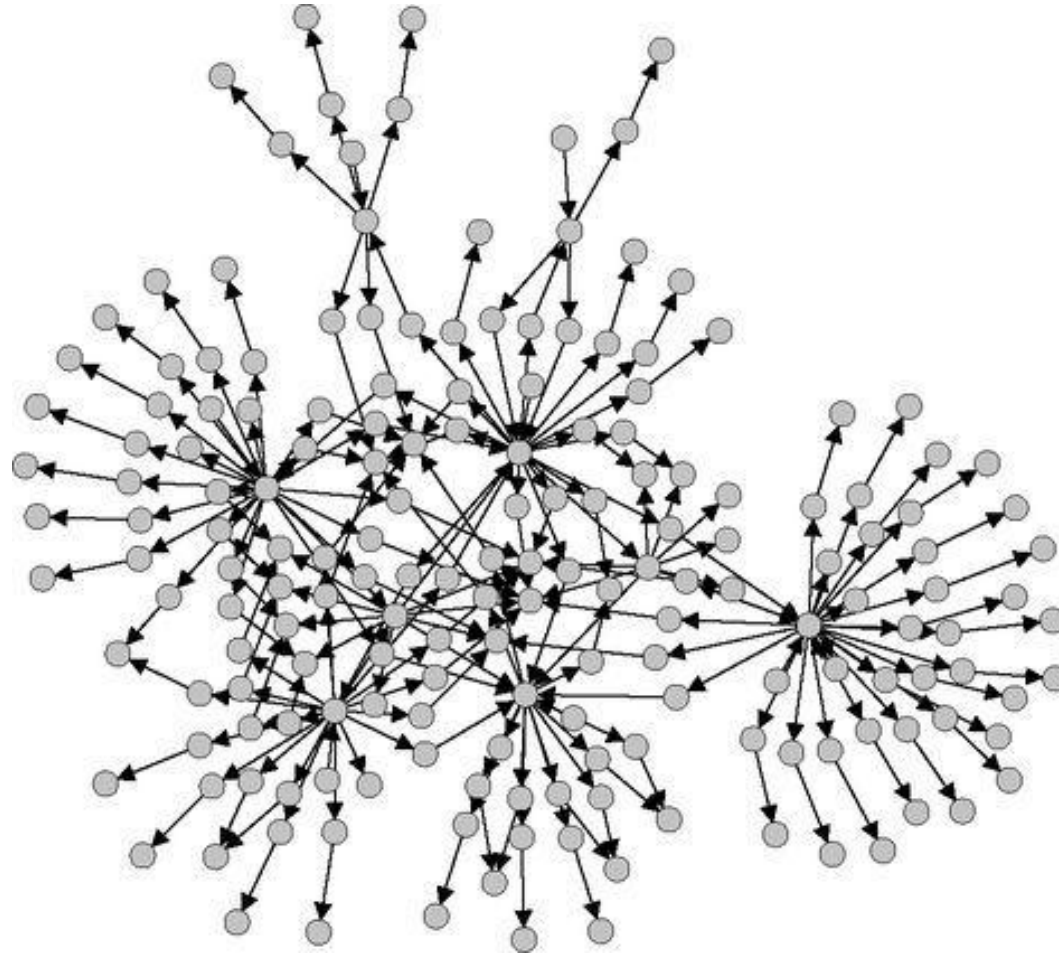


Information Networks

World Wide Web

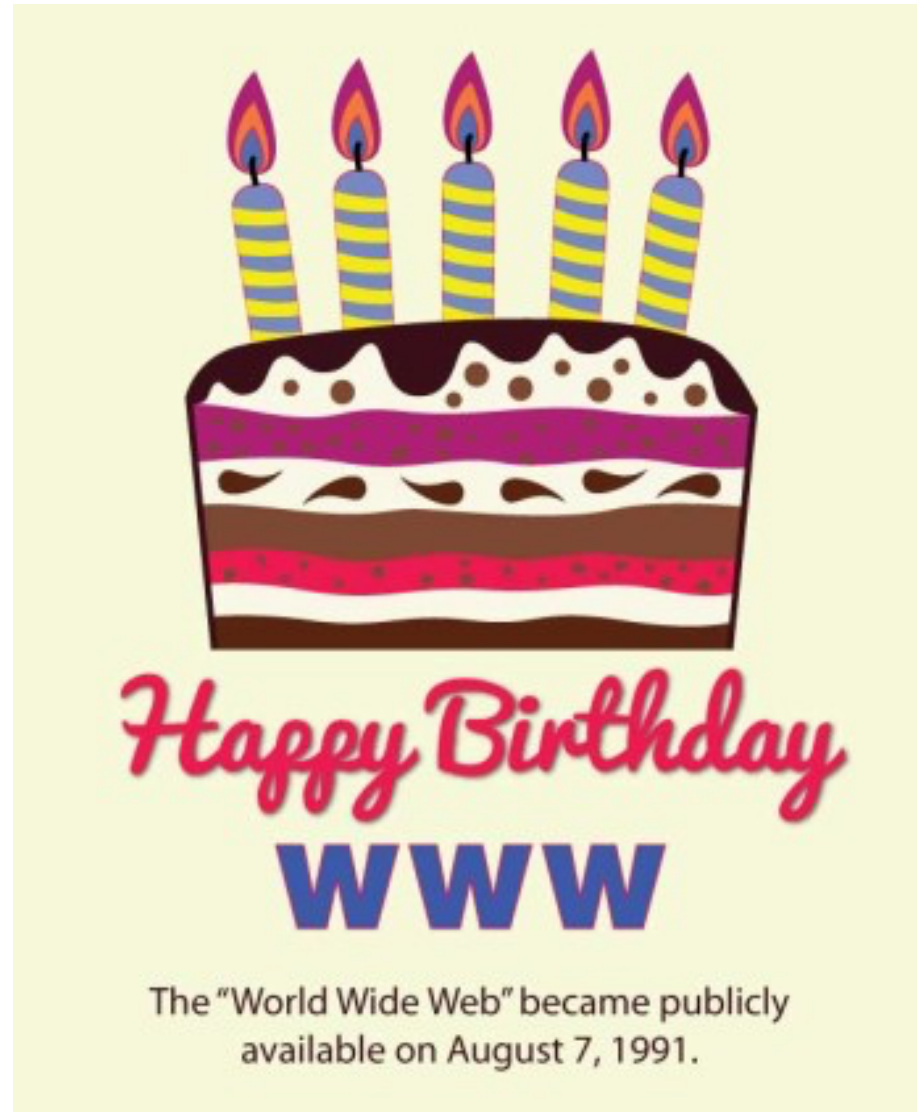
Network of a corporate website



Vertices: web pages

Directed edges: hyperlinks

World Wide Web



Developed by scientists at the CERN high-energy physics lab in Geneva

World Wide Web

Key software innovations:

HTML – the **Hypertext Markup Language** used to construct web pages

HTTP – the **Hypertext Transport Protocol** used to transmit pages over the internet

