Computer Networks, Internet and Mobile Computing

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Big picture

- The purpose of computer networks is to get information to where it is needed as quickly and reliably as possible with the least amount of resource use.

Ingredients

- Media: cable, fibre, wireless
  - Governed by laws of nature
- Devices: computers, phones, sensor, actors, …
  - Governed by various things: application, available power, state of technology
- Protocols: link layer, network, transport, DNS, routing, security
  - Governed by standards or conventions
- Codes: modulation, error correction, compression
  - Governed by the laws of information theory
- Topology: who connects to what where
  - Governed by geography, the law of the land, commercial interests and politics
- Humanity:
  - Governed by Murphy's Law

How does Computer Science connect to this?

- Media: Data representations for physical states, signal processing

- Devices: Software, drivers

- Protocols: Design and implementation, correctness, testing, troubleshooting, APIs, utilities, libraries

- Codes: Design, performance, implementation

- Topology: Routing algorithms, diagnostic software, load balancing, billing, configuration, management, …

- Humanity: Usability, performance, security, planning, monitoring…
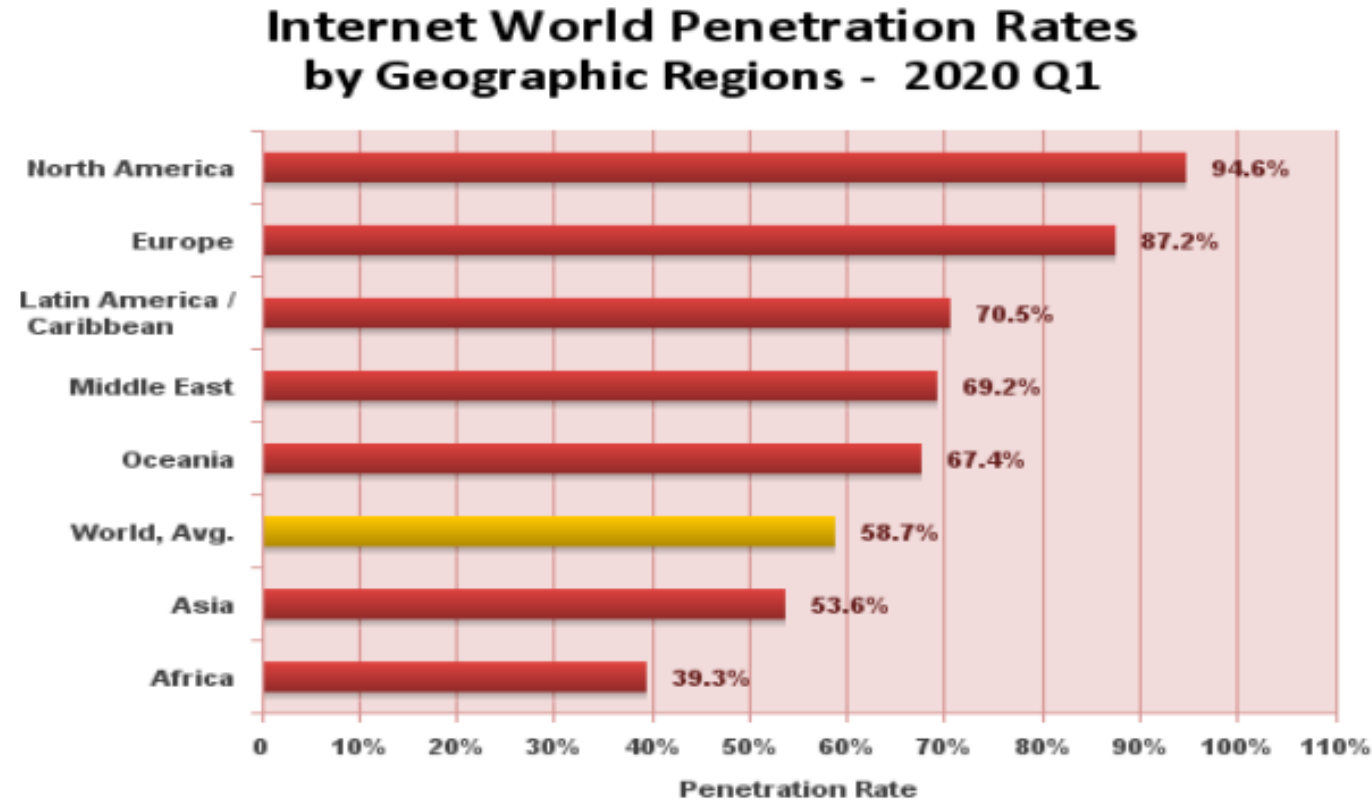
Research challenges

- Managing growth
  - From a handful of mainframes on the early Internet to 50 billion connected devices under 5G?

