UDC 004.7 DOI: 10.30748/nitps.2019.36.13

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METHOD OF INFORMATION FLOW CONTROL IN A HYPERCONVERGENT SYSTEM

In a hyperconvergent system, maintenance costs are reduced. But system performance decreases due to centralized control. Therefore, in such a system, the task of optimizing the distribution of information flows has a significant role. ***The purpose of the article*** *is to develop a method of information flow control in a hyper-convergent system.* ***Results of the research.*** *The analysis of the causes of packet delay in a hyperconvergent system has been performed. An analytical expression is obtained for calculating the value of the data packet delay on the route. The main factors of delay are revealed. Analytical expressions are obtained for calculating the maximum intensities of information flows in a hyperconvergent system. A method for selecting the optimal packet length is proposed. The formulation of the problem of distribution of information flows along routes is formulated.* ***Conclusions.*** *The proposed method is effective with centralized control and the absence of heterogeneous components. This method allows you to reduce the cost of computing resources, especially with increasing network dimensionality.*

Keywords: *hyperconvergent system, bandwidth, information flow, packet delay.*

Introduction

Problem analysis and scientific publications. Today in the market of IT technologies distributed cloud platforms are gradually being replaced by converged and hyperconverged [1–2]. The infrastructure created on the converged platform involves the pooling of memory, computing and network resources into a pool preassembled to work in the datacenter [3]. With a hyperconverged infrastructure, the computing power, storage, servers, networks are combined. This is done through software. They are control through a common administration console [4–5]. With a hyper-convergent structure, one system administrator is enough to control the system. This significantly reduces the cost of maintaining the system. But at the same time, system performance is falling due to centralization of control [6]. Therefore, in such a system, the task of optimizing the distribution of information flows plays a significant role [7–8].

Methods of distribution of information flows under centralized control are considered in many scientific works [9–12]. However, the majority of papers do not take into account the peculiarities of the functioning of hyperconvergent systems. Therefore, **the purpose of the article** is to develop a method of information flow control in a hyperconvergent system. The method should take into account the features of centralized control and the lack of heterogeneity of software and hardware.

1. Analysis of the causes of packet delay in a hyperconvergent system

The delay of a data packet on a communication channel consists of four components [13]:

- delay data packet for processing (switching);
- the delay of the data packet in the queue;
- the delay in the transmission of the data packet;
- propagation delay of a data packet.

This consideration does not take into account the retransmission of the data packet over the communication channel. Due to transmission errors or any other reasons. For most real channels of communication, retransmissions are rare. Therefore, they will not be considered further. Also we will assume, that the packet processing delay does not depend on the amount of information flow. The delay of a packet is defined by expression [12]:

$$T_z = T_{comm} + T_{wait} + T_{transfer}\,, \tag{1}$$

where T_c – total time of switching of a packet;

T_{wait} – total waiting time of a packet in queue;

$T_{transfer}$ – total transmission time of a packet on communication channels.

Expression for definition of total time of switching of a data packet has an appearance [12]:

$$T_{comm} = \sum_{b=1}^{h_w} t_{comm_b}\,, \tag{2}$$

where h_w – number of the communication channels entering a route;

t_{y_b} – packet switching time in the device, incidental b-th to a communication channel.

Total waiting time of a packet in queue to communication channels decides on the expression help:

$$T_{wait} = \sum_{b=1}^{h_w} t_{wait_b}\ , \tag{3}$$

where t_{o_b} – waiting time of a packet in queue to b-th communication channel.

Waiting time of a packet in queue to a communication channel depends on queue length, length of the transferred packet, communication channel bandwidth. It is defined by expression [12]:

$$t_{wait_b} = \frac{\ell_{wait_b}}{p_{z_b}}\cdot \ell_\rho\ , \tag{4}$$

where ℓ_{wait_b} – queue length of packets to b-th communication channel;

ℓ_ρ – the volume of the packet transferred on route;

p_{z_b} – bandwidth b-th communication channel taking into account its loading.

