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Tsiutsiura Svitlana
DSc (Eng.), Professor, Head of Department of Information Technologies, *orcid.org/0000-0002-4270-7405*
Kyiv National University of Construction and Architecture, Kyiv
Yerukaiev Andrii
PhD (Eng.), Associate Professor of Department of Information Technology, *orcid.org/0000-0002-9956-3713*
Kyiv National University of Construction and Architecture, Kyiv
Kostyshyna Nataliia
Assistant of the Department of Information Technologies, *orcid.org/0000-0003-0521-7228*
Kyiv National University of Construction and Architecture, Kyiv

USE OF FUZZY PETRI NETWORKS FOR INFORMATION DESCRIPTION OF THE HOUSING ENVIRONMENT

Abstract. *The current state of comfort of an apartment building indicates many problems that exist in this area. First, there is a need for clear planning of comfortable housing, which should take into account the current socio – economic needs of the population. Secondly, there is no clear definition of comfort levels of an apartment building. Also, there is a need to identify the main factors that affect the life and comfort of the population. The article is based on two main areas of research. The first is to present a description of the information model of a hybrid intelligent system (GIS) for the comfort of the living environment of an apartment building. This tool allows you to model the effects of interaction, adaptation, which can be observed in the system when making decisions. The study also simulates complex systems based on the use of fuzzy Petri nets (FPs) to describe comfort. MP and its various types are one of the classes of models that provide an opportunity to present the structure of integrated organizational – information systems and complexes, as well as logical – temporal processes of system operation. Fuzzy Petri nets are divided into two parts. The first part describes the structure of the network, it is usually standard, the processes of initial marking and movement of markers on the network are determined by means and methods of fuzzy sets and fuzzy logic. The biggest area of their application is complex objects. Fuzzy logic is used to formalize fuzzy concepts in terms of semantics and provides efficient information processing along with clear data. With the help of this network the endurance of modeling systems and the optimality of its structure are investigated. To date, a large number of different types of Petri nets are known, which provide an opportunity to present the structure of the models in the absence of analytical representation of the influence of certain factors.*

Keywords: Fuzzy Petri nets; comfort; information model; convenience of housing

Introduction

The comfort of housing plays a significant role in the socio – economic phenomena of any population, which necessitates the study of this topic in the scientific space. To analyze the comfort of housing, information technology uses methodological tools [5].

The development and reclamation of modern systems in various fields of mankind are inextricably linked with the development of information technology for modeling and operation of complex systems. The quality of the created system depends on the quintessence of the models used at the design stage. [6].

The efficiency of the system and the optimization of parameters in solving problems by simulation allow you to reproduce the process of functioning and management of the system more informed, in contrast to analytical modeling [2].

The development of technology determines the growing need for simulation of complex systems for optimal management and decision making.

One of the simulation technologies is the Petri net, which makes it possible to create a configuration of complex systems with structural elements. The technology of this network allows to achieve an abstract and detailed description of the processes of functioning of the information system [1].

MP received its name in 1962 in honor of the German mathematician Karl A. Petri, who published his work describing a new class of networks.

- In order to present our system by means of fuzzy Petri nets it is necessary:
- Identify the main events in the system that occur and align them with the transition of the Petri net.

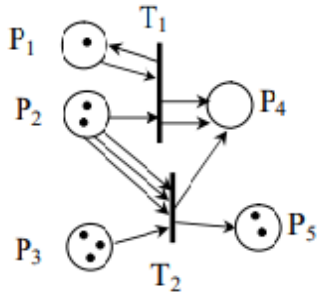

Figure 1 – Fragment of the Petri net

• Find out the conditions that arise in each of the events and match each condition of the MP position.

• Determine the number of chips in the position of the MP, which symbolizes the fulfillment of the condition.

• Connect positions and transitions that correspond to the logic of events in the system.

• Find out what changes are happening in the system during the event.

• Determine the numerical values of time delays in the transitions of the MP.

• Determine the state of the Petri net at the beginning of the process.

To date, a large number of different types of formalism of Petri nets are known, namely:

– temporary MP;

– algebraic;

– e – networks.

The Petri net allows you to build and modify models and provides a convenient presentation of simulation models to the user. Using this visual modeling, you can see the high speed and flexibility of the process of designing simulation models [4].

The goal of the work

The purpose of this article is to describe the information model of GIIS for the comfort of an apartment building. And to achieve this goal it is necessary to perform the following tasks: 1. To present a structural – functional scheme of comfortable housing; 2. Develop a fuzzy Petri net model for a hybrid home comfort information system.

