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RPath Algorithm in Multimedia Transmission

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Abstract: Aiming at the problems in service oriented real-time multimedia transmission, such as a long delay, frequent jitter and low reliability, this paper proposes LD/RPath algorithm LD/RPath estimates the dynamic data volume on service nodes and links through reasonable data volume approximation. And the data splitting technique is imported to convert the node delay into the edge delay. In the mean time, the reliability of nodes is considered so that the multimedia delivery problem is transformed into a conventional shortest path problem. The experimental simulation results show that the algorithm is a kind of high efficient and reliable algorithm spending smaller complexity achieving good path selection performance.

Keywords: Multimedia; Approximation of the amount of data; Node; Price label

1. Introduction

Real-time multimedia transmission system is widely used in real-time monitoring system, video conferencing and the others [1]. However, with the development of the mobile devices' ability and wireless communication technology, the traditional single network environment gradually becomes heterogeneous equipment and pervasive computing environment made up of network. Multimedia transmission has obvious differences with traditional file transmission, the transmission of traditional file for transmission delay, jitter is not too many requirements, but there are strict error control and retransmission mechanism. In the transmission of real-time multimedia transmission, demanding synchronicity, and requires small transmission delay. Multimedia transmission can endure packet loss caused by the error and abnormal, can endure due to no retransmission or error correction mechanism of packet loss or latency, but it will not tolerate caused by error control mechanism based on retransmission display discontinuity or confusion. In the pervasive environment, the difference of different links' transmission capacity is huge, and in particular, wireless link bandwidth is smaller and unstable; the difference of each node's processing capacity is huge, and in particular, the mobile node's processing power is often weak [2-4]. These features can not ensure the reliability of real-time multimedia transmission system.

Multimedia network transmission technology, however, because of the multimedia compression, compression and transmission problem not solve, have not been able to achieve the ideal effect. In recent years, multimedia communication technology

SOA uses the available service to build loose coupling application. As the key technology of SOA, service composition can combine independently distributed and available basic service to meet user's complex business requirements, which makes it adapt to the pervasive computing environment [5-8]. These characteristics help SOA use the existing distributed service resources to dynamically build loose coupling multimedia transmission system in pervasive environment.

In the service-oriented real-time multimedia transmission system, a number of multimedia services deploy in different nodes in the network beforehand. These services can be divided into functional and non-functional services. Features services meet the functional requirements of users through subtitle's embedment, tags' addition and codes' conversion and the other necessary processing for the source information. Non-functional services can reduce the amount of data transmission and reduce the time delay of data transmission through media compression and sampling, etc. In particular, for mobile users using wireless access, these non-functional services can effectively improve the achieved services' reliability of users, but it has the function itself to deal with time delay and reduce the multimedia video's quality. The function of the system is as follows. When receiving the users' request, the system starts from the data source and builds a multimedia information processing chain after a number of functional and nonfunctional service processing nodes so as to transfer multimedia information with relatively low latency and high reliability to end users . In this paper, it is assumed that the user's service requests arrive one by one and they don't affect each other.

2. Multimedia Transmission Model

2.1. Define the parameters

In a pervasive multimedia transmission environment, the multimedia service nodes and the parameters of the network link directly affect the routing effect of algorithm.

This section mainly shows that the parameters of the model and defines the problems.

Combined with the research question, the definitions of related parameters are given: bandwidth, unit processing time, IORatio and reliability. For the sake of simplicity, the difference between transmission and spread is ignored. In the below description, the transmission is used to represent the process that the data transmits from a node and it is accepted by the next node.

Bandwidth: bandwidth refers to the current links' transmission capacity the link between the two service nodes in multimedia transmission environment, which is shown by B. Unit processing time: the unit processing time refers to the time which is taken to process unit data in a certain service node, which is shown by O according to the characteristics of the multimedia information. Multimedia system is data intensive application and the size of the amount of data has a great influence on processing time. In addition, due to the heterogeneity of service node, there are great differences among different service node's computing capacity. Therefore, the time which is taken to process unit data is used to measure the node's processing capacity.

IORatio: the IORatio is defined as the ratios of unprocessed data and processed data after a certain service processing, which is shown by r. It is also closely related to the characteristics of multimedia system. The services with different functions tend to have different effects on the amount of data. For example, the embedment of subtitles could hardly affect the quantity of the data, but the media data compression tends to make the amount of data become smaller. In general, the IORatio of services with different functions is different, but the IORatio of different copies of the same service is the same.

