Metcalfe's Law :
Why is the Web so Big?

Noah Mendelsohn
Tufts University
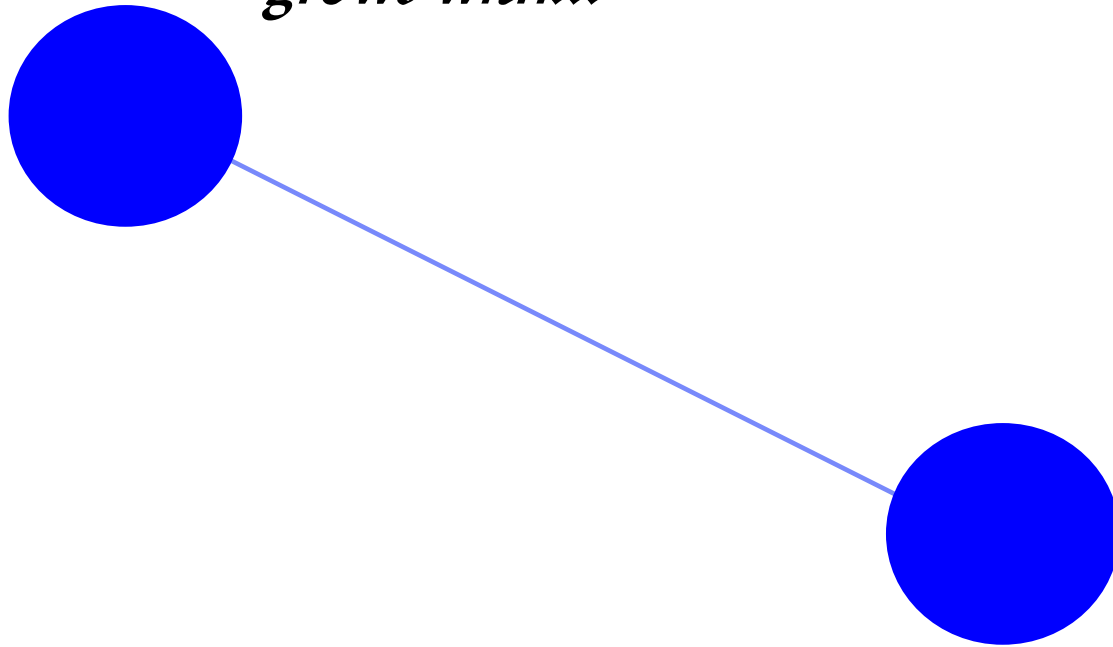Email: noah@cs.tufts.edu
Web: http://www.cs.tufts.edu/~noah

What you should get from this session

- **You will learn what Metcalfe's law is**

- **You will understand why Metcalfe's law (network effects) informs so many important decisions about the design and use of the Web**
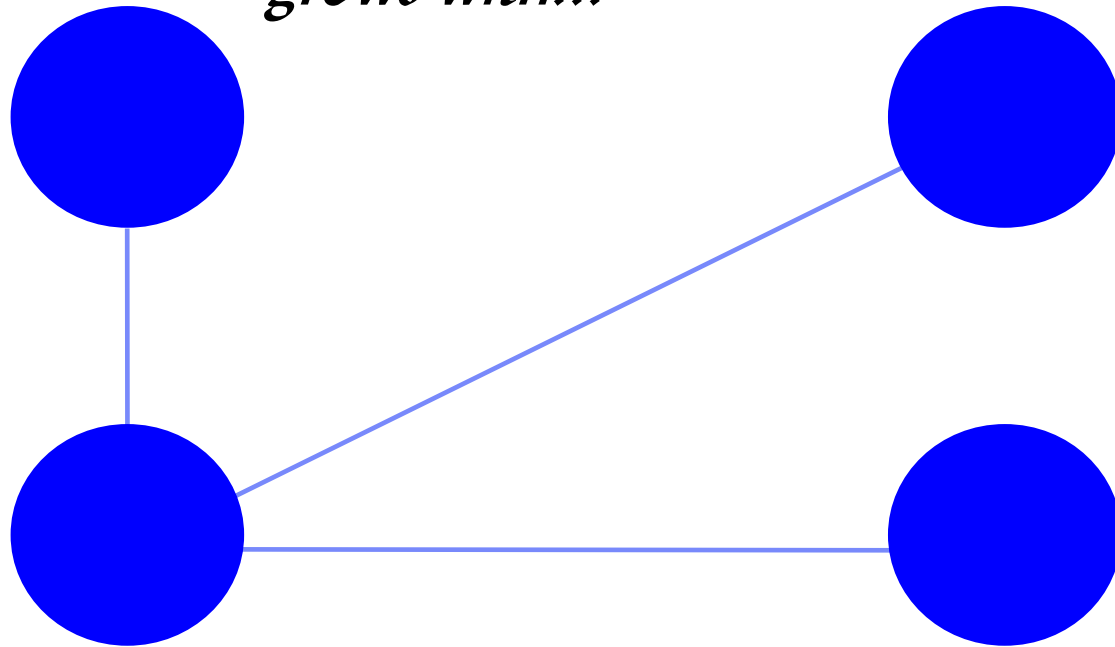
Metcalfe's Law