Presenting main material

In the general case, the system modeling process can be represented in the form of interconnected parts, each of which performs the appropriate actions, which are aimed at constant and subsequent use in information models [1].

1. One of the main principles of system modeling is a problem in the analysis of construction and use of models [1].

The main value of the first stage is a logical understanding of the problem in the context of system modeling methodology [1].

2. The purpose of this stage is to build a system model appropriate to the subject area and the most general context for solving the original problem [1].

3. The system model is developed to obtain some new information about the system in order to improve the original problem [1].

4. The content of this stage is about the material or informational impact on the system in order to solve the original problem. It may be necessary to plan organizational measures for the implementation of such influences and control their implementation [1].

5. The purpose of this stage has already been formulated above, namely – to make changes to the existing model, which aims to ensure its solution. That is, its inclusion in the original model of auxiliary components, as well as radical changes.

The model of the structural – functional scheme of the hybrid intelligent information system of comfort of the apartment house is presented on (fig. 1). The initial parameter of this system is: the location of the area.

The first stage of GIIS development is the choice of the location of the district depending on the individual needs of each family. That is, at this stage it is important to consider several of the following factors:

– Transport interchange;

– Safety and ecology of the area (preference is usually given to quiet areas with green areas).

The next stage of this system is the choice of neighborhood [9]. This includes the study of the factor of influence that is responsible for the presence in the pedestrian accessibility of important for human life social objects:

– School;

– Polyclinic;

– Kindergarten;

– Banks;

– Coffee;

– Pharmacies;

– Shopping centers;

– Cinemas and other equally important objects.

After finishing the previous stage, the house is selected. It can be divided into five subtypes. The initial results are processed by a situational analysis of the operating conditions. If the house is equipped with all technical means, then there is a transition to the next stage, which is called "Choosing an apartment" [5].

Next is the choice of additional parameters of the convenience of planning an apartment, as well as the preservation of the basic features of housing. The obtained results are saved thanks to the methods of situational analysis of functioning.

After that, the formation of comfort assessment is generated (information about the comfort of all possible apartment plans is formed) and the formation of situation identification to determine situational factors (determined with complex indicators, all indicators interact with each other).

After the next processing, the result is displayed to determine the consequences of the situation or modeling the process of the situation, the processing process is shown below in Figure 2.

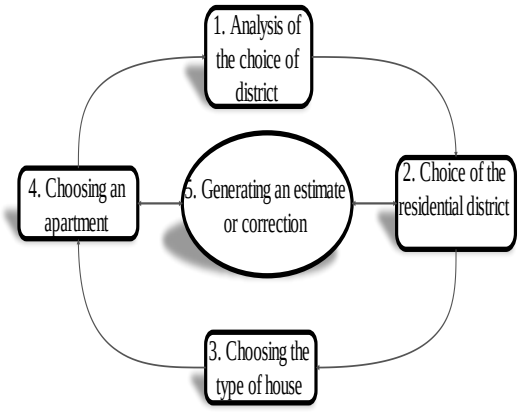

Figure 2 Conceptual scheme of the system modeling process

In the general case, the assessment of the comfort of the house involves such basic activities as collecting data about the area, neighborhood, neighborhood, condition of the house, apartment planning. After receiving them, the data is analyzed, after which decisions are made on comfort [7]. The main principles of the monitoring process are the purposefulness, continuity of the process and objectivity of the data, the availability of tools and algorithms for processing.

