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New Thinking

Electrical & Computer Engineering

Seminar

Presented by:

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(joint work with M. Lou, graduate student,
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Traffic pattern analysis in negatively curved networks

Besides the self-similar temporal distribution of network traffic, another strange phenomenon is that that traffic tends to spatially concentrate around specific points of the network. In this talk we will formulate, and prove in some specific cases, a general conjecture that this phenomenon is due to the geometry of the network—more specifically, its negative curvature in the sense of Gromov. Large scale negative curvature of a network means that the network is isometric to a negatively curved Riemannian manifold, up to bounded distortion. A first concept is that of *network center of mass*, or *centroid*, defined to be a point relative to which the network moment of inertia is minimum. For some appropriately defined traffic measure, the first part of the conjecture is curvature independent: maximum of the traffic occurs at the centroid. Next, for a Busemann nonpositively curved space, the inertia has a well-defined minimum, the network has a unique centroid, so that for such space traffic has singular distribution around the centroid. It should be emphasized that this phenomenon is *not* the heavy-tailed phenomenon of traffic concentration around a highly connected subnet, the "core," for we will provide counterexamples of graphs of constant degree, yet with traffic concentrating around a precise point. At the other extreme of the curvature spectrum, if the network is positively curved, the inertia is nearly uniform, the centroid is not well defined and the traffic is uniformly distributed. Between the two extreme curvature cases, we will unveil the phenomenon of discontinuity of the traffic measure around zero curvature. The conjectures will more specifically be formulated in the Poincaré disk, where the centroid of a domain is defined as the fixed point of a conformal map, itself given by a system of holomorphic partial differential equations. The conjecture can also be formulated in the spirit of the Carathéodory-Ahlfors extremal length theory, here the extremal traffic on a set of paths of a domain, achieved for a hyperbolic metric.

Edmond A. Jonckheere received the Electrical Engineer degree from the Université de Louvain, Louvain-la-Neuve, Belgium, in 1973; the Doctor in Engineering degree in Aerospace Engineering from the Université Paul Sabatier, Toulouse, France, in 1975; and the PhD degree in Electrical Engineering from the University of Southern California, Los Angeles, in 1978. From 1973 to 1975, he was with the Laboratoire d'Analyse et d'Architecture des Systèmes, Toulouse, France, as a Research Fellow of the European Space Agency. From 1975 to 1978 he was a Fulbright/Hays Fellow and Teaching /Research Assistant in the Dept. of Electrical Engineering-Systems and subsequently a Research Associate in the same department. From 1978-1979 he was with the Royal Military Academy, Brussels, Belgium. From 1979 to 1980, he was with the Philips Research Laboratory, Brussels, Belgium. In 1980, he returned to USC, where he is currently a Full Professor of Electrical Engineering and Mathematics, an Associate Member of the Center for Applied Mathematical Sciences (CAMS), and a member of the newly established Center for Computer Systems Security (CCSS) of the Information Sciences Institute (ISI) of the University of Southern California. He is a Fellow of the IEEE.