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Construction and Organization Methodology of Complex Monitoring System under Conditions of a Priori Informational Sources Uncertainty

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ABSTRACT

In this article, the main problems of data acquisition and processing in the automated monitoring systems were solved. We consider the circumstances of uncertain quantitative and qualitative structure and spatial instability of information sources. New methods and framework for monitoring system designing were presented. In difference to existing solutions, our approaches take into account the spatial-temporal instability of the primary data sources. Proposed methods have been successfully tested during the operation and creation of telecommunication components on the national scale. Simulation results showed the ability of our monitoring system to effectively operate in conditions of spatial and temporal instability of data sources and environmental conditions. Simulations were conducted in the conditions of variable number of members, motion parameters and spatial distribution of information sources. A set of intelligent measuring devices for our proposed monitoring system also has been developed.

Keywords: *Monitoring System, Measuring Devices, Environmental parameters, spatial-temporal instability, Monitoring Objects.*

1. INTRODUCTION

Modern stage of the development of social, economy-ical, military and other processes is characterized with dynamic and complexity, improved management, increase the terrorism threat, periodical ecological disasters, transformation of traditional and emergence of new informational and social relations that determine the transition of the humanity from industrial to informational society. Thus, the necessity of increasing the role of information and new information technologies arises and the qualitative increase of information volume that is transferred and stored as in state management system (military forces, emergency control ministry and others) so in management systems in total is going on. This leads to the necessity of forming of unified informational space of the state. As the result there are special requirements to indexes of quality of service and reliability of management system of telecommunication and information networks, especially in crisis situations.

The irreplaceable component of functioning of any system is monitoring processes of the chosen objects with the aim of obtaining information for making decisions and direct forming of management instructions. The stated above is realized based on the monitoring system of inner processes and outer conditions (situation) and detection the critical change requires efficient management. The functioning peculiarity of modern systems form the monitoring point of view is the significant number of distributed complex objects of monitoring over the space with significant dynamics of heterogeneous processes and change of their position, state, properties and parameters. For this reason it is necessary to use significant number of distributed over the space and in time heterogeneous information sources - sensors (measuring devices). This ensure total informational awareness concerning the situation that is constructed through the forming of the unified informational space for the respective decisions making. In parallel, the noted above generates prior uncertainty of information sources considering their location, constitution, type of incoming information, their informativeness, preciseness, validity, operativeness and completeness of primary data.

However, physical capabilities of existing systems that perform processes of monitoring the info-communication networks in zones (region) where the emergency situation has occurred is beforehand unknown and the number of users that simultaneously perform technical and informational activities for the situation overcoming may not satisfy the requirements to informational exchange by important and critical and control information. Depending the existing in a location info-communication systems infrastructure and its characteristics and considering the previous practices in such situations the peak loads occur, and the system is not able to solve complex guaranteed service of specialized traffic with required quality indexes. Therefore, there are contradiction between the possibilities of collecting, transferring to the users with the required efficiency indexes in the near real time mode and the actual possibilities of existing state monitoring system in cases of emergence of crisis situations.

Thus, there is an actual problem of development of methodological materials for organization of complex monitoring and management under the priory uncertainty of information sources, e.g., their location, constitution, type of incoming information, informativeness, preciseness, validity, operativeness and completeness of primary data, quantitative and spatio temporal distribution of subject of management (consumers of monitoring information) under the conditions of emergence of crisis situation in zone that is controlled by cluster with individual features. Its solution objectively leads to the necessity of organization of rational management and monitoring of the objects in the conditions of prior uncertainty of information sources as subsystems within the single system, i.e., existing general cluster that is responsible for information management [1].

2. Monitoring Objects Under Conditions Of Prior Uncertainty Of Information Sources

One of the possible ways of prevention of technological disaster and timely reacting and decreasing the negative effects in case of crisis situation emergence is creation of efficient environmental monitoring system in ecologically dangerous zones.

The main goal of creating the automated monitoring system is to decrease the level of danger of crisis situations emergence in nuclear field to the accepted threshold and minimize their negative effects. This goal can be achieved through improvement of organization and increase of workflows efficiency in the field of timely detection and admonishment of the threats of natural, technological and anthropological (including terrorism) character with respect to nuclear and radioactive objects.

The system of continuous monitoring of nuclear and radio-dangerous objects and cargos must ensure performance of standard set of functions, i.e., collection, processing, storing and transferring data including informational support of decisions making processes and also support of modeling and forecasting functions [3, 4].

The monitoring system is based on continuous development of scientific and methodological basic and software facilities for complex analysis of the threats of nuclear and radio-dangerous stationary and mobile objects, deployment of modern methods and facilities for control, analysis and forecasting state of nuclear and radio safety and also their managing using the generalized safety index (fig.1).

