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Utilization of command & control solution in smart networks for national monitoring and fire fighting in Iran

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Abstract

According to the fires that have threatened the country's recent life of natural areas, a system for monitoring, notification and extinguishing the fire was quickly designed and built. This system is generally based on two network segments, smart sensors and communications networks. Scenario is that in certain pilot of natural areas, fire warning information by network sensor system that is finally processed by software algorithms, will be sent to the local command & control center via the communication network.

Considering the extent and severity of the event, the center operator with respect to the extent and severity of fire events; will send the coordination of that point into latitude & longitude, provide instructions for forester, command vehicle & the helicopter carrying the water. Fire operations center also monitors the real-time feedback and reports to the headquarter centers.

Keywords: fire monitoring system, Internet of Things, smart sensor, video monitoring camera

1. Introduction

Fire as one of the most important factors affecting forest ecosystems, destroys an average of 27.7 million hectares of forest and 1.5 million hectares of woodlands. Forest fires, regardless of their origin (natural or synthetic), can directly affect the physical and chemical properties of soil and indirectly effect on habitat quality, plants, foliage, fauna and soil mass. In addition to the above effects, forest fire causes significant changes in other parts of the ecosystem such as wildlife, air quality and surface water flow(Li, Nadon, and Cihlar, 2000; Oliveira and Rodrigues, 2011). Iran is arid and semi country arid that has near the 12.4 million hectares of forests and 90 million hectares of rangeland. According to the FAO, about 94% of fires occurred in areas of natural world has anthropogenic origin that with proper management can be prevented from occurring and the damages caused by the fire but unfortunately before people realize the fire, and inform the flame arresters, fire spread most of the forest. Therefore, the use of intelligent and efficient system that can announce fire officials before it gets out of control and become a crisis is undeniable requirement. According to forests and pastures organizations need to design intelligent systems for monitoring forest fires and protect this heritage. The aim of this paper is to present proposals to implement networks consisting of sensor nodes and cameras for forest fire notification

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and also intelligent communication solutions for fighting forest fires on time. Due to the variety of technologies using fire monitoring system in terms of sensor and camera combination is unprecedented anywhere in the world.

Each of these systems with optimal performance in fire monitoring, increases the coverage factor, the performance of the system and reduce costs in the national arena. And also, the completion of the cycle in terms of monitoring and ultimately firefighting with radio communication method similar project cannot be found, that can integrate all land and air systems in a joint operation to conserve the natural resources.

According to the orders of the great leader of the revolution to explain the resistance economy, all intelligent systems that continue to be introduced, are designed based on intelligence and knowledge of Iranian engineers and, not only in this way which can maintain the country's financial capital but also, can be a step to offer this knowledge to the rest of the world.

Suggestion of this system in five sections, including smart monitoring system on the national arena, command and control system of the local ranger systems, vehicle command and appointed system installed on the helicopter flushing system will be presented in this paper from monitoring cycle to firefighting, respectively.

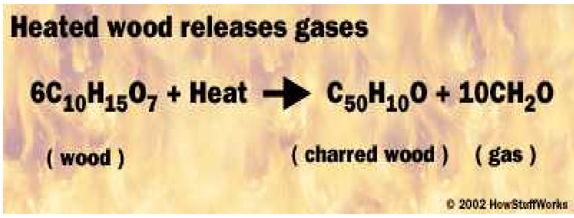
2. Smart monitoring system on the national arena

From long time ago, the satellite monitoring method has been common for fire monitoring but a lower resolution observation satellites and long period of scanning the area in accordance with Li, Nadon and Cihlar (2000) and also impossibility of predicting fire on time, caused to use smart system solutions that is referred in this article for standard method of national monitoring at the world. This system monitors all the different parts of the forests and rangeland real-time, and in case of detection of any signs of smoke and fire, sending alarm with location of the fire to the regional command and control center. This system generally consists of the sensor system and camera system that are described in the following.

2.1 Review of burning wood

Due to the nature of fire, it will create several gases. When a piece of wood ($6C_{10}H_{15}O_7$) is exposed to heat, convert in a wood-burned ($C_{50}H_{10}O$) and the amount of gas ($10CH_2O$) is shown in Figure 1.

Figure 1. Reaction of a piece of wood to heat



This gas ($10CH_2O$) that is created by the reaction of wood and heat, subjected to the atmospheric oxygen (O_2) exhibit luminescence to gas (H_2O, N_2, CO, CO_2).

