Physiological Stress Related Data Monitoring using Multi-hop Wireless Networks for Soldiers in Warfield

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Abstract

Civilian society has moved from the industrial age focus on automation and scale to an information age economy based on computing and communications. Warfare is also moving towards an information age paradigm based on information sharing, situational awareness, and distributed points of intelligence, command and control. A widely-networked fighting force is better able to share information about tactical situations that may be geographically widespread, asymmetric, and rapidly changing. Commanders must be able to better assess situations across broad theaters, with extensive data, voice, and especially video feeds as strategic inputs. Thus, network-centric warfare improves effectiveness at both the tactical "point of the spear" and in the achievement of broader strategic goals. In this paper we proposed network for soldier welfare. By this network we can monitor every soldier's physical fitness. Since the soldiers are battery powered stress related parameters are used to transmit the critical situation of the solider. The stress related parameters are heart beat, temperature and etc. in this paper we proposed a multi hop network design and embedded system prototype is designed and simulated using mplab.

Keywords –Stress; Multi-parameter; Monitoring system, Multihop wireless network

I. Introduction

The vast majority of these information assets, command, communications, and control must be delivered wirelessly, with seamless connections to wired networks for intelligence resources and other data. Further, these wireless technologies must support data, voice, and increasingly, video traffic flows. Beyond those basic capabilities, four key cornerstone capabilities must be incorporated in the networks designed to support modern warfare: mobility, high performance support of real-time protocols, distributed frequency agility, and
distributed topologies and network formation. The multi hop wireless mesh network is correct solution to the above criteria.

Wireless mesh networks (WMNs) have emerged as a key technology for next-generation wireless networking. Because of their advantages over other wireless networks, WMNs are undergoing rapid progress and inspiring numerous applications. Wireless mesh networks (WMNs) are dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. The wireless network is scalable since the prototype is not a infrastructure based network. We can also provide high range of QOS to the different data flows.

Chia-wci-chang[1] et al. proposed a networked medical monitoring system [1]. In this paper they proposed a battlefield soldier monitoring system using peer-peer networking using UAVs. This will increase the distortion. In [2] the soldiers are monitored using the Wi-Fi access point. In this paper only two hop network is designed which will limit the area of coverage.
WMNs are comprised of four types of nodes: mesh point and mesh access points, mesh clients and mesh portal (gateway). Through multi hop communications, the same coverage can be achieved by a mesh router with much lower transmission power. In the proposed design of wireless network soldiers are mesh clients and the military trucks are the mesh point and mesh access points. Any truck or tower will be the mesh portal.

The paper has been organized as follows. The introduction to wireless network is given in section II. The stress related parameters are discussed in section III. The proposed wireless design and embedded system design is given in section IV. Simulation results are presented in the section V. section VI concludes the paper.

II. Evaluation of wireless mesh networks

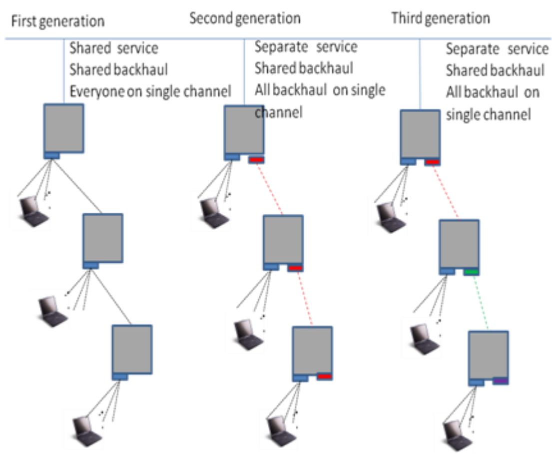

Fig 1: (L-R) Ad-hoc, 1 radio mesh network, Multi radio mesh network

Wireless network refer any type of computer network that is wireless, and is commonly associated with a telecommunication network whose interconnections between nodes are implemented without the use of wires. Wireless Network may spread throughout the area or a neighborhood, a wireless mesh network covers a much larger area. Beyond those basic capabilities, four key cornerstone capabilities must be incorporated in the networks designed to support modern warfare: mobility, high performance support of real-time protocols, distributed frequency agility, and distributed topologies and network formation. By using mesh network we can able to achieve the above criteria. The development of the mesh network can be explained in three generations.