Bob Metcalfe's Law
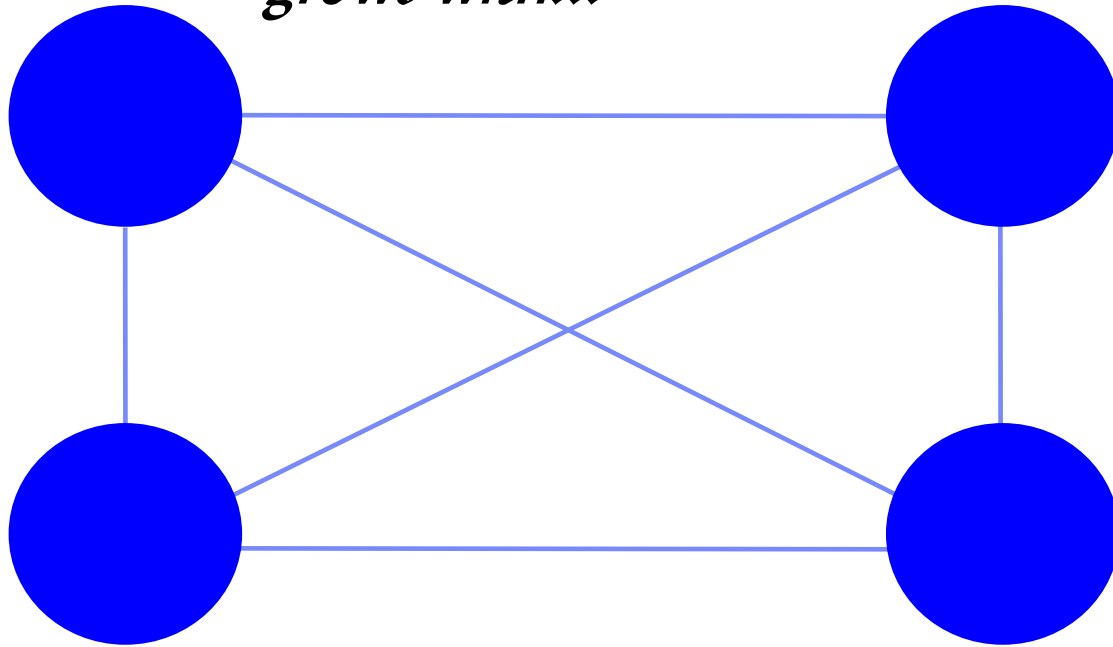
"The value of a network grows with..."

