Virtual Light Communication Based Traffic and Road Information Broadcasting Systems

Muhammad Syafiq Bin Harun

Faculty of Electrical Engineering,

University Teknologi MARA, 40000 Shah Alam, Selangor

Abstract -This paper presents on the road safety smart system using virtual light communication (VLC). The system developed was to enhance the safety for the driver to be alert with the traffic light to avoid accident or collision. Most accident happened at the traffic light and this situation become the top reason of the accident in urban country. In addition this system are developed to offer more benefits by interfacing it with virtual light communication technology. Traffic safety information broadcast from traffic lights using Virtual Light Communication (VLC) is a new cost effective technology which can draw attention to drivers to take necessary safety measures. The new designed system are based on transceiver that using virtual light as a medium to transferring data to a receiver.

The transmitter on the traffic light and areas at risk zone will show the warning and remaining seconds of the light transition in the monitoring display in user's vehicle to alert the driver on the road condition. To achieve this, both hardware and software developed suite to its objectives to show its functionality. The main development tools used for this system are, Arduino IDE 1.0, LCD display, and photodetector.

Keyword: Arduino, IR transceiver, virtual light

I. INTRODUCTION

Road accidents which cause loss of material and most importantly human lives are becoming severe even with the deployment of many intelligent communication devices on board vehicle and alongside the road. According to world health organization report [2] road crashes are the second leading cause of death globally among young people aged five to 29 and the third leading cause of death among people aged 30 to 44 years. Over 1.2 million people are killed annually because of road accidents.

The study predicted that road accidents would become the sixth largest cause of death in the world in 2020 whereas it was the ninth largest cause of death in 1990.

Virtual light communication (VLC) is becoming an alternative choice for the future wireless technology that offer low cost, unregulated, and harmful infrastructures support. Furthermore, the technology can be used in a wide range of

applications both indoor and outdoor. Visible Light Communication (VLC) uses light for the dual role of
illumination and data transmission. This paper presents the application of VLC in road safety system that can reduce the most accident causes that bring to fatality which is Red-Light running violation by sending the remaining time for the vehicle to be ready to stop and remaining time for a car to continue their journey. LED-based VLC systems can be deployed in vehicular environment on existing infrastructure such as LEDs traffic signal lights.

There are many high priority road safety applications and services of VLC systems in vehicular environment. All of them assist drivers making safe decisions in traffic and complying with traffic regulations. The VLC systems can broadcast road traffic safety information in real time or pre-recorded, minimizing the possible accidents and increasing smooth flow of traffic on road. This concept of communication is not harmless for human because of no harmful gasses or radioactive effect to human body and environment.

VLC is an Optical Wireless Communication which uses IR LED to sending and receiving information. Recent advancement in LED technology has challenged the most popular and inexpensive conventional lamps, the compact fluorescent lamp (CFL) [1]. LEDs have been gradually replacing traffic lights and other conventional lamps because of their energy saving, long life, low maintenance cost, and low temperature generation. If the angle are not in range, the data will not be read by the receiver. Along with many access technologies, LED-based VLC can be used.

Additional traffic control and monitor unit is included which can provide additional support information. Since replacement of conventional traffic light with LED-based traffic light is getting widely use, it is desirable to use the dual function LED.

There are many projects being investigated and realized related to Intelligent Transportation Systems (ITS) worldwide, such as, PREVent [12], and CALM [13] to reduce road fatality. VIDAS (Visible light communication for advanced Driver Assistance Systems) is one such project, under the framework of which this thesis was developed. VIDAS exploits VLC [18, 19]. VLC based on Light Emitting Diodes (LEDs), is an emerging research area.

VLC is a novel kind of Optical Wireless Communication (OWC) [20] which uses white and coloured LEDs to simultaneously provide human visible light. Recent progress and advancement in LED technology has challenged the most popular and reasonably inexpensive conventional lamps, the Compact Fluorescent Lamp (CFL) [16]. LEDs have been gradually replacing traffic lights and other conventional lamps because of their merits of huge energy saving, long life, low maintenance cost, better visibility and low temperature generation. Being semiconductor devices, LEDs have inherent characteristics of high rate switching.

