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Analysis of the Data Using a Semantic Network as a Tool for Management Non-Conformities in Quality Management System

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Abstract

The article discusses the use of a semantic network in a management of nonconformities in quality management systems. It describes basic network elements and their mapping to basic concepts of the management of nonconformities. The author gives an example of a fragment of the semantic network to illustrate the visual representation of management of nonconformities data detected in practice of real construction organization. The article includes the block diagram of algorithm, which shows how to add a new node-nonconformity into the semantic network.

Keywords: quality management system, nonconformity, chain of nonconformities, classification of causes of nonconformities, node-reason, node-nonconformity

1. Introduction

An effective management of nonconformities is one of the important hallmarks of an effective quality management system (QMS) of any construction organization or enterprise. The most important tasks of nonconformities management are: identification of possible causes of non-conformities; development of necessary corrective actions to prevent errors; detection and elimination of potential nonconformities in construction products through the preventive action development (Okes, 2009; Lukmanova & Nezhnikova, 2014; Smith & Keeter, 2010).

2. Methods

The greatest success in the nonconformities management tasks solution can be achieved by using the appropriate software (Rallabandi et al., 2011; Petrova, 2010). As a rule, in those organizations where QMS actually works, Corrective & Preventative Action (CAPA) tracking software is the core of quality system. When implemented properly, a CAPA-software improves product quality and safety, increases customer satisfaction, and more importantly, ensures regulatory requirements ISO compliance.

However, for many Russian small and medium enterprises of the construction industry that have implemented a quality management system, any use of such programs is not possible due to two reasons at minimum. The first-large financial costs for the purchase of software compared to size of considered enterprise groups. The second-a lack of qualified employees, who can implement and then exploit CAPA software.

In this regard, there is a need for such software that enables users, who often do not have any programming skills and experience, to quickly and accurately solve a particular problem without programming process and only based on verbal description in terms of the problem domain and original data.

This approach is characteristic of widely distributed expert systems, intelligent software packages, calculation and logical systems.

As a rule these systems perform a sequence of steps:

- a verbal description of a problem facing a user is performed;
- a mathematical model of the problem is automatically created on base of the verbal description;
- a task is formulated in the framework of the model. And finally, a working program, which solves the task, is automatically created.

3. Building a Functional Semantic Network

A model of the problem domain is the main component of the system that implements all of the functions of the transition from the verbal description of the user's problem to the working program.

Below is considered one of the ways to represent the problem domain model-using *functional semantic network* (FSN) for representing knowledge and procedures for working with them.

The following is one of the ways to represent the problem domain model, using FSN to represent knowledge and procedures to work with it.

FSN is a directed graph. Directed graph (or digraph) is a graph, or a set of nodes connected by edges, where the edges have a direction associated with them. In formal terms, a digraph is a pair

G = (V, A):

- set V consists from elements called vertices or nodes;
- set A consists from ordered pairs of vertices called arcs.

The set of nodes is formed by nodes of three types V1, V2 and V3.

Nodes of the first type V1 correspond to different reasons, each of which is the source of certain non-conformities. The definition of the initial number of nodes and node structure can be laid by multi-level qualifier of the causes of nonconformities, composition and rules of the organization is sufficiently detailed in (Petrova, 2011).

Based on the structure of the classifier, all nodes of this type can be divided to a number of major groups-directions manifestations reasons. First, a detailing within each group is performed according to the base reason, and then according to the levels of details of the classifier.

Nodes of the second type V2 correspond to nonconformities with the requirements of the standard ISO 9001-2008, identified in the organization. If the chain of nonconformities (Ivanov, 2014; Ivanov, 2015; Hani et al., 2014) is built as a result of the search for a root cause of detected nonconformity; then, some part of V2 type nodes appears in the network as satellites nodes for a particular type of node V1, i.e., it turns out that the reason, why it corresponds to the node of type V1, is itself an inconsistency relating to one or a number of reasons described by nodes V1.