Bob Metcalfe's Law

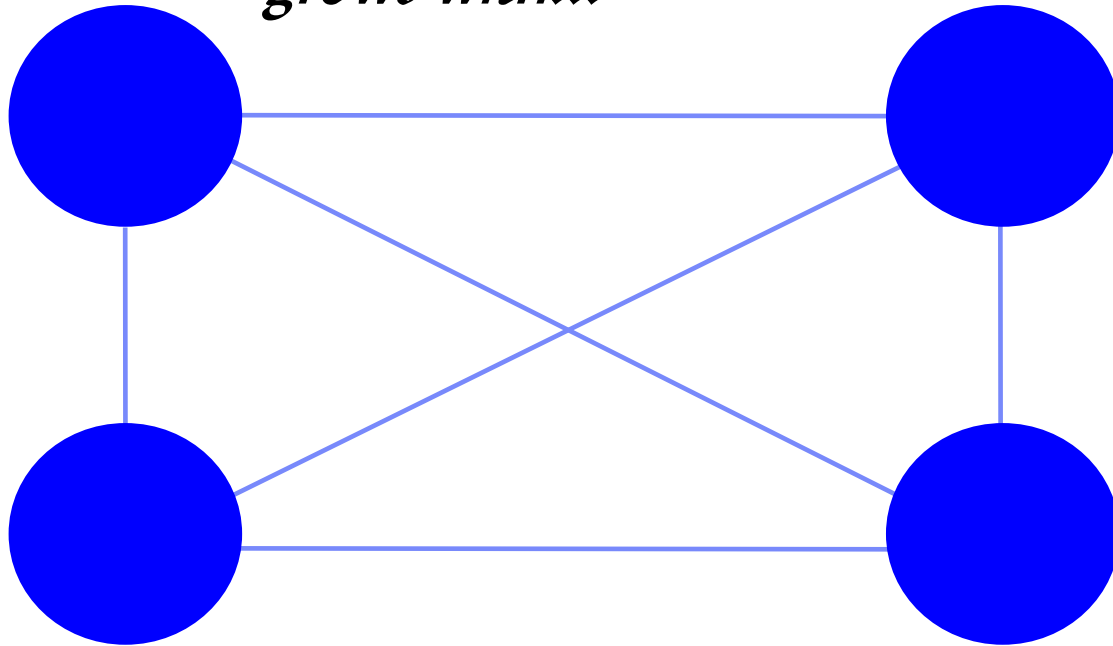*"The value of a network grows with..."*

Bob Metcalfe's Law

