Mobile Telemedicine for Accident and Emergency Scenes in Tropical Regions

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Abstract: - A wireless communication system utilizing wideband point-to-point link is proposed in this paper. The system provides transmission of telemedicine information for an ambulance attending an accident or emergency scene where different types of information related to the patient can be received by the hospital prior to the patient's arrival so that necessary preparations can be made. The system's reliability is evaluated for operation in tropical regions where persistent heavy rainfall can severely affect availability of radio links at microwave frequencies.

Key-Words: - Modulation, rain attenuation, telemedicine, wireless networks

1 Introduction

Telemedicine systems utilize wireless communication technologies for the reliable delivery of medical information and services. The need for telemedicine in emergency vehicles is critical in life saving. Paramedics attending an accident scene can utilize telemedicine systems to retrieve medical history about a person and any other necessary information to provide necessary assistance with minimal time. Earlier work in [1], [2] have developed mechanisms for telemedicine systems used in scenes of emergency. These systems, although provide a framework for providing real-time information to paramedics, further improvements on provide two-way real-time information exchange and maximizing system availability can help save lives by minimizing time wastage in providing necessary treatment both on scene and upon arriving at the hospital.

This paper presents an experimental system operating at 13 GHz developed by utilizing technological advancements in wearable computers and the use of broadband wireless access (BWA) networks for real-time information retrieval using systems such as that proposed by [3]. Our work considers the operational performance of our system based on earlier work in [4]. The main contribution of this paper is to present the framework of this telemedicine system for both information retrieval from the hospital database and delivery of video information back to the hospital so that necessary preparation can be made prior to the patient's arrival. We evaluate the system operational performance under the influence of tropical rainfall since persistent heavy rainfall can severely affect operations of outdoor wireless systems.

This paper is organized as follows: Section 2 outlines the methodology used and describes the

system set up followed by its performance evaluation

System gain	110 dB
Transmitter antenna gain	18 dBi
Receiver antenna gain	28 dBi
Receiver sensitivity	-85 dBm (BER = 10^{-9})
Maximum distance from hospital [7]	14 km
Data rate	4 Mbps (point-to-point)
Modulation scheme	QPSK

Table I. System Parameters

under the influence of rainfall in Section 3. Finally, we conclude our work in Section 4 and give an overview of our work in progress.

2 Methodology

The system consists of a wearable device that captures information such as extent of injury, electrocardiogram (ECG), and heart rate and the information is sent to the hospital before the injured person reaches the hospital. Video images are also sent to the hospital showing the extent of injury using a high speed link. The system layout is summarized in Fig. 1, the device used at the scene is operated under constraints as described in [5]. A 13 GHz point-to-point link is used for data transmission. A wireless based transmission system that sends data across several kilometers with high reliability is developed. Over the hospital side, a patient record database is accessible so that information such as drug allergy and medical history can be made available to on scene paramedics.

This system provides real-time network access to paramedics providing critical care on an accident scene that enables direct two-way communication between an ambulance and the A&E unit of the hospital by an ultra-portable computer linked to central hospital with a microwave link. The hospital database servers store a large amount of information including a patient's medical history. The next generation of this system would facilitate integration of GPS tracking that enables hospital staff to obtain an accurate estimate of the ambulance's arrival time so that necessary preparations can be made with minimal delay.

A local multipoint distribution service (LMDS) based system is used to provide telemedicine services as shown in Fig. 2. The data transmission rate is 4 Mbps point-to-point and the system supports ATM trunking for connection to the hospital's network backbone that uses a TDM physical link providing direct access to the database and other resources stored in the hospital, where there are two major parts; a set of network access equipment carried in the ambulance providing access points to nearby portable devices, and a fixed system in the hospital linked to various databases as well as providing communication services such as video teleconferencing. The system operational parameters are summarized in Table I. The ambulance carries equipment for servicing link between the portable node used by paramedics and the hospital.