Reliability: the reliability expresses the degree of the reliability when a service processes nodes, which is shown by e according to historical data. This paper uses the definition in literature [4] that inspects K times system's calls for a certain service node in the past period of time and if the number of successful calls is C, e will be equal with C/k. Because the reliability is product parameter, the reliability of a service path refers to the product of all service nodes in this path (it is believed that all the links are reliable).

Delay: The delay includes transmission delay and data processing delay, which is represented by d. Because the delay is cumulative parameters, a service path delay refers to the sum of all nodes' processing delay and links' transmission delay in this service path.

3. RPath Algorithm

RPath algorithm is an approximation algorithm whose idea is to transform the original problem into a conventional shortest path problem through a series of approximate conversion and then use classical the shortest path algorithm (such as Dijistra algorithm) to solve. The LD/RPath algorithm can in polynomial time complexity yields better results, since the original problem is NP-complete problem, it is not guaranteed to get the optimal results, but the experimental results show that, the algorithm obtains results close to the optimal solution. Next, from beginning of the amount of data approximation, design step by step LD/RPath algorithm's designed idea is introduced step by step.

3.1. Node splitting

To solve the shortest path algorithm is the single source weights at the edge of the shortest path problem, but our service on the node graph have cost (weight), so we need to make some transformation of service graph, which can be used the shortest path algorithm.

Choi et al proposed method of node splitting to translate some network problems. This method is used. For example, in figure 2, we will s_2 split into two nodes $s_{2,1}$ and $s_{2,2}$, then let all the precursor node s_2 are connected to the $s_{2,1}$, $s_{2,2}$ connected to all nodes of S2. Data processing delay raw to s_2 node above, now use between $s_{2,1}$ and $s_{2,2}$ the cost of edge to said, it is called such as between $s_{2,1}$ and $s_{2,2}$ for the internal side edge (inner- link). Our service in every node splitting process, adding a new node, eliminating the vertices above cost, the price converted services diagram exists only on the edge.

3.2. Reliability conversion

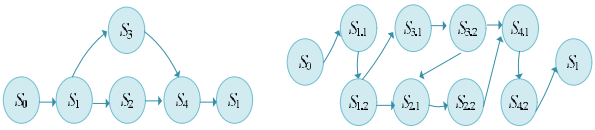
Due to the dynamic and mobility in pervasive environment, service replica node may fail. System requirements is to find a delay as small as possible, path of service and reliability as high as possible. The idea is to make the reliability of the parameters, the processing delay of the node.

The previous QoS related research work, a coefficient for each service internal edges in graph, the coefficient of reliability service node is an internal edge represents the inverse of E. After this treatment, the service replica node distribution coefficient of higher reliability coefficient is relatively small, low reliability of service replica node distribution the relatively large. These internal edge new delay cost is the original price multiplied by the respective coefficient, as processing delay internal edge new.

This process idea is straightforward: for the single source shortest path algorithm for the shortest path, a service copy reliability makes the low reliability of the inner side of the price is relatively high, the higher reliability of service copy internal edge cost becomes lower, and the shortest path algorithm to select the the shortest path selection bias in service copy the higher reliability. That is to say, the service replica node reliability higher more easily by the algorithm. The LD/Rpath algorithm of time

delay is small selected path, at the same time, high reliability, to achieve a balance between the two.

Figure 1 shows a simple conversion example. Figure 1 (a) is a service graph, assume that the only 1 copies of each service service (similar to handle multiple copies), node splitting, converted to figure 1 (b). s_0 and s_t shown is the node of source data and the destination node.



(a) Aservice graph **(b) Transformed service graph**

Figure 1. Shows a simple conversion example

Considering the amount of data approximation and reliability conversion, assuming the initial data in the s_0 for the amount of M, then figure 1 (b) between $s_{1,1}$ and $s_{1,2}$ in the inner side of the price for $\frac{1}{e_1} m.r_0.o_1$, said the reliability of node s_1 data processing delay is multiplied by s_1; $s_{3,2}$ and $s_{2,1}$. Edge costs

$$\frac{m.r_0.r_1.r_3}{T_{3,2}} \tag{1}$$

Composed of transmission delay on the link between $s_{2,2}$ and $s_{4,1}$; on the side of price is as follows.

$$\frac{m.r_0.r_1.r_2 + m.r_1.r_0.r_2.r_3}{2T_{2,2-3,1}} \tag{2}$$

Because of this edge on the amount of data has two possible values (one is from s_0 through s_1 and s_3 transfer to s_2, two to s_2 from $s\,s_0$ by s_1 transmission), the cost of data approximation; $s_{4,1}$ and $s_{4,2}$ between the inner side of the price.

$$\frac{1}{e_4}.\frac{m.r_0.r_1.r_3 + \frac{m.r_0.r_1.r_2 + m.r_1.r_0.r_2.r_3}{2}}{2}.o_3 \tag{3}$$

The internal side represents the service node has two precursor node, but also one of the precursor node still has two precursor node. So, in two the amount of data approximation.

