Forest fire detection system based on Node wireless sensor Network

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Abstract

Forests are one of Earth's primary air filter scrubbing the atmosphere of CO_2, a greenhouse gas and contributor to global warming. Fire, whether started by natural causes, cigarettes, agricultural techniques or and other reason, is contributing to massive losses of forest land, and it is time to use technology to help Mother Nature preserve those land.

A sensor network can provide the early warning necessary to allow firefighting resources to converge on the source of the fire as soon as possible By definition, a sensor network is a set of nodes or motes distributed in the forest that periodically reports data to a coordinator for processing based on Moteview software which introduce big advantages and high flexiblity and self configuration and scalability , embeded montoring and control. In a forest, hundreds of low-cost, low-power smoke detecting nodes could be distributed within wireless transmission range of the central, or coordinato node .

The coordinator node would gather information from the nearby sensor nodes through a ZigBee compliant wireless network and by Moteview software provide graphics , process the data and if any smoke is detected, send out an alert using a larger wireless network, such as 3G or GPRS. This alert could be sent directly to the firefighting station, with not only fire location information but also the time of the detection. Environmental parameters such as smoke, temperature and humidity in the forest region can be monitored in real time. From the information collected by the system, decisions for firefighting or fire prevention can be made more quickly by the relevant government departments.

Keywords: wireless sensor network, smoke, humidity and temperature sensors, network node, Zigbee wireless network.

الخلاصة

تعتبر الغابات اكبر فلتر لجو الارض للمحافظة على البيئة حيث يقوم هذا الفلتر بتنقية جو الارض من جميع الملوثات وخصوصاً ثاني اوكسيد الكاربون وكذلك تخليص الارض من ظاهرة الاحتباس الحراري.

ان ملخص البحث هو استخدام حساسات ذكية لدرجة الحرارة والرطوبة والدخان ولكشف حرائق الغابات. حيث تم شرح وتعريف الحساس الذكي وكيفية ربطه بمنظومة لاسلكية ثم تم تعريف كل حساس على حدة ومن ثمة عمل تصميم هندسي وقد نفذ في مختبرات جامعة بولي تكنك قسم الحاسبات علماً ان جميع هذه المعدات التي ظهرت بالبحث متوفرة وقد عملنا محاكاة لاظهار بعض النتائج والرسوم واثبتنا قابلية وكفاءة النظام وقابليته للتوسع ليشمل آلاف المتحسسات والتطبيقات كما ان البحث يشمل جميع التفاصيل العلمية لنظام اللاسلكي والانظمة المستعملة وكيفية عملها... علماً ان النظام مازال يعمل ونحن بصدد تطويره والحصول على نتائج جديدة وخصوصاً معامل الاداء واستخدام النظام في بيانات مختلفة وعدوانية وكيفية اداءه اضافة الى استخدام البطاريات ومراقبة عمرها وتفي مختلف الظروف.

واخيراً فاننا قدمنا نظام حديث يستطيع الانذار المبكر لرجال الاطفاء ويزودهم بالبيانات الضرورية لاتخاذ القرارات المناسبة وفي الوقت المناسب.. ان هذا النظام يعتمد على مراقبة الحساسات والتي تتصل بعقد عنقودية تتصل باجهزة المراقبة والتحكم وميزة هذه الشبكة سريعة وقابلة للتوسع ورخيصة ومن الممكن ان تبرمج نفسها ذاتياً للتواصل مع منظومة الانترنت والشبكات الاخرى لنقل المعلومات وان نظام البرمجة ما يسمى MOTE-VIEW هو المستخدم لغرض البرمجة والتحكم والمراقبة.

ان شبكات الحساسات الذكية تفتح الافاق للتطوير التكنولوجي ونستطيع القول ان تكنولوجيا الحساسات الذكية هي حقاً الثورة الصناعية بعد ثورة المعلوماتية والكومبيوتر والمستقبل القريب سوف نشاهد السيارات الذكية والبيت الذكي وتطبيقات كبيرة في الفضاء والصناعة والصحة والطيران وجميع مجالات الحياة.

