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Smart Village as an action system supporting people with special information and communication needs

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Abstract. The paper presents selected results of theoretical research regarding the concept of a smart village as an intelligent operating system oriented to supporting people with special information and communication needs. Such a system is a developing system of socio-technical nature, which in its area enables the cooperation of its inhabitants as a local society. The presented idea of Smart Village is therefore based on the combination of modern tools and information and communication technologies to improve the quality of life and raise the standard of public services for citizens with much better use of resources and with less negative impact on the environment. It was pointed out that

before proceeding with the design of the Smart Village as an intelligent operating system, it is important to identify the needs and capabilities of subsystems in a specific village and commune, and then, on this basis, design a model of an operating system supporting people with special information and communication needs as a hybrid system. The concept of Smart Village as a system of action is therefore very important for the development of rural areas, both because of new opportunities to create new jobs, as well as from the point of view of the quality of life and work in the countryside. More and more attention is paid to these problems, especially in terms of practical aid programs, but so far no one has defined a smart village system. For these reasons, this study is pioneering and awaited due to the need to develop a modeling method and possible subsequent implementation of the Smart Village system model in system practice.

Keywords: Artificial Neural Networks, Computer-Aided System, MATLAB and Simulink, Smart Village, Systems Development Engineering

1 Introduction

In recent years, on the one hand, the phenomenon of rural depopulation has been observed, and on the other hand, there have been changes in the role of the village, where people living in it more and more often do not earn their living from work in agriculture, but from activities related to the surroundings of the village, and even work in cities far away from it. Following this, the population living in rural areas more and more often uses modern technologies to improve the quality and standard of their lives and work, taking advantage of the opportunities offered by sustainable development programs.

However, not all rural residents are prepared for radical changes in terms of full use of modern information and communication technologies, which is especially true for older people who have been abandoned by their children, choosing to live in cities or going abroad [1, 11, 19, 21, 23]. There is also a large part of the population who, despite their young age, are unable to independently prepare themselves for the new living conditions in the countryside, including the use of information and communication technologies at work and in personal, family and social life.

In order to meet these types of problems, this work attempts to show the Smart Village (SV) system as an intelligent operating system that enables supporting people with special information and communication needs. Such a system is a developing system of socio-technical nature, which in its area enables cooperation of its inhabitants [10, 13, 21, 24, 29, 44, 50-51]. The presented concept of the Smart Village system is therefore based on the combination of modern tools and information and communication technologies to improve the quality of life and raise the standard of public services for citizens with much better use of resources and with less negative impact on the environment [11, 16, 19, 45].

It should be noted that the Smart Village system is an intelligent operating system shaped differently in individual villages and communes, depending on the current needs and possibilities of action [16, 19, 28]. Nevertheless, despite the fact that the concept of the Smart Village system is not currently based on the implementation of a universal solution, its definition is possible in a systemic way using the closer and further system environment, and there are already many Smart Village concepts developed around the world, including in Poland [11,

19]. For these reasons, before proceeding with the design of the Smart Village system as an intelligent operating system, it is important to identify the needs and capabilities of a given village, and then, on this basis, design a model of an operating system supporting people with special information and communication needs [16, 19, 37-38, 60].

The concepts of the Smart Village system developed and made available in the literature on the subject are very important for the development of rural areas, both because of new opportunities to create new jobs, as well as from the point of view of improving the quality of life and work in rural areas, which applies to both Europe, as well as Asia, South America and Africa [2, 4, 14, 39, 48, 56].

More and more attention is paid to these problems in the field of practical assistance programs [3, 5-6, 27], but so far no one has defined the Smart Village system in terms of systems engineering and control theory, or more broadly, the Smart Municipality system [10, 18, 24, 29, 44, 50-52]. For these reasons, this article is a pioneering approach to this intelligent operating system, both in terms of the definition of the system as well as the possibility of obtaining its model using identification modeling or neural modeling [29, 34, 44, 52-53, 59].

Research in this area is very important, because it is estimated that by 2050, 70% of the world's population will live in urban areas, and smart cities use at least one or many smart systems, including from: smart healthcare, smart transport, smart infrastructure, smart power grids, etc.

