

Relative Traffic Density and Network Topological Design

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Abstract

Since network topological design has been shown to be NP-hard, we turn to heuristics for solution. However, heuristics may perform differently given different input data. In this report, relative traffic density is defined in terms of sustainable cell rate and fiber capacity for the purpose of predicting the performance of a heuristic for network topological design presented in [1].

Key Words: relative traffic density, network topological design

1 Network Topological Design

Given traffic demand and cost information of network components, what is the most cost effective network topology? This question is answered by network topological design.

Since network topological design has been shown to be NP-hard, we turn to heuristics for solution. In [1], we model network topological design problem as a non-linear integer programming problem and use a row-generation based heuristic to solve the problem. Since the heuristic can only provide an approximate solution, we developed a lower bound analysis procedure to evaluate the quality of our heuristic solution which is given by the ratio of the cost of the heuristic solution and the lower bound of the network cost. The experimental results show that in heavy traffic case, the heuristic can provide an approximate solution which nearly coincides with its lower bound solution, but in light traffic case, the lower bound solution is about 60% of the heuristic solution.

In [1], the “relative traffic density” is used to determine whether a traffic demand is classified as heavy traffic or light traffic. However, the relative traffic density in [1] is not well defined. In this note we will define it in terms standardized traffic descriptor, such as sustainable cell rate.

2 Relative Traffic Density

The given traffic demand is described by:

- **num_connection:** Number of connections for each (origin, destination, class).
- **traffic descriptor:** Peak cell rate, sustainable cell rate, and maximum burst length.
- **QoS:** The maximal acceptable cell loss ratio, and maximal acceptable delay for each (origin, destination, class).

We can define a relative traffic density for each (o,d) pair as following:

$$RTD(o,d) = \frac{\sum_k SCR(o, d, k) * num_connection(o, d, k)}{CCF(o, d)} \quad (1)$$

where *RTD* denotes relative traffic density, *o* denotes origin, *d* denotes destination, *k* denotes class, *SCR* denotes sustainable cell rate, and *CCF* denotes capacity of the cheapest fiber and corresponds to the fiber with the cheapest cost per unit capacity.

We can see that $RTD(o,d)$ defines as above corresponds to link utilization assuming the cheapest fiber is assigned to $link(o,d)$. The reason we pick the cheapest fiber is that when we solve the lower bound problem if we approximate the capacity of $link(o,d)$ by a continuous variable the cheapest fiber will be assigned to $link(o,d)$ with no integer restriction on capacity and in most cases it is not a integer. When $RTD(o,d)$ is high, the error incurred by approximating the capacity of $link(o,d)$ by a continuous variable is relatively small, while when $RTD(o,d)$ is low, the error can be relatively large. This is the rationale for the definition of RTD .

QoS standards for Quality of Service

3 Use of Relative Traffic Density

The use of relative traffic density can be in three areas of application:

1. *Predict the tightness of the lower bound.* When we solve the lower bound problem, we approximate link capacities of a set of links, Δ , by continuous variables. If most of the links in Δ have low relative traffic density, then we know that the lower bound can not be tight.
2. *Guide the choice for links in Δ .* It is obvious that if we want a tight lower bound we can not put costly links with low relative traffic density in Δ .
3. *Guide the design process.* When relative traffic density for an (o,d) pair is high, we can treat the capacity of link(o,d) as continuous parameter and the network topological design problem can then be modeled as mixed integer programming problem with fewer integer variables. The fewer the integer variables, the easier it is to solve the problem.

References

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