Expression for definition of total transmission time of a packet on communication channels has an appearance [12]:

$$T_{transfer} = \sum_{b=1}^{h_w} t_{transfer_b}\ , \tag{5}$$

where $t_{transfer_b} = k_{z_b}\cdot \ell_\rho / p_{z_b}$ – transmission time of a packet on b-th communication channel;

k_{z_b} – load factor b - th communication channel.

In determining the average delay of a data packet in a data network, in addition, the following parameters should be considered [14]:

- *length of routes of information transfer;*
- *information density s transferred along routes;*
- *total information density.*

Using these parameters and expressions (1–5), let's calculate average delay of a packet:

$$T_\rho = \frac{1}{c_u}\times$$

$$\times\sum_{j=1}^{h_r}\sum_{a=1}^{h_m}\left(c_{ma}^{\,j}\cdot h_{wa}^{\,j}\cdot\left(t_{comm} + k_z\,\frac{\ell_\rho}{p_z} + \frac{\ell_{wait}}{p_z}\cdot \ell_\rho\right)\right), \tag{6}$$

where c_u – total information density;

h_r – number of information flows between a set of nodes of network;

h_m – number of routes for transfer to j-th flow in distribution γ;

$c_{ma}^{\,j}$ – density of the j-th flow on route m_a^j;

$h_{wa}^{\,j}$ – route length m_a^j, determined by number of the communication channels entering a route;

t_{comm} – average time of switching of a packet;

k_z – average load factor of a channel;

ℓ_{wait} – average length of queue to a channel;

ℓ_ρ – the average volume of the packets transferred to networks;

p_z – average bandwidth of communication channels taking into account their loading.

The average load factor of communication channels is defined by expression [14]:

$$k_z = k_u + k_c\ , \tag{7}$$

where k_u – average load factor of communication channels, created by the distributed information flows;

k_c – average load factor of communication channels, created by office flows.

The total information density of the distributed information flows is defined by expression [14]:

$$c_u = \sum_{j=1}^{h_r}\sum_{a=1}^{h_m} c_{ma}^{\,j}\ . \tag{8}$$

On the basis of expressions (1–5) let's calculate delay factor of a data packet on a route:

$$T_m = \sum_{b=1}^{h_{wa}^j} t_{comm_b} + k_{z_b}\cdot\frac{\ell_\rho}{p_{z_b}} + \frac{\ell_{wait_b}}{p_{z_b}}\cdot \ell_\rho\ . \tag{9}$$

Communication channel density p_{z_b} at the set load factor k_{z_b} [14] it is equal

$$p_{z_b} = k_{z_b}\cdot p_{w_b}\ ,$$

where p_{w_b} – communication channel throughput.

So, delay factor of a packet on a route depends on the following parameters:

- numbers of the communication channels entering a route;
- time of a packet switching;
- density of communication channels;
- the volume of the packet transferred on route;
- queue length.

We will determine the queue length of data packets to a communication channel by Pollacheka-Hinchin's formula:

$$\ell_{wait_b} = \frac{k_{z_b}^2}{2 - 2\cdot k_{z_b}}\ . \tag{10}$$

The load factor of a communication channel is defined by expression [14]:

$$k_{z_b} = c_{w_b} \big/ p_{w_b} \,, \quad (11)$$

where c_{w_b} – total information density of the transferred information flows on b-th channel.

The total information density of the transferred information flows on a communication channel has an appearance:

$$c_{w_b} = \sum_{j=1}^{h_r} \sum_{a=1}^{h_m} c_{m_a}^{j} \cdot k_a^j \,, \quad (12)$$

where $$k_a^j = \begin{cases} 0, & else \;\; w_b \notin m_a^j; \\ 1, & else \;\; w_b \in m_a^j, \end{cases} \quad (13)$$

w_b – b-th communication channel.

So, the queue length of packets to a communication channel and its load factor depend on parameters:

- total information density;
- communication channel bandwidth.

The load factor of a communication channel is defined by the value of total information density. So, influence a delay of a packet:

- density of information flows;
- length of routes;
- time of switching of a packet;
- throughput of communication channels;
- packet length.

At information flow control it is possible to influence length of routes and intensity of data streams. Let's stop on a way of calculation of the maximum information density in a hyperconvergent system. It will allow to find value of the minimum delay of a packet.

