Research Article

Diagnosis System for Building Management Network

Zafer Al-Makhadmee

King Saud University/Community College, Riyadh 11437, Saudi Arabia

Abstract: In this study the author used multi-criteria decision-making design to provide optimal structure of the developed and modified modern Building Management Systems (BMS). While modern BMS is used to provide effective and securable activity of enterprises solving complex tasks of their operability. However a lot of problems such as system structure flexibility in an ever changing market of the BMS and industrial network hardware can be solved by means of the hardware structure development automation. Problems of optimal hardware structure composition solving all the necessary building management task support providing reliable and effective system operation have to be solved.

Keywords: Building management system, hardware structure development, industrial network, multi-criteria decision-making

INTRODUCTION

Optimal hardware structure design problem Creation of building management system is one of the most important directions of the providing of securable and effective activity of modern corporations and other objects (Schürmann, 1998).

Now in the market of Building Management System (BMS) hardware there is a considerable quantity of the products having a wide spectrum of technical and economic characteristics. Creation of individual projects of industrial network segments is connected with necessity of constant replenishment and updating of the nomenclature of the design-available hardware. Besides, the increase in total of names of means leads to that the quantity of possible variants of combinations of the given devices increases at realization of Building Management Network (BMN). Therefore, creation of decision-making support system during the automated designing of structure of a hardware structure is relevant (Fuller, 2010; McCoy, 2007).

Information gathering in managerial process by BMS is very important component. On the one hand, the fuller volume of the information is received by the operator, the better from the point of view of adequacy of representation of a situation. However, thus the perception of the information considerably becomes complicated and process of processing of the information is slowed down. Therefore, distribution of problems of management, in particular, information preparations, between hardware of various levels is very important. The major distribution principle is to avoid information overload of operator and the combination of the automated preparation of the information to definitive decision-making by the operator is optimum. Thus the information is subdivided into such kinds:

- The primary information which is received from gauges of the raw information (acoustic, thermal, video cameras etc.)
- The information on a state of elements of system (separate premises and their groups). The given information turns out by preliminary processing of the primary information on a system state
- **The general information on a system state:** In this research paper, to solve this problem we proposed a new model and algorithm which are flexible for modern hardware market and optimal decision making during the development process

MATERIALS AND METHODS

Project decision-making criteria choice: At synthesis of a hardware structure we choose the approach based on synthesis of models of variants of project, its separate parts and elements with the subsequent choice of the optimum. The task in view dares as follows:

- Creation of uniform information files of hardware of a various functional purpose
- Exception of paper documents at intermediate design stages
- Automation of process of preparation and release of the text and graphic documentation
- Automation of engineering calculations
- Carrying out of the multiple analysis and optimizing calculations

Generally hardware structure choice is defined by following criteria (American Standard International, 2006):

- The maximum probability of detection of possible abnormal situation:

$$Q_1(\tau) \to max$$

- The minimum probability of false operation of system:

$$Q_2(\tau) \to min$$

- The minimum labor content of designing of system of network:

$$Q_3(\tau) \to min$$

- The minimum cost of system:

$$Q_4(\tau) \to min$$

The probability of detection of a abnormal situation is connected with probability of that the given situation will not be found out, as a difference between one and $Q_1(\tau)$. Then the first of criteria will be transformed to a view:

$$1 - Q_1(\tau) = Q_{11}(\tau) \to min$$

Then criteria function looks like:

$$Q(\tau) = \arg ext\big(Q_{11}(\tau), Q_2(\tau), Q_3(\tau), Q_4(\tau)\big) \to \min \qquad (1)$$

As the base we use the approach based on construction of the function reflecting quality of work of a control system according to parameters of structure. For this purpose it is necessary to allocate a priority specify. At realization of BMS carried out providing function redundancy we accept a set of the functions which are carried out by system as the main priority specify.

Hardware selection model: It is possible to present a set of the functions which are carried out by system in the form of a vector (Emmerich and Deutz, 2006):

$$X = f\big(x_1, x_2, ..., x_i, ..., x_n\big) \qquad (2)$$

where, x_i is the i-function which is carried out by the given subsystem.

It means that all the functions of the developed system are supported when all the elements of the vector equal 1.

For the description of model of object the vector (or matrix) form of representation of hardware is used:

$$Y = f\big(y_1, y_2, ..., y_i, ..., y_n\big) \qquad (3)$$

where, y_i is element of vector which equals 1 if appropriate hardware unit can execute i-function of the BMS hardware and 0 in opposite case.

For minimization of criteria $Q_{11}(\tau)$ and $Q_2(\tau)$ it is necessary to provide duplication of functions of protection by means of various types.

At the automated designing of a complex of hardware the iterative method is used as base. The basic requirements are:

- Maintenance of a minimum of time expenses at designing
- Exception of identical devices of various modifications or manufacturers

For this purpose it is necessary to provide comparison of properties of hardware units in the automated mode. For comparison of the specified properties we use a method of comparator identifications.

