WIRELESS SENSOR NETWORK BASED SYSTEM FOR FIRE ENDANGERED AREAS

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Abstract

This paper describes a system design approach for a wireless sensor network based application that is to be used to measure temperature and humidity as well as being fitted with a smoke detector. Such a device can be used as an early warning fire detection system in the area of a bush fire or endangered public infrastructure. Once the system has being develop, a mesh net work topology will be implemented with the chosen microchip technology with the aim of developing a sophisticated mesh network. This paper fully describes the domain problem as well giving an over all system design description, with a software simulation technique which will be used to demonstrate how data will rotate from one node or sensor to the other.

Keywords: Wireless Sensor Networks, Disaster Management, Mesh and Topology.

1. INTRODUCTION

Wireless sensor networks hold the promise of many new applications in the area of monitoring and control. Examples include target tracking, intrusion detection, wildlife habitat monitoring, climate control, and disaster management. The underlying technology that drives the emergence of sensor applications is the rapid development in the integration of digital circuitry, which will bring us small, cheap, autonomous sensor nodes in the near future. Wireless sensor networks are an emerging technology consisting of small, low-power, and low-cost devices that integrate limited computation, sensing, and radio communication capabilities. This technology has the potential to have enormous impact on many aspects of emergency operations. Figure 1 shows the heat threat of bush fire during the fire seasons (Bureau of Meteorology 2004) in Australia.

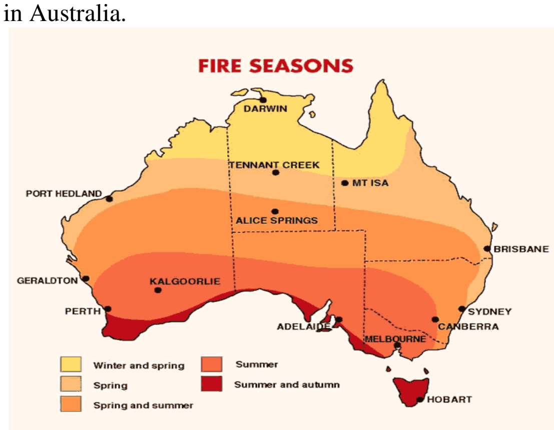

Fig 1: Bush fire threat in Australia.

Sensor devices can be used to capture continuous, real-time vital signs from a large number of infected areas, relaying the data to handheld computers carried by emergency fire technicians [6] can store data such as identification, history, and treatments, supplementing the use of back-end storage systems and paper charts. In a mass casualty event (MCE), sensor networks can greatly improve the ability of first responders to triage and treat multiple patients while knowing the history of the infected region. Such an approach has clear benefits for mankind but raises challenges in terms of reliability and complexity. While there have been many recent advances in biomedical sensors [4] low-power radio communications [1, 8, 3] and embedded computation [4, 9] here does not yet exist a flexible, robust communication infrastructure to integrate these devices into an emergency care setting.

With the on going continuous advances in wireless communication networks, and the emerging technologies related to small, low power, and economically viable sensors, a new area of an emerging data communication technology is the wireless sensor networks, this devices consist of a computation power and radio communication capabilities. The potential of such technology will have an enormous impact in many aspects of environmental [5], awareness and monitoring, however a specific application will be in the area of a bushfire early warning systems [11, 12, 14, 17].

Wireless sensor network systems have the potential for broad application in many areas of environment [5] monitoring systems. Today, it is possible to obtain sample air measurements of a specific location, at the same time we could have different types of sensors to measure temperature and humidity, as well as sensors to detect a wide range of different chemical particles that the air could be carrying. Such devices could be used in an area of national security, in the case where there is a situation of chemical or biological attacks on civilians. This type of sensor could be used to detect and monitor such attacks and provide vital information. It could also be used in the area of product quality monitoring as well as in virtual keyboards.

