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Research paper

Development of Wireless Sensor Network (WSN) and Mobile Ad-Hoc Network (MANET) Communication for Military Operation and SAR (Search and Rescue) Operation

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Abstract

The study investigates and develops components for implementing an effective military and SAR (Search & Rescue) acknowledge/information/communication in closed network architecture. Since military and SAR personnel are always on the move, the dissemination of knowledge/information/communication needs a mobile platform to accommodate mobility of people. The mobile and wireless network platform should be able to sustain the remoteness and seclusion of military operation areas. Communication is one of key problems of a military operation especially due to environmental constraints. This study proposes on establishing a future soldier and SAR communication device with mobile Wireless Sensor Network (WSN) and Mobile Ah-Hoc Network (MANET) to suit the infantry operations in the urban and rural areas. The operational areas are considered to restricted and challenging locations. Wireless sensor network (WSN) and Mobile Ah-Hoc Network (MANET) will become inexpensive and common over the next decade Thus, a thorough study is vital to develop the most suitable smart equipment and network requirements for Malaysia's military and SAR eco-system. Finally, this study has successfully developed new low cost device prototype using WSN and MANET approach for Military and SAR operation. This approach is able to transmit death and location status, movement location status, health monitoring status to the base station.

Keywords: *Wireless Sensor Network (WSN); Mobile Ah-Hoc Network (MANET); Military; Knowledge; Mobile; Prototype; Health; Search and Rescue (SAR)*

1. Introduction

Cutting edge computer network technologies facilitates sharing knowledge and information among personnel in many organizations. Knowledge and Information must now be treated as a critical resource to the organization in addition to land and raw materials. In military, initiatives labeled as Knowledge Management (KM), the focus is on learning and the sharing of tacit knowledge, particularly in the many areas of military operations [1, 2]. Since military personnel are always on the move, the dissemination of knowledge and information needs a mobile platform to accommodate mobility of people. The mobile and wireless network platform should be able to sustain the remoteness and seclusion of military and SAR operation areas.

Future Soldier is a concept of how the future Soldier and SAR team might be equipped. The future Soldier and SAR team shall be tailored with design considerations for each technology area name below with special emphasis on cognitive performance to improve Soldier and SAR effectiveness and an increase in operational tempo. There are seven major areas within Future Soldier [3]: i) Human Performance & Training, ii) Soldier Protection; iii) Lethality; iv) Mobility and Logistics, v) Soldier Network; vi) Soldier Sensors; vii) Soldier Power & Energy. The smart device using Wireless Sensor Network (WSN) is developed based on four areas i) Lethality, ii) Mobility, iii) Soldier Network, and iv) Soldier Sensors. This approach is focusing on military and SAR team unit on operation information but it is also can be applied to others enforcement unit.

Communication, observation, early detection and indication are key problems in military and SAR operation especially i) no death notification status mechanism, ii) unable to track the movement and location of soldier and SAR team in real time, iii) unable to monitor injured soldier or SAR unit from base station. Hence, this study proposes establishing new future soldier and SAR unit communication device embedded with wireless sensor network (WSN) and Mobile Ah-Hoc Network (MANET) to suit the military operations in the jungle. Thus, a thorough study is vital to develop the suitable equipment and network requirements for Malaysia's military eco-system and SAR unit. Thus, the objectives of this research are as follows:

i. Develop and execute processes that engage current soldiers and SAR in the identification and analysis of future Soldier and SAR unit.

ii. Innovators in the research community to better understand how future science and technology can enable future Soldier and SAR unit

iii. To develop a smart device communication based on Internet of Things (IoT) approach.

iv. To provide low cost device, small size, mobility and weightless.

2. The proposed wireless sensor and mobile ad-hoc network structure

The approach of this research will be conducted according to the objectives that have been stated as above. Initial study would be concentrated in understanding the mechanics and characteristics of a wireless sensor network and mobile ah-hoc network. A handful of papers related to the research and development of the wireless network will be studied [4, 5, 6]. A wireless sensor network/mobile ad-hoc network is a group of network which usually uses wireless or cabled network where each of the devices is connected from one to many. It needs to be configured to allow connections to be rerouted by avoiding obstacle objects that may be block the signals from being transmitted by hoping the nodes from one device to another until it reaches its destination. Wireless sensor networks and mobile ad-hoc network are self-healing and very reliable [7, 8, 9]. Figure 1 illustrates the proposed framework of wireless sensor network/ mobile ad-hoc network structure for infantry and SAR operations [9, 10].