2 The state of development of the Smart Village concept in the light of the literature

The state of development of the Smart Village concept has been extensively discussed, e.g. in works [11, 16, 19, 30, 32, 35, 49, 57], from where e.g. shows that the first concepts of smart villages were not based on the uncritical use of solutions used in solutions for smart cities, but from the very beginning were associated with focusing on the use of specific features of the rural area, including the use of its individual natural resources, geographical and cultural location, as well as, above all, human potential to improve the quality of life of its inhabitants. As a rule, it was emphasized that the role of technology, especially information and communication technologies, should be taken into account in the first place. Such an approach is worth developing and noting that information and communication technologies are important here, but the more important is the skilfully treated systems built into Smart Villages, of course functioning as intelligent operating systems and related intelligent development systems based on digital technology, both in the field of energy as well as other technical and even administrative infrastructure systems [8-9, 12, 17, 20, 26, 36, 40-41, 55, 58].

Therefore, building a methodology for designing and implementing intelligent systems of this type, such as the Smart Village system, is possible on the basis of operation engineering, and more precisely on the basis of cybernetics and systems development engineering [10, 15, 24-25, 29, 31, 51-53]. In this approach, an intelligent operating system is subject to development in a specific area of operation, in its closer and further system environment. In systems engineering, the products manufactured and the services provided are outputs from an intelligent operating system, in which material, energy, information and decision-making supply streams are the inputs, subject to processing in this complex operating system, which is an intelligent system such as the Smart Village system [51-52].

Let us therefore note that in this approach, information and communication technologies, which are elements of the system, can be assigned the right place as elements of infrastructure, which applies in particular to systems of equipping facilities with intelligent elements [7, 37-38, 41, 53, 60]. For these reasons, input streams and output streams of an intelligent operating system should be clearly separated from the structure of the intelligent system, including its technical, social and other infrastructure [29, 51-53].

Therefore, support for rural areas not only in terms of technical and social infrastructure, which are undoubtedly very important, but also support in the area of information and communication infrastructure, which makes these operating systems intelligent systems, is now a priority action [11, 33, 38 -39, 42-43, 46-47, 53, 60], because only such equipped systems can contribute to improving the attractiveness and quality of life of rural residents at the current stage of development.

It is worth noting that the information and communication potential of rural areas is much lower than the information and communication potential of urban areas and other urbanized areas, which by the way also translates into definitely lower skills of people in the field of digital education, and thus into definitely lower organizational and innovative. Therefore, in parallel with equipping rural areas with information and communication infrastructure, it is necessary to enable the population living in rural areas to implement solutions leading to learning new ways of using information and communication infrastructure of a new quality. This observation is related to the need to identify the assessment of needs and opportunities in individual villages and settlements of small towns, often far away from their urbanized centers, in order to determine development directions adapted to the current state of development on this basis [11, 29, 50-53]. In order to build appropriate models of intelligent operating systems, it is therefore also important to identify and assess the existing state of villages functioning as operating systems within communes.

Therefore, first of all, the process of identifying the village in systemic categories should be designed in order to examine its functioning status and its possible directions of development as a smart village. The research methodology may be based, among others, on: on identification methods [24, 29, 50-52, 59] and on neural methods [34, 47, 53] in order to obtain adequate models of the smart village system. This type of approach integrates the quantitative and qualitative approach to the system and its assessment, e.g. using the theory of control and systems [18, 24, 29, 44, 50-52] in order to show the degree of internal organization of the system and the height of the control level.

This approach provides an in-depth analysis and a more consistent interpretation of the results [11, 29, 52]. At the same time, the research results can be strengthened with statistical methods and data visualization techniques, even of the cluster analysis type [53-54], which ultimately allows for comprehensive and reliable mapping of the directions of development of the researched area, creating rankings and identifying systems that are related to each other in terms of operational security [24 , 50-51]. In recent years, interest in identification and neural methods, as well as other methods of artificial intelligence, has been growing in the scientific community, which means that we are increasingly talking about various Smart systems. However, identification research or neural research requires access to large databases and their subsequent competent use. In this regard, there are no available research results in the literature on the subject.