1-Introduction

Forests have a significant importance for human survival and social development that protect the balance of the earth ecology. However, because of some uncontrolled causes activities and abnormal natural conditions, forest fires occur frequently. These fires are among the most serious disasters to forest resources and the human environment. In recent years the frequency of forest fires has increased considerably due to climate change, human activities and other factors The prevention and monitoring of forest fires has become a global concern in forest fire prevention organizations Currently, forest fire prevention methods largely consist of patrols, observation from watch towers and lately satellite monitoring . Although observation from watch towers is easy and feasible, it has several defects.

Currently three main wireless standards are used namely WiFi, Bluetooth and ZigBee, respectively. Wi-Fi networks, a standard named IEEE 802.11, is a radio technology to provide reliable, secure, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wire networks. Wi-Fi networks work in the unlicensed 2.4 GHz and 5 GHz radio bands, with a data rate of 11 Mbit/s or 54 Mbit/s. They can provide real-world performance similar to that of the basic 10BASE-T wired Ethernet networks. Unlike a wired Ethernet, Wi-Fi cannot detect collisions, and instead uses an acknowledgment packet for every data packet sent(Ali, 2012) .

ZigBee is a low-power, low-cost, wireless mesh networking standard. The low power allows longer life with smaller batteries, the low cost allows the technology to be widely developed in wireless control and monitoring applications and the mesh networking provides high dependability and larger range. ZigBee operates in the industrial, scientific and medical radio bands with 868 MHz, 915 MHz, and 2.4 GHz in different countries. The technology is intended to be simpler and less expensive than other WPANs such as Bluetooth. Of those, ZigBee is the most promising standard owing to its low power consumption and simple networking configuration (Suraiya, 2011).

We suggest the ZigBee wireless sensor network technology and explain its application as a monitoring system. This system can monitor real-time related parameters, e.g., smoke , temperature, relative humidity, and send the data immediately to the computer of the monitoring center. The collected data will be analyzed and managed by the computer based on Mote-view software. Compared with the normal meteorological information and basic forest resource data, the system can make a quick assessment of a potential fire danger. The analytical results will then be sent to the relevant department , like example fire fighting police department to make the right action and fighting the fire(Grard, 2008).

2. Forest fire environmental parameters

There are three parameters effected in the forest fire: relative humidity , air temperature and smoke are regarded as the two main factors which affect the moisture content of the fuel. Therefore, to reflect the humidity content indirectly, these two parameters are the main objects of our investigation, which should provide an important basis for the prediction and monitoring of forest fires. Certainly, forest fires are also caused by other factors, such as the active degree of thunder and lightning above the forest, human factors, wind speed, and condition of area vegetation. Smoke due to the forest fire it’s very important parameter to monitoring and control(Crossbow catalogue NI 3202).

3. Wireless sensor Network for forest fire monitoring system:

We propose the distribution of several nodes, from N1 to Nn. Each node is a smart sensor operating in a Plug-and-Play mode and each node communicates to a server, over a wireless network by using a Zigbee standard wireless communication , Each node connects with a smart sensor, namely a transducer detection device, transducer interface model (TIM) and Network Capable Application processor (NCAP) as shown in Figure 1. Zig Bee is a low-rate, low-cost and low-power kind of short range wireless network communication protocol. Compared with other wireless technologies, ZigBee has unique advantages of safe and reliable data transmission an easy and flexible network configuration, low equipment costs and long-lasting batteries. Thus, it has great development potential and a promising market application the field of industrial control as shown in Fig.2 Each node connects with one of smart sensor, like: a smoke detection, humidity, temperature devices, transducer interface model (TIM) and Network Capable Application processor (NCAP)

