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High-throughput computing optimization of cloud computing platform based on Markov jump

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Abstract. Cloud computing platform transport (CCPT) is a new transport protocol based on Stream Control Transmission Protocol (SCTP), which uses the the multi-destination feature of the SCTP protocol, and multiple paths in an end-to-end coupling. The parallel data transmission is carried out in parallel, and the bandwidth of the single-path transmission can be improved, and the end-to-end throughput can be enhanced. In this paper, the data transmission of the cloud computing platform is optimized according to whether the amount of transmission is affected by the received cluster value. The CCPT throughput model based on Markov jump association is analyzed in this paper, and the congestion window of the two phases is analyzed, and the congestion window is analyzed in the second stage of the timeout period, the slow start stage and the congestion avoidance stage. Secondly, we get a high-throughput function of RTT, RTO and packet loss in the data transmission process of a cloud computing platform, which can estimate the high throughput of data transmission protocol in the cloud computing platform. Finally, the result analysis verifies the validity and accuracy of the data transmission throughput model of the cloud computing platform.

Key words. Cloud computing platform data transmission, throughput model, transmission volume, Markov jump.

1. Introduction

Internet-based end-to-end transmission mainly uses TCP protocol. The new end-to-end transmission protocol SCTP (Stream Control Transfer Protocol) [1–2] uses the multihake (multihoming) and multi-flow (multistreaming) technology. TCP has a high end-to-end path fault tolerance and other advantages. Based on the SCTP cloud computing platform data transmission CCPT (Concurrent Multipath Transfer) [3] that is relative to SCTP end-to-end bandwidth aggregation and many other advantages [4], it can make full use of bandwidth resources, and it also presents a new challenge to the research and application of the basic theory of the Internet transport layer. In recent years, the research has also attracted the attention of

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scholars [5] because of its unique advantages, which has become the object of concern for the next generation in the network transport layer protocol [6].

The next generation of Internet in the cloud computing platform data transmission requirements are mainly reflected in the protection of a wide range of applications. It can be on the network resources for dynamic and reasonable scheduling and can use of the need to transfer the association of multiple paths as a whole. To take full account of the relevance of the path, for each path such as the bandwidth, delay, packet loss rate and other network attributes, especially the throughput, this paper should give high attention to how to establish a highly efficient and reasonable throughput transfer model in this paper as the focus.

In recent years, many scholars have given different throughput optimization methods for SCTP single path transmission characteristics, which are of some inspiration for establishing the multi-path transmission throughput model. As in [7], with the reference to traditional TCP throughput model [8], I first consider the mathematical expectation of the three phases of the slow start, the congestion avoidance and the overtime retransmission, and then I establish the throughput model of the SCTP [9]. The establishment of the model gives a more detailed discussion. In the literature [10–12], the whole model is divided into two parts from the perspective of Markov chain analysis.

Based on the analysis of the above research results, this paper proposes a CCPT high throughput optimization method in accordance with the Markov transition and the influence of the amount of transmission or the value of the received cluster. With the CCPTHOMJ (CCPT high-throughput optimization based on MarkTH jump, CCPTHOMJ), the TCTH data transfer time, the slow start phase and the congestion avoidance phase data transmission, the CCPTHOMJ is established in detail. Secondly, by comparing the calculation results of the model and the simulation results in NS2, it verifies the accuracy of the model and compares it with the existing model to verify the advanced nature of the model. Finally, the work is summarized and forecast.

2. CCPT's high-throughput algorithm optimization based on Markov jump

Based on the CCPT transmission model established in Section 2, the high-throughput calculation process of CCPT is derived here. For the description of Step 3 in the CCPT transmission model, the calculation process is based on the concept of Table 1 to give a description of the variables involved in the calculation and the related meaning.