Nevertheless, many interesting solutions have already been developed in the literature on the subject, especially in the field of implementing Smart Village systems, which are worth presenting here at least in a synthetic way. Well, e.g. in [32] we find a statement that there are many intelligent subsystems, which, as the authors show, are in fact, in the case of the concept of Smart City or Smart Village, a system of systems, i.e. cyber-physical subsystems built using the Internet of Things (IoT), etc.

However, as noted in [28], in the times of an advanced technological revolution called Industry 4.0, indicators that could be used to define and assess the degree of development of the Smart Village system have not yet been developed. Despite ambitious plans for the development of villages and rural areas, in many countries of the world, communities still struggle with poverty, illiteracy, unemployment, and even the lack of technical and social infrastructure (e.g. health, education), etc. [39, 45], which makes the road to the level of the Smart Village system in many areas of the world still a long way off, and therefore the matter of building this level of society requires even more systemic action.

It can therefore be seen that what is important here is, above all, the high level of development of digital technology [8] and artificial intelligence methods [53], which can enable more adequate connections between rural areas, hence, for example, research conducted in Indonesia showed, among others, that the most important there are three key technologies that determine the existence of the Smart Village system, namely: IoT, artificial intelligence and big data sets [4].

The authors of the article [12] also add blockchain technology in addition to IoT, so that local leaders can manage and support the local community. The authors of the article [48] from India, in turn, go even further in their considerations and claim that the development of each country depends on the development of the countryside, hence the Smart Village concept should be a priority concept nowadays. They claim that the key role should be played by the measurement system, which should be used to monitor, control and automate the operation of agricultural systems, water and energy infrastructure systems, etc. The authors of the article [42] also indicate that in India the Smart Village goal is associated with the need to combine knowledge with technology so as to significantly improve the conditions of the population and introduce sustainable development without economic and social inequalities.

In [55], the authors indicate the need to ensure the stable functioning of urban infrastructure, because the transformation of traditional infrastructure into intelligent infrastructure introduces a number of new challenges resulting from the underdevelopment of IT networks as well as the limitations of AI technology. At the same time, they proposed that the smart infrastructure system should take into account the relationship with the seven subsystems of the smart city, i.e. with: smart home, smart medicine, smart transport, urban planning and traffic management, smart energy management, smart crisis management and smart environmental protection. They also proposed examining four indicators, i.e. how the smart infrastructure system is affected by: information flow, product life cycle, lifestyle and social behavior. Although they refer to the Smart Ccity concept, they can also be easily adapted to the Smart Village conditions.

In this spirit, the authors of the article [2] propose, for the conditions in Indonesia, which has a lot of villages scattered over 17,506 islands, the use of a geographic information system in addition to information technologies to build a database on which a Smart Village can be based. Also in style, the article [3] shows the importance of three intervention Smart Village

development programs, that is, the Indonesian smart card for education, the Indonesian health card for health care, and the food program for households to ensure an adequate standard of living for Indonesian residents. On the other hand, in the work [43], it was pointed out that, unlike the Smart City, where it is important to analyze mass behavior, in the case of Smart Village, it is important to analyze the behavior of individuals.

Without exhausting the relatively rich literature on the subject in the field of Smart Village, it is worth emphasizing that they usually concern a large number of publications on implementation directions, and only a small number of them concern the concept and modeling of Smart Village. Therefore, in this regard, the publication [31] deserves attention, in which the authors used the preferred items for systematic reviews and meta-analyses (PRISMA) based on 56 articles to construct the concept and model of the smart village, obtaining four main components of the conceptual model of the smart village: objectives, strategies, dimensions and fundamentals.

It is worth noting that each component also has its own sub-components, and the elements of the dimension cover seven thematic areas, such as: economy, ICT, people, management, environment, life and energy. This is an important review article enriching the theoretical research on the smart village and showing the existing expectations for the development of the concept and theoretical model of the Smart Village system.