This combined feature of LEDs (lighting and switching) is unique, and opens the door for very important applications in Intelligent Transportation Systems (ITS) where the switching characteristics of LEDs are used for data communication without interruption to its normal function of human-visible signalling or lighting. LED-based traffic lights and VLC systems can become an integrate component of ITS and play a key role in road safety applications by broadcasting traffic information in advance to drivers running vehicles which incorporates a low cost photodiode-based receiver. VLC systems have an impressive advantage of potentially simple implementation on existing infrastructures, requiring only small modifications.

To minimize road accidents and fatalities, various modes of vehicular communications, such as vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V) and infrastructure-to-vehicle (I2V) are being investigated. Emergence of IEEE 802.11p standard [14] for short to medium range inter-vehicle communication and the allocation of a dedicated frequency band for ITS communication in Europe have paved the way for future implementations of communication-based ITS safety applications. The standard 802.11p for vehicular environment [15] or WiMax currently contribute to road safety. The Car2Car Communication Consortium [21] is dedicated to the objective of further increasing road traffic safety and efficiency by means of cooperative ITS with Inter-Vehicle Communications supported by Vehicle-2-Roadside Communications and vice versa. ITS [11] are new transport systems for the purpose of the minimizing road transportation problems, aiming for efficient traffic flow and reduction of the environmental load. A lot of research activities in ITS are seen recently to solve various traffic problems.

Many ITS related projects such as SAFESPOT [22], PREVent [12], and CALM [13] are being investigated to reduce road fatality. VIDAS (Visible light communication for advanced Driver Assistant Systems) is another challenging project which promises to be used on existing infrastructures resulting in low cost communication systems. VLC is normally based on LEDs which have many advantages such as highly energy efficient, long life, harmless to human and friendly to environment (green technology).

LED-based VLC [20] systems can be deployed in vehicular environment on existing infrastructures such as LEDs traffic signal lights. The VLC systems broadcast road traffic safety information minimizing the possible accidents and increasing smooth flow of traffic on road. Furthermore, LED-based road lights can offer ubiquitous road to vehicle communication (URVC) [17] throughout travel.

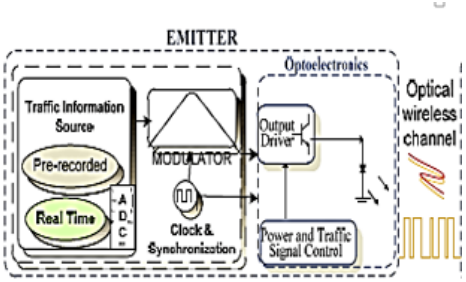


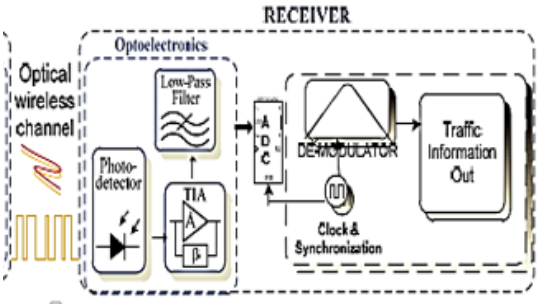
Figure 1. Transmitter block diagram

I. The VLC Transmitter

The traffic information either picked in real time or pre-recorded gets modulated with the purpose to switch the LEDs at the expected rate of data transmission.

The transmitter that used are IR LED that produce 38 KHz frequency range. In a practical aspect, the modulator also receives information from the traffic control unit so that it can hold information while the light colour changes.

This ensures that, there is no transmission in the brief period of change in traffic signal and the transmission is synchronized. The resulting signal is then used to control the switching of the LED through the output driver. The output driver combined with the control signal should ensure sufficient optical power, in order to achieve the expected range of communication. The transmitter in this system will send a data and turn buzzer ON when the car are approaching dangerous zone or traffic light area.



II. VLC Receiver

The VLC receiver is an optic-electronic transducer that receives information, previously modulated in the virtual light spectrum, and converts it into electrical signal capable of being processed by a demodulator-decoder.

The correct design of this device is crucial to ensure good performance of the overall VLC system. Among other concerning factors are the presence of low-level signal and high noise interference.

The receiver in this project will receive the warning data from the transmitter and will be displayed on the LCD screen with the sound of buzzer to alert the driver on the road condition. The LCD display will show the remaining time for next traffic light transition to assist driver to make an early decision.

