Kevin Bacon, 6 Degrees of Separation & Backbone Vulnerabilities

by John G Schwitz, April 20, 2011

This briefing is unclassified

Degree Separation 1

Make an Observation of the distribution {Events of degree d} -- degree vs. # events

Normalize to frequency distribution (simply divide # events by total events

In many domains this yields an exponential distribution:

{earthquakes, forest fires, traffic congestion, disturbances on electric grid, transmission of biological & computer viruses, diseases, and fads}
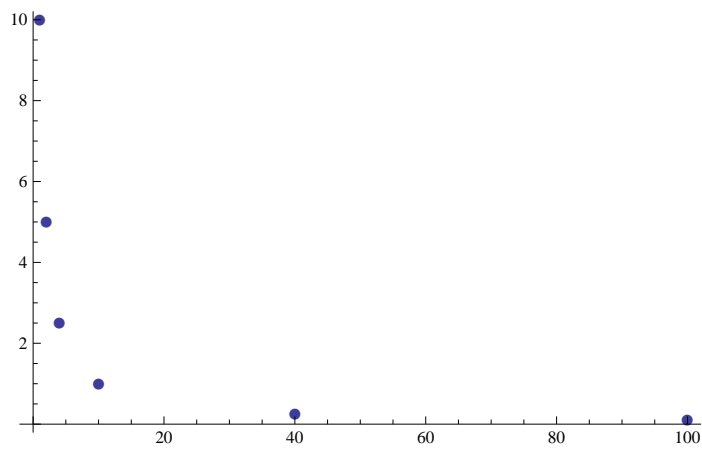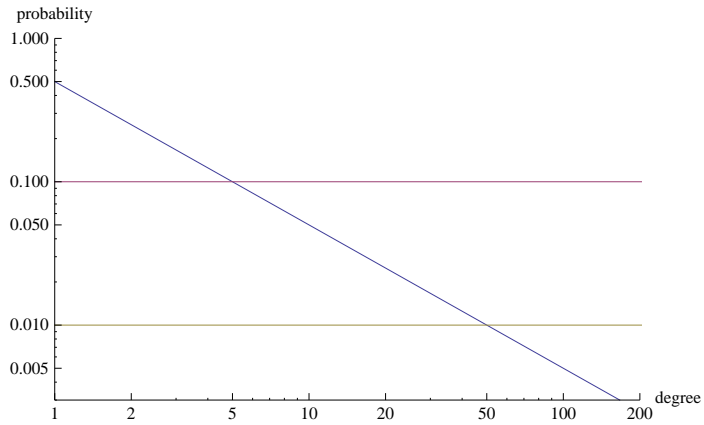

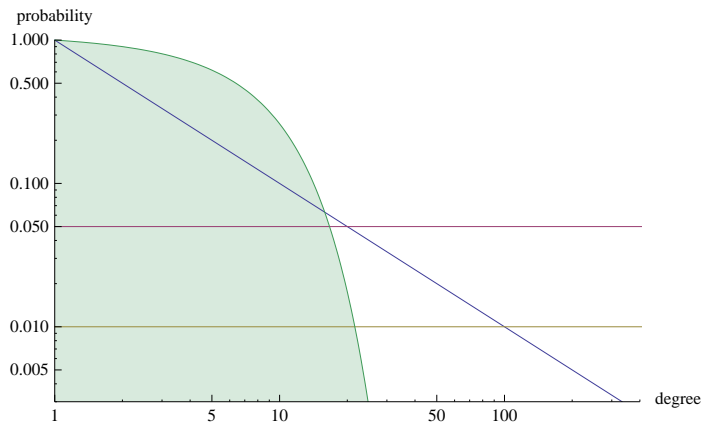Normalize events by {# events / total # events} = frequency {probability}
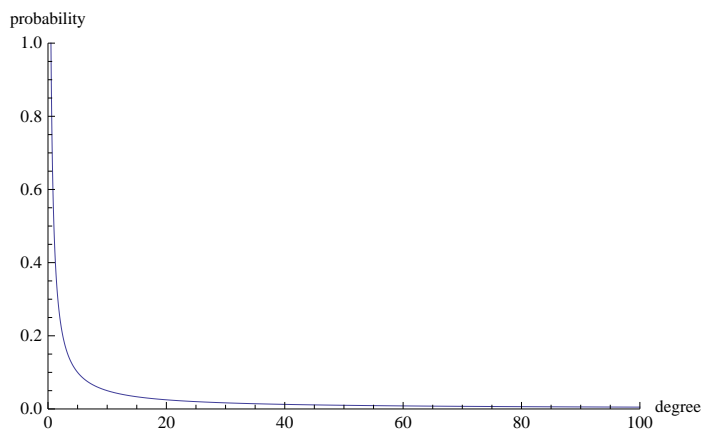
Degree Separation 2

