K-shell decomposition method applied in patent citation network

K. Angelou, M. Maragakis, P. Argyrakis
Aristotle University of Thessaloniki

Patent Citation Network is the network that is formed from the references of a patent to other patents [1]. The nodes of the network are the patents and the links between the nodes exist if a patent cites another patent. All links are directed as they point only to one direction and the network is acyclic as the references are only to prior patents. The network of all patents in the European Patent Office (EPO) and the Patent Cooperation Treaty (PCT) for the period 1978-2016 was formed. Data was taken from OECD [2]. The network includes 14,031,393 patents and 22,107,570 links. At first, the degree distribution was studied and it was found that both the in- and out- degree distributions follow a power law, with a slope of 2.9 and 2.8, respectively. Consequently, the majority of patents have only a few citations, while there are not many highly cited or citing patents.

The k-shell decomposition [3] method was applied in the undirected network to identify its core. Using this method once can find the most important patents for a networks stability and robustness. The result showed that the core of the patent citation network is at k-shell=90. Surprisingly, this shell was not comprised of the patents with the highest number of citations. On the contrary, it contains 226 patents with citation degree (sum of both in and out degrees) in the range of 94-462, while the highly cited patents (degree up to 2500) are in much lower shell number. The highest concentrations of highly cited patents are in cells 57 and 70, where there are 510 and 155 patents, respectively. Additionally, it is important to note that the geographic region where patents of the highest shells come from, is often that of only one continent. This points to some form of spatial separation in the highest shells. Further investigation of the time patents were issued in each shell, hints to a possible continental level organization of citations for shells with old patents, and an intercontinental one for shells with newer ones.

[l] S.-B. Chang, K.-K. Lai, S.-M., Technological Foreca **76**, 107 (2009).
[2] http://www.oecd.org/, oecd (2017).
[3] S. Carmi, S. Havlin, S. Kirkpa, PNAS **104**, 24 (2012).