Construction and Field Testing of Broadband Transceiver Modules Applied for ITS Environmental Surveillance

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Abstract

The high complexity of the road traffic management and the vehicles mobility management is the main concerned cases to study amongst the governmental regulator and the academicians living at the big cities all over the world including Makassar city. The R&D activity presented in the manuscript outlined several interesting solutions to address the crucial road traffic problems that may also increasing in the near future encountered in the capital city of South Sulawesi Province. The modern technique, smart and effective, to control and to monitor the road traffic situations as well as the continuous observation concerned the actual events such as the potential traffic jamming, the road accident, the crime acts and so on, are the main important things and very urgent to be applied in the city. Furthermore, to improve the safety and the comfort of ITS users the availability of the up-dated info regarding the environmental conditions and the CO emission level are also very important to be monitored. The designed surveillance system to be deployed later in Makassar city intelligent transportation system consists of sensor array module and its corresponding broadband transmitter, the transmission medium (i.e. the wireless link 95 MHz and the optical cable), the broadband receiver and PC-Desktop server. Several models of a broadband transceiver module intended to be installed along the road network infrastructure to continuously monitor the road situations and to regularly transmit the collected data to the main server was experimentally tested and assessed.

Keywords

Traffic management, Vehicle mobility management, ITS-Intelligent Transportation System, Sensor array and Environmental Surveillance

1. Introduction

A large variety of innovative models have existed globally regarding the transportation system operation and management to optimally utilise the available information and communication technology (ICT) well known as the intelligent transportation system (ITS). Based on some R & D activities that have been studied during the last decade, for instance in [1-4], the adoption of the transportation management system has increased significantly in order to maintain the better quality of the transportation network. For example, researchers from the University of Cambridge

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(UK) has developed intelligent transportation system project that covers many aspects, including monitoring activities and data collection; as well as the transmission and analysis of vehicles traffic data on the highway. In the study, there are a number of things investigated including efforts to improve the "intelligent-ePilot services", identifying assets and collecting data of the highway environments; leading edge technology applications to build better road traffic environments and the design of multimodal biometric identification system for travel documents.

There are a number of important and crucial issues influencing the transportation system in the entire territory of Indonesia. These are dominantly characterized by a variety of conditions including an increase use of vehicles on the highway which may have a significant impact on congestion to be getting worse; an increase of crime acts (such as robberies, muggings, and rapes on the vehicle), the rate of road accidents is increasing, and the potential impact of environmental pollution existed due to the continued prevalence of the use of fuelled vehicles (such as diesel and gasoline) and it is the highest probability existed still in the society. Besides, the inappropriate model of urban areas governance applied may have the significant effect on the poor quality of the transportation management system. It is therefore very urgent to optimally utilise of ICT technology to improve the real operation and management of the transportation system.

In practical, there are basically two types of data/information flow should be managed in ITS network. These include flow of data/information that goes toward the centre of highway traffic management and flow of data/information out of the highway traffic management centre. There are many resources needed to build an intelligent transportation management system such as to implement and to maintain the public services system in emergency conditions existed (i.e. accidents or crime acts occur) it is therefore required the reliable communication infrastructures (i.e. mobile telephone media or fixed telephone connection) along the road must be installed and are connected to the monitoring unit station; and many more others that can be researched and developed later on. Use of other ICT devices such as cameras to monitor the speed of vehicles or real events along the way is also very important in supporting the creation of the more reliable and powerful of highway traffic management system. Besides, various types of electronic sensors such as speed sensors, electronic sensors for monitoring ambient air quality, and various types of other electronic detectors can also be integrated into the intelligent highway traffic monitoring system prototype.

Basically, the model of data/information flow that comes from highway traffic management centre should be easily accessible, inexpensive and is reliable (anytime, anywhere, and anyone). The importance of broadband communication infrastructures development for purposes of the distribution of all types of ITS information/data and to perform various functions whatsoever along the highway to users has stimulated many researchers to work on the very challenging area. Varieties innovative ITS R&D projects are required to be consistently studied and implemented in accordance with the environmental characteristics of highway in urban areas. The undergoing studies should also be adjusted with the behaviour of people who use highway (user behaviour). The prototype of the designed broadband transceiver units that are placed in locations that have been determined will then be connected via the existing optical fiber network connection available in the Metropolitan Makassar go to a main collection centre, processor and distributor of web-based server. In the study, the environmental data transmission has also utilised the broad bandwidth of wireless link connection, sequentially, to guarantee the more reliable surveillance system. Through the optimal utilization of the communications network capability that has a wide frequency operation band would allow all types of flow data/information can be exchanged and distributed to the entire highway customer with the high level of satisfaction, comfort, speed of data update and quick access. This condition will ensure the better highway transportation network management and security. By utilizing the rapid ICT technology development, the modes of communication that can be researched and developed for the sharing and distribution of ITS data/information that is varied in terms of both the type and capacity can be performed in various applications platforms such as radio/TV broadcasting, internet media, mobile communication media, and many others.