- Managing reliability
  - Everything keeps changing constantly – how do we ensure things don't break down, collapse, or are no longer delivered on time?

- Avoiding digital divides
  - If money and effort goes towards where most money is to be made, how do we ensure everyone can get connected?

Internet growth

WORLD INTERNET USAGE AND POPULATION STATISTICS
2020 Year-Q2 Estimates

World Regions	Population (2020 Est.)	Population % of World	Internet Users 30 June 2020	Penetration Rate (% Pop.)	Growth 2000-2020	Internet World %
Africa	1,340,598,447	17.2 %	566,138,772	42.2 %	12,441 %	11.7 %
Asia	4,294,516,659	55.1 %	2,525,033,874	58.8 %	2,109 %	52.2 %
Europe	834,995,197	10.7 %	727,848,547	87.2 %	592 %	15.1 %
Latin America / Caribbean	654,287,232	8.4 %	467,817,332	71.5 %	2,489 %	9.7 %
Middle East	260,991,690	3.3 %	184,856,813	70.8 %	5,527 %	3.8 %
North America	368,869,647	4.7 %	332,908,868	90.3 %	208 %	6.9 %
Oceania / Australia	42,690,838	0.5 %	28,917,600	67.7 %	279 %	0.6 %
WORLD TOTAL	7,796,949,710	100.0 %	4,833,521,806	62.0 %	1,239 %	100.0 %

NOTES: (1) Internet Usage and World Population Statistics estimates are for July 20, 2020. (2) CLICK on each world region name for detailed regional usage information. (3) Demographic (Population) numbers are based on data from the United Nations Population Division. (4) Internet usage information comes from data published by Nielsen Online, by the International Telecommunications Union, by GfK, by local ICT Regulators and other reliable sources. (5) For definitions, navigation help and disclaimers, please refer to the Website Surfing Guide. (6) The information from this website may be cited, giving the due credit and placing a link back to www.internetworldstats.com. Copyright © 2020, Miniwatts Marketing Group. All rights reserved worldwide.

https://www.internetworldstats.com/stats.htm

Internet growth

Internet World Penetration Rates by Geographic Regions - 2020 Q1

| Region	Penetration Rate
North America	94.6%
Europe	87.2%
Latin America / Caribbean	70.5%
Middle East	69.2%
Oceania	67.4%
World, Avg.	58.7%
Asia	53.6%
Africa	39.3%