2.1. Division of CCPT data transmission phase

The symbol S_i shows the ith first stage of the data transfer process, from the beginning of the first ith timeout period to the end of the $i+1$th first timeout period. When denoting the time-out stage as Z_i^{TO}, the slow start phase as Z_i^{SS} and the congestion avoidance phase as $Z_i^{C\Lambda}$, the ith stage of the data transmission process can be expressed by the formula

$$S_i - Z_i^{TO} + Z_i^{SS} + Z_i^{C\Lambda} \tag{1}$$

Table 1. Variable names and related meanings in CCPT high throughput models

Variable name	Meaning
$Sund$	The size of sender window
q	The probability for the successful transmission in each Data Chrnik [2]
P	Packet loss probability
b	Cumulative response factor
SS	Slow start
CA	Congestion avoidance
TO	Overtime
B	Throughput capacity
QDP	The stage between two packet dropping instructions in the congestion avoidance phase
QD	4 times repeated confirmation
Q	When the packet loss occurs, the probability of packet loss produces due to timeout
SST	Slow start threshold
$Cund$	Sender congestion window (CW)
RTO	Timeout retransmission time
RTT	Round-trip time

Symbol Y_i represents the number of packets transmitted in the S_i phase. This symbol also consists of three parts: the number of packets transmitted in the timeout phase denoted as Y_i^{TO}, the number of packets transmitted in the slow start phase denoted as Y_i^{SS}, and the number of packets transmitted in the congestion avoidance stage, which is denoted as $Y_i^{C\Lambda}$. The number of packets transmitted in the ith stage can be then expressed as

$$Y_i - Y_i^{TO} + Y_i^{SS} + Y_i^{C\Lambda} . \tag{2}$$

The handling capacity B can be expressed as

$$B - E\left[Y\right] / E\left[S\right] . \tag{3}$$

The change condition for data forwarding phase of CCPT is shown in Fig. 1.

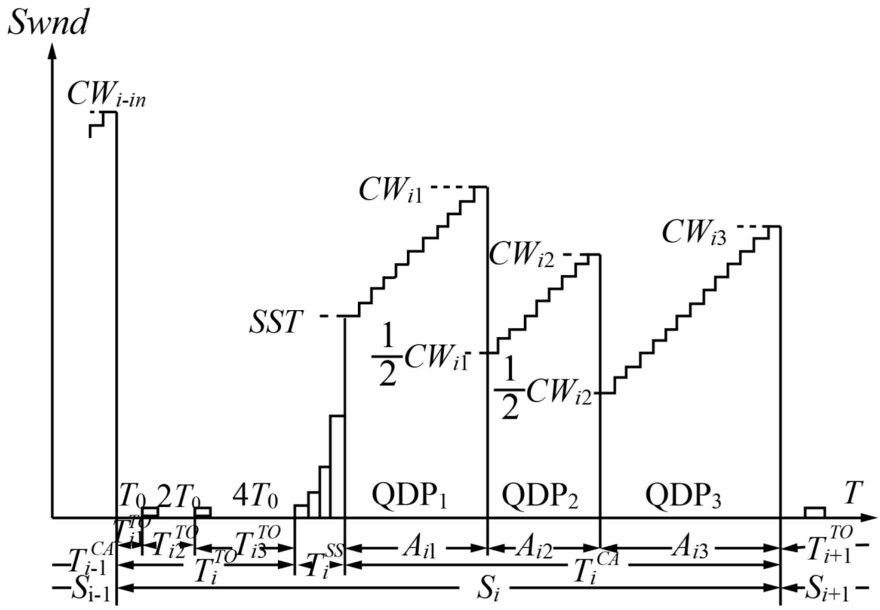

Fig. 1. Description of the window change in the CCPT data transmission phase

Because the amount of transmission ($Swnd$) depends on the minimum value of both the congestion window ($Swnd$) and receiver's cluster value ($Rwnd$) at the end-to-end transmission environment, the derivation of the model is divided into two parts: Part 1: when the congestion window is less than the reception cluster value, the throughput model is not affected by the received cluster value. Part 2 is the throughput model when the congestion window is larger than the received cluster value. The throughput is affected by the received cluster value.

2.2. Throughput model when the CCPT data transmission is not affected by the received cluster value (CCPTHOMJ)

According to the Markov jump method, from the beginning denoted as $t = 0$, the sender has to send the data and define N_t as the number of packets transmitted as a $[0, t]$ period of time. Quantity B_t is the throughput for that time and also for time $t > 0$. For the latter case

$$B_t = N_t/t\,. \tag{4}$$

We define the throughput expression for the long-term stability as follows:

$$B = \lim_{t\to\infty} B_t = \lim_{t\to\infty} \frac{N_t}{t}\,. \tag{5}$$

Figure 2 shows the window change in the congestion avoidance phase.

