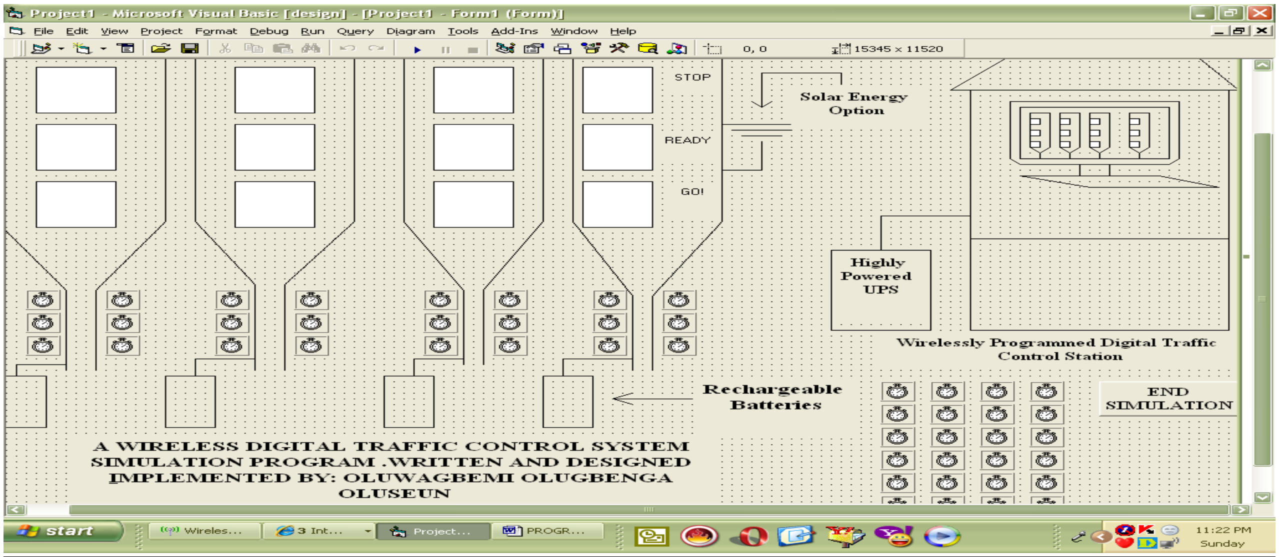


Fig.4

The third design in this proposed Wireless Traffic Control System is an architecture that will help to minimize traffic congestions especially on African, European and Asian cross-roads or round-about roads. It's a design that incorporates four different traffic light systems, regulated wirelessly from a Central Base Station.

4. IMPLEMENTATION

This section presents the developmental process of the WTCS prototype. This aims to validate our approaches of capitalization and re-use of experience of the experts in traffic control systems technology, in order to develop subsequent training, improvement and development of traffic control scientists and engineers. The final objective is development of a system which will allow experts in Computer Science, Public health, and Electrical Engineering to invent real–life equipments of this model in solving public health and safety challenges. It is also to provide a teaching and illustration tool to students of higher learning in the areas of Simulation and modeling.

The implementation was done using the Visual Basic programming language as a suitable tool to demonstrate the operations of the WTCS architecture and to illustrate the various displays at different time points. The programming aspect dealt with the three following modules, namely; model design, model implementation and model simulation.

Model design was implemented in the design phase of the integrated development environment of the Visual Basic compiler. The model implementation was done by coding in Visual Basic.

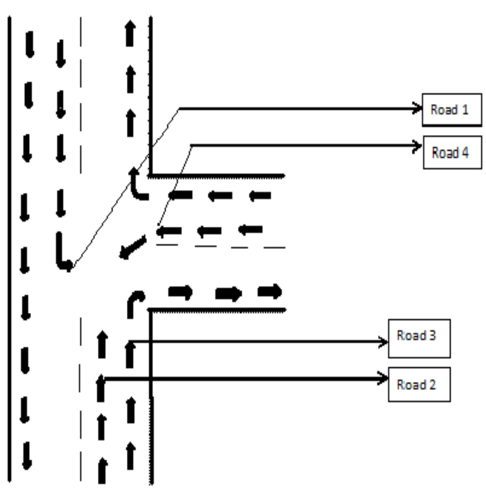
The simulation has to do with the running of the model's performance.