The system includes components of sectoral and objective levels. Each level of the monitoring system consists of centers of systematic monitoring and operative management, controlling and measuring devices, complexes and facilities for obtaining and processing information about parameters of the objects and cargos safety and also telecommunication systems and facilities for collection, data transfer and notification.

Merging of informational resources of different levels of monitoring system centers is realized using systems and facilities of info-communication system (ICS) considering the requirements to information security.

2.1 Main Task Management ICS in A Crisis Situation

A crisis situation is understood as a set of emergency circumstances, including a terroristic acts and are divided into:

- Crisis situations of terroristic nature;
- Crisis situations of criminogenic nature, not related to terrorism;
- Crisis situations of natural and technological nature.

Depending on the territory of crises situations, the latter are divided into local, regional, general, public, transboundary (which occurred abroad and affecting the territory of Ukraine). In the event of a crisis the Government in the prescribed manner makes decision on the introduction of the operation mode of administration authorities, forces and facilities of the state system - complex of measures taken by government and by the state system in case of the threat emergence, termination and liquidation of consequences of the crisis. The main objective of the system is operational management of interaction, coordination and management of the forces that are used in crisis situations and means.

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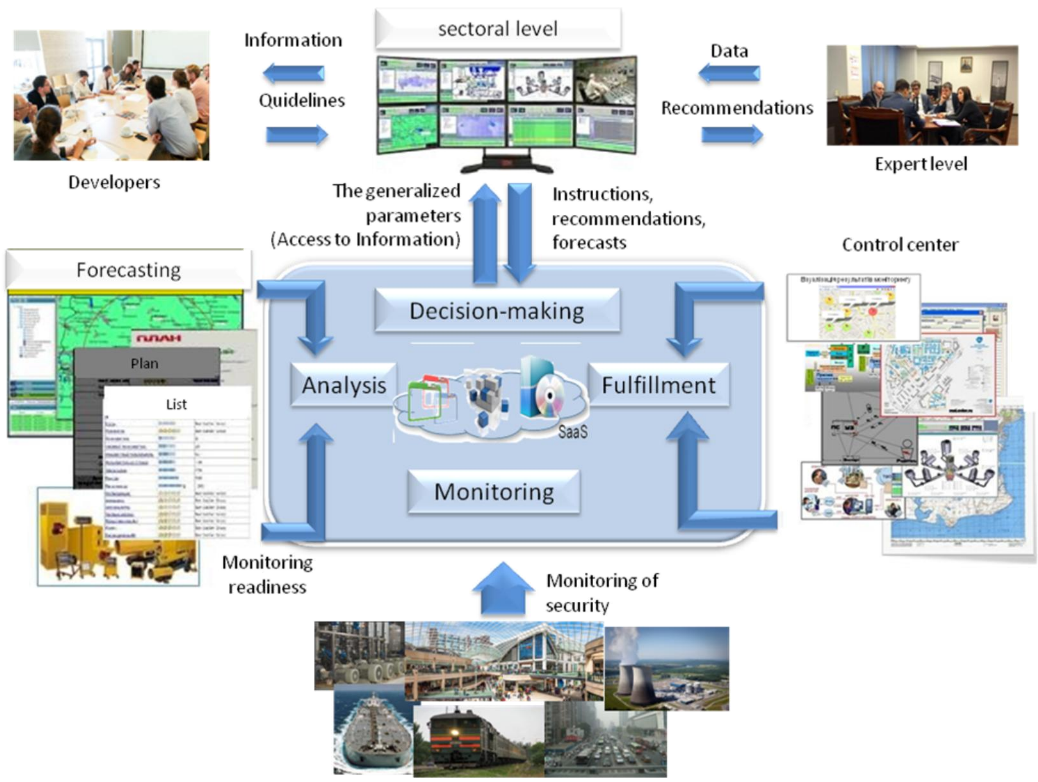

Fig. 1. The structure of the control system monitored

To fulfill the above requirements it is necessary to create more sophisticated control systems PCM that have the following characteristics.

First, the ability to manage complex systems. Modern ICS consists of a large number of different elements and relationships and relate to complex systems that are characterized by incomplete control information (fig.3).

The concept provides management system in the form of two major subsystems: management subsystem of "intellectual superstructure" and management subsystem of transport network.

The main objectives of management PCM are:

- operational and technical management, designed to provide real-time adaptation of the network structure and flow schemes to changing states of controlled objects and volumes of incoming load;

- organizational and technical management (defined as a network planning), designed to provide adaptation schemes of network structure and directed flows to predictable situations, including planning renovations, required to provide support of networks bandwidth at the highest possible level.

