Resilience of Backbone Provider Networks

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The Global Internet is a complex, critical infrastructure and the research community has been analysing the topology of the Internet for over a decade. The primary focus has been on the logical aspects of the topology, since tools were developed to collect, measure, and analyse IP-layer properties of the Internet. Physical topologies provide services for logical layers, and defining physical connectivity is a major research challenge. Moreover, to study behaviour of the Internet under correlated geographic failure scenarios, physical topologies are necessary.

Physical topologies provide the necessary connectivity, while logical topologies enable data communication between end systems. Resilience characteristics of the two topologies differ in part due to differences in the topological properties and in part due to different challenges networks face. For example, while a DDoS attack aims to consume network resources on an end host, the underlying physical infrastructure can be intact. Likewise, an earthquake might damage the physical infrastructure and if there is no geographical diversity built in the system this might cause the overlaid logical topology to become dysfunctional. We argue that resilience analysis of individual topologies (e.g. AS-level, IP-layer) alone is not enough and a collective analysis of networks is required to design resilient networks. Therefore, understanding the resilience characteristics of networks and further developing cost-efficient mechanisms to cope with network challenges of such complex systems is crucial.

While the physical topologies are crucial in understanding and modelling Internet, public data about physical topologies are limited. Two primary reasons that the service providers unwillingness to share the data are business competitiveness and security concerns. We discuss the necessity of physical topologies to realistically evaluate network resiliency. We argue that a collective topology information is needed to realistically evaluate resilience properties of networks. Furthermore, while geographic diversity is an essential mechanism to increase the resiliency of network, there is a trade-off between the increased level of resiliency and the cost of building such resilient systems.