II. METHODOLOGY

A. Flow Chart

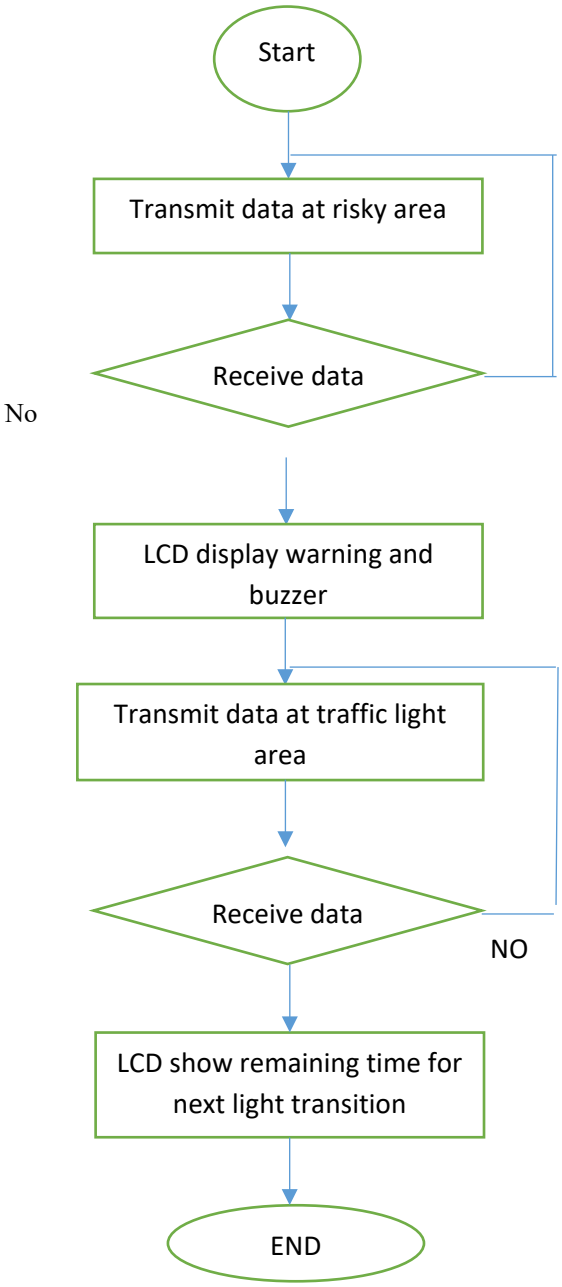


Figure 2. Operation of the system

Figure 2 shows the flow chart of the road traffic indicator using visible light communication (VLC). Once the driver are near the school area, there will located a transmitter that will send a digital signal to the transmitter and display a warning on LCD display to slow down their vehicle.

Furthermore, at the traffic light area, the transmitter will send a countdown data of the light for their remaining time for next traffic light transition. The countdown timer will give the driver a decision on either they have time to pass the traffic or they must stop. The receiver sensor will detect the data that will looping and repeat to send data to the receiver.

B. Circuit Design

The design of the circuit in this project are basically from the Arduino open source circuit. The functionality of the circuit are tested using the programming from the Arduino IDE software.

The connection of a pin in Arduino microcontroller are important to make it synchronize with the declaration of the pin in the software. On transmitter part, the component used are IR LED to transmit the data, meanwhile on the receiver circuit, IR receiver, buzzer and LCD display to monitor the data are used.

The circuits are separately on different Arduino microcontroller board. Transmitter circuit are on the Arduino Uno board and receiver circuit are on the Arduino Mega board.

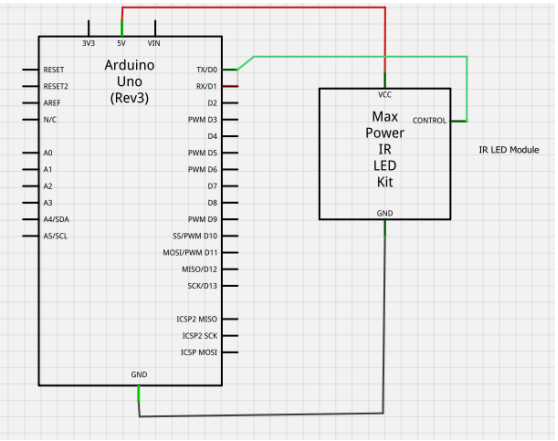


Figure 3. Transmitter circuit

Figure 3 shows transmitter circuit connected to Arduino Uno. Control pin or data are connected to receiver pin (Rx) on microcontroller. The