- To implement these tasks IC network management system has to perform the following functions:

- control over the technical conditions of the controlled objects (CO) networks and
- localization of damage;
- control over traffic and quality of service for customer;
- collecting, processing, storing and displaying information about the state of network, testing equipment and tracts;
- control over traffic and schemes of directed flows and
- operation of controlled network objects and the reconstruction of the network;
- collecting, processing, storing and displaying information about the state of network testing equipment and tracts;
- traffic control and schemes aimed flow and load
- operation controlled network facilities and the restructuring of the network;redistribution of means between networks according to the situation;

- planning of forecasting situations, including planning schedules checkups and replacements;
- planning of schedules, coordination of the timing of repairs and monitoring their implementation;
- ensuring deployment of equipment, including organizing processes of the necessary switching and changes in the structure of the network;
- interaction with the services of technical operation;
- interaction with management systems of communication networks in other countries and independent Communication Administrations;
- collection and analysis of statistical data on networks operation in order to improve the performance of networks and their elements and methods of technical exploitation; load flows study;
- expertise of projects of changes in technical or quantitative characteristics of networks and their elements in terms of compliance with existing and planned load, the basic principle of construction and development of networks and their requirements;
- development of algorithms for network management.

The control system of "intellectual superstructure" is a special online service designed to ensure the efficiency of network planning and registration of all of its components. This service is formed from a set of distributed network hardware and software tools, and information resources located over the whole network systems.
Second, guaranteed privacy preservation of circulating in the IR system information. The control system of "intellectual superstructure" which structure is based on applied processes should provide protection against unauthorized access to the information that is transmitted.
Third, the possibility of taking into account changes in the characteristics of ICS. Existing info-communication systems are usually unstable and often change their structural and functional characteristics.
Fourth, to manage weak deterministic effects. The main elements of ITS may respond differently to the same effect.
Fifth, technological openness. Management systems should be based on open technologies for the quick modernization of ICS is changed.
Sixth, adaptability. Control systems must use algorithms and predictive management of complex systems based on fuzzy logic, neural networks, genetic algorithms and so on.
Seventh, accounting subsystems connectivity. Relationship between subsystems is constantly growing due to globalization and increasing degree of integration.
The main tasks of the system of operational and technical management of PCM in crises situations are to provide:

- continuous and effective management of PCM in these conditions;
- PCM operation with the predefined settings, including monitoring in order to ensure uninterrupted provisioning of telecommunications services;
- improve the reliability and efficiency of traffic of special purpose;
- organization and performing activities of the operative restoration, removal of damaged or overloaded PCM using the resources available in telecommunications networks and provide control over the implementation of these measures;
- primary allocation, backup and recovery resources of national telecommunication systems for government communications, national system of confidential communications and special customers;
- analysis of reliability and sustainability of PCM operation in crisis situations, development of proposals for the improvement of public telecommunication networks and present them to the Administration of State Service.

Today more than ever is especially important to identify and solve problems and challenges of readiness network management in crises situations, emergent and special period. Under these conditions the centralized resource management of telecommunication networks should be implemented. And traffic of special purpose and use of these resources for the benefit of governance, security of restoration works, emergencies, etc., and to ensure the highest possible level of service quality to all customers.
PCM control system should provide the means for collecting data and controlling actions of staff and for processing message about events and reports about resources status. PCM resources include: facilities necessary for the functioning of the network elements and interaction protocols, and also management data that contains state information about PCM functional environment. Within the PCM management there are the following basic functions:

- Failures management;
- Accounting management;
- Configuration and names management;

- Efficient operation management;
- Security management.

Management of failures is a set of tools initiated as a result of unstable PCM functional environment in critical situations. Failures occur as failures in the operation of the network. Fault management services provide means for analyzing facts of failures registration, receiving and processing reports of failures detection, failures administr-ative support, performing test sequences, correction of failures.

Management of accounting is a set of tools that provide resources and determine the cost of paying for their use. Management of accounting provides a means to notify users about the payment or amount of resource consumption accounting defined limits on the use of resources, determine the part of used aggregate resources.

Configuration management by names is a set of controls, identification, collection and provisioning of data to ensure continuous operation and interaction of services includes tools to set parameters for open systems, initiating and closing PCM resources, collecting data about open systems, providing specific data on request.

Managing operation efficiency is a set of tools needed to assess the behavior of PCM resources and the effectiveness of the interaction. This includes the collec-tion of statistical data needed for maintenance and analysis of state registration files.

Security Management is a set of tools for PCM resources securing, that means authorization, access control, encryp-tion and key management, authentication, maintenance and analysis of security log files.

On the basis of above mentioned we can conclude that the implementation of the SU with intellectual PCM it is necessary to find one of the most important parameters which is the minimal volume of managing information that provides the required precision of parameters of controlled objects.

Integrated solution for management of forces and means of special purpose of departmental structures in modern terms of confrontation objectively leads to the need for effective management of PCM within a single communication system of the state, to ensure good governance, both in peacetime and in a particular period.