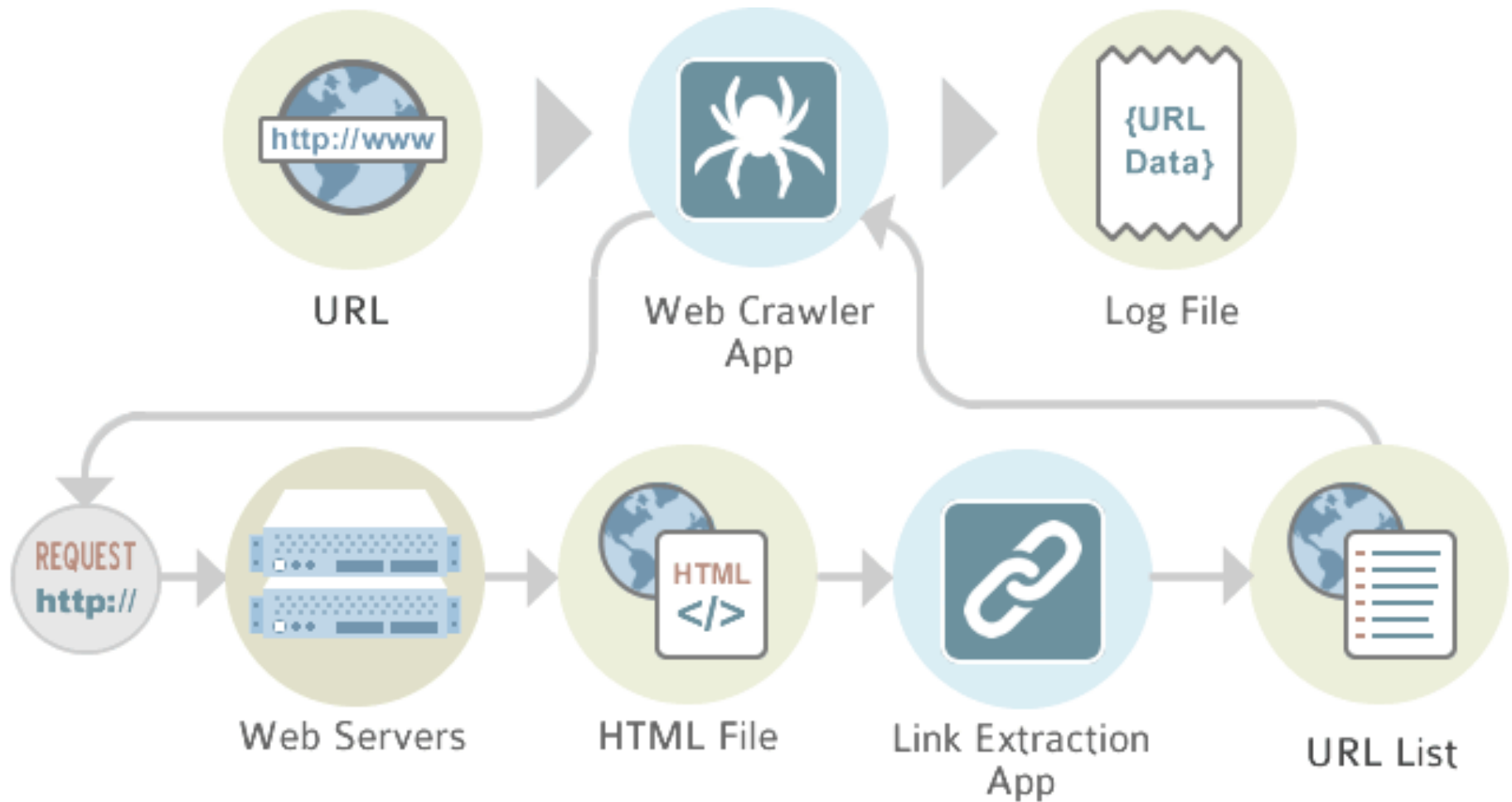
How popular is the WWW? **1 billion** static websites as of 2014

The Internet is Old By Comparison



Before the WWW, computer networks were largely for sharing resources among scientists and those working in the defense industry. A tiny fraction of the population!

Crawling Through the WWW



URL = Uniform Resource Locator

Citation Networks

From one of my papers:

Insulin secretion in healthy rodents, dogs, and humans is pulsatile, with mean period of ~ 5 min (1). This pulsatility has been reported to enhance insulin action at the liver (2), although not all studies have shown this (3). The consequences of pulsatile insulin secretion and its dysfunction in people with or at risk for type 2 diabetes has been recently reviewed (4). The focus of this Perspective, rather, is the mechanism of insulin pulsatility, in particular the rhythmogenesis of ~ 5 -min oscillations in activity of pancreatic prominent Na^+ currents, but the similarity of the slow oscillation periods suggests that the underlying mechanisms are similar in rodents and humans.