A set of connectors (arcs-links) between nodes-causes from the set V1 and nodes-nonconformities from the set V2 forms a set of arcs of the first type R1. Each arc of this type has rank r, which describes the incidence of any of the nonconformities, for whatever reason. The arc $\mathbf{R_1^{ij}}$ has rank 0 (r=0), if the cause $\mathbf{V_1^{i}}$ could potentially lead to nonconformity $\mathbf{V_2^{j}}$, but this nonconformity has never arisen. The arc $\mathbf{R_1^{ij}}$ has rank $\boldsymbol{k}$ (r=k), if the nonconformity $\mathbf{V_2^{j}}$ was revealed $\boldsymbol{k}$ times and the cause of it was the reason $\mathbf{V_1^{i}}$.

Nodes of the third type V3 correspond to different control variables of Boolean type. The values of these variables are set by the user in the formulation of the problem facing him. A user's decision about the *significance* of nonconformity in the distribution of money and / or time resources to carry out corrective and /or preventive actions can act as an example of this type of nodes. A set of connectors (arcs-links) between nodes-nonconformities from set V2 and nodes-control variables from set V3 forms a set of arcs of the second type R2.

4. Example Using the FSN

Consider the example of the formation of the FSN on data of detected nonconformities and their causes, shown in Table 1. The fragment of the functional semantic network is presented in figure 1.

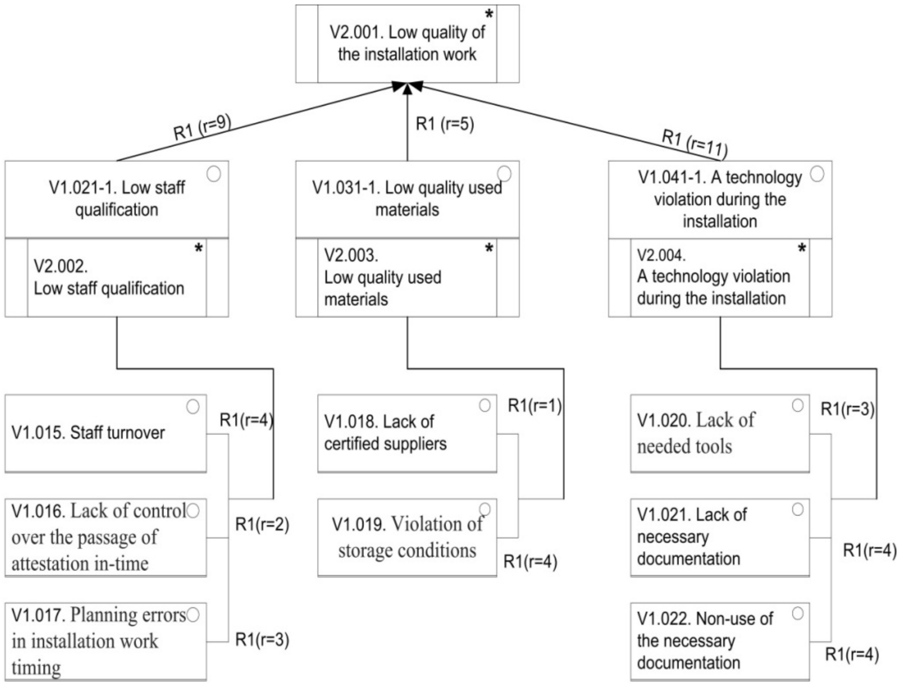

Figure 1. A fragment of the functional semantic network

Table 1. Nonconformity and reasons of its occurrence

Nonconformity: low quality of the installation work		
The cause of the nonconformity		Number of detections
Reason code	Name of reason	
021-1	Low staff qualification	9
031-1	Low quality used materials	5
041-1	A technology violation during the installation	11
051-1	Unsatisfactory condition of mounted equipment	3

The big advantage of the FSN is its ability to develop and adapt. There are several major modes that are used when making any changes to the FSN. These include:

-an addition of node-nonconformity to the FSN;

-a removal of node-nonconformity out the FSN;

-a change of a number of node-reasons, which were included in the FSN;

-a change of a number of node-control variables, which affect the activation of the FSN elements;

-a change of a number of connections between nodes of types V1 and V2 without changing the total FSN nodes number.

The figure 2 shows a block diagram of the enlarged algorithm that implements the append mode of node-nonconformity in the FSN.

