

## QUALITATIVE MEASUREMENTS IN COMPLEX ORGANIZATIONAL SYSTEMS USING THE TECHNOLOGY OF OPEN DISTRIBUTED REGISTRIES

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*Abstract:* The modern theory of measurements involves quantitative and qualitative measurements. This type of measurement is relevant in the evaluation of complex organizational systems. In them, the use of informal methods of evaluation becomes as relevant as in formal methods. In the practice of assessing complex systems at a qualitative level, the most commonly used group of methods of expert evaluation. A comparative analysis of the most commonly used procedures of expert measurements is carried out, their merits and demerits are revealed. It is shown that the lack of the methods considered is the impossibility of securing consensus in an anonymous group of experts, which contains participants who do not trust each other. The solution of the problem for organizational systems is provided by the technology of open distributed registries. The main principles of technology construction are considered. Strategies for achieving consensus have been analyzed using the technology of distributed registries.

*Key-Words:* quantitative measurements, qualitative measurements, distributed registries

### Introduction

Half a century ago, the Soviet scientist Nikita Moiseev noted that "when solving difficult problems one has to resort to informal methods of analysis". And further, "... one of the main tasks of system analysis is to learn how to combine mathematical and informal methods of analysis, rigorous ways of studying formalized models with experiment, heuristic methods, expert judgments" [1].

### 1. Research methods

The toolkit of informal methods is now very widely represented. There are many approaches where instead of strictly axiomatic construction of procedures a heuristic approach is used. The difference between such methods and formal ones is the use of qualitative ones with quantitative measurements. Quantitative measurements, as a rule, are successfully used in technical systems. However, their use in organizational systems is difficult. Because the information here can not only have a quantitative form. It can be represented in the form of heuristic knowledge. In this case, to ensure the functioning of organizational systems, it is necessary to use qualitative measurements.

Expert assessment is one of the main methods of qualitative measurements in organizational systems. Here, as an axiom, a provision is adopted that in any sufficiently narrow subject area there is a group of specialists. They have full knowledge. It is taken into account that the knowledge of each specialist is

subjective. But the collective opinion of a group of actors is approaching an objective characterization of the given subject area.

The general idea of expert evaluation is to compare the state of the domain with  $\langle X_n \rangle$ , where  $X_n$  is an n-dimensional rating scale. The task of expert evaluation is posed as a measurement problem using a scale of one type or another. If we talked about qualitative measurements, then the scale should be of a qualitative (nominal type, scale of order with its modifications).

The process of conducting expert assessment can be represented as follows (Figure 1).

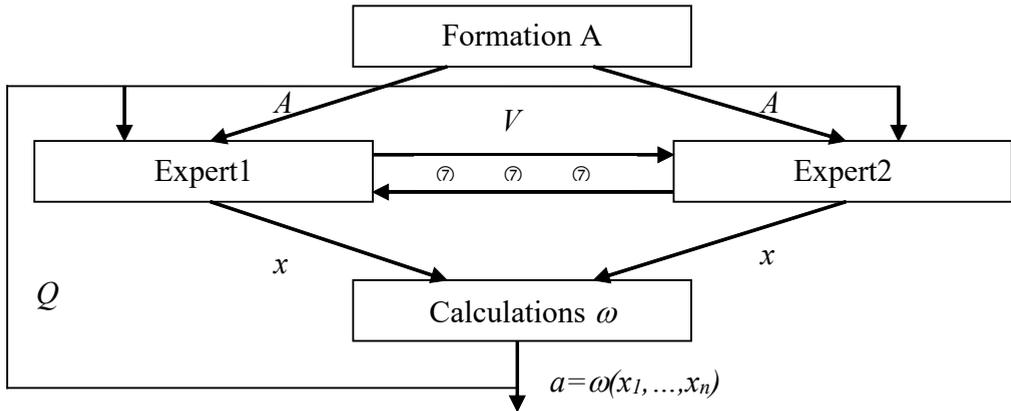
When organizing expert evaluation, the following should be considered:

- the set of admissible estimates A is determined by the statement of the problem being solved;
- for the interaction of experts V, the following methods can be used: free information exchange; regulated nature of the exchange; the exchange of information is prohibited;
- it is possible to organize feedback Q. When the result of the examination a is presented to each expert for the subsequent refinement of the assessment.

