

**Attack Vulnerability of Power Systems Under an Equal Load Redistribution Model**

**Abstract:**

This paper studies the vulnerability of flow networks against adversarial attacks. In particular, consider a power system (or, any system carrying a physical flow) consisting of *N* transmission lines with initial loads *L*1*, . . . , LN* and capacities *C*1*, . . . , CN*, respectively; the capacity *Ci* defines the maximum flow allowed on line *i*. Under an equal load redistribution model, where load of failed lines is redistributed equally among all remaining lines, we study the *optimization* problem of finding the best *k* lines to attack so as to minimize the number of *alive* lines at the steady-state (i.e., when cascades stop). This is done to reveal the worst-case attack vulnerability of the system as well as to reveal its most vulnerable lines. We derive optimal attack strategies in several special cases of load-capacity distributions that are practically relevant. We then consider a modified optimization problem where the adversary is also constrained by the *total* load (in addition to the number) of the initial attack set, and prove that this problem is NP-hard. Finally, we develop heuristic algorithms for selecting the attack set for both the original and modified problems. Through extensive simulations, we show that these heuristics outperform benchmark algorithms under a wide range of settings.

**Existing System:**

With existing power systems is the seemingly unexpected large scale failures. Although rare, the sheer size of such failures has proven to be very costly, at times affecting hundreds of millions of people e.g., the recent blackout in India. Such events are often attributed to a small initial shock getting escalated due to intricate dependencies within a power system. This phenomenon, also known as cascade of failures, has the potential of collapsing an entire power system as well as other infrastructures that depend on the power grid. Thus, understanding the dynamics of failures in power systems and mitigating the potential risks are critical for the successful development and evolution of many critical infrastructures.

**Proposed System:**

We continue our study of the robustness of power systems under a simple model based on *equal* redistribution of flow upon the failure of a power line. Namely, we consider a power system with *N* transmission lines with initial loads *L*1*, . . ., LN* and capacities *C*1*, . . ., CN*. If a line fails (for any reason), its load is assumed to be redistributed equally among all lines that are *alive*.

Thus, the load carried by a line *i* may exceed its initial value *Li* over time due to load redistribution. The capacity *Ci* defines the maximum flow allowed on the line *i*, meaning that if the load carried by *I* exceeds this capacity at any time, the line will be tripped (i.e., disconnected) by means of automatic protective equipments so as to avoid costly damages to the system. Subsequently, the load that was carried by line *i* before failure will be redistributed to remaining lines, which in turn may cause further failures, possibly leading to a *cascade* of failures.

The equal load redistribution model gets its appeal from its ability to capture the *long-range* nature of the Kirchhoff’s law, at least in the mean-field sense, as opposed to the *topological* models where failed load is redistributed only *locally* among neighboring lines. For example, it was suggested by that equal load redistribution is a reasonable assumption1 especially under the DC power flow model; the DC model is known to approximate the AC model well in many cases.