Swarms, Chaos and Self-Organizing Networks

Michael Grube
@michaelgrube

Decentralized Infrastructure

- Becoming increasingly important
- Potential to change economics of information flow
- Fault tolerance
- Hard to track
- Communication becomes dramatically cheaper

Building the World Brain: What is Ideal?

- Free discourse
- Minimized surveillance
- Extreme Resilience
- Shared Compute Resources
- Decentralized
- Adaptive to operating conditions and user needs

SpiderCache

- Decentralized, Cached version of the web
- Kademlia DHT
- Key: URL, Timestamp Value:Data
- Static Data
- https://github.com/mgrube/SpiderCache
- Falls short - not enough!
- Dead

Self-Organizing Systems

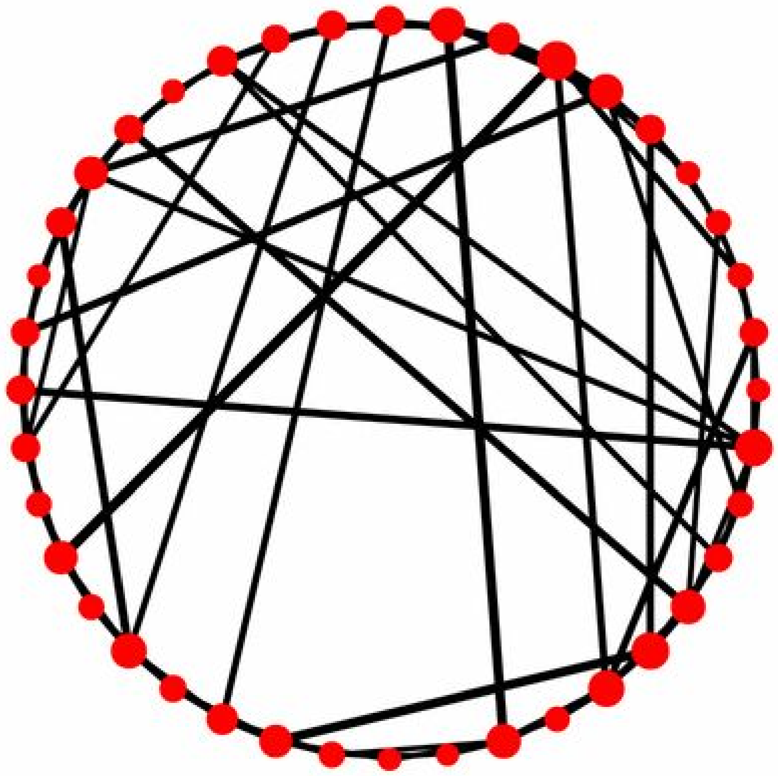
- Chaos is everywhere
- Nature's order comes from chaos
  - Evolution of organisms
  - Social Networks
  - Ecosystems
  - Biological Neural Networks
  - Many others

Approaches

- Particle Swarm Optimization
- Self-Organizing Maps
- Intelligent Agents
- Borrow directly from nature
  - Ant colonies(pheremones)
  - Fluid diffusion?

Small World Networks

- Watts-Strogatz
- Kleinberg Adaptation
- Sandberg Metropolis-Hastings Adaptation
    - Greedy restricted routes!
    - Somewhat scalable, has issues
    - “Pitch Black” Attack renders network useless



