Sustainability
and Future of the WWW

Fall 2018

The Power of the Web

- The World Wide Web serves many purposes.
- But
  - Who is the Web for?
  - How big is the Web?
  - Is it being developed in a sustainable way?

Invention of the Web

- Tim Berners-Lee, credited as Inventor of the Web
  https://amturing.acm.org/award_winners/berners-lee_8087960.cfm
- The World Wide Web has seen explosive growth since its invention in 1989.
- Originally, it was a place to seek content and information. http://info.cern.ch/hypertext/WWW/TheProject.html
- From the beginning, Web was considered to open to everyone. Famous quote in 1997:

  "The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect."

  Tim Berners-Lee, October, 22, 1997

Web in 2018

- Since 1991, when the web went public, it has grown tremendously – in number of websites and ways people use it.
  - https://www.washingtonpost.com/graphics/2017/entertainment/tech-generations/?utm_term=.5ffc94ac2d6e
- With the rapid global adoption of smart phone and mobile devices that are less expensive than traditional computers and laptops, the WWW is increasingly accessible to an ever-growing population.

Founder's Observations

"Access to the Web is now a human right. It's possible to live without the Web. It's not possible to live without water. But if you've got water, then the difference between somebody who is connected to the Web and is part of the information society, and someone who (is not) is growing bigger and bigger."

Tim Berners-Lee

2011, MIT Symposium

The year open-data went worldwide

At TED2009, Tim Berners-Lee called for "raw data now" – for governments, scientists and institutions to make their data openly available on the web. At TED University in 2010, he shows a few of the interesting results when the data gets linked up. [February 2010]

http://www.ted.com/talks/tim_berners_lee_the_year_open_data_went_worldwide.html

Size and Impact of the Web

- There are over 7.5 billion people in the world.
  https://population.un.org/wpp/
  https://www.unfpa.org/press/state-world-population-2018

- The WWW has close to **2 billion websites** – and counting!
  http://www.internetlivestats.com/total-number-of-websites/

- The WWW has an enormous impact around the world
  http://thewebindex.org/

- The way the web is being used is rapidly changing.

Berners-Lee's Take

*"I've always believed the web is for everyone. That's why I and others fight fiercely to protect it. The changes we've managed to bring have created a better and more connected world. But for all the good we've achieved, **the web has evolved into an engine of inequity and division**; swayed by powerful forces who use it for their own agendas."*

Tim Berners-Lee

Sept. 29, 2018

One Small Step for the Web … Blog

https://medium.com/@timberners_lee/one-small-step-for-the-web-87f92217d085

Energy Use

- "Printing on paper wastes energy but sharing information electronically doesn't" – not exactly!
- **Pixels** are real things.
  - A "pixel" is a relatively light-weight physical entity. (We're talking electrons, here.)
  - In 2011, estimated that the public Internet transferred 72 **exabytes** of information worldwide.
    - 1 exabyte ~= 10^{18} bytes = a billion gigabytes
    - All those electrons weigh only a few ounces
  - But, it requires energy to store them, transmit them, and display them on a screen.

How much energy does it take?

- Global computing power demand from *Internet and Communications Technology* (ICT) – internet-connected devices, high resolution video streaming, emails, surveillance cameras and a new generation of smart TVs – is increasing 20% a year, consuming roughly **3-5% of the world's electricity in 2015**

- Without dramatic increases in efficiency, the ICT industry could use 20% of all electricity and emit up to 5.5% of the world's carbon emissions by 2025.
- http://www.climatechangenews.com/2017/12/11/tsunami-data-consume-one-fifth-global-electricity-2025/

Search Engines

- Software tools used to find websites meeting specific criteria
- Examples of general **search engines**:
  - Google, Bing, Baidu, Yahoo, …
- Search engines use the following three components:
  1. Robot or "spider"
  2. Database (also used by search indexes)
  3. Search form (also used by search indexes)

http://www.google.com/insidesearch/howsearchworks/crawling-indexing.html

11

Popular Search Engines

- % of Market Share for Mobile and Desktop devices:

[November 2016, 2018]