The development of ICT technologies with their integration into a new global network infrastructure based on broadband technologies pose special performance requirements to the quality indexes of resource managem-ent of information and telecommunication networks. Information exchange is directly related to the operation of complex information systems (CIS) of different classes that provide the required quality and appropriate status of circulating information and the number and characteristics of the information sources and subjects of informational exchange. At the same time there are specific requirements to quality indexes of resource management system of information and telecommuni-cation networks of Ukraine especially in crisis situations.

However, the physical capacity of the existing PCM in a zone (district) where there was a crisis, when some a priori unknown number of users simultaneously conducts technical and information support actions to overcome the crisis, can not meet the needs of information exchange of the most important and critical control information. Depending on the existing infrastructure of PCM and its characteristics in the area, as the practice has shown, e.g., ATO, there are peak loads and the system is not able to solve problems of complex guaranteed traffic service with a special set of quality indicators.

There is a contradiction between the necessary capabilities for servicing specific traffic (sharing of specific information collection, transmission to the users) with the set quality indicators in near real time mode and actual capabilities of the existing PCM of the state in the event of a crisis.

Thus, there is the problem of improving the methods of effective management of PCM under the a priori uncertainty of characteristics, quantitative and spatial and temporal distribution of subjects (sources) of special and general traffic under the conditions of crisis situations in the zone where the location and availability of PCM is determined by the local and territorial distribution. Determining effective methods to ensure efficient management of PCM objectively leads to the necessity of managing PCM (districts, regions) as a subsystem within a single communication system in a global information and communication space - the existing general information and communication cluster (GICC).

2.2 Cluster Construction Principle ICN

Information and communication cluster is a combination of local, regional information and communication clusters (formal concentration of geographically distributed nodes) technologically connected and geographically concentrat-ed and located within certain areas, related with general objectives and complementarities. Their coordinated activities ensure provisioning of information and comm-unication services. Within the existing IC cluster for the defined area (region), with its distinctive characteristics, in terms of crisis situations, there is formed situational information and communication cluster.

The paper presents the implementation of the strategy of cluster formation, development and implementation of organization of network-centric management of informa-tion and communication networks with a priori uncertainty in performance, quantitative and spatial and temporal distribution of subjects (sources) under special and general traffic conditions in crisis situations in the zone where the location and availability of PCM is determined by the local and territorial location. Let's suppose there are many local clusters combined into one network which represents the topology of the "related clusters" type or as the above mentioned term - general information and communication cluster.

Cluster - is a graph. It is assumed that this graph is strongly connected, but not necessarily. Clusters are interconnected with ribs. The ribs that connect the clusters also connect nodes belonging to these clusters. In a cluster there can be any number of nodes and edges, and any number of edges that connect the specific cluster with the other clusters. Network nodes don't exist outside of the cluster. Laying channels on the network can be implemented in different ways and meet certain criteria of path search. As it is necessary to combine many subscribers (terminals), and the order of their connections is unknown, then the attempt to lay the channel between a pair of poles will be called request. A sequential process of requests fulfillment or channel laying will be called sequential process of filling the network. Satisfaction of the requests for the construction of channels on the network to connect pairs of subscribers in a way that grantees the largest possible number of applications is a major challenge that is worth solving. Since the lifetime of the request is not defined and is considered infinitely long, then we assume that it is considered the static way of sequential network filling.

The initial network can be divided into clusters according to some attributes such as the strength of the relationship, territorial (geographical) location of nodes, bandwidth of the edges between the nodes, expert division (grouping) of local clusters.

Today regions having significant potential growth in the field of telecommunications and software development, need to increase their competitive advantages by applying a systematic approach to the development strategy of local, regional and info-communication clusters.

It is necessary to take into account different scenarios of innovations, both in general and at the regional level. Thanks to the coordinated interaction of the enterprise and ICC company it is possible to solve the problem of reducing the cost of information and communication services, logistics and management costs, and create a zone of continuous coverage and expand their range.

Therefore, there is urgent and primary task of forming local (regional) ICC to ensure availability of qualitative information and communication services, advanced computer control systems, customer relationships and logistics throughout the Ukraine especially during an emergency situation.

The task of state authorities in this area is primarily to provide conditions for accelerated development of regional ICC. According to this goal it is necessary to create a regional committee consisting of representatives of public authorities and employees of leading research centers and companies working in the field of information technology and telecommunications operators directly involved in shaping the information and telecommunication environment regions. However, there are still underdeveloped aspects of the creation, operation, management and development of clusters remain. In particular, there are still poorly understood process of developing and implementing strategies for cluster development, formulation and implementation of cluster policy, as well as identifying the main trends of state regulation of the cluster. In case of extraordinary crisis emergence in the defined area within the existing ICC, with its distinctive characteristics, the situational information and communication cluster is formed where the network-centric situational management is applied. In such circumstances, the necessity to move from the distribution scheme of the PCM to the cluster is understood. The cluster scheme includes a hierarchy of geographically distributed nodes (computing and networking equipment, information resources, databases, application subsystems, etc.). Principle of cluster construction of PCM involves the use of public networks that allows to associate a single management interface, monitoring, provisioning information for making rational decisions, i.e., the speed of exchanging accurate and necessary information data.

