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MODELING INFORMATION FLOWS IN A SYSTEM WITH UNIDIRECTIONAL DATA FLOW

In the context of the digitalization of the educational environment, it is extremely important to create a reliable information system. The subject of this study is a specialized information system for educational institutions, designed to facilitate the centralized distribution of academic and administrative information. This project is based on the creation of a two-tier information ecosystem designed for fast and secure data exchange between users within an educational institution. The system architecture consists of two main components: the administrator panel and the user interface. In such a complex network, a special model for managing information flows is necessary to ensure the stability and security of data sources.

There is a conflict between the need to provide users with open and rapid access to up-to-date data through various interfaces and the need to preserve the integrity of the database from accidental or intentional interference by the client side. The aim of this study is to develop a model of an information system for the dissemination of educational and administrative information.

In today's world, the exchange of information plays a crucial role. Information flow refers to the movement of data to the end user. A unidirectional flow is one that involves only a single direction, which does not change [1]. In other words, information is transmitted from an administrative source to a client interface, which is considered one of the most resilient directions to external interference. In this case, the client interface functions solely as a read-only system. Therefore, such a model is referred to as Unidirectional Data Flow (UDF).

The functional model can be represented by the following relationship:

$$Y=F(X)$$

where:

- X – input data received from an administrative source;
- F – a software system that structures the X data;
- Y – information displayed to the end user on the client interface.

The model is deterministic, which means that for any set of input values, only one output result is obtained [2]. Therefore, for our model, the system's state depends entirely on the administrative source, and the results of erroneous user actions do not affect the system's stability or performance in any way. Since an analytical evaluation must also be implemented, an objective function of performance is constructed for this purpose:

$$W=f(p1, p2, p3,\ldots, pn)$$

where pi represents the criteria for information flows. The optimization of the system involves finding the extrema of this function to determine the points, using the method of partial derivatives, so that the resource costs associated with information transmission are minimized.

In a unidirectional system, information security must be ensured not through administrative restrictions, but through the asymmetry of the communication channel. This principle is based on the logic of asymmetric systems, specifically the RSA encryption algorithm: the data transmission function is open to everyone, while the function of modeling and analyzing the data is strictly restricted. This algorithm uses two keys – a public key and a private key – which together form a key pair [3]. In the data flow model, the data input function corresponds to the private key, and access rights remain exclusively with the administrator. On the other hand, the viewing function corresponds to the public key and allows any user of the client interface to access the information but does not grant the right to modify it.

In practice, this model is implemented as a two-tier architecture, specifically consisting of a website for administrators and a Telegram Mini App for users. The website functions as the input data generation point (X), and the administrator has special rights to modify the content (similar to a private key). In contrast, the Telegram app serves as a display device (Y) and is technically limited to a read-only mode (similar to a public key). This approach demonstrates that a unidirectional data flow is most suitable for information systems in educational institutions, as it enables the isolation of a critically important database from thousands of potential entry points via the client interface. This eliminates the need for bidirectional state synchronization, thereby reducing the load on the server.

Modeling information flow in a unidirectional system made it possible to identify several key advantages. One of these is integrity, as users cannot modify the data flow. The ability to impose restrictions on data transmission ensures system stability, while asymmetric distribution reduces security vulnerabilities. Systems based on Unidirectional Data Flow also significantly reduce the load on server infrastructure, confirming their cost-effectiveness. Unidirectional Data Flow enables the creation of an information channel that combines fast data transmission with complete security of data sources. Further research will focus on scaling the proposed architecture to integrate additional information sources and conducting a comparative analysis of the effectiveness of the proposed approach compared to traditional bidirectional systems.

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