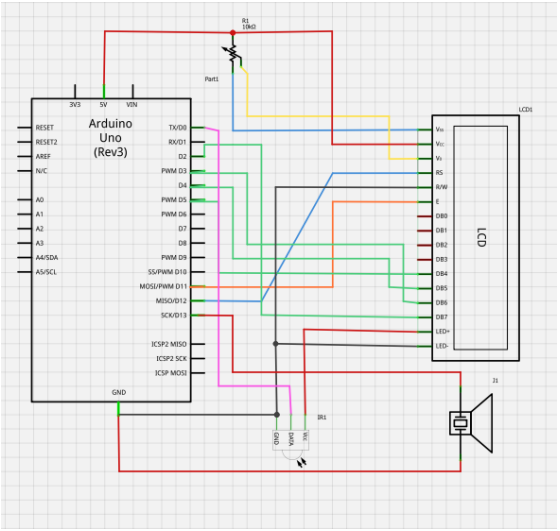


Figure 4. Receiver circuit

Figure 4 shows receiver circuit with the output. The output of this circuit is are the LCD display unit and a buzzer as the indicator to assist driver alertness.

C. Design specification

Figure 5. IR transmitter module

IR transmitter module used in this project is the same like the other IR communication device used in controlling remote device for a short line of the distance. This module work with 5V source and produce 38 KHz modulating frequency with digital interface.

Figure 6. IR receiver module

IR receiver module are miniaturized receiver for infrared remote control system. PIN diode and preamplifier are built on lead frame. PIN diode is a diode that has wide, lightly doped

'near' intrinsic semiconductor region between a p-type and a n-type semiconductor region. The wide intrinsic region makes the PIN diode suitable for attenuators, fast switches, photodetectors, and high voltage power electronics applications. The epoxy package is designed as IR filter. The demodulated output signal can directly be decoded by a microprocessor.

III. RESULTS AND DISCUSSION

i. Information data

The system begin to transmit data in looping for the whole system. When a vehicle that has a receiver module are near to the transmitter at the risky zone or area, the transmitter will send a data and buzzing sound to alert the driver. The LCD display in the car will show the message from the transmitter. The example of risky place for accident to happen is school area, factory area, and the area of fatal crashes frequently.

Figure 7. Transmitting data at school area

Figure 7 shows the display on LCD of the school area so that the driver will be alert and slow down their vehicle. The output are assisted by a buzzer to make the driver that not alert with their vision to hear the buzzing sound and be more alert.

ii. Traffic Light

The traffic light in this project are sending the data by infrared LED in form of information and countdown remaining time for the next light transition when the green light is lit. Transmitter will send data to a receiver in the car and the LCD will display the information for the driver to continue their journey.

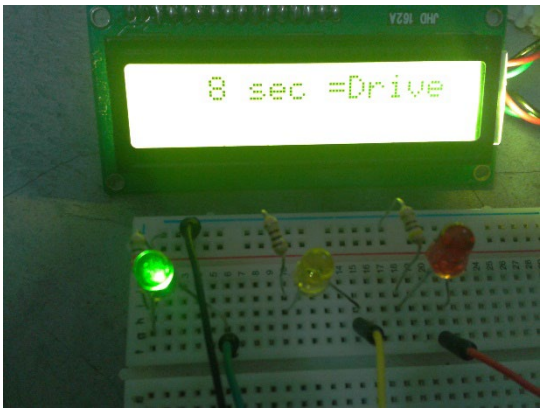


Figure 8. LCD display the instruction

Figure 8 shows the instruction when the transmitter transmit the countdown remaining time for a green light.