In the search for the biophysical mechanisms of oscillations in β -cell activity, several classes of models (both qualitative and mathematical) have emerged. We describe the key elements of these models, along with experimental findings that should be explainable by any proposed model. We conclude with a description of one recent model, the Integrated Oscillator Model (IOM), which combines features

Citation Networks

References

1. Song SH, McIntyre SS, Shah H, Veldhuis JD, Hayes PC, Butler PC. Direct measurement of pulsatile insulin secretion from the portal vein in human subjects. *J Clin Endocrinol Metab* 2000;85:4491–4499
2. Matveyenko AV, Liuwantara D, Gurlo T, et al. Pulsatile portal vein insulin delivery enhances hepatic insulin action and signaling. *Diabetes* 2012;61:2269–2279
3. Grupert JM, Lautz M, Lacy DB, et al. Impact of continuous and pulsatile insulin delivery on net hepatic glucose uptake. *Am J Physiol Endocrinol Metab* 2005;289: E232–E240
4. Satin LS, Butler PC, Ha J, Sherman AS. Pulsatile insulin secretion, impaired glucose tolerance and type 2 diabetes. *Mol Aspects Med* 2015;42:61–77
5. Nunemaker CS, Satin LS. Episodic hormone secretion: a comparison of the basis of pulsatile secretion of insulin and GnRH. *Endocrine* 2014;47:49–63
6. Cook DL. Isolated islets of Langerhans have slow oscillations of electrical activity. *Metabolism* 1983;32:681–685
7. Henquin JC, Meissner HP, Schmeer W. Cyclic variations of glucose-induced electrical activity in pancreatic B cells. *Pflugers Arch* 1982;393:322–327

