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Research of the High Reliability Algorithm on Real-time Transmission of Multimedia

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Abstract—With development of the computer communication network technology, especially the advanced multimedia network technology on mobile handset, the network environment has changed gradually from the traditional and single structure to larger differences in the structure and more complex in the environment. The reliability of the real-time multimedia transmission system can't be guaranteed, for the complexity of the network environment and the diversity of the network devices. LD/RPath(lowest delay/reliability path) Algorithm is proposed in this paper to achieve better results in the path selection in order to improve the reliability of real-time multimedia data transmission. It can convert the data transmission problem into the traditional Shortest Path problem by fitting the service nodes with the reasonable approximation of an amount of data and changing the dynamic data on the edge of the transmission.

Keywords-reliability, multimedia, transmission, Shortest Path

1. Introduction

Real-time multimedia transmission system has important value in application, and it is widely applied to real-time monitoring, remote video and telephone conference and so on. However, with the development of computer networks and communication continues, there is a higher requirement in the capacity of multimedia data transmission in the complex and heterogeneous networks, especially the various requirements of mobile devices such as mobile TV, mobile phone GPS and so on in 3G network. But the reliability of the real-time multimedia transmission system can't be guaranteed for the diversity of the network structures and the huge differences of the network equipment. Therefore, finding a way to solve the problems of the reliability in real-time multimedia data transmission ignoring huge differences of the structure and equipment in the network is a real focus in today's multimedia researches.

Service-oriented architecture SOA can make use of the existing service resources to build loosely coupled networks dynamically for different multimedia data transmission systems, so it is suitable to build structures of real-time multimedia data transmission systems. This paper proposes LD/RPath(lowest delay/reliability path) algorithm to achieve better results in routing, from real-time multimedia transmission systems. It can improve the reliability of real-time multimedia data transmission.

2. Model of multimedia transmission systems

2.1 Reliability

Reliability is used to indicate the reliable degree of a service processing node. In this paper, we define reliability as:

We assume that the system invoked a service processing node K times in the selected period of the past time, but the service processing node was only be invoked successfully for C times. Then the reliability of this service processing node is defined as

$$e=C/K$$

RAfter this, we can assume that each service processing node in the service line is independent, so the reliability of such a service line can be represented by the product of the reliability of all the service processing nodes in this service line.

For a service line with N service processing nodes with $(e_1, e_2, \ldots\ldots, e_N)$, its reliability can be expressed as:

$$e = \prod_{i=1}^{N} e_i$$

2.2 Relationship between Functional Graph and Service Graph

In reality, we often can find a variety of solutions for the demand of a certain type. And we can often find a number of the receiving node paths from the starting nodes to the receiving nodes in a network for data transmission. At this time, we can use Functional Graph FG to represent the network the combination of relations of all the possible paths from the starting nodes to the receiving nodes.

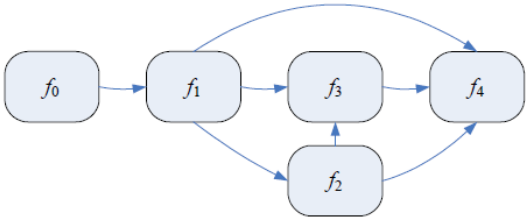


Figure 1 Functional Graph

As is shown in Figure 1, the system has 5 basic types of multimedia service nodes $(f_0, \ldots\ldots, f_4)$, and there are a total of 4 possible pathways data transmission from f_0 to f_4 , which are $((f_0 f_1 f_4, f_0 f_1 f_3 f_4, f_0 f_1 f_2 f_4, f_0 f_1 f_2 f_3 f_4)$.

Considering that each multi-media processing service node may have more than one copy, if all copies of each processing service node are extended directly in the Functional Graph, it will be shown as Service Graph SG in Figure 2. Service Graph is be used to describe the interdependent relationship services of the copies of all the nodes in the Functional Graph. Here, we assume that the number of copies for five nodes in Figure 1 is 1, 2, 1, 2 and 2. Then there will be the 8 copies of the processing service nodes from S_0. We need special attention here because f_4 have 2 copies, which makes it impossible to reach only one receiving node. So we must add S_t as the termination after the 2 copies of the last node f_4. Now, we get the Service Graph shown in Figure2.