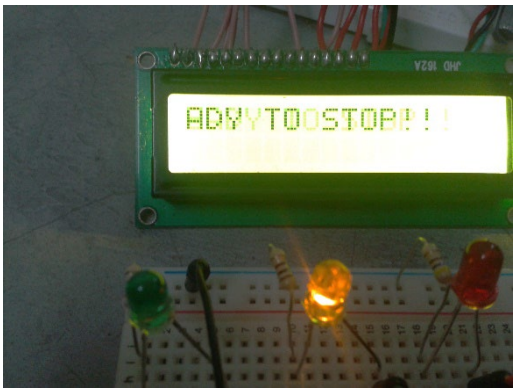


Figure 9. Yellow light warning

Figure 9 shows the warning message when the light turn to yellow. The transmitter will also turn on the buzzer to alert the driver. This action will give driver to make an early decision to stop their vehicles to avoid collision from the other road junction.

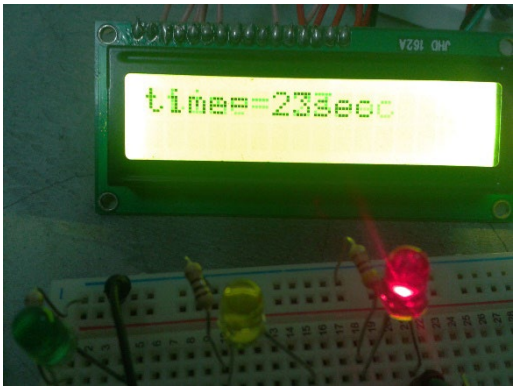


Figure 10. Red light countdown

Figure 10 shows the remaining time sent by IR transmitter. When a car approaching the IR transmitter placed at the traffic light, the receiver will get the real time countdown for the red light.

The transmitting frequency has been measured to identify the frequency output from the IR LED. The frequency gained is 38 KHz. The data are transmitting with the frequency of 38 KHz to be read by the receiver.

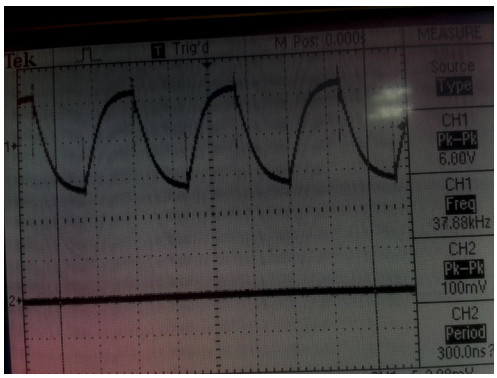


Figure 11. Transmitter wave on oscilloscope

Figure 11 shows the transmitting frequency with data transmit at 38 KHz on channel 1 of oscilloscope with 6V peak to peak voltage.

Distance and time taken is important to know the real-time transmitting properties. Below is data on distance versus time taken of transmitting and receiving signal.

TABLE 1. DIFFERENT BETWEEN TIME AND DISTANCE

	Distance of IR transmitter and receiver (cm)							
	5	10	15	20	25	30	35	40
Time taken (sec)	1.3	1.5	1.7	1.9	1.9	1.9	2.4	2.0

The time taken for a transmitter and receiver to transmit and receive data are small.

The difference in between a distance delay is small. Figure 12 below shows difference of time and distance for a data to transmit and receive.

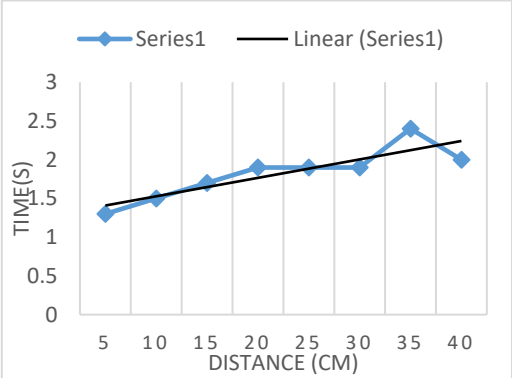


Figure 12. Time vs. Distance graph

IV. CONCLUSION

A Virtual Light Communication Based Traffic and Road Information Broadcasting Systems
was developed. The preliminary testing of the system shows that low cost wireless communication system is able to enhance the road safety and management of traffic.

Thus, the system in this microcontroller designed to overcome the main cause of the fatal accident. VLC provides a unique opportunity to provide communication capabilities that is not noticed.

However, VLC requires cost effective platforms, and this paper describes a simple design that leverages modern microcontrollers to overcome the limitations of simple, mass-produced LEDs when used for VLC.

V. FUTURE DEVELOPMENT

The system can be improved by using a visible light type of LED, which is compatible to be in the traffic light itself.