"The value of a network grows with..."

the number of connections you can make."
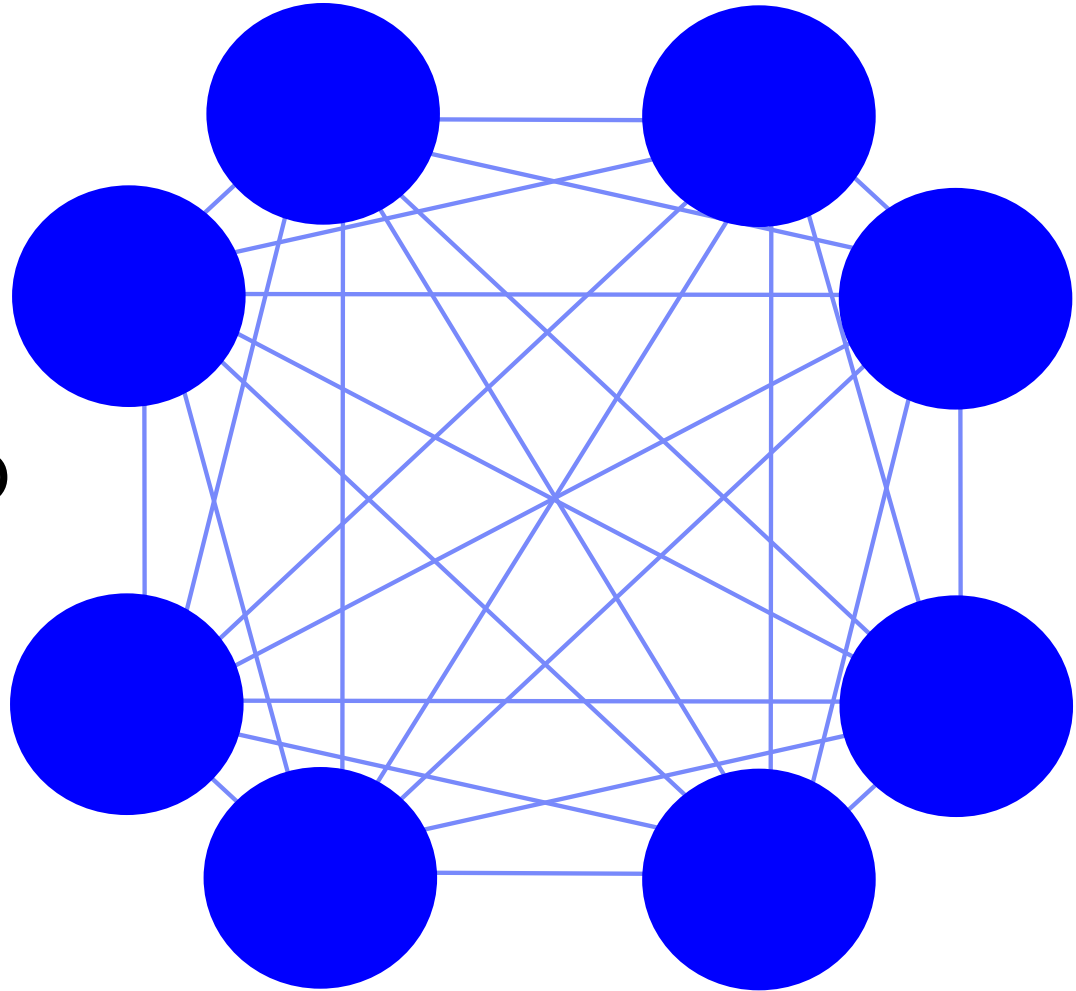
Bob Metcalfe's Law