5. RESULTS

The results of the simulations show how the simulations were applied to different scenerios of typical African road networks.

The prototype simulation show that the signals from the computer in the Digital Traffic Control Station was sent through a highly powered transmitting devices to the receiver of the traffic control stands and it was displayed at real-time, thus signaling to coming vehicle to either stop, get ready or go. It can be clearly observed that the display on the computer screen in the Base Station is the same as those on the Traffic Computer Stands on the busy roads around the round-about roads. The schematic implementation of this can be observed in subsequent pages of this research manuscript.

The process of applying the simulated prototype of WPDTCS required conducting simulations on four typical African roads. Below is a diagrammatic representation of roads 1, 2, 3 and 4 respectively;



The flow of traffic on these different roads occurs when each road is allowed to pass alternatively. Presented here is a possible flow of traffic between the four lanes. The representation above does not allow any lane pass, it is simply a depiction of the road design. At this phase, the traffic light is displayed as blank for all roads as shown below.

Figure 12

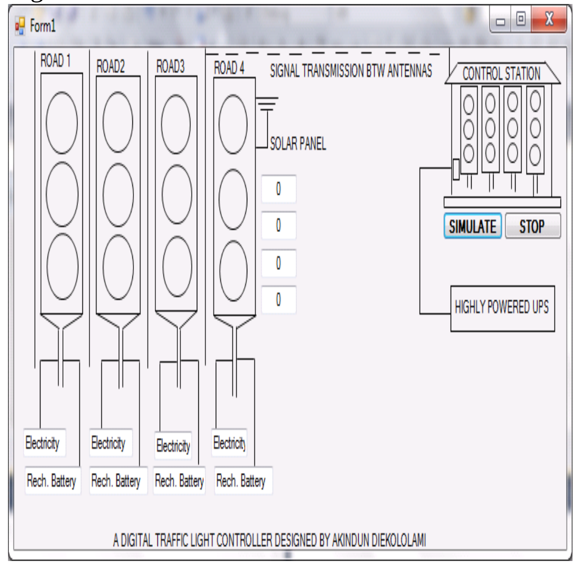


Figure 13

PHASE 1

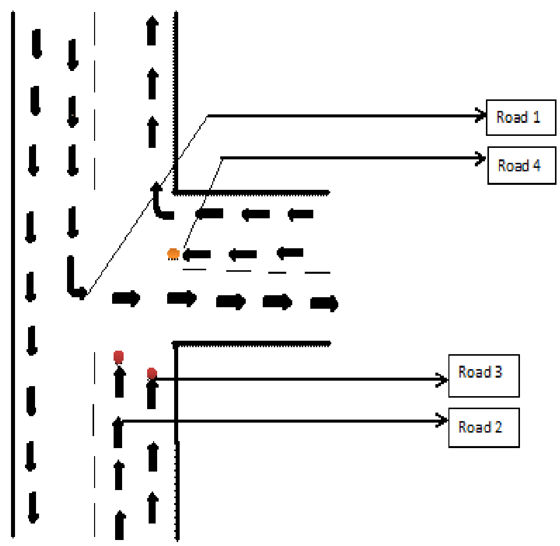


Figure 14 shows that when vehicles on Road 1 are moving, those on Roads 2, 3 and 4 come to a halt. Vehicles on Road 3 are restricted from moving to avoid collision between cars. The traffic light controller for Road 1 displays the green light; Roads 2 and 3 display the red light while that for Road 4 displays the yellow/ amber light as shown below.