Effective Analysis requires loglog transformation

k = -1 => 10 x's Event Size decreaces probability by .1

Comparison of Power Law to N(1,8)

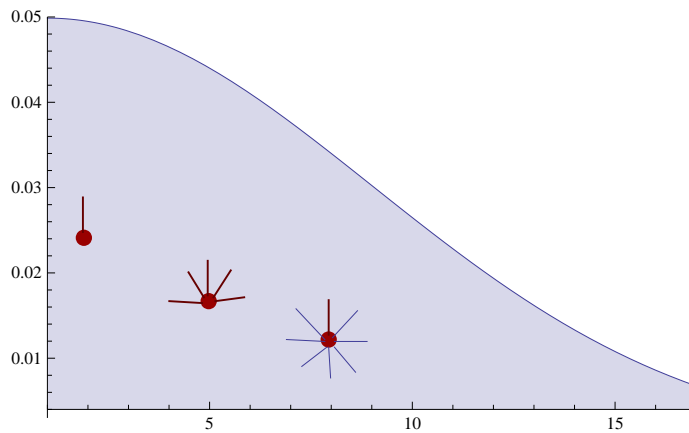A Power Law is a different beast because it has infinite variance.

Degree Separation 3
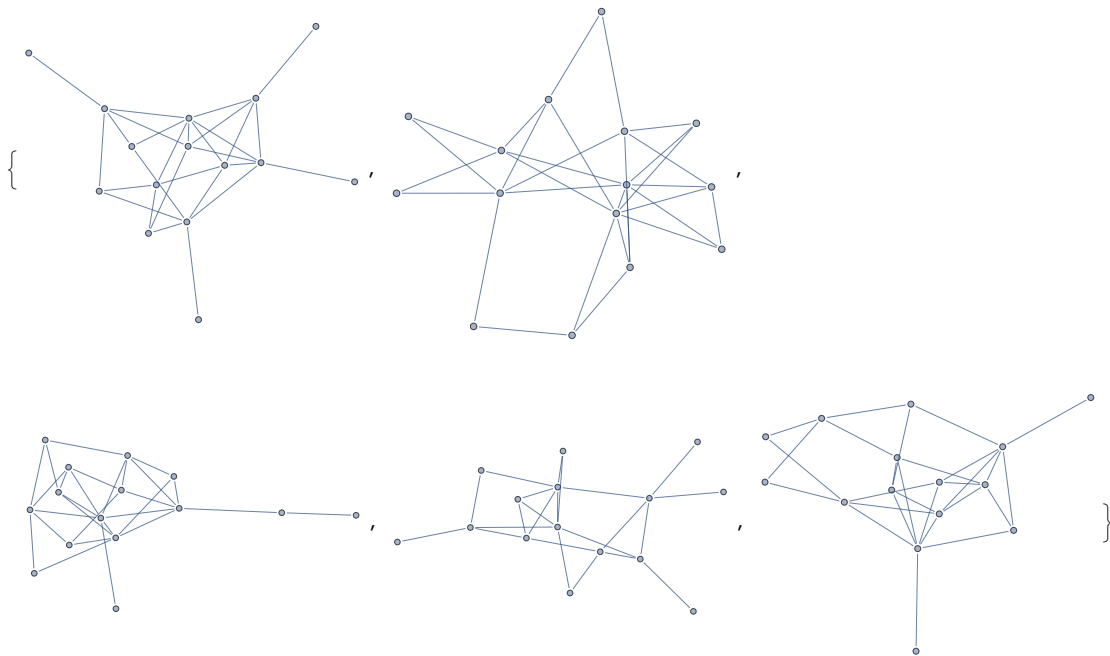
The distribution of router degree in a Normal[1,8].