2. Broadband Environmental Surveillance Network

The designed environmental surveillance system to real-timely monitoring various numbers of road traffic and its environment situation is illustrated in Figure 1. The constructed surveillance system consists of several electronic instrumentations including environmental sensors array module; switching stuff; transmitter unit; hybrid data transmission media (i.e. optical fiber and wireless links); receiver unit; the display monitoring, and recording unit.

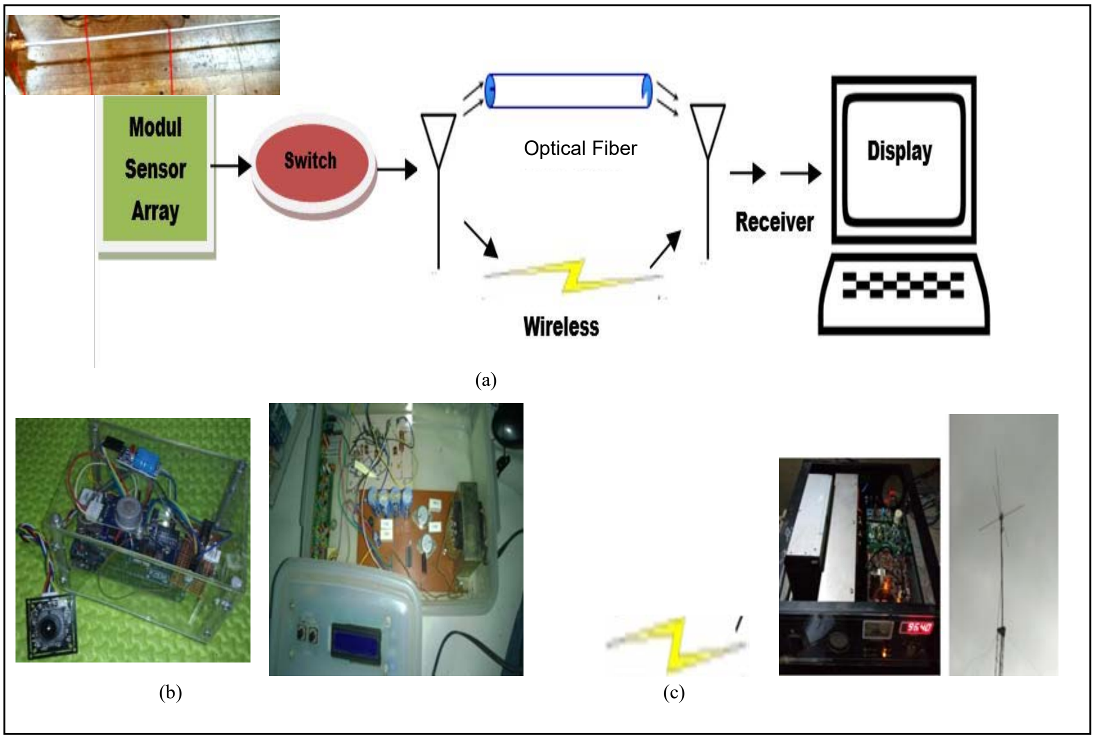

Figure 1: A typical Broadband Environmental Surveillance Network exploiting the powerful combination of hybrid transmission media, i.e. optical fiber cable and wireless communication link.

