Analysis of factors affecting the quality of network services provided by the user in smart home internet of things technology

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Abstract: The internet of things technology smart home system operates on an extensive knowledge base, and stores all the information necessary to achieve the goals of energy efficiency and user comfort. Its intelligence is also realized inside a multi-agent system, which also ensures the openness of the system to the outside world. As a first estimate, it is developed and verified by modeling a profile management strategy.

Today, all companies in the world, gradually moving to more advanced and efficient methods, are guided by the methodology of strategic management, which includes many different working, basic and auxiliary tools.

The expediency of developing a functional diagram of the service provision process lies not only in a visual representation of the "work" of the quality system, but also in the fact that it allows you to identify and eliminate possible gaps in the organization of this activity, when the necessary performers may not be available to perform some functions. In the future, this will ensure a clear functioning of the quality system.

Keywords: Internet of Things, IoT smart home system, Quality of network services, operability, transmission speed, reliability, latency, energy efficiency, quality of perception.

The definition of "**smart home**", which first appeared in 1985, and the “Internet of Things” technology, which was first mentioned in 1999 in practice, denotes two different concepts of home automation: home automation (SMART-HOME) and residential building automation (BUILDING AUTOMATION). [1]

SMART technology is a new approach to organizing the set goals, which allows you to combine all the available information at an early stage, determine the list of necessary materials, set the deadlines for the work and set specific and understandable tasks for all participants in the process. SMART-HOME is a solution in which the operation and control of all systems at the level of an individual household is automated, providing a specific room with a high level of security and all the necessary living conditions, while remotely without unnecessary interference from service organizations. The building is equipped with special monitors with sensors that help to detect threats to both the system and the residents themselves. [4]

It should be noted that the topic of the quality of network services in the smart home of the Internet of Things has not been sufficiently studied. Since this section describes the concept of *quality of network services*, it is necessary, first of all, to define this concept.

Quality of Service (QoS) is the overall effect of a service that determines the user's satisfaction with the service. In a broad sense, it is customary to distinguish two types of service quality assessment. That is the quality of service (QoS) and quality of experience (QoE). The definition of the first type is given in ITU-T Recommendation E.800 [5].

QoS - is the aggregate of all the characteristics of a service that affect its ability to meet the stated or implied needs of the user of the service. This indicator should include a certain number of network characteristics considered as the most important from the point of view of their impact on the quality of service. These are such parameters as: bandwidth; reliability of the network / network elements; delay (ms) and delay variation (jitter); coefficient (probability) of losses (%); survivability of the network - the ability to maintain the operability of the network in the event of failure of individual elements. [6,7]

The bandwidth (or data rate) of a network service is defined as the effective transmission rate, which is measured in bits per second.

The reliability of the communication network and its elements is determined by a number of parameters, among which the availability factor is most often used. The availability factor is the ratio of the time of the object's working state to the total observation time. With absolute reliability (in the ideal case), the availability factor should be equal to 1, which means 100% network availability. Such a value is practically unattainable, therefore the availability factor is normalized by values that are smaller, but close enough to one. Data packet transmission latency is defined as the delivery time of a data packet from entering the network to exiting the network.

QoE – is the overall acceptability of the service as perceived by the subjective end-user. In this case, the perceived quality includes all systemic effects "from end to end" (client, terminal, network, server program). In general, acceptability may depend on user expectations and context. in this regard, the perceived quality is defined as the aggregate measure of the satisfaction of the user working with the network service.

Quality of Experience (QoE) by the user includes the entire path from source to destination (subscriber terminal, network, service infrastructure, etc.) and may be influenced by the human factor associated with the individual's inherent expectations or the content of the information received (content). Differences in individual perception and individual preferences can influence the user's assessment. Consequently, measurements of the quality of perception should be carried out on the basis of the survey of the ratings received from the group of participants. At the same time, the perception is influenced by the level of culture, motivation, factors of concentration of attention, the emotional state of the expert, etc. [2].

№	Conceptual characteristics of the concept, updated by the surrounding context	Description
1	Security/crime Prevention	• protection against leaks; • short circuit protection in the power supply network; • fire protection (smoke sensor); • autonomous power supply (diesel generator); • automatic fire extinguishing system; • alarm to call service. • perimeter integrity control (doors and windows); • imitation of the presence of the owners; • automated control of access to the premises; • video surveillance of the adjacent territory; • automatic lighting of the territory upon entry; • control of protective shutters; • the ability to call private security; • receiving pictures from any CCTV camera via the Internet • prevention of situations that threaten human health: protection from fire, gas leaks, etc. • the necessary comfort and safety to ensure optimal childcare, video babysitting, etc.