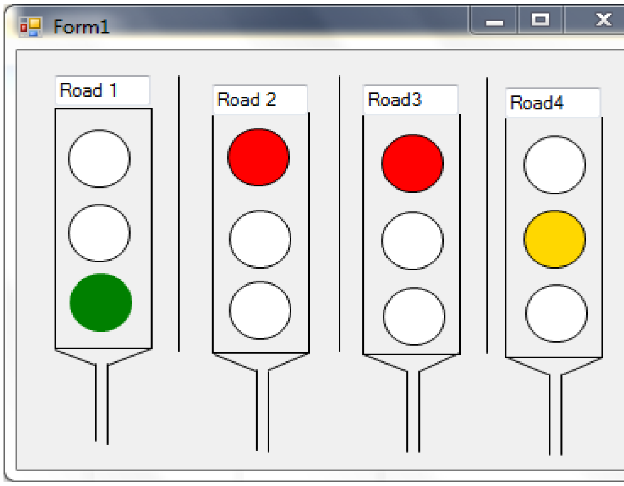


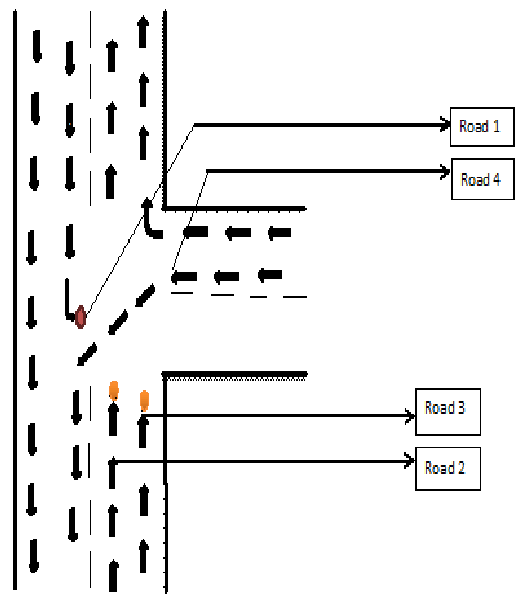
Figure 15 shows the digital simulations for the African road network illustrated in Figure 14.

TABULAR REPRESENTATION OF TIME SCHEDULE FOR PHASE 1

Roads	Time Interval (in seconds)	Color Display
Road 1	0s – 8s	Green
Road 2	9s – 17s	Red
Road 3	9s – 17s	Red
Road 4	18s – 22s	Yellow

Table1: Tabular schedule for the African road network illustrated in Phase 1.

PHASES 2 AND 3 MERGED



In the diagrammatic representation above, it can be seen that vehicles on Road 4 are moving as vehicles on Roads 1, 2 and 3 are put on a hold. The traffic light representations for these phases display the green light for Road 4, the yellow/amber lights for Roads 2 and 3 and the red light for Road 1 as shown below.

Figure 16

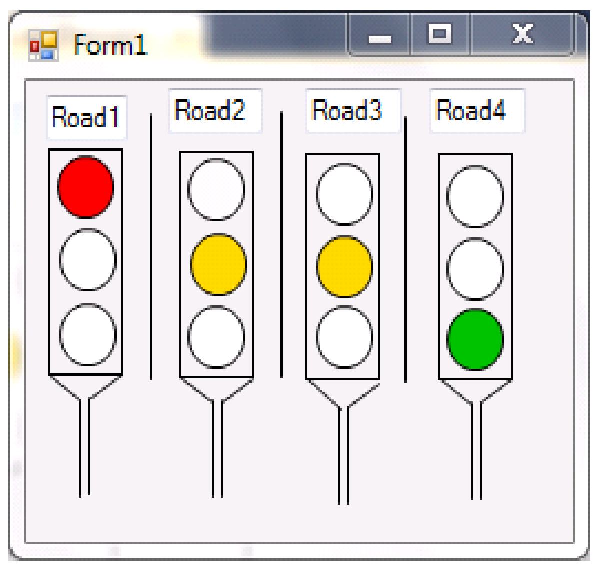


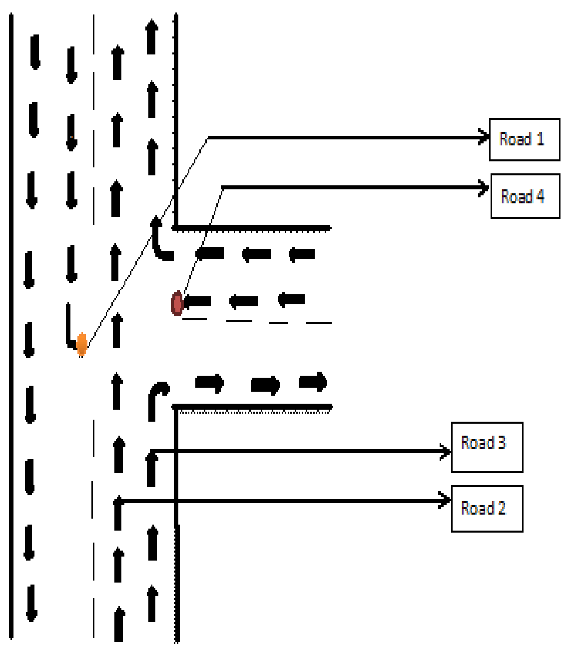
Figure 17: Figure 17 shows the digital simulations for the African road network illustrated in Figure 16.