Figure 2. Burning wood with atmospheric oxygen

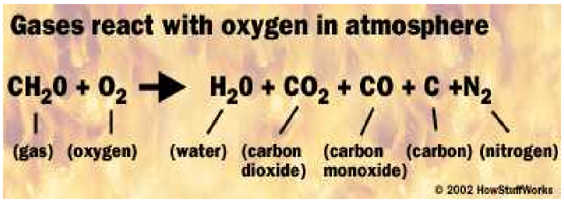
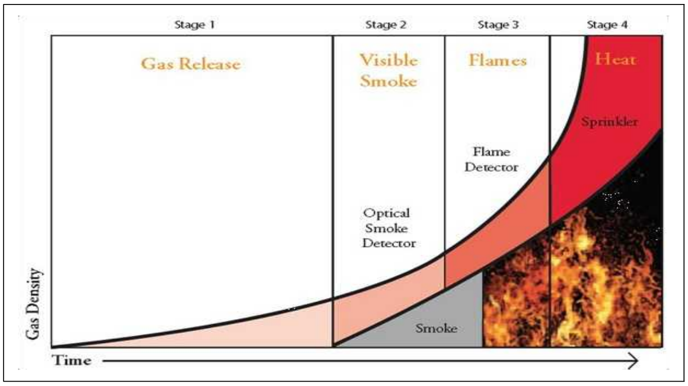


Figure 3 shows the four stages of a fire, such as temperature and gas to the point that is detectable by sensors, and the best time to diagnosis is stage 2. After this step, the fire can be quickly formed and within a few hours will affect a large area.

Figure 3. Diagram of fire formation



2.2 Sensor boxes network

A wireless sensor network based on intelligent sensor networks (Son, Her and Kim, 2006), consisting of a large number of sensor nodes that are widely in an environment with self-regulation in accordance with Wang, Cao and La Porta (2003) will spread and collect environmental data, processing and sending information (Oliveira and Rodrigues, 2011).

Due to its ability to organize protocols and algorithms for sensor networks, it is not necessary that, where the sensor nodes are should be predefined before. Each sensor node in this article that is checked, has a processor on its board and instead of sending raw data, a series of initial and semi-processed data will be send to the integration device.

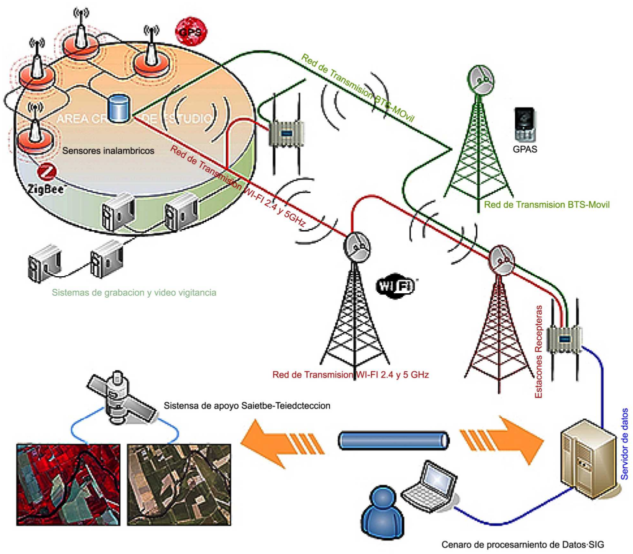
2.3 Introduction to sensor box

Sensor box platform used in this article, in fact, a ready platform in the field of wireless sensor networks and can support a variety of Internet of things protocols and various sensors to set things up and put them under different protocols for sensor networks and then send them in star topology to the center (Chi et al., 2014).

