Simulative Research on the Function of Internet of Things Basing on the Changing of Topological Structure

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Abstract

As for the next generation of Internet, the Internet of things impacts people's lives profoundly, its application will be more broadly. There are many kinds of things network terminal, network topological structure is complex, the reset of network resource will drive the topological structure, changes, which have an important impact on network performance. By using the Simulative method, we study the relationship between the changes of topological structure and network performance before the network resource reset, which can improve the project of resource replacement, furthermore, improve the network performance.

Keywords: *network resource, topological structure, network performance*

1. Introduction

The Internet of Things is a kind of network, which links any article to the Internet for information exchange and communication by such information sensing equipment as radiation frequency identification, infrared sensor and GPS and according to the agreed protocol, so to realize the intelligent identification, positioning, tracing, monitoring and management for articles [1]. Its core and basis are still the Internet, however, the application of the Internet of Things is wider and the structure is more complex, the occupation rate of system resources is higher. In the process of network operation, when some critical value comes, it is necessary to dynamically adjust the system structure of the Internet of Things, conduct scientific and reasonable distribution for present resources, so to meet the requirements on optimizing the performances and targets of system at maximum. Researching the change of network performance under different topological structures by utilizing simulative structure has important sense for the reconfiguration of network resources.

2. Research Method on Network Performances

Generally, the methods for researching and analyzing network performances may be divided into qualitative analysis and quantitative analysis, in which, the quantitative analysis means to find the value rations among quantitative indices reflecting the network performances and the influences caused by the change of some index or some indices to network performance by mathematical tool or measurement method, it may more precisely reflect the actual network performances. The normal quantitative analysis methods include mathematical analysis, actual measurement and computer simulation [2]. In the thesis, computer simulation method is applied to discuss the relation between the topological structure and network performances.

3. Brief Introduction on the Simulative Software NS-2

The network simulation software NS-2[3] with open source code is the widest network performance simulation tool in the world, its process and result may be exhibited by visualized graph tool, thus a designer may make accurate forecast for the performances of his/her designed network. It is constituted by OTcl language, network module, scheduling module and network simulation. It applies in-layer software model, the core applies high-efficiency compiled C++ language, while the shell applies OTcl Script language [4]; the core completes the data processing task and the shell completes the configuration and control task.

4. Performance Parameters of Network

The performance parameters of network are the technical indices balancing network performances [5]. There are many parameters that describe network performances, in the thesis, the following three parameters will be selected for research [6].

Transmission delay of IP package: The parameter is defined for successful transmission result of IP package and wrong transmission result of IP package, its value is $T_{start} - T_{end}$, in which, T_{start} is the start time of package transmission and T_{end} is the time when the package reaches the target end.

Network throughput: The throughput means the maximum speed that the equipment may accept in the case that no frame loses.

Network Loss Tolerance: The said Loss Tolerance is the ratio between the lost portion of data package and the total quantity of the transmitted data package. Loss Tolerance= Quantity of ICMP within unit time/quantity of all reports within unit time [7].

5. Researching Network Performance by Utilizing Computer Simulation Method

5.1. Topological structure and simulative environment

According to present application of network structure, it is proposed to apply 2 normal topological structure types for research, they are respectively star type and net type, as shown in Figure 1.

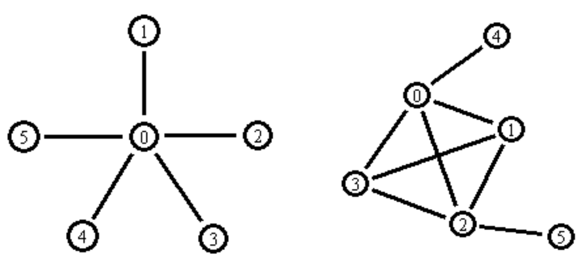

Figure 1. Scheme on topological structure of network

Each topological structure contains 6 nodes, the bandwidth of bidirectional chain is 2Mb, the chain delay is 10ms, the size of the data package transmitted by the data source CBR with fixed data package length is 500 and the transmission interval is 0.005.

5.2. Model of simulation design

5.2.1. Concept and contents of simulative design model

The design on the simulation model is the core of simulation test and the implementation basis of work [8]. It means as follows: Before a simulation test is begun, under the simulative environment of simulative tools, by utilizing the means provided by the simulation tools, a simulative design will be carried out for the necessary network structure, node, chain and data source in the test, the design on the simulation model is the key to the success of simulative application [9].