The size of the dispatched volume of CCPT is $Swnd$. In the congestion avoidance

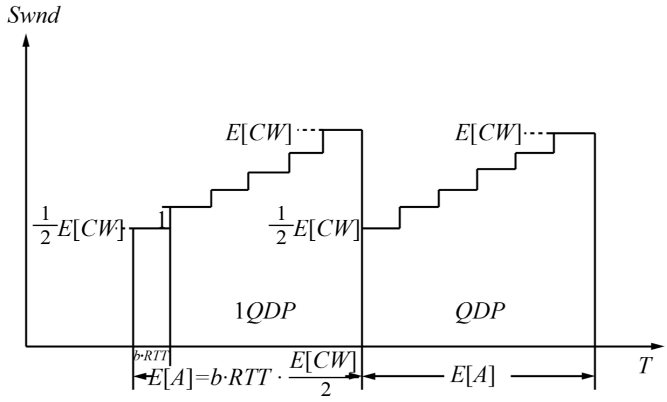

Fig. 2. Schematic diagram of the average window change in the congestion avoidance

phase, the sending end will increase the size of the SACK. If there are $Swnd$ packets that are sent successfully in the ith time, the sender will receive $Swnd/b$ SACK, assuming that the size of the window is $Swnd'$ in the next round, so that

$$Swnd' = Swnd' + \frac{1}{b}\,. \tag{6}$$

Therefore, if there is no packet loss, $Swnd$ will grow linearly. The slope is $1/b$, and if the packet is detected, the window value will be reduced, depending on whether the packet loss is caused by repeated confirmation, or the overtime. If the packet is caused by a duplicate acknowledgment, it remains in the congestion avoidance. If the packet loss is caused by a timeout, the timeout period enters.

If H_{ij} is the number of j packets of QDP transmitted in the i phase, the congestion avoidance stage consists of j QDPs: Λ_{ij} is the time of the jth phase and QDP stage and CW is the size of the congestion window at the end of each QDP phase. Quantity X_{ij} is the the packet loss occurred in the round in the ith phase and the QDP stage. Symbol b is the cumulative response factor and it is the confirmed number of $S\Lambda$CK data packets. The congestion avoidance phase of the throughput is as follows:

$$B_{CA} = \frac{E\,[H]}{E\,[A]}\,. \tag{7}$$

In order to derive the B_{CA} expression, we first derive the expressions for $E\,[H]$ and $E\,[A]$.

The i of the QDP stage is shown in Fig. 3.

The QDP stage begins from the instruction on packet loss. When the current window value is $CW_{ij-1}/2$, QD occurs in half of the window. The value of the window increases in each time. When 1 increases in time b, we define a_{ij} as the lost data packet of QDP. Then, a packet is sent before the packet is detected, and $CW_i - 1$ packet is sent on the a_{ij} time of occurrences and subsequent times, so that the total number of packets sent in the $x_i + 1$th round is as follows

$$H_i = a_i + CW_i - 1\,. \tag{8}$$

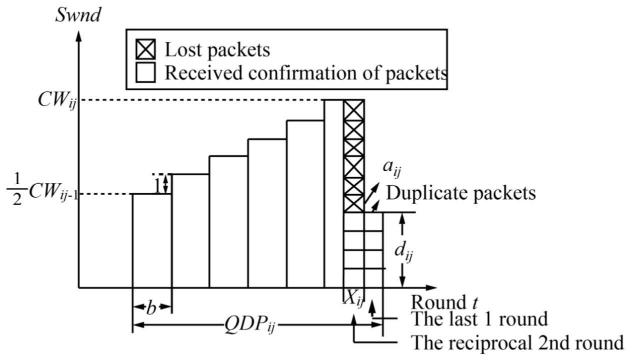

Fig. 3. Diagram for packet generation in step of repeated confirmation phase for 4 times