2	High technologies of computerization	ZigBee, Z-Wave, Wi-Fi, Bluetooth
3	Energy efficiency	It is no coincidence that energy companies are among the most ardent supporters of various smart home systems that include remote meter reading. Under such a system, wasteful use of energy can be so obvious and unnecessary that it becomes a social taboo'
4	Multifunctionality	The multi-agent approach provides multifunctionality of the system, robustness to system errors, as well as optimization of computing resources
5	Comfort, reliability	In 1984, the National Association of Home Builders (NAHB), which coined the term "smart home", developed the idea of a computer-controlled home, be it a home or an apartment, that would allow owners to live more comfortable lives and spend less time on routine household tasks' (MILLMANH. // MAG: COMPUTE! 1991 (Ost)).
6	Contemporaneity	Various automation standards are also being developed for SMART spaces

Table 1. Content analysis of the "smart home" concept.

There are other factors that affect user-generated quality ratings. This is, first of all, the user's previous experience with network devices (for example, experience with devices), etc.

Depending on the subject of service assessment, methods of quality assessment are distinguished from the point of view of the consumer and the manufacturer. Evaluation methods from the perspective of the consumer are aimed at evaluating aspects of the service that are perceived by the consumer and/or are of particular importance to him.[3]

This category includes the following methods:

objective

- included observation;
- trial purchase;
- expert supervision;

Subjective

- critical;
- process rooms;
- problematic.

Evaluation methods from a manufacturer's point of view characterize an “internal” view of quality. They are subdivided into personnel-oriented methods and management-oriented methods.

Modeling any management system (company, project, urban space) as a method of obtaining integral estimates of efficiency for a variety of indicators of various options for management systems is quite simple and economical. The model of the control system takes into account the impact of various input and output parameters that characterize it, the controllability of information flows at various levels of the control hierarchy, as well as the presence of feedback (cybernetic) communication.

When developing a mathematical model for assessing the reliability of the integrated system "Smart House", a unified technique of the general logical-probabilistic modeling method is used, which is characterized by the following main stages:

– analysis of initial data for modeling;

– determination of the structural diagram of the "Smart House" system for the formalized formulation of the problem of modeling the assessment of its reliability and determination of the initial data (probabilistic, time parameters of the elements of the "Smart House" system);
– acceptance and formulation of the main restrictions and assumptions;
– formation of a list of assessed reliability indicators;
– formalized formulation of the problem of modeling and calculation, including the development of a diagram of the functional integrity of the "Smart House" system and setting a logical criterion for its functioning;
– construction of a logical model of the Smart House system performance;
–construction of a computational probabilistic model that allows to quantify the investigated property of reliability of the "Smart House" system;
– calculation of the estimated reliability indicators, analysis of the data obtained.

It is necessary to formulate a logical criterion of functioning (LCF) of the "Smart Home" system, that is, under what conditions the "Smart Home" system performs its target function.
The logical criterion for the functioning of the "Smart Home" system is interpreted as follows, see table.2. the system performs its target function, that is, it is operational when all its subsystems are operational: both the access control and management system, etc.

All structural elements of the Smart Home system are being restored. This means that during the operation of the "Smart House" system, the restoration of e elements begins immediately after the moment of their failure and is carried out with a constant intensity, regardless of the number of simultaneously failed elements in the system. This provision is permissible, since in the projected "Smart House" system all elements are highly reliable, and the intensity of their restoration is many orders of magnitude higher than the failure rate. In this case, one temporary failure of two or more elements in a short recovery time interval is extremely unlikely and can be neglected.

№	Equipment name	Quantity, pcs.	Mean time between failures, h (no less)	Recovery time, h
1	Monitoring and control panel "S2000M"	1	20 000	24
2	Signal and launch unit "S2000-SP1"	39	20 000	24
3	Switching device "UK-VK"	31	20 000	24
4	Terminal device "GSM UO-4S"	1	20 000	24
5	Radio receiving device "Astra-RI-M RPU"	1	20 000	24
6	Radio transmitting device "Astra-RI-M RPDK"	3	20 000	24
7	Access controller "S2000-2"	4	20 000	24
8	"JB-EX06P" exit button	3	200 000	24
9	IO 102-6 detector	3	200 000	24
10	IO 102-14 detector	23	200 000	24
11	Electromechanical lock "CISA 11 931.60.1"	2	150 000	24
12	Electric roller shutter drive "ALTUS RTS"	2	150 000	24
13	Crane with electric drive "JW5025"	9	50 000	24
14	Electromechanical rotary device	1	50 000	24

15	Water leakage sensor "NEPTUNE SW 005"	5	60 000	24
16	Gas leak sensor "COMPUTHERM M5000"	1	60 000	24
17	Contactless reader "S2000-PROXY"	3	60 000	24
18	UPS "SKAT-1200 S"	6	40 000	24
19	Battery 12 V; 1 Ah	3	40 000	24
20	Battery 12 V; 26 Ah	3	40 000	24
21	Fire alarm control panel "Signal 20P"	3	20 000	24
22	IO 409-34 detector ("Ik ar-5A")	30	60 000	24
23	IO 329-2 detector ("Glass-2")	15	60 000	24
24	Fire smoke detector IP 212-78 ("Aurora-DN")	58	60 000	24

Table. 2. Description of the equipment of the "Smart House".

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