Comparison Table of Aviation systems for forest fire extinguishing.

System // Parameters.	Explosive-pulverize aviation bomb-author's patents.		Traditional pouring off Jettisoning pulverization
	TSA-500 (Bazalt)	WB-160, WB-220, WB-350	
% effective usage exiting. agent Bomb's Agent.Mass/ Specifi cal. mass kg/sq.m	10 – 30 330 / 2 – 3	60-90 160 / 0,5 – 0,7	1 – 3 3000 / 10 – 50
Height air-apparatus flight, m	100 – 3000	100 – 3000	< 200
Pulverize height from ground, m "Bombing" precisely Square Extingh. Sq.m. Timely Blowing Flame sq.m.	1 – 3 High 80 – 110 1000	10 – 30 High 220 – 350 250 – 310	10 – 50 Poor 100 – 150 1500 – 2500
Firefighting cost per m^2, USD.	0,4-0,5	0,9 – 1,4	20 – 30
Pulverizing agent and materials	Water, solutions	Water,solution, gel, wet sand, dirty, miry	Water, solution
Ensure evacuation way peoples Blow wave and splinters defeat	dangerous for life of people	Effective- safe for people	Poor effective

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PROBLEMS OF ORGANISATION OF TEST PERFORMANCE IN SENSOR NETWORKS APPLIED FOR ENVIRONMENT MONITORING

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Currently sensor networks are widely used in many areas such as aerospace, automation, weather forecast, medical monitoring, natural event monitoring, object tracking, monitoring product quality, combat field reconnaissance, military command and control and environment monitoring. Working conditions of sensor networks applied for environment monitoring have placed new challenges to sensor networks developers due to the low availability of resources and mobile nature of sensor nodes. Harsh environment where the sensor nodes are deployed often leads to sensor node failures. Requirement to continue monitoring even when some sensor nodes have failed increases to a great extent the requirement to ensuring fault-tolerance of sensor networks. Technical diagnosis is considered as a major part of the facilities allowing providing fault-tolerance of any complex system. Any omitted error can lead to failure of a complex system such as sensor network is. Mostly, detection of faulty sensor nodes can be performed by network itself without external facilities. Such diagnosis requires appropriate organization of individual test performance. In the paper we consider different organization of tests performance in complex system such as sensor network**.** Each possible organization of tests performance is evaluated and the corresponding recommendations about its applicability are given. **Keywords:** diagnosis, sensor networks, environment monitoring, environment.

Проблеми організації виконання перевірок у сенсорних мережах, яки застосовуються для екологічного моніторингу. В.А. Машков, О.А. Машков, С.Т. Абідов. В даний час сенсорні мережі широко використовуються в різних областях – аерокосмічна, автоматичне управління, прогноз погоди, моніторинг в медицині, моніторинг різних явищ у природі, дотримання об'єктів, контроль якості на виробництві, військова сфера, моніторинг навколишнього середовища. Умови роботи сенсорних мереж, які застосовуються для моніторингу навколишнього середовища, висувають нові завдання перед розробниками сенсорних мереж, пов'язані з низькою доступністю і мобільним характером елементів мережі. Можливі суворі умови роботи сприяють виникненню відмов сенсорів. Вимога забезпечити безперервний екологічний моніторинг навіть при відмовах окремих сенсорів мережі веде до підвищення вимог до забезпечення відмовостійкості сенсорної мережі. Діагностика відмови сенсорів розглядається як головна частина коштів, що забезпечують відмовостійкість комплексних систем. Будь-яка допущена помилка може призвести до відмови всієї сенсорної мережі. У багатьох випадках при виявленні відмови сенсорів можливе виконання власними засобами самої сенсорної мережі без залучення зовнішніх діагностичних засобів. Такий вид діагностики вимагає відповідної організації проведення перевірок. У статті розглядаються різні організації виконання перевірок у комплексній системі, якою є сенсорна мережа. Оцінюється кожна можлива організація проведення перевірок і даються рекомендації щодо їх застосування. **Ключові слова:** діагностика, сенсорні мережі, екологічній моніторинг, навколишнє середовище.

