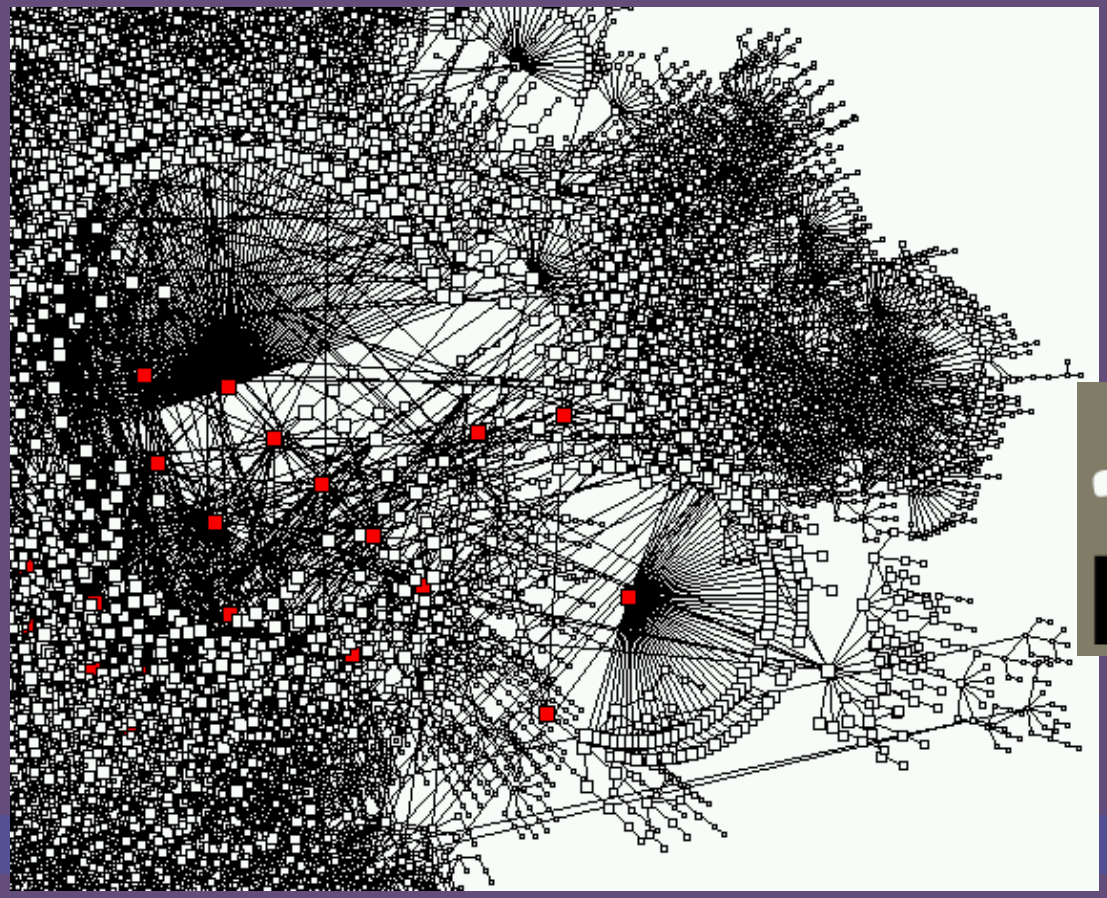
Metcalf's Law, P2P, and Complexity

..or: There Be Dragons

Owen Densmore http://backspaces.net



Three Points

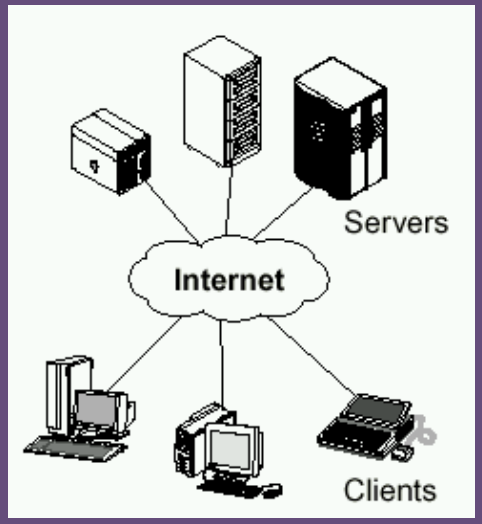
1: The Internet is Frozen

2: => Peer Systems

3: New Tools: Complexity

Metcalf's Law Repealed!

