Paper Summary and Critique

Classic Meets Modern - a Pragmatic Learning-Based Congestion Control for the Internet

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Summary

The main limitation of most classical TCP CC algorithms is that they are designed around assumptions about the network environment, and a violation of those assumptions may degrade the performance of the algorithm. Some CC algorithms attempt to be generalized, but do not perform exceptionally well in a given environment.

The paper introduces an adaptive TCP congestion control (CC) algorithm called **Orca**, which combines classical TCP CC methods with deep reinforcement learning (DRL) to adapt to various network conditions and environments. The DRL segment of the solution is responsible for monitoring the environment's statistics and adjusting the classic algorithm's congestion window (*cwnd*) accordingly.

Strengths

- Orca mitigates the limitations of clean-slate learning-based algorithms, such as under-utilization and over-utilization of the network.
- Orca can also mitigate the limitations of its underlying TCP CC algorithm - Cubic, which performs poorly on inter-continental test simulations by itself. Integrated with the DRL segment of Orca however, and the algorithm performs 5x - 20x better.
- Because it is a generalized and adaptive model, Orca does not need to maintain any a priori assumptions about the network.

Weaknesses?

- Lower MTP times would require a higher computational overhead.

    - Not an issue when deployed over the internet, as their $20ms$ fixed MTP falls within reasonable delay windows. However, for high-speed and/or low-latency networks, the MTP's overhead may need to be considered.
- As the authors state in Computers Can Learn from the Heuristic Designs and Master Internet Congestion Control, online RL techniques fail to effectively generalize over complex domains.

Applicability to practice

- As stated above, considerations were taken to emulate real-world applications, such as fixing the MTP to expected delays over the internet.
- I am uncertain as to whether the model would be able to scale effectively over a large network deployment.

Comments for improvement

- The Orca model was only trained on 6 hours of data of simplified network environments. If introduced to a longer training period and a more diverse set of network environments (e.g. multi-bottleneck scenarios and cellular environments), the model may perform better and generalize more.
- The MTP was fixed to $20ms$ in the experiments carried out by the authors. A lower MTP would require a higher computational overhead, but the MTP could be dynamically allocated to adapt to a variety of network environments and provide tailored performance optimization.
- Orca was trained on a small dataset, with a limited diversity of network environments. If the model was larger, and deployed to a large user-base (e.g. in the millions), would the relative computational overhead increase significantly?