Проблемы организации выполнения проверок в сенсорных сетях применяемых для экологического мониторинга. В.А. Машков, О.А. Машков, С.Т. Абидов.. В настоящее время сенсорные сети широко используются в различных областях – аэрокосмическая, автоматическое управление, прогноз погоды, мониторинг в медицине, мониторинг различных явлений в природе, следование объектов, контроль качества на производстве, военная сфера, мониторинг окружающей среды. Условия работы сенсорных сетей, применяемых для мониторинга окружающей среды, выдвигают новые задачи перед разработчиками сенсорных сетей, связанные с низкой доступностью и мобильным характером элементов сети. Возможные суровые условия работы способствуют возникновению отказов сенсоров. Требование обеспечить непрерывный экологический мониторинг даже при отказах отдельных сенсоров сети ведет к повышению требований к обеспечению отказоустойчивости сенсорной сети. Диагностика отказавших сенсоров рассматривается как главная часть средств, обеспечивающих отказоустойчивость комплексных систем. Любая пропущенная ошибка может привести к отказу всей сенсорной сети. Во многих случаях обнаружение отказа сенсоров возможно выполнено собственными средствами самой сенсорной сети без задействования внешних диагностических средств. Такой вид диагностики требует соответствующей организации проведения проверок. В статье рассматриваются различные организации выполнения проверок в комплексной системе, каковой является сенсорная сеть. Оценивается каждая возможная организация проведения проверок и даются рекомендации относительно их применения. **Ключевые слова:** диагностика, сенсорные сети, экологический мониторинг, окружающая среда.

Problems of organization of test performance in sensor networks ap plied for environment monitoring

For providing system level self-diagnosis the tests among system units can be performed

• either in accordance with a pre-set schedule (i.e., defined a priori)

• or in an adapted manner when, at the beginning, the tests are performed in accordance with defined a priori testing assignment. Once a unit is diagnosed as fault free, the tests it performs are considered reliable, and therefore, any other units should only be tested ones by this fault-free unit to correctly determine its status. Thus, the testing assignment is adapted such that units diagnosed as fault-free perform all the testing in the system [1].

• or entirely randomly (i.e., from the beginning to the end of testing)

• or adaptively randomly. At the beginning, all units are engaged in tests performing. Tests are performed randomly. Once a test reset takes the value of 1, the units participated in this test (so-called suspected pair) should only be tested by other system units (i.e., should not perform tests on other units). The choice of each pair of units for testing is performed randomly.

In all cases, the intention is to minimize the time of performance of the set of tests (T_Σ).

Schedule of tests performance

Scheduling allows to eliminate the situations when tests are queuing. Different values of T_Σ may be obtained for different schedules of test performance. The task arises to find such schedule

which ensures minimal value of T_Σ (i.e., optimal schedule).

Usually, system diagnosis model is presented in the form of a graph. In view of that, it will be convenient to solve the problem of optimal schedule determination also on the basis of model presented in the form of a graph.

Major parameters in this case are:

Q - the total number of tests which should be performed

$$Q = \frac{\sum_{i-1}^{N} \alpha_i}{2}$$

where αi - is the local degree of i-th vertex of a non-oriented system testing graph.

N - is the number of vertices in the graph.

Since there are two units involved in every test, it follows that at every step d tests can be performed, where d is equal to $\lfloor N/2 \rfloor$. Under step we mean the amount of time which is equal to the time of one test performing. Therefore, the total number of steps, *Ks*, needed to perform all tests, is equal to

$$Ks = \lceil Q/d \rceil.$$

It should be noted that the minimal number of steps, *Kmin*, required to perform all tests, cannot be less than the value of local degree of any graph vertex. Thus,

$$Kmin = \max (Ks, \max \{\alpha_i\}) .$$

Hence, the minimal time of performing all tests, *Tmin*, is equal to

$$Tmin = Kmin\ t_\tau ,$$

where t_τ - is the time of test performing.

To find the optimal schedule of tests performance that will provide *Tmin*, it is necessary to fulfil the following operations in the initial testing graph. Firstly, in the graph *G(V,E)*, all edges are numbered form 1 to *Q* (e.g., see Fig. 1a).