First Generation: 1-Radio Ad Hoc Mesh (left). This network uses one radio channel both to service clients and to provide the mesh backhaul. The ad hoc mesh radio, marked AH, provides both services – client access and backhaul. This architecture provides the worst services of all the options, as expected, since both backhaul and service compete for bandwidth.

Second Generation: Dual-Radio with Single Radio Ad-Hoc meshed backhaul (center). This configuration can also be referred to as a "1+1" network, since each node contains two radios, one to provide service to the clients, and one to create the mesh network for backhaul. The "1+1" appellation indicates that these radios are separate from each other – the radio providing service does not participate in the backhaul, and the radio participating in the backhaul does not provide service to the clients. Performance analysis indicates that separating the service from the backhaul improves performance when compared with conventional ad hoc mesh networks. But since a single radio ad hoc mesh is still servicing the backhaul, packets traveling toward the Internet share bandwidth at each hop along the backhaul path with other interfering mesh backhaul nodes - all-operating on the same channel. This leads to throughput degradations which are not as severe as for the ad-hoc mesh, but which are sizeable nevertheless.

Third Generation: Multi-radio Structured Mesh (right). The last architecture shown is one that provides separate backhaul and service functionality and dynamically manages channels of all of the radios so that all radios are on non-interfering channels. Performance testing by military organizations indicates that this provides the best performance of any of the methods considered here. Note that the two backhaul radios for the 3-radio example shown in Figure 1 are of the same type - not to be confused with 1+1 so-called dual radio meshes where one radio is for backhaul) and the other for service. In the 3-radio configuration, 2 radios are providing the uplink and down link backhaul functionality, and the third radio is providing service to the clients.

III. Stress based biomedical parameters

Selection of parameter is based on the physiological responses to physical stress. [3,4]

Parameter	Sensor	Position
Electrocardiogram (ECG)	Lead sensors	Chest/Hands and legs
Heart rate	Button Sensor	Chest
Respiration rate	Capacitive sensor	Chest
Body Temperature	LM35 Sensor	Skin

TABLE I Selection of Parameters

A physiological parameter survey along with detection methods in the literature is tabulated in Table 1. Based on the survey and the requirements of our application, three groups of parameters are chosen:

- Cardiovascular system: ECG, heart rate, heart rate variability, QRS complex amplitude
- Respiratory system: Respiration rate and depth of respiration
- Heat regulation: Body surface temperature, environmental temperature and skin conductance.

IV. A. Wireless design

In wireless mesh network there are four different types of nodes[5-7]. They are mesh clients, mesh access point, mesh point and mesh portal. In this section the warfare nodes equivalent to mesh nodes are explained.

Mesh clients:

Here mesh clients are soldiers. Each solider is equipped with biomedical sensor to monitor the stress related parameter, wireless system and embedded system to interface both .each solider is identified by MAC ID. The individual soldier is connected to a nearby tanker using Bluetooth or Wi-Fi. It is an ambulatory monitoring system.

Mesh access point (MAP)

It is the node which interconnects the mesh clients and mesh backhaul. It also forwards the packet form another mesh point. In our proposed design the MAP will be the truck or tanker to which the nearby solider get connected. It will get the data from the soldier and forward it to the central control unit through mesh points. It consist of two different radios, one is to interface the soldiers another is to serve the mesh backhaul. Trucks with gray color are mesh access point nodes.

Mesh point (MP)

The MP has less sophisticated functionality. In essence, it acts as a layer 2 router as it determines how to route packets through the mesh backbone toward the destination (MPP) from there it is forwarded to control unit. It is equipped with only one radio since there is no mesh clients get connected to the MP. In our design the mesh point is another truck or tanker which is designed to just forward the packets. In figure the trucks with green color are mesh point.

Mesh portal point (MPP)

Mesh portal point is also a truck which is connected to the central control unit. The connection is by GSM or GPS. It also has two different radios one to connect with mesh backhaul another to connect with central control unit.