Situational information and communication cluster ensures speed and mobility characteristics, sensitivity of nodes of information distribution regarding overloads and uniform decision-making regardless of the location of subscribers in a critical situation. This structure effectively functions under normal conditions, under conditions of crisis and special period, taking into account the situation that occurs suddenly and unexpectedly. In the event of crisis situation, the management system operates under peak loads that is different than under normal mode of operation.

Use of network-centric principle to build ITM today shows significant tangible benefits of the new approach to the informatization of large corporations. It creates a single space of collective management and access, monitoring risks and making rational decisions.

Thus, these urgent problems should be solved in the most effective way in order to implement them in communication networks of Ukraine to ensure the defense ability of the state.

3. Network-Centric System Management

In terms of variety of telecommunication and information technologies, their rapid progress and convergence, diversity of types and branching of the networks, growing demand for new services and increasing demands for quality, new challenges associated with network management in crisis situations. In order to create and develop operational and technical management the PCM uses modern telecommunication and information technologies with application of methods for data processing, analysis and forecasting of situations in real time and methods of expertise marks and collective decision-making based on the recommendations of the International Telecommunication Union.

In these circumstances it is necessary to provide a centralized management of public PCM, as well as of departmental networks (regardless of ownership or departmental affiliation), enabling operational and technical management of PCM for their sustainable performance, benefit for state governance, security of restoration work, elimination of crisis situations and ensuring the highest possible level of service quality to all subscribers.

Due to such trends it is necessary to move from a distributed scheme of information and communication network to network-centric, i.e., centralized management system.

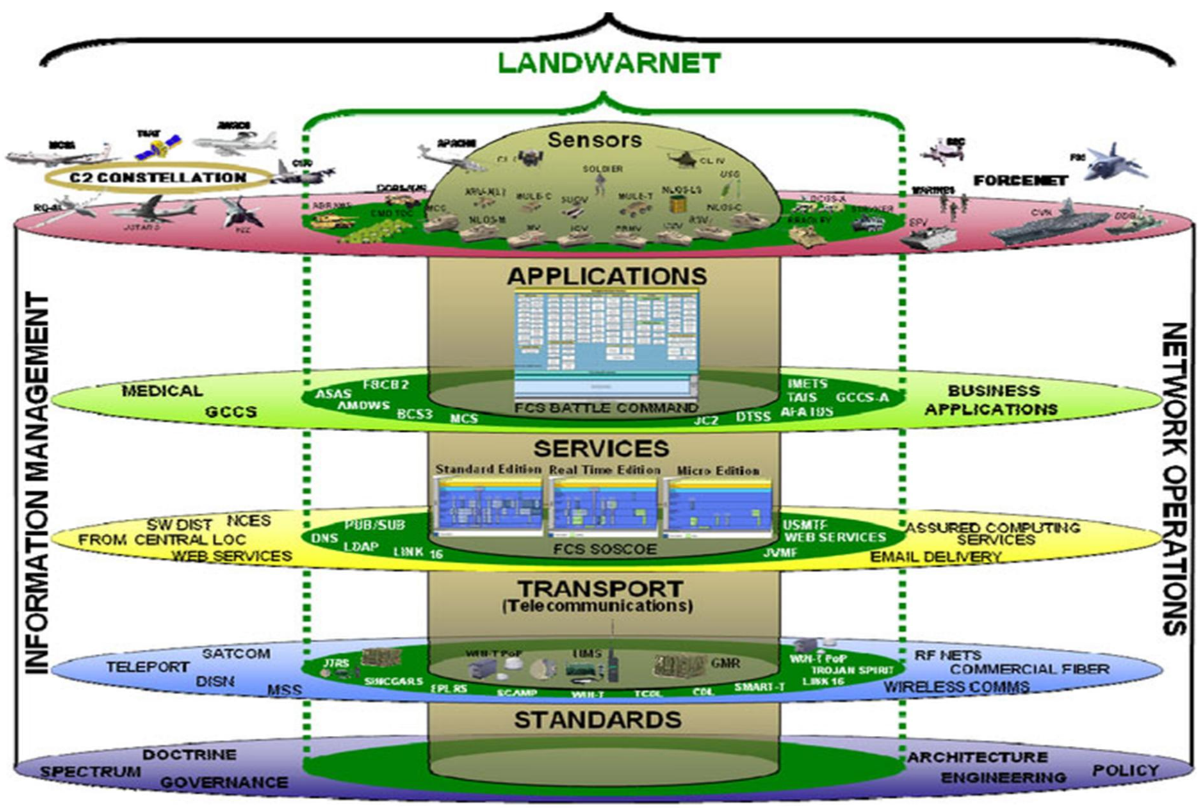

Fig. 2. Scheme of network-centric system management

What exactly must be understood under the term "network-centric" in respect to the whole system, as well as management.