1σ (9) is 68%, 2σ (17) 95%, 3σ (25) 99.7%.

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Plot[PDF[NormalDistribution[1, 8], d], {d, 1, 17},
 Filling → Axis, PlotRange → {{1, 17}, {.003, .05}}]
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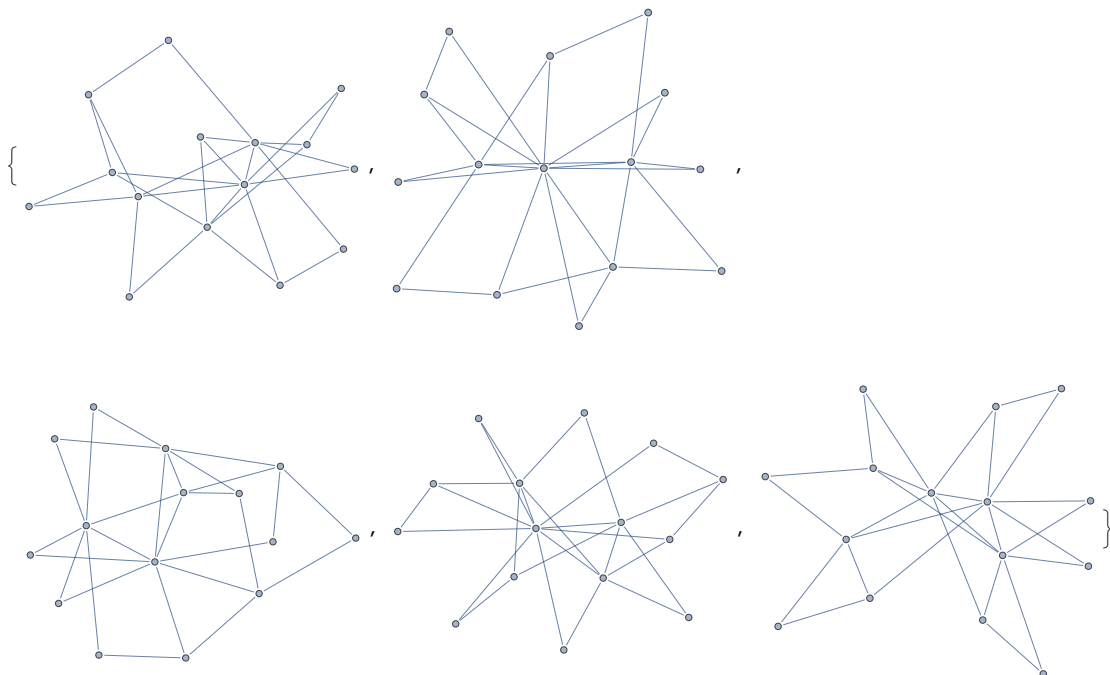
Degree Separation 4

Distribution of Random Network

Distribution of Small World Network

Degree Separation 5

Behavior of Network Diameter (d) and Cluster Size (C) under Random Failure & Attack
Critical infrastructure is robust under random failure, but extremely vulnerable to destruction
under attack.

