From the Editor

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Look around—Is there anything that is not networked to something else out there?

You'll find that everything is indeed networked together in some sense and in some form, in one way or another: one can see or think of various wired and wireless communication systems, power grids, human relationships, economic trading, biological neural networks, and so on and so forth—you name it. Even our planet is networked to the universe through gravity in nature, not to mention today's man-made giant Internet.

It was interesting to read a piece of news from the *IEEE Spectrum* on March 26, 2010, "U.S. Power System Security" [1], reporting that "A theoretical paper by a Chinese graduate student and professor about the vulnerability of electric power systems like those in the United States to cascading failure has drawn attention in the U.S. press and prompted testimony to U.S. Congress."

Well, this was already an old story for the network science and engineering community. The Circuits and Systems Society (CASS) was perhaps the first society within the IEEE to notice the emerging and critical area of the so-called "complex networks" in science and engineering, and the first article within the CASS about the subject was published in this *Circuits and Systems Magazine* in the first issue of year 2003 [2], echoing to some earlier observations of the potential vulnerability of the U.S. power grids [3–5], followed by some other reports from different academic and professional societies, all addressing the same topic of "U.S. Power System Security" (see, moreover, some earlier articles [4–9]).

After learning that the vulnerability of electric power networks had been noticed and analyzed in subtle details a long while ago, which was well understood from a complex network theoretical point of view lately, no one seemed to continue to make any more fuss about such a trifle in headline news again, at least not in the IEEE media.

The power grid crashing story relies heavily on a fundamental network theory, which can be traced back to a decade before or even earlier. The first two seminal articles that had led to the profound establishment and rapid development of the new research direction of network science and engineering were archived to [10, 11], which proposed the now-well-known small-world network and scale-free network models, respectively, as very valuable additions to the classical random-graph network framework [12, 13]. Thereafter, this new notion of complex networks has been studied intensively as well as extensively over almost all kinds of sciences, ranging from physical to biological, even to social sciences. Its impact on modern engineering and technology is prominent and will be far-reaching. In fact, the research on modeling, evolution, control, synchronization, and various fundamental properties and dynamical features of different forms of complex networks has become overwhelming recently [14].

Motivated by all such exciting and stimulating history, research and development, and particularly many potential and foreseeable real-world applications, the *IEEE Circuits and Systems Magazine* has organized this Special Issue on Complex Networks Applications in Circuits and Systems, edited by Michael Tse, the Deputy Editor-in-Chief of the Magazine, with seven invited overview and feature articles written by a total of 17 leading experts in the field, mostly from the CASS.

This Special Issue is organized as follows. A review of the progress of research in complex networks over the past decade and the key developments in applications is first presented by Cui, Kumara and Albert, the purpose being to orient the readers to a network perspective of analyzing engineering problems. This also serves as an introduction of the fundamental issues of network optimization and network dynamics in the context of engineered (human-made) networks. The next article by Rad, Khadivi and Hasler is devoted to information processing, which is an important area within the circuits and systems community. Complex networks have been found highly relevant to the processing of information, as evidenced by the two most prominent complex networks, namely, the human brain and the Internet, that have demonstrated tremendous power and capability in processing massive information. A closely related problem is the transmission of information through a physical channel, for which the use of complex networks has been found very fruitful in the enhancement of information transmission via an application of coding. A

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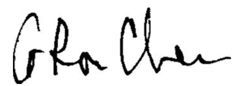
detailed exposition of channel code construction that takes advantage of some desirable features of scale-free networks is provided by Lau and Tse. The Internet is one of the largest man-made networks that have demonstrated superb capability in information processing and transmission. In the next paper by Trajković, the analysis of Internet topologies is expounded. Extending the discussion along the direction of applications of networks, Wu's paper addresses the issue of emergence of properties of a complete global network which are not inherent in the individual "parts". In particular, Wu examines several areas in the resurgent science of networks and how they impact research in various areas of interest to the circuits and systems society. The last two contributions address the synchronization and control issues in complex networks. Specifically, De Lellis, Di Bernardo, Gorochowski and Russo look at the problem from the viewpoints of contraction, adaptation and evolution, and make an attempt to mimic the features of natural networks and propose new strategies for the adaptation and evolution of complex networks of dynamical systems that guarantee the emergence of some asymptotic behavior of concern, namely a synchronous solution. Finally, Wang, Li and Lu consider the impact of applying a "pinning" strategy to control the flocking of networked multi-agent systems. They provide a comprehensive survey of some recent advances in pinning control of dynamical flocks toward some desired common behavior.

It is expected that this carefully edited Special Issue in the *Circuits and Systems Magazine* can serve as a report of the state of the art and a milestone of the research progress and can also provide new stimulus to further spur future developments of the well-going research on network science and engineering within the CASS.



References

[1] B. Sweet. (2010, Mar. 26). *U.S. power system security. IEEE Spectr.* Available: http://spectrum.ieee.org/energywise/energy/the-smarter-grid/us-power-system-security

[2] G. Chen and X. F. Wang, "Complex networks: Small-world, scale-free and beyond," *IEEE Circuits Syst. Mag.*, vol. 3, no. 1, pp. 6–20, Mar. 2003.

[3] B. A. Carreras, D. E. Newman, I. Dolrou, and A. B. Poole, in *Proc. Hawaii Int. Conf. System Sciences*, Maui, Hawaii, unpublished.

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[4] M. L. Sachtjen, B. A. Carreras, and V. E. Lynch, "Disturbances in a power transmission system," *Phys. Rev. E*, vol. 61, pp. 4877–4882, May 2000.

[5] A. E. Motter and Y.-C. Lai, "Cascade-based attacks on complex networks," *Phys. Rev. E*, vol. 66, p. 065102, 2002.

[6] I. Dobson, B. A. Carreras, V. E. Lynch, and D. E. Newman, "Complex systems analysis of series of blackouts: Cascading failure, criticality, and self-organization," in *Bulk Power System Dynamics and Control-VI. Cortina d'Ampezzo*, Italy, August 22–27, 2004.

[7] P. Crucitti, V. Latora, and M. Marchiori, "Model for cascading failures in complex networks," *Phys. Rev. E*, vol. 69, p. 045104(R), Apr. 2004.

[8] D. Newth and J. Ash, "Evolving cascading failure resilience in complex networks," in *Proc. 8th Asia-Pacific Symp. Intelligent and Evolutionary Systems*, Cairns, Australia, 6–7 Dec. 2004, vol. 11, pp. 125–136.

[9] P. Crucittia, V. Latorab, and M. Marchioric, "A topological analysis of the Italian electric power grid," *Physica A*, vol. 338, pp. 92–97, July 2004.

[10] D. J. Watts and S. H. Strogatz, "Collective dynamics of 'small world' networks," *Nature*, vol. 393, pp. 440–442, June 1998.

[11] A.-L. Barabási and R. Albert, "Emergence of scaling in random networks," *Science*, vol. 286, pp. 509–512, Oct. 1999.

[12] P. Erdös and A. Rényi, "On the evolution of random graphs," *Publ. Math. Inst. Hung. Acad. Sci.*, vol. 5, pp. 17–60, 1959.

[13] B. Bollobás, *Random Graphs*, 1st ed. New York: Academic, 1985; Cambridge, U.K.: Cambridge Univ. Press, 2nd ed., 2001.

[14] M. E. J. Newman, *Networks: An Introduction*. London: Oxford Univ. Press, 2010.