In the conceptual and theoretical terms, network-centric management model can be represented as a system consisting of subsystems: informational, sensor (primary sources), realizable.

The concept of PCM represents a new approach to the principles of the network where the focus shifts to the global information infrastructure. This term refers not only to vertical integration between information sources, decision-making nodes and executive bodies, but to extensive development of horizontal connections between disparate suppliers, handlers and consumers of circulating information.

Network-centric principle of building PCM is based on the creation of equal geographically distributed nodes that perform different functions and allow users to work with applications and databases through a Web browser from any location and from any device connected to a public network (departmental communication, Internet, etc.) using the satellite network and others. The object of control in this case is equitably geographically distributed infocommunication system.

Built this way, network-centric information and communication system allows to associate a single interface to manage, monitor and develop control solutions for all subscribers, software, web pages, multimedia data, and the necessary personal information that is used by various software applications regardless of location of subscribers.

The distinctive features of network-centric management are :

- •all elements of the system should be connected to a single coordinate-temporal field, i.e., to act in the same state space;
- shared data should be provided promptly and smoothly;
- the system must be self-organizing, i.e., able to maintain, recover and adapt to the new conditions of the structure and behavior, in particular to be resistant to partial failures of nodes and lines;
- the system must be open, i.e., must share resources with the environment.

Thus, system description can be changed as following. Network-centric management system – system for managing the territory distributed information and communication system, which featured with principles of openness, self-organizing and low hierarchical decision making. Network management system is able to take promptness decisions in crisis situations.

Important feature of network-centric system is that each of territorial distributed entity operates to achieve joint goal and get equal opportunities to access the necessary information to provide all functionality regardless of data location in the system.

The example of network-centric management system is US Future Combat System (FCS). FCS is a multi-layer system of network-centric integration of fixed and mobile entities with different purposes, equipped with artificial intellect within a shared informational and functional management space with real time interaction. In the proposed scheme, main functional components of network-centric management scheme have been shown. These components correspondingly called “applications”, “services”, “telecommunication” and “standards”.

4.1 Self-organizing military communication system monitoring based on MESH networks

In this paper the concept of wireless heterogeneous network for military purposes is proposed. The concept is built on using NFV and LTE technologies. By virtualizing the core of LTE and locking it into the highly protected container, the core of LTE can follow the military units and provide coverage area where it is necessary. While the core is virtualized, it can be scaled up or down on demand. The core can server several base stations that can be paired to it or distributed over the area using radio interface or communication [2].

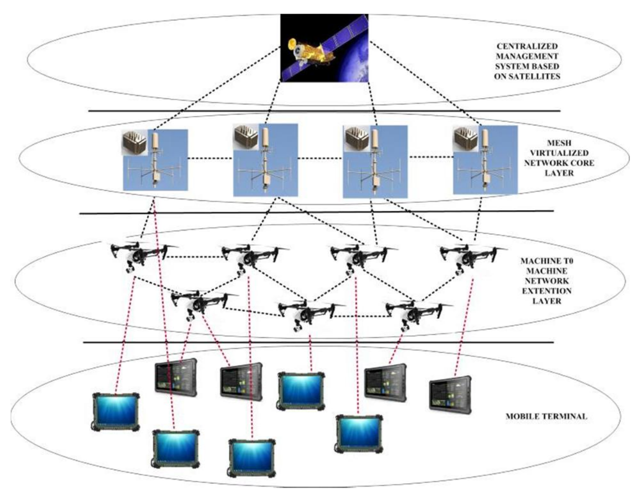

Fig. 3. The concept of system monitoring military assignment

This chapter is devoted to realization of mesh network model architecture that is used for integration of mobile systems of fourth generation. In this paper this model is used for describing functioning of mesh network that is constructed of quad copters for extension of coverage area of military communication systems. The example of such network is shown on fig.3 where small quad copters form a mesh network by communicating with each other using radio interface.

According to system requirements the mathematical model of structural self-orgnization is proposed in this paper. Within this model the next input data is selected:

$\left\{R_{i,\, i=\overline{1,N}}\right\}$ – set of mesh-nodes, where N – general number of mesh-nodes in the network; m_i – number of radio interfaces per node R_i ; K – number of channels that are used in the network and don't interfere. Moreover, let $\left\{G_{i,\, z=\overline{1,Z}}\right\}$ – number of zones with stable receiving – clusters (Transmission Range, TR), that are created with location distributed mesh-nodes, where Z – general number of these zones in the network. In this paper it is assumed that zone of stable receiving can be created with a big number of mesh-nodes with maximal power, within which nodes can transfer information between each other, i.e., they can exchange data using selected wireless technology in the mesh-network.