2. Calculation of the maximum information density in a hyperconvergent system

For execution of distribution of information flows it is necessary to make predesign of information density values, which circulate in it.

Data on transfer from nodes of network come to accidental timepoints t. The set of nodes of network generates a stochastic data flow information density u. The data transmission network can be presented as a complex multiphase system of mass service [15]. On limited intervals t_0 it is possible to assume stationarity of a data flow [11]. Let's assume that the data flow has properties of ordinariness and lack of an after-effect. Probability of that in time t_0 will be received h data packets at information density u, it is equal:

$$P_h(t_0) = \frac{(u \cdot t_0)^h}{h!} \cdot e^{-u \cdot t_0} \,. \quad (14)$$

Expected value and dispersion of the packets number which came to network during this time are equal

$$m = D_x = u \cdot t_0 \,. \quad (15)$$

It means that the number of the data packets arriving in unit of time can fluctuate in quite wide limits.

Let's calculate $u_{a,i}$ – density of a data stream from a node y_a in a node y_i.

For this purpose we will set network by means of the nondirectional weighed graph

$$S = \left(Y, \varphi_y, W, \ell_w, p_w \right), \quad (16)$$

where Y – set of the graph nodes S, being in isomorphism with nodes of network;

$h_y = |Y|$ – number of the graph nodes S;

$\varphi_y : \; Y \to N_+$ – the weight function defining for each node y_i its productivity

$$\varphi_{y_i} = \varphi_y \left(y_i \right); \quad (17)$$

$W = Y \times Y$ – set of the graph edges S;

$\ell_w : W \to N_+$ – the weight function defining to each communication channel $w_{a,i}$ its length

$$\ell_{w_{a,i}} = \ell_w \left(w_{a,i} \right); \quad (18)$$

$p_w : W \to N_+$ – the weight function defining to each communication channel $w_{a,i}$ its bandwidth

$$p_{w_{a,i}} = p_w \left(w_{a,i} \right). \quad (18)$$

For a nodes of set Y let's construct the graph B also we will create a matrix

$$H_B = \left\| h_{B\,a,i} \right\|, \quad (19)$$

where $h_{B\,a,i}$ – quantity of hierarchy network levels, through which the data packet needs to pass at exchange between nodes y_a and y_i.

Using the Danzig algorithm let's define the shortest ways between each two nodes y_a and y_i. We will create a matrix

$$L_m = \left\| \ell_{m\,a,i} \right\|, \quad (20)$$

where $\ell_{m\,a,i}$ – length of the shortest way between nodes y_a and y_i. Bandwidth of a way between nodes y_a and y_i is defined as

$$p_{m_{a,i}} = \min_{w_j \in m_{a,i}} p_{w_j} \,, \quad (21)$$

where p_{w_j} – edge bandwidth w_j of the graph S, way which is a part $m_{a,i}$.

Let u_a – maximum value of total density of data streams of node y_a, which it exchanges with all nodes of a set Y. Let $u_{a,i}$ – the maximum density of a data flow between nodes y_a and y_i. Then:

$$u_a = \frac{\ell_\rho \cdot \varphi_{y_a} \cdot p_{m_a} \cdot \sum_{i=1}^{h_y} \ell_{y_i} \cdot \sum_{i=1}^{h_y} h_{B_i}}{h_y \cdot h_o \cdot \sum_{i=1}^{h_y} p_{m_i} \cdot \ell_{y_a} \cdot h_{B_a}}, \qquad (22)$$

where ℓ_ρ – packet length, $\ell_\rho = 1 \div 64$ Kb [11];

p_{m_a} – the weighted average density of a way between node y_a and other nodes of a set Y,

$$p_{m_a} = \frac{\sum_{i=1}^{h_y-1} \frac{p_{m_{a,i}} \cdot \ell_{m_{a,i}} \cdot h_{B_{a,i}}}{\varphi_{y_i}}}{\sum_{i=1}^{h_y-1} \frac{\ell_{m_{a,i}} \cdot h_{B_{a,i}}}{\varphi_{y_i}}}; \qquad (23)$$

