Commentaries on Albert-László Barabási's *Links*

Networks101Link11.1 The Awakening Internet ©frederick david abraham, 25 September 2013

Just as I thought Barabási had just about filled us in on the basic properties and evolution of the concepts of small networks and that the rest of the book would be rather coasting through applications, this Link, 'The Awakening Internet', provided an explosion not only of the history of the intenet, its topology and functioning, but also an appreciation of its unknowability and thus an object of research itself, and its own potential for self-organization and self-awareness. The writing is, as usual extraordinarily clear, and thus the only points I can make are to whet the appetite of those who have not yet delved into the book.

The first thing about the internet is that the architecture was based on defending against nuclear attack, and then evolved to perform into its mass communications functions for which it is not optimal. This history from ARPA to Intenet and the World Wide Web along with explanations of how packet switching, protocols, and routing tables over growing numbers of interconnected routers is brief and interesting and well-illustrated by significant events such as the Red Worm and the attempts to map the Internet, a now impossible task . The main generalization is that maintenance of the scale-free topology is due to the interaction of four factors, growth, preferential attachment, physical distance between routers, and a fractal self-similarity over scale of the distribution of routers geographically.

In section 7, there is a discussion of his pioneering work on parasitic computing which leads to his consideration of distributed computing[1], with distinctions between voluntary and involuntary participation of your computer in distributed computation, research, and decision-making. He conjectures that the Internet could evolve to operate without human supervision, as a self-organizing system. In the final section 8, he carries this idea further. Many authors have focused on various artificial devices as loci of the singularity of surpassing human intelligence and culture (e.g., in our crowd, mainly Goertzel, and to a lesser extent myself and

[1] Some of you may be familiar with the now many examples, which include Draves' use for creating Electric Sheep screensavers; see e.g., Draves, S., Abraham, R., Viotti, P., Abraham, F.D., & Sprott, J.C. (2008). The aesthetics and fractal dimension of electric sheep. *International Journal of Bifurcation and Chaos*. *18*, 1243-1248. Also presented to the Society for Chaos Theory Annual Conference, Portland OR 2007. http://www.ralph-abraham.org/articles/MS%23120.Electricsheep/sheepdim06.pdf

Frank Mosca)[2]. Barabási offers the internet as the prime candidate. The Internet has sensors, processing, and effector capacities that have now exceeded that of the human brain, and thus could develop not only self-organization but self-awareness. The difference from previous surveillance and data collection and processing from previous technologies is that ". . . for the first time, these sensors are feeding information into a single integrated system" of billions of interconnected computers and cell phones "which grows and evolves at an unparalleled rate".

Since the writing of Links, there has been an explosion of research on how the dynamics of patterns of information flow and evolution are interdependent with network structure and topology, especially in social network analysis. As I write this in Dumaguete 26 October, a reading discussion group at the Center for Complex Systems at UVM, some 12,000 miles away is discussing one of these articles, so it seems to postscript this to one of Barabási's Links. Here is a link, abstract, and a couple of figures from this article:

Title: Virality Prediction and Community Structure in Social Networks

Authors: Lilian Weng, Filippo Menczer, Yong-Yeol Ahn

URL: http://www.nature.com/srep/2013/130828/srep02522/full/srep02522.html

Abstract: How does network structure affect diffusion? Recent studies suggest that the answer depends on the type of contagion. Complex contagions, unlike infectious diseases (simple contagions), are affected by social reinforcement and homophily. Hence, the spread within highly clustered communities is enhanced, while diffusion across communities is hampered. A common hypothesis is that memes and behaviors are complex contagions. We show that, while most memes indeed spread like complex contagions, a few viral memes spread across many communities, like diseases. We demonstrate that the future popularity of a meme can be predicted by quantifying its early spreading pattern in terms of community concentration. The more communities a meme permeates, the more viral it is. We present a practical method to translate data about community structure into predictive knowledge about what information will spread widely. This connection contributes to our understanding in computational social science, social media analytics, and marketing applications.