With this future technology, the wireless communication using IR LED also can be a medium to control the mechanical component in the car to avoid the accident from happen. This technology can be in many sector of industry to enhance the system in a country.

REFERENCE

[1] M. S. Shur and R. Zukauskas, "Solid-State Lighting: Toward Superior Illumination," *Proceedings of the IEEE,* vol. 93, pp. 1691-1703, 2005.

[2] Y. M. J Nam-Tuan Le, “Virtual Cognitive MAC for Visible Light Communication System,” International Journal of Smart Home, vol. 6, pp. 1 – 6, 2012.

[3] M. Akanegawa, Y. Tanaka, and M. Nakagawa, "Basic study on traffic i formation system using LED traffic lights," IEEE Trans. On Intelligent Transportation System, vol. 2, pp. 197-203, 2001

[4] B. W. Haswani, K. Toshihiko, H. Shinichiro, and N. Masao, "Visible Light Communication with LED Traffic Lights Using 2-Dimensional Image Sensor," IEICE Trans. Fundamentals, vol. E89-A, 2006.

[5] E. S. o. Jens Eckstein, “Dynamic Collision Detection in Virtual Reality Applications,” Saarland University, Germany.

[6] H. P. G Andrea Basso, nave Gibbon, Eric Cosalto, Shun Liu “VIRTUAL LIGHT: DIGITAI2LY –GENERATED LIGHTING FOR VIDEO CONFERENCING APPLICATIONS,” Univ. of Southern California, USA 2001.

[7] O. L. Davies. (September 2012). World Health Organization Media Centre. [Online]. Available: http://www.who.int/mediacentre/ factsheets/fs358/en/index.html

[8] Wireless Access in Vehicular Environment (WAVE), IEEE, 2010.

[9] G. Davis and B. McKeever (July 2006). Research for V2I Communication and Safety Applications. ITE Technical Conference Available:http://www.its.dot.gov/presentations/pdf/V2I_Safety2011_ITE_Technical_Final.pdf

[10] P. Dietz, W. Yerazunis, and D. Leigh, “Very low-cost sensing and communication using bidirectional leds,” in *UbiComp 2003: Ubiquitous Computing*. Springer, 2003, pp. 175–191.

[11] ITS, "Intelligent Transportation Systems," http://www.its.dot.gov/research.htm, 2010.

[12] PREVENT, "Project PREVent," http://www.prevent-ip.org/, 2010.

[13] CALM, "Communication Access for Land Mobile," http://www.isotc204wg16.org/concept, 2010.

[14] IEEE 802.11p,”Wireless Access in Vehicular Environment (WAVE)”, IEEE, 2010.

[15] S. Eichler, "Performance Evaluation of the IEEE 802.11p WAVE Communication Standard," in Vehicular Technology Conference, VTC-2007 Fall, IEEE 66th, pp. 2199-2203. 2007.

[16] M. S. Shur and R. Zukauskas, "Solid-State Lighting: Toward Superior Illumination," Proceedings of the IEEE, vol. 93, pp. 1691-1703, 2005.

[17] S. Kitano, S. Haruyama, and M. Nakagawa, "LED road illumination communications system," in IEEE 58th Vehicular Technology Conference, pp. 3346-3350, 2003.

[18] Navin Kumar, Nuno Lourenço, Michal Spiez and Rui L. Aguiar, “Visible Light Communication Systems Conception and VIDAS,” IETE Technical Review, vol. 25, no. 6, pp. 359-367, Nov-Dec 2008.

[19] Navin Kumar, Luis Nero Alves, and Rui L. Aguiar, “Visible Light Communication for Advanced Driver Assistant Systems,”7th International Conference on Telecommunication (ConfTele‟09), Feb. 2009.

[20] Y. Tanaka, Haruyama, S.and Nakagawa, M, "Wireless optical transmissions with white coloured LED for wireless home links," in PIMRC, The 11th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, , pp. 1325 – 1329, 2000. 75

[21] C2C, "Car 2 Car Communication Consortium." http://www.car2car.org, Car2X Communication System, 2008.

[22] SAFESPOT, “SAFESPOT Integrated Project, Cooperative vehicles and road infrastructure for road safety.” http://www.safespot-eu.org/., 2010.