ℓ_{y_a} – the weighted average distance between node y_a and other nodes of a set Y,

$$\ell_{y_a} = \sum_{i=1}^{h_y-1} \frac{\ell_{m_{a,i}} \cdot \varphi_{y_i} \cdot p_{m_{a,i}}}{h_{B_{a,i}}} \Bigg/ \sum_{i=1}^{h_y-1} \frac{\varphi_{y_i} \cdot p_{m_{a,i}}}{h_{B_{a,i}}}; \quad (24)$$

h_{B_a} – weighted average radius of the graph B with the center in node y_a, equal

$$h_{B_a} = \sum_{i=1}^{h_y-1} \frac{h_{B_{a,i}} \cdot \varphi_{y_i} \cdot p_{m_{a,i}}}{\ell_{m_{a,i}}} \Bigg/ \sum_{i=1}^{h_y-1} \frac{\varphi_{y_i} \cdot p_{m_{a,i}}}{\ell_{m_{a,i}}}; \quad (25)$$

h_o – number of housekeeping processor operations of a packet at input-output, usually, accept $h_o = 10^6 \div 2 \cdot 10^6$ oper. [11].

The received value u_a it is distributed between the interacting nodes. Then for node y_i:

$$u_{a,i} = \frac{u_a \cdot \varphi_{y_a} \cdot p_{m_{a,i}}}{\ell_{m_{a,i}} \cdot h_{B_{a,i}}} \Bigg/ \sum_{j=1}^{h_y-1} \frac{\varphi_{y_j} \cdot p_{m_{a,j}}}{\ell_{m_{a,i}} \cdot h_{B_{a,j}}}. \qquad (26)$$

For each pair of nodes y_a and y_i, using expression (26), values are calculated $u_{a,i}$ and $u_{i,a}$. These values generally can be not equal each other. Therefore the average maximum density value of a data flow between these nodes is calculated [11]:

$$\overline{u_{a,i}} = \left(u_{a,i} + u_{i,a}\right)/2.$$

If the structure of network changes, then recalculation of the maximum density values of the data streams between network nodes is carried out. Let's note what has an essential role for calculation ℓ_ρ – packet length (formula numerator (22)).

3. Choice of a packet length

For messages in a hyperconvergent system packet length ℓ_p it is selected by constant. Packet length ℓ_p cannot be too small. Because with a fixed length of an office part of a packet the share of information part decreases, this is transferred in one packet. Besides, time expenditure increases by assembly and dismantling of messages.

Also memory size increases by storage of packets descriptors and their headings.

With a big length of a packet ℓ_p and the set reliability of data transmission on a communication channel the probability of a packet transfer with an error increases. Therefore the frequency of repeated packets transfers increases. It reduces overall performance of a system. Besides, the share of the unused random access memory which is taken away for packets of messages grows.

Proceeding from the above and taking into account practical recommendations [16], a rational packet length can be determined by the following expression:

$$\ell_p = \min\left(\ell_{p1}, \ell_{p2}\right), \qquad (27)$$

where ℓ_{p_1} – a rational packet length in economy terms of memory and system expenses minimization of the processor when processing the message; ℓ_{p_2} – packet length providing the maximum transfer speed of the message on a communication channel at the set distortion probability of one bit.

The received value ℓ_p it is rounded to the next value equal $2^{\mu+1}$, where μ – integer number, i.e. $l_\rho = 2^{\mu+1}$.

Let's assume that length of the transferred messages in a hyper convergent system is distributed under the exponential law with mathematical expectation, equal ℓ_p bit. Let's consider requirements of economy of memory and costs for assembly dismantling of the message, which increase with reduction of packet length. Then the trend is defined on increase in length of the transferred messages by expression [16]:

$$\ell_{\rho 1} = k_1 \cdot \left(\ell_b + \sqrt{k_2 \cdot \ell_b \cdot \ell_s}\right), \qquad (28)$$

where k_1 – coefficient of processor costs of assembly the message dismantling;

ℓ_b – packet header length;

k_2 – blockiness coefficient.

