Object-evolutionary model of the system for monitoring the water environment of the hydrophysical fields

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Abstract. The paper examines the development of an object model that maps the structure of an information measurement system for water environment research and the process of information evolution from a physical measured quantity to a data file. The presented object instance action and behavior models allow to describe the operation of the system by object-oriented design tools.

1. The problem relevance
The oceans have a huge impact on the life of the planet. The development and rational use of ocean resources and spaces were important priorities of public policy not only at present but also in the future. The relevance of these problems is enhanced by the increasing role of oceans as the most promising area of economic activity.

In this regard, there is a task of constantly monitoring the state of the country's water resources, monitoring and analysis their basic parameters. The main characteristics of water media are rather heterogeneous in depth, dynamic and probabilistic [1,2,3]. The experimental study of the aquatic environment involves expensive expeditions, the main costs of which relate to the research phase. In this situation, the task of developing a computerized system for monitoring the heterogeneities of the hydro physical fields of the aquatic environment is urgent, as they are the ones that contribute dynamics and instability.

2. Problem statement
Structural-algorithm analysis of the system for monitoring the fine structure of water medium hydro physical fields, made in [4], is the basis for determining the configuration of the system designed to obtain targeted information on vertical profiles of hydro physical parameters in turbulized layers. It is necessary to develop an object-evolutionary model of the system, on the basis of which by means of simulation modeling it is necessary to simulate the measurement process in order to determine the quality of the developed system.

As a result of analysis of functions implemented by the system of monitoring of hydro physical parameters of the aquatic medium [5], it is determined that the system configuration consists of:

- number of parts;

- the main part which turns on the obligatory equipment providing the set function of a system of monitoring;
• the variation part which is turning on the equipment which structure can be changed depending on problems of monitoring.

The main part the monitoring system configuration includes:

• inertia-free measuring channels (speed, pressure, conductivity);
• analog-digital converter;
• cable-robe or radio channel;
• computer complex of the system onboard part.

The equipment of the system variation part includes:

• the most inertial measuring channels. as a rule, in STD-probes it is channels of temperature for which variation by their amount and constants of time is possible;
• the analog multiplexer which quantity of entrances is defined by the chosen number of all measuring channels;
• RAM determining the volume of the intermediate buffer for accumulation of the transmitted data blocks;
• the operated engine providing regulation the speed of sensing.

The selection of the optimal system structure can be realized by changing the composition the variation part of the equipment. This equipment performs two tasks according to its functional purpose:

• measurement of hydro physical parameters with the set discretization on depth;
• accumulation of information for block data transmission.

Equipment configuration options are possible to implement the measurement function:

1. One measuring channel providing the required depth sampling discreteness by adjusting the probing speed of the software-controlled engine;
2. Use of several measuring devices of the same parameter, distributed at a distance providing the required depth sampling discreteness;
3. Combination of the two previous configurations.

The information storage function for block data transfer is implemented by using an additional storage device, the volume of which must be determined for various system configuration options.

An object-event approach was used to build a model the part of the monitoring system that provides the implementation of the function measuring hydro physical parameters.

3. Research result

In order to develop the model, the process of monitoring the hydro physical parameters of the aquatic environment was decomposed. The monitoring process involves providing vertical probing of the aquatic medium to a predetermined depth [6], which results in measurement of the required hydro physical parameters, their conversion into digital form, transmission via a communication channel to a computing device, processing of the obtained information and formation of new records in the experiment database. Vertical probing - lowering of measuring devices - is performed at constant or variable speed with the help of engine. Measurement of hydro physical parameters is performed by analog sensors connected through analog multiplexer to analog-to-digital converter to obtain digital code. Data is buffered in random access memory before data transmission. Receivers and a communication channel are involved in data transmission. Processing of information arrays and generation of records into database is implemented by means of software module on computing device.
In the development of new information systems [7], an adequate representation of the real process (running in space and time) that forms the basis of the functioning of these systems has a great effect.

Object-evolutionary analysis of information systems is a mutually related process of establishing a model of precedents [8], object and evolutionary knowledge, model of actions and behavior of instances of objects.

4. Creating a precedent model
The precedent model describes the information system under study and the world external to it. The external environment is represented as a set of subjects, and the system under study is represented as a set of processes by which subjects interact with the system. The term "precedent" is some way an external entity interacts with a system, i.e., some process. Precedent contains many scenarios that explain the different sequences of interactions between a subject-precedent pair.

![Figure 1. A model of precedents.](image)

For the example in question, the subject (researcher) requires experimental data on vertical distributions of hydro physical parameters, which are given to him as a result of the process of obtaining this information - a precedent. The precedent model is shown in figure 1. The precedent is represented by a hyphen. Interaction between subject and precedent is shown by arrow line.

5. The formation object (informational) model
When you create an information model, you must highlight the primary object whose transformation is the goal of system development. In monitoring systems, such an object is information about the process or phenomenon under investigation.