3.3. Time complexity

After the cost of labeling on service chart, you can use the shortest path algorithm to solve the problem. For the shortest path, node sequence we will produce a reduction to convert before service graph, paths can be obtained from LD/RPath. We'll let N_n and N_e respectively to represent a number of the number of nodes and edges the original service in the graph. The approximate second algorithms in data quantity, because each node at most connected with the N_n nodes, so the process of traversal of all edge up N_n times, the complexity of this part is $O(N_n N_e)$; in the third part the same each node is visited once, at the same time to find the all of its possible precursor node, this part of the complexity is $O(N_n N_e)$. The process of node splitting and data approximation are very similar, need to deal with each node, and then determine the precursor node and

4. Experiment and Simulation

4.1. Evaluation methods

There are two main experimental purposes: one is to evaluate the efficiency of LD/RPath algorithm, two is to evaluate the effect of selection algorithm. We have implemented two other algorithms to compare efficiency: one is random (random) algorithm, Random algorithm to select the service path, a successor node of the current node randomly selected as the processing nodes in the next step; two is the optimization (optimal) algorithm, Optimal algorithm traversing all possible paths, and then select the best path.

Comparison of results on the algorithm, we in different network size LD/RPath algorithm, Random algorithm and Optimal algorithm are executed many times, comparing the path they produce, respectively, compared with the 3 path delay, reliability and delay. Delay / reliable than smaller is better, better reliability, delay / reliable the smaller the better.

Huge computational complexity of Optimal algorithm makes it very time-consuming. In the real-time multimedia transmission system, the user can tolerate delay is relatively small, so Optimal algorithm in the service graph node scale up to a certain extent is not practical. So in our simulations, delay when the Optimal algorithm over a larger value after the operation efficiency and effect of selection, we only compare Random algorithm and LD/RPath algorithm.

4.2. Simulation design

The simulation experiments on Inter (R) Core (TM) 2Duo CPU E8200 @ 2.66GHz, execute the 2GB RAM machine.

The simulation experiment using Java language, mainly includes the generation of various parameters services diagram and 3 kinds of algorithm. Parameters in the figure are designed to be adjustable, if we set the MaxNode=2000 service node. These service node, no multimedia processing service replicas initially, then according to the different network scale to produce functional diagram. For example, a MaxService=7 service in some settings, each service is at least MinInstance=3 copies, at most MaxInstance=7 copy, then we randomly generate a connected graph function, for each service between Mi-

nInstance and MaxInstance generates a random real copy number, and then in the MaxNode node randomly selected some nodes to deploy services. Service copy of compression ratio, the service node unit processing time and reliability, link bandwidth according to a normal distribution, then the service. We can through the MaxNode, MaxService, MinInstance and MaxInstance parameters to scale adjustment services graph, comparative experiments were carried out in different network scale. In the design of 3 algorithms, Random algorithm is easy to implement, Optima L algorithm dynamically apply the memory to hold all the possible path, LD/RPath algorithm according to the 4 steps in the previous section of the processing.

4.3. Results of analysis

The running time of 3 algorithms were compared in the topology of the network scale under different operation respectively. 3 kinds of algorithm 100 times, and then take the average execution time of 100 runs for comparison, as shown in Figure 4. We can see, the running time of LD/RPath algorithm and Random algorithm are much less than the optimal algorithm. When the network size is large, the running time of LD/RPath algorithm and Random algorithm are almost the same, therefore, the higher the efficiency of LD/RPath algorithm. In addition to the data shown in Fig., we also compared the running time of each algorithm is more large-scale network topology, node number reached 70, Optimal algorithm execution time was more than 80s. in a real-time multimedia transmission system, 80s delay is clearly not acceptable. So in the following experiments, when the number of nodes exceeds 70, we no longer consider optimal algorithm.