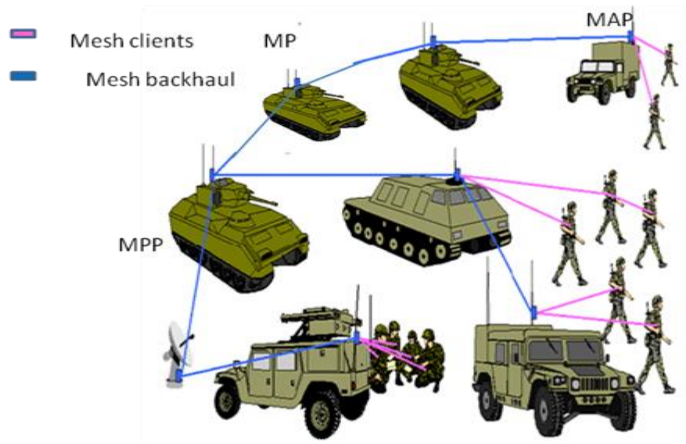

Fig 2: Multi hop mesh architecture for warfare

B. Mesh client node design

The Mesh client node (soldier) consists of base station, bio medical sensors, wireless transceivers and battery. The device is a wearable (ambulatory) soldier monitoring system. The base stations consist of microcontroller, signal conditioner, memory and display devices. In this project we used PIC16F877A microcontroller as processor. The signal conditioner consists of amplifiers and filter to make the signal compatible with the controller. Since the soldier unit is battery powered the transceivers are switched on only during the critical points. The critical points are set based on stress related parameters.

The physiological stress related parameters such as Respiration rate, skin conductance, body/environmental temperature and heart rate is taken by means sensors. The output of the sensors is given to the multichannel inbuilt ADC of the PIC16F877A. This has multiplexed selection of data thus thereby selecting the required input at once. The output of ADC is 8 bit binary data. The PIC Microcontroller reads the data and then displays in LCD and also provides the respective codes for the printer port thereby instructing running dynamics like library files to read the respective data from the parallel port which is designed with the help of Embedded C for further communication with VB send to the PC by means of GSM technology .

The heart of the project is the PIC16F877A Microcontroller. Whenever the stress is obtained the microcontroller displays the alert message in the displayed in the LCD of the transmitter section and as well as send the data to a specified GSM which is interfaced with the PC.

The hardware components used in this proposed work are

- PIC Microcontroller(16F877A)
- Wireless Transceiver
- Sensors
- LCD
- Power supply

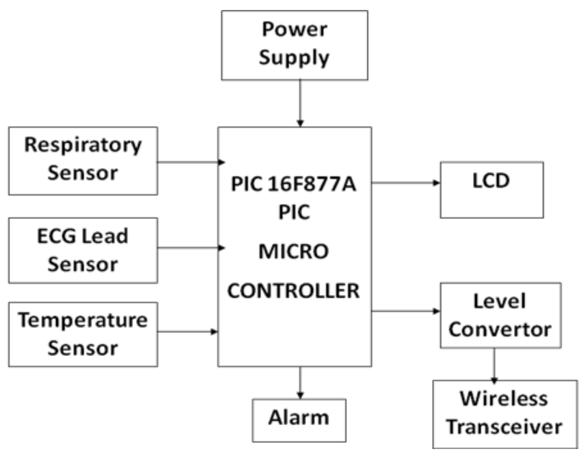

Fig.3: Block diagram of monitoring system

In the design of sensor integrations, the ECG three lead conductive sensors have been employed in the ECG signal acquiring. A three electrodes chest strap and a two electrodes flexible strap have been modified for measuring. ECG signals have been amplified with the gain of 350, and filtered with the cut-off frequencies of 4.1 Hz for removing the low frequency activity caused EMG components from the ECG signal. The signal has been amplified with the gain at 278 and with the cut-off frequency at 1.94Hz for removing the motion caused artifact noise.

In the respiration circuit development, this system is capable for providing both Piezo Film sensor and accelerometer signals to estimate respiration signals. These signals have been filters at 0.1Hz and 2Hz for noise reduction.
In the temperature sensor design, the temperature sensor LM35 is used as the external Temperature sensor, which is able to detect either the skin temperature or environmental temperature. As the normal medical using, a copper cladding has been shied the sensor. LM35 is able to be placed any part of body near chest.

