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I. K. Sagynganova[1], V. B. Markin[2]

[1]D. Serikbayev East Kazakhstan state technical university, Ust-Kamenogorsk, Kazakhstan,
[2]I. Polzunov Altay state technical university, Barnaul, Russia.
E-mail: diko_s777@mail.ru, Mvb.v.1942@mail.ru

THE ORGANIZATIONS OF THE TASKS IMPLEMENTATION IN THE DISTRIBUTED AUTOMATIC CONTROL SYSTEMS OF HEAT SUPPLY STATIONS

Abstract. In this article we proposed a data processing technology that provides the ability to form the efficiency indicators of the different processors that implement pipeline plans of data processing systems (DPS) and automated control systems (ACS) of the heat supply stations in general. The implementation of this technology will have a significant effect in practice as the internal technology of ACS work is being improved. In addition, the described approach offers the following advantages: the increase of the capacity of the pipeline data processing system; the implementation of the functions uniformity of the pipeline data processing system which allows to reduce the requirements for the ACS of the heat supply stations; the reduction of the time and the improvement of the quality of communications in the system linking and coordinating the work of several heat supply stations.

Keywords: a data processing system (DPS), an automated control system (ACS) with heat supply stations, a district heating supply system (DHS).

Introduction. Currently distribution and regulation of thermal energy, both inside and outside buildings, according to demand is considered one of the most fundamental approaches to energy conservation in Kazakhstan, and just as so in all developed countries.

In December 2017 the chairman of Kazakhstan power association, Shaimerden Urazalinov, mentioned the following while discussing problems in the heat supply sector [1]:

– there is high intellectual and physical wear of primary and secondary equipment on heat stations, in boiler rooms, in heat networks and heat consumptions systems;

– the most pressing problem of elimination of excess losses of heat energy is not being dealt with;

– there is a lack of resolution concerning financial and organizational issues that would arise during reconstruction and modernization of individual components of the heat supply system;

– currently operating centres of heat consumption, used in buildings which are connected to the city's district heating systems, usually don't have any automatic machinery and only an insignificant amount of them have heat meters and coolant meters at heat points;

– most consumers connected to district heating systems don't have the capability to regulate the consumption of heat used for heating according to their wishes.

Whereas the use of modern technology for control of heat supply points, connected into a single network, would allow for significant power savings and smoother heat distribution in living and industrial spaces.

The advantages of having pipelined task completion machinery in distributed automated control systems logically follow from the theory of production development and information conversion. In this work we offer a methodology for typification of tasks in an automated control system of a heat station with pipelined data processing, since one of the stages of organising data processing technology is the stage of identifying typical tasks and typical task queues, which are then organized into a pipelined data processing plan. It's obvious that organising homogenous task queues into a pipelined plan leads to raised effectiveness of distributed automated control systems.

Theoretical and methodological aspects of task typification in modular data processing system are reflected in the works of domestic and foreign authors, such as A.G. Mamikonov [2], V.V. Kul'ba, S.A. Kosyachenko [3, 4], A.S. Mironov, Ye.N. Sidorov, A.A. Ashimov [5], YU.YU. Kess, V.M. Revako [6], A.V. Tovmasyan, B. Dyuran, P. Odell [7], Kh. Berzh, O. Ore [8]. Models and methods of data processing in technical and logistical system are examined in the works of V.V. Voyevodina [9-11], B.A. Golovkina, K.G. Samofalova [12], G.M. Lutskogo, A.B. Barskikh, Ye.L. Shlimovicha [13], A.P. Shabanova, D. Fillipsa, A. Garsia-Diasa [14], R.V. Konveya, V.L. Maksvella [15], L.V. Millera. Pipelined typical task completion in distributed automated control systems signifies a new stage in automated control system design and requires model-algorithmic task completion guarantees and adaptation of task typification methodology for pipelined data processing system [16].