Value of a packet length ℓ_p, at which message transmission rate on a communication channel V_ρ accepts the maximum value, corresponds to packet length

ℓ_{p_2}. Message transmission rate for one packet [16]:

$$V_\rho = \frac{\ell_\rho - \ell_b - \dfrac{h_b}{(\ell_s/\ell_\rho - \ell_b)+1}}{t_y + \dfrac{\ell_\rho}{V_w} + P_o \cdot \dfrac{\ell_\rho}{V_w} \cdot \left(1 + P_o + P_o^2 + \ldots\right)} = \frac{\ell_\rho - \ell_b - \dfrac{h_b \cdot (\ell_\rho - \ell_b)}{\ell_s + \ell_\rho - \ell_b}}{t_y + \dfrac{\ell_\rho}{V_w} + \dfrac{P_o}{1-P_o} \cdot \dfrac{\ell_\rho}{V_w}}, \qquad (29)$$

where h_b – number of free bits in the last packet;

t_y – time of a packet switching;

P_o – error probability in a packet;

V_w – data transmission rate on a communication channel.

The number of free bits in the last packet is defined from expression

$$h_b = \ell_\rho - \left(\operatorname{mod}\left(\ell_s, \left(\ell_\rho - \ell_b\right)\right) + \ell_b\right), \qquad (30)$$

where $\operatorname{mod}\left(\ell_s, \left(\ell_\rho - \ell_b\right)\right)$ – remainder of division ℓ_s on $\left(\ell_\rho - \ell_b\right)$, and error probability in a packet can be determined as

$$P_o = 1 - \left(1 - P_{dis}\right)^{\ell_\rho}, \qquad (31)$$

where P_{dis} – distortion probability of one transmit data bit.

Packet length ℓ_{ρ_2} it is selected by discrete search of expression values (29):

$$V_\rho\left(\ell_{\rho_2}\right) = \max_{\ell_\rho}\left(V_\rho\left(\ell_\rho\right)\right). \qquad (32)$$

4. Research the method of information flow control in a hyperconvergent system

As an efficiency indicator of a method we will select target expenses function of a computing resource for distribution γ [17]:

$$F^{(\gamma)} = \frac{1}{c_u} \cdot \sum_{j=1}^{h_r} \sum_{a=1}^{h_m} c^j_{m_a} \cdot \ell^j_{m_a}, \qquad (33)$$

where

$$\ell^j_{m_a} = \sum_{b=1}^{h^j_{w_a}} \ell_{w_b}, \qquad (34)$$

ℓ_{w_b} – communication channel length w_b, route which is a part m_a^j.

Average a packet delay $T_\rho^{(\gamma)}$ for distribution γ it can be defined by expression (6).

Expression for definition average load factor of communication channels has an appearance [16]:

$$k_z = \frac{\sum_{j=1}^{h_r} \sum_{a=1}^{h_m} \sum_{b=1}^{h_{w_a^j}} \dfrac{c_{w^j_{ab}}}{p_{w^j_{ab}}}}{\sum_{j=1}^{h_r} \sum_{a=1}^{h_m} h_{w_a^j}},$$

where $h_{w_a^j}$ – number of the communication channels entering a route $m_{a,j}$;

$c^j_{w_{a_b}}$ – total density of the transferred data streams on b-th to the communication channel entering a route m_a^j;

$p^j_{w_{a_b}}$ – throughput b-th communication channel, entering a route m_a^j.

Average throughput of a communication channel p$_z$ is defined with its loading as:

$$p_z = \frac{\sum_{j=1}^{h_r} \sum_{a=1}^{h_m} \sum_{b=1}^{h_{w_a^j}} k^j_{z_{a_b}} \cdot p^j_{w_{a_b}}}{\sum_{j=1}^{h_r} \sum_{a=1}^{h_m} h_{w_a^j}},$$

where $k^j_{z_{a_b}}$ – load factor *b*-th communication channel, entering a route m_a^j.

Considering the aforesaid, it is possible to give the formalized problem definition of distribution information flows along routes.

Graphs are set $S = (Y, W, p_w, \ell_w)$, $U = (Y, R, u_r)$ and values ℓ_p, k_z, t_y, T_{max}, $M_w^1(\gamma) = M_w^2(\gamma) = 0$.