Figure 4. Sensor box including temperature, humidity and carbon dioxide sensors, solar cell and telecom link

· Operating temperature - 10C ° to + 50C °
· Waterproof: IP65
· Telecom link: Lora wan (868MHz) or SIM card
· On / off button available
· Battery: 7 days without Solar Panel (6month with solar panel)

Figure 5. Transmitting sensor network information and then send into the command and control monitoring and firefighting operations center

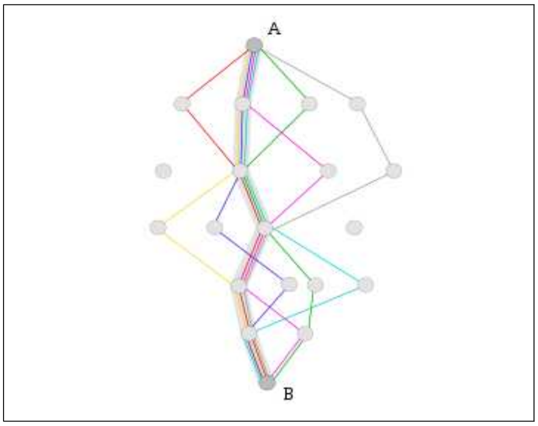


In each sensor node, the sensor data deposit to a fuzzy algorithm for fire detection. This algorithm makes that we use all the sensors capacity proportional to its influence in the region and distinguish the fire. By this work, error rate detection becomes low and fire can be detected with high certainty.

2.4 Transmitting smart data detected by the sensor nodes

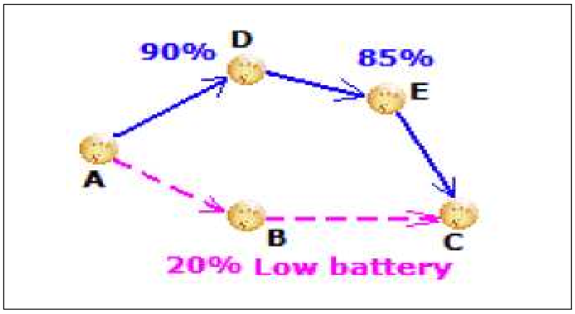
Consider that 80% of sensor box power needed to send monitoring fire data, so required to track the shortcut path to the integrator with the lowest sensor should be selected (Ssu, Ou and Jiau, 2005). To achieve this, sensor nodes use a self-learning artificial intelligence algorithm called ant colony, so in addition to reducing power consumption, data rate also significantly increased in fire detection. In figure 6 understandable example for this algorithms is shown to get information in the shortest path from the sensor node B to the sensor node A.

Figure 6. Ant colony algorithm for finding the shortest path



Maybe due to the passage of time and the use of a commute, its battery power on that path declines and it is not the good path for sending and receiving. It is therefore important that algorithm always consider the energy consumption of the selected route. Figure 7 clearly illustrates this issue.

Figure 7. Redirect transmission line considering power consumption



Sensor model presented, because of having solar cell and internal battery, even in the absence of sunlight will also be able to benefit from a period of 6 months from its internal battery power use and if using the sun light, lasts for up to 5 years.

2.5 Radio link sensor network data collection

Considering that forest fire monitoring includes vegetation and trees, therefore, scattering due to the sensors and the possibility of damage to vegetation, wired link is not recommended, and so according to performance of Lora wan radio network in Forest coverage, the link is used to send data to the command and control center.

The distance between the sensors, depends on the mass of vegetation, so due to the distribution of forest and pasture in this method, it can be computed about 70% in about 1 hectare for each sensor and about 50 meters between the sensors. Then, in a radius of about 500 meters, equivalent to 10 hectares, the integrated device is installed to get information about 10 to 20 box sensor in mesh topology and then sensor input to each of these integrators outputs that is done in a long-range connection between integrators with center, complete network of sensors centralized command and control center are carried out in accordance with experiences for 100 sensor box, with vegetation of about 70%, about 100 to 200 hectares can be covered.

2.6 Integrator

As noted above, this device sends information received from sensors under a specified protocol to the long-range link so this information be submitted to decision-making centers. It should be noted that the efficiency of this device is quite similar to other sets of sensors and sensor nodes, this device is known as a leader and tries to connect through the nearest way to it (Heinzelman, Chandrakasan and Balakrishnan, 2002). In addition to this task, group of sensors similar to the previous , is placed in this device that algorithm can use these sensors to calibrate sensor nodes, that this calibration will perform annually according to the experience in Wu, Xu, Tang and Lee (2007), in addition fine-tuning parameters, including setting up the sending, receiving, and the sensor when it is sleeping. On the other hand, when the fire become crisis, the software used in the control center, will model the spread of fire by the climate detection control system installed on integrators sensors.