There are many methods of expert evaluation. These can include: voting, ranking, pair comparison, multiple comparison, etc. Let us dwell on the first two. Which are often encountered when conducting expert assessments in organizational systems.

Vote. Applicable if the elements in the set of admissible estimates of A are less than the number of experts. The simplest method is to pass a

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*Fig. 1 - Scheme of the Examination Process*

*Where: A is the set of admissible estimates; V is the interaction between experts; Q is the feedback; ω is the processing expert opinions ( $\omega=f(x_1, \dots, x_n)$ ); x is the function of selecting each expert; a is the solution.*

decision by a majority vote. But this method has a significant drawback. Since the decision is made by an unqualified majority. The voting procedure can be significantly strengthened. The following approaches should be used [2]:

- a majority vote (for example, 2/3 votes). Used for increased responsibility of choice;
- voting with the right of "veto";
- coupon voting (you can vote only if you have a coupon);
- a round of voting;
- a round of voting with an introduction of experts to the results of voting after each round (the Delphi method).

Ranging - is the ordering procedure, partitioning a set of objects in order of preference, with the introduction of the relationship between them strict or non-strict order. To effectively solve the ranking problem, you can use: the Kemen-Snell method, the Condorcet method, the Bord method [2].

Each of the methods of expert evaluation has its advantages and disadvantages. But all of them are united by the fact that they are not able to provide a consensus of a group of experts. Experts are anonymous and do not trust each other.

This situation is typical in many organizational systems. Which are connected with the financial sector, banking services, state administration, logistics, transport.

The principle possibility of solving this problem is provided by the use of the principle of coalition

rationality.

"Coalition rationality is the rationality used in the formation of a unified strategy for the actions of a number of entities. Which have both common and individual goals. The defining condition is the finding of a compromise of contradictory individual goals from the position of achieving the necessary level of common goals. This stage of rationality is the basis for the search for collective agreed decisions of the group examination"[3].

In the last decade, innovative technology has emerged and is actively developing. In which this principle is practically realized. This is the technology of open distributed registries or Blockchain. This technology is the basis of a number of cryptocurrencies. It is used to solve important state problems in a number of countries. It is also used in other important applications.

Let us give several definitions of this technology, given in [4].

"Blockchain is a peer-to-peer public register. Which is supported by a distributed network of computers. Which does not require any central administrator or third-party intermediaries".

"Blockchain is a distributed public register. It contains a database of all previously performed operations. Which are decentralized and are contained in the public sources of the Internet".

"Blockchain is the technology of storing and coordinating data between participants who do not trust each other".

The general principles of Blockchain's work in [4] are described as follows.

"Any transaction in the blockchain is information. It is subsequently checked by independent participants. It is built into blocks and built into the global history of the transactions. The blockchain has a set of mechanisms. They allow the system to remain independent and transparent. By blocks of transactions, you can track the probability of each transaction ... For the blockchain, the following principles of construction are typical.

1. The blockchain is distributed to all nodes of the network. It is decentralized, a copy of all records is available to all peer network participants. This eliminates the need to have centralized authorities.

2. To ensure consensus, the blockchain system uses many network members, they use their computers to check each new block. New blocks are accepted by the network, as soon as most of its participants agree that they are permissible.

3. Blockchain uses cryptography and digital signatures for identification.

4. The blockchain has mechanisms that make it difficult to change the chronology of the record. "

We can distinguish such basic properties of the blockchain:

- decentralization;
- publicity;
- Consensus of the participants;
- absence of intermediaries.

At the same time, it stands out that "... the mechanism of the blockchain is based on ... consensus and an open history of transactions". And further "... The essence of the consensus is that confirmation of transactions in the network of users of the blockchain account is carried out by periodically synchronizing the consent of the majority of its participants with a single version of the history of transactions" [4].

The synchronization process represents an expert evaluation report. It is organized accordingly.

Let's consider the main types of consensus used by technologies of open distributed registries.

### 2. Proof-of Work (PoW)

In this case, the majority of participants through solving mathematical problems prove the network that their version of the history of transactions is legitimate. In practice, this means that in order to add the following block to the chain, it is necessary to solve the combinatorial mathematical problem correctly. The first one who does this is rewarded. At the same time, the processing of counterfeit transactions becomes simply unprofitable.

This consensus algorithm is characterized by the

following conditions.