The technology offered here grants the opportunity of forming the performance identifiers of individual processors realising pipelined plans, of the data processing system and of an automated control system of the heat station in general. Implementing this technology gives significant practical advantages, since the internal technology of operation of an automated control system is being perfected. Besides that, the explained approach grants the following advantages: increase in throughput of pipelined data processing system; guaranteeing the homogeneity of functionality of pipelined data processing system, which allows to decrease the requirements to an automated control system of a heat station; the decrease in latency and improvement of the quality of system communications linking and coordinating the operation of several heat stations.

Research methodology. Let's examine model-algorithmic procedures allowing to trace back the influence of data collection process in an automated control system on the effectiveness of task planning assuming pipelined execution. For a task class in distributed automated control systems, the problem of the minimization of resources is solvable in general form using the method of estimating the sufficient capacity of the data processing system.

The method is based on the mathematical apparatus of the queueing theory. The problem of developing a model allowing to get an estimate of the capacity of a data processing system with data collection is currently relevant. Said problem is related to the problem of the minimization of resources of the automated control systems of the heat stations. Using the known mathematical apparatus as an instrument, let's use the following model of estimation of the influence of the data collection process on the effectiveness of the pipelined data processing in an automated control system:

$$P(\leq T_z) \geq \frac{1}{Q}\left(P_{const}^{k=1}(0) + P_{const}^{k=2}(1) + P_{\varphi\{\tau[V(t)]\}}^{k\geq 3}\right.$$

where T_z is the specified maximum allowed waiting time for a service demand; $P(\leq Tz)$ is the specified minimum allowed probability of not exceeding T_z; Q is the maximum amount of demands serviced in a continuous time period (busy period); V(t) is the amount of recorded information. The value of V(t) changes with time; $\tau\,[V(t)]$ is the duration of a single servicing period. It is a dependent quantity of the amount of information V(t) and is defined as:

$$\tau[V(t)] = \frac{\tau_{const} + \tau_{var}[V(t)]}{M}$$

M is the amount of processor in a data processing system; τ_{const} is the constant component of the servicing interval, determined mostly by the time directly spent on demand handling; $\tau_{var}[V(t)]$ is the component of the servicing interval dependent on the amount of information.

The parameter of $\tau_{var}[V(t)]$ is determined by the time spent on managing information and decision-making,

k is the ordinal position of the demand in the busy period,

j is the waiting period for the demand numbered k expressed in the amount of servicing intervals,

$P_{const}^{k=1}(0)$ is the probability that the demand received in the data processing system isn't waiting for service. In a single busy interval only one demand (k=1) can be such a demand, such that $P_{const}^{k=1}(0)$ for every Q is a constant of 1,

$P_{const}^{k=2}(0)$ is the probability that the waiting period of the second, in the order of servicing, demand (k=2) is equal to one servicing interval. In a single busy interval $P_{const}^{k=2}(0)$ for every Q is a constant of 1.

$P_{\varphi\{\tau[V(t)]\}}^{k\geq 3}(j \leq J)$ is the probability that each demand, starting with the third one in the order of servicing in a busy interval, waits for no more than j servicing intervals,

j=1,2,…,J, J – is the maximum allowed servicing time expressed in the amount of servicing intervals. The parameter of J corresponds to the parameter of Tзад and is dependent on the parameter of τ [V(t)].

The model allows to obtain the dependence between the maximum amount of Q demands serviced in a data processing system during a continuous time interval (busy interval) and the amount V(t) of recorded information under the assumption of adherence to the given values of waiting time T for servicing demands and probability P(≤Tz) that it's not exceeded. The considered model allows identifying the dependence between the capacity of the data processing system and the amount of information, gradually collected and mastered by processors of pipelined data processing plan. An important application of the model is selecting a strategy for organising the process of demand servicing with the capability of quantitative assessment of different alternatives during distribution of the major tasks between processors.