[2] As well as authors in various academic areas of AI, many science fiction authors have used such themes, from using dolphin cultures (Leo Szilard, 1961, *Voice of the Dolphins)*, to giant computers such as the movie *Colossus: The Forbin Project* (see for a discussion relevant to raising the question of the meaning of being human, Abraham, F.D. (2007). Cyborgs, cyberspace, cybersexuality: The evolution of everyday creativity. In R. Richards, (ed.), *Everyday creativity and new views of human nature*. Washington, D.C.: American Psychological Association.

.

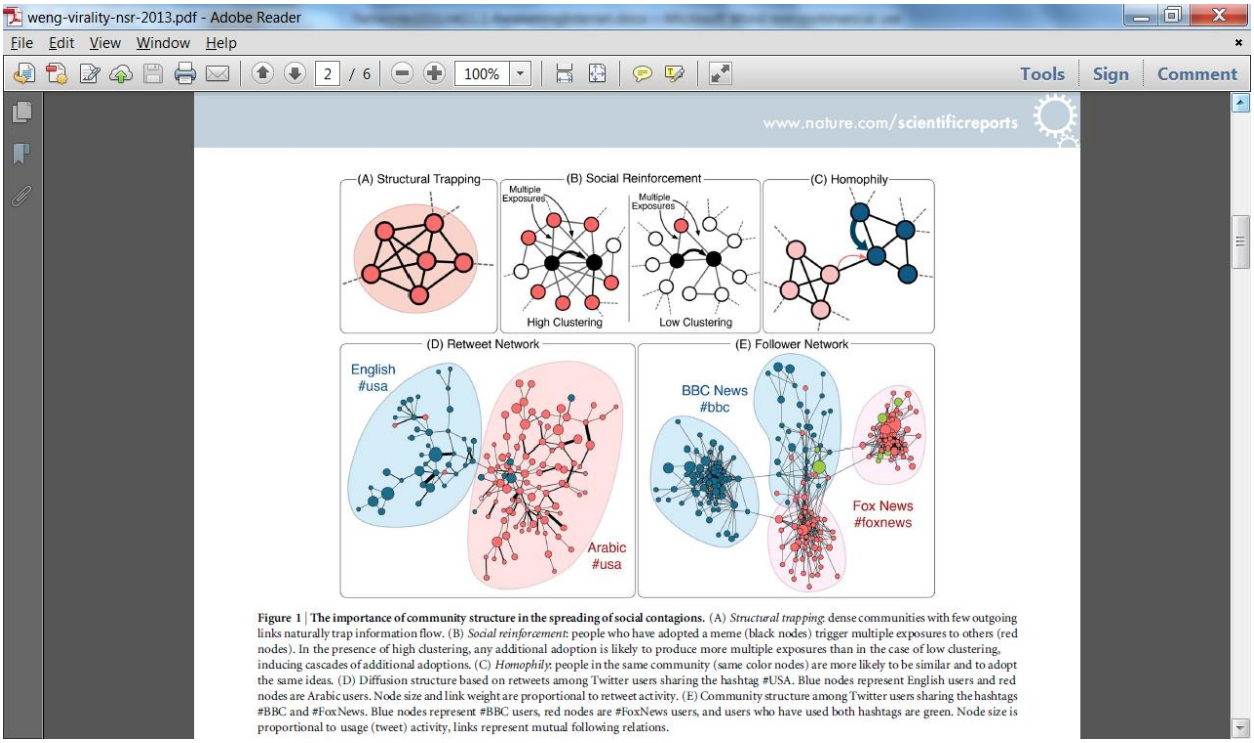

Figure 1 | The importance of community structure in the spreading of social contagions. (A) *Structural trapping*: dense communities with few outgoing links naturally trap information flow. (B) *Social reinforcement*: people who have adopted a meme (black nodes) trigger multiple exposures to others (red nodes). In the presence of high clustering, any additional adoption is likely to produce more multiple exposures than in the case of low clustering, inducing cascades of additional adoptions. (C) *Homophily*: people in the same community (same color nodes) are more likely to be similar and to adopt the same ideas. (D) Diffusion structure based on retweets among Twitter users sharing the hashtag #USA. Blue nodes represent English users and red nodes are Arabic users. Node size and link weight are proportional to retweet activity. (E) Community structure among Twitter users sharing the hashtags #BBC and #FoxNews. Blue nodes represent #BBC users, red nodes are #FoxNews users, and users who have used both hashtags are green. Node size is proportional to usage (tweet) activity, links represent mutual following relations.