1. The number of participants is unknown.

2. Participants are anonymous and do not have a reputation.

3. The voice is supported by proof of work.

4. Consensus is achieved if the parties that control the majority of computing power in agreement.

This kind of consensus is most often used in practical applications using open distributed registry technology. Moreover, according to many experts, this is the only way to reach a consensus in the above harsh conditions. However, the consensus of PoW has significant shortcomings that complicate its practical implementation. To them, first of all, you can include:

- artificial delay in the release of blocks, which reduces the capacity of systems using PoW;

- Resilience is provided by the complexity of the work performed;

- colossal energy costs.

To combat these shortcomings, other types of consensus have been developed.

### 3. Proof-of Stake (PoS)

This is the mechanism in which the holders of most of the assets play a decisive role. The general idea of PoS is as follows. Each participant has some assets, some of which he can bet as a stake. The probability of forming a block by each participant is proportional to the size of the bet. Thus, in order to offer a new block, it is enough to support the work of a complete network node and have some asset. The more the user has an asset, the more he is interested in the correct consensus of all nodes of the network. Any attacks lose their meaning. As assets are depreciated. Their owners are poor.

The basic principles of PS can be formulated as follows:

- The creator of the cloud is determined by the algorithm;

- the probability of voting is proportional to the asset (stake-y);

- the user loses his bet if he assures wrong or conflicting blocks (loses reputation);

- Consensus is achieved if the owners of the majority of the size of the rates have agreed the state of the database.

This type of consensus has significant advantages in comparison with PoW.

1. Substantially faster (in tens, hundreds of times).

2. Bandwidth is limited only by delays in network synchronization.

3. No expensive equipment is required.

4. No excessive energy is required.

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5. If the block is not accepted, the user does not take any damage.

4. Byzantine Fault Tolerance (BFT)

Named after the name of the problem of "Byzantine generals." Here the conditions of the problem are simplified. The number of users is known in advance and they are not anonymous. The basic conditions for the work of consensus are as follows:

- interaction of peers in the network;
- the coordinated (malicious) behavior of a limited number of participants is allowed;
- "honest" nodes are more than 2/3;
- "malicious knots" are not known to "honest" participants;

- Delays and network failures are possible.

Advantages of BFT are as follows.

1. Very fast, because the voting procedure is actually used.

2. Does not use crypto currency.

3. Formation of the final (unchanged in the future) state is ensured for a fixed number of steps.

4. Reliable operation with 2/3 "honest" nodes in unreliable networks.

5. Good scaling.

The drawback of consensus is the restriction in use. Can be used only in corporate systems.

5. Federated Byzantine Agreement (FBA)

Is the development of consensus BFT.

The basic principles of the FBA are as follows:

- the participants are equal, not anonymous, the amount is not fixed;
- participants choose only those whom they trust;
- when choosing, participants form the groups in which consensus is reached;
- as the groups overlap, consensus is reached among all participants.

6. Delegated proof-of stake (DPoS)

The basic idea is as follows. All participants are divided by roles: users, committee, validators. Members of the committee and validators are not anonymous and have a reputation. Members of the committee are chosen by users. They can quickly change the rules of the game. Validators are also chosen by users. They can form blocks and approve transactions. Elections take place according to the rules of the PS. The weight of each elector is proportional to the asset. It can be divided into several candidates. As a result of elections, rating lists are formed. Of which N participants are selected as members of the committee and validators, respectively. These lists can be quickly changed as a result of re-elections. For example, when the assets of users change. The validators are given the

opportunity to form blocks in turn. Which in each period of time varies in a special way. Moreover, the procedure and the queue itself are not known in advance. To form a block, each time-line is allocated to each validator. If within the framework of this window the block was not formed for some reason, the right to form the block goes to the next one in turn.

DPoS has the following advantages over PoS.

1. The majority of assets are involved in the work.
2. A strict queue of validators for creating blocks allows you to optimize the process. That is, increase bandwidth.
3. Allows you to delegate your authority to another user more competent in this matter (Proxy Voting).

### Conclusions

The report considers only the main types of consensus. Which are used in technologies of open distributed registries. On their basis, various protocols are being developed to solve various practical problems. The use of a specific protocol depends on the specifics of the task. Thus, the degree of control over the problem of finding coordinated decisions of group expertise as a form of qualitative measurements in organizational systems is not only preserved, but has recently increased.

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