The wireless sensor networks technology will provide a vital link between the outside environment [5] and resource allocation departments. In the case of environmental monitoring and bushfires [17] it means that having an sufficient intelligence about the condition of that area, will help management to more efficiently and intelligently allocate resources in terms of personnel and machinery, this will lead to the targeting of the exact area where a fire is occurred or by having enough personal on stand by close to the area [6, 10] of the likelihood of a fire will occur in a particular regain.

We are proposing the development and adaptation the mesh topology communication network, as means of providing un-interrupted data communication hopping between sensors devices [9, 13]. The organisation of the paper in the next two sections introductions to the technology and wireless infrastructure are presented. In the fourth section the simulation results described. The paper is concluded in section five.

2. TECHNOLOGY

3.1 MICA-2 Wireless Sensor Motes [4]

Currently there are a number of new viable technologies that are available for the introduction of the wireless sensor network. One of those is the wireless sensor device, such as the Berkeley MICA [4, 19] depicted on figure2, which consists of an embedded microcontroller, low power radio with a reasonable amount of local storage in an area of (5.7 cm 3.2 cm 2.2 cm) package. This could be powered by 2AA batteries and consumes approximately about 20mA in the active mode resulting in a battery lifetime of 5-6 days continuously running. That device could switch into a sleep mode and could consume low power of approximately 10θA thus resulting in a life expectancy of 20 years [16]. The Berkeley MICA runs using the TinyOS operating system, which particularly addresses the resource management need of sensor nodes as well as concurrency in the network.

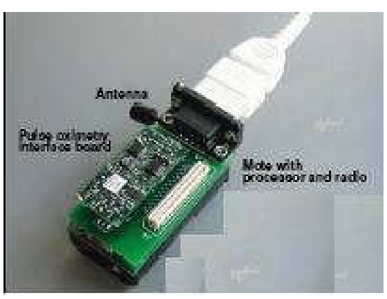

Fig 2 the Berkeley MICA sensor

3.2Radio communication

These devices use an existing commercial wireless transceiver technology; however the MICA [19] CC1100 Chipcon single chip radio as a communication platform with an operating frequency range between 433 or 916 MHZ, with a maximum data rate of 76.8kbps at approximate range of 20-30 m within a particular enclosed area. Currently this device has a limited computational capabilities and limited bandwidth, these make it impossible to use specified communication protocols such as the Internet based protocols known as TCP/IP, DNS, and ARP. The demands for better technology and the push by industry are not too far of in the future. There is the next generation, with a incorporated radios that follow the IEEE 802.15.4 operating at 2.4 GHz with 250 kbps, ultra low power, limited range wireless communication, which are well suited for a wide range of industrial applications. However we are interested in understanding the security and reliability of this technology for purpose of environmental monitoring.

To demonstration the environmental monitoring scenario using sensor network devices, we have developed a small enough integrated compact package in a mote- temperature and humidity, as well as thermal radiation sensor with the MICA [4], the device transmits periodic packets containing data on the temperature, humidity.

A vital signal data can come from multiple sensors, adapting, and multi-hop routing schemes to station such as a PC or Laptop, or to multiple users.

The scattering of a large number of wireless sensors networks in a bush land will provide continuous real time vital signal and data on the current environmental condition of that particular landscape as shown in figure 2, which can then be processed by a computer with the results being monitored by emergency personnel.

Having this continuous real time data pouring from thousands of different points or a specific landscape to an emergency unit headquarters will provide enamours information in terms of moving heat waves or cold fronts. Further processing can be performed on this data to pinpoint the positions and the magnitude of the most likely of bushfire in that landscape. while such approach will provide clear benefit for a emergency personal and fire fighting units it raises forward the challenges in terms of the large geographical area that must covered and issues of reliability as well as complexity. With the over whelming advances in the area of wireless communication network as well as in the area of the thermal radiation, and IR sensor it is not possible yet to cover an area more then a few meters in diameter, there are also issues of system robustness and the communication security required to provide a accurate data.