![Figure 2. Hierarchy of objects in the information and measurement system the type "Simple-Complex".](image)
As a result of the monitoring system functioning, primary data is converted into information arrays and files. Therefore, the process of obtaining experimental data can be represented in the form of a hierarchy "Simple-complex" (figure 2). The arrow that links objects shows the inheritance relationship from super type to subtype. The objects organized in this way will be called the "trunk" of information model.

To form an object model, we will define the elements on which the evolutionary objects defined in the first step depend: "mean of movement", "means of measurement", "means of transformation", "RAM", "communication Channel", (figure 3). Set the usage relationship between objects and define its appearance: one-to-one (1:1), many-to-many (N: N), one-to-many (1:N) (usage relationship is represented by lines with arrows in both directions). Attributes describe the properties of the objects considered. For example, for a "Measured parameter" object, the depth value, the parameter value, are the attributes.

**Figure 3.** The object model of the information-measuring system.

### 6. Formation an evolutionary model

The objects’ evolutionary model is one of the features object-evolutionary analysis [9]. Its purpose is to form an idea of the objects' development as a result their interaction. Arrows linking objects and interactions between them indicated the direction of development of objects. The interaction is outside of objects and contains many scenarios that explain the different ways in which object instances act and behave.
The interaction of "Measured parameter", "Movement means", and "Measuring means objects creates an Analog Signal object. The interaction between these objects is defined in the form of objects "Lower the sounding device" and "Measurement". As a result of the interaction the "Analog signal" and "Means transformations" objects, the "Digital code" object is created. A "Transformation" object was added for the interaction between these objects. The interaction of objects "Digital code" and "RAM", the "Buffered information" object is created. That shown as a object "Save". The interaction between the "Buffered information" and "Communication Channel" objects, the "Intra-Machine information" object is created. Interaction between objects is defined in the form of the "Information transfer" object.

Objects that participate in the interaction and have a cyclic line of behavior are connected through the interaction by bidirectional arrows from the object to the interaction and Vice versa. For example, the object "Measuring means" and the interaction "Lower the sounding device".

![Diagram of objects interaction](image)

**Figure 4.** Model evolution of information and measurement system objects.

7. **Creating a model actions and behavior of object instances**

Each interaction of the evolutionary model is revealed in form a model of actions and behavior of objects [8]. The models of all object interactions are shown in figures 5 – 8.

The model actions and behavior of objects instances is generated as follows. First objects that participate in the interaction according to the generated evolutionary model are declared. Objects are indicated by circles and are located along the objects axis. Then objects' instances are declared (indicated by labels placed in circles). A network done of objects' changing States and actions is creating. Each new state of the object corresponds to the circle and the label placed in it, and is marked in italics. Each action is indicated by a dash, linked to instances of objects by directed line segments, and marked in bold.
The interaction models shown in figures 5 to 7 are cyclical, since object instances are returned to their original state.

The final state corresponding to the destruction of an object instance is indicated by a shaded circle.

Figure 5. Model of the interaction «Transformation».

Figure 6. Model of the interaction «Save».
The model can be used as a scenario [9]. On the left in the figures held on the axis of events. The implementation each action associated with the occurrence of some event. The scenario reflects the sequence actions of objects’ instances. One or more objects’ instances can be created to each object. The scenario for considered interaction is a technological graph. The event axis corresponds to the sequence of actions performed in accordance with the measurement process.

![Diagram of information transfer](image)

**Figure 7.** Model of the interaction «Information transfer».

Actions should be defined as a model of actions and behaviour in which actions are represented by operators. At the same time, auxiliary attributes can be introduced to execute the operators.

Based on the object-evolution model, classes of objects that form the structure of the monitoring information system are developed. Class descriptions include object parameters that affect the composition and operation of the system, and methods that define actions with class instances. The software implementation of the model is performed in the algorithmic language C++. Class descriptions are implemented in a separate file. The program interface allows you to set all the necessary system parameters in a convenient user mode. The developed software implementation of the proposed object-evolution model is used to determine the structure of the system for monitoring the aquatic environment hydro physical fields, which allows obtaining a sufficient non-redundant amount of data for the minimum time probing with the required accuracy [10].

8. Conclusion

As a result of the performed research:

1. The monitoring system's structural elements are highlighted, the parameters of which affect the performance the measurement process with the specified accuracy and speed.

2. We have developed an object model and a model the objects’ evolution of the information measuring system for monitoring inhomogeneities of the water environment hydro physical fields, the "trunk" of which is the process of converting information from a physical measured value to a data file.

3. On the basis of these models, models actions and behaviour of object instances are formed that allow to describe the functioning the system with help the object-oriented design language.

4. Developed class diagram, object model, software implementation allowed to define the structure information-measuring monitoring system inhomogeneities of the aquatic environment hydro physical parameters.
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