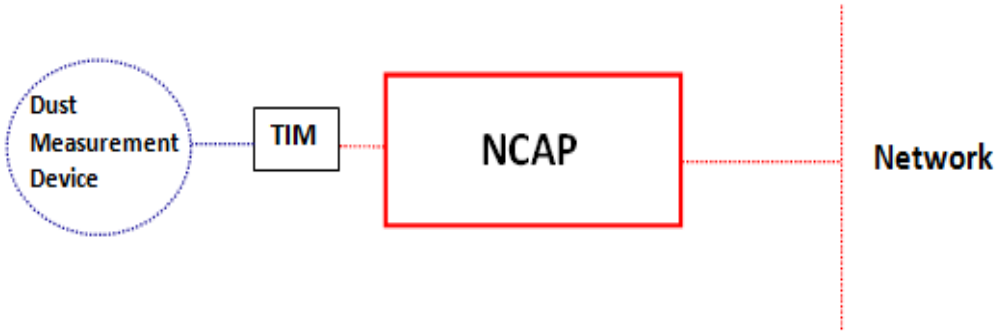


Fig.1 Wireless sensor Node

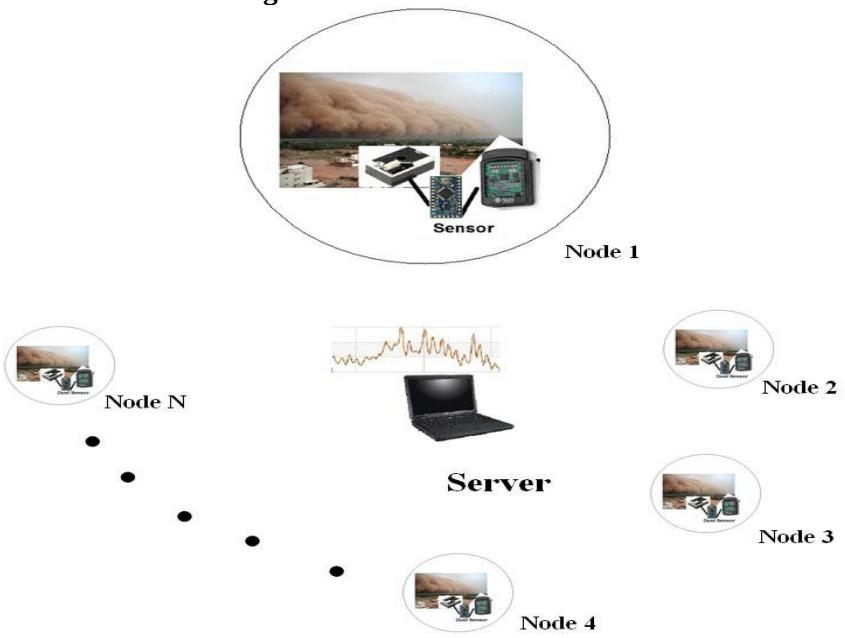


Fig.2 Forest wireless Monitoring Network

By applying a wireless sensor network based on ZigBee to a forest fire monitoring system, information such as smoke, temperature and humidity at any part of the forest covered by the network could easily be collected, dealt with and analyzed at any time(Jacob, 2004).

Each node should operate as a Plug-and-Play device used to provide minimal downtime for the network. Through microcontrollers embedded in each node, each sensor can upload measurement results directly to a server within the network which use Moteview software from crossbow to control and manage the Nodes and to view results. The clustering of networks enables each individual network to focus on specific areas and shares only relevant information with other networks, enhancing the overall knowledge base through distributed sensing and information processing(Zhu, 2006).

