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CONSTRUCTION AND REGULATION OF STATIC CHARACTERISTICS FOR CONTROL OBJECTS

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Abstract: This article discusses the issues of digitalization in stream generation systems, as well as their shortcomings in existing Industrial Ethernet solutions, which were addressed using a new innovative approach. In addition, such solutions are often limited in their flexibility. However, these aspects are becoming increasingly important in the future. Existing control systems are characterized, as a rule, by branched hierarchical structures, and the quality of their functioning is assessed according to vector criteria. Such systems include the national economy as a whole, its branches, industrial enterprises, information systems, targeted programs in various subject and applied areas. It should also be noted that from the point of view of the system approach, any systematization is a fragment of a more general hierarchy of such systems. Automation of control processes and their analysis of modern complex control systems more and more often uses hierarchical models, which makes the problem of their development and research more relevant today. The method proposed by the authors for solving such problems does not seem unnecessarily cumbersome, since it is necessary not only to automate processes at each level, but also to carry out interlevel control. The conclusion is that none of the existing solutions is suitable for meeting the challenges of the future regarding scalability, flexibility or reliability.

Keywords: *Resource security, modified protocol, digitalization*

Introduction. Already today, the implementation of control issues in the field of automation requires additional specialized equipment to guarantee reliable operation in real time. On the other hand, in P2P networks, the premise of the TDMA-based timeslot method is a single time base for all participating nodes. Therefore, all nodes in the CAD network must be synchronized.

This can be done using the NTP or PTP protocol, or directly in Kad. After running the IDST algorithm and synchronizing all nodes, each node can determine when it is allowed to communicate access to the common Ethernet communication medium [1, 2, 3].

It is recommended that you export the IDST algorithm immediately after the DST algorithm, since only the termination criterion is different and the previous calculations are identical. Thus, it is possible to save a significant part of the time for export [4].

Since the presented approach is intended for automation scenarios, it is necessary not only to guarantee deterministic data exchange between nodes. Rather, it is also necessary to provide real-time behavior of the CAD nodes regarding data processing.

Under these conditions, the chosen form of the target platform must be supported by the real-time operating system. Embedded system was chosen according to the industrial automation use case. The target platform for ZedBoard will be an ARM processor clocked at 680 MHz Avn. With the help of the developed prototype for the digitalization of resource security, it is possible to determine at all times what corresponds to the TDel in relation to the creation, sending, receiving and processing of exchanged UDP packets. Software Stack: As the basis for the software, ZedBoard serves as an ARM-based system. FreeRTOS was chosen as the operating system because it allows tight control of Rea's real-time CAD nodes [5, 6].

In particular, LwIP is used as part of FreeRTOS as a lightweight implementation of the TCP/IP stack to enable communications over Ethernet Free [7]. At the ninth level is the resource security digitization application, which manages media access and thus enables real-time communication through the implementation of time slots. At this level, a new approach is being implemented. At the same time, the digitalization of resource security is understood not only as an application, but also as middleware for other applications that are not related to the digitalization of resource security.

Formulation of problem. After starting other threads, it goes into a waiting state. External control is given second priority in responding to external triggers, such as a human-caused fire alarm. External triggers can also be dedicated lines/devices used to perform highly critical processes such as connected sensors on a digitalization site to further secure our resources. The CAD communication thread has the n-th lower priority and is responsible for processing CAD packets. The following are at most three threads that monitor Kad lookup objects and delete them when the appropriate conditions are met. Because three lookup objects are actively maintained, there can be at most three threads in this regard. The network stream buffers packets from the network interface and forwards them to the application to digitize resource security. Three service flows are responsible for keeping the network up to date. Finally, there is a waiting thread, which serves to generate new threads.

Let's try to find the correlation function $R_{xx}(\tau)$ and the spectral density $S_{xx}(\omega)$ of the variable $x = x_m \sin(\beta t + \varphi)$, if the amplitude is $x_m = 16$ and the angular frequency is $\beta = 1{,}5\ c^{-1}$. Find also the variance of this variable from its spectral density.

The correlation function

$$R_{xx}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t)x(t+\tau)dt. \tag{1}$$

In this case, the function $x(t)$ is periodic, so expression can be replaced by the formula

$$R_{xx}(\tau) = \frac{1}{2T_0} \int_{0}^{T_0} x_m^2 \sin(\beta t + \theta)\sin(\beta t + \beta\tau + \theta)dt = \frac{x_m^2}{2}\cos\beta\tau, \tag{2}$$

where $T_0 = 2\pi/\beta$ — is the period. Substituting th enumerical values, we obtain $R_{xx}(\tau) = 128\cos 1{,}5\tau$, $R_{xx}(0) = 128$.

