

摘 要

交换结构和调度算法的性能分析是交换机研究中的核心问题。在理论分析和仿真实验这两种分析方法中，仿真实验因具有良好的可操作性而被广泛使用。传统仿真方法基于个别流量负载分布模式，流量以随机到达模式为主，存在诸多缺陷。第一，基于个别流量模型的实验难以如实反映调度算法的性能，使得结论缺乏说服力；第二，在有限几种流量模型上的实验难以发现调度算法可能存在的性能较差情况，获得的结果往往过于乐观；第三，流量模型过少使得无法系统地检验性能被部分证明的调度算法在证明的条件之外性能是否会不同；第四，随机输入使得难以准确地判断仿真的稳态，无法保证测量到的吞吐率的准确性，降低了结论的可信度。

从传统仿真方法的缺陷出发，本文提出了一种基于流量模型大规模采样和周期输入的交换结构性能评价方法。具体包括以下两方面：

(1) 流量模型的大规模采样。通过穷举或者随机生成双随机矩阵，可以获得任意多的流量负载分布模式，远多于传统仿真中使用的几种。建立在大量流量模型上的仿真能够更全面的反映调度算法的性能，同时也有助于发现调度算法可能存在的性能较差情况。

(2) 通过交换结构和调度算法的状态判定周期性调度，从而准确地测量调度算法的吞吐率。在确定性的周期输入下，不含随机选择的调度算法最终极有可能进入周期性调度，此时仿真的稳态就是周期性调度阶段。由于在单个调度周期内的吞吐率和多个调度周期完全相同，因此可以准确地测量调度算法在稳态下的吞吐率。这种测量方法能够保证结果的准确性，结论的可信度远高于传统仿真方法。

以上两方面既能分别使用也可以结合使用。二者的结合不但能够提高仿真实验结论的说服力，而且提供了一种系统的方法来检验吞吐率的理论证明结论，同时也能够系统地检测吞吐率被部分证明的调度算法在证明条件之外吞吐率性能是否会不同。

最后，选取了输入排队交叉开关和缓冲交叉开关这两种主流交换结构下部分具有代表性的调度算法，利用本论文提出的性能评价方法进行吞吐率分析。一方面获得了比以往更为全面的吞吐率性能分析结果；另一方面说明了本文提出的性能评价方法的实用性。

关键词：交换结构；调度算法；流量模型；周期输入；吞吐率

Abstract

Switch simulations based on extensive workload patterns and periodic arrival patterns.

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The performance evaluation of the switch fabric and scheduling algorithm is significant to the switch research. Due to its good practicability, the simulation is widely used. But the traditional simulation method, which adopts sporadic workload patterns and stochastic arrival patterns, has some drawbacks. Firstly, the simulation based on few traffic patterns is hard to draw reliable conclusions. Secondly, it is difficult to find the stuck state through few of traffic patterns, at which the algorithm shows quite poor performance. Thirdly, the performance of some algorithms has been partially proved. But the traditional simulation is incapable of systematically identifying whether the performance beyond the proved condition is all the same or not. Fourthly, the stochastic arrival makes it hard to accurately determine the steady state in a simulation, and unable to guarantee the accuracy of the measured throughput.

In this dissertation, we propose a new simulation method for the performance evaluation of the switch fabric, including extensive workload patterns and periodic arrival patterns.

The first aspect is to generate extensive workload patterns. By means of enumerating or randomly generating doubly stochastic matrices, we can obtain as many workload patterns as we wish, far exceeding the traditional few ones. The simulation based on such traffic pattern set is not only able to reflect an algorithm's performance more comprehensively, but also find out the potential poor performance of an algorithm.

The second aspect is to determine the periodically scheduling via the state of the switch fabric and scheduling algorithm, and then accurately measure the throughput. For the scheduling algorithm without random policies, it is very probably to enter periodic scheduling after running enough time. At that time, the steady state is the periodic scheduling stage and the throughput in multiple periods is exactly equal to that in any period. Thus we can measure the throughput of an algorithm accurately in the simulation, making the result as convincing as the theoretic conclusion.

The above two parts can be used separately or combined together. Their combination can not only make the simulation conclusion much more reliable, but also provide a systematic method to check the theoretic conclusion on the throughput. Additionally, it is able to systematically testify whether the throughput of the algorithm, whose throughput has been partially proved, beyond the proved condition is all the same or not.

Finally, we choose some typical scheduling algorithms under the crossbar fabric and buffered crossbar fabric as the test-bed of our performance evaluation method. The simulation draws conclusions about the throughput of these scheduling algorithms more comprehensive than ever before. And it exhibits the good practicability of our method.

Keywords: switch fabric; scheduling algorithm; traffic pattern; periodic arrival; throughput