INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:
On Placement of Controllers and Hypervisors in Software Defined Networks

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SHORT ABSTRACT

Software defined networking shifts the control plane of forwarding devices to one or more external entities known as controllers. The placement of controllers in the network influences every aspect of a decoupled control plane, from state distribution options to fault tolerance to performance metrics. Determining the number and placement of controllers is an important problem in software defined networking. Failure of a controller results in disconnections between the controller and the switches that are assigned to it. The administrator can reassign each switch of the failed controller to a working controller with enough capacity that is nearest to the switch. However, the reassignment of switches result in a significant upsurge in the worst case latency.

In this thesis, we propose optimization models for the failure foresight capacitated controller placement that avoids disconnections, repeated administrative intervention, and drastic increase in the worst case latency in case of controller failures by maintaining a list of μ(> 1) reference controllers for every switch. The objective is to minimize the worst-case latency between switches and their μ^{th} reference controllers while satisfying the capacity and closest assignment constraints. First, we design an optimization model for a single controller failure and extend it to multiple controller failures. We also design a variant of failure foresight capacitated controller placement that minimizes the sum of worst-case latencies from switches to their 1 st , 2 nd ,. . . , μ^{th} reference controllers. Next, we relax the failure foresight assumption of switches and investigate a capacitated next controller placement strategy that not only considers capacity and reliability of

controllers but also plans ahead for controller failures. We design an optimization model for a single controller failure and extend it to multiple controller failures. We also present a simulated annealing heuristic to produce fast and viable solution on large networks.

When deploying controllers in real networks, large networks such as wide area networks are always partitioned into several smaller ones. To this end, we propose a controller placement strategy that partitions the network using k-means algorithm with cooperative game theory based initialization and deploys a controller in each of the partitions. We model the partitioning of the network into subnetworks as a cooperative game with the set of all switches as the players of the game. The switches try to form coalitions with other switches so as to maximize their value. We also propose two variants of the cooperative k-means strategy that tries to produce partitions that are balanced in terms of size.

The locations of the hypervisors and controllers together determines the latency of network elements in a virtualized software defined network. In this thesis, we propose two strategies for determining the placement of hypervisors and controller in a virtualized software defined network. The first strategy fixes the hypervisor(s) in the physical network and then determines the placement of controllers in each of the virtual network. It allows the network operator to dynamically add new virtual networks on demand basis. The second approach jointly determines the placement of hypervisors in the physical network and controllers in each virtual network.

All the proposed strategies are evaluated on various networks from the Internet Topology Zoo and Internet 2 OS3E. Results demonstrated that, it is possible to avoid disconnections, repeated administrative intervention, and drastic increase in the worst case latency in case of controller failures by planning ahead for failures. Our proposed models not only performs better in terms of the worst case latency in the event of failures but also in terms of maximum and average inter controller latencies. Results also show that the simulated annealing heuristic is able to achieve near optimal solutions in less than half of the time required by the optimized formulations. The k-means algorithm with cooperative game theory based initialization not only results in solutions that are close to optimal solution but also deterministic in nature. The load aware cooperative k-means strategies results in solutions with less partition imbalance when compared to the load unaware cooperative k-means approach. Determining the placement in each of the virtual network while fixing the hypervisor(s) in the physical network and jointly determining the placement of hypervisors in the physical network and controllers in each virtual network are efficient than determining the hypervisor(s) in the physical network while fixing the controllers in each of the virtual network.