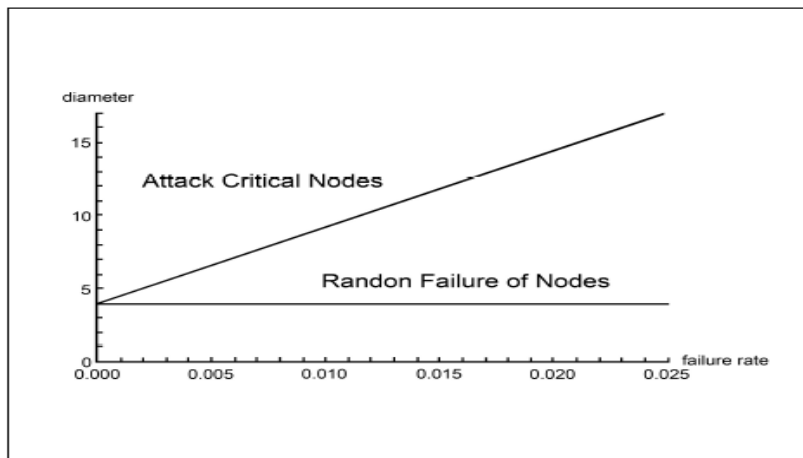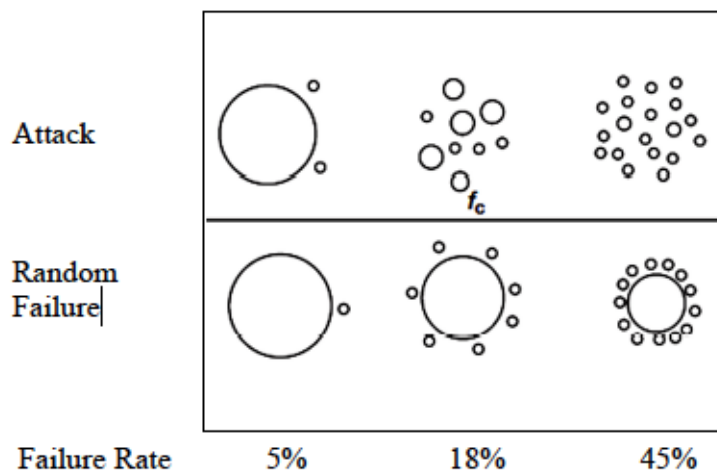*Figure 6: Network diameter vs. failure rate [5]*

Figure 7: Cluster Size by Failure Rate [5]

Degree Separation 6

Fortunately the internet backbone (Core) and connectivity to Independent Service Providers (Edges) has evolved to the topology described above.The primary causal factors shaping this topology are economic incentives and evolving router technology.

Three other critical components of the internet. Autonomous Systems (AS), roughly corresponding to ISPs, connect to each other and the backbone through the Border Control Protocol (BGP). Internet addresses are resolved through Domain Name Servers (DNS).

Sparce, mesh-like core of fast, low-degree routers

High degree nodes are at edges
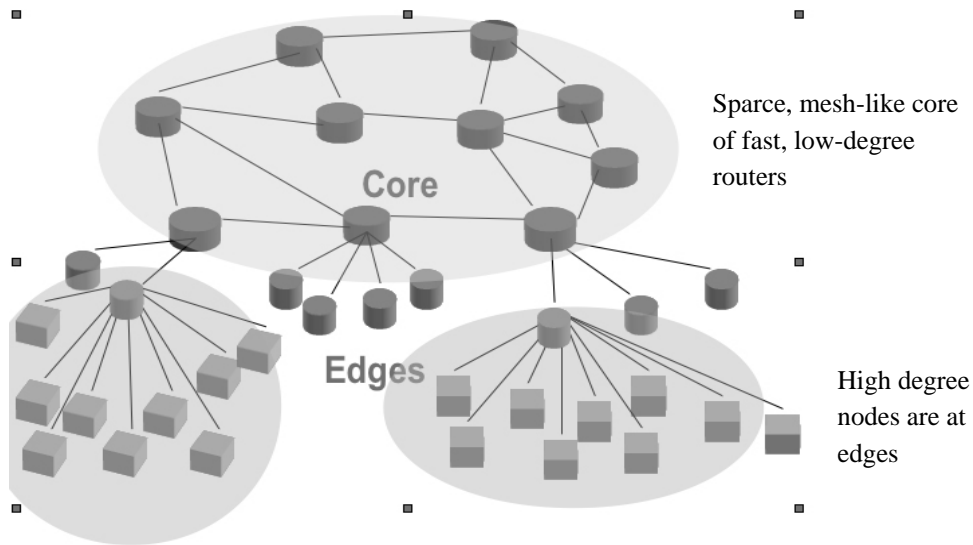
Governance of the Internet & Trajectory

- ICANN (Internet Corporation for Assigned Names and Numbers)
- Steps to Register & Deploy Domain
- Evolution of Backbone
- IPV6 Protocol
- BGP (Protocol (Border Gateway Protocol)
- "Kill Switch" Law
- Privacy versus Attribution