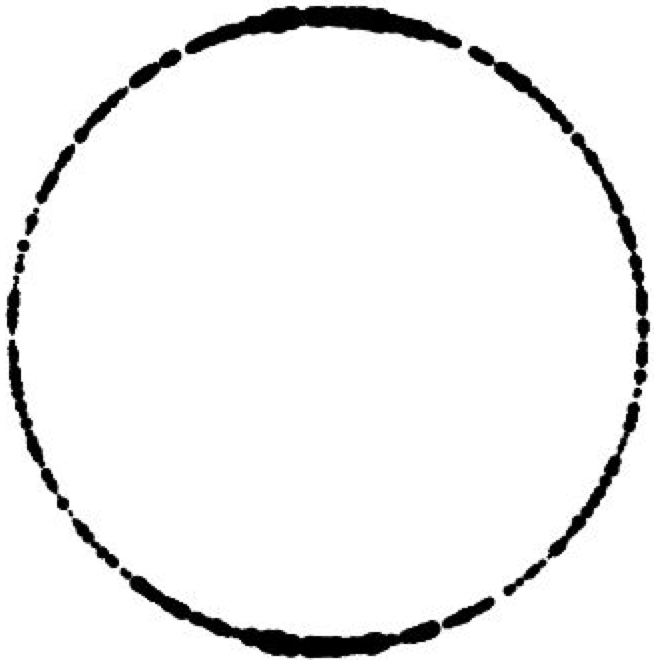
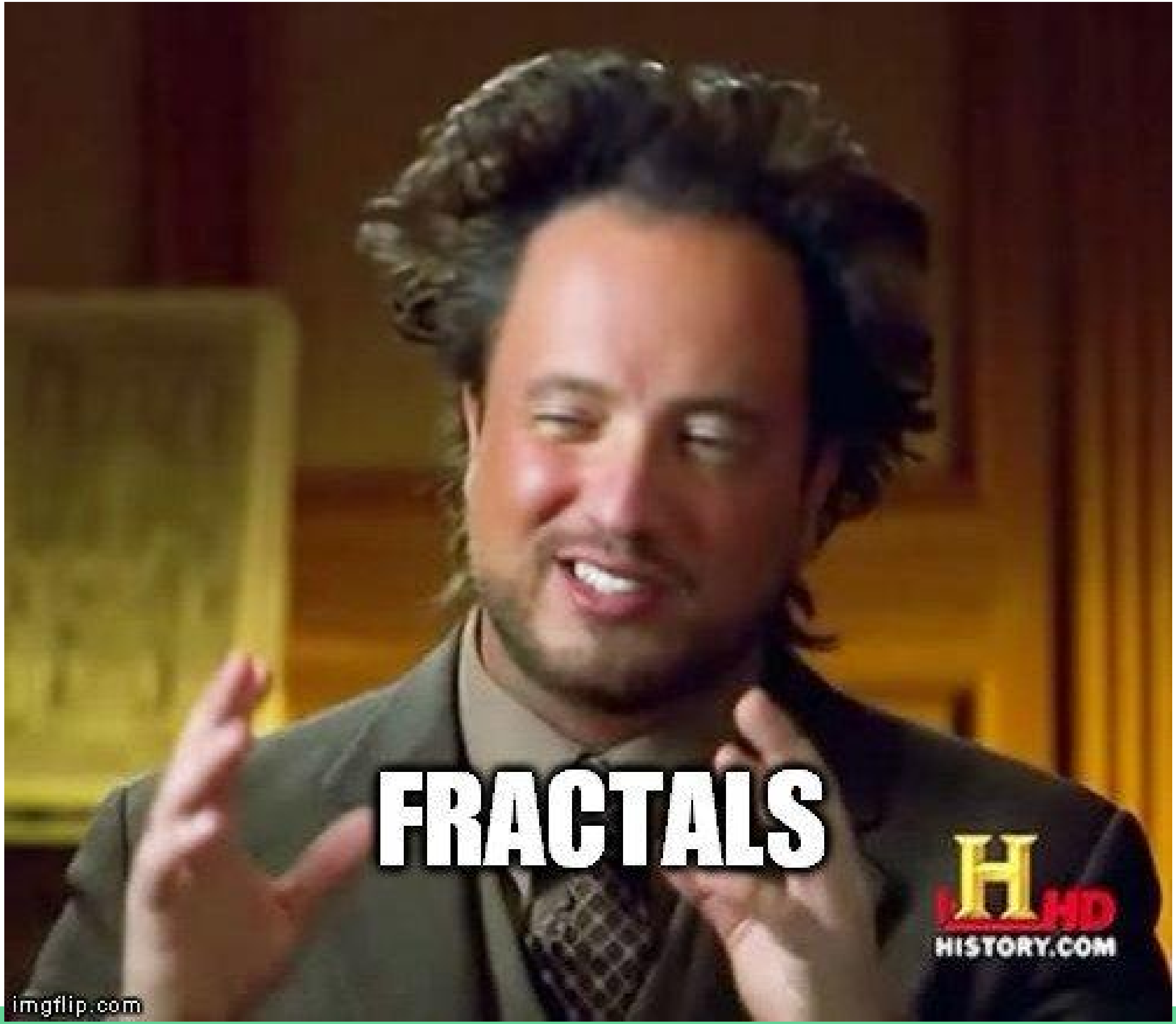


Figure 7. Plot of 800 initial node locations before the attack. Plot points increase in diameter as the density of peers nearby to that location increases.

Figure 8. Plot of 800 node locations after the attack by 2 malicious nodes. Plot points increase in diameter as the density of peers nearby to that location increases. The large plot points indicate the success of the attack in clustering most nodes around the 8 chosen locations.

What solves our problem?