To achieve the goal of accounting distribution of mesh-network nodes, it is introced the definition of stable reception zones or TR matrices. Matrix consists of the number of rows that correspond to number of stable zones of reception Z and of the number of columns that correspond to general number of mesh-nodes N in the network, i.e.:

$$D = \left\| d_{i,j} \right\|, i = \overline{1,Z}, j = \overline{1,N}, \tag{1}$$

where $d_{i,j} = 1$, if j node is located in i TR , in other case $d_{i,j} = 0$.

Within the proposed model, according to the methodology of solving the task of channel distribution over the radio interfaces of mesh-nodes of the network, it is necessary to ensure the calculation of bool variable:

$$x_{i,j} \in = \{0,1\}, \left(i = \overline{1,Z}, j = \overline{1,N}\right), \tag{2}$$

where $d^k_{i,j} = 1$, if j radio interface works in k - frequency channel , in other case $d^k_{i,j} = 0$.

The total number of variables (2) that define the order of channel distribution depends on the number of nodes in the network, number of radio interfaces that use channels i , respectively, can be calculated as $N \times m \times K$. The result of the calculation of variables (2) is a division of the mesh-network as a whole and each zone of stable reception separately on the interconnected between each other collision domains, where mesh-nodes operate using the same channel. Because of this, finding variables $x^k_{i,j}$ in each separately taken G_Z , it is necessary to fulfill a set of very important conditions-constraints (8, 9):

The condition of the node for connecting the network is[7]:

$$\sum_{k=1}^{K} x^k_{i,j} \sum_{j=1}^{m_i} x^k_{i,j} \geq m^* \left(i = \overline{1,N}\right), \tag{3}$$

where $1 \leq m* \leq m_i$ is a parameter that characterizes minimal number of radio interfaces on the arbitrary selected mesh-node; $\sum_{k=1}^{K} x^k_{i,j} \sum_{j=1}^{m_i} x^k_{i,j} x^D_{i,j},$ is a number of active radio interfaces on one mesh-node. As a rule, the number of radio interfaces on a mesh-node equals 2÷3 (10, 11).

The condition of allocating of a single channel to the j radio interface of i mesh-node is:

$$\sum_{k=1}^{K_i} x^k_{i,j} \leq 1 \left(i = \overline{1,N}, j = \overline{1,m_i}\right) \tag{4}$$

The condition of attaching k channel to i node to not more than one radio interface:

$$\sum_{j=1}^{m_i} x^k_{i,j} \leq 1 \left(i = \overline{1,N}, j = \overline{1,K}\right) \tag{5}$$

The condition of operating of two mesh-nodes on one the same channel (for one zone of stable reception):

$$\sum_{k=1}^{K} \left[\sum_{j=1}^{m_i} x^k_{i,j} * \sum_{j=1}^{m_i} x^k_{s,j} \right] \leq 1, \tag{6}$$

(for (i,s) – node pairs, i,s=(1,N); i≠s), which is introduced for elimination of unwanted structural redundancy and fits the square character.

The condition of interconnection level of the network (interconnection of mesh nodes bewteen collision domains):

$$p = \sum_{i=1}^{N} \sum_{i=1}^{N} \sum_{i=1}^{N} x^k_{i,j} \geq N + K - 1 \tag{7}$$

the performance of which is common with (7) under the conditions of lack of channels $K \leq N - 1$ guarantees, that the number of active radio interfaces (p) and number of mesh-nodes and supported by the wireless technology channels will ensure high level of interconnection of multichannel mesh-network.

Two domains of the network are interconnected if there is a mesh-node that at the same time operates on the channels of these two domains, i.e., the first radio interface operates on one channel and the second radio interface operates on another channel.

Two mesh-networks are interconnected if they are located in one collision domain, i.e., they operate on the same channel.

It is recommended that in the process of structural self-organization of mesh-network, the nodes should be distributed over the collision domains equally, since the performance of the domain depends on the number of nodes the conclude it. With this goal, lets introduce the condition of balancing of mesh-nodes over the collision domains of wireless telecommunication system.

The condition of load balancing of the number of mesh-nodes depending on the location distribution, nodes activity and number of zones of stable reception will have several interpretations.

If all nodes are located in one TR, the condition of balancing of mesh-nodes over the collision domains will have the next form:

$$p = \sum_{i=1}^{N}\sum_{i=1}^{m_j} x_{i,j}^{k} \le \beta(k = \overline{1,k}), \tag{8}$$

where $\sum_{i=1}^{N}\sum_{i=1}^{N} x_{i,j}^{k}$ is a number of mesh-nodes in the network that operate on k channel; β is a top dynamically controlled threshold of the number of mesh-nodes in the arbitrary selected collision domain in the multichannel network.