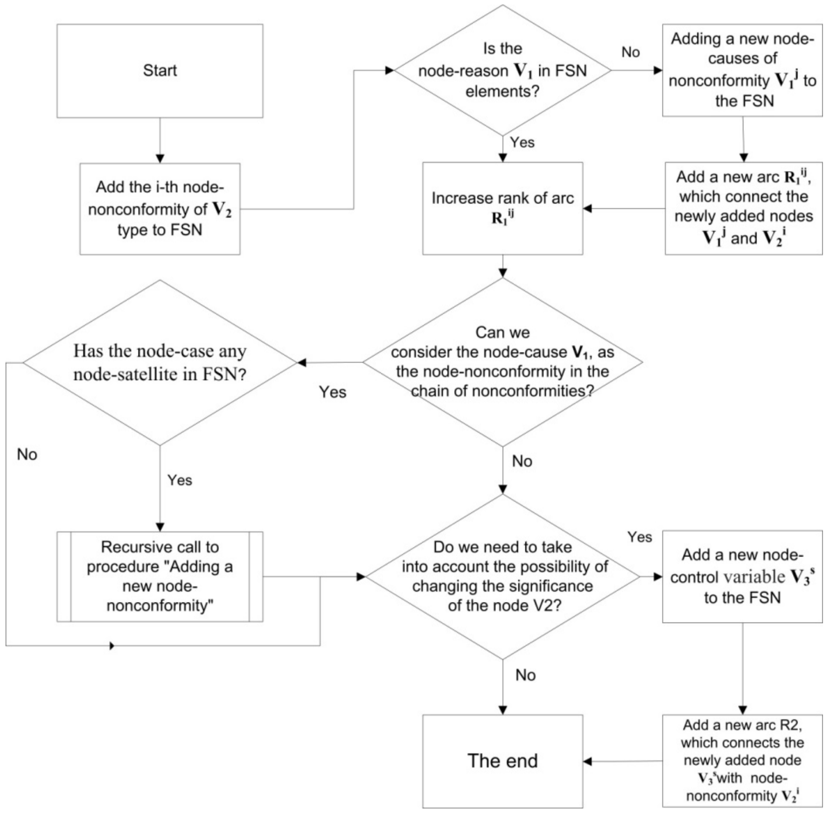

Figure 2. Block diagram of the enlarged algorithm that implements the append mode of node-nonconformity in the FSN

The following notations used in the description of the algorithm:

N–a number of nodes-reasons of nonconformities in FSN;

M–a number of nodes-nonconformity in FSN;

L–a number of nodes-control variables that affect the activation of the FSN elements;

$V1=(V_1^1, V_1^2, \dots V1^i)$, i=1, … N–a set of nodes-causes of nonconformities;

$V2=(V_2^1, V_2^2, \dots V_2^j)$, j=1, … M–a set of nodes-nonconformity;

$V3=(V_3^1, V_3^2, \dots V_3^s)$, s=1, … L–a set of nodes-control variables;

R_1^{ij}–an arc-connector between nodes V_1^i and V_2^j;

R_2^{ij}–an arc-connector between nodes V_1^i and V_3^s.

Let us introduce a number of additional definitions:

- the node V_1 is considered ***active*** if there is at least one arc R_1-type with nonzero rank connecting this node with any node V_2-type; otherwise, the node V_1 is considered ***passive***;
- the arc R_1^{ij} is considered as ***activated***, if it links the active node-reason V_1^i to the node non-nonconformity V_2^j; otherwise, the arc is considered a ***passive*** arc;
- the node V_3^s is considered ***active*** if the value of the corresponding control variable is assigned the value "true" during the formulation of the problem;
- the arc R_2^{sj} is considered as ***activated***, if it links the active node V_3^s to the node V_2^j;
- the node V_2^j is considered ***active*** , if there is at least one active arc R_1-type, associated with this node, and all arcs R_2-type, associated with this node, also are active.

5. Conclusion

The above described approach of data representation of the identified nonconformities and their causes can be applied in practice for implementation of the requirements of ISO 9001, related to the concept of "risk-based thinking". Draft International Standard (DIS) ISO 9001: 2015 makes concept of risk more explicit and builds it into the whole management system. Risk-based thinking is already part of the process approach and makes preventive action part of risk management. Risk-based thinking can help not only to identify actions to address risks but identify opportunities of enterprise.

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