3. WIRELESS INFRASTRUCTURE

Implementing a low power wireless senor network device, in bush land will produce a number of challenges. Currently we could demonstrate the system operating in small numbers within a limited geographical area under fairly static conditions, however scaling this system up to handle a lager geographical area as well as ensuring robust operation, high degree of stability and mobility and minimum loss of data packet transfer poses a number of unforeseen problems. However we have made the assumption that the infrastructure of a wireless network system does not exist and that the system will operate in an *ad hoc* manner.

During the development of a prototype for the wireless sensor network, a number of critical challenges have emerged. We have explored some of those challenges in our design, however to achieve a high level of system robustness, reliabilities and extendibility also there a need for significant research to be undertaken in the area of develop power consumption and energy distribution.

Developing a secure, reliable group of wireless network sensors communicating among them selves or to mobile or fixed terminals using a mesh topology was a challenge in it self. It is unlike the 802.11 network, however the wireless sensor network is designed to operate on limited energy consumption therefore it is desirable for the nodes to limit their transmission power to achieve an adequate connectivity without other network interference and the requirement to archive minimal computational resources, at the same time being a self- organizing network. In addition, a prioritized data network transmission is being adopted in the case of an emergency or a fire occurring.

High level security and super encryption techniques [23] are not suitable for this wireless sensor network due to the limited computational power, however a pass word keying system has been implemented but there is no desire to establish a high level encryption keying system, however this system will allow management, emergency personnel and other authorized users to quickly access at any time and logoff when the desire.

Finally, the underlying system operation requires the coordination of the hardware devices and a cohesive coordination between the communication and programming models. However the current software does not provide a higher level service [23]. Our objective is to develop a protocol that allows a range of wireless sensor devices to integrate and communicate effectively in critical circumstances.

The wireless network sensor is designed to scale across a wide range of network of different densities, ranging from bush land into suburban areas, as well as having the capabilities to operate on a range of different wireless devices such as PC-class systems. Currently we are in the early stage of design and prototyping of the wireless network sensor, however the following discussion will outline our current design goals and the challenges that emerge in this area.

The wireless sensor network offers a scaleable, robust information system for coordination and communication across a wireless environmental monitoring system [5]. Using the *ad hoc* networking topology with the wireless sensor network to perform an inner connectivity and communicate between a multiple nodes or sensors extended across a specific landscape or in bush land in a mesh topology manner, which result in flexibility of extending and upgrading the network when it is required. However the idea behind using an *ad hoc* or a mesh topology network will result in self organizing, which means that the loss of a given node or sensor or a network can rapidly detected and data re-routed accordingly as well as data in the lost node or sensor can be recovered from anther node or sensor, which result in reliable transmission of critical data either through a prioritized channel or dynamically.

A flexible security model support will require the implementation of a range of polices e.g. processing information on the database will be authenticated by the network before they are able to access any information on that data base, as well as allowing a multi user access right, in the scenario of a rescue team trying to access the data in an emergency or disaster situation, as well as a decentralized access control to avoid dependency on a single authoritative system.

Wireless sensor network policies, security protocols and the connectivity will simplify application developments and data processing as well as providing a rich infrastructure for outback wireless network connection. That means data coming from multi terminals or multi sensors can be relayed to fixed wired terminals or into mobile wireless computers which then can be integrated or update the current data base.

4. SIMULATION RESULTS

The simulation results have been taken from the Mathlab and Netsim real-time sensor software. Figure 3 shows the first stage of the test that uses the matrix of sensors scattered into the environment. In the first phase the connectivity of the network is tested, i.e. data sent and received across every node. Once the network is fully connected then the connection established can be seen in the simulation below in fig.4.