Results. Having carried out calculations with real parameters of the network of heat supply stations, we defined the dependence of the information volume and the duration of the service interval from the time of information update.

The dependency of the amount V(t) of information on time t is determined based primarily on the composition of the entities in the production environment of task consumers and on the operating conditions of the data processing system providing such tasks. For example, figure 1 provides the dependency of the amount of recorded information on its update time in the conditions of organising an automated control system of a heat station with pipelined data processing.

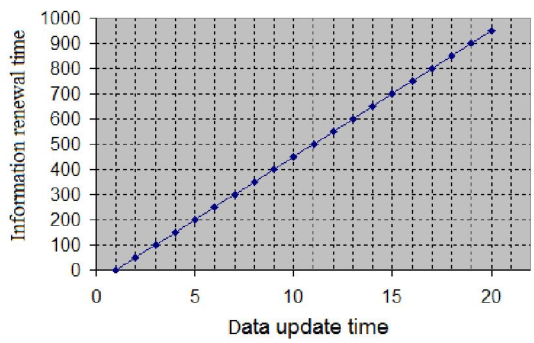

Figure 1 –
The dependence of the amount of recorded information on its update time

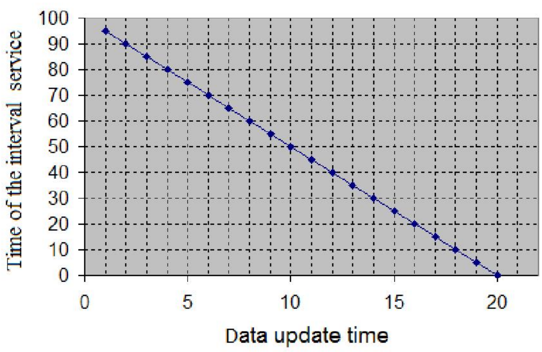

Figure 2 –
$\tau_{var}[V(t)]$ as a function of the data update time

The dependence of the variable component $\tau_{var}[V(t)]$ of the servicing interval is mostly determined from the type of processors of the data processing system, from organization of servicing of the demands being received from task consumers. For example, figure 2 shows the change of variable $\tau_{var}[V(t)]$ as a function of the data update time.

Using derived dependencies, we have selected an optimal time for the data update while processing the next nine parameters at ten heat stations: the temperature of network water in the supply line, the temperature of network water in the return line, the flow temperature, the flow rate of network water in the supply line, the flow rate of network water in the return line, the pressure of network water in the supply line, the pressure of network water in the return line, the indoor temperature, the heat released. Using four personal computers, each with an i5 CPU (4x4=16 cores) with pipeline processing of all the parameters from 10 heat stations the optimal update time for the data is 10ms. Adding to that, the time to receive full information decreased approximately tenfold compared to the current technology of gathering and processing data from the heat stations.

Conclusion. The developed model of the system with pipelined data processing with data collection has practical applications most obviously seen in the task of organizing the operation of several heat stations into a uniform system, where said approach tested.

The obtained results show that it is possible to create information systems with the new architecture proposed in [17]. In particular, by calculating the duration of the service interval it is possible to set the optimal switching time between tasks performed by the processor. This will allow creating a software complex for the management of heat supply stations with pipelined data processing.

И. К. Сагынганова[1], В. Б. Маркин[2]

[1]Д. Серікбаев атындағы Шығыс Қазақстан мемлекеттік техникалық университеті, Өскемен, Қазақстан,
[2]И. И. Ползунов атындағы Алтай мемлекеттік техникалық университеті, Барнаул, Ресей

