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# Dynamic Resource Allocation in Power Grids using Evolving Gene Regulatory Networks

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Resource allocation and deployment is a ubiquitous logistics optimization problem, *e.g.* in delivery services, industrial production, and business management. We describe a bioinspired optimization system for allocating resources, based on Gene Regulatory Networks (GRNs) (see (Disset et al. (2017)) for details). Specifically, our system allocates intervention teams to be deployed during catastrophic climatic events to sites with failures in an electrical distribution grid covering  $\approx 17000 \text{ km}^2$ . Our work is concerned with the minimization of the breakdown time for the users of the power grid. Here, we describe our system, including the allocation problem, the choice of GRN as control system and its optimization with an Evolutionary Algorithm (EA), and a test scenario of the deployment of teams to repair failures during a heavy storm.

In our model, each agent is assigned to one of 17 bases, each responsible for a specific area, and storms may cross the grid generating incidents, *e.g.* a tree cutting a line. During major climatic events, some bases may not have enough agents to rapidly solve incidents in their respective areas, and must resort to available agents from other bases. Our problem consists in allocating teams to bases to minimize the time during which the clients of the electrical grid suffer power loss: we optimized a GRN, a bioinspired computational model simulating a network of proteins, to adequately deploy teams to bases depending on the state of the system. GRNs have been used in many developmental models (*e.g.* Cussat-Blanc et al. (2012)), and to control robots (Joachimczak and Wróbel (2010)). We train the network to simultaneously minimize the total duration of electrical breakdowns summed over all the clients and the total distance covered by the agents that moved from their bases. Candidate GRNs are evaluated on a set of scenarios (either from historical or synthetic meteorological data); the worse fitness is kept, which pushes evolution toward generalist individuals with high fitness over different scenarios, instead of specializing on a single one. The GRN is optimized using a master-slave parallel genetic algorithm (Cantú-Paz (2001)) that optimizes a set of objectives using tournament selection on a randomly selected objective (either duration of break-

downs, or distance covered by the agents). The best GRNs found by the EA w.r.t. both criteria are returned, and can be queried to decide how to allocate teams to failure locations. Figure 1 shows indicators during a test scenario (with a storm causing failures, depicted in Figure 2) of the execution of an evolved GRN.

We have presented an evolutionary GRN-based system that allocates intervention teams to failure sites over a power grid network. The GRNs are evolved to minimize the time to reestablish power upon failures on a series of scenarios. Preliminary experiments show that our system is able to allocate teams between bases so that failures are efficiently repaired. In-depth evaluation of the evolved GRNs, *e.g.* their robustness, and comparison with other learning methods, could provide insights into appropriate design choices to further improve resource allocation in our system.

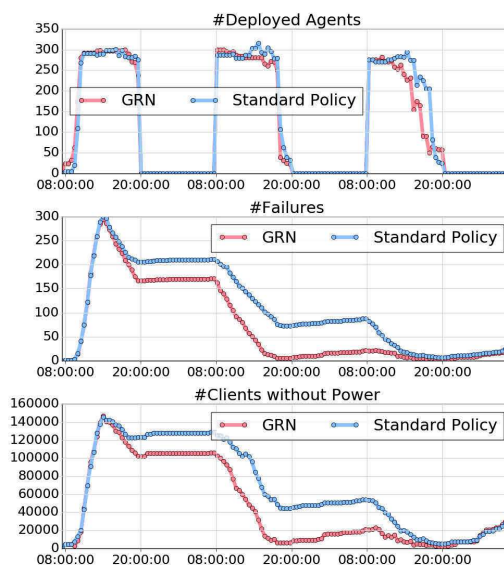


Figure 1: Number of deployed agents (top), failures (mid), and clients without power in a test scenario of an evolved GRN (orange) and the company’s standard policy (blue).

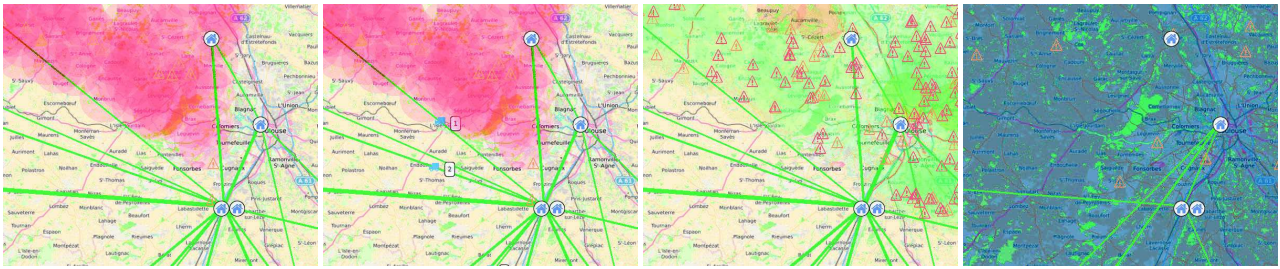


Figure 2: Map of Occitania region (France), with a set of bases (blue nodes) from where the intervention teams depart (blue trucks with white squares over the green links, 2b) toward the locations of failures (alert signs) in the power distribution grid. An evolved GRN is loaded into the system, and controls the allocation and deployment of teams in response to failures. In the figure, a storm approaches from the west (2a), generating failures over the grid. The GRN decides how to deploy teams to repair the failures (2b, c). The teams return to the bases at night, with nearly every failure repaired (2d).

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