It would seem that

$$E\,[H] = E\,[a] + E\,[CW] - 1\,. \tag{9}$$

Here, a_{ij} is the number of packets sent by the sender before the packet loss occurs, including the loss in the first packet. In order to introduce $E\,[a]$, we consider $\{a_i\}\,i$ of random process, and $\{a_i\}\,i$ is an independent and distributed random variable. It is assumed that $a_i = k$th and $k - 1$th data packets are sent successfully before the packet loss. It can be concluded as

$$P\,[a - k] - (1-p)^{k-1}\,p, \quad k = 1, 2, \ldots\,. \tag{10}$$

The expectation of the variable a_{ij} is

$$E\,[a] = \sum_{k=1}^{\infty} (1-p)^{k-1}\,pk = \frac{1}{p}\,. \tag{11}$$

Formulae (9) and (11) can be combined as

$$E\,[H] = \frac{1}{p} + E\,[CW] - 1\,. \tag{12}$$

In order to derive the expressions of $E\,[CW]$ and $E\,[A]$, we define r_n as the RTT in the nth round in QDP_{ij}. The A_i of the QDP_j in time is

$$A_i = \sum_{n=1}^{X_i+1} r_n\,. \tag{13}$$

Here, r_n is the random variable, and its size has nothing to do with the window size. It can be concluded that

$$E[A](E[X]+1)E[r] \,. \tag{14}$$

In the following section, I can use the expression $RTT = E[r]$ at the average time of RTT. We derive the $E[X]$th expression. Quantity CW_i is the function of number of rounds in order to simplify the model derivation. We assume that $CW_{i-1/2}$ and X_i/b are integers. Firstly, we observe the ith QDP stage. The window value changes between $CW_{i-1/2}$ and CW_i, the $\frac{1}{b}$ is the linear slope. We can conclude that

$$CW_i = \frac{1}{2}CW_i + \frac{X_i}{b}, \quad i = 1, 2, \dots . \tag{15}$$

3. Simulation results and model validation

To verify the accuracy and advancement of the proposed model (CCPTHOMJ), we use the CCPT module provided by the Protocol Engineering Laboratory of Delaware University in USA. Figure 4 shows the topological structure diagram of the simulation environment.

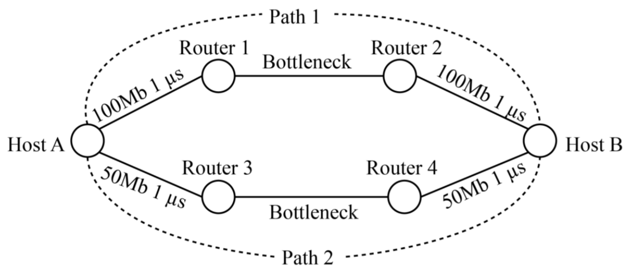

Fig. 4. Simulation topology

As shown in Fig. 4, Host A and Host B represent CCPT terminals with dual NICs, respectively. To simulate various network scenarios, different bandwidths, latency, and packet loss rates are set here, with the design of [3] CUC, SFR and DAC algorithm. The data block is set to 1468 Bytes and is used the traditional file transfer protocol FTP for the application layer protocol. The following for this article is not affected by the received cluster value and received by the cluster value of the two cases. The high throughput model CCPTHOMJ of the CCPTH data transmission carries on the simulation experiment and the result analysis.

3.1. Comparison with the simulation results and calculation results of CCPTHOMJ model affected by the received cluster value

Figure 5, upper part, depicts the packet loss rate of 1 % and 5 %, CCPTHOMJ model of the simulation results and the results of the calculation change by$CW_{\max}$.

The cumulative response factor is 1, the transmission round trip delay is the fixed value of 100 ms. From $E[CW] = \sqrt{8/3bp}$ of expression (19), the average of the window size is $E[CW] = 51.64$. We set the $CW_{\max}$ of simulation results and calculation results of the 5 MSS (Maximum Segment Size), 10 MSS, 20 MSS, 30 MSS, 40 MSS and 50 MSS.