C. SENSOR PLACEMENTS
Sensor Placement is an important, integral part in the hardware design of a monitoring system. Incorrect placement of physiological sensors leads to erroneous results especially during physical activity. Through testing, ECG[3] was found to be the most susceptible to distortions. Sensors placement between the chest and abdominal wall was found to be the optimal position for reliable ECG measurements during activity. An ECG signal acquired by the sensor node during activity.
As mentioned above, the ECG chest strap is not only the sensor part of this system, but also the fastener connects the body to front-end unit. Three snap fasteners in skin conductance strap are embedded for connecting the electrodes to the circuit of front-end unit and fasten front-end unit to chest strap.
Respiration however was not easily obtained from this same location. This is consistent with the physiology of respiration as two types of breathing are defined in the literature, chest and abdominal breathing.

V.SIMULATION RESULTS
The purpose of the simulation is to check the operation of the client node. The proto type of the client node is designed in microchip IDE simulator. The design consist of three sensor interfaces, amplifier, display devices and serial communication (wireless transmission)

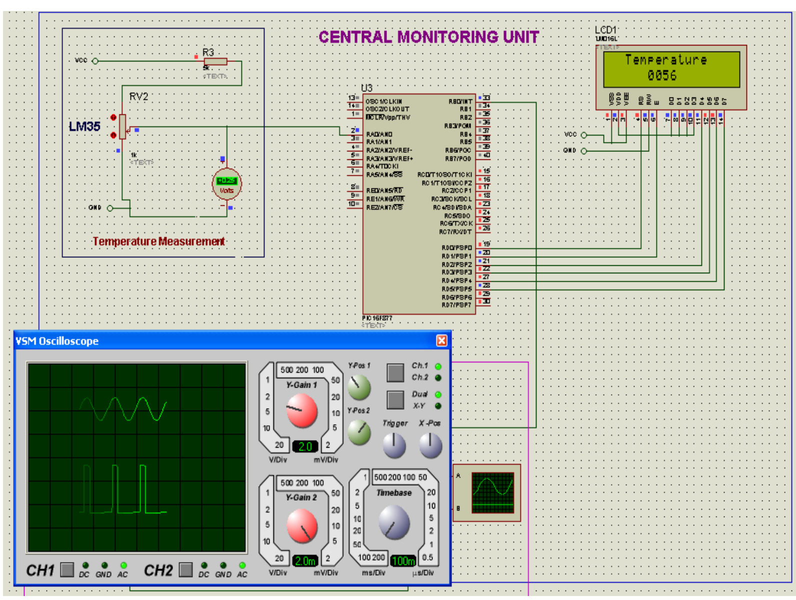

Fig.4: Response of the prototype for increase in body temperature

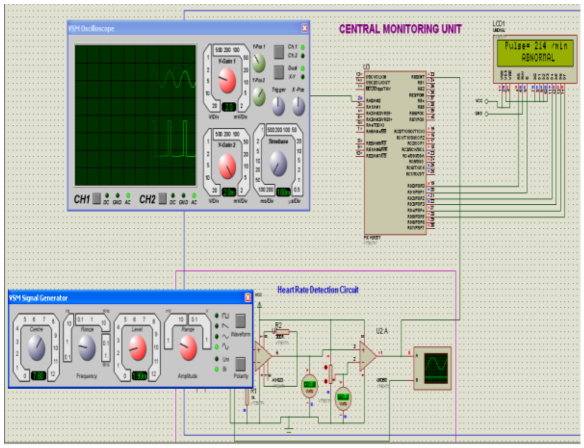

Fig.5: Response of the prototype for increase in ECG Heart rate

In this simulation the critical parameter is given manually and the display output is verified. The serial output is witnessed when the sensor parameter exceed the critical points

VI. CONCLUSION AND FUTURE SCOPE

In this paper we proposed the wireless design for soldier monitoring system and we also gave the hardware module for wireless Mesh client node. The system is designed and simulated using mplab software. To reduce power, stress related parameters are used to monitor the soldiers. Using this system we can monitor each and every soldier from the single point and can also provide medical access to the soldier immediately. So this project will decrease the risk factor in war field. Here in this paper we proposed system to monitor the soldiers' biomedical parameters. We can extend this paper to also send command from control unit to the soldiers.

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