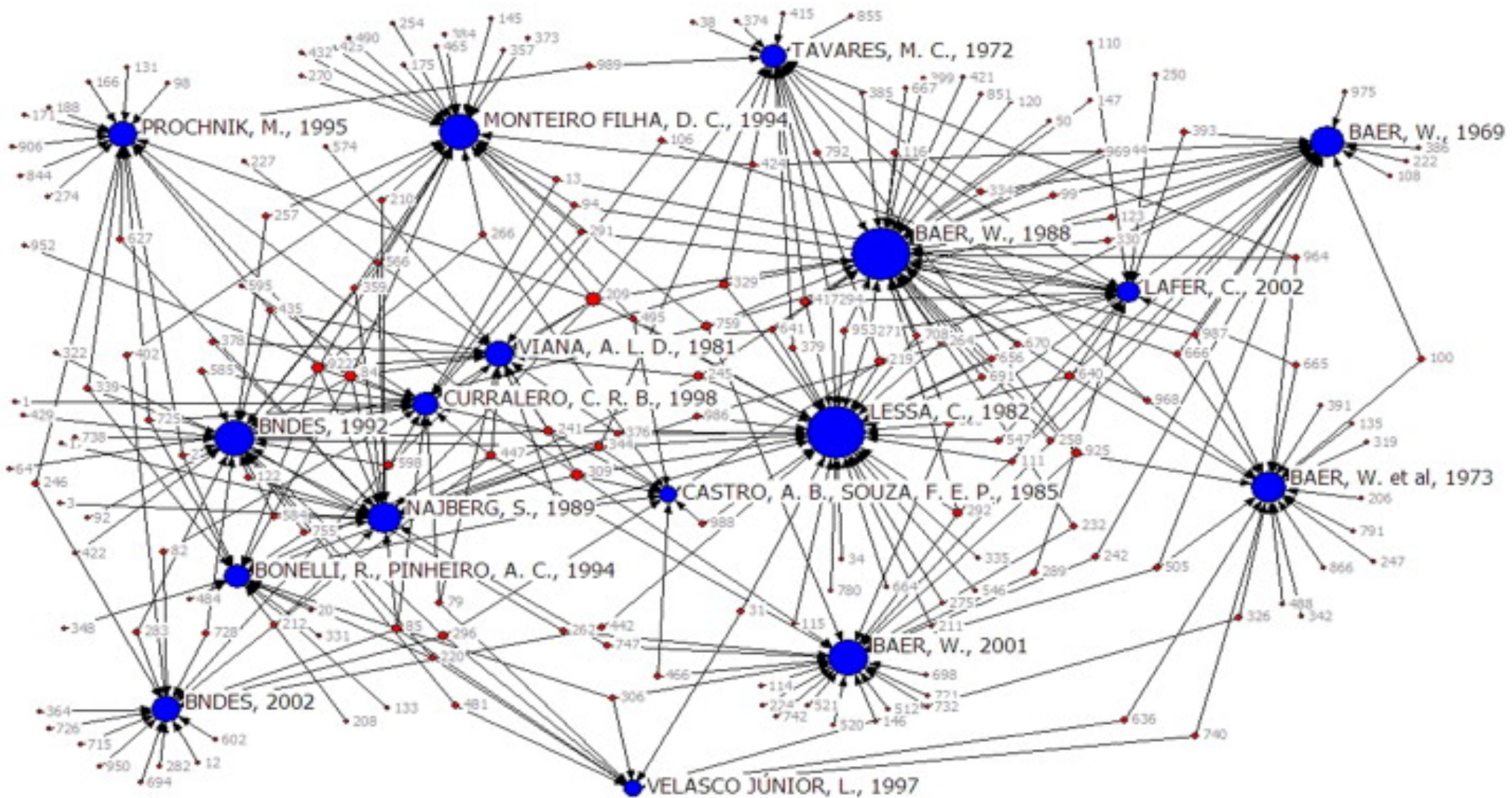
Citation Networks

Vertices = published papers

Directed edges = citation in paper A of paper B

Citation networks are **acyclic**; as you follow the directed edges you go backwards in time.

Example With Variable Vertex Size



The 17 vertices represent papers. The size of the circle reflects the number of citations to that paper (i.e., the **in-degree** of the vertex)

Some History of the Study of Citation Networks

The **Science Citation Index** began publication in 1961. This is currently the premier data base for scientific citations.

Derek de Solia Price first described the citation relationships in terms of a network of interconnected papers in a 1965 article.

The term **bibliometrics** was first used in a 1969 study by **Alan Pritchard**. It was defined as "the application of mathematics and statistical methods to books and other media of communication"

Until recently the construction of citation data bases was done manually. Now algorithms exist for the proper extraction and handling of citations, such as **CiteSeer** and **Google Scholar**.

Some Depressing Numbers

47% = percentage of papers in the Science Citation Index that have in-degree of 0 (never been cited by another paper)