"The value of a network grows with..."

"..the square of the number of participants."

Bob Metcalfe's Law

$$\text{Connections} = (n^2 - n)$$

Bob Metcalfe's Law

Connections = (n^2 − n)
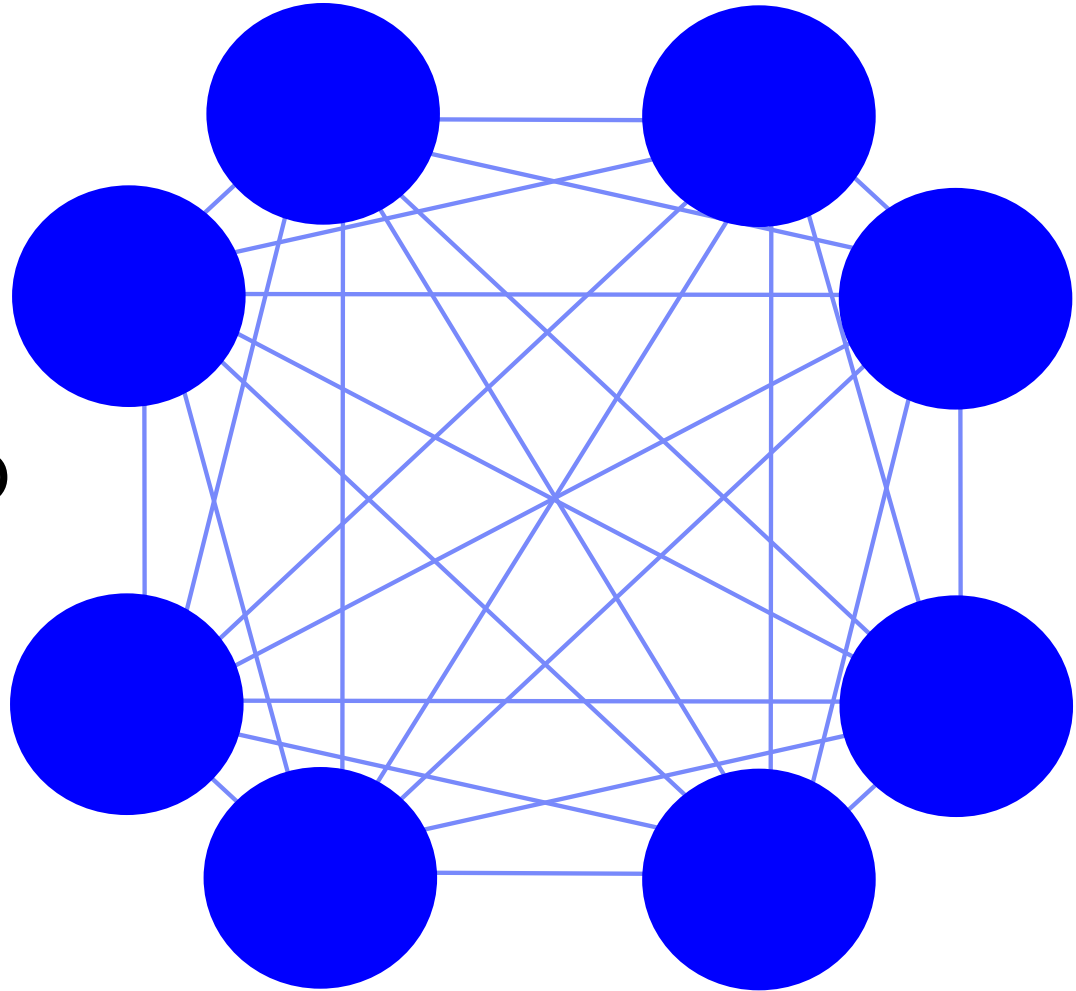
What about lots of little webs?
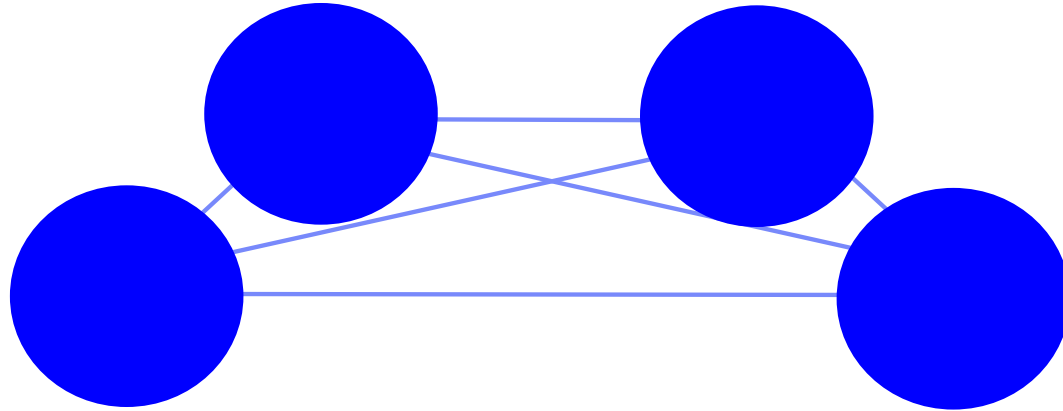
One big network is worth a lot more than lots of smaller ones!
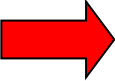
There can be only one Web!

Metcalfe's law and the Web

- **The Web is a good place to publish your page because:**
  - There are lots of users with browsers who can read it
  - *There are lots of other pages out there for you to link*
  - *There are lots of other pages that can link to yours*

