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Multiservice Networks in Digital Houses

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Abstract: *The paper considers problems connected with the construction of intelligent living environment. The investigation in this paper is focused on problem formulation and directions, in which methods and tools have to be developed for inter-operation of heterogeneous digital systems in multiservice networked digital houses that have extendible functionality.*

Keywords*: Digital home, integrated system, multiservices network, energy saving.*

1. Introduction

The digital home systems are natural extension of the existing electronic, information and communication technologies. There are already technological standards for Home and Building Automation (HBA) including KNX (www.knx.org), ZigBee (www.zigbee.org) and LonWorks (Echelon Corporation, www.echelon.com).

Currently most of the professional and home digital systems, such as audio and video electronics have network functions and connection to Internet. The broadband is widely available in living environment, personal digital devices become very popular, local networks and wireless technologies get growing interest. This gives the possibility to monitor and control various home appliances in a network, using web technologies. These facts are recognized by home techniques manufacturers, computer and interface developers, mobile operators, civil engineers and other organizations. There is already developed software and hardware with current emphasis on the "internet of things". This conceptually desirable technology provides a new kind of lifestyle.

Using digital technologies in the living environment is oriented to comfort, entertainment and health. Moreover, the digital systems in houses have economical benefits too. Specialists estimate that using digital systems for intelligent control in living environment allows the decreasing of exploitation costs up to 30%, of electricity costs 30%, of water costs 41%, of heating costs 50%, decreasing of CO_2 – up to 30%. The economic effects may come from reduction of the operative personal for support of complicated engineer systems that will be assisted by intelligent systems.

Large attention is paid to energy-saving buildings worldwide. However, this concept considers mainly HVAC – Heating, Ventilation, & Air Conditioning, but it does not take into account other systems in living environment. Besides that, the existing technologies offer only static automation capabilities, consisting of pre-designed application scenarios. They do not allow autonomic adaptation to the environment and dynamic context-awareness. A still widely neglected potential for energy savings resides in the use, control and interaction of digital home facilities [1].

Using of information and communication technologies for installing, connecting and automatic controlling a number of building elements [2, 3, 4] may give better comfort and convenience for inhabitants and economy in energy consuming.

But a lot of problems still have to be resolved, for example: how all these house's devices will communicate, how they will be managed, aggregated, and how the data will be distributed. The investigation in this paper is focused on problem formulation and directions, in which methods and tools have to be developed for inter-operation of heterogeneous digital systems in smart living environment that have extendible functionality and address energy saving.

2. Main challenges of digital home control systems

At present methods for automation in living environment are focused on the construction of relatively static structures, designed in advance. This technology needs further research and development in order to meet the users' long-term requirements for implementation of intelligent systems in houses.

The problems connected to the construction of intelligent living environment are various and have different scientific, technological and psychological aspects. The main challenges in this area concerning information processing and energy saving technologies can be formulated as:

- *integration* of the infrastructure of the smart living environment with services for providing information processing and energy savings;
- taking into consideration the *heterogeneous* data and processes in the distributed information networks and necessity of integration of various *interfaces.*

In the survey of the scientific investigations in the area of *integration of infrastructure with services*, some problems appear that concern the resource control, inter-operation and possibility for reconfiguration of the digital systems. But uniform technologies and methods for integrated inter-operation of

heterogeneous digital systems in living environment, orientated towards optimal use of the resources and energy are not developed yet.

Inspite of the advance of network technologies, it is still necessary to design and implement robust and productive computers environment, that is able to ensure control of information traffic and transport of different volumes of various information [8] for providing maximum security and comfort, convenient communication tools, monitoring of the resources in accordance with social, psychological and economic aspects.

The local networks in a digital house are usually realized with different technologies, regarding the volume of information that is transferred from the integrated devices. However, sensors may not use standard communication protocols suitable for computers. In fact, sensors need cyclic isochronous real time exchange of a small amount of data, while computers and other multimedia devices exchange large data volumes without strong time restriction. Heterogeneous networks in a digital house are shown on Fig. 1.

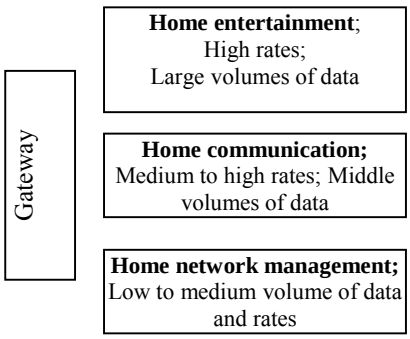

Fig. 1

Hence, the scientific tasks set the need for modeling of flexible adaptive algorithms directly connected to the features of distributed information networks with heterogeneous data.