	Desktop	Mobile
Google	75.2%, 72.68%	94.18%, 81.71%
Baidu	7.7%, 13.68%	0.33%, 16.0%
Yahoo!	6.9%, 3.87%	3.51%, 0.87%
Bing	8.4%, 7.76%	1.26%, 0.78%

- Source:
  http://www.netmarketshare.com/

12

Curious Facts

- In 1999, it took Google one month to crawl and build an index of about 50 million pages.
  In 2012, the same task was accomplished in less than one minute. [4]
- 16% to 20% of queries that get asked every day have never been asked before. [4]
- Every query has to travel on average 1,500 miles to a data center and back to return the answer to the user. [4]
- A single Google query uses 1,000 computers in 0.2 seconds to retrieve an answer. [7]

Number of Google Searches

- According to Internet Live Stats:
  - 2017: Google processes
    3.5 billion searches every day
    = 40,000 search queries every second
    = 1.2 trillion searches each year

  - 2018: approaching
    5.5 billion searches per day
    = 63,000 search queries done per second,
    = **2 trillion searches** for the year.

http://www.internetlivestats.com/

Cloud Computing

- Computing power can be shared among many computers and distributed over the internet.

- Cloud computing involves
  - Warehouse Scale Computers (WSC)
  - Software as a Service (SaaS)
  - "Mobile Apps" - a portion of the software runs on the mobile device, and a portion runs in the Cloud

- Examples: Amazon and Google data centers

Main Components of IT Electricity Consumption
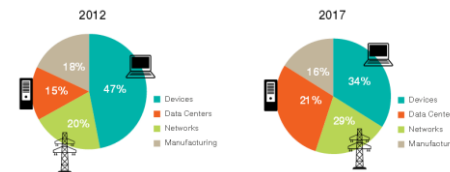
Source: *Clicking Clean: A Guide to Building the Green Internet,* Greenpeace.org, May 2015.
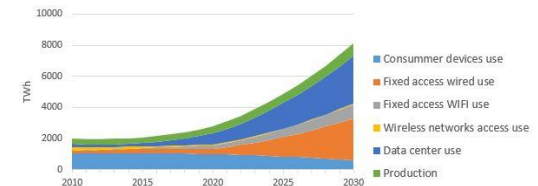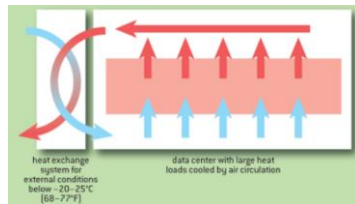
Source: Andrae October 2017

https://www.researchgate.net/publication/320225452_Total_Consumer_Power_Consumption_Forecast

Data Center Cooling

- The challenges of data center cooling are enormous
  - Approximately 2% of energy has been used by data centers in U.S.
  - With thousands of computers in a data center, a huge amount of heat is generated
- Cooling is typically done with air or water

heat exchange
system for
external conditions
below −20–25°C
(68−77°F)

data center with large heat
loads cooled by air circulation

17

Google Data Center

- https://www.google.com/about/datacenters/inside/index.html

- YouTube link:
  https://www.youtube.com/watch?v=XZmGGAbHqa0

What does Sustainability mean?

- Most widely accepted definition of sustainability comes from the Bruntland Report in 1987:

    Humanity has the ability to make development sustainable to ensure that it *meets the needs of the present without compromising the ability of future generations to meet their own needs.*

- For a product, service, or anything else to be truly "sustainable," it must consider **social** and **economic** considerations as well as **ecological** ones.

In terms of web devlopment

- A sustainable website is one whose
    1. Content is easy to find
    2. Performance is optimized
    3. Design is efficient and accessible
    4. Host web server runs on renewable energy.

- Use Ecograder to test website
  https://ecograder.com/

Specific recommendations

1. Be aware of energy use in our field
2. Use your voice, vote, and wallet to hold politicians and companies accountable.

References

- September, 2013
  http://alistapart.com/article/sustainable-web-design
- March, 2017
  http://www.oliverrussell.com/insights/blog/article/sustainable-web-design-2017

Good suggestions, but a little more advanced:

- http://inspiredm.com/12-steps-to-sustainable-web-design/