Metcalfe's law and the Web
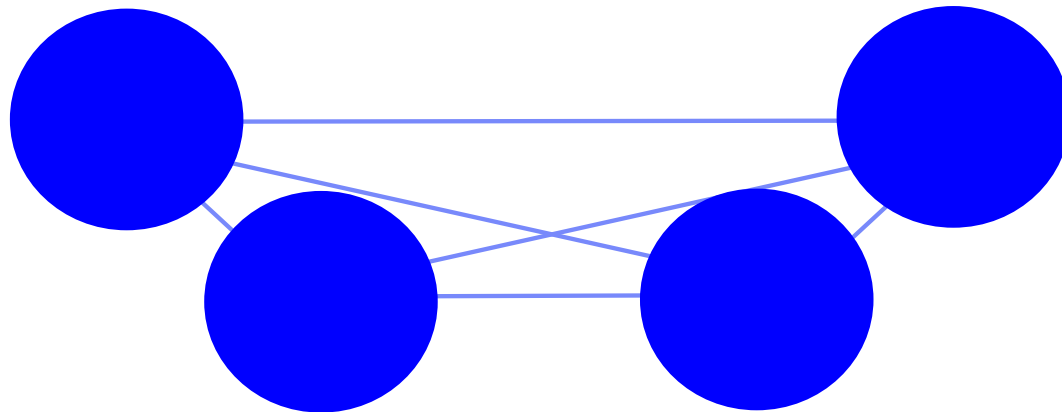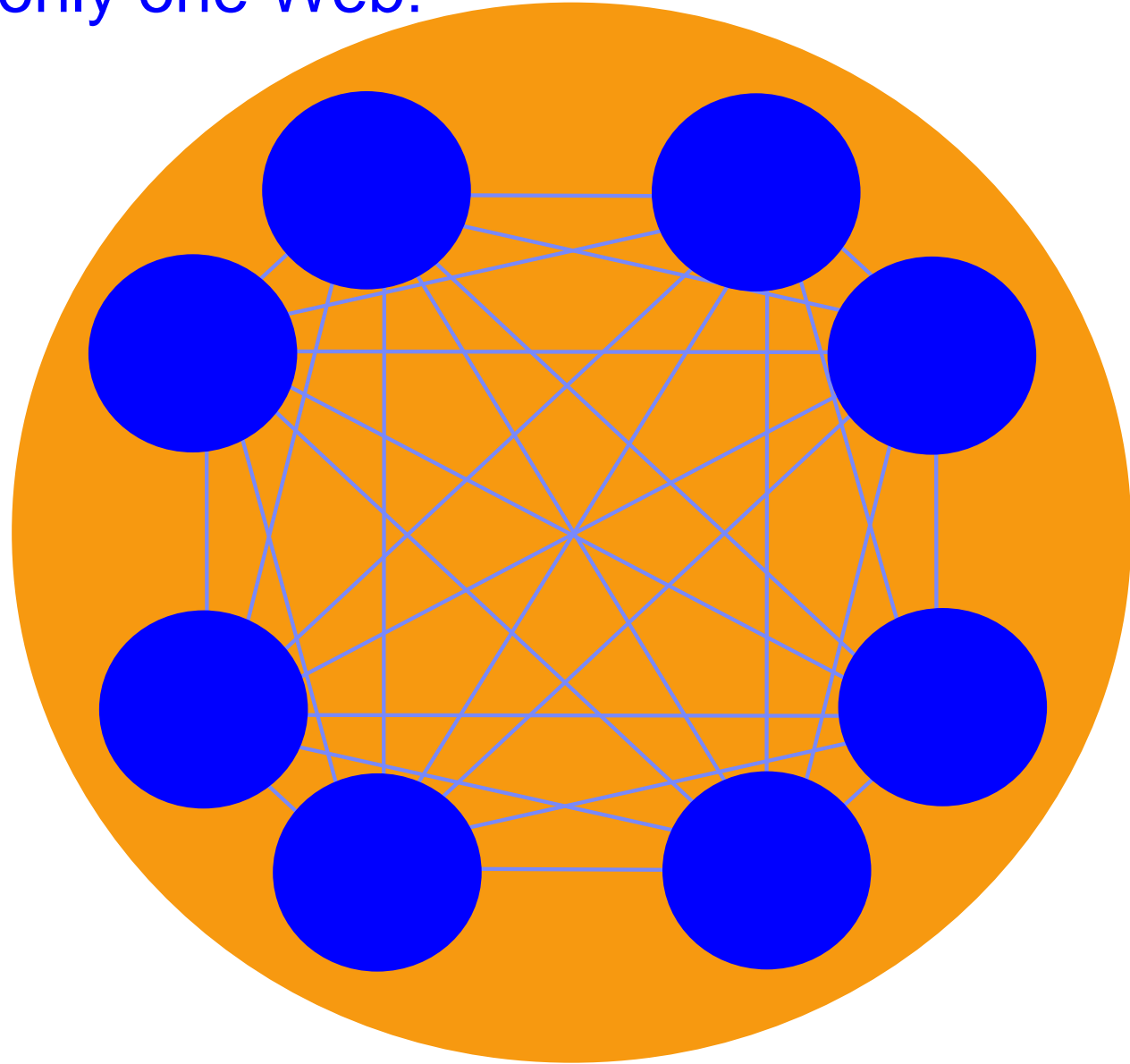
- **The Web is a good place to publish your page because:**
  - There are lots of users with browsers who can read it
  - *There are lots of other pages out there for you to link*
  - *There are lots of other pages that can link to yours*