3 Development of the Smart Village concept in Poland

The first concrete actions in Poland in the field of the Smart Village system concerned implementation solutions and took place during the Rural Activation Forum, when, among others, "Conclusions and recommendations for the implementation of solutions related to the development of smart villages (Smart Village) in Poland" were developed during the International Workshop on Smart Villages, which took place in the building of the Ministry of Agriculture and Rural Development in Warsaw on October 21-22, 2019 [19].

At that time, examples of initiatives in line with the idea of Smart Village undertaken in European countries, especially in the region of Central and Eastern Europe, were presented, which showed that there are Polish initiatives, even awarded and distinguished in the competition entitled "My SMART Village", organized by the Institute for Rural Development and Agriculture of the Polish Academy of Sciences, which became an inspiration for an important discussion on this important topic of the development of intelligent technologies in the Polish countryside.

It is worth quoting some conclusions drawn at that time, including that:

- there is a need for the Smart Village approach to be accessible, common and flexible, as well as supporting the creativity of ideas and originators, and at the same time being an effective, attractive and engaging approach for people, etc.,
- it is necessary to develop such strategies and forms of Smart Village development so that the very name of the SV does not "deter" from the implementation of this idea, which should be a long-term idea, not seasonal, and therefore scientifically justified, and not focused only on raising funds from various sources,
- it is important to develop such solutions that the Smart Village concept has commercial aspects, not ending with planning and developing ambitious strategies not related to their implementation,

- it is important to work out that the Smart Village approach serves to intelligently develop such approaches as e.g. partnerships for innovation, "village renewal" and establishing and developing local and supra-local cooperation, etc.,

- the aim of the Smart Village idea should be to stimulate the development and dissemination of mobile solutions in rural areas, including the development of access to broadband Internet, removing infrastructural barriers, disseminating access and improving the quality of e-services, as well as solving problems with digital competences of rural residents, including building consumer awareness, building the farmer's awareness of the need to care for the method of production and proper relations with the environment; bringing consumers and producers closer together by building short food supply chains, etc.

Without presenting here all the conclusions developed, which were described in the extensive work [19], it is worth adding that based on the above conclusions, e.g. the following recommendations:

1) in global solutions, a Smart Village approach should be proposed based on the following attributes: integration, multi-sector and multifunding, diversity of local ideas, the possibility of using local partnerships, building trust with risk acceptance;

2) in the approach to the Smart Village, knowledge and skills to use it should be used based on one's own strengths reinforced by external experts with building trust between the participants of the process;

3) assume that there is no single Smart Village model, hence each time with the help of leaders, it is necessary to adapt to the needs and capabilities of a given community, using its common vision and each innovative idea for Smart Village;

4) develop the terminology regarding the Smart Village based on the expectations of the local community, so that it is not so much a fashionable terminology as it flows from the rural community, and therefore identified with it;

5) rebuild the village on the basis of the existing tradition and lifestyle, which requires gradual support for changes and implementation of Smart Village with coordinated support by various types of advisory entities, including: Local Action Groups, agricultural chambers, or local government;

6) the experience of the National Rural Network should be used and its tasks should include the obligation to support the development of the Smart Village idea, e.g. through networking, promotion, good practices so that the countryside becomes an increasingly better place to work and live for the population based on local resources;

7) in the implementation of Smart Village, the experience of vertical communication should be used, which involves the development and use of strict and unambiguous terminology in this area, understandable at all implementation levels;

8) the principle should be applied that financial support for the implementation and development of the Smart Village idea should be directed to partnerships composed of at least two local entities, intended for analytical and research, promotional, educational and advisory activities;

9) the introduction of a bonus system for the most active and most interesting implemented Smart Village solutions should be considered;

10) it should be ensured that the Smart Village approach is a flexible approach related to the generation of ideas depending on the real needs and aspirations of the inhabitants of a

specific village, and not on the amount of the fund obtained, in order to prevent the occurrence of the so-called "instrumental over training";

11) identification of the village level should be carried out, and on this basis a catalog of criteria, reference points, etc. should be defined and developed in order to measure the level of Smart Village, and only on this basis should research be conducted towards the use of development stimulators;

12) conduct IT education on a larger scale in the use of information and communication technologies and build help centers for their use in order to popularize their use in many areas of life, including bringing consumers and producers closer together through effective short food supply chains, etc.;

13) develop a way of using advanced information, communication and logistics technologies by all Smart Village residents in a trust-building way by combining it with solid consulting and information brokerage, as well as by building a business model.