TABULAR REPRESENTATION OF TIME SCHEDULE FOR PHASE 2 AND 3

Roads	Time Interval (in seconds)	Color Display
Road 1	9s – 17s	Red
Road 2	18s – 22s	Yellow
Road 3	18s – 22s	Yellow
Road 4	0s – 8s	Green

Table 2: Tabular schedule for the African road network illustrated in Phases 2 and 3

PHASE 4



As shown above in Figure 18, the traffic flow pattern allows vehicles on Roads 2 and 3 to proceed, while it halts vehicles on Roads 3 and 4. The simulated traffic light controller displays the green light to vehicles on Roads 2 and 3, red light to vehicles on Road 4 and displays yellow/amber light to vehicles on Road 1. The traffic light displays for represented African roads above are displayed below.

Figure 18

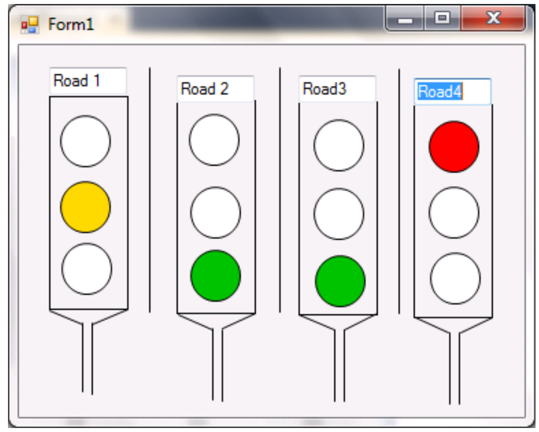


Figure 19: Figure 19 shows the digital simulations for the African road network illustrated in Figure 18.

TABULAR REPRESENTATION OF TIME SCHEDULE FOR PHASE 4

Roads	Time Interval (in seconds)	Color Display
Road 1	18s – 22s	Yellow
Road 2	0s - 8s	Green
Road 3	0s – 8s	Green
Road 4	9s – 17s	Red

Table 3: Tabular schedule for the African road network illustrated in Phase 4

7. DISCUSSIONS

Notable Improvements in WPDTCS

One of the improvements in **WPDTCS** is the addition of solar enabled power platform, which allows the traffic stand to receive solar energy and store this energy in a rechargeable battery. This is particularly important in some African countries where epileptic power supply has been a constant trend. The power stored in these batteries will be used as a constant backup for these traffic light systems to power the traffic control system display even when the major source of electricity supply is tripped off due to power shedding or power outage.

Another improvement upon the existing system is that, it makes use of highly powered transmitting devices to transmit signals from the Base station to the traffic control stands by using the microwave transmission technology. This implies that, highly powered digital antennas can be stationed at strategic locations; this will ensure effective and efficient communication between the Base stations and the individual traffic control stands at real-time.

Economic advantage

It will help improve public health and safety of citizens of African countries if fully implemented on the African road networks. Healthy citizens will have quality service to contribute to the economic development of their home country. Another improvement, in this architecture, is that the electricity charges supplied by the major electric line can also help in charging the rechargeable batteries connected to each traffic control systems, thus providing a dual –supply of electric power into the batteries.

In snowy regions, like the U.S and the European countries, the rechargeable batteries can be adjusted to produce a heating effect upon the body frame of the traffic control system without causing any damage to the framework, so as to prevent snow from beclouding the clarity of traffic signals to oncoming car drivers.

Contribution to knowledge -Proposed New Architecture

A novel traffic control system architecture was proposed which has some major improvements on existing systems.

8. CONCLUSION

This proposed Wireless Traffic Control system technology (WPDTCS), is a new innovation that will help drastically reduce the rates of road injuries, fatalities, and congestions. It will also complement already existing systems. In conclusion, implementing and deploying this model in real-life among African road networks will help promote public health and safety.

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