Various numbers of ITS data such as actual traffic intensity along the highway, the quality of exhaust emissions from vehicles (e.g. level of CO emissions), the speed of the vehicle, the potential for congestion on the highway captured through real- time CCTV network, and many more can be collected and transmitted quickly over existing optical fiber link network and received them with low of bit error rate at the central monitoring and processing station. A new strategy is offered here in the form of the application of artificial intelligence to the design of the traffic data processing systems as well as the recorded data of all the events can be monitored and the data stored on the monitoring unit center-based web server that can be accessed on-line and up-to-date. Results of the monitoring of large varieties of traffic highway parameter obtained through sensors and CCTV transducer (such as density/traffic volume of vehicles on the highway; the vehicle speed; and air pollution) are firstly processed on the motherboard to be later transmitted over hybrid telecommunications transmission networks, i.e. optical fiber link and wireless link. The constructed broadband transceiver system is relatively inexpensive, superior performance (powerful) and reliable. The parameters of the monitoring results will be received on a transceiver unit in the data processing centre and displayed on the display monitor as a component of the system output. This process is clearly illustrated on Figure 1 (a.). Figure 1 (b) describes the fabricated prototype of the environmental sensor array module which is built-up from various electronic sensors such as Sensor DHT11, Sensor MQ7, and camera VC0706. The current visual display of all the received environmental parameters was designed using visual basic software and it is configured in such away to allow the graphical visualizations of the environmental parameter to be obtained. To guarantee the accurate sensing and data collection of the CO sensor (sensor MQ7), the carbon monoxide meter of the Extech type was used for the data comparison during the system performance testing.

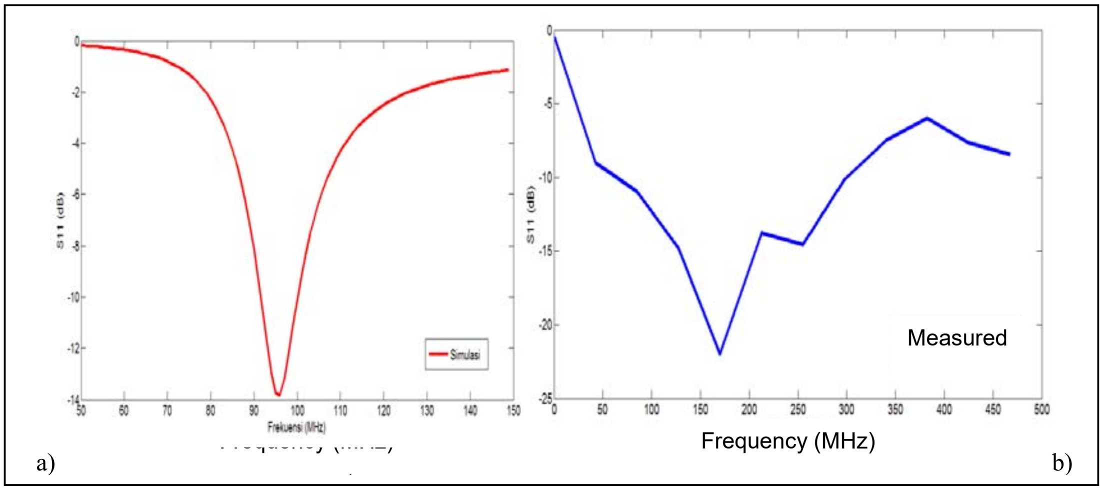

Figure 2: The antenna system reflection coefficients deployed at one end transceiver of Broadband Environmental Surveillance.

3. Performance Testing and Evaluation

In order to evaluate the electrical properties of the constructed environmental surveillance system, several experimental investigations and testing were performed. These include the testing of designed antenna system, electronic instrumentation circuits, the data transmission quality through the hybrid transmission media (i.e. optical fiber cable and wireless link) and many others. Figure 2 shows antenna system performance, both for the simulated model and the fabricated one. The antenna is a monopole wire antenna intended to apply in the frequency operation band lied from about 90 MHz up to 350 MHz. It is clearly seen that the constructed antenna allow the wide bandwidth for the data transmission from the sensor array module and transmitter to the central monitoring unit. The available impedance bandwidth of approximately larger than 350 MHz is possible to be achieved in the practical situation, even though the numerical computation shown a relatively big different performance in terms of the impedance bandwidth provided (approximately 40 MHz).

The experimental testing to evaluate the data transmission quality through the hybrid transmission media (i.e. optical fiber cable and wireless link) and to study the electrical properties of the constructed environmental surveillance system have been performed for several times. However, in this conference manuscript the results of the experiment to assess the quality of ITS environmental data transmission over the wireless link will be dominantly discussed and only little part presenting the whole testing transmission over the optical fiber cable. Table 1tabulates several testing results to characterize the performance of ITS data/information transmission via 96.4 MHz frequency band communication link. The experiment was set-up in such a way to study of how the actual sensed data collected through the environmental sensors array module could be transmitted from various distances (or different locations) along the highway network.