It is required to distribute data streams along routes in network, i.e. to create families of sets $M^{(\gamma)}$, $M_\text{v}^{(\gamma)}$, sets $C_W^{(\gamma)}$, $C_r^{(\gamma)}$, vector $\mathbf{u}_y^{(\gamma)}$ and matrixes $M_W^{1(\gamma)}$, $M_W^{2(\gamma)}$ so that at the maximum value of total intensity the distributed data streams of cu and conditions execution:

1) $\forall\, w_{x,y} \in W \quad c_w(x, y) \le p_w(x, y);$ (35)

2) $\forall\, r_{x,y} \in R \quad c_r(x, y) \le u_r(x, y);$ (36)

3) $c_u \le \sum_{r_{x,y} \in R} u_r(x, y);$ (37)

4) $\forall\, m \in M \quad T_m \le T_{\max},$ (38)

data transmission in the direction of the final addressee was carried out along two routes, i.e. in matrixes $M_W^{1(\gamma)}$ and $M_W^{2(\gamma)}$ values of elements $m_W^1(x, y)$ and $m_W^2(x, y)$

should be other than zero, value $F^{(\gamma)}$ accepted the minimum value, i.e.

$$F_0 = \min_{\gamma | c_u(\gamma) = c_u^{(\max)}} F^{(\gamma)}. \tag{39}$$

For a solution of optimization model with goal function (39) and constraints (35)-(38) the simulation model was developed.

Results of modeling are shown on the Fig. 1.

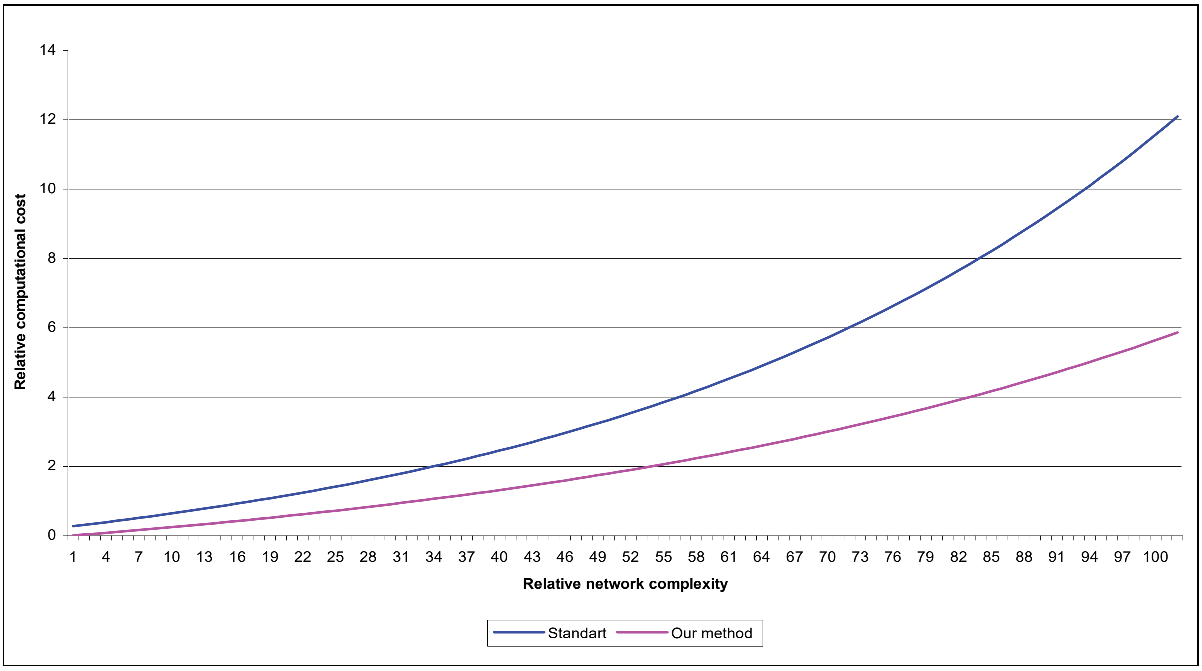

Fig. 1. Dependence relative expenses of a computing resource on network relative complexity

It is visible that with growth of network relative complexity the offered method allows to reduce expenses of a computing resource to two times.