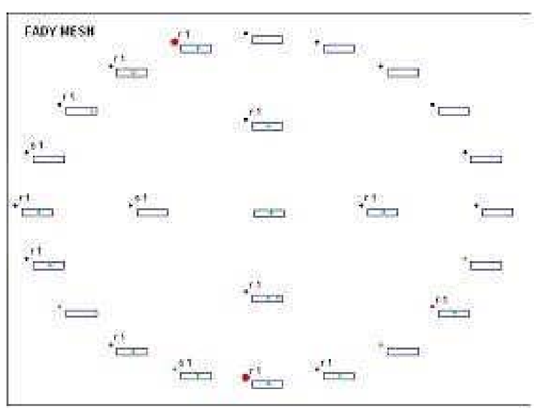

Fig 3 Initialisation State of wireless mesh sensor

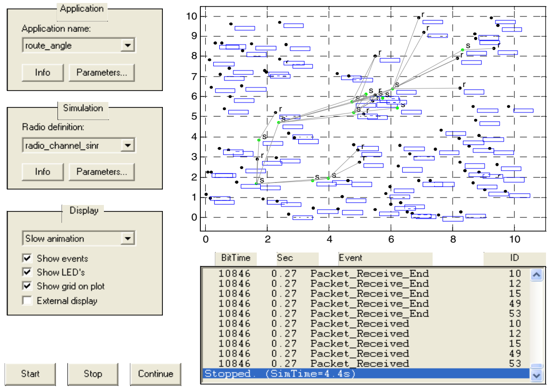

Fig 4 Initialisation State of wireless mesh sensor

The figure below can be scaled to a real environment scenario. Figure5 below shows a partial mesh transition behaviour which completes its whole network after some time as shown in fig.6.

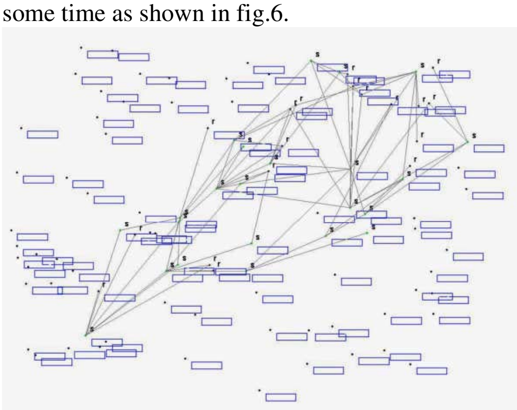

Fig 5 illustrate the mesh when the sensors are un-evenly scattered

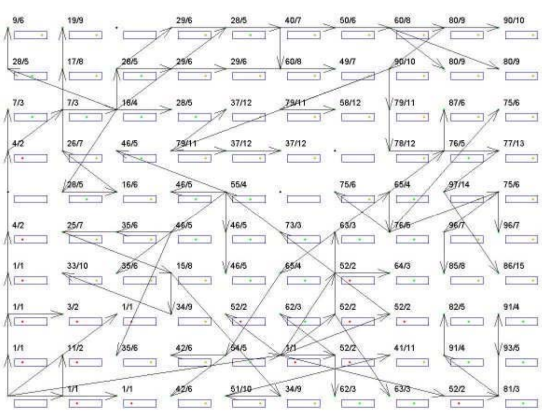

Fig. 6 is a confirmation test of the test in figure 10 results

Results from NetSim:
The following are the results taken from the NetSim; the map of National park of Sydney was used as environment in the program.

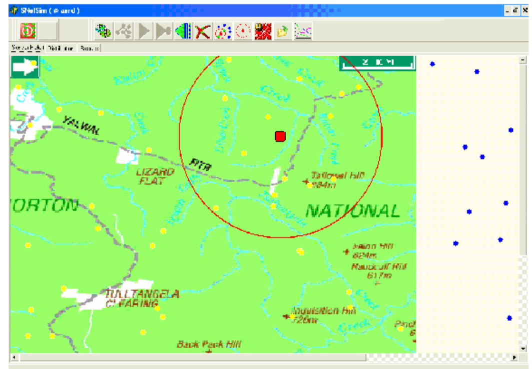

Fig 7 Relationship of the sensor network to a real life scenario in an Australian national park