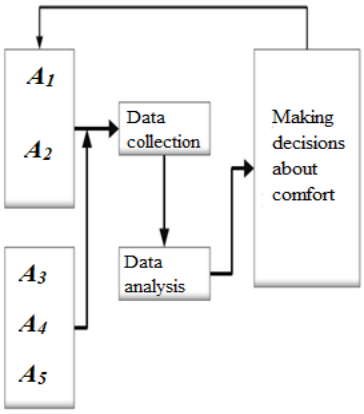

Figure 3 – The process of monitoring comfort in general

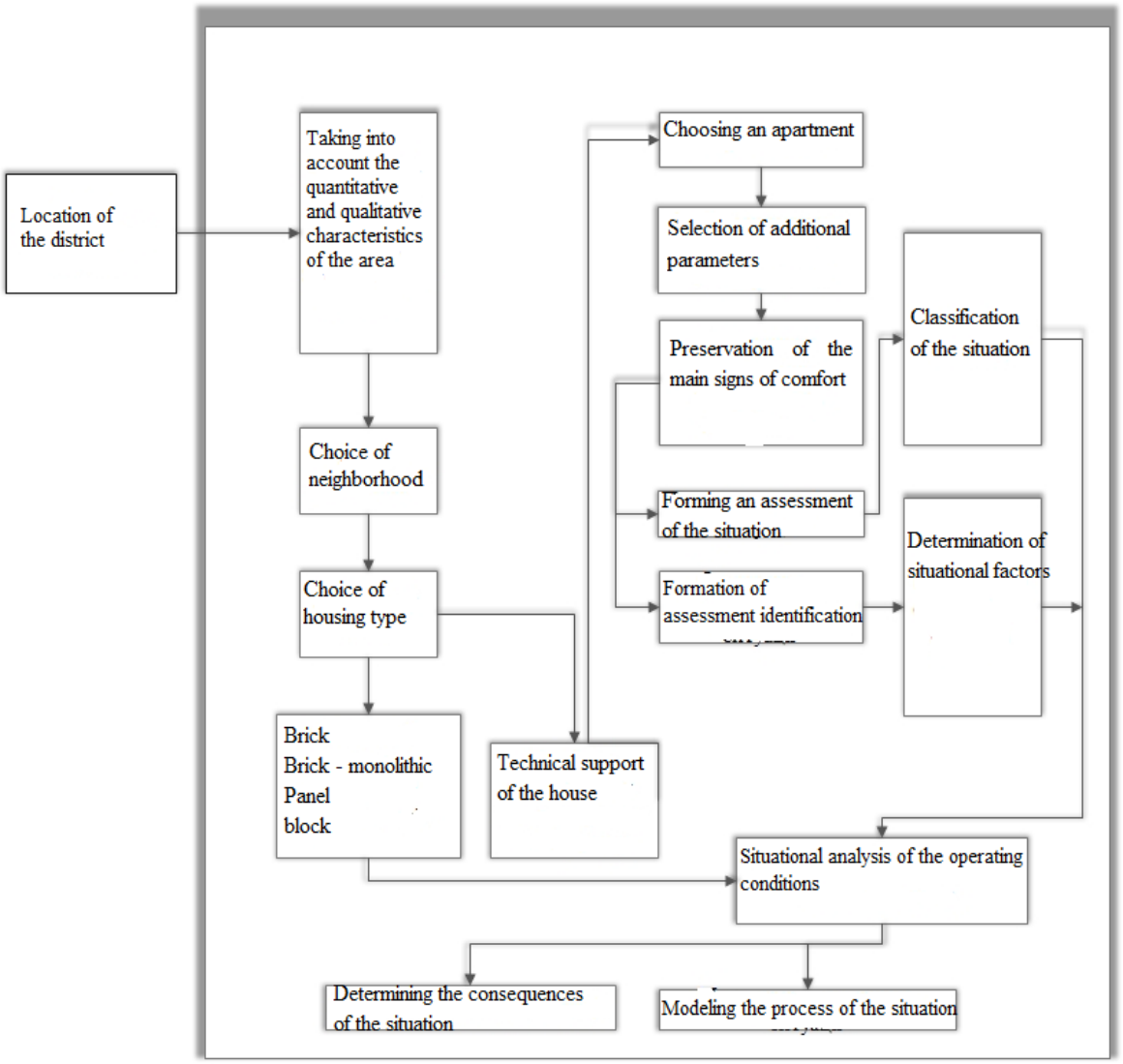

Figure 4 – Hybrid intelligent information system for the comfort of an apartment building

Information on the assessment of the practical living environment can be divided into separate indicators in the form of parameters:

• A1 – assessment of the area (conditions of transport, the presence of architectural monuments).

• A2 – assessment of the neighborhood (saturation of cultural objects, noise regime, the presence of social services in this neighborhood, the density of buildings, which can be divided into two:

– a) the number of people living in the neighborhood.

– b) total building area [8].

• A3 – assessment of the adjacent territory (insolation of the territory, microclimate, noise level, landscaping).

• A4 – assessment of the type of house (age, characteristics of technical condition, compliance of the house with modern requirements, architectural appearance, the presence of an elevator, garbage, the location of the house relative to the highway).

• A5 – Assessment of the comfort of the apartment (planning, floor area).

Intelligent information system (IIS) is a type of automated information systems based on knowledge; it is also a set of software, linguistic and logical – mathematical tools for the implementation of basic solutions [3].

Modeling of GIIS, which describes the comfort of an apartment building, is based on Petri nets [3].

Petri nets and their modifications – a class of models that allows the developer to fully imagine the structure of complex organizational – technological systems and complexes, but also the logical – temporal features of the processes of their operation [1].

Formally, Petri nets are a graph of a special type with additional rules that determine the dynamics of the operation of Petri nets [1].

To analyze the information representation of comfortable living conditions, it is proposed to use fuzzy Petri nets [10].