In order to realize an automated system for intelligent control and energy saving in smart living environment, the followings scientific tasks have to be solved:

- investigation on the models describing heterogeneous digital systems;
- investigation on the models for interaction between heterogeneous digital systems; selection of inter-operation approaches (asynchronous message exchange, web services; centralized or distributed interaction), communication style;
- development of connection types for digital systems interaction;
- development of mechanisms for discovering and connecting digital systems and services, used in the interaction process;
- analysis of different levels of inter-operation, visualization, logic of the interaction, data integration, information filters;
- analysis of the semantic differences and support of the interaction under different data schemes;

- intelligent adaptation of the house to different inhabitants, profiles creation (owner, elderly, children);
- distribution of large volumes of information on different access levels for processing and storing;
- application of the best energy saving practices and renewable energy sources technologies in EU;
- establishment of the public layer of data to be published on-line by every house in order to be used for forecasting the energy consumption;
- design of protocols for information exchange between separate smart houses and forming intelligent villages and cities.

In order to reach the full efficiency of the HBA during operation, a comprehensive software system that orchestrates all energy facilities in the home is needed.

3. Information flows in digital networked homes

The complex structure of the digital networked home has the purpose to ensure comfort, security and economy. It is characterized by various distributed information processes (Fig. 2).

The connection of sensors and actuators in a communication home network is intended to improve the system characteristics by means of simultaneously processing and diagnosing and by sharing information in Internet.

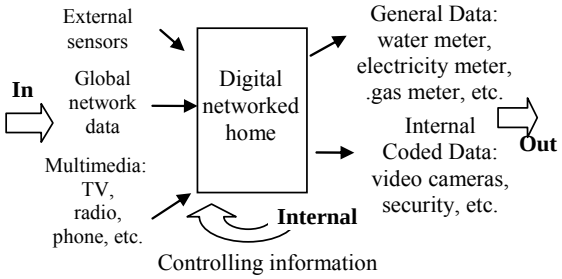

Fig. 2

Using information from different inside and outside sensors as the internal ones in a feedback loop gives the possibility to achieve desired control conditions.

4. Trends and possible solutions

In building automation, the trend can be seen within the growing demand of smart environments [9]. Several researches suggest the idea to enhance sensors and actuators with semantic description of their capabilities.

The integration of knowledge representation features and reasoning techniques (originally devised for the Semantic Web) into standard home automation protocols can offer high-level services to users [7].

Web-services for information interaction in the integrated system for building management. The combination of web services with sensor services is a promising approach for building intelligent systems in the living environment [11]. This may facilitate the technological maintenance and increase the control on the usage of the resources and energy.

Each device is connected with a particular service or a set of services. Thus a multiservice network [13] is established. The multiservice network provides existence of multiple traffic types within the house.

The service may be shared between different devices and dynamically assigned to some of them depending on inhabitants' desires. For a very simple example, music or video call may follow the indweller everywhere in the house. The service can be transferred from one device to another with inference about possibilities for the transfer and service delivery.

Sensor network environment may content two types of services: basic sensor services and sensor processing services. Each sensor is related to a web service. Processing of a service combines data from different sensors/services. The semantic description of the services allows combining them on the basis of ontological matching of their capabilities [10].

The monitoring and control of the smart living environment can be realized through a secure personalized web portal [5]. It can provide the opportunity to make a connection with the house from an arbitrary place, to check its state, to adjust its parameters for optimal use of the resources.

Energy efficiency can be achieved by automatic control of different digital systems – for example, daytime-based dimming of lights and occupancy control systems change the parameters depending on the sensor data, integration with other systems (persiennes regulator) or weather forcast from Internet.

The digital house may work on multiple scenarios, which can be controlled and monitored by a computer. The scenario is a predefined system behaviour which reacts to an event, such as a motion sensor signal, temperature level, or a command from the central unit. These events can operatively change the situation in the house. Different scenarios can be defined within different regimes – daytime, during the night, evening, in the presence of guests or absence of people, etc. The computer control may provide development of very sophisticated scenarios to ensure efficient energy consumption.

Conceptual framework. A conceptual framework for house building automation is proposed, supporting semantic-enhanced characterization of the user requirements and services/resources provided by the devices. The framework is shown on Fig. 3. Decision Support System (DSS) is a coordination unit that integrates heterogeneous data.