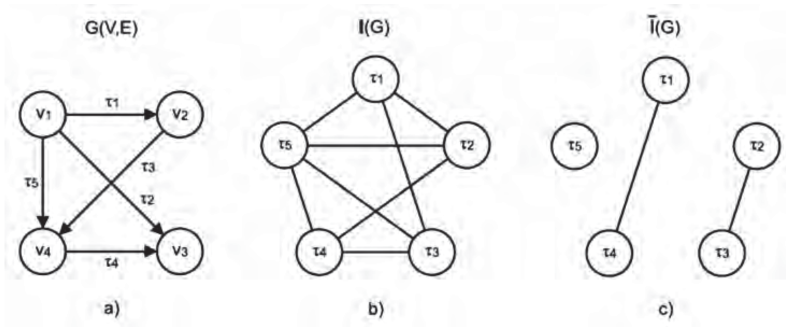

Figure 1: Graphs G(V,E), I(G) and Ī(G) for system with four units

Secondly, for the graph *G(V,E)* it is determined the graph *I (G)* (see Fig. 1b) whose vertices will be the edges *E* of graph *G*, and whose edges will be couples (*E,E'*). Then, the complement of the graph *I (G)* is generated (see Fig. 1c). Thirdly, for graph *Ī (G)* the adjacency matrix, *M[Ī (G)]*, is formed (Table 1).

If, in graph *Ī (G)*, vertex τ_i and vertex τ_j are connected, or entry *(i, j)* of matrix *M[Ī (G)]* is 1, then tests τ_i and τ_j

, where $i, j \in [1,Q]$ and $i \neq j$, can be performed at the same step (that is, concurrently).

	1	2	3	4	5
1	-	0	0	1	0
2	0	-	1	0	0
3	0	1	-	0	0
4	1	0	0	-	0
5	0	0	0	0	-

Table 1: Adjacency matrix $M[\bar{I}(G)]$

Hence, the sought optimal schedule of test performance can be determined by using either graph $\bar{I}(G)$ or adjacency matrix $M[\bar{I}(G)]$. From matrix $M[\bar{I}(G)]$ it is possible to derive which of the tests can be performed concurrently (case of entry (i, j) is 1). However, determining the schedule of tests performance is not an easy task, especially when total number of test, Q, is great. For the case when Q is not so large, there can be helpful the trivial method of matrix transformation. By way of permuting the rows and columns of matrix

$M[\bar{I}(G)]$ it is possible to reach the state when all entries of $M[\bar{I}(G)]$ which are 1 lay along the main diagonal (see Table 2)

For the example under consideration, such transformation of matrix $M[\bar{I}(G)]$ can be performed by permuting the 2nd and 4th rows, and 2nd and 4th columns. In Table 2, the permuted rows and columns are highlighted. After such matrix transformation, it is possible to read the sough schedule of tests performance directly from the table caption. For our case, the result is the sequence {1,4,3,2,5}. Taking into account which tests can be performed concurrently, there can be determined the following schedule of test performance 1, 4 → 3, 2 → 5.

	1	4	3	2	5
1	-	1	0	0	0
4	1	-	0	0	0
3	0	0	-	1	0
2	0	0	1	-	0
5	0	0	0	0	-

Table 2: Matrix $M[\bar{I}(G)]$ after permutation

In the situations when there should be performed a large number of tests, there can be useful the following method. The method consists in decomposition of the set of vertices of graph $\bar{I}(G)$ into k disjoint subsets $P_1, P_2, .., Pk$, where each subset P_i, $i = 1, .., k$, forms the complete graph on vertices belonging to graph $\bar{I}(G)$ and

$$|P_1| = |P_2| = ... = |Pk| = \lfloor N/2 \rfloor = q$$

In the given case, all tests τ_i, $i = 1, .., q$, corresponding to vertices that belong to the same subset P_i can be performed concurrently.