When assessing the location distribution of the nodes, i.e., when nodes are located in different zones of stable reception, the condition of balancing will have the next form:

$$\sum_{i=1}^{N} d_{z,i} \sum_{i=1}^{m_j} x_{i,j}^{k} \le \beta \tag{9}$$

(for each (z,k) – pair, $\left(i = \overline{1,N}, k = \overline{1,K}, j = \overline{1,m_i}\right)$ where in the left part of the inequality the number of nodes in z TR is represented.

The important factor of balancing the number of stations over the collision domains is their level of activity. Here, activity denoted a coefficient that depends on the frequency of the node being active over the radio, duration of sessions and intensity of traffic that is transmitted.

According to this, the condition of balancing mech-nodes over the collision domains will have the next form:

$$\sum_{i=1}^{N} d_{z,i} * \beta_i \sum_{i=1}^{m_j} x_{i,j}^{k} \le \beta \tag{10}$$

(for each (z,k) – pair, $\left(z = \overline{1,Z}, k = \overline{1,K}\right)$

where β_i is a coefficient of activity of i node that depends on the number of connected terminals, intensities of incoming and outgoing traffic, type of traffic.

According to unequal load of radio interface of the node and considering their operating in different directions, for obtaining precise condition (8) it is recommended to use normalized coefficient of activity of mesh-nodes

$$\beta_i \Big/ \sum_{k=1}^{K}\sum_{j=1}^{m_j} x_{i,j}^{k}.$$

Then, the balancing condition will have a form of:

$$\sum_{i=1}^{N} \times \frac{\beta_i}{\sum_{k=1}^{K}\sum_{j=1}^{m_j} x_{i,j}^{k}} \times \sum_{j=1}^{m_j} x_{i,j}^{k} \le \beta \tag{11}$$

The calculation of unknown variables (2) and β parameter according to conditions that are formalized by inequalities (3-11), it is recommended to perform optimization task, ensuring minimum or maximum of selected criteria of decision quality of structural self-organization. The main requirements to the optimal criteria on the one hand should be physics of the task, i.e., task of channel distribution in the mesh-network and on the other hand should be the abilities to obtain solutions that can be practically realized. This way, the input conditions and the task itself must not be too complicated. For its solution the effective method must be developed.

Due to the fact that the number of nodes in the mesh-network overwhelms the number of channels that do not interfere, thus there is a necessity of solving such problems as interference and hidden node exist, as a optimization criteria the minimal number of working mesh-nodes in created collision domains is selected, as it is well known that it helps to increase total performance of the multichannel mesh network.

Then, within the proposed mathematical model, the task of structural self-organization form the point of view of distribution of channels in the mesh-network obtains the form of optimization task. When solving this task, the next criteria should be taken into account:

$$\min_{x,\beta} \beta \tag{12}$$

when following conditions-constraints (2-11).

The formulated task from the point of view of physics of the processes that are held in multichannel mesh-network is related to the class of network resources balancing tasks – weighted number of mesh-nodes in collision domains regarding to location distribution and activity. From mathematical point of view it is a task of mixed integer non-linear programming – MINLP (Mixed – Integer Non Linear Programming). In the model, the searched variables $x_{i,j}^{k}$ (2) are of the bool type; variable β, that is minimized is of an integer type (under the conditions (8-11)) or real (under the conditions (11-12)) and constrains on the

searched variables can be both of linear and non-linear character.
For solving the tasks of this class it is used a set of effective methods such as: rounding – off, branch – and – bound, serial linearization (SLP), penalty function, lagrangian relaxation, simulated annealing and also genetic algorithm and different mixed hybrid methods.
Thus, the concept of incremental increase of network coverage is realized. Starting the development of the network in one point, it is possible to extend its coverage area without bounds by simply adding new nodes.

5. Conclusions

Based on the conducted analysis of theoretical fundamentals and technical solutions of monitoring and management system deployment with information controlled clusters, we note the following.
Monitoring and management process should be implemented based on the principles of automatic information controlled system. Herewith it is necessary to ensure operation in both global and local management system. Moreover system should effectively operate even when there is not any prior information about location, composition, type, precision, confidence, promptness and completeness of output data. On the other hand, conditions of space-time distribution and quantity uncertainty of management subjects (consumers of monitoring data) in the circumstances of crisis situations in a zone, which corresponds to information-controlled cluster with individual features, should be satisfied.
The monitoring system with space-time variability of primary information sources is proposed that allows to obtain information about fixed and mobile military entities.
For above mentioned tasks it is possible to use mobile sensors installed on the aerial vehicles (quadcopters and drones). Those aerial vehicles can be equipped with video and thermographic cameras to identify object and determine its location.
The identification process provided based on the analysis of graphical and thermal images of environment, which obtained from sensors of aerial vehicles.

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