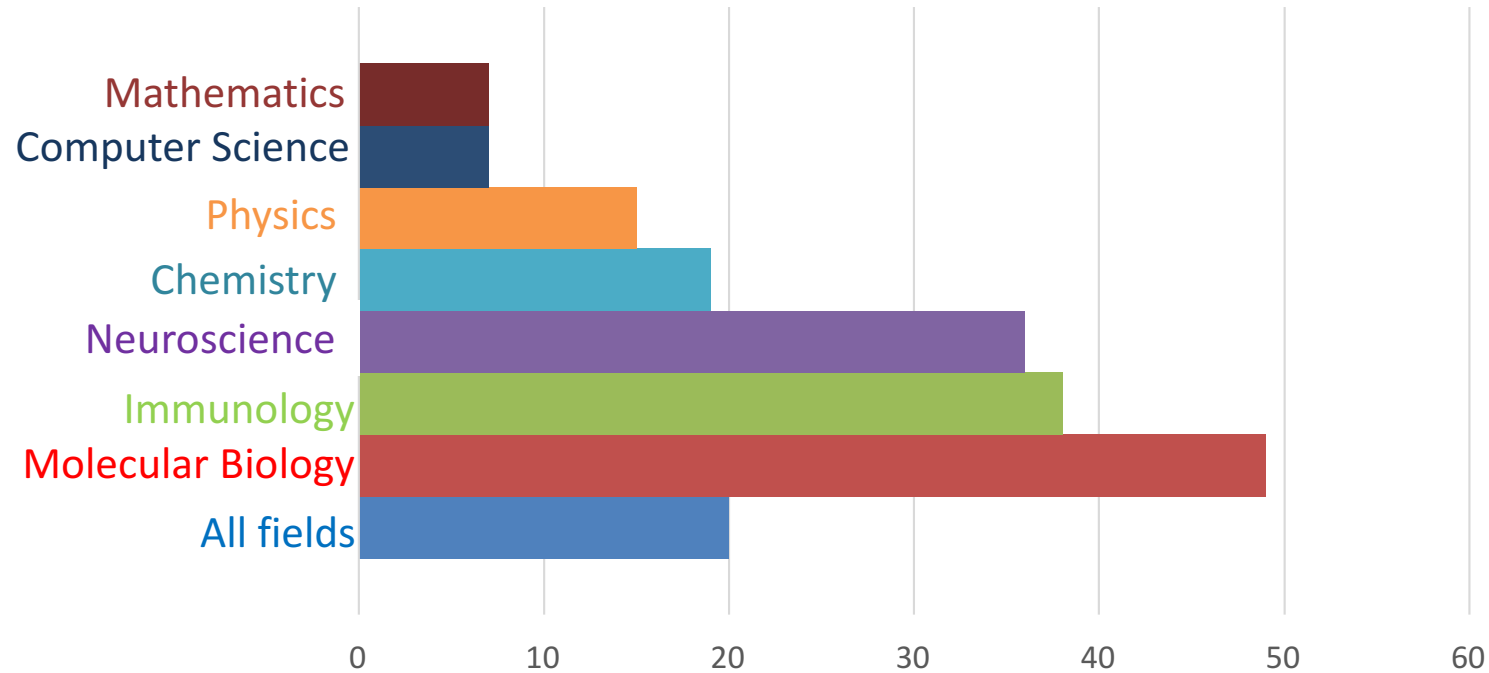
9% = the percentage of the remainder that have been cited once