For vertices belonging to subset P_i the following expressions should be met

$$\Gamma(\tau_\alpha) \bigcap \Gamma(\tau_\beta) = P_i - \{\tau_\alpha\} - \{\tau_\beta\}, \quad \alpha, \beta \in [1, .., q],$$

$$\left|\Gamma(\tau_\alpha) \bigcap \Gamma(\tau_\beta) \bigcap ... \bigcap \Gamma(\tau_\gamma)\right| = q - |\{\tau_\alpha\} + \{\tau_\beta\} + \{\tau_\gamma\}|, \quad \tau_\alpha, \tau_\beta, \tau_\gamma \in P_i.$$

The given expressions are used for determining subset P_i. The algorithm of determining all subsets P_i, $i = 1, ..k_s$, consists in the following. Here are presented only main features of algorithm (details are omitted).

In matrix $M[\bar{I}(G)]$, the i-th row (first in order) is selected and set $\Gamma(\tau_i)$ is determined. Then, the j-th row is selected, where $\tau_j \in \Gamma(\tau_i)$, and set $\Gamma(\tau_j)$ is determined. After that, the following new set A_1 is determined $A_1 = \Gamma(\tau_i) \cap \Gamma(\tau_j)$, for which $(P_1 - \{\tau_i\} - \{\tau_j\}) \subseteq A_1$.

If $A_1 = \varnothing$, then it is necessary to select another element from set $\Gamma(\tau_i)$ if such exists, and continue with new set A_1.

If $A_1 \neq \varnothing$, then element τ_{n1} is selected from set A_1 and the new set A_2 is determined

$$A_2 = \Gamma(\tau_{n1}) \cap A_1,$$

for which $(P_1 - \{\tau_i\} - \{\tau_j\} - \{\tau_{n1}\}) \subseteq A_2$. Then element τ_{n2} is selected from set A_2 and new set A_3 is determined $A_3 = \Gamma(\tau_{n2}) \cap A_2$.

After repetition of this procedure k times, we obtain $A_k = \Gamma(\tau_{nk-1}) \cap A_{k-1}$, where $A_k = \varnothing$. It means that $P_1 - \{\tau_i\} - \{\tau_j\} - \{\tau_{n1}\} - \{\tau_{n2}\} - ... - \{\tau_{nk-1}\} = \varnothing$.

From the last expression the sought subset P_1 is determined. After that, it is necessary to remove from matrix $M[\bar{I}(G)]$ the rows and columns which correspond to the elements of subset P_1. Using the remaining matrix, subset P_2 can be determined the same way as subset P_1 was determined. This procedure can be spread on all other subsets P_i, $i = 3, 4, .., k$. The following simple example shows how the above considered algorithm can be applied.

Let system consists of seven units and has graph $G(V,E)$ depicted in Fig.2

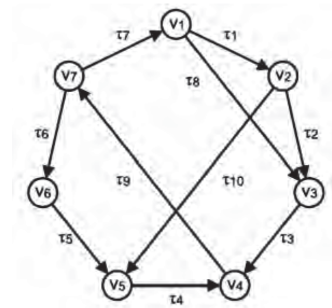

Figure 2: System with seven units

For the given graph $G(V,E)$ graphs $I(G)$ and $\bar{I}(G)$ are as shown in Fig.3

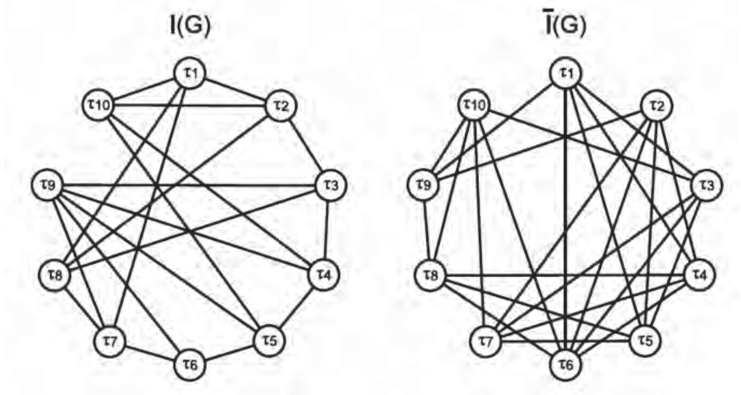

Figure 3: Graphs I(G) and $\bar{I}$(G) for system with seven units

Adjacency matrix $M[\bar{I}(G)]$ is shown in Table 3.