Penetration Rate

Source: Internet World Stats - www.internetworldstats.com/stats.htm
Penetration Rates are based on a world population of 7,796,615,710
and 4,574,150,134 estimated Internet users in March 3, 2020.
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Digital divide: satellite users in the Pacific
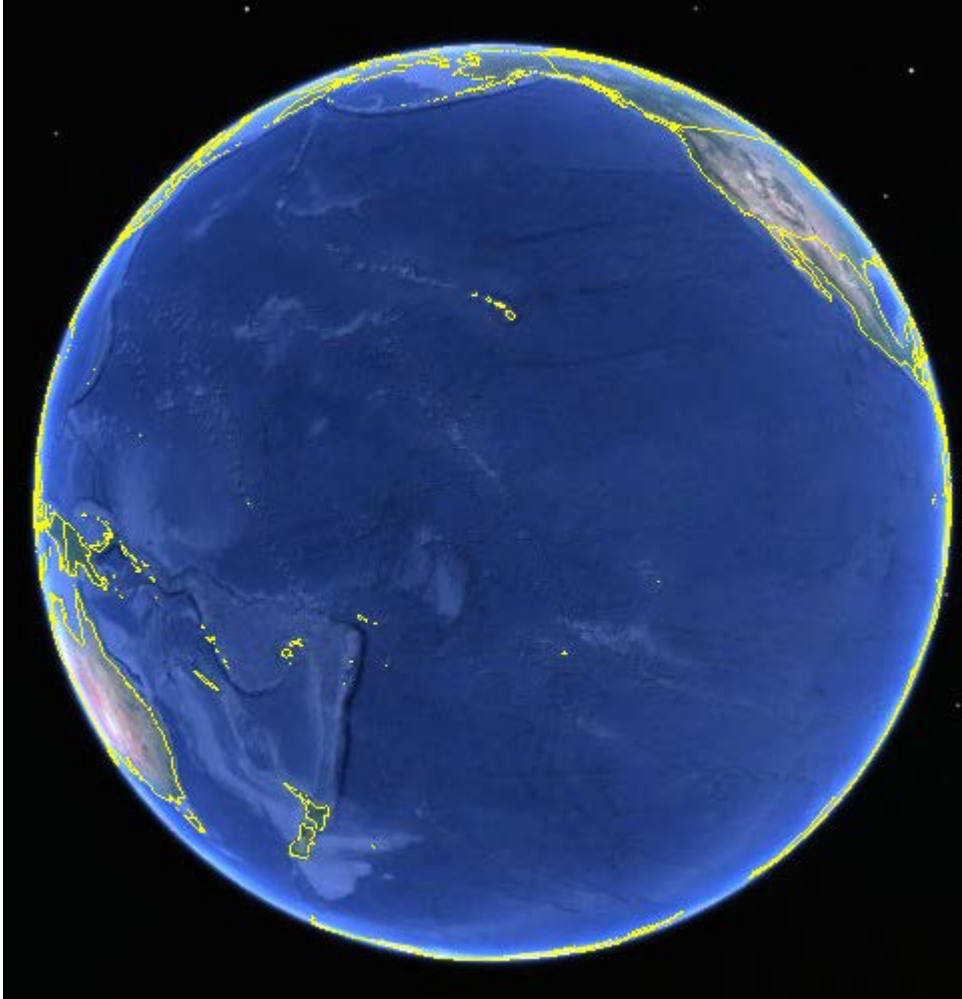
Using coding to get data into remote places

Tuvalu, February 2015, own measurements for 20 MB TCP transfers
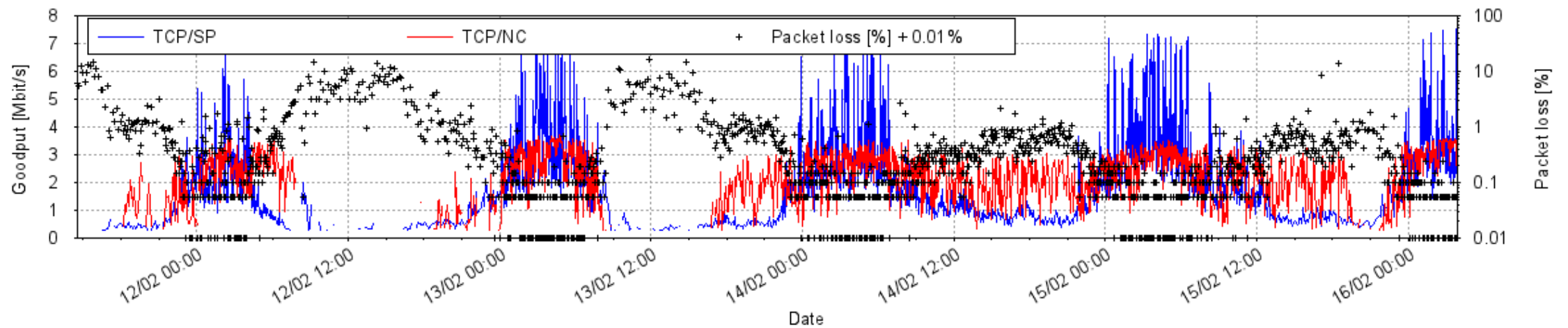
Tuvalu time

Not all connections are the same: MEO vs GEO