21% = the percentage that have been cited 10 or more times

1% = the percentage cited 100 or more times

Large Variation of Citation Number Among Fields

Citation Averages; papers published in 2000



Data from Science Citation Index

Cocitation

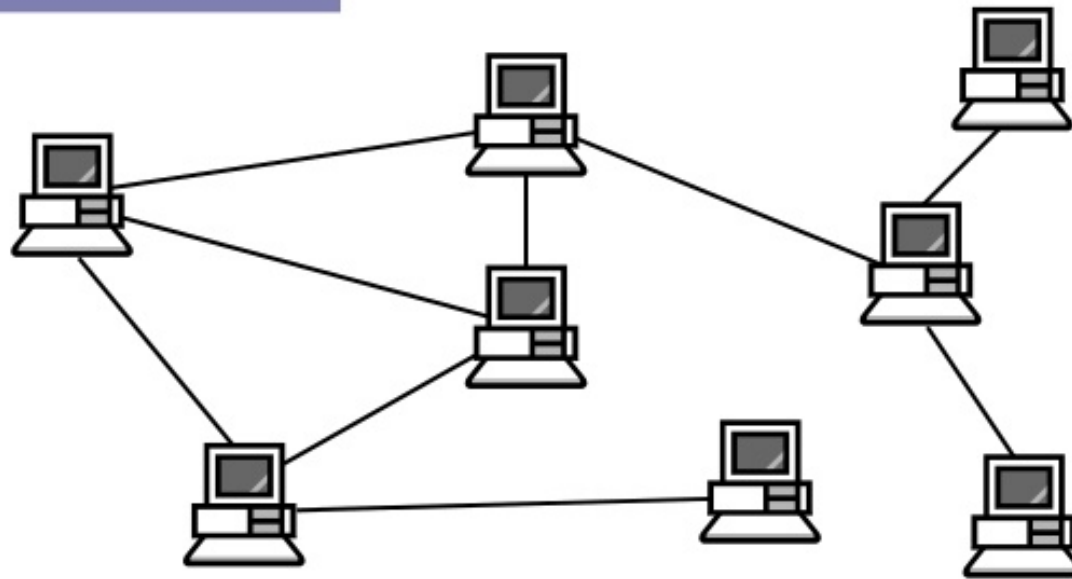
References

1. Song SH, McIntyre SS, Shah H, Veldhuis JD, Hayes PC, Butler PC. Direct measurement of pulsatile insulin secretion from the portal vein in human subjects. *J Clin Endocrinol Metab* 2000;85:4491–4499
2. Matveyenko AV, Liuwantara D, Gurlo T, et al. Pulsatile portal vein insulin delivery enhances hepatic insulin action and signaling. *Diabetes* 2012;61:2269–2279
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These paper are cocited, since both were cited by the same paper.
In a **cocitation network** they would be vertices connected by an edge.

Peer-to-Peer (P2P) File-Sharing Networks

Pure Peer-to-Peer Architecture



From James Salter

- No central server
- Clients connected to one or more peers
- Resilient
- Large #messages

Vertices: computers containing discrete files, such as music or video files

Edges: software allowing one computer to provide access to another should the need arise

Advantages of P2P Network Structure

Lack of any central servers or hubs means the network is highly distributed.

- Resilient to damage; if one vertex goes down there is little impact
- Hard to shut down. Without a central hub who do you go after?
- Perfect for illicit sharing of copyrighted material

How do you find which computer has the desired material?

Use a central server containing none of the material, but just an index of which computers the material is stored on.

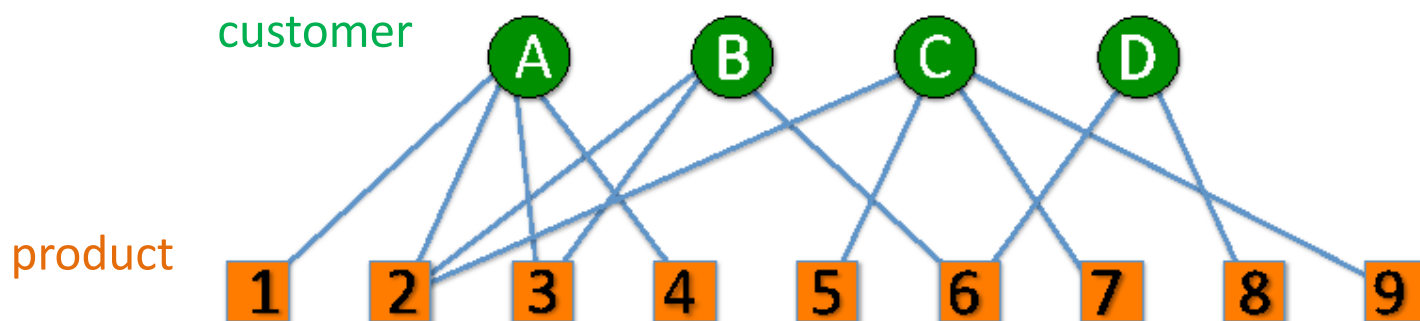
Example: [Napster](#), used to share music. The central server was forced to shut down in 2011. Now reorganized and used by the recording industry (legally).

Recommender Networks

How does *Amazon* know what you want to buy, or *Netflix* know which movies you would like to watch?

Recommender Networks

How does *Amazon* know what you want to buy, or *Netflix* know which movies you would like to watch?



Bipartite network where one set of **vertices** represents customers and the other products. An **edge** means that a customer bought the product. Edges can be weighted according to number purchased or survey score.

Collaborative Filtering Uses Recommender Networks to Make Predictions

Collaborative filtering is the method of making automatic predictions about the interests of a user by collecting preferences from many users.

Assumption is that if a person A has similar opinions to person B on a number of items (like TV shows), then A is more likely to have B 's opinion on a different items (like a new TV show) than that of a randomly chosen person.

A simpler, but probably less effective, approach is to base predictions on the average scores of the items, without regard to who gave the scores.

The End