ЖЫЛУ ПУНКТТЕРІН ҮЛЕСТІРІЛГЕН АВТОМАТТЫНДЫРЫЛҒАН БАСҚАРУ ЖҮЙЕЛЕРІНДЕ МІНДЕТТЕРДІҢ КОНВЕЙЕРЛІК ОРЫНДАЛУЫН ҰЙЫМДАСТЫРУ

Аннотация. Мақалада, мәліметтерді өңдеу жүйелерінің (МӨЖ) және жалпы жылыту пункттерінің басқару жүйелерінің автоматтандырылуын, конвейерлік жоспарларды іске асыратын жеке процессорлар жұмысының тиімділік көрсеткіштерін қалыптастыру мүмкіндігін беретін мәліметтерді өңдеу технологиясы ұсынылған. Бұл технологияны іске асыру, АБЖ жұмысының ішкі технологиясы жетілдірілетіндіктен, тәжірибеде маңызды нәтиже береді. Сонымен қатар бұл сипатталған тәсіл келесі артықшылықтарға ие: мәліметтерді өңдеудің конвейерлік жүйесінің өткізу қабілетін арттырады; жылыту пунктінің АБЖ талаптарын төмендетуге мүмкіндік беретін, мәліметтерді өңдеудің конвейерлік жүйесі қызметінің біркелкілігін қамтамасыз етеді; бірнеше жылыту пункттерінің жұмысын байланыстыратын және үйлестіретін жүйедегі коммуникация сапасын жақсарту және уақытын азайту.

Түйін сөздер: мәліметтерді өңдеу жүйесі (МӨЖ), жылу пункттерін (АБЖ) автоматты басқару жүйесі, орталықтандырылған жылумен қамту жүйесі (ОЖҚЖ)

И. К. Сагынганова[1], В.Б. Маркин[2]

[1]Восточно-Казахстанский государственный технический университет им. Д. Серикбаева, Усть-Каменогорск, Казахстан,
[2]Алтайский государственный технический университет им. И. И. Ползунова, Барнаул, Россия

ОРГАНИЗАЦИЯ КОНВЕЙЕРНОГО ВЫПОЛНЕНИЯ ЗАДАЧ В РАСПРЕДЕЛЕННЫХ АВТОМАТИЗИРОВАННЫХ СИСТЕМАХ УПРАВЛЕНИЯ ТЕПЛОПУНКТОВ

Аннотация. В статье нами предложена технология обработки данных, которая предоставляет возможность формирования показателей эффективности работы отдельных процессоров, реализующих конвейерные планы, системы обработки данных (СОД) и автоматизированные системы управления (АСУ) теплопунктов в целом. Реализация этой технологии даст существенный эффект на практике, так как совершенствуется внутренняя технология работы АСУ. Помимо этого описанный подход дает следующие преимущества: увеличение пропускной способности конвейерной системы обработки данных; обеспечение однородности функций конвейерной системы обработки данных, что позволяет снизить требования к АСУ теплопункта; уменьшение времени и улучшение качества коммуникаций в системе, связывающие и координирующие работу нескольких теплопунктов.

Ключевые слова: система обработки данных (СОД), автоматизированная система управления (АСУ) теплопунктами, система централизованного теплоснабжения (СЦТ).

Сведения об авторах:

Сагынганова Индира Кенесовна – докторант кафедры «Приборостроение и автоматизация технологических процессов» Восточно-Казахстанского государственного технического университета им. Д. Серикбаева, Казахстан, специальность 6D070200 – Автоматизация и управление; e-mail: diko_s777@mail.ru; https://orcid.org/0000-0003-2654-3348

Маркин Виктор Борисович – доктор технических наук, профессор Алтайского государственного технического университета им. И. И. Ползунова, РФ, Барнаул, Россия; Mvb.v.1942@mail.ru; https://orcid.org/0000-0003-3094-8479

Information about authors:

Sagynganova I. K., D. Serikbayev East Kazakhstan state technical university, Ust-Kamenogorsk, Kazakhstan; diko_s777@mail.ru; orcid.org/0000-0003-2654-3348

Markin V. B., I. Polzunov Altay state technical university, Barnaul, Russia; Mvb.v.1942@mail.ru; orcid.org/0000-0003-3094-8479

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