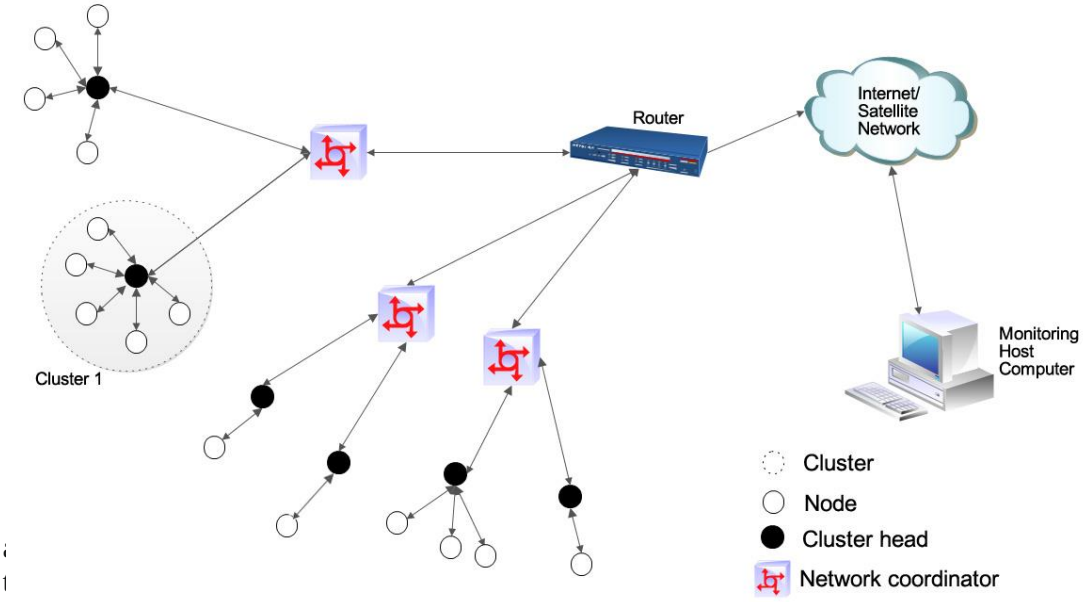
3.1 Architecture proposed of the Zigbee wireless system

The ZigBee WSN (wireless sensor network) system consist of sensor nodes, gateways (routers) and a monitoring host computer. To decrease the loss of energy and data packets, a cluster tree network topology structure (shown in Fig. 3) is applied in this design. Sensor nodes fitted with microprocessors of low processing capacity are distributed randomly

in the forest and nearby areas to collect fire monitoring parameters such as smoke, relative humidity and atmospheric temperature

Depending on the part the different sensor nodes play in the whole network, they are divided into three categories: ordinary bottom nodes, cluster heads and network coordinators.

Data collected is transmitted to its own cluster head by an ordinary bottom node. A cluster head mainly handles data fusion and data packet transmission. Via the cluster head, data collected by ordinary bottom nodes in the cluster can be fused and transmitted to the nearest network coordinator and data packets transmitted by the network coordinator can be broadcast to related clusters(Calle *et al.*, 2006).



local database and then transmit the data to the monitoring host computer via internet, which provides a decision-making basis for forestry or fire prevention departments(Yu *et al.*, 2005).

4. Sensors for forest fire Monitoring

4.1. FIRERAY® 5000 Reflected And Motorized Range smoke detector

The FIRERAY® 5000 is the latest in Optical Beam Smoke Detector technology. Its design has been inspired by the advantages of the existing FIRERAY® projected and reflected units supported by the concept of addressing the needs during installation, setting-up, commissioning and operation.

FIRERAY® 5000 combines a ground level System Controller and reflective technology, with a motorized Transceiver detector head as shown in Fig.4 .

LASER Assisted Alignment: once the Detector Head is connected, an integral LASER can be activated. This allows the Reflector to be sighted quickly and with confidence.

- Auto Beam Alignment: once the Laser has been used to coarsely align the IR beam, the Auto Beam Alignment process takes over.

- Multi-Detector Wiring: Subject to local installation guidelines up to 4 detector heads can be wired into one controller, thus saving on wiring and power supply requirement.

Fig.4 FIRERAY 5000 smoke detector (Product Guide Picture)

The Optical Beam Smoke Detector works on the principle of light dispersion. And then particles of smoke pass on the lighting area, the dispersion light pulse was generated in accordance with size of particles. It outputs voltage pulse converted from the dispersion light pulse.