- *Each page can add value to the others*

- **Example:**
  - There are sites with weather reports, another with hotel rooms, yet another with airline flights
  - You can link the weather report from the flight page and hotel pages
  - *That makes both the weather report and the flight pages more valuable!*

- **Your page is more valuable when it's part of a larger Web…**

- **… and so are all the other pages!**

The Universal Web

"By Universal I mean that the web is declared to be able to contain in principle every bit of information accessible by networks. It was designed to be able to include existing information systems such as FTP, and to be able simply in the future to be extendable to include any new information system."

Tim Berners-Lee
December, 1996

The Many Implications
of
Metcalfe's Law

An amazing range of issues are related to Metcalfe's Law

- **The technology must be portable to a tremendous variety of systems**

- **The technology must integrate a wide (and growing) range of content**

- **"Walled gardens" divide the Web:**
  - What's a walled garden? An area of the Web that requires login for access to material that would otherwise be freely linkable,

An amazing range of issues are related to Metcalfe's Law

- **The technology must be portable to a tremendous variety of systems**

- **The technology must integrate a wide (and growing) range of content**

- **"Walled gardens" divide the Web:**
  - What's a walled garden? An area of the Web that requires login for access to material that would otherwise be freely linkable, *e.g. Facebook!!*
  - In that sense, a page in Facebook is less valuable than one on the public Web

An amazing range of issues are related to Metcalfe's Law

- **The technology must be portable to a tremendous variety of systems**

- **The technology must integrate a wide (and growing) range of content**

- **"Walled gardens" divide the Web:**
  - What's a walled garden? An area of the Web that requires login for access to material that would otherwise be freely linkable, *e.g. Facebook!!*
  - In that sense, a page in Facebook is less valuable than one on the public Web

- **Browser-specific features divide the Web**

- **Failure to follow specifications divides the Web**

- *View Source* **promotes growth of the Web – demonstrates network effects**

- **Network neutrality is vital**
  - If your network provider gives you good access only to resources that *it* likes, then your Web is effectively much smaller
  - Video of Tim BL: https://www.youtube.com/watch?v=Jev2Um-4_TQ (2006)

- **The Web must *integrate* all countries, cultures and languages**

- **Compared to the Web, proprietary systems tend to have less value, and their use devalues the Web –** *iPad apps don't do linking!*

Economics, the law, and ubiquity

- **Tim viewed the decision to make the Web free as crucial to success**
- **Patents impede the adoption of Web technologies**
  - Licensing fees
  - Friction: you don't know when it's OK to innovate
- **Copyright issues**
  - The Web gains value when content can be linked freely

The Challenge of Scaling

Scaling is hard

- **Need to name (link to) billions of "resources"**

- **Need to run over slow links (dialup = 400bytes/sec) and fast (GBit Ethernet = 100Mbytes/sec), sometimes for the same request**

- **Deal with hot spots: millions of people accessing the same resource at the same time**

- **Span administrative, legal and political boundaries**
  - Differing cultural expectations
  - Differing spoken languages
  - Differing devices and input/output modalities

- **Systems like the Web become socially important**

- **Big systems are big targets**

Goals and requirements for the Web

- **Integrate all of the world's online information – plus "non-information resources"**
- **Integrate with other systems**
  - The Web is implemented on systems ranging from mainframes to traffic lights
- **Allow references (URIs) to be:**
  - Memorable
  - Conveyed in other systems (like the links in this slide show!)
  - Written "on the side of a bus"
- **Explorable – random browsing/crawling should work, and should do no harm**
- **Support all users, regardless of location, spoken language or disability**
- **Extensible to new types of content, new devices, new modalities of interaction, etc. Must work for decades, maybe centuries!**
- **Open: content, naming and extensions should not require concurrence of a central authority**
- **Safe to use: e.g. should not unduly compromise your privacy**
- **Provide non-discriminatory access**

Systems like the Web become socially important, and critical to society

Next session…

- **How do we design a Web to meet these goals?**