Research on Model Structure of SDN Based on QoS Strategy

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Abstract: The network candidate routing data stream is restricted to reroute the data stream of same origin and same destination, which brings great limitation to the application of the algorithm. This paper proposes a multi-objective optimization oriented rerouting algorithm for congested data streams. The algorithm detects and aggregates data streams on congested links, and reroutes the detected data streams. When there is no data stream, the data streams are arranged from large to small in the congested links, and the appropriate number of data streams are selected as candidate data streams, and small streams are aggregated by source and destination addresses. In order to determine the maximum network traffic and the optimal routing of candidate data streams, multi-objective optimization is introduced to jointly optimize the network load data stream maximization and network load balancing. Finally, a non-dominated genetic algorithm with elite strategy is designed to solve the multi-objective optimization problem.

1. Introduction
Based on the resource reconfiguration routing framework, a multi-objective optimization congestion data stream reroute algorithm is proposed. In this chapter, the basic concept of multi-objective optimization algorithm is briefly introduced. Then, combined with the specific application scenes in SDN network, the network is modeled and analyzed, including system model, algorithm design and algorithm flow analysis [1].

In the case of certain network resources, when congestion occurs, the scheme selects the appropriate candidate data stream through the data stream detection and aggregation flow. When routing the candidate data stream QoS, it can optimize the following two objectives: The first is that the network can accommodate as many data streams as possible, that is, no or less data streams are discarded; the second is load balancing of the whole network; the multi-objective optimization problem is a classic NP-hard optimization problem. Combining with the actual application scenario, this paper designs the corresponding non-dominated sorting genetic algorithm with elite strategy to solve [2-4]. From the final simulation results, the proposed method can effectively improve the network throughput, optimize the maximum link utilization of the network, and achieve the optimal network performance.
2. Introduction of QoS strategy optimization concept

2.1 Basic concept of QoS strategy optimization

QoS policy optimization is a common problem in various fields. Multiple objectives restrict each other, and it is impossible to achieve the optimal solution at the same time. However, it is necessary to find a relatively optimal solution.

Objective function:

\[
\min \text{ or } \max \quad f_i(\lambda), \quad n = 1, 2, \cdots, m
\]

Subject to:

\[
\eta_i(\lambda) \geq 0, \quad i = 1, 2, \cdots, m
\]

\[
\mu_j(\lambda) = 0, \quad j = 1, 2, \cdots, m
\]

\[
\lambda_i' \leq \lambda_i \leq \lambda_i '', i = 1, 2, \cdots, m
\]

Where, \( \lambda \) is an m-dimension vector containing n decision variables, as shown below:

\[
\lambda = [\lambda_1, \lambda_2, \cdots, \lambda_n]
\]

There are m optimization objectives, and it needs to combine them with i inequality and j equation, and each variable \( \lambda \) has corresponding upper bound and lower bound [5].

The solutions that satisfy all the above constraints are called feasible solutions, and the set of all feasible solutions is the feasible domain. When the feasible solutions \( \lambda_1 \) and \( \lambda_2 \) satisfy the following relations, \( \lambda_1 \) dominates \( \lambda_2 \):

1. \( \lambda_1 \) is not inferior to all optimization goals.
2. There is at least one optimization goal, and the value of \( \lambda_1 \) is better than that of \( \lambda_2 \), as shown in schematic diagram 1.

![Schematic diagram of dominance relationship](image)

Fig. 1 Schematic diagram of dominance relationship

Among them: 1 dominates 3 and 2 dominates 4, and 1 and 2 are not dominated by each other.

Based on the above assumptions, another concept can be extended, namely, non-dominated solution set. Given a set of solutions, the non-dominated solution set refers to the set composed of solutions not dominated by any other solutions [6]. If this set of solutions is all feasible solutions in the entire search space, the non-dominated solution set can also be called pareto optimal solution set [7].

2.2 Non-dominant sorting genetic algorithm with QoS strategy

The NSGA - II (ElitistNon - DominatedSortingGeneticAlgorithm NSGA - II) is one of the classic QoS strategy optimization algorithms, and is based on the global searching capability of genetic algorithm
to solve the QoS strategy problem optimal solution, and the first generation of the NSGA algorithm flow is shown in Fig. 2:

Fig.2 Main flow chart of NSGA algorithm

2.2.1. Fast non-dominant sorting
For NSGA algorithm, the population size is n and there are m optimization objectives. In order to find all non dominated solutions, each optimization objective of each population needs to be compared with other populations, and the computational complexity is $\theta(mn)$. After this step is completed, it is necessary to traverse the whole population again to find all the individuals on the first non dominated layer, and the total computational complexity is $\theta(mn^2)$. Since it is necessary to find out the dominating layer of all individuals, in the worst case, there is only one individual in each level, so the total time complexity is $\theta(mn^3)$ [8].

