1 A Principle is Born: The Granovetter Study

In the late 1960s students had a rather revolutionary life in universities. In the midst of all this, Mark Granovetter, a PhD student at Harvard University, set himself to figure out how people find their jobs. He interviewed about a hundred people and sent out another 200 questionnaires in the Boston area.

The summary of his first results showed that more than half of the people found their jobs through personal contacts. We instinctively agree with these results. We may browse newspapers or web pages for a new job, but the real hints often come from our best friends. Or do they? In fact, this is not quite true. The really surprising result of the study was that, in most cases, the informants were not particularly close to the job seeker. They rarely spoke to each other, and they saw each other only seldom.

Why was this surprising? Granovetter had good reasons for thinking that strong links would be more useful for finding a new job. Close friends will give all their information to the job seeker and will mobi-

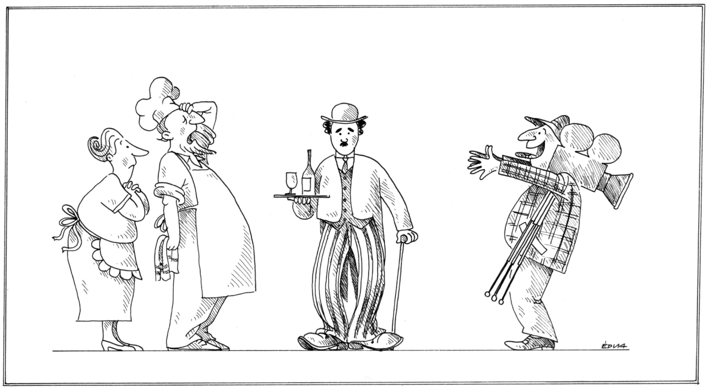

Fig. 1.1. In most cases, the best informants were not particularly close to the job seeker

lize all their contacts to help. Moreover, they meet the job seeker more often, and know more about her skills and preferences. And yet weak contacts still proved to be more useful. Were close friends biased? Did they overestimate the abilities of the job seeker?

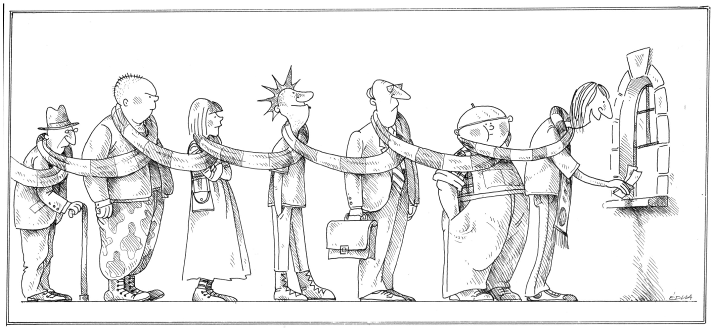

Fig. 1.2. Weak ties play a role in effecting social cohesion

Granovetter was puzzled and started to analyze earlier data. He considered an earlier hysteria incident, where more and more workers in a textile plant in the deep south of the USA were claiming bites from a mysterious and non-existent 'insect', until eventually the plant had to be closed (Kerckhoff et al., 1965). Although the rumor starters were isolated people, they had numerous weak links in the community. In Granovetter's meta-analysis, weak links also proved to be useful in the famous Milgram experiment (Milgram, 1967; Korte and Milgram, 1970). In this example, people were instructed to send a letter to an unknown person[1] in the USA by asking the help of persons they knew on a first-name basis. If the starter was white, and the target was an Afro-American, the 'chain of friends' worked efficiently only if the critical point, where the chain of white friends was switched to a chain of black friends, was a weak link. Finally, Granovetter showed that the friendship network of Rapoport and Horvath (1961) was best covered if one used weak links to search for the acquaintances of the acquaintances of a given person. In contrast, the 'best-friend' networks did not cover the whole community. It seemed to be a general result that weak links are more useful for information searches than strong ones.

[1]In the Milgram experiment only the postal address of the 'unknown person' (the target) was not revealed to the starter, and she did not know the endpoint personally. However, the starter did know the name and a few personal features of the target, e.g., the target is Rebecca Smith, a catholic Latin teacher in Cleveland, who is a chess champion.

Granovetter went further. He analyzed social networks in a general context, and observed that weak links also link network modules, a concept confirmed in many later studies. Finally, he came to the conclusion: "Weak ties play a role in effecting social cohesion." He published his findings under the title *The Strength of Weak Ties* (Granovetter, 1973). A principle was born. However, more than a quarter of a century was to pass before we started to learn that weak links not only connect, but also stabilize all complex systems. And now, we have reached

THE END

Indeed we are already at the end. You have now heard the central statement of the book: weak links stabilize all complex systems. I described Mark Granovetter's landmark paper introducing this idea more than 30 years ago. I indicated the path leading to the generalization of this idea in the Preface. What more is there to say? *"How can you ask such a question? You have not even defined what you mean by 'weak links'?"* Thanks a lot, Spite, for the reminder. I will try to give a starting definition now, but if you would like to have a more complete version, please go ahead and check Sect. 4.2.

Weak links are links between network elements, which connect them with a low intensity. Weak links may also connect network elements with a higher intensity, but in this case they are only transient. I will show later that, in real networks, we have a continuous spectrum of link strengths starting with a few strong links and ending with more and more links, which become weaker and weaker. In most cases, it is rather difficult to cut the continuously changing strength parameter somewhere and say: up to here, all the links were strong, but from this point on, we shall say that they are weak. Consequently, in this book I will use the functional definition[2] of weak links given by Berlow (1999).

Definition of Weak Links. A link is defined as weak when its addition or removal does not change the mean value of a target measure in a statistically discernible way.

[2]It is a question of future research how much these 'functional weak links' overlap with the weak links, which are weak due to their low affinity or intensity.

The target measure here is usually an emergent property[3] of the whole network, or a response the network gives to a certain stimulus. The mean value of the target measure is changed if a strong link is deleted from or added to the network.

Will we lose weak links in the future? Please note that, in this functional definition, the discrimination between strong and weak links depends on the desired or available accuracy of our measurements. If the mean value is measured a hundred times more accurately, the 'statistically discernible change' in the mean value will be achieved by changing much weaker links than in the case of a measurement that is a hundred times less accurate. *"Why are you writing this book then? Your weak links will have vanished in a few years, when my generation has learnt how to measure things more accurately than your generation can."* I have bad news for you, Spite. When your generation has learnt how to measure things more exactly than we can measure them now, you will certainly lose a number of weak links according to this definition, since you will have to reclassify them as strong links. However, with the extension of detection limits, you will be able to measure a thousand times more 'new' weak links instead, which are even weaker than the weakest links my generation could detect. At the end of the day, your generation will have to deal with far more weak links than we ever did. As a conclusion, the younger you are, the more important this book is for you.

Having learnt a starting definition of weak links, this book will show that hierarchical networks are governed by the same principles, from molecules to the whole Universe, and that weak links stabilize us in all these levels. To understand all this, we must first learn more about networks. So let us begin.

[3]For the explanation of the meaning of 'emergent property' and other unusual words in the text, please see the glossary in Appendix B.