The spectral density is determined by the Fourier transform

$$S_{xx}(\omega) = \int_{-\infty}^{\infty} R_{xx}(\tau)e^{-j\omega\tau}d\tau. \tag{3}$$

Taking into account (2), we get

$$S_{xx}(\omega) = \int_{-\infty}^{\infty} \frac{x_m^2}{2}\cos\beta\tau e^{-j\omega\tau}d\tau.$$

The integral in this expression is determined by the equation

$$\int_{-\infty}^{\infty} \frac{x_m^2}{2}\cos\beta\tau e^{-j\omega\tau}d\tau = \pi[\delta(\omega-\beta) + \delta(\omega+\beta)],$$

where $\delta(\omega-\beta)$ and $\delta(\omega+\beta)$ — are shifted δ-functions dependent on the frequency of ω.

Therefore,

$$S_{xx}(\omega) = \frac{\pi x_m^2}{2}[\delta(\omega-\beta) + \delta(\omega+\beta)], \tag{4}$$

i.e., the spectral density of the harmonic variable $x = x_m \sin(\beta t + \varphi)$ represents two infinitely short pulses located at frequencies $\omega_1 = -\beta$ and $\omega_2 = \beta$, the area of each of which is equal to $\pi x_m^2 / 2$.

The variance of some quantity $x(t)$ with spectral density $S_{xx}(\omega)$ can be determined by the formula:

$$D_x = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{xx}(\omega) d\omega. \tag{5}$$

Therefore, in this case

$$D_x = \frac{1}{2\pi} \int_{-\infty}^{\infty} \frac{\pi x_m^2}{2} [\delta(\omega - \beta) + \delta(\omega + \beta)] d\omega = \frac{x_m^2}{2} \int_{0}^{\infty} [\delta(\omega - \beta)] d\omega = \frac{x_m^2}{2},$$

since the integral of the δ-function is 1. By substituting numerical values, we obtain $D_x = 256/2 = 128$.

Comparing with the value of $R_{xx}(0)$, we conclude $D_x = R_{xx}(0)$.

A random stationary process $\varphi(t)$ has spectral density $S_{\varphi\varphi}(\omega)$. Calculate its mean value $\bar{\varphi}$, variance D_φ and correlation function $R_{\varphi\varphi}(\tau)$.

Since $S_{\varphi\varphi}(\omega)$ of a given process does not contain the δ-function $\delta(\omega)$ at $\omega = 0$, the average value $\bar{\varphi} = 0$. Therefore, the variance D_φ is equal to the mean square of the random process, i.e., $D_\varphi = \sigma_\varphi^2$, where σ_φ is the standard deviation of the process $\varphi(t)$. On the contrary, according to formula (3.59), we have:

$$D_\varphi = \frac{1}{2\pi} \int_{-\omega_n}^{\omega_n} N d\omega = \frac{N}{2\pi} (\omega_n - (-\omega_n)) = \frac{N \Delta\omega_\varphi}{2\pi}, \tag{6}$$

where $\Delta\omega_\varphi = 2\omega_n$ — is the angular frequency band (in radians/s) of the random process $\varphi(t)$. The formula (6) can be written as follows:

$$D_\varphi = N \Delta f_\varphi, \tag{7}$$

where $\Delta f_\varphi = \Delta\omega_\varphi / 2\pi$ is the bandwidth in hertz of the random process in $\varphi(t)$.

Let us find the correlation function $R_{\varphi\varphi}(\tau)$ by the formula

$$R_{\varphi\varphi}(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{\varphi\varphi}(\omega) e^{-j\omega\tau} d\omega = \frac{1}{\pi} \int_{0}^{\infty} S_{\varphi\varphi}(\omega) \cos\omega\tau d\omega$$

Or

$$R_{\varphi\varphi}(\tau) = \frac{1}{\pi} \int_{0}^{\omega_n} N \cos\omega\tau d\omega = \frac{N}{\pi\tau} \sin\omega_n\tau.$$

Therefore, we once again have

$$R_{\varphi\varphi}(0) = \lim_{\tau \to 0} \frac{N\omega_n}{\pi} \frac{\sin\omega_n\tau}{\omega_n\tau} = \frac{N\omega_n}{\pi} = D_\varphi,$$

Time τ_1 is defined by the equality $\sin\omega_n\tau_1 = 0$, i.e., $\tau_1 = \pi / \omega_n$. As can be seen, at $\omega_n \to \infty$ the amplitude of the correlation function $R_{\varphi\varphi}(0) \to \infty$ and the time $\tau_1 \to 0$, i.e. the correlation function $R_{\varphi\varphi}(\tau)$ tends to the δ-function, which corresponds to the white noise correlation function.

Analysis of the obtained results. The use of a modified Kademlia protocol and real-time CAD nodes enables the creation of demanding real-time applications based on P2P technology.