Establishing a simulative design model mainly includes establishing a network simulation model and a flow model.

Establishment of network topology simulation model: For the design on a topology simulation model, it is necessary to preliminarily determine such attributes as the quantity of network nodes, linking manner & chain bandwidth, chain delay, transmission interval and data source of a topological model according to the design scheme on topological model, in addition, it is necessary to establish a dummy network of some topological structure by utilizing simulative tool.

Establishment method on flow model: There are two methods for the determination of a flow model, one is self-established, and the second is to select an existing model. The first method needs to consume much time and strength, the process is quite complex, it requires us to determine a proper probability distribution, estimate the parameters of probability distribution and the accuracy of a model [10], in addition, utilize statistic method or tool to demonstrate and adjust the efficiency of a flow model, the realization is difficult. If we select a necessary flow model in the existing achievements, we will have a lot of options, in addition, it is not necessary for us to spend time and strength on demonstrating its efficiency, we may directly use it.

5.2.2. Simulative scheduling module of system

In general, the simulation of a simulator starts from establishing a simulator type of case. A simulator type of case expresses a simulative environment, it includes the topological structure of network, setting of data flow, simulation event function, script simulation network environment and simulative functions, *etc.* [11].

A simulative software is an event driving simulator, in which, an event specifies the change of system, the simulative clock enters the next event occurrence moment from an event occurrence moment. In the event scheduling method, events will be scheduled as per the time sequence. An event scheduler selects the time record of the earliest occurrence time from the event list, then the simulative clock will be amended to the occurrence moment of the event; for every type of events, there is a corresponding event subprogram, in which, the change of system state will be processed, so to conduct a statistic calculation needed by a user; after the event has been processed, it will return to the event scheduler.

A simulative network event is a data package, the data package class is the subclass of the event class. In a data package, there are a time mark and a data processing package object pointer. When a data package is sent, the values of these items have been set and submitted to the scheduler for processing. The scheduler will insert it into the total event list, the data packages in the total event list are arrayed as per time sequence. Each data package has a pointer for processing the objects of the data package, the pointer will show who will process the package. Before a scheduler enters a run state, all events have occurred and entered the total event list. The structure of the data package is shown in Figure 2.

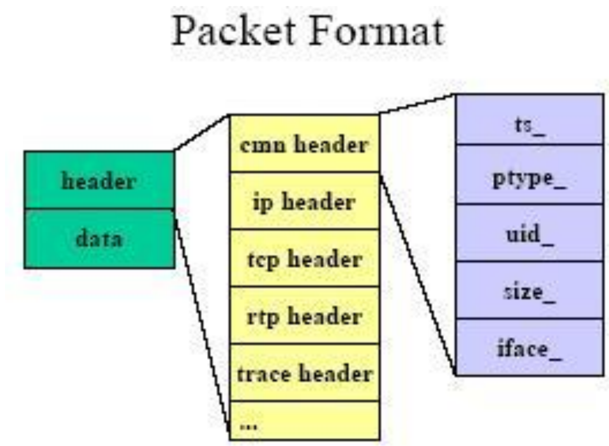

Figure 2. Structure of Data Package

After the scheduler enters run state, it will not do any other thing, it only takes out the data package, hands it to the processing object of the package, in addition [12], adjusts clock to the time marked in the data package, then takes the next data package, until the end.

5.2.3. Design on a simulative model of system

In the thesis, the classification model of system simulation applies the object-oriented structure concept [13], the base class TclObject is established by a user under the explanation environment, its purpose is to establish/clear off the assembly object under simulative environment, complete the mapping of OTcl and C++ language; its subclass NsObject is the basis of all network assemblies, its main task is to process data package, classifier and connector, which are all the direct subclasses of NsObject and the father class of all basic network assemblies [14]. Its data flow applies the data source CBR and FTPbusiness flow with the size of fixed data package, as shown in Figure 3:

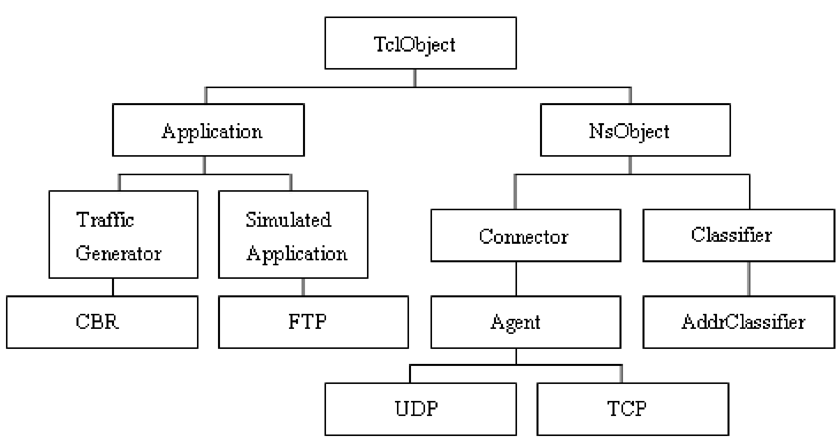

Figure 3. Figure on Model Type of Structure of the system

5.2.4. Part of the source code:

Part1：Obtain the delay of performance parameters from end-to-end.

```
BEGIN {
    highest_packet_id = 0;
}
{
   action = $1;
   time = $2;
   node_1 = $3;
   node_2 = $4;
   type = $5;
   flow_id = $8;
   node_1_address = $9;
   node_2_address = $10;
   seq_no = $11;
   packet_id = $12;
   if ( packet_id > highest_packet_id )
              highest_packet_id = packet_id;
   if ( start_time[packet_id] == 0 )
             start_time[packet_id] = time;
   if ( flow_id == 1 && action != "d" ) {
      if ( action == "r" ) {
         end_time[packet_id] = time;
      }
   } else {
      end_time[packet_id] = -1;
   }
}
END {
    for ( packet_id = 0; packet_id <= highest_packet_id; packet_id++ ) {
       start = start_time[packet_id];
       end = end_time[packet_id];
       packet_duration = end - start;
       if ( start < end ) printf("%f %f\n", start, packet_duration);
   }
}
$awk -f 1_delay.awk out.tr > cbr_delay1
```

Part2: Obtain the number of packet lossed.

```
BEGIN {
              fsDrops = 0;
              numFs = 0;}
{
   action = $1;
   time = $2;
   node_1 = $3;
   node_2 = $4;
   src = $5;
```

```
    flow_id = $8;
    node_1_address = $9;
    node_2_address = $10;
    seq_no = $11;
    packet_id = $12;
    if (node_1==2 && node_2==0 && action == "+")
    numFs++;
    if (flow_id==1 && action == "d")
    fsDrops++;
  }
  END {
  printf("number of packets sent:%d lost:%d\n", numFs, fsDrops);
  }
```

The methods:$awk –f 1_loss.awk out.tr

The end:number of packets sent: 978 lost:41

Part 3: Obtain the equally of throughput capacity

```
BEGIN {
init=0;
      i=0;
{
     action = $1;
     time = $2;
     node_1 = $3;
     node_2 = $4;
     src = $5;
     pktsize = $6;
     flow_id = $8;
     node_1_address = $9;
     node_2_address = $10;
     seq_no = $11;
     packet_id = $12;
     if(action=="r" && node_1==0 && node_2==5 && flow_id==1) {
     pkt_byte_sum[i+1]=pkt_byte_sum[i]+ pktsize;
     if(init==0) {
     start_time = time;
init = 1;
}
     end_time[i] = time;
     i = i+1;
  }
$awk -f 1_throughput.awk out.tr > cbr_throughput1
```

5.3. Simulative visualization and result analysis

5.3.1. Simulative visualization

When we start cbr and ftp data source and send constant data flow to some node, the simulative visualization is shown as Figure 4:

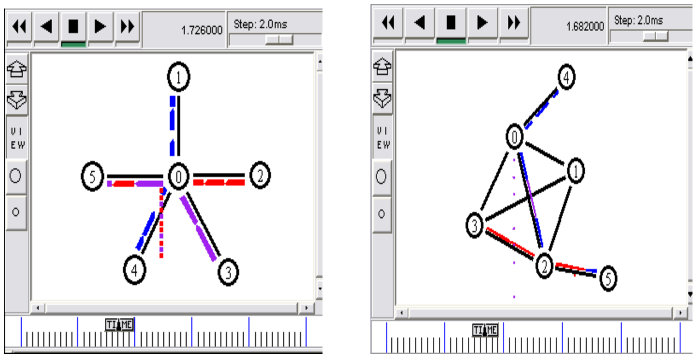

Figure 4. (a)Star-type topology (b) Net-type topology

5.3.2. Comparative analysis on simulative result

Transmission delay is shown as Figure 5:

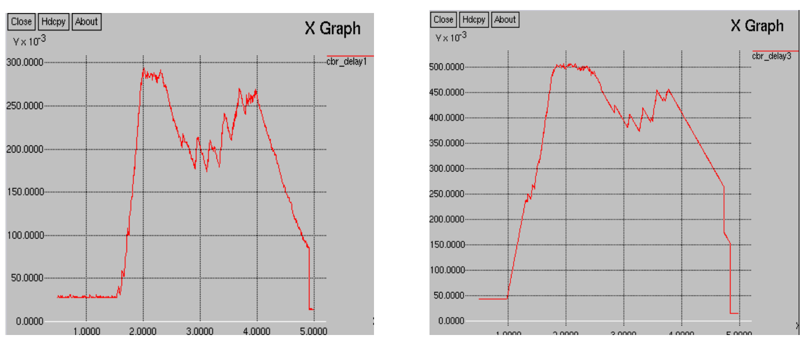

Figure 5. (a) Delay of Star-Type Topological Structure
(b) Delay of Net-Type Topological Structure

According to the figure, following the sending of cbr data flow, the delay between nodes starts to increase quickly, the delay realizes the maximum value at the instantaneous moment when ftp flow participates, subsequently, the delay fluctuates following the sending and receiving of ftp flow. The delay interval of the star-type topology is [29,270] and the delay interval of the net-type topology is [44,490]. The delay curve of star-type topology is steep and the delay curve of net-type topology is relatively gentle, therefore, in a topological structure with small quantity of nodes, the delay of star-type topology is small, while the delay of net-type topology is large due to its relative complexity, however, its reliability is excellent.

Network throughput is shown as Figure 6:

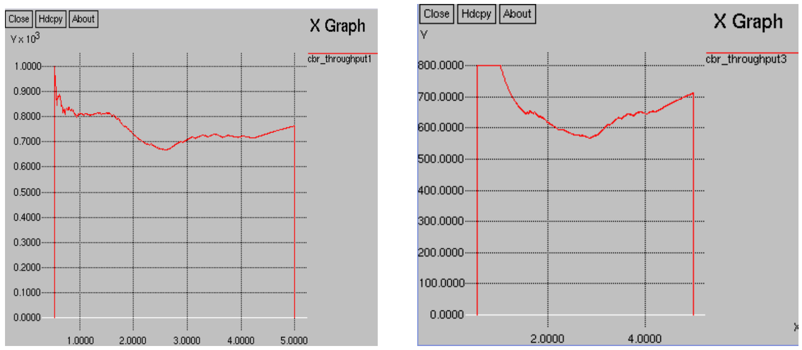

Figure 6. (a) Throughput of star-type topological structure (b)Throughput of net-type topological structure

According to the above figure, the mean throughput of star-type topological structure is above 640b/s, the throughput interval is [600， 1000] b/s， the mean throughput is large and the throughput change is small; the mean throughput of net-type topological structure changes between [570， 810] b/s and [550， 790] b/s respectively. It may be known that the star-type topological structure is simple, the transmission error is low and the throughput rate is high.

Loss Tolerance:

For the two kinds of topological structure, the chain Loss Tolerance attained by measurement and calculation is shown in Table 1:

Table 1. Loss Tolerance

	Cbr data flow		ftp data flow	
	Star-type	Net-type	Star-type	Net-type
0－1	(0/0)0	(0/0)0	(3/1007)0.003	(0/0)0
0－2	(0/0)0	(54/1599)0.034	(0/0)0	(5/987)0.005
0－5	(31/1007)0.031	(0/0)0	(3/108)0.028	(0/0)0
1－2	(0/0)0	(0/0)0	(0/0)0	(5/117)0.043

6. Conclusion

It may be known by simulative research that the network delay of the star-type topological structure is small, the throughput is large and the Loss Tolerance of each chain is small; the change of network delay time of the net-type topological structure is small, the reliability of this kind of topological structure is high and stable. Due to relatively complex structure, such network performance parameters as the transmission delay and the Loss Tolerance of chain are relatively large, the results are consistent with the network performances of two kinds of topological structure attained by us in the network establishment process, the conclusion may provide powerful referential basis when we carry out resource reconfiguration for the Internet of Things with different topological structures.

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