NSGA-II has been improved on the above basis, and the overall flow is as follows:

1) Set two parameters for each individual $\rho$, namely, $\alpha_\rho$ and $\beta_\rho$, where $\alpha_\rho$ represents the number of individuals capable of dominating individual $\rho$ in the population, and $\beta_\rho$ represents the set of individuals dominated by individual $\rho$ in the population [9].

2) Identify the individuals whose $\alpha_\rho$ is equal to 0 in the population and represent them as set $f_i$ (the initial value of i is 1, indicating the dominant level) [10].

3) Traverse all individual $j$ in $f_i$, and traverse the individual set $\delta_j$ dominated by individual $j$, and added individual i to $f_{i+1}$ when $\eta_i - 1$.

4) Repeat the above flow until all individual levels are allocated.

2.2.2. Calculation of congestion degree
The concept of crowding degree is used in NSGA-II to ensure the diversity of the population. Crowding degree represents the density of other individuals around an individual in the population. It can be expressed intuitively as: draw a rectangle around an individual, which only contains the length and width of the largest rectangle of the individual itself. The overall calculation process is as follows:

1: $\mu = |I|$
2:foreachi,setl[i].distance=0
3:foreachobjectivemdo
4: $\mu = \text{sort}(\mu, m)$
5: l[i].distance=l[i].c[istance]=oo
6:forflowi=2to($\eta$—1)do
7: l[i].distance=l[i].distance-$\eta$-(l[i+1].m+l[i-1].m)/(fm,max-fm,min)
e:endif

The solution of QoS strategy optimization problem is not unique, but a set composed of Pareto optimal solutions. The ultimate goal of QoS strategy optimization is to find a Pareto optimal solution set that meets the conditions.

3. Simulation test analysis

In the test environment, in order to verify the network performance, it needs to use iPERF to generate the corresponding data stream to test the target network. The calculation time of the total network throughput and maximum link utilization algorithm is tested and analyzed respectively for the ondemand routing algorithm, and CATS routing algorithm and the routing algorithm proposed in this chapter are tested and analyzed. At the same time, it also simply analyzes the number of data streams generated and the number of data streams finally guaranteed by the network under different iteration times.

The overall throughput of the network can be expressed by the sum of the data traffic bandwidth of the receiver. If the sum of the throughput of the receiver is equal to the sum of the data sent by the sender, then the network bandwidth is sufficient and there is no congestion. On the contrary, the network performance is reduced to a certain extent.

With the iPERF tool, we randomly generate a series of data streams at four time nodes of 0, 5, 10 and 15 minutes in the experiment to test the network. Fig. 3 depicts the total throughput trend relationship of the three algorithms[11-12].

![Fig. 3 Comparison of total throughput simulation](image)

From the throughput simulation diagram, it can be concluded that the throughput of the three algorithms is roughly the same between 0-10 minutes, which is about 7m. Because there is no congestion in the network at present, the curve changes obviously after 10 minutes. The throughput of ondemand routing algorithm is stable at 10Mbps, while the throughput of cats and the scheme proposed in this chapter is about 11m, because new data stream enters the network in about 10 minutes. For the newly arrived data stream, the network congestion occurs because the three algorithms all use the shortest path algorithm. Since ondemand algorithm is greedy algorithm, all data streams will be congested on the link e6, and the maximum throughput is the physical bandwidth of the link. Fig. 4 shows the maximum link utilization at different times obtained by applying three different algorithms in the network[13-14].
In Fig. 4, for the on-demand algorithm, the network congestion occurs 15 minutes later, and the link utilization rate reaches 100%. (Generally speaking, congestion occurs when the link utilization rate exceeds 95%), while congestion occurs in CATS algorithm after 20 minutes. In comparison, the routing algorithm proposed in this chapter can effectively utilize network resources and realize network performance optimization.

4. Conclusion

The maximum link utilization optimization is an important means of traditional routing optimization. In a network, the larger the maximum link utilization value is, the more unstable the network performance is, and that is, the more likely congestion will occur. On the contrary, when the maximum link utilization ratio is smaller, it means that the overall bandwidth resources of the network are sufficient, and there will be no obvious network performance degradation problem in a short time.

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