Based on the above conclusions and recommendations of this type, the position of the participants of the international workshops was developed to be presented at the session of the 4th European Rural Parliament, which took place in Candas (Asturias, Spain) on November 6-9, 2019, which concerned, among others, [19]:

- building a Smart Village based on experience while avoiding bureaucracy, which should and should serve to intelligently develop partnerships for innovation, village renewal, etc.;
- implementation of the partnership in a bottom-up manner conducted by local governments, starting from one village in consultation with local action groups and advisory entities as well as local development center's;
- preventing the digital exclusion of villages, which requires prior coordinated action to prepare rural areas for the implementation of Smart Village, including the provision of broadband Internet infrastructure, e-services everywhere and ensuring digital competences of residents;
- preparation of local community leaders and people involved in rural development, as well as involvement of relevant NGOs and volunteers;
- developing a method of distinguishing active local societies for the most interesting initiatives;
- preparing the possibility of building short supply chains in areas with a large number of small farms, which is associated with the earlier construction of a purchasing platform as well as strengthening cooperation between farmers and consumer institutions with the creation of local patriotism;
- providing consultancy and institutional support for Smart Village implementation processes using new environmental technologies in conjunction with building a business model.

4 Neural modeling of the Smart Village system

As we tried to show in chapter 3, the concept of the Smart Villages system, although it has many features of a scientific concept, is often described without any reference to theory, results of research experiments or theoretical scientific publications. It is based more on implementation solutions, which causes some scientists to believe that it lacks a properly formulated theoretical basis. There are even views that the evolution of support for the

development of local communities, including Smart Village, has taken place basically without reference to theory, which in its development does not keep up with practice, as is the case in other IT implementations. However, recently there has been an increased interest of scientists and other researchers in the Smart Village concept and models, which translates into an ever-wider catalog of publications, mostly publications on implementation solutions, but recently there are also theoretical concepts and proposals [1, 11, 16, 19, 21, 23].

Undoubtedly, the concept of the Smart Village system, like many other concepts of this type that preceded it, such as: Smart City, Smart Metering, Smart Power System, Smart Grid, etc. belongs to the concept of artificial intelligence systems. Following R. Staniszewski, it is worth presenting the states of the world of artificial intelligence systems (Table 1), among which the Smart Village system can be placed among the OS (environment-society) and SO (society-environment) systems of the world [53].

In this perspective, the Smart Village can be viewed from two sides, i.e. from the point of view of the environment (infrastructure) affecting the local society, e.g. information and communication infrastructure supporting the operation of the local society or from the point of view of the local society affecting the environment (information and communication infrastructure) . Both states of the systems can be modeled using known analytical and identification methods as well as artificial intelligence methods, such as methods using artificial neural networks (neural methods) [29, 34, 47, 52-53, 50]

Table 1. The world of states of the world of artificial intelligence systems and intelligent systems according to the concept of Robert Staniszewski. Selected markings: in the text. Designations: OM - One Man, GP - Group of Peoples, SO - SOciety, EN - ENvironment, SU - Surrounding, MA - MAchine. Source: [53]

Elements	**OM**	**GP**	**SO**	**EN**	**SU**	**MA**
OM	OM-OM, OM^2	OM-GP	OM-SO	OM-EN	OM-SU	OM-MA
GP	GP-OM	GP-GP, GP^2	GP-SO	GP-EN	GP-SU	GP-MA
SO	SO-OM	SO-GP	SO-SO, SO^2	SO-EN	SO-SU	SO-MA
EN	EN-OM	EN-GP	EN-SO	EN-EN, EN^2	EN-SU	EN-MA
SU	SU-OM	SU-GP	SU-SO	SU-EN	SU-SU, SU^2	SU-MA
MA	MA-OM	MA-GP	MA-SO	MA-EN	MA-SU	MA-MA, MA^2

Neural modeling of the Smart Village system (SV, SV system) is convenient at the current stage of development using identification methods or artificial intelligence methods, e.g. artificial neural networks, e.g. in the MATLAB and Simulink environments. The system situation of the Smart Village system is presented in terms of systems engineering in Figure 1 [25, 29, 52]. The Smart Village system (and thus the SV system model) is related to the closer environment (recipients and providers of information and communication services) by two types of coupling, i.e. coupling of actual services provided and financial coupling regarding remuneration for the services provided.