Below is the definition of Petri nets, which is the basic formalism of this network on the basis of which various generalizations and extensions of MP are built. But it should be remembered that the class is determined by the formal or graphical representation, but also by the rules of operation [1].

Fuzzy Petri nets are five components of P, which are described as follows:

$$C = (P, T, I, O, m0),$$

where **P** = {p1, p2… pn} – finite set of Petri positions; **T** = {t1, t2… tn} – finite set of transitions of Petri nets; **I** – input function of transitions; **O –** initial function of transitions; **m0 {m1, m2… mn}** – vector of initial marking; **F –** The set of arcs, which includes input and output, arcs, according to the transition [1].

Next, we present the purpose and position of our Petri net, in the form of a table.

Table 1

Positions	Appointment
P_0	Location of the district (set of events)
P_1	The results obtained about the area
P_2	Quantitative and qualitative parameters about the comfort of the area
P_3	Choice of neighborhood
P_4	The transition to choosing the type of housing
P_5	Compliance of the house with modern requirements
P_6	Correspondence of the characteristic of a technical condition of the apartment house
P_7	Data processing
P_8	Choice (the presence or absence of a marker in the position is important for the user to choose comfort)
P_9	Data in the situational analysis of the operating conditions
P_{10}	Analysis processing
P_{11}	Receipt of processed analyzes to situational formation
P_{12}	Choice of additional comfort parameters
P_{13}	Preservation of the main signs of comfort
P_{14}	Forming an assessment of the situation
P_{15}	Formation of situation identification
P_{16}	Classification of the situation
P_{17}	Determination of situational factors
P_{18}	Modeling the process of the situation

In table 2, which is shown below, we present the transitions and their purpose for building the model.

Table 2

Transition	Appointment
T_0	Getting information about the area
T_1	Obtaining data on the main parameters of the area
T_2	Obtaining data about the neighborhood
T_3	Data on comfort for processing
T_4	Processed data
T_5	Use of all data known to us
T_6	Compliance with the technical characteristics of the house
T_7	The process of choosing an apartment
T_8	Highlighting the main features of comfort
T_9	Forming an assessment of the situation
T_{10}	Classification of the situation
T_{11}	Determination of situational factors
T_{12}	Determining the consequences of the situation
T_{13}	Modeling the process of the situation

Next, consider how transitions work, how markup changes in the network, in the process of its operation.

MP oriented two-part multigraph of a special type. A feature of the graphical representation of the Petri net is the image of positions in the form of circles, and transitions in the form of dashes. The arcs of the graph connect the transitions only with the positions, and the positions – only with the transitions, so the graph is bipartite. The initial marking is represented by dots inside the circles (natural number) in the corresponding individual positions [1].

The transition can work if in each input point of this transition there are markers not less than multiplicity of an arc leaving this place in transition.

In other words, the operation of some active transition of Petri nets moves the markers from the input positions of this transition to its original position so that in all its input positions disappears as many markers as the arcs connecting this input position with this transition [1].