Table I Transmitting data using FM Creator 96.4 MHz transmitter on the situation no vehicles in the nearby location

Distance (km)	Time	Transmitted Data			Received Data			Receiver Vout (V)	Air Quality Category
		K (%RH)	T (°C)	CO (PPM)	K (%RH)	T(°C)	CO (PPM)		
1	02:00	64	28	26	64	28	26	1.940	Good
	02:02	64	28	26	64	28	26	1.940	Good
	02:04	64	28	26	64	28	26	1.940	Good
2	02:35	64	27	26	64	27	26	1.90	Good
	02:37	64	28	26	64	27	26	1.90	Good
	02:39	64	28	26	64	28	26	1.90	Good
3	02:45	64	28	26	64	28	26	1.87	Good
	02:47	64	28	26	64	28	26	1.87	Good
	02:49	64	28	26	64	28	26	1.87	Good
4	02:56	63	28	26	63	28	26	1.910	Good
	02:58	63	29	26	63	28	26	1.910	Good
	03:00	63	29	26	63	28	26	1.910	Good
5	03:08	63	28	26	63	28	26	1.928	Good
	03:10	63	28	26	63	28	26	1.928	Good
	03:12	63	28	26	63	28	26	1.928	Good

It is obviously known based on the above table that the whole constructed environmental surveillance system has performed in the very accurate manner during the mobile testing measured from several locations. The communication range between the local sensor array transceiver module and the centre monitoring and processing unit located at Universitas Hasanuddin campus, Tamalanrea Makassar is no more than 5 Km. Outside the area the communication quality was very poor and in the crucial condition it was disconnected. The measured ITS data described in Table I could be further processed for the purpose of analytical assessment regarding the data transmission characteristic in several parts of the entire ITS network and the results are plotted in Figures 3, 4, 5, 6 and 7.

Figure 3. **Graphical properties of Transmitter 96.4 MHz positioned in the distance 1 km where no vehicles presented around the area of testing (a) Time 02:00, (b) Time 02:02, (c) Time 02:04**

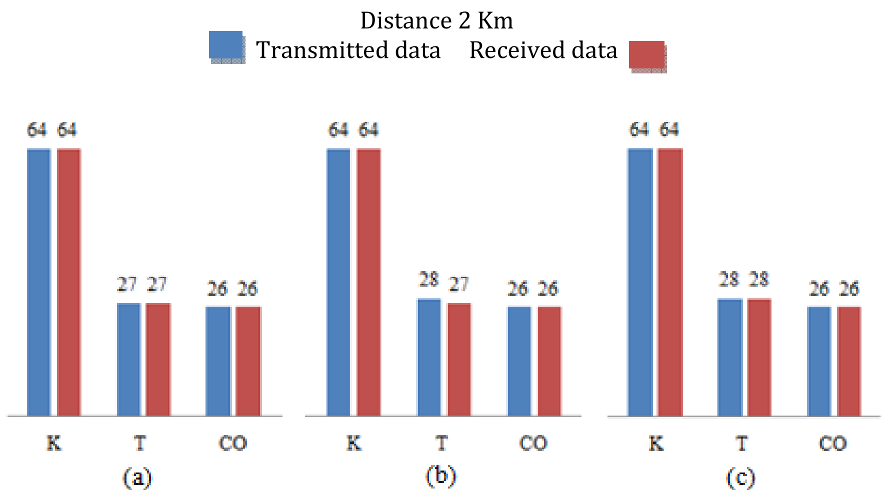

Figure 4. **Graphical properties of Transmitter 96.4 MHz positioned in the distance 2 km where no vehicles presented around the area of testing (a) Time 02:35, (b) Time 02:37, (c) Time 02:39**