Conclusions

It is offered a method of information flow control in a hyperconvergent system. The analysis of the packets delay in a hyperconvergent system is carried out. Analytical expression for calculation the delay factor of a data packet on a route is received. Pacing factors of a delay are revealed. Analytical expressions for calculation the maximum density of information flows in a hyper convergent system are received. The way of the choice of optimum length of a packet is offered. Problem definition of distribution the information flows along routes is formulated. The offered method is effective at centralized operation and absence heterogeneous a component. This method allows to reduce expenses of a computing resource, especially at increase in dimension of network.

Direction of further researches – development a solution method of the offered optimization task.

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Надійшла до редколегії 29.04.2019
Схвалена до друку 16.07.2019

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МЕТОД УПРАВЛІННЯ ІНФОРМАЦІЙНИМИ ПОТОКАМИ В ГІПЕРКОНВЕРГЕНТНІЙ СИСТЕМІ

Н.Г. Кучук

У гіперконвергентній системі істотно знижуються витрати на обслуговування. Але через централізацію управління при цьому падає продуктивність системи. Тому в такій системі завдання оптимізації розподілу інформаційних потоків відіграє істотну роль. ***Мета статті*** *– розробка методу управління інформаційними потоками в гіперконвергентній системі. Метод повинен враховувати особливості централізованого управління і відсутність гетерогенності програмних і апаратних засобів.* ***Результати дослідження.*** *Проведено аналіз причин затримки пакетів в гіперконвергентній системі. Отримано аналітичний вираз для розрахунку величини затримки пакета даних на маршруті. Виявлено основні чинники затримки: кількість каналів зв'язку, що входять до маршруту; час комутації пакета; пропускна здатність каналів зв'язку; обсяг пакета, переданого по маршруту; довжина черги. При управлінні інформаційними потоками можна впливати на довжину маршрутів і інтенсивність потоків даних. Виходячи з цього отримані аналітичні вирази для розрахунку максимальних інтенсивностей інформаційних потоків в гіперконвергентній системі. Показано, що істотну роль для розрахунку грає довжина пакета. Запропоновано спосіб вибору оптимальної довжини пакета. Сформульована формалізована постановка задачі розподілу інформаційних потоків за маршрутами. Проведено дослідження розробленого методу управління інформаційними потоками в гіперконвергентній системі. Для перевірки працездатності методу розроблена відповідна імітаційна модель. Як показник ефективності методу обрана цільова функція витрат обчислювального ресурсу для розподілу. Рішення оптимізаційної задачі отримано за допомогою розробленої імітаційної моделі.* ***Висновки.*** *Запропонований метод ефективний при централізованому управлінні і відсутності гетерогенних компонент. Даний метод дозволяє зменшувати витрати обчислювального ресурсу, особливо при збільшенні розмірності мережі.*

Ключові слова*: гіперконвергентна система, пропускна здатність, інформаційний потік, затримка пакета.*

МЕТОД УПРАВЛЕНИЯ ИНФОРМАЦИОННЫМИ ПОТОКАМИ В ГИПЕРКОНВЕРГЕНТНОЙ СИСТЕМЕ

Н.Г. Кучук

В гиперконвергентной системе существенно снижаются затраты на обслуживание. Но при этом падает производительность системы из-за централизации управления. Поэтому в такой системе задача оптимизации распределения информационных потоков играет существенную роль. ***Цель статьи*** *– разработка метода управления информационными потоками в гиперконвергентной системе.* ***Результаты исследования.*** *Проведен анализ причин задержки пакетов в гиперконвергентной системе. Получено аналитическое выражение для расчета величины задержки пакета данных на маршруте. Выявлены основные факторы задержки. Получены аналитические выражения для расчета максимальных интенсивностей информационных потоков в гиперконвергентной системе. Предложен способ выбора оптимальной длины пакета. Сформулирована формализованная постановка задачи распределения информационных потоков по маршрутам.* ***Выводы.*** *Предложенный метод эффективен при централизованном управлении и отсутствии гетерогенных компонент. Данный метод позволяет уменьшать затраты вычислительного ресурса, особенно при увеличении размерности сети.*

Ключевые слова: *гиперконвергентная система, пропускная способность, информационный поток, задержка пакета.*