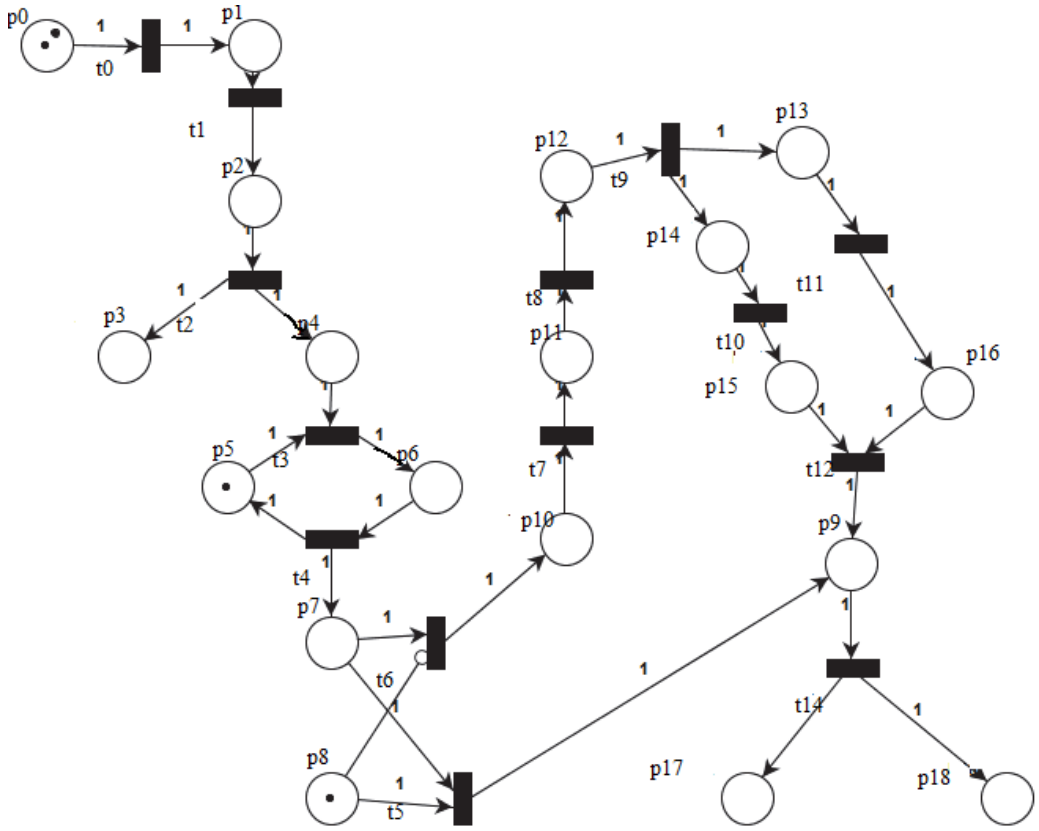

Figure 5 – GIIS model of apartment building comfort based on Petri nets

Conclusion

Thus, comparing the analysis of work, we see that in the context of socio – economic transformations taking place in Ukraine, there are new trends in the development of comfort at the theoretical and practical level. The problem of improving the living environment remains one of the basic human needs.

The use of Petri nets (MPs) makes it possible to model and study complex systems and processes. The use of MP allows to describe in more detail the structure and content of the studied system: description of housing comfort and its parameters, allows to increase the efficiency of fuzzy situational networks as a modeling tool in solving problems of management of complex organizational and technical means [10].

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Цюцюра Світлана Володимирівна
Доктор технічних наук, професор, професор кафедри інформаційних технологій, *orcid.org/0000-0002-4270-7405*
Київський національний університет будівництва і архітектури, Київ
Костишина Наталія Вікторівна
Асистент кафедри інформаційних технологій, *orcid.org/0000-0003-0521-7228*
Київський національний університет будівництва і архітектури, Київ
Єрукаєв Андрій Віталійович
Кандидат технічних наук, доцент кафедри інформаційних технологій, *orcid.org/0000-0002-9956-3713*
Київський національний університет будівництва і архітектури, Київ

ВИКОРИСТАННЯ НЕЧІТКИХ МЕРЕЖ ПЕТРІ ДЛЯ ІНФОРМАЦІЙНОГО ОПИСУ ЖИТЛОВОГО СЕРЕДОВИЩА

Анотація. *Сучасний стан комфортності багатоквартирного будинку вказує на безліч проблем, які існують у цій галузі. По-перше, є потреба в чіткому плануванні комфортабельного житла, яке має враховувати сучасні соціально-економічні потреби населення. По-друге, не існує чіткого визначення рівнів комфортності багатоквартирного будинку. Також є потреба у визначенні основних чинників, які впливають на життя і комфортність населення. В основу статті покладено два основних напрямки дослідження. Першим є представлення опису інформаційної моделі гібридної інтелектуальної системи (ГІС) для комфортності житлового середовища багатоквартирного будинку. Цей інструмент дає можливість моделювати ефекти взаємодії, адаптації, які можуть спостерігатися в системі при прийнятті рішень. Також об'єктом дослідження є імітаційне моделювання складних систем на основі використання нечітких мереж Петрі (МП) для опису комфортності. МП і її різноманітні види є одним із класів моделей, які надають можливість представити структуру інтегрованих організаційно-інформаційних систем і комплексів, а також логіко-часових процесів функціонування системи. Нечіткі мережі Петрі поділяються на дві частини. Перша частина описує структуру мережі, зазвичай вона є стандартною і процеси початкової розмітки та переміщення маркерів по мережі визначаються засобами та методами нечітких множин і нечіткої логіки. Найбільша сфера їх застосування – це складні об'єкти. Нечітка логіка використовується для формалізації нечітких понять з точки зору семантики і забезпечує ефективне оброблення інформації нарівні з чіткими даними. За допомогою такої мережі досліджується витривалість систем моделювання і оптимальність її структури. На сьогодні відома велика кількість різних видів мереж Петрі, які надають можливість представити структуру функціонування моделей в умовах відсутності аналітичного представлення впливу тих чи інших факторів.*

Ключові слова: нечіткі мережі Петрі; комфортність; інформаційна модель; зручність житла

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