- Metcalf's Law: The value of a network
  - V(n) ~ n^2
  - ...assuming a complete, combinatorial graph
- But Web Created Hub/Spoke Imbalance
  - DHCP/DynDNS, MCast, IPSec, IPv6, NAT, FireWall

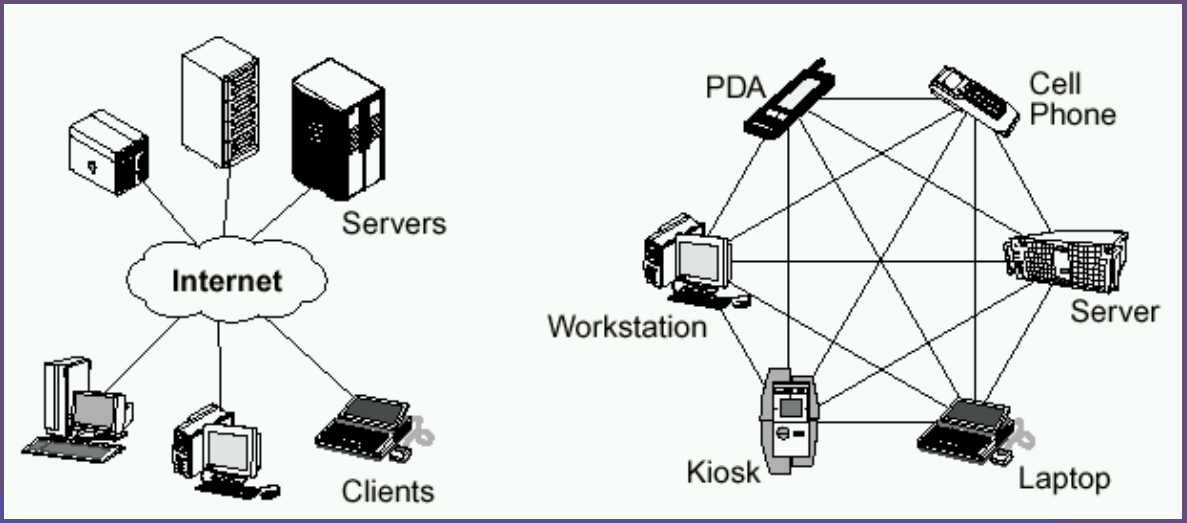


Hub/Spoke Problems

- DHCP: Nameless; No Dynamic DNS
  - Phones, Fax: Yes Computers: No
- Security: So why not after all these years?
  - HTTPS good enough.
- Multicast: Not Just Media
  - Cheap Session Management
  - Serverless Server: http://MCastChannel/...
- OK .. If the Internet is Frozen, How Fix?
  - Peers -> Application Level Protocols

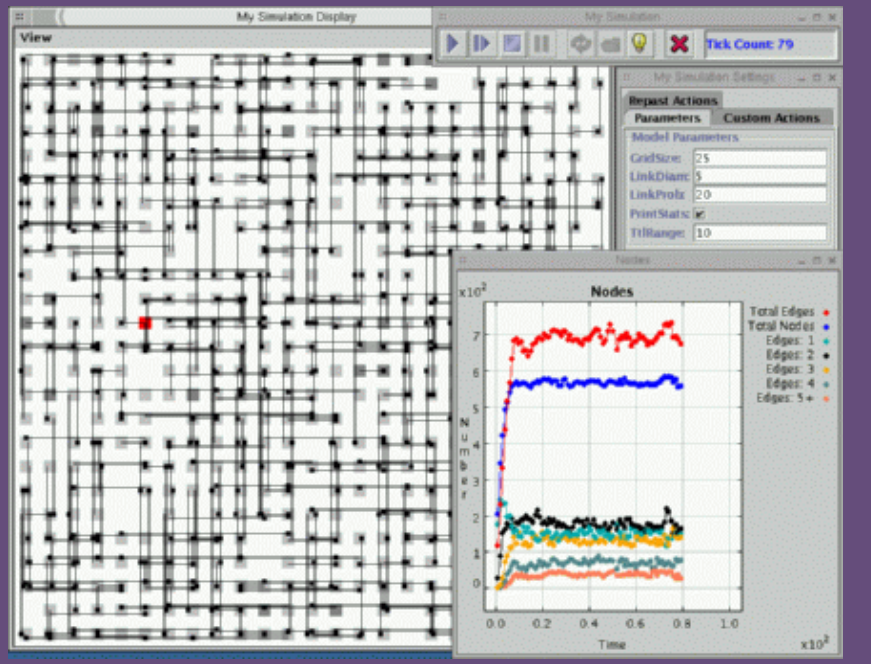
Peer To Peer: Combinatorial Again

- Began as File Sharing
  - Server: Napster, Serverless: Gnutella, Freenet
  - Clip2: Analysis and Super Peer
- ..But Way Beyond Files:
  - Emerging New Network: Application Protocols
  - Key: Deterministic -> Statistical!!