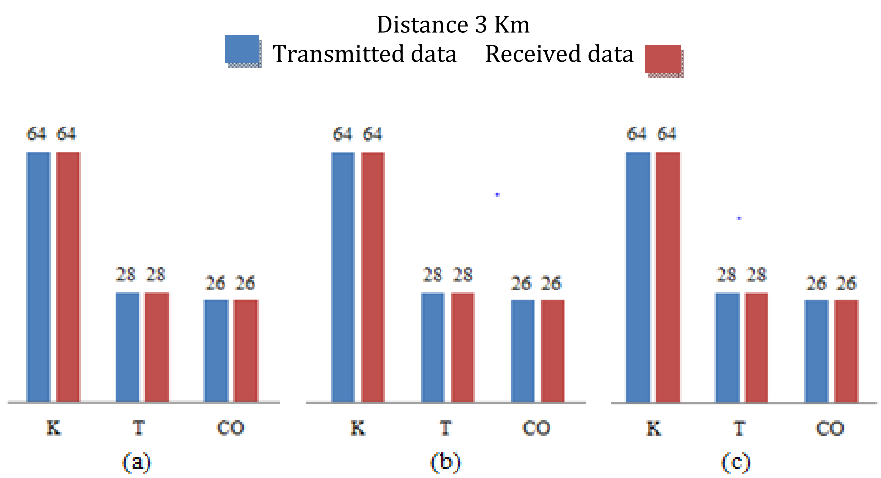

Figure 5. **Graphical properties of Transmitter 96.4 MHz positioned in the distance 3 km where no vehicles presented around the area of testing, (a) Time 02:45, (b) Time 02:47, (c) Time 02:49**

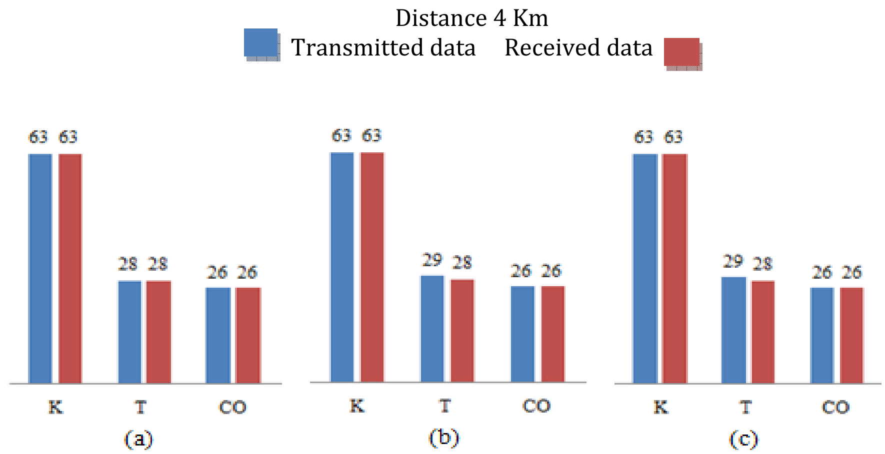

Figure 6. Graphical properties of Transmitter 96.4 MHz positioned in the distance 4 km where no vehicles presented around the area of testing (a)Time 02:56, (b) Time 02:58, (c) Time 03:00

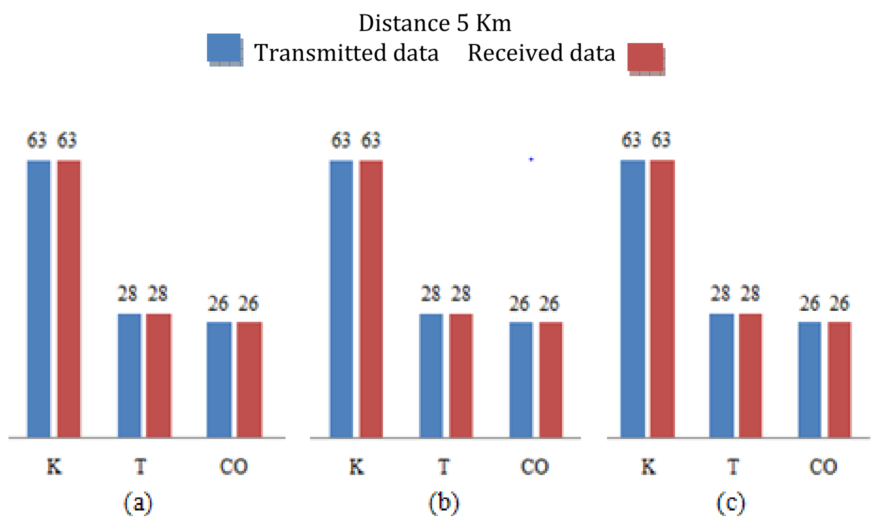

Figure 7 Graphical properties of Transmitter 96.4 MHz positioned in the distance 5 km where no vehicles presented around the area of testing, (a) Time 03:08, (b) Time 03:10, (c) Time 03:12