4.2. Temperature/ Humidity Sensors

The LM35 for temperature and HIH 3605 for humidity level measurements connected with MDA 300 data acquisition from crossbow and these sensors communicate wirelessly to NI wireless sensor network (WSN) from Crossbow instrument devices(Node and base station) as shown in Fig 5 and Fig 6 provide the same quality and accuracy as traditional wired measurement systems, but with increased flexibility, lower costs, and the ability to create smart WSN systems based on MOTEVIEW software(MDA 300 Manual).

The humidity sensor (HIH 3605) consists of a polymer capacitive sensing element with on-chip integrated signal conditioning and a second polymer layer to protect against dirt. The humidity sensor has an linear voltage output with an accuracy of ±2% RH (relative humidity) and ±0.5% RH linearity. If the measurement is realized in slowly moving air at 25°C the response time of this sensor is of maximum 15s. The LM35 is calibrated directly in Celsius degrees and has an sensitivity of a 10.0 mV/°C and an 0.5°C accuracy over -55°C to +150°C range. This sensor was chosen because does not require any external calibration or trimming to provide its typical accuracy .

Fig.5 Temperature humidity wireless Node Sensor (Politehnica University Bucharest Live picture)

Fig. 6 Wireless Base station (Politehnica University Bucharest /Live Picture)

A communication network is composed of many nodes, each of which can transmit and receive data over communication links, wireless or cabled supports network topologies. The ZigBee network layer supports star, tree and mesh topologies. The ZigBee coordinator is responsible for initiating and maintaining the devices on the network, and all other devices, known as end devices, directly.

5. Simulated results based on MOTEVIEW software :

Each node was implemented using a FIRERAY 5000 smoke sensor that is based on the optical principle dispersion and HIH 3605 sensor for humidity and LM35 for temperature , The network consists from 3 nodes via data acquisition MDA300 with NI WSN-3202 for smoke, temperature and humidity. Figure 7, depicts the practical picture of the NI WSN 3202 and MDA 300.

The NI WSN-3202 measurement node as shown in Fig.6 is a wireless device that provides four ±10 V analog input channels and four bidirectional digital channels that we configured on a per-channel basis for input, sinking output, or sourcing output. The 18-position screw-terminal connector delivers direct connectivity to sensors and offers a 12 V, 20 mA sensor power output that use to drive sensors that require external power. the power for the measurement node is similar to NI WSN -3226 (four 1.5 V, AA alkaline battery cell) (Crossbow catalogu NI 3202).

A 2.4 GHz radio wirelessly transmits data to the WSN gateway, where you can connect through Ethernet to other network devices. NI-WSN software delivers easy network configuration in NI Measurement & Automation Explorer (MAX) and data extraction with NI MOTEVIEW software. The nonprogrammable WSN-3202 does not include a license to target and program the node with the MOTEVIEW Wireless Sensor Network (WSN) Module Pioneer((Crossbow catalogu NI 3202) .

Fig. 7 Real-Life picture of used equipments (Politehnica University Laboratory /Bucharest)

The simulation results were obtained by using several types of smoke: and different humidity and temperatures. The front panel of the application used for monitoring and measurement of environmental parameters is presented in Figure 8. As can be observed, each signal from the sensor is displayed:

INSERT into mda300_results (result_time,nodeid,parent,voltage,humid,humtemp,adc0
,adc1,adc2,digi0,digi1,digi2) values (now(),0,126,377,960,6678,2500,2243,2505,0,
0,0)

The application allows the user to set the variation limits for every channel (Mote-view user Manual, 2006).