2.7 Video surveillance sites network

To speed installation operations with lower costs and higher efficiency in some cases to network sensor box, a set of video surveillance sites are used for the completion of sensor network monitoring. Given the wide range of the camera view to 15 km radius able to cover 700 square kilometers and a cloud of smoke, 15 x 15 meters, these sites are used. Of course, these sites have a fundamental difference with sensor network and have better coverage of the densely areas by the sensor box to the video surveillance sites and sensors in these conditions is more responsive and it is preferred that we use these sites in areas of low-density and pastures that can cover large amount of areas. However, the use of video surveillance sites for fire detecting in day and night has added confidence and efficiency to the system (Roy, Bose and Saddar, 2016).

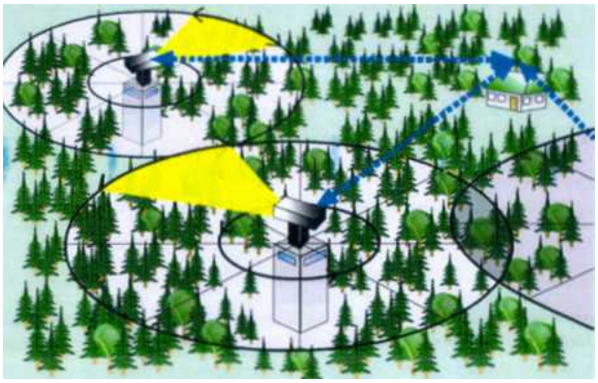
These sites are used for 24 hours recognition, surveillance and tracking and can be installed on fixed land or fixed platform at the proper height. Each site has a spectroscopic optical camera in day that the main task is to create the image of the target in the field and transmit data to each site to perform video signal processing, and image initial preparation, to send via high-capacity microwave radio link to command and control center.

Figure 8. Video surveillance site

Due to the use of heat detection facilities, sites are also able to operate at night. Because of thermal camera imaging capabilities (thermography) these sites could be used for day and night and in the dark to detect and obtain information and understanding of the different objectives and detailed analysis of their heat.

The basis of this analysis, is on video image processing that can be achieved through a 360 degree turn of camera. Method is that every 10-degree 3-dimensional photo is taken and in the next 10 degrees shooting of this sector, previous and next photos are processed together and the information will be send by detection of smoke patterns in the video image processing software. In order to promote the process of discovering and also quicker response, multiple site video surveillance information in accordance with Stula, Kristinic and Seric (2012) and Son, Her and Kim (2006). will be combined in the center as the panoramic images in output to better visualize and understand cloud of smoke.

Figure 9. Fire detection in day and night by the spectral analysis of light at each video surveillance site.



Due to the need for a detailed breakdown of charcoal smoke and factory surroundings from the clouds, we use software with powerful image processing algorithms to improve image quality and provide timely predictions. This software is able to analyze previous history and builds on previous and new fire, the fire spread prediction model and give us best solutions and define maximum processing times to firefighting before it spreads.

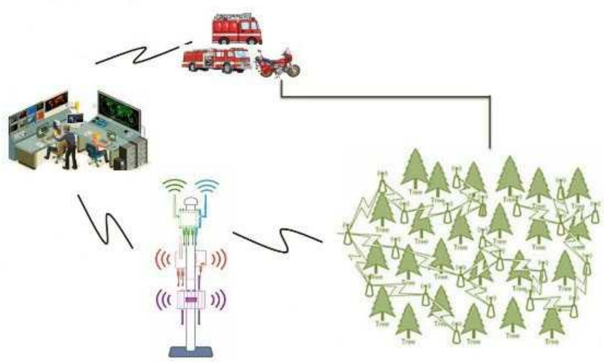
It should be noted that whatever is farther away from the tower installation of fire, the minimum size required to detect smoke and fire automatically becomes larger. Atmospheric factors affect the accuracy of detection, so that if foggy weather conditions, which is a common occurrence in the forest, the depth of camera to see become less and be more difficult to clear separation of the smoke from cloud. In addition to the existing optical sensors, fire detection, perimeter surveillance cameras using PTZ, which allow you to monitor suspicious activity, including robberies and vandalism of each site is provided for command and control center.

3. Local command and control center

Need to build a central command and control center and monitoring forest events is obvious. It is assumed that the design of the center for buildings and infrastructure necessaries at one point in the forest where concentrator device is installed under the coverage of the telecommunications mast and it should have a room of at least 30 square meters with electricity and water, bed and other amenities along with it.