Optimal hardware unit choice can be provided using expression:

$$\forall j \forall k \; Y_j(x_i) \veebar Y_k(x_i) = 0, i =$$
$$= [1; n] \Rightarrow Q(\tau) = min(Q^j(\tau), Q^k(\tau)) \qquad (4)$$

It is made by means of element-by-element XOR function with different examples of the hardware unit *Y*. In the case of matching of hardware unit properties optimal device is proposed to be chosen using specified earlier criteria's.

In order to define does new hardware unit "covers" new hardware complex function following condition can be used:

$$\exists t \; X \veebar (X \vee X_t) \equiv 0 \qquad (5)$$

where, *t*-number of iteration (step) of the hardware structure development process. It's provided if condition (5) is false.

Duplication of hardware function can be checked as follows:

$$\exists t \exists i \; \big(x_i \wedge x_i^t\big) = 1 \qquad (6)$$

If condition (6) is true duplication of functions is provided.

In order to define, once the given function duplicated or is more additional vector is proposed to be created:

$$Z = f\big(z_1, z_2, ..., z_i, ..., z_n\big) \qquad (7)$$

where, z_i equals 1 if duplication of hardware complex functions is provided (Hutton, 2006).

Thus using formula (6) we can modify vector Z in order to specify that appropriate function of BMS network hardware complex is duplicated:

$$\exists t \exists i \left(x_i \wedge x_i^t \right) = 1 \Rightarrow \left(z_i = 1 \right) \tag{8}$$

RESULTS AND DISCUSSION

Development of the search algorithm: Algorithm of search of an optimum variant in a set of devices of similar appointment consists in the following:

- Choice of the first element of a set Y_1
- Comparison with the following under the list the device on appointment parameter and, at coincidence of properties, comparison of values of criteria function (expression (4))
- Exception of the device with greater value of criteria function from the list
- Repetition of points b and c for other devices in a database
- After search end-repetition of all algorithm for other devices until the database will not be completely cleared

In order to develop method of the BMS network hardware structure automated development we need specify some conditions:

- All the BMS functions must be supported
- Each function must be duplicated at least once upon a time

Further the algorithm of BMS network hardware automated formation is developed:

- Select the first element from the list
- Select the following element and check up, whether the new nonzero element of a vector X is added (false result of expression (5) execution
- Define, whether there was a duplication of the functions which are carried out by system (expression (6))
- In the case if duplication of functions has occurred, check did duplication provided before checking appropriate element of the vector Z. If duplication occurred before current element must be excluded (Fig. 1)

Repetition of items b-d gives possibility to compose BMS network hardware complex structure step-by-step.

Thus condition of including of hardware element to the BMS network hardware complex structure is:

$$\exists t \exists i \neg \left(X \veebar (X \vee X_t) \equiv 0 \right) \vee \left(\left(\left(x_i \wedge x_i^t \right) = 1 \right) \wedge \left(z_i = 0 \right) \right) \tag{9}$$
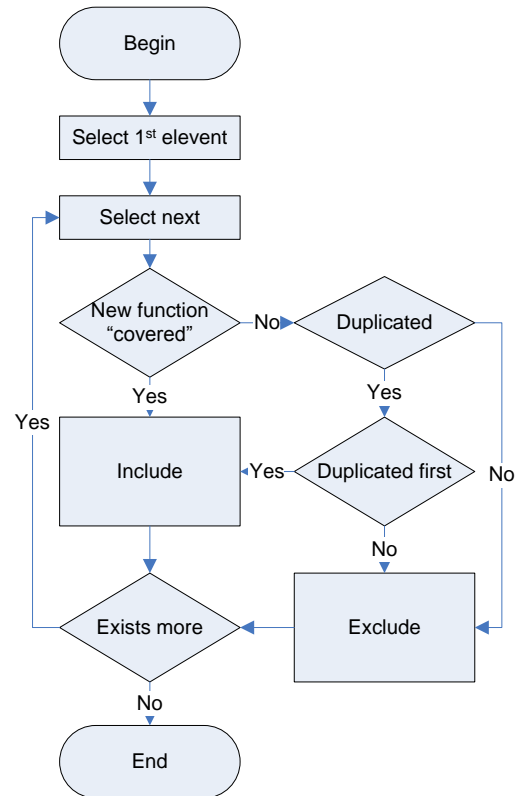

Fig. 1: Hardware choice algorithm

It means that hardware unit can be added to the BMS network hardware structure in the case if it either covers new specified hardware complex function or duplicates already covered function first time. In other cases considered element cannot be used for the hardware complex structure developments.

Further with use of one of methods of combination theory drawing up of other sets of available set of means is made for definition of all possible combinations.

After that, by application of any of sorting methods, search of the optimum set having a minimum of criteria function is carried out.

Thus, the model which application will allow to lower, first, material and time expenses for designing of a complex of BMS network hardware is developed; secondly, operatively to react to change of the nomenclature of means available in the market.

CONCLUSION

The advantages of the proposed model and algorithm are in the flexibility on the modern hardware market changes and optimal decision-making during the development process.

Duplication of the BMS functions gives possibility to improve system reliability and to avoid problems with possible errors during system operation.

Described approach can be applied in the developments of complex object hardware structure such as BMS, security systems etc., making development process more fast and effective.

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