Tracking MaxWeight: Optimal Control for Partially Observable and Controllable Networks

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***Abstract*—Modern networks are complex and may include components that cannot be fully controlled or observed. Such network models can be characterized by overlay-underlay structures, where the network controller can only observe and operate on overlay nodes, and the underlay nodes are neither observable nor controllable. Classic network control algorithms may fail to work properly if they are only applied to the overlay nodes. To tackle this issue, we propose the Tracking MaxWeight (TMW*) algorithm that does not require direct observations of underlay nodes and only operates on overlay nodes. TMW* maintains virtual queues that track the dynamics of the underlay nodes and makes control decisions based on those virtual queues. We show that TMW* is throughput optimal as long as the network is stabilizable. We further extend our analysis to the setting that the estimates of the underlay state is erroneous and show that as long as the errors scale sub-linearly in time, TMW* preserves throughput optimality.**

***Index Terms*—Network control, resource allocation, routing, queueing theory.**

given by the network controller. Therefore, we propose the Tracking MaxWeight algorithm (TMW*)[1] to stabilize such an overlay-underlay network. To the best of our knowledge, TMW* is the first algorithm to stabilize networks with unobservable and uncontrollable nodes.

Classical network control algorithms such as MaxWeight and BackPressure [2] are capable of stabilizing queue backlogs effectively, yet directly applying them to our overlay-underlay network model might lead to instability. In section VI-B, our simulation results show that applying MaxWeight only to overlay nodes can lead to linear growth in queue backlogs.

The design of overlay control algorithms for overlay-underlay networks has been studied from different perspectives. In [3], the authors model the overlay nodes as routers and the underlay nodes as forwarders, assuming that only routers are controllable. They then propose the Threshold-based Backpressure (BP-T) algorithm that is shown to be throughput