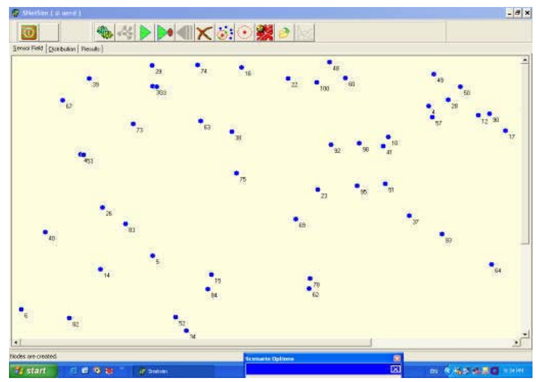

Fig. 8 Initialization of the wireless sensor network configuration.

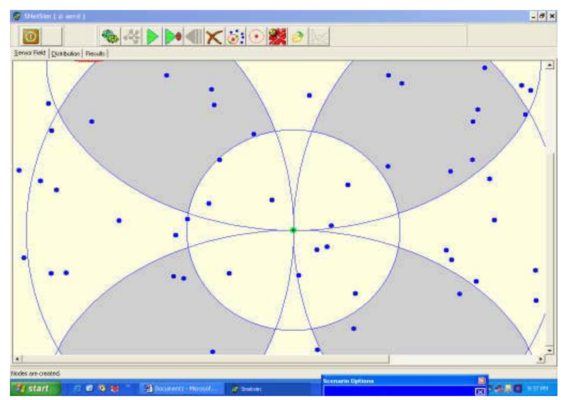

Fig. 9 Initialization of the wireless sensor localization Function.

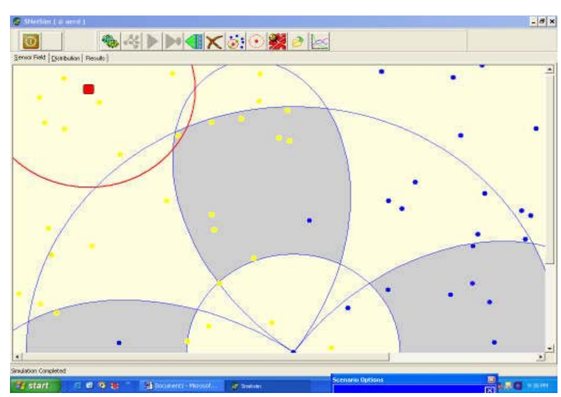

Fig.10 pin pointing the localised node in the network

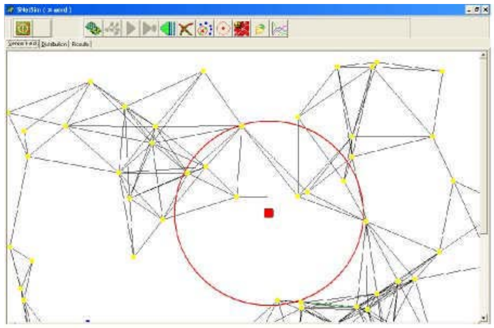

Fig. 11 illustrate mesh connectivity between the wireless sensor network

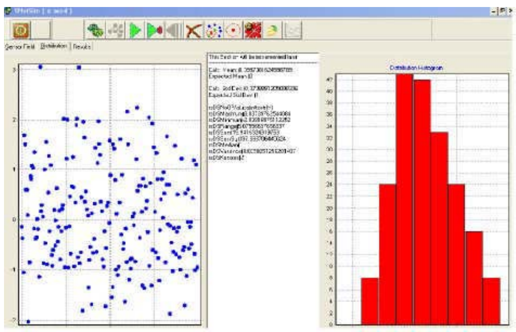

Fig. 12. Gaussian distribution vs. the network topology of the wireless sensor network.

5. CONCLUSION

In this paper we have demonstrated a real time technique to control and monitor bushfire fighting especially in the areas where mass causality are likely to happen. Our mission is to eradicate the short coming of the existing methods where no real time activity can be monitored.

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