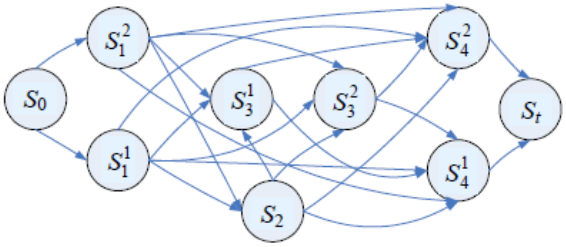


Figure 2 Service Graph

How to choose a service path from S_0 to S_t to make the reliability of the service line as high as possible in a given graph SG (V, E) will be the contents our will describe in detail next.

3. Introduction of LD / RPath algorithm

LD / RPath algorithm is an improve algorithm based on the shortest path for the service graph of the multimedia transmission paths. Its main idea is to make a series of fitting conversions for each edge in the Service Graph to make sure that it can meet the solving requirements of the traditional shortest path problem. Thus, the optimal choice of the paths in the topological structure can be solved by the simple and practical shortest path algorithm.

3.1 Data Estimation and Node Splitting

Since there is a wide selection for the paths of data transmission, and the choice is not known in advance, we have no way to calculate the actual data quantity of each service node in the absence of clear data transmission path. In reality, we can only get a roughly estimate for data quantity of the service node conduct the following studies.

If a copy of a node S_i has L precursor copies, then we can estimate the data quantity S_i received as the arithmetic mean of the sum of all the L precursor copies' data quantity. The approximation algorithm is mainly divided into two parts: Sorting the copies of service nodes in the Service Graph and then approximating the data quantity of each service node according to the order.

The shortest path algorithm can just solve the problem of how to find the right edge in the graph with the lowest price, which requires each edge to calculate must be the internal side of the graphics, and the weights are present on the edge. So we have to do some conversions with the Service Graph to make sure that it can be applied to the shortest path algorithm. Here, we split each node based on the number of its copies, using new nodes to eliminate the price of the nodes. In this way, the costs will only exist in the edge of the Service Figure by the conversion. So now, we can approximate the the shortest path with the Service Graph.

3.2 Reliability Conversion and Cost Mark

For the complexity of modern multimedia network, especially the dynamics and mobility of mobile multimedia, the copy nodes in the Service Graph may fail, so we need to do reliability conversion with the results of the shortest path approximate algorithm. Reliability conversion can effectively raise the cost of the internal side formed by the low-reliability copies while reducing the cost of the internal side formed by the high- reliability copies. Thus, as long as a certain threshold is given, it is easy to obtain the paths below the threshold, which are just the copies with high reliability chosen out by the shortest path algorithm.

After we have done data estimation, node splitting and reliability conversion, it is the time to mark the cost.

In the Service Graph, if the edge needs to be marked is an internal edge, its cost formula is defined as follows:

$$\frac{m_i \times o_i}{e_i}$$

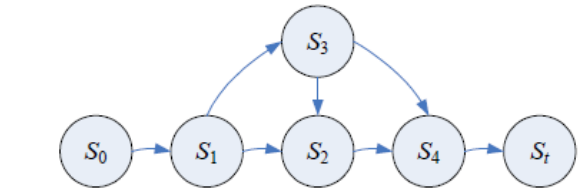
Among them, e_i is the reliability of this edge, o_i is the processing time required of this edge, and m_i is the approximate data quantity amount of transmitted on this edge.

If the edge needs to be marked is not an internal edge, its cost formula will be defined as follows:

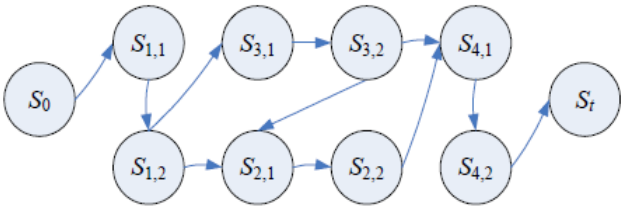
$$\frac{m_i}{B_i}$$

Among them, B_i is the bandwidth of the service edge, m_i is the approximate data quantity amount of transmitted on this edge.