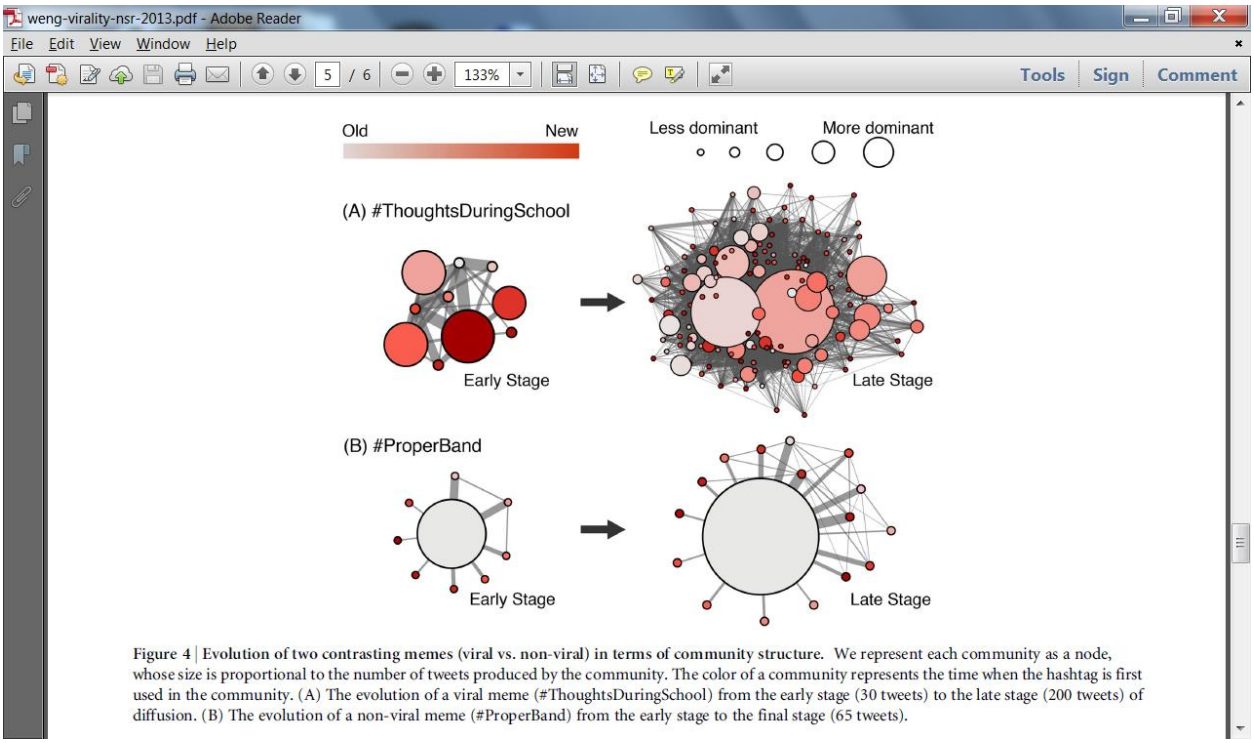

Figure 4 | Evolution of two contrasting memes (viral vs. non-viral) in terms of community structure. We represent each community as a node, whose size is proportional to the number of tweets produced by the community. The color of a community represents the time when the hashtag is first used in the community. (A) The evolution of a viral meme (#ThoughtsDuringSchool) from the early stage (30 tweets) to the late stage (200 tweets) of diffusion. (B) The evolution of a non-viral meme (#ProperBand) from the early stage to the final stage (65 tweets).