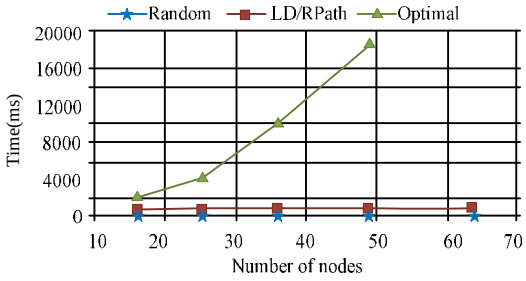
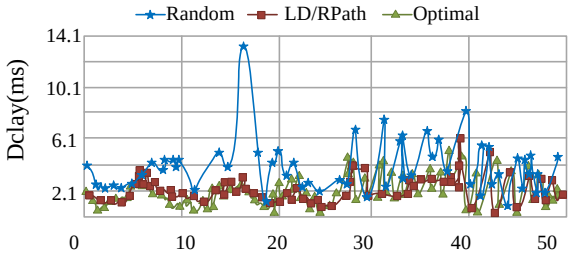


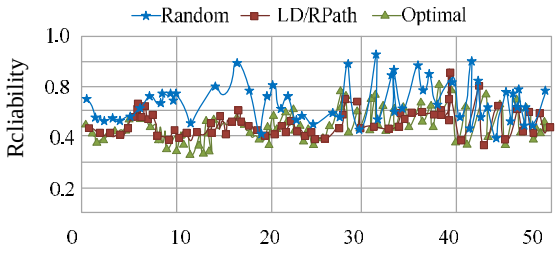
Figure 2. The effect of 3 kinds of algorithms are compared in different network size

Then, the effect of 3 kinds of algorithms are compared in different network size. The experimental data shown in Figure 3 is the MaxService=7, MinInstance=2, MaxInstance=7 configuration. Under this configuration, we run 50 experiments in each experiment, the topological structure of network is to randomly generated, each experiment included 1 times 1 times LD/RPath algorithm, Optimal algorithm and Random algorithm 20 times, the results of the Random algorithm, the best results in 20 , time delay, reliability and delay / reliable ratio as shown in Figure 5.

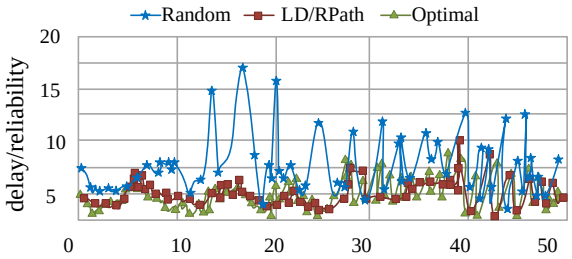
Figure 3 (a) that is the 50 set of experiments, comparing 3 delay path generation algorithm. We can see, the LD/RPath algorithm is very close to Optimal algorithm, are better than Random-Best. statistical information discovery. In a 50 experiment, a 44 LD/Rpath delay path generated by the algorithm is smaller than the Random-Best algorithm, a the path with the Optimal algorithm to generate the same 24. Figure 3 (b) is the reliability comparison, in the 50 set of experiments, the reliability of route LD/RPath generated by the algorithm is 26 times more than the Random-Best algorithm, 1 have 6 times more than the Optimal algorithm. Figure 3 (c) is in contrast to delay / reliable ratio, delay / observe the path to produce LD/RPath and Optimal algorithm is very close to the reliable, are better than in most cases Random-Best algorithm. The results show that, in the 50 set of experiments, a Random-Best algorithm is better than the LD/RPath algorithm 42 times, 9 times better than Optimal algorithm.



(a) comparisons of delay



(b) Comparison of reliability



(c) comparisons of delay/reliability

Figure 3. 3 kinds of algorithms the delay, reliability and delay / reliable than contrast

5. Conclusion

Aiming at the problems in service oriented real-time multimedia transmission, such as a long delay, frequent jitter and low reliability, this paper proposes LD/RPath algorithm LD/RPath estimates the dynamic data volume on service nodes and links through reasonable data volume approximation. And the data splitting technique is imported to convert the node delay into the edge delay. In the mean time, the reliability of nodes is considered so that the multimedia delivery problem is transformed into a conventional shortest path problem. The innovations of this algorithm are as follows: the reliability is integrated into the edge weights reasonably, which guarantee the reliability in the choice of the shortest path ; the reasonable approximate of data reduces the problem's complexity; node split integrates node weights into edge weights.

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