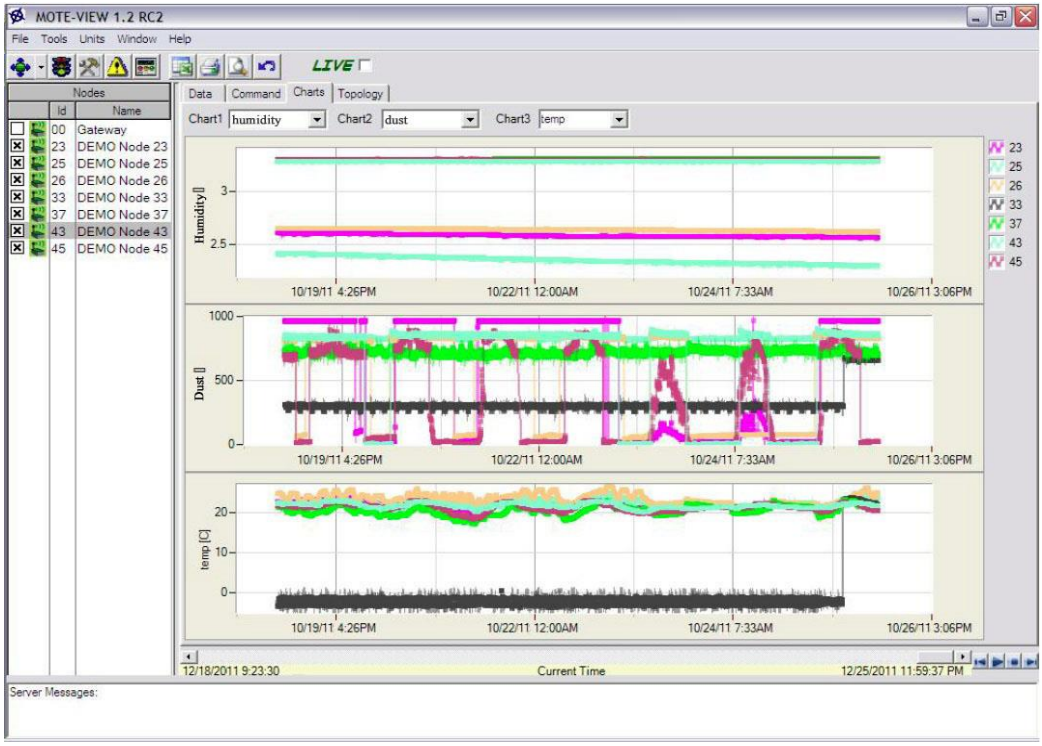


Fig. 8 Acquired data from sensor MOTEVIEW front panel application (simulated acquired data /Politehnica university/Bucharest)

Based on the user configured thresholds, the server will either take no action, but to record the data for statistic purposes, or send a signal to other devices for specific tasks, such as provides a decision-making basis for forestry or fire prevention departments. This depends on the specific application for which sensor network is used(Hassanzadeh *et al.*, 2008).

6. Conclusion

This paper describe Wireless sensor network for forest fire detection system by use distributed motes and the softeware and configuration by using Mote-view software which introduce several advantage like self configuration and easy to program and logging also scalability and show graphics to uses like a data base for monitoring centeres , wireless sensor network has a significant importance Especially in difficult and harsh environments, it has advantages that traditional monitor systems lack. Also, compared to human observation, the introduction of a smart sensor network is more flexible when it comes to dangerous and hostile environments where humans can't penetrate, allowing access to information previously unavailable from such close proximity . In addition, wireless sensor technology has a broad application background in the field of real-time forest fire monitoring.

But given the complexity and signifacant features of the forest, the system has not been extensively applied in practical forest fire monitoring. To monitor smoke, temperature and humidity in the forest in a more timely and precise way, we pointed out unique advantages of safety in data transmission,flexibility in building the network, and low cost and energy requirements for a forest fire monitoring system based on a ZigBee wireless sensor technology that we designed, which needs to be improved in future investigations. Sensor scheduling can be obtained by enabling the sensor nodes to modify communication requirements in response to network conditions and events detected.

Low power consumption is one of the advantages of the Zigbee networks, but we must change batteries when the power were exhausted. Owing to the sunlight being sufficient on the field, the solar cell will be used to support the power for sensor nodes in the future. In other words, we propose this system as a first attempt and complement to existing forest fire monitoring and prevention methods. To extend the potential of the system and improve forest fire monitoring technology, the problems of energy consumption, nodes location and clock synchronization need to be addressed in the future. From the experience of already existing

devices, we can expect that in the coming decade a large number of monitoring systems for all physical phenomena will emerge, with great application in the human health sector, industrial sector and the environment.

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