



South Carolina
Department of Transportation



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SUMMARY REPORT

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EVALUATION OF COMMUNICATION ALTERNATIVES FOR INTELLIGENT TRANSPORTATION SYSTEMS

Communication systems enable effective and reliable traffic control and management applications. Although fiber optics and telephone lines have long been used for managing and controlling highway traffic systems, wireless communication technology shows great promise as an up-and-coming solution in traffic management applications due to the flexibility for deployment and cost-effectiveness for system expansion.

There have been few studies aimed at developing a process for systematically evaluating emerging wireless technologies for intelligent transportation systems. In addition, the reliability and performance of these wireless communication technologies have not been systematically examined. Therefore, the primary focus of this study involved developing a process for the evaluation of wireless technologies for intelligent transportation systems, and for conducting experiments of potential wireless technologies and topologies.

To achieve this objective, the authors first conducted an interview to identify the specifications of existing communication infrastructures deployed for various ITS related applications and the usage of wireless technologies in different states. Two wireless technologies: Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMAX) were chosen to demonstrate the proposed evaluation process. The authors performed numerous field tests on these technologies to evaluate various critical parameters of wireless communication. The authors also implemented a network design process using Wi-Fi and WiMAX technologies to support a traffic surveillance system in seven metropolitan areas of South Carolina. A video surveillance test was conducted to study the transmission of real-time traffic video over a wireless network. Making use of the results from the field study, the authors applied a communication simulator, ns-2, to compare the communication performance of a traffic sensor network under simulated environmental conditions. They also built an integrated simulator using ns-2 and a vehicular traffic simulator, PARAMICS. This integrated simulator was then used to study the communication behavior of the system during traffic incidents. Additionally, the authors conducted a performance-cost analysis for selected wireless technologies and topologies.

The case study results identified the key limitations for both Wi-Fi and WiMAX technologies. The Wi-Fi field test indicated that wireless communication performance between two traffic sensors significantly degrades after 300 ft with an off-the-shelf radio employing transmission power up to 70 mW and omnidirectional antennas. This distance was observed to vary with the modulation rates and transmission power used by the system. The WiMAX nomadic test suggested that line-of-sight (LOS) greatly affects the connectivity level. Moreover, the capabilities and the performance of the WiMAX network are affected by the specifications of the client radio. Through a video-transmission field test, the research team found that a jitter threshold of one second and a packet rate of 23 packets per second were sufficient for acceptable quality of traffic surveillance video.

The performance-cost analysis indicated a Wi-Fi mesh network solution has the highest throughput-cost ratio (109 bits/dollar) for supporting traffic surveillance systems. The research team found that the WiMAX infrastructure option provides the greatest amount of throughput (9.15Mbps per device) allowing for future system expansion.

A simulation analysis using ns-2 revealed the effects of environmental parameters on the multi-hop behavior of a WiFi traffic surveillance network. An analysis using the integrated ns-2 and PARAMICS simulations revealed that in order to facilitate a low false incident detection rate, the sensor spacing is critical. During this simulation, communication latency was found to have a low impact on the incident detection performance.

Although the researchers conducted multiple field tests and considered numerous simulation analyses, the SCDOT may need to carry out additional field studies before adopting a wireless communication option. For this reason, a detailed evaluation process is described in this report, providing a systematic method for evaluating new and/or existing deployments of ITS communication infrastructure. This report also presents an implementation strategy for applying the methodology during further studies.

To facilitate better management of the ITS infrastructure and to support its future expansion, a suitable asset management system is necessary. The researchers conducted a study wherein three asset management platforms were analyzed. They determined that as the SCDOT already implements enterprise based Geographic Information System (GIS) for other applications, the best option would be to extend its use for ITS applications rather than implement new software. However, because this transition may take time, off-the-shelf ITS asset management software may be a feasible option if SCDOT wishes to implement a system in the short term. If this latter option is used, databases developed for the off-the-shelf system are expected to be transferable to the enterprise system with minimal effort.

This study provided an important foundation for evaluating the performance and reliability of different wireless technologies and topologies. The research results presented in this study will benefit the SCDOT, other transportation agencies, and stakeholders in evaluating and selecting cost-effective wireless communication options for different traffic control and management applications.

The study was conducted by the Intelligent Transportation Systems group at Clemson University under the guidance of Drs. Ronnie Chowdhury and K.C. Wang. For further details contact Dr. Chowdhury at 864-656-3313 or mac@clemson.edu.