Scenario is that in a pilot area with a maximum radius of 20 km from the center, with the diagnosis and initial processing by each sensor box and video surveillance site takes place, output information send through a dedicated radio network to the command and control center of forest. then, the central control system starts to process the input data and in the event or likelihood of occurrence of fire has been reported anywhere, by getting the volume amount of smoke, the arrival time to be in the place and the spread of fire and rugged topography of the region send coordination in the format of latitude and longitude in accordance with HU and Evans (2004) and Ssu, Ou and Jiau (2005) for the forestry operation team.

Figure 10. The process of sending information and operation team



3.1 Central control system

This system has software that all information and data obtained from comprehensive forest fire detection system and meteorological information, and will be integrated and showed for the operator, and allows continuous monitoring, supervision, notification of all incidents and accidents and consequently gives him faster decision making. The software also has the ability to analyze data in times of crisis, and could be due to advanced algorithms, predict the path of the fire and the fire spread dispersion model in the GIS map.

Determine the exact location of the fire and personnel, region topography, access roads, water sources, human habitation regions, determining the exact state of emergency in the fire and the procedures for applying evacuation of residents to protect the resources at risk, quick dispatch and accurate reinforcements to the firing region in digital radio communications ,tracking and recording of reinforcements, providing emergency plans to rescue forces graphically on map. Logging and recording all operations events to analyze and do next practices, online monitoring from the operations scene, inform the headquarter centers, risk assessment prior to the incident and assess the damage after the incident and submit plans for renovation after fire, determining the boundaries of the area burned in the fire and save the records for use. These are the other features of this system software.

Figure 11. Software of central control system

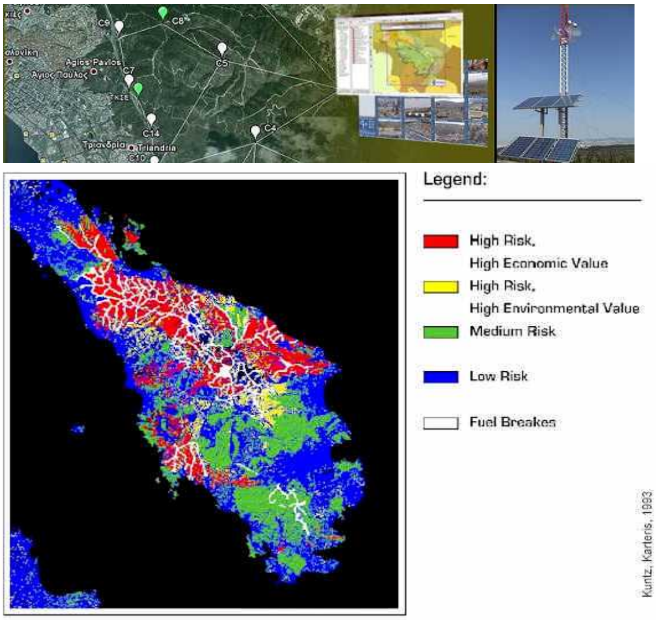
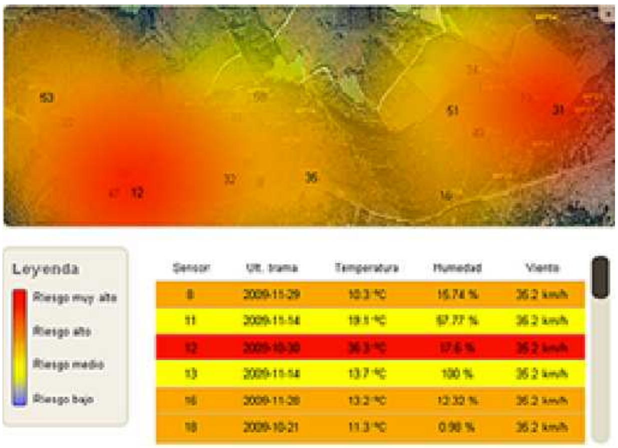


Figure 12. View real-time status of the sensors in the center



4. The woods ranger system

Ranger in the forest has DMR(digital mobile radio) for voice and tablet with geographic map system to communicate to the dispatching system in center. He inspects any place suspected to smoke in the forest and gives the center the latest information gathering and firefighting's last condition. When fire or smoke detection in the center happens, the center dispatchs the woods ranger who is driving all-terrain vehicle and quickly gets to the scene called ATV. The ATV can communicate with helicopter without causing overload for ranger.