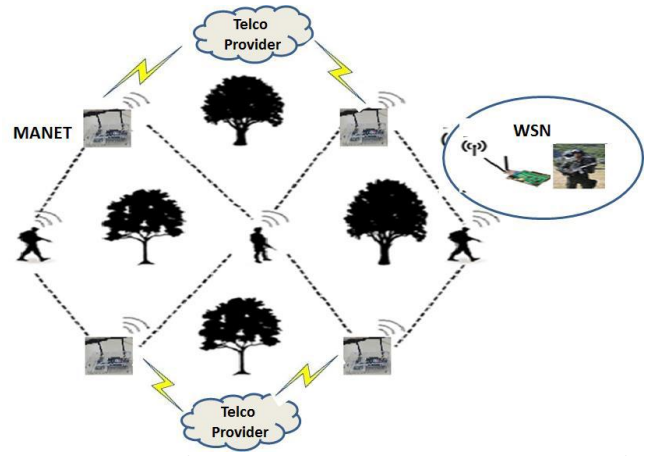

Fig. 1: Framework of wireless sensor network, mobile ad-hoc network for military and SAR unit [9]

3. Research methodology

The following methods would be applied to complete the project objectives (refer to Figure 2):

3.1. Abstraction modelling

In the first step, it is required to design the WSN and MANET which have a communication component. The layout of device system with its components are designed on the drawing paper (Abstraction Modelling)

3.2. Block diagram design

Next, from abstraction modelling the WSN and MANET device communication will transform to the Block diagram design. In this stage, the communication components need to arrange and link each other's. The Radio frequency (RF) sensor, GPS sensor, GPRS, temperature & humidity sensor, 6DOF sensor and Controller unit are used as communication unit.

3.3. Device architecture

The next step, the block diagram design would be to transform into device architecture. The WSN and MANET device will then be integrated with activation programming communication system. The WSN and MANET device prototype will be tested and the best performance will be used on WSN and MANET device communication for military/SAR unit team.

3.4. Real smart device communication

In the final stage of the project, it is expected to have a successful communication on real network between smart device WSN, MANET wireless gateway and HQ base station. It helps to enhance the driving experience to be safer by having an effective communication between them. After that, the performance will be test and analyze in real operation monitoring and tracking situation.

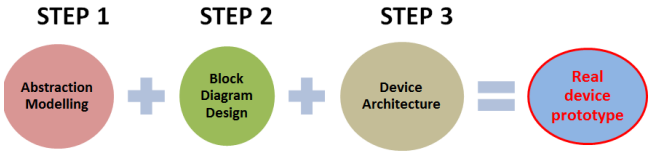

Fig. 2: Research Methodology for WSN and MANET Development

4. Design and result

4.1. Abstraction model- soldier unit

In the first phase, the overview of the smart device unit using wireless sensor network and Mobile Ah-Hoc gateway (MANET) have been sketch properly. Figure 3 shows the illustration layout of smart device embedded with wireless sensor network and Mobile Ah-Hoc gateway (MANET).

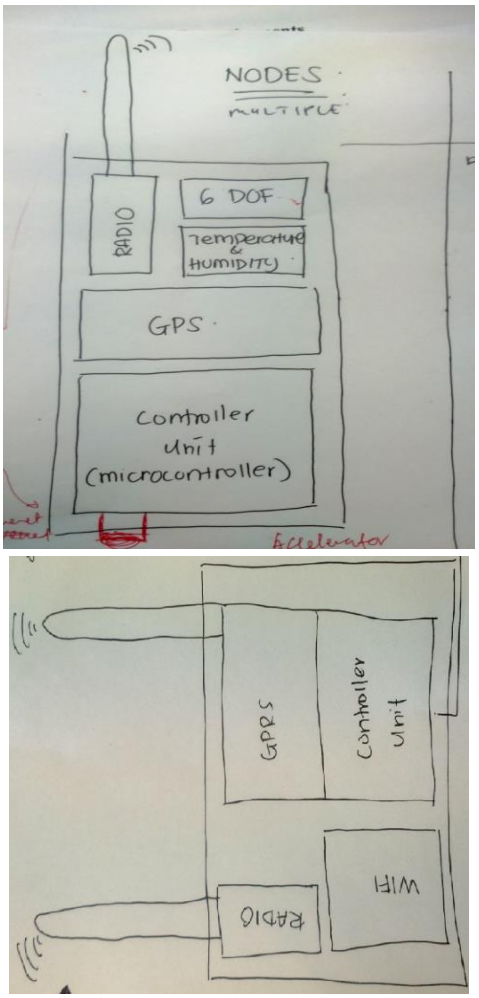

Fig. 3: Illustration of Smart Device Wireless Sensor Network and Mobile Ad-Hoc Network Gateway.

4.2. Block diagram design of wireless sensor network

The second phases, all the sensor components have been assembled and connected to block diagram design (Refer to Figure 4). There are six components have been used in development of smart device WSN for military operation such as: GPS sensor, Radio Sensor (RF), Temperature sensor, humidity sensor, 6DOF sensor. Five of these sensors have connected/linked to the Micro Controller Unit. While, MANET gateway have three sensors (RF, GPRS and WiFi) attached on the block diagram.

