1. Abstract

Congestion avoidance mechanisms allow a network to operate in the optimal region of low delay and high throughput, thereby, preventing the network from becoming congested. It is formulated as system control problems in which the system senses its state and feeds this back to its users who adjust their controls. The algorithms used by the users are compared with different performance metrics. The key metrics are efficiency, fairness, convergence time and size of oscillations. A simple additive increase and multiplicative decrease algorithm satisfies the sufficient condition for convergence to an efficient and fair state regardless of the starting state of the network.

2. Contents

The point which the packets start getting lost is called a cliff due to the fact that the throughput falls rapidly after this point. The point after which the increase in the throughput is small, but when a significant increase in the response time is called a knee. Congestion avoidance is operated at knee point which ensure that the users are encouraged to increase their traffic load as long as this does not significantly affect the response time.

Traffic loads from the users are \( x(t) = \{x_1(t), x_2(t), \ldots, x_n(t)\} \). Use binary feedback \( y(t) \) indicates whether is network is heavy loaded. Updating equation is \( x_i(t + 1) = x_i(t) + f(x_i(t), y(t)) \). We consider \( f \) as a linear function here. So

\[
\begin{align*}
    x_i(t + 1) & = a_I + b_I x_i(t) \quad \text{if } y(t) = 0; \\
    x_i(t + 1) & = a_D + b_D x_i(t) \quad \text{if } y(t) = 1.
\end{align*}
\]

We have four criteria for selecting controls.

1. Efficiency: The efficiency of resource usage is defined by the closeness of the total load on the resource to its knee.
2. Fairness: The fairness index defined as \( F(x) = \frac{\left( \sum x_i \right)^2}{n(\sum x_i^2)} \).
3. Distributedness: The implementation can be distributed.
4. Convergence: Convergence is generally measured by the speed with which the system approaches the goal state from any starting state. The binary feedback system reaches an equilibrium. The time taken to the reach the equilibrium and the size of oscillations jointly determines the convergence. The time determines the responsiveness, and the size of oscillations determines the smoothness of the control.

**Definition 2.1.** In order to satisfy the requirements of distributed convergence to efficiency and fairness without truncation, the linear decrease policy should be multiplicative, and the linear increase policy should always have an additive component, and optionally it may have a multiplicative component with the coefficient no less than one.

3. Remarks

Graphical interpretation is clear and easy for understanding. But mathematical derivation is much more important. Make clear definition of different criteria, then use mathematical model to measure them.