The coupling of actual services includes their delivery and sale, and the financial coupling is related to the payment for the services provided (incurred cost), and thus to the revenues obtained depending on the amount of the average price obtained and the size of the volume of services sold. As a result of, for example, neural modeling, it is possible to obtain a model of the Smart Village system in the form of one learned artificial neural network system or

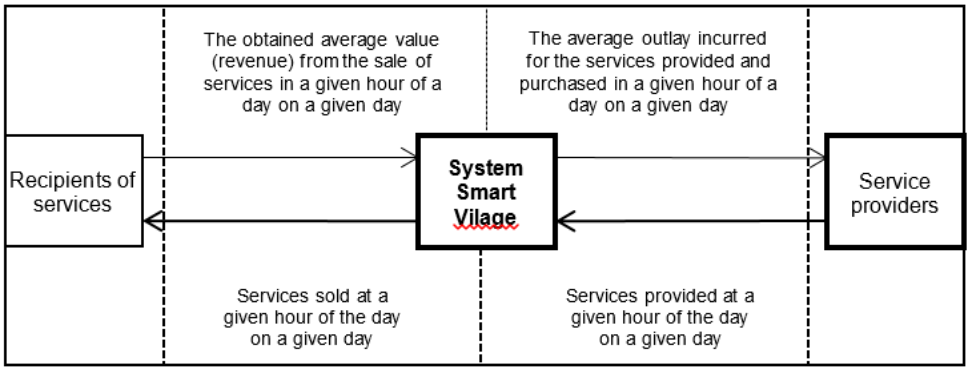

Figure 1. Location of the Smart Village system in terms of systems engineering in the closer environment. Source: own study based on [25, 29, 52].

many artificial neural networks coupled with each other, which are neural models of the distinguished subsystems.

Therefore, the research experiment should use the numerical data of individual subsystems present in the Smart Village system, which can be recorded either as part of the specially generated statistics of the Central Statistical Office or as part of the data records kept by individual communes. Then it is worth adopting a contractual data measurement period and with the progress of e.g. one month or one quarter, teach artificial neural networks a catalog of models.

In the case of the obtained neural models, we obtain in this way two equations for each learned subsystem of the Artificial Neural Network, i.e.: the equation for determining the adder of weighted input signals (net) and the activation function of neurons on each neuron and in each layer of the Artificial Neural Network. Thus, in a systemic way, the process of modeling the identification and/or neural Smart Village system is shown in Figure 2.

As a result of designing the Smart Village system, a real system is obtained that functions in a closer and further systemic environment. By subjecting it to identification or teaching a properly designed Artificial Neural Network, a model of the Smart Village system is obtained. The obtained model can be used to carry out appropriate simulation and comparative studies, or to test sensitivity, and even to measure specific quantities. In this approach, the neural modeling of the Smart Village system in a formalized way can be reduced to the problem of finding a mapping of the measurement data matrix recorded on the real SV system in the form of training pairs:

$$ZN = [input, output] \quad (1)$$

into model parameter vectors $[\theta]$ written in the form of parameters describing weighted adders and activation functions of artificial neural networks, where N is the number of ordered observations of successive values of input variables and successive values of output variables [34, 47, 53]. It should be emphasized here that there are no relevant results of research on