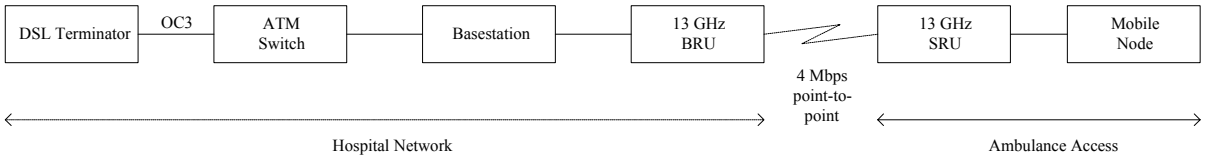

Fig. 1 Network Layout

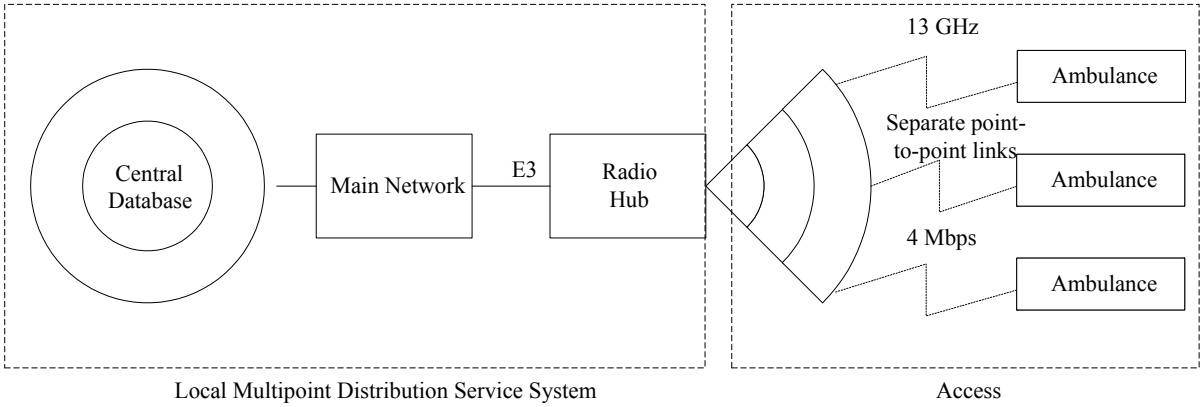

Fig. 2 LMDS based system providing each ambulance with a dedicated link

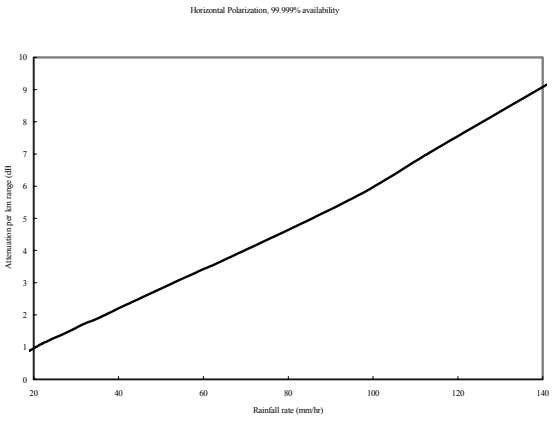

Fig. 3 Point Rainfall attenuation

3 System Performance

The system performance is evaluated under the influence of persistent tropical heavy rain up to 145 m/hr as specified by ITU region-P [6]. The rate of signal attenuation is shown in Fig. 3 and Fig. 4 shows the link performance with 99.999% link availability. The link availability is maximized by using vertically polarized signals. Finally, the paper will discuss how heavy rain affects system operation and fade margin necessary for reliable operation [7]. Results show that the system can be operated about 10 kilometers away from the hospital's base station when there is no rain and the range drop to approximately a quarter when the rate of rainfall reaches 140 mm/hr. It also shows that the level of system reliability can be maintained despite of the reduction in range coverage. Finally, The amount of cross-polarization per kilometer path is shown in Fig 5, it shows that when two links are used with alternately polarized signals only a mere 1 dB maximum difference exists when both horizontal and vertical polarizations are utilized.

The received signal is described by the envelope:

$$r(t) = a(t).\sum_{k=1}^{N} s_k(t - kT) \qquad (1)$$

where *s(t)* is a signaling pulse and *T* is the symbol period; *N* is the total number of possible signal paths.

The distortion *a(t)* caused by multipath fading is given by:

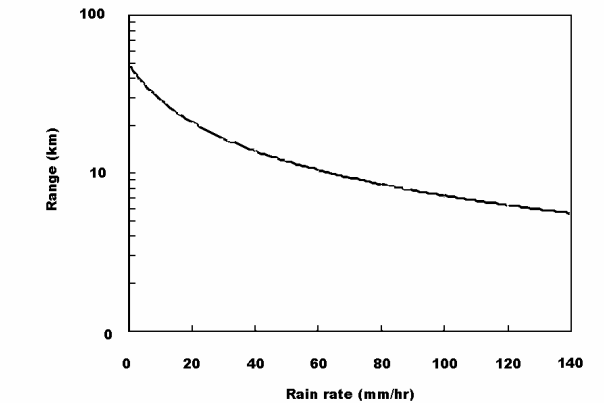

Fig. 4 The effect of rain on range

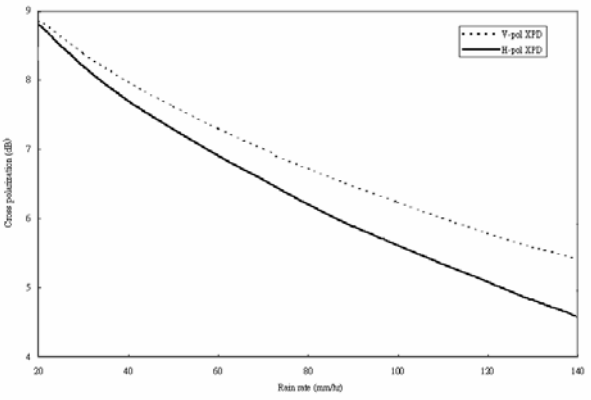

Fig. 5 XPD plot

$$a(t) = a_k(0) + a_k(1)\frac{t - kT}{T} \qquad (2)$$

4 Conclusions

We present a system that provides real time information about an accident scene to the hospital and to allow information retrieval by medical personnel attending the scene by using a wireless system operating at 13 GHz. with QPSK as its modulation system due to its suitability as described in [8]. Such system saves critical time when the hospital can prepare for arrival of patients. Measurement results presented in this paper has shown adequate margins for telemedicine deployment and trial on performance of the actual

system is underway. It is expected, based on preliminary results, that the proposed system is capable of providing reliable communication links for telemedicine application with high reliability and availability.

The next phase of development will involve customization of portable nodes for enhancement of coverage for other emergency rescue support personnel such as air and marine operations and these are carried out in more challenging environments for providing reliable network access. Further service enhancement for search and rescue in remote areas will also be supported.

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