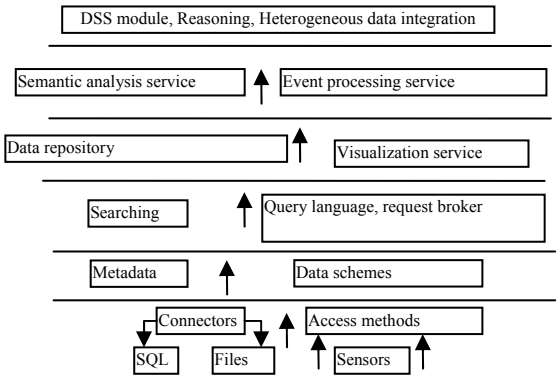

Fig. 3

Each device is enhanced with metadata and it is associated with a service. This allows discovering the functionalities and request services from other devices.

The services are discovered by semantic matching. Logic-based ranking of the approximated matches must be developed, allowing the selection of resources/services, best satisfying a request, also taking user preferences and context into account.

5. Energy saving by information aggregation

The main purpose in increasing the functions of automated control in digital houses is directed to developing tools for rational consumption of various kinds of energy. Energy saving can be achieved by aggregation information from the sensors in the house, integrated with data from Internet, in order to manage different devices optimally and to support the microclimate in the house by controlling air-conditioning, ventilation and heating devices.

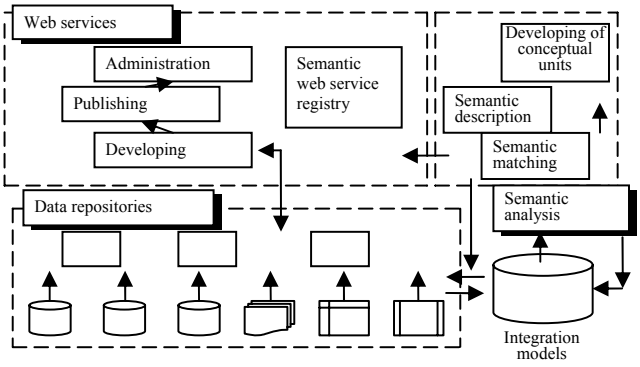

Fig. 4

The research work is intended to design, construct and evaluate systems that will allow inhabitants to modify the parameters in accordance with their personal requirements on the basis of contemporary communication technologies,

personalization, and integration of these systems with other building systems in the directions.

The full exploitation of semantics in user and device description has several benefits which include:

- development mechanisms to detect and connect the necessary digital systems used in the process of interaction;
- analysis of different levels of interaction: visualization, logic of interaction, integration of data;
- development of different management scenarios – depending on the daytime, on the presence of guests, in the absence of people, and others. Reporting of energy consuming and efficient control;
- development of software, supplemented by service-oriented architecture for managing resources, and opportunities for interaction;
- tools to support the relay timers, and establish the functions executable in time (including the heating, lighting, etc.). Support for sending and transmission of messages, such as a warning or a reminder.
- using of dynamic content from Internet for different needs and users with different skills in the living environment, for example, development of algorithms to manage resources according to the weather.

6. Conclusion

Current solutions of automated control systems in digital networked homes poorly support dynamic scenarios and context-awareness. Ongoing research covers virtual sensors and how to include the description of these sensors in the control system for smart living environment [12].

It is recognized that methods, that ensure integration between the various subsystems automatically and in real time, still have to be designed.

Solving the problems of integration, the infrastructure with services in distributed information systems, considering the processes heterogeneity in the smart living environment will enable to:

- optimize the network infrastructure;
- increase reliability of the whole system;
- increase the operability of the control of separated objects;
- improve the perception of the system information and its equipment on different levels (object, area, address) by visual representation;
- provide technical diagnostics;
- improve the living condition of certain social groups (disabled people, elderly people, children) [6];
- enhancement of the efficiency of control operability of separate objects;
- monitor the resources and implementation of the best energy saving practices.

Multiservice networks in digital houses will provide a basis for different operations such as VoIP, streaming media, video and interactive applications together with tools for innovative control systems over the same physical infrastructure.

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Мультисервисные сети в цифровом доме

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(Резюме)

Статья посвещена проблемам создания интеллектуальной среды обитания. Исследования фокусированы на формулировке проблем по направлениям, в которых должны быть разработаны методы и средства, обеспечивающие взаимодействие гетерогенных цифровых систем в мультисервисной сети цифрового дома.

Эти сети должны иметь расширяемую функциональность.