The whole experimental testing results described above confirm the very good operation of the designed ITS surveillance system. There were no differences between the transmitted data and the received data for the distance measurement between the remote sensors array module and the main central processing and monitoring set-up 1 Km, 3 Km, and 5 Km, for the duration of 2 minutes of transmission. Meanwhile in the distance of 2 Km and 4 Km, respectively, there were slightly differences results during the experiments especially on transmitting the temperature value 28^0 C and the receiving value 27^0 C and on transmitting the temperature value 29^0 C and the receiving value 28^0 C. The differences are highly possible caused by the existing air noise, circuit noise or perhaps due to the obstacle along the road.

4. Conclusion

The current designed broadband environmental surveillance system was configured to allow for the transmission of various environmental parameters representing the actual conditions of a particular intelligent transportation system developed in Makassar city. A constructed environmental sensors array incorporated with a transmitter module was used to collect a number of parameters including the visual situation of ITS (in form of picture streaming or short video file), humidity, temperature and CO level. The broad bandwidth could be provided during the transmission of those ITS data from the remote location are possibly performed using the hybrid transmission technique, i.e. wireless transmission and optical fiber transmission modes. The transmission tasks were executed sequentially and continuously using the two modes of transmission media in order the reliable transmission of various data from the remote station to the central station. Many more advanced investigations must be performed later including the testing through the optical fiber network and the development of mobile computing application to allow users for the easy real-time access to the ITS surveillance network via a mobile phone or any other smart phones.

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References

A. G. P. Rahbar, “Dynamic impairment-aware RWA in multifiber wavelength-routed all-optical networks supporting class-based traffic,” *IEEE/OSA Journal of Optical Communications and Networking*, vol. 2, no. 11, pp. 915–927, 2011.

Dimitrakopoulos G., and Demstichas P.,”Intelligent Transportation Systems, “IEEE Magazine on Vehicular Technology, Vol.5, Issue 1, Maret 2010, pp.77-84.

F.Y. Wang, C. Herget, and D. Zeng, ”Guest Editorial Developing and Improving Transportation Systems,” The Structure and Operation of IEEE Intelligent Transportation Systems Society, ” IEEE Transaction Journal on Intelligent Transportation System, Vol.6, Issue 3, 2005, pp.261-264.

I. Ramesh, S. Sundaravadivelu, “Reliable Routing and Wavelength Assignment Algorithm for Optical WDM Networks”, European Journal of Scientific Research ISSN 1450-216X Vol.48 No.1, 2010.

I.Mollers et al.,”Plastic Optical Fiber Technology for Reliable Home Networking: Overview and Results of the EU Project POF-ALL,” Topics in Optical Communications, IEEE Communication Magazine, Agustus 2009, pp.58-68.

J. S. Kim, D. C. Lee, and H. Sridhar, “Route-metric-based dynamic routing and wavelength assignment for multifiber WDM networks,” *IEEE Journal of Selected Areas in Communications*, vol. 24, no. 12, pp. 56-68, 2006.

Kouji Hirata, Khamisi Kalegele, Yoshinobu Higami, Shin-ya Kobayashi, “Replica Selection and Downloading based on Wavelength Availability in λ-grid Networks,” Journal of Communications, Vol 5, No 9 (2010), 692-702, Oct 2010.

S.C.K. Lye, Z.W. Siew, S. Eng Tan, C.H. Wong, and K.T.K. Wong, "A Wireless Network with Adaptive Modulation and Network Coding in Intelligent Transportation System," The sixth UKSim/AMSS European Symposium on Computer Modeling and Simulation (EMS), 2012, pp.412-417.

Xinping Yan, Hui Zhang dan Chaozhong Wu, "Research and Development of Intelligent Transportation System," The 11th International Symposium on Distributed Computing and Applications to Bussiness, Engineering and Science (DCABES) 2012, pp.321-327.

Y. Zhao, "Mobile Phone Location Determination and Its Impact on Intelligent Transportation Systems, " IEEE Transactions on Intelligent Transportation Systems," Vol.1, No.1, March 2000, pp.55-63

Zang, J. P. Jue, and B. Mukherjee, "Review of Routing and Wavelength Assignment Approaches for Wavelength-Routed Optical WDM Networks," Optical Networks Magazine Vol.1 No.1 (2008) pp. 47-60.