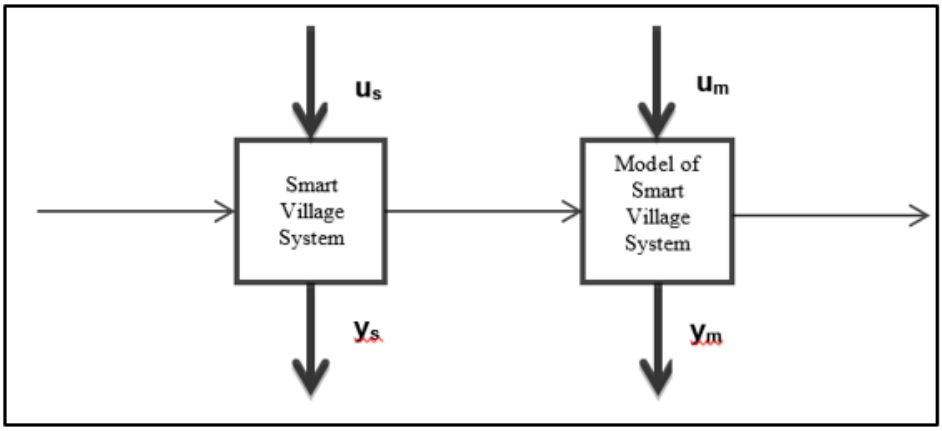

Figure 2. Illustration of the Smart Village system modeling process. Notations: u_s – s-th input, y_m – m-th output, s – system, m – model. Source: own study using systems engineering [24, 52].

neural modeling of the Smart Village system conducted in order to obtain its models as substitute schemes of real systems. Therefore, an extremely important research problem is to define the research object itself, i.e. the Smart Village system as a management system (MS) on the map of smart systems of cities, communes and villages. It is therefore assumed in terms of control and systems theory that the structure of the Smart Village system as a management system consists of the following subsystems (Figure 3): – information (SI), analytical (SA) and decision-making (SD) systems, which are part of the control system (SS), – the system of internal organization, the so-called internal organization of the Smart Village (SOW) system, – service executive system, as an execution system (SW).

Designations for Figure 3:

SI - information system,

SA - analytical system,

SD - decision system,

SOW - internal organization system (information and decision-making system),

SW – executive system,

SS - control system,

U – stream of input quantities, i.e. vector of the volume of services provided in particular hours of the day,

y – the stream of output quantities, i.e. the vector of average prices obtained for ee delivered and sold in individual hours of the day,

i_u – a stream of information about the volume of services provided in particular hours of the day,

i_y – a stream of information about the average price paid for the services provided in particular hours of the day,

du – a stream of decisions regarding the average price obtained for the service delivered and sold in particular hours of the day,

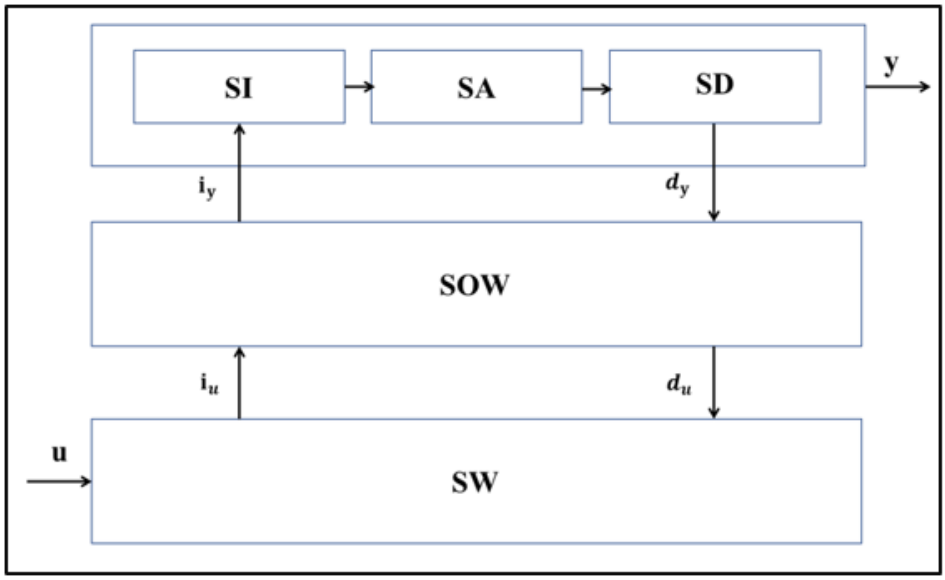

Figure 3. Drawing illustration of the Smart Village system as a management system. Designations in the text. Source: own study based on [24, 29, 52].

dy – stream of decisions regarding the obtained average price for the service provided in particular hours of the day.

