The control system of heterogeneous wireless sensor networks

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Abstract: In this paper demonstrates the feasibility of using cost effective, flexible, and scalable sensor networks to address critical bottlenecks of the emergency response process. The directions of efficiency increase of the wireless sensor networks are proposed. They consist in the implementation of new methods and radio network management functions, coordination and intellectualization of the methods, corresponding to different OSI-model levels, and also coordination of the network resource management purposes distribution.

Keywords: wireless sensor networks, control system, mobile sensor, OSI model

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Introduction

When a disaster occurs, the chaotic setting of limited resources, unreliable communication infrastructure, and inadequate information produces a very difficult environment for the emergency services. Wireless sensor networks (WSN) is a type of ad-hoc network that can change locations and configure itself in real time. WSN is self-organizing networks that have been recently deployed in many emergency areas, agriculture areas and livestock monitoring. However, these applications rely mainly on manually measuring and controlling the parameters such as moisture, homogeneity, temperature, pH, oxygen, soil nutrients, etc. Autonomous monitoring devices such as sensors warrant potential use in emergency or agriculture monitoring, in military sphere.

Distinctive features of WSN are network self-organization, dynamic topology, decentralized control and heterogeneity of network elements. Advantages of the WSN are easy nodes configuration into the network, lack of network infrastructure, high survivability, and work on the motion of all the network elements etc., Sitharama et al. (2012).

Main text

Most networks are heterogeneous and consist of a set of different types of networks: stationary, mobile, aircraft, underwater, allowing to monitoring a large number of physical parameters.

The effectiveness of WSN functioning depends on the efficiency of the network control processes and therefore variants of the control systems building.

Features of WSN control system are:

- multidimensional caused a large number of sub-systems, components and connections between them;
- multi-variability determined by a variety of individual subsystems targets, the diversity of their characteristics, requirements and performance indicators;
- versatility and hierarchy resulting from the need to solve a variety of management tasks at different levels and stages of system operation;
- the strong dependence of the functioning of the WSN parameters and external influences.

At the same time to WSN control system should meet the following basic requirements:

- providing the monitoring of specific objects (zones) with a certain intensity in a given time with a given quality;
- transferring different types of monitoring traffic (data, video);
- providing adaptive and distributed functioning the network with the possibility of self-organization;
- making decisions in real or near-real time;
- minimum amount of service information; optimizing network performance;
- maximum automation of network control processes.

The main WSN control principles are: adaptability, functionality, distribution, coordination of interactions, hierarchy and optimal automation of management processes.

Earlier construction of MANET control system was reviewed, in Minochkin et al. (2008), and with using with UAVs in Lysenko et al. (2015). We propose a new functional model of the network control system with allocation of two major subsystems: monitoring control and telecommunications control.

Monitoring control includes the following functions:

- deployment management - collecting information about the objects of observation, define methods the of nodes placement, selection the type of sensor nodes within the parameters and environmental monitoring, type of the organization of a sensor network, etc.
- covering control – defining the type of object cover (targets, areas, zones, sectors, selecting covering pattern depending on the degree and cover ratio);
- supervision control – calculation of sessions observation of sensors and network connectivity.
- quality monitoring control.

Control of telecommunications component includes the following steps:

- collection information about the state of the network (the decision on the network volume, frequency, depth data collection method);
- analysis of this information: identifying of the situation in the network (zone and the node), verifying that the network implement its functions and determine the necessity for control action;
- identification of management objectives with further detailing them on the sub-targets and development of decision (choosing access protocol, routing method, the method of service information distribution, etc.);
- implementation of decisions (set the transmission power, a method of monitoring, resource reservation, distribution service messages, etc.).

At the stage of operational management according to accepted performance criteria consistently evaluated the state of the sensor network, and measures are taken (in accordance with the plan and the actual situation) to retain its indicators of efficiency functioning within specified limits or takes their optimization.

The number and specific operating control tasks determined by the characteristics and conditions of functioning of the network, as well as the accepted technological solutions in its inception.

