We are witnessing an emergence of a variety of large-scale man-made information networks, including the wireless or wired Internet, World Wide Web, social, and economic networks. Similarly, on a microscopic scale, large biological protein networks inside the cell and inter-cellular neuronal networks are just being uncovered.

While these networks operate on entirely different temporal and spatial scales, address unrelated applications, and use diverse mediums to represent information, many of them are governed by the same underlying mathematical principles. Most commonly, these networks exhibit very high variability of their parameters, either in their connectivity, the statistical properties of information they carry, or the delays for processing and transferring the information.

Predrag Jelenkovic uses the mathematical theory of heavy-tailed and power law distributions to capture the highly variable characteristics of these networks. His research focus is on mathematical modeling, analysis, and control of large-scale information networks with heavy-tailed characteristics.

His recent research resulted in a discovery of an entirely new phenomenon in communication networks that shows that retransmissions can cause long (heavy-tailed) delays and instabilities even if all messages and files in the network are relatively short (light-tailed). This finding is important in general since the retransmission-based failure recovery is at the core of the existing communication network architecture, and especially in wireless networks where communication link failures are frequent.

In addition, he focuses on developing the statistical ranking mechanisms for rapidly growing information webs (e.g., the World Wide Web, scientific data, biomolecular and neural networks, social networks, news, and e-commerce). Given that the scale and complexity of these information sets will continue to increase in the future, a new statistical approach for their ranking and understanding is needed in the same way that statistical mechanics were needed for understanding large sets of molecules. Interestingly, this research reveals that the ranks of pages on the World Wide Web, according to Google’s page ranking, follow heavy-tailed power law distributions as well.

Jelenkovic is a member of the Communication & Networking and System Biology groups in the department. Within these groups, he works to advance the mathematical foundation of the underlying design principles of both man-made and biological information networks. Furthermore, his work on heavy-tailed distributions applies more broadly to insurance risk theory, financial mathematics and economy, where heavy tails are widely used.

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Unwinding Heavy Tails

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