- Need scalability
- Resistance to Pitch Black
- Must be greedy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Kleinberg Navigation in Fractal Small World Networks

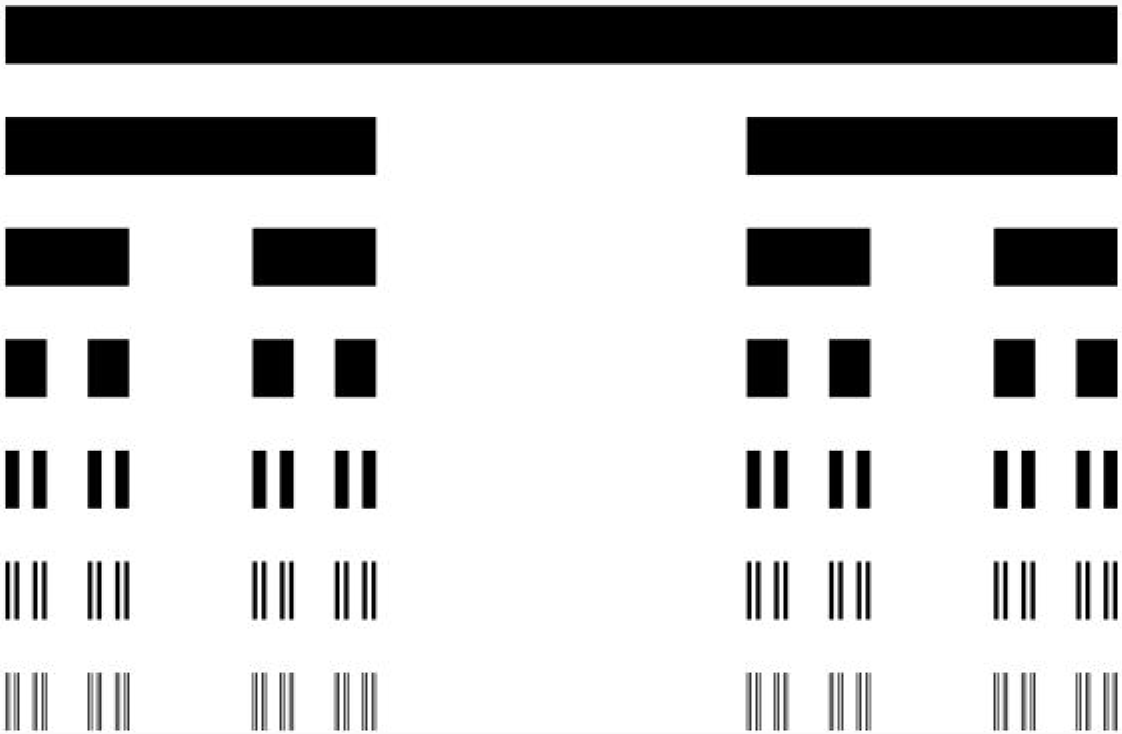
Mickey R. Roberson and Daniel ben-Avraham*
Department of Physics, Clarkson University, Potsdam NY 13699-5820

We study the Kleinberg problem of navigation in Small World networks when the underlying lattice is a fractal consisting of $N \gg 1$ nodes. Our extensive numerical simulations confirm the prediction that most efficient navigation is attained when the length r of long-range links is taken from the distribution $P(\mathbf{r}) \sim r^{-\alpha}$, where $\alpha = d_f$, the fractal dimension of the underlying lattice. We find finite-size corrections to the exponent α, proportional to $1/(\ln N)^2$.

PACS numbers: 89.75.Hc 02.50.-r, 05.40.Fb, 05.60.-k,

Making our keyspace fractal

- One dimensional sierpinski carpet? Cantor set!
- Navigate our new keyspace by generations(iterations)
- Compute the likelihood of our neighbors:
  - Fd*Gn/Gs
  - Fd - 1/3d - where d is fractal distance
  - Gn - 1/3n - where n is the generation our neighbor belongs to
  - Gs - 1/3s - where s is our generation



It works!

:O

Implications

- We now have a super scalable, decentralized structure that allows darknet routing and is resistant to the pitch black attack
- What if we add additional dimensions?
- Is the concept change distributions or change metric space or both?
- Swappable routing kernels -- need a better name perhaps

Applications

- Web Scraping
- Language/Semantic Overlay
- Learning overlay
- Adaptive decentralized search engine
- Solving problems

Blockchains(Shared Ledgers)

- Good for tracking state and transactions, not a fix-all
- Storage Limitations
- Square peg, round hole
- Mining Costs
- Economic games
- Pay to Play
- Serious scalability problems
- Excessive energy use