Figure 13. Motor ATV and command vehicle

5. Command vehicle system

This system includes all radio equipment and processing video images monitoring sites and sensors and, if necessary, after receiving orders from the center as a regional monitoring center as an alternative of center, will be sent to the forest area. Upon deployment of the system in the proper location, open up the mast and do regional command within the forest. In the event that the need to monitor the surroundings from above, the drone inside the car will be sent to the desired location and then its videos and images transmitting to headquarter through satellite with the help of video conferencing system.

6. The helicopter water injection system

The mission of this helicopter begins by voice communication from the center to helicopter or helicopter airport. After delivering mission to the helicopter, and specifying the location of the mission, the regional map must be loaded before flying. For example, if you have deployed to Shiraz, then Shiraz map should load with the previous maps in helicopter's tablet. After sending the location and upon reaching a distance of 30 km from the center or command car system (in the radio coverage area) already in place, forest fire coordination information in accordance with Hu and Evans (2004) and Ssu, Ou and Jiau (2005) or other guide icons within 30 km gets listed in the tablet for better guidance and then the water injection mission starts.

The route over the fire place should be visible in the center via digital mobile radio dispatching installed on helicopter system because the center must ensure that the helicopter has been dispatched to the area. At the time of water injection the helicopter will be guided by the forest rangers to be directed to the desired location of the water supply in the forest and the helicopter to be informed of feedback.

7. Results

With the integration of the items listed in the form of integrated network we create a full cycle of monitoring and firefighting that achieves the following objectives:

. Discovery of any fire in the shortest time possible
. Estimate the size and exact location of the fire
. The ability to check the exact location of the fire
. Ability to predict the spread of fire
. Ability to display all regions monitored in a control center
. Ability to connect to surveillance cameras
. Ability to provide alarms to digital radios and phones
. Smart mobile communications within range of fire

With systems like these, due to the experience gained from this project, extend it to other IT applications of the Internet of Things such that monitoring air pollution and flood estimation are fulfilled. You can also use other agricultural applications of this technology. Smart roads and smart city are also the opportunity to spend research funding to be operational.

References

Chi, Q., Yan, H., Zhang, C., Pang, Z. and Xu, L. D. (2014). A reconfigurable smart sensor interface for industrial WSN in IoT environment. *IEEE Transactions on Industrial Informatics.10*(2), 1417-1425.

Heinzelman, W. B., Chandrakasan, A. P. and Balakrishnan, H. (2002). An application-specific protocol architecture for wireless micro sensor networks. *IEEE Transactions on Wireless Communications, 1*(4), 660-670.

Hu, L. and Evans, D. (2004). Localization for mobile sensor networks. *In Proceedings of the 10th Annual International Conference on Mobile Computing and Networking* (MobiCom '04). ACM, New York, NY, USA, 45-57.

Li, Z., Nadon, S. and Cihlar, J. (2000). Satellite-based detection of Canadian boreal forest fires: development and application of the algorithm. *International Journal of Remote Sensing, 21*(16), 3057-3069.

Oliveira, L. and Rodrigues, J. R. (2011). Wireless senor networks: a survey on environmental monitoring. *Journal of Communications, 6*(2), 143-151.

Roy, S., Bose, R. and Saddar, D. (2016). Self-servicing energy efficient routing strategy for smart forest. *Brazilian Journal of Science and Technology, 13*(3), 1-21.

Son, B., Her, Y-S., and Kim, J-G (2006). A design and implementation of forest-fires surveillance system based on wireless sensor networks for South Korea mountains. *International Journal of Computer Science and Network Security, 6*(9B), 124-130.

Ssu, K. F. Ou, C. H. and Jiau, H. C. (2005). Localization with mobile anchor points in wireless sensor networks. *IEEE Transactions on Vehicular Technology, 54*(3), 1187-1197.

Stula, M., Kristinic, D. and Seric, L. (2012). Intelligent forest fire monitoring system. *Information Systems Frontiers, 14*(3), 725-739.

Wang, G., Cao, G. and LaPorta, T. (2003). A bidding protocol for deploying mobile sensors. *In Proceedings of 11th IEEE International Conference on Network Protocols*, 315-324.

Wu, M., Xu, J. Tang, X. and Lee, W. C. (2007). Top-k monitoring in wireless sensor networks. *IEEE Transactions on Knowledge and Data Engineering, 19*(7), 962-976