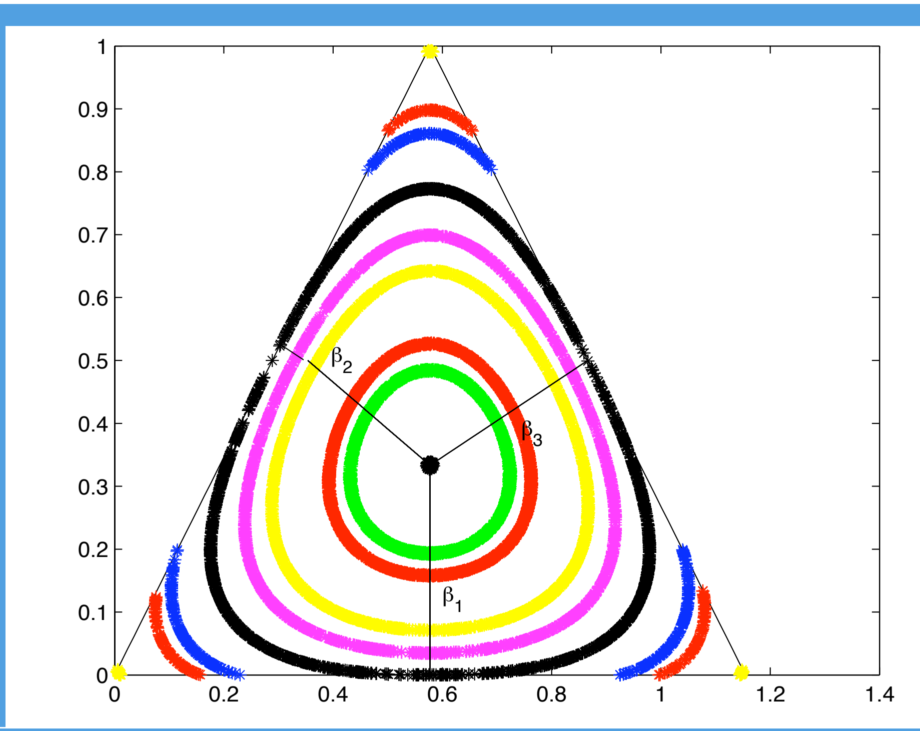
Fern Hunt

complex systems

IMAGE OF THE MONTH

August

Possible Route Probability Distributions



In order to control congestion and maximize network utility, a variety of routing protocols can be used to allocate traffic. When multiple paths linking a source and destination are available but only a single path e.g. a shortest path or path of minimum cost is selected we have the Open Shortest Path First (OSPF) protocol. On the other hand, traffic could be allocated uniformly when the paths have the same cost. A spectrum of path specification strategies lies in between these extremes. The accompanying figure represents these possibilities in the case of a single source destination pair with 3 possible connecting paths. If Beta1, Beta2, Beta3 are the fractions (probability) of traffic assigned to paths 1, 2, and 3 respectively, then each allocation can be associated with a point in or on the equilateral triangle with an altitude height of 1. Here, Beta1, Beta2 and Beta3 are the lengths of perpendiculars from points on edges of the triangle.

More information available at: http://www.itl.nist.gov/ITLPrograms/ComplexSystems/Presentations.html

The entropy associated with an allocation, $H(\beta_1, \beta_2, \beta_3) = -(\beta_1 \log(\beta_1) + \beta_2 \log(\beta_2) + \beta_3 \log(\beta_3))$ provides an important quantitative description of its degree of randomness. OSPF is associated with H = 0, and traffic is allocated according to one of the vertices of the triangle. This is the least robust allocation. Equal cost multipath allocation, assigned to the center of the triangle has the maximum value of H = log(3), and is the most robust but it has reduced network utility. Bands of points with the same value of H (up to accuracy .001) are given the same color. As H decreases an oval emerges from the center point and grows until it touches the sides of the triangle at the maximum entropy for a network with 2 paths. Our theoretical studies predict a change in network dynamics for values of H smaller than this critical value and this is reflected in the figure where we see the ovals break up into discontinuous curves that shrink toward the triangle vertices as H tends to 0.

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Information Technology Laboratory

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

2008

The Complex Systems Program is part of the National Institute of Standards and Technology's Information Technology Laboratory. Complex Systems are composed of large interrelated, interacting entities which taken together, exhibit macroscopic behavior which is not predictable by examination of the individual entities. The Complex Systems program seeks to understand the fundamental science of these systems and develop rigorous descriptions (analytic, statistical, or semantic) that enable prediction and control of their behavior.

Program information at: `www.itl.nist.gov/ITLPrograms/ComplexSystems`