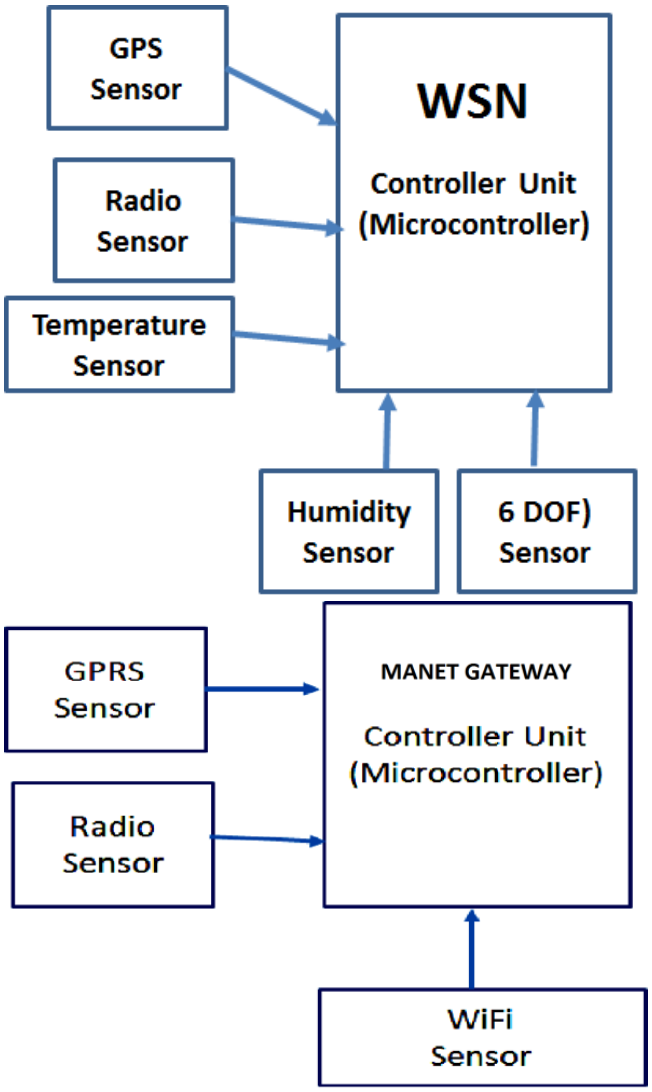

Fig. 4: Smart Devices WSN and MANET Gateway - Block Diagram Design for Military Unit and SAR

4.3. Device architecture layout

4.3.1. GPS sensors

The GPS sensor is used for soldier and SAR position tracking and health indication status monitored from the base station (refer to figure 5). The GPS receiver is used to log the longitude and latitude of military and SAR team unit, which is stored in microcontroller memory. GPS Receiver receives and compares the signal from orbiting GPS satellite to determine geographic position.

4.3.2. 6DoF sensor

Six degrees of freedom (6DoF) refers to the freedom of movement of a rigid body in three-dimensional space. Specifically, the body is free to change position as forward/backward (surge), up/down (heave), left/right (sway) translation in three perpendicular axes, combined with changes in orientation through rotation about three perpendicular axes, often termed pitch, yaw, and roll [11]. In this research 6DoF is used to detect the death status of the military and SAR victims (refer to figure 5).

4.3.3. Temperature and humidity sensor

This temperature and humidity is used for health monitoring and death status. The humidity sensor is used to measure the surrounding air. This temperature sensor is used to measure the military and SAR victims body temperature (refer to figure 5).

4.3.4. Radio Frequency (RF) sensor

This RF sensor is used for communication between military team to Mobile Ad-Hoc Network (MANET) gateway, then Mobile Ad-Hoc Network (MANET) gateway will be linked to the Base station (HQ) for real time monitoring [12] (refer to figure 5).

4.3.5. GPRS sensors

The **GPRS** is the central part of the general packet radio service (GPRS) which allows 2G, 3G and WCDMA mobile networks to transmit IP packets to external networks such as the Internet. The GPRS system is an integrated part of the GSM network switching subsystem. (Refer to figure 5). The GPRS is used to communicate with mobile service provider/Internet. It used for wireless services on cellular phones and mobile Internet devices. The information can be accessed anywhere, any place and anytime.

