

Design of Fault Tolerant Networks: The Slime Mold Approach

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Always thought you had to be an engineer to design complex networks? Think again because even a slime mold can do it. *Physarum polycephalum*, a true slime mold without central consciousness, constructs a network while gathering food from its surroundings. This network consists of fine tubes that transport the collected nutrients throughout its body. Tubes transporting a lot of nutrients grow and create clear paths from one food source to another, while idle tubes shrink and eventually disappear. The fundamental principles of this process have been mathematically modeled in literature and turned into a networking algorithm.

Does this mean that the slime mold mastered the art of network design? No, it still needs some help to design useful, fault tolerant networks. The slime mold and its mathematical model do not really focus on high fault tolerance, needed for example in telecommunication networks. To improve robustness of the networks, the model can be extended with a stimulation and a migration mechanism. The stimulation mechanism reinforces alternative paths by redistributing the simulated nutrient flow. This results in backup links that prevent full network failure when the primary paths fail. The migration mechanism allows links to be moved during the design phase. The links migrate according to the local nutrient flows, optimizing their location and offering more freedom to the algorithm.

The slime mold model with its new tricks was tested by redesigning several national and international networks. In a first test, the extended model was unleashed on a model of the Belgian road network. It was able to provide a completely fault tolerant network with a significantly lower total length than the existing road network. The extended model did the same for models of Mexico, the UK and Spain and Portugal in other experiments.

By extending the existing model of *Physarum polycephalum* with a stimulation and a migration mechanism, it can design networks with high fault tolerance, necessary in road and telecommunication networks. We can handle traffic jams and broken cables if we just work together with a simple slime mold.