	1	2	3	4	5	6	7	8	9	10
1	0	0	1	1	1	1	0	0	1	0
2	0	0	0	1	1	1	1	0	1	0
3	1	0	0	0	1	1	1	0	0	1
4	1	1	0	0	0	1	1	1	0	0
5	1	1	1	0	0	0	1	1	0	0
6	1	1	1	1	0	0	0	0	0	1
7	0	1	1	1	1	0	0	0	0	1
8	0	0	0	1	1	1	0	0	1	1
9	1	1	0	0	0	0	0	1	0	1
10	0	0	1	0	0	1	1	1	1	0

Table 3: Adjancency matrix $M[\bar{I}(G)]$ for graph $\bar{I}(G)$

Since $Q = 10$ and $d = \lfloor N/2 \rfloor = 3$, the total number of steps, *Ks*, needed to perform all tests, is equal to

$$K_s = \left\lceil \frac{Q}{d} \right\rceil = \lceil 10/3 \rceil = 4$$

At the beginning, there will determined subset $P_1 = \{\tau_1, \tau_3, \tau_5\}$. It means that tests τ_1, τ_3 and τ_5 can be perofrmed concurrently at the first step. Then, there will be sequentially determined the subsets $P_2 = \{\tau_2, \tau_4, \tau_6\}$, $P_3 = \{\tau_8, \tau_9, \tau_{10}\}$ and $P_4 = \{\tau_7\}$.

The considered method of determining tests schedule allows to receive several different variants of scheduling the tests. In order to choose one variant, it is needed to take into account additional parameters related to efficiency of tests performance. For example, there could be accounted the period of time between two subsequent tests performed on the same unit. It is important when intermittent faults are allowable.

Random performing of tests

Random performing of tests is considered both in context of system selfchecking and system self-diagnosis. Self-checking is the process which aims at discriminating between two states of a system: fault-free and faulty. The result of self-checking doesn't indicie which of the system units has failed, and only testifies the presence of fault(s) in the system. Self-checking may require small number of tests. When $P_{AT} = 1$ and $P_S = P_F = 1$, it is only needed to find out if each of the system units has been tested, at least, once. It may happen that *N* tests could be sufficient for system self-checking (see Fig. 4), where N is the number of system units.

For providing system self-checking it is not necessary to form the syndrome, and, consequently, to perform its analysis. Only message or signal Informix about system fault-free (resp. faulty) state is sufficient. This can be done, for example, by the unit which has produced the test result equal to 1.

Further we are going to consider the case when tests are performed during the system operation. Hence, it is not possible to determine in advance which

of the system units will be idle at the definite moment of time and, thus, will be able to test (or be tested by) another system unit. From this it follows that not only the pair of units that provides a test, but also the instant of test performg is random. Random is also the number of tests which will be performed in the system during a certain period of time.

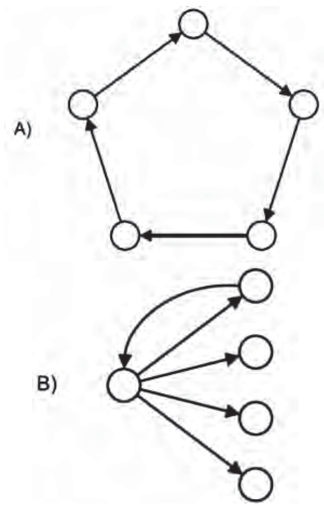

Figure 4: Cases when each unit is tested

At the beginning, the self-checking procedure is performed to find out if the system possesses a faulty unit(s). The period of self-checking durativ depends on the requirements to the credibility of self-checking result. If no test result equal to 1 is obtained during the self-checking (i.e., all test results are equal to 0), then the self-checking procedure ends, and the respektive message or signal is delivered to the system environment. The self-checking procedure and subsequent delivering of information about the state of the system can be repeated at certain intervals as long as the systém is operating. Otherwise, that is, when the test result indicating the presence of a faulty unit in the system is obtained, the self-checking procedure is terminated immediately, and the procedure of self-diagnosis will be started. The aim of self-diagnosis procedure is to identify the faulty unit(s).

As the research results show, one of the most difficult tasks is the task of determining the time duration of self-checking when all test results indicie that there are no faulty units in the system (i.e., all test results are equal to 0). For our consideration we need to introduce the term of cycle of self-checking.