We propose a new architecture of building heterogeneous WSN management system that includes: for heterogeneous network - coordination and intellectualization decision-making processes for each class of WSN; for each WSN - coordination and integration of OSI layers by objectives and functions of control (Fig. 1).

Functional model consists of the following subsystems:

- collecting and storing information about the network status;
- analysis and decision making separately for monitoring and telecommunications;
- intellectualization and coordination;
- implementing solutions for network control.

Features of functioning of WSN and specificity of tasks assigned to them, requires an amount of different telecommunication control solutions, main of which are: control of radio resource topology, routing, loading, data quality (QoS), security, and others (Fig. 2).

Coordination and integration of OSI layers (cross-level).

Existing approaches to designing telecommunications networks require the independence of the OSI layer control functions. Since each level of the stack protocol works independently.

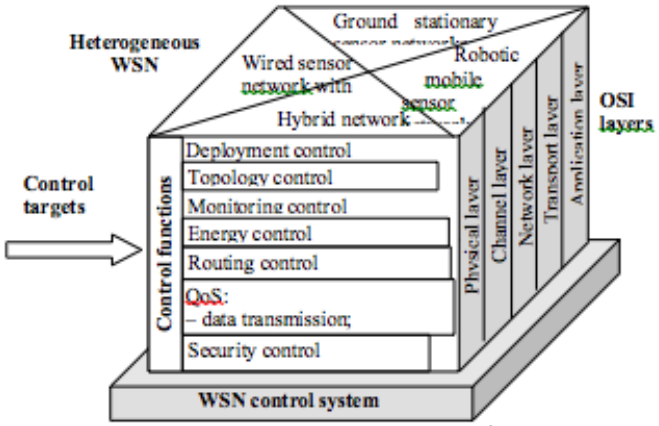

Fig. 1.Levels and WSN control functions

However, this approach ignores the WSN features and does not allow optimization of performance at each level of the OSI (or at all) under requirements of network functioning and different conditions of particular type of traffic. Therefore, proposed introduction of add-on OSI layers, that will coordinate the control levels and implement this optimization.

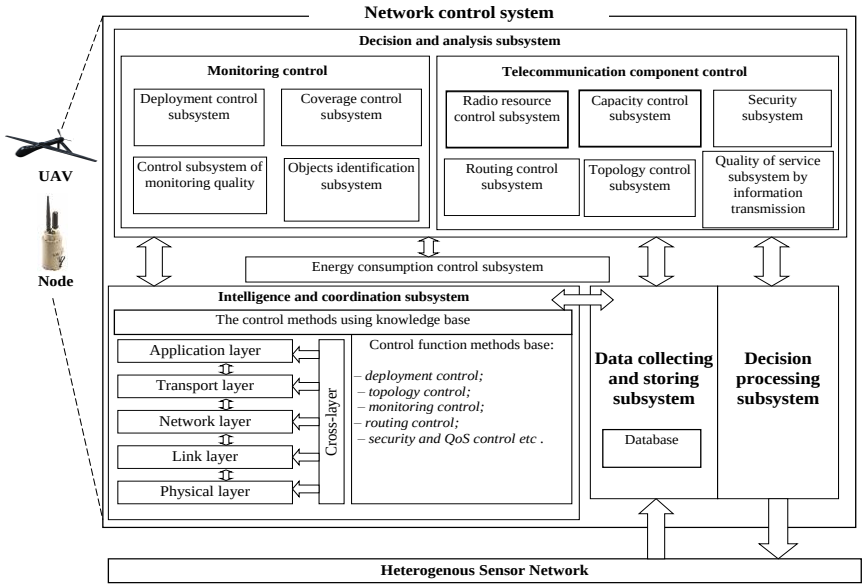

Fig. 2. Functional model operational control system of the WSN

Intellectualization network control.

For taking decisions to transfer information control system should identify the situation - the state of the network, directions (this is available for the device to use fuzzy sets in the absence of full information on network status) and choose from a variety of possible management methods by optimum for a given situation.

Conclusions

Proposed new architecture of heterogenous WSN. Its features are: splitting management tasks into functional monitoring subtasks, data transmission, reducing energy consumption, coordination and intellectualization of control functions.

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