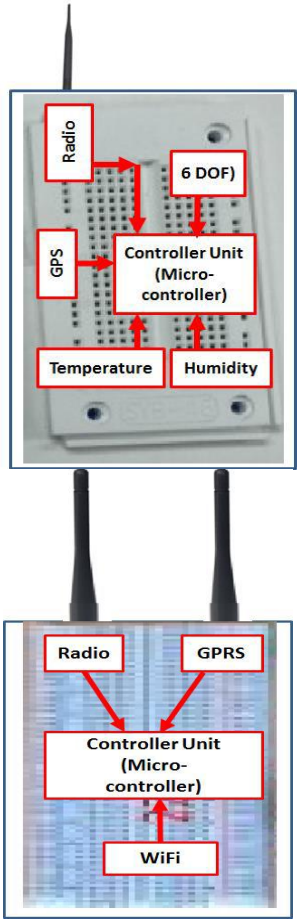

Fig. 5: Device Architecture Layouts – WSN and MANET Gateway

4.4 Real smart device WSN prototype

At the end of the research, we are finally successfully developed Real Smart Device Prototype using Wireless Sensor Network (WSN) and Mobile Ad-Hoc Network (MANET) gateway approach. Figure 6 shows the top view and side view of real Smart Device prototype. In addition, Figure 7 shows the top view and side view Mobile Ad-Hoc Network (MANET) gateway

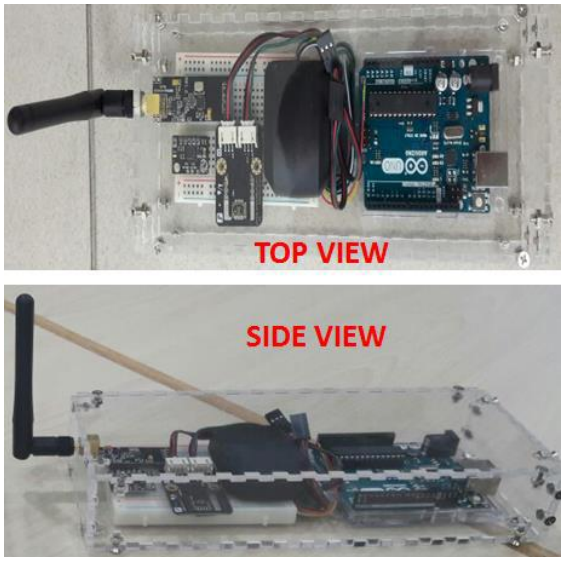

Fig. 6: Real Smart Device Prototype using WSN Approach

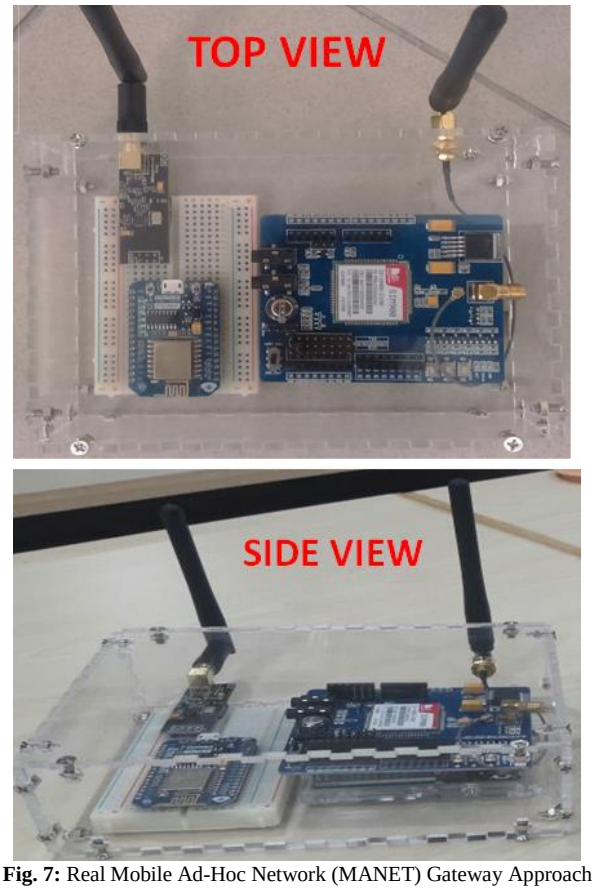

Fig. 7: Real Mobile Ad-Hoc Network (MANET) Gateway Approach

5. Significant contribution and future works

Finally, this study has successfully developed new smart device prototype using Wireless Sensor Network (WSN) and Mobile Ad-Hoc Network (MANET) gateway for Military operation. In addition, this prototype can be used for Search and Rescue (SAR) operation. This prototype is able to transmit death and location status, movement location status, health monitoring and status to the base station. In general, the contribution of this research would benefit the university, military and SAR. Next future work needs to be focused on consumption of power energy and distance coverage. The architecture of this smart device can further extend to add display unit and motion detection.

Acknowledgement

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Some of the findings and results of this paper is a reiteration from the corresponding author's paper publish in 2016 [9].

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