Definition:

Cycle of self-checking is the interval between two subsequent delivering of self-checking results.

In Fig. 5, the cycle of self-checking (SSC) and, eventually, self-diagnosis are depicted.

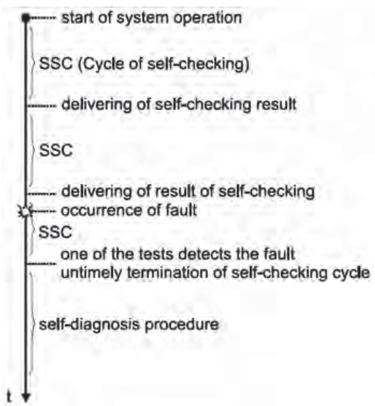

Figure 5: Self-checking cycles and fault occurrence

Fig.5 can also help to elucidate the important features of self-checking.

From Fig. 5, it is seen that fault occurrence doesn't lead immediately to termination of self-checking procedure. Self-checking, as a rule, will continue until the fault is detected (caught) by one of the tests. After normal termination of each SSC, the result of self-checking is delivered to the system environment. This result indicates that the system is faultfree. Only in case of exceptional termination of SSC (see Fig. 5), no reset of self-checking is delivered to the system environment.

Thus, normally, the same information is delivered to the system environment. Consequently, the idea springs to mind, that self-checking could be organized in such way that its result will not be delivered at all. In this case, absence of information about system state would mean that the system is fault-free. However, this proposition has not been enough researched both from the theoretical and practical points of view. Nevertheless, it is worth noting that this situation can be considered in contex of our consideration as a particular case when the time duration of self-checking cycle approaches the infinite.

For organization of SSC (mainly, for defining the time duration of SSC) there were suggested several solutions [2], [3], [4]. Basically, SSC continues until one of the following conditions is met:

1) pre-set time has expired.

Time duration of SSC is a constant value and is pre-set in advance (denoted as tc).

2) certain number of tests has been received.

Time duration of SSC is defined by the certain number of performed tests, i.e., SSC continues until there is performed pre-set number of tests. Time duration of SSC is random.

3) certain testing graph (TG) has been formed.

SSC continues until the tests form a certain testing graph (resp. TG which belongs to the subset of diagnosis graphs defined a priory. Time duration of SSC is random.

The cases when time duration of SSC is pre-set or defined by a certain number of performed tests can be further described from the point of view of whether the analysis of the received diagnosis graph has to be performed or not. When such analysis doesn't have to be performed, the task arises to compute the probability of the event that all system units have been tested at least once. However, in practice there can be applied the opposite attitude when the time duration of SSC (resp., the required number of tests) is computed basing on the required probability of the event that all systém units will be tested. Analysis of the obtained TG aims at checking whether all system units have been tested or whether the formed TG belongs to predefined subset of testing graphs. It depends on the value of required credibility of selfchecking result. When analysis shows that not all of the system units have been tested, it is possible to continue the SSC by the predefined period of time (so-called, extended period). After this extended period expires, the analysis is repeated. But this time, all of the tests both performed during the main and extended periods are accounted.

Determining the optimal number of possible extended periods of SSC and the time of their duration is a separate problem. Its brief consideration will be presented further. It is worth noting that not all tests are of the same importance, respectively deliver the same diagnosis

information. Generally, there could be laid constraints on tests execution which eliminate less important tests. As an example of less important tests, we can name the duplicated tests. Laying constraints on these tests, results in obtaining the testing graph without multiple edges.

Fig. 6 represents the summary of the above consideration concerning the self-checking procedure.