In the conducted analytical studies, the systemic background was adopted according to the interpretation used in systems engineering [24, 29, 44, 50-52]. The subject of research is therefore the process of, for example, identification modeling or neural modeling. It is conducted using a set of input and output values of the Smart Village system, i.e., respectively: the volume of the supplied and sold information and communication service and the volume-weighted average price of the information and communication service received on this account in individual hours of the day.

As a result of identification or neural learning, the parameters of the model catalog are finally obtained, e.g. in a rolling system, which can be used in assessing the level of control of the Smart Village system and in assessing the degree of its internal organization, in which the research is continued

5 Conclusion

In the literature on the subject, one can note a significant potential of scientific works on various solutions in the field of implementing the Smart Village system. Note the first attempts to build a concept and theoretical approach to the Smart Village system. In this paper, an attempt was made to show the main achievements in this area, including recommendations as well as theoretical concepts of building the Smart Village system.

On this basis, the paper presents selected results of theoretical research regarding the concept of a smart village as a system of action oriented towards supporting people in general, including supporting people with special needs, especially those unprepared for the use of intelligent information and communication technologies.

In addition, an attempt was made to define the Smart Village system as an intelligent operating system enabling support for people with special information and communication needs. Such a system is a developing system of socio-technical nature, which in its area enables the cooperation of its inhabitants. The presented definition of the Smart Village system is therefore based on a combination of intelligent tools and intelligent information and communication technologies used to improve the quality of life and raise the standard of public services for citizens with much better use of resources and with less negative impact on the environment.

It was also pointed out that before designing the Smart Village system as an intelligent operating system, it is important to identify the needs and capabilities of the subsystems present in a specific village, and then, on this basis, design a model of an operating system supporting people with special needs as a hybrid information and communication system.

The concept of the Smart Village system as a system of action is therefore very important for the development of rural areas, both because of the possibilities of creating new jobs, as well as from the point of view of raising the quality of life and quality of work in the countryside to a higher level.

More and more attention is paid to these problems, especially in terms of practical solutions implemented as part of aid programs, but no one has yet defined the Smart Village system. For these reasons, this study is pioneering and expected due to the possible subsequent implementation of the model in systemic practice, while shaping the future, it is necessary to use appropriate tools supporting the development of this concept as well as its implementation [25, 31, 50-51]. It is therefore worth clearly indicating three directions of research regarding the management system of the smart village, i.e.:

1) the method of systemic transformation of a real system, such as an existing village, into a real system of a smart village, which involves, among others, equipping it with information and communication solutions to an extent accessible to every person,

2) method of obtaining a model of the real system at the present moment and at each subsequent moment related to obtaining the status of a smart village system,

3) method of measuring the degree of development of the smart village system, e.g. using the smart village system model, and especially the degree of its internal organization and the level of control, of course, obi=ok many other problems related to the development of the village and its surroundings, including the method of systemic transformation. This work concerns the search for a concept for joining the research trend related to the modeling of a smart village and the search for a way to develop a uniform indicator for assessing the degree of rural development towards a smart village system, hence research, especially in these two directions, will be continued.

Therefore, the fundamental problem related to changes introduced in the real system that is the village concerns: identifying an existing specific village in order to obtain its model, designing the strategy, vision and goals of its development and designing a model of a smarter village with a method of introducing the necessary changes, including measurement from using both models of the degree of development of both rural states, i.e. the currently existing state

and the planned state, assuming its full technical, economic and social feasibility, along with paying special attention to the introduction of necessary services that make the lives of people with special needs, including the elderly, easier to live and other people expecting support in various areas of life, in particular information and communication support, in addition to the traditionally used methods addressed to people with special needs. In such modeling, artificial intelligence methods, including: training an Artificial Neural Network system model seems to be a noteworthy direction of research next to machine learning methods, especially regression methods used in system identification.

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