To determine the performance of the system, it is necessary to prototype the scenario using the resource security digitalization nodes. The two nodes accurately represent a discrete period of the time interval during which they have exclusive access to the media. Thus, it can be concluded that of the NSLOT time slots, two instances per discrete time slot are best suited for the entire system. Thus, all n different parameters can be defined. This setup supports two operations between two flanges. These are read and write operations that can be performed in a resource security digitalization application.

When the user performs a read operation, a series of integer values is requested. The number of values is specified by the user in the UserRequest packet. It also specifies the hash value of the node that should provide the cumulative values. The first ZedBoard accepts and processes a batch of user requests. Because the first ZedBoard is not designed for a read request, it searches the Kad network for the node that, according to the hash value in the user's request packet, is responsible for the request request. Therefore, the first ZedBoard communicates with the second one with a kad request, because it is designed for requests, and checks if this node exists [8].

The second ZedBoard responds with a Kad response package. When the first ZedBoard receives the Kad response packet, it can contact the second board again and perform a read action. The action is performed using an action request packet, which in this case is a read request packet. After receiving the first Read Action Response Packet, ZedBoard sends the integer values to the user using the User Response Packet.

When performing a write operation, a number of integer values are passed in the user request packet. As with the read operation described earlier, the Kad network searches for the responsible node for the write operation. In this case, it is also the second ZedBoard. It will now receive an action request packet, which is a record action request packet from the first ZedBoard. The package includes integer values that will be stored on the second ZedBoard. The second ZedBoard sends a Write Action Response packet as an acknowledgment in uck, which is transmitted from the first ZedBoard to the user as a user response packet [9, 10].

Time was measured for both operations, including cad operations and packet processing. The first measurement point is taken when the first ZedBoard receives a packet of user requests. The second time value is received when the user response packet is sent back to the PC. Clearly, results can be achieved in less than a millisecond. In addition, there is a linear behavior depending on the amount of requested and unsolicited data, respectively, to recognize integer data values.

The use of business intelligence software today often makes the difference between winners and losers. The existing industry in software methods uses analytics to monitor and optimize all aspects of their operations - from marketing to the supply chain - in real time. They rely on analytics to make fast, data-driven decisions, drive revenue growth, develop new business models, deliver best-in-class customer service, support employees, gain a competitive edge, and more. Economics in software methods without analytics - or without good analytics - are forced to make decisions based solely on intuition and experience.

This growth has been accelerated by issues of digitalization, which has forced many existing solutions to explore new business opportunities, cut costs and navigate the turbulent “new normal”. Analytics, business intelligence and data science are the most common use cases, which have become even more important as a result of the pandemic, overtaking the Internet of things and cloud applications. Problem-solving capabilities and predictive analytics are helping organizations address urgent pandemic-related challenges, such as accurately forecasting demand, protecting vulnerable workers, and identifying potential supply chain disruptions.

This simple form of analysis uses basic mathematical calculations such as averages and percentage changes to show what has already happened in our sector. Descriptive analysis, also known as business intelligence, is the first step in the analysis process and serves as a starting point for further research.

But continuing the descriptive analysis, identifying, examining and correlations between the available data in order to get to their essence and determine the causes of events and behavior.

This advanced analysis sub-discipline uses the results of descriptive and diagnostic analysis—along with sophisticated predictive models, machine learning, and deep learning techniques—to predict what will happen next.

This modern form of analysis is based on the results of descriptive, diagnostic and predictive analysis and uses modern tools and methods to assess the impact of possible solutions and determine the best course of action in a situation.

Business intelligence includes many different components and tools. The most common components include:

Data aggregation: Before data can be analyzed, it must be collected, organized and cleaned from many different sources. A solid data management strategy and a modern data warehouse are essential for analytics.

Data mining uses statistical analysis and machine learning algorithms to search large databases, analyze data from different angles, and look for previously unknown trends, patterns, and relationships.

Big data analytics uses sophisticated techniques such as data mining, predictive analytics, and machine learning to analyze large amounts of structured and unstructured data in databases, data warehouses, and Hadoop systems.

Text mining examines unstructured text datasets such as documents, emails, social media posts, blog posts, call center scripts, and other text sources for qualitative and quantitative analysis.

Data visualization and storytelling: With data visualizations such as charts and graphs, trends, outliers, and patterns in data can be better captured and made understandable. These visualizations, taken together in context, can provide a more complete picture and support decision making.

Conclusion. Analytics are used by companies of all sizes in all industries – retailers, healthcare, and even sports clubs. Many analytics solutions are tailored to a specific industry, purpose, or business area.

The explosive growth of e-commerce, increasing market volatility, globalization and other factors have made supply chains even more complex. With supply chain analytics, companies can prevent supply disruptions, ensure a steady flow of goods, and optimize supply chain stability and agility. They use real-time data from various sources such as IoT sensors to optimize everything from purchasing to manufacturing and inventory to transport and logistics.

The results are TDel, which corresponds to the creation of the search object, the search phase, and the exchange of integer values. These results can be used for further consideration.

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