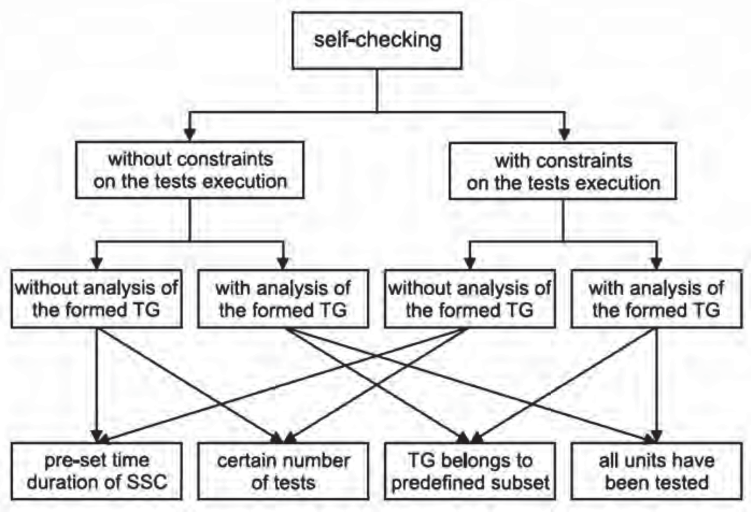

Figure 6: Possible variants of self-checking procedure

Conclusions

Sensor networks exploited for environment monitoring can work in bad conditions and can be placed in harsh environment. In such situations, the probability of sensor failures may increase significantly. Specifics of sensor nets deployment can result in impossibility to use external testing and diagnosing facilities. In many cases detection of faulty sensor nodes can be performed by sensor network itself. It means that one sensor node will test another sensor node. On the basis of obtained test results it is possible to provide diagnosis of the whole network. The main problem that arises when performing such mutual testing is the problem of organization of test performance. There exist several different organizations of test performance. In order to choose the most appropriate organization for diagnosis of each particular sensor network, preliminary analysis should be conducted. The paper gives developers and users of sensor networks the idea of attainable level of network reliability and fault-tolerance.

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АДСОРБЦІЯ НА ВУГЛЕЦЕВИХ НАНОТРУБКАХ: ОГЛЯД

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Розглянута проблематика використання вуглецевих нанотрубок в адсорбційних процесах очищення води і водних розчинів. Наведена коротка характеристика структури одношарових та багатошарових вуглецевих нанотрубок. Проаналізований взаємозв'язок між внутрішньою будовою, хімією поверхні та адсорбційними властивостями вуглецевих нанотрубок. З'ясовано механізми адсорбції на поверхні вуглецевих нанотрубок на молекулярному рівні. Представлені експериментальні докази ефективності нанотрубок в процесах адсорбційного видалення з водних розчинів широкого асортименту органічних, неорганічних та біологічних забруднювачів. **Ключові слова:** вуглецеві нанотрубки, адсорбційна активність, гідрофобна взаємодія, функціональні групи, електроно-донорна взаємодія.

Адсорбция на углеродных нанотрубках. Иваненко Ирина Николаевна. Рассмотрена проблематика использования углеродных нанотрубок в адсорбционных процессах очистки воды и водных растворов. Приведена краткая характеристика структуры однослойных и многослойных углеродных нанотрубок. Проанализирована взаимосвязь между внутренним строением, химией поверхности и адсорбционными свойствами углеродных нанотрубок. Выяснены механизмы адсорбции на поверхности углеродных нанотрубок на молекулярном уровне. Представлены экспериментальные доказательства эффективности нанотрубок в процессах адсорбционного удаления из водных растворов широкого ассортимента органических, неорганических и биологических загрязнителей. **Ключевые слова:** углеродные нанотрубки, адсорбционная активность, гидрофобное взаимодействие, функциональные группы, электронно-донорными взаимодействие.

Adsorption on carbon nanotubes. Ivanenko Irina. The problems of carbon nanotubes using in the adsorption process of cleaning water and aqueous solutions considered. The brief description of single-walled and multi-walled carbon nanotubes structures shown. The relationship between the internal structure, surface chemistry and adsorption properties of carbon analyzed. The adsorption mechanism on the surface of carbon nanotubes elucidated at the molecular level. Experimental evidence for the nanotubes effectiveness in the process of adsorption removal from aqueous solutions of a wide range of organic, inorganic and biological contaminants provided. **Keywords:** carbon nanotubes, adsorption activity, hydrophobic interaction, functional groups, electron-donor interaction.

Вступ

Адсорбційні процеси достатньо давно і широко застосовуються при підготовці питної води, води спеціального призначення, для очищення стічних вод від різноманітних забруднювачів як органічного так і