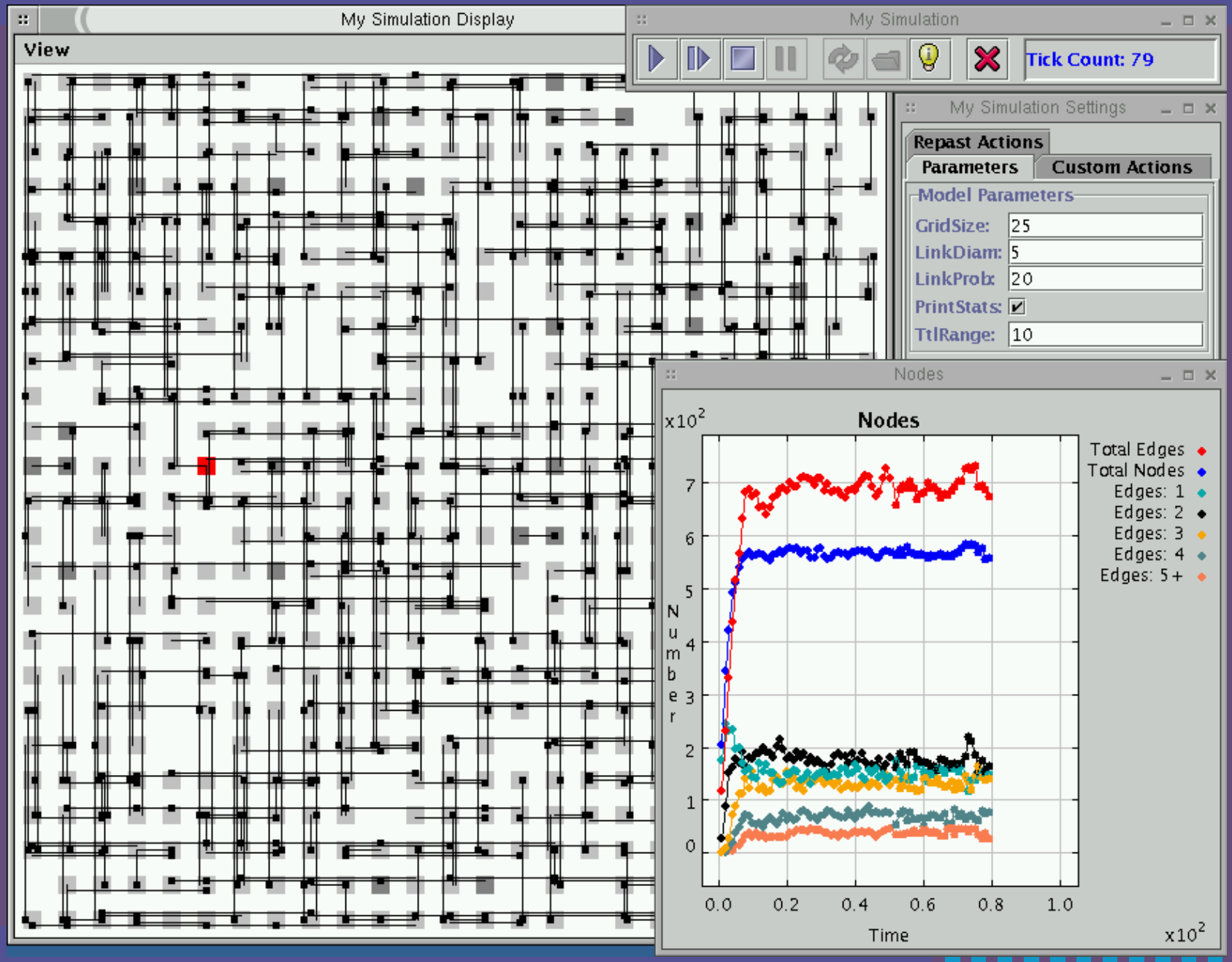


Two Worlds: Complexity & P2P

- Complexity: Whole >> Sum of Parts
- Rapid Awareness in P2P World
  - Small World Networks: 6 Degrees
  - Dynamic Network -> Power Law
  - Tools: Agent Systems
- Complexity Help:
  - Session Scaling
  - Local Knowledge Search
  - Connected Network
  - Trust & Reputation



