

Session 4-5. Advances in computing and communication

Dr. Milovantseva

Digital Transformation of the World Economy