Figure 3 shows an example of the cost mark for the service nodes in the Service Graph. Among them, Figure 3 (a) is the original Service Graph before converted and Figure 3 (b) is the Service Graph has been conversed. In Figure 3 (b), each service processing node has been divided in accordance with the number of its copies, and the costs are all transferred to the edge. So the approximate data quantity of each node can be calculate by the shortest path algorithm.



(a) Original Service Graph



(b) Service Graph Transformed

Figure 3

4. Specific Experiments and Evaluations

4.1 Experiment Method

We have chosen the other two algorithms: Random algorithm and Optimal algorithms to to compare with LD / RPath algorithm on the reliability. In our choices of these two algorithms, Random algorithm makes a random selection of all the successor nodes to the current node, and takes it as the object we should deal with in the next step. And Optimal algorithm ultimately chooses the best path after the Service Graph traversal of all possible paths.

We have selected different scales of network topologies, then run LD / RPath algorithm, Random algorithm and Optimal algorithm respectively under the same scale of nodes, and finally analyze their reliability by comparing the data transmission paths they choose. In the two algorithms we choose, Optimal algorithms requires large computation and consuming time, so it is no longer practical when the scales of network topologies are too large. In the large-scales of network topologies, we only use the reliabilities of Random algorithm to compare with those of LD / RPath algorithm.

4.2 Results and Analysis of the Experiment

First, we can use Random algorithms, Optimal algorithms and LD / RPath algorithm to select the appropriate transmission path for data transmission in small topologies, and calculate the reliabilities individually. Here, we randomly selected 50 groups of data to do the comparison. Figure 4 shows the comparison of the reliabilities of Random algorithm, Optimal algorithm and LD / RPath algorithm on the 50 data groups.

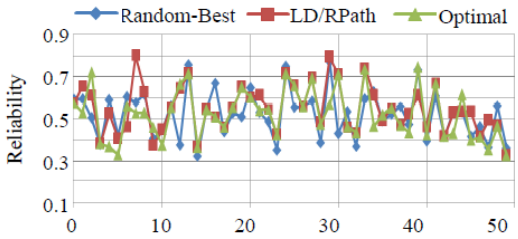


Figure 4. Comparison of the Reliabilities of Random Algorithm,Optimal Algorithm and LD / RPath Algorithm in Small Topologies

We can see from Figure 4 that the reliability of LD / RPath is better than that of Random-Best algorithm for 26 times, and better than that of Optimal algorithm16 times on the 50 data groups. However, considering that the complexity of the Optimal algorithm can making serious delay problem, we can believe LD / RPath algorithm is a very practical high-reliability algorithm for multimedia data transmission in small topplogies.

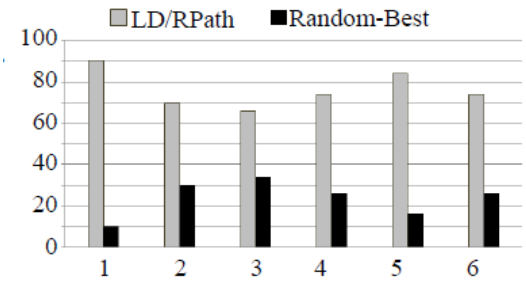


Figure 5. Comparison of the Reliabilities of Random Algorithm and LD / RPath Algorithm in Large Topologies

We compared the selection effect of the reliabilities of LD / RPath algorithm and Random algorithm when the node size is 30, 60, 100, 400, 900 and 1600 in the experiment of data transmission in large topologies. The results of the comparisons are displayed in Figure5. We can see From Figure 5 that all the node scales, LD / RPath algorithm can achieve higher reliability than the Random algorithm.

Random Algorithm and LD / RPath Algorithm in Large Topologies

We can clearly see the reliability of LD / RPath algorithm in multimedia data transmission from the comparison in the above experimental results. LD / RPath algorithm gets the better path selection by a small time complexity, which is much higher than the reliability of Random algorithm, especially in large topologies more similar with the real multimedia data transmission when Optimal algorithms is too complex to be used. On the whole, LD / RPath algorithm is a high reliability algorithm for real-time multimedia data transmission.

5. References

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