Simulation


My Simulation Display
View
My Simulation
Tick Count: 79
My Simulation Settings
Repast Actions
Parameters
Custom Actions
Model Parameters
GridSize: 25
LinkDiam: 5
LinkProb: 20
PrintStats:
TtlRange: 10
Nodes
Nodes
x10^2
Number
Time
x10^2
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
5
6
7
Total Edges
Total Nodes
Edges: 1
Edges: 2
Edges: 3
Edges: 4
Edges: 5+

Late Breaking News

Search in Power-Law Networks

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Abstract

Many communication and social networks have power-law link distributions, containing a few nodes which have a very high degree and many with low degree. The high connectivity nodes play the important role of hubs in communication and networking, a fact which can be exploited when designing efficient search algorithms. We introduce a number of local search strategies which utilize high degree nodes in power-law graphs and which have costs which scale sub-linearly with the size of the graph. We also demonstrate the utility of these strategies on the Gnutella peer-to-peer network.

1 Introduction

A number of large distributed systems, ranging from social [13] to communication [11] to biological networks [9] display a power-law distribution in their node degree. This distribution reflects the existence of a few nodes with very high degree and many with low degree, a feature not found in standard random graphs [5]. An illustration of the power-law nature of such networks is given by the AT&T call graph. A call graph is a graph representation of telephone traffic on a given day in which nodes represent people and links the phone calls among them.

As is shown in Figure 1, the out-link degree distribution for a massive graph of telephone calls between individuals is power-law, with an exponent of approximately 2.1. The

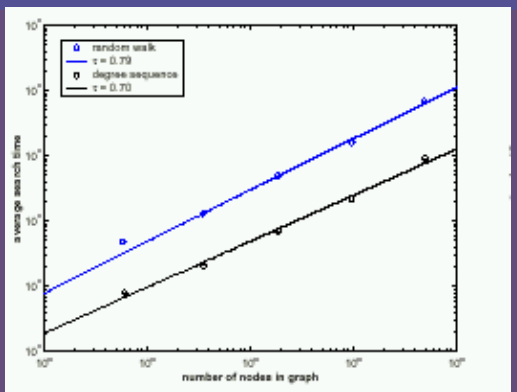


Figure 3: Scaling of the average node to node search time in a random power-law graph with exponent 2.1, for random and high degree seeking strategies.

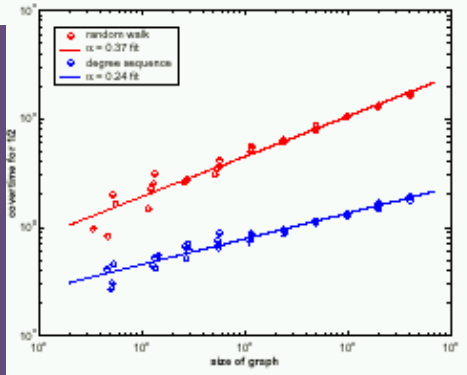
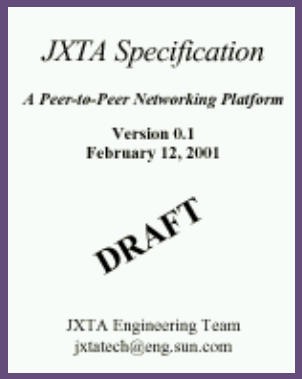


Figure 4: Scaling of the time required to cover one half the graph for random and high degree seeking strategies.

Does Industry Care? Yes!

- Disruptive Technology
  - Appliance Servers 
  - Grid Software 
  - Peer Servers 

  - Peer Clients 
  - Peer Infrastructure


JXTA Specification

A Peer-to-Peer Networking Platform

Version 0.1
February 12, 2001

DRAFT

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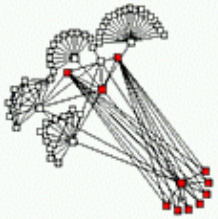
Local Knowledge Networking

Introduction



This is a compilation of ideas for a project on local knowledge networking. It is related to the recent Peer to Peer phenomenon, but attempts to distill out a more formal framework for understanding such systems.

What is Local Knowledge Networking?

Local Knowledge Networks establish computing sessions without central control, with no fragile global state, thus are more adaptive during failure and are more robust. They propagate requests via alternative techniques such as rings of neighbors. Study of these systems has yet been sparse. Sun has started a core effort in this area, Jxta, and has developed an earlier digital collection library system, LOCKSS. Sun's recent acquisitions of Grid, Cobalt and InfraSearch are potential components of local knowledge fabrics.

Project Goal:

Create tools for analyzing Local Knowledge Networks by building a prototype "Peer" system, using existing components being developed within Sun, while in parallel building concrete, Java based, multi-agent models for investigating system properties such as scaling, session management and local trust models.