Defining network robustness using a dual connectivity perspective

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We discuss a dual perspective approach in assessing the robustness of a network with respect to a node elimination process (attack). With any process of sequential node removal occurring on a network, we associate and examine two distinct networks: (i) the Active Network (AN) composed of the active (unaffected) nodes and edges and (ii) the Idle Network (IN) composed of the eliminated (affected) nodes and edges. The existing literature defines robustness solely in terms of AN. We demonstrate that the rate of building-up the connectivity of the IN is not complementary to that of destroying the connectivity of the AN, and their relationship depends on both the attack strategy and the structure of the original network. Accordingly, we define robustness of a network by accounting for both the efficiency of destroying the AN, and the efficiency of building-up the IN, as well as the possible interactions between the two. We explore the robustness of different network models under different types of attack and report the emergence of a surprising crossover phenomenon, which changes the robustness-based ranking of different systems under an attack depending on the weight attributed to Active/Idle part of the process. Examples of natural systems heavily affected by taking into account the IN dynamics are discussed.