Designing scalable networks with multiple personalities

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Abstract

In this paper we describe physical network topologies which readily support the establishment of overlays that greatly reduce and/or greatly increase the distances between nodes. Reducing pairwise distances (i.e. *compression*) implies that the overlay exhibits significantly lower mean latencies than the ambient physical network, implying that the overlay can be used to implement a "high-performance mode" that could be suddenly required in critical mission circumstances. Increasing pairwise distances on the other hand (i.e. *expansion*) implies that the overlay exhibits significantly higher mean latencies than the ambient physical network, a feature that is useful in settings where a malicious worm or virus has infected the network and where such an overlay would slow down the rate of infection propagation, allowing greater time for antidote generation.

1 Introduction

In the last decade, we have witnessed a surge in the application of peer-to-peer overlay networks. Each logical link in the overlay network consists of a multi-hop connection in the physical network. Data can travel along a logical link in the overlay without undergoing expensive routing or manipulation at the nodes. Overlay networks enable network designers to consider alternate network topologies whose properties deviate from those of the physical network. While modifying the physical network topology is time consuming and expensive, altering the overlay topology is, by comparison, fast and cheap.

Overlays have a profound impact on the objectives of physical network design. Historically network designers have sought physical networks that exhibit good performance metrics, yet

Finally we present a sequence of graphs with multiple personalities.

Theorem 2.11. *The sequence of graphs $\mathcal{G} = (C_{j,j} * K_j \mid j \in \mathbb{N})$ is both ultraexpandible and ultracompressible.*

3 Conclusion

Ultraexpandible sequences of graphs provide a recipe for building networks that support extreme expansion of pairwise distances between their constituent nodes using overlays. Such networks possess overlays that exhibit significantly higher mean latencies than the ambient physical network, a feature that is useful in settings where a malicious worm or virus has infected the network, where such an overlay would slow down the rate of infection propagation and allow greater time for antidote generation. Ultracompressible sequences of graphs, on the other hand, provide a recipe for building networks that support the extreme reduction of pairwise distances between their constituent nodes using overlays. Such networks possess overlays that exhibit significantly lower mean latencies than the ambient physical network, a feature that is useful for implementing a "high performance mode" for the physical network that could be suddenly required in critical mission circumstances. In this paper we have described the mathematical formalisms surrounding these two classes of networks and provided some examples of each of these two important classes, as well as shown that the two classes have sequences in common.

In our future work we plan to further explore the relationships between the properties of graph compressibility and expandibility. We will also seek to extend the notion of multiple personalities using overlays to metrics other than those based on graph diameter and pairwise distances that we considered here.

References

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