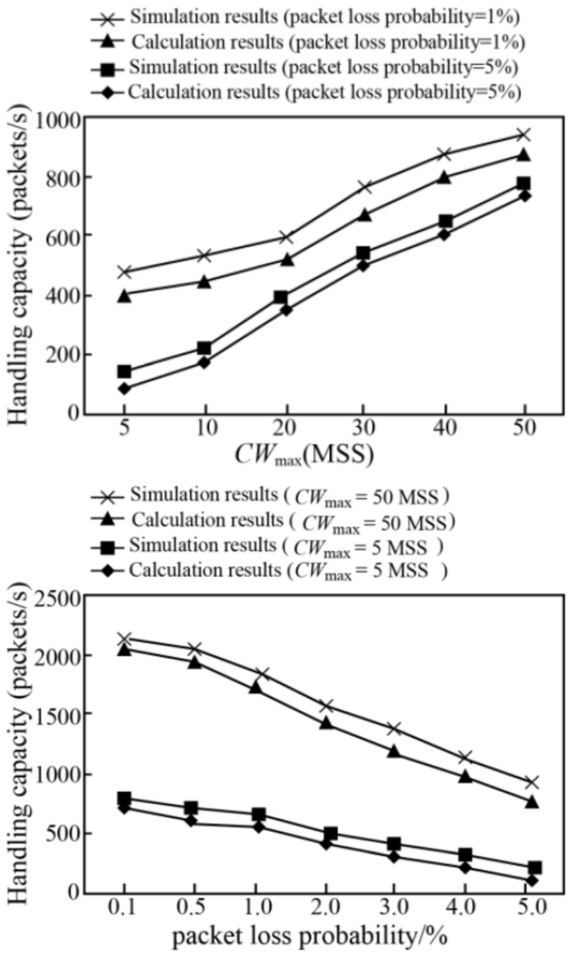

Fig. 5. Comparison of the simulation results and model results

It can be seen from Fig. 5, bottom part, that, when $CW_{\max}$ is 5, the simulation results of the model are basically the same as those of the calculated results, and the model can predict the handling capacity. The handling capacity increases with the growth of the packet loss rate. The simulation results are in good agreement with the calculated results, and the different packet loss rates also has a certain influence on the accuracy of the model. When the packet loss rate is 1 %, the simulation results are close to the calculation results.

When the packet loss rate increases to 5 %, the separation distance of the two curves becomes larger and the accuracy of the model decreases, but on the whole, the calculation result of CM-ORM model can well reflect the change of handling capacity.

In order to verify the accuracy of CCPTHOMJ model in multi-angle, we analyze the fixed value and the delay of path transmission. The calculation result and simulation result of the model change with the packet loss rate. When the rates are 0.1 %, 0.5 %, 1 %, 2 %, 3 %, 4 %, and 5 %, the approximate values of the path were respectively 50 MSS, 40 MSS, 30 MSS, 20 MSS, 10 MSS, and 5 MSS (but without losing the general meaning). The model simulation results and calculation results are compared, as shown in Fig. 5, bottom part.

Figure 5, bottom part, shows that when the packet loss rate is 0.1 %, the model can better predict the throughput, but with the packet loss rate increases, the model simulation results and the results show a certain deviation. The $CW_{\max}$ of different paths have the effect on the model accuracy. When $CW_{\max}$ is 5 MSS, the simulation results of the model are not the same as those of the calculated results. When $CW_{\max}$ increases to 50 MSS, the spacing between the two lines increases to a certain extent, and the accuracy of the model reduces to a certain extent. On the whole, the model of the calculation results can still be a good response to the changes in the trend of handling capacity.

The above analysis shows that the CCPTHOMJ model has high accuracy regardless of whether the amount of transmission is affected by the received cluster value or the amount of transmission is not affected by the received cluster value.

4. Conclusion

In this paper, it is firstly established a model of CCPT data transmission, and on the basis of this model we consider the influence of CCPT on handling capacity in different stages of congestion control, slow start and timeout retransmission, and propose a kind of cloud computing platform through the optimization of the handling capacity. According to whether the amount of transmission is affected by the value of the received cluster, the model is divided into two cases to obtain a high-throughput relationship with the packet loss rate. At the same time, we can verify the model accuracy, time delay, packet loss rate and simulation experiment. The comparison between the simulation results and the calculated results shows that the model designed in this paper can predict the trend of handling capacity and has a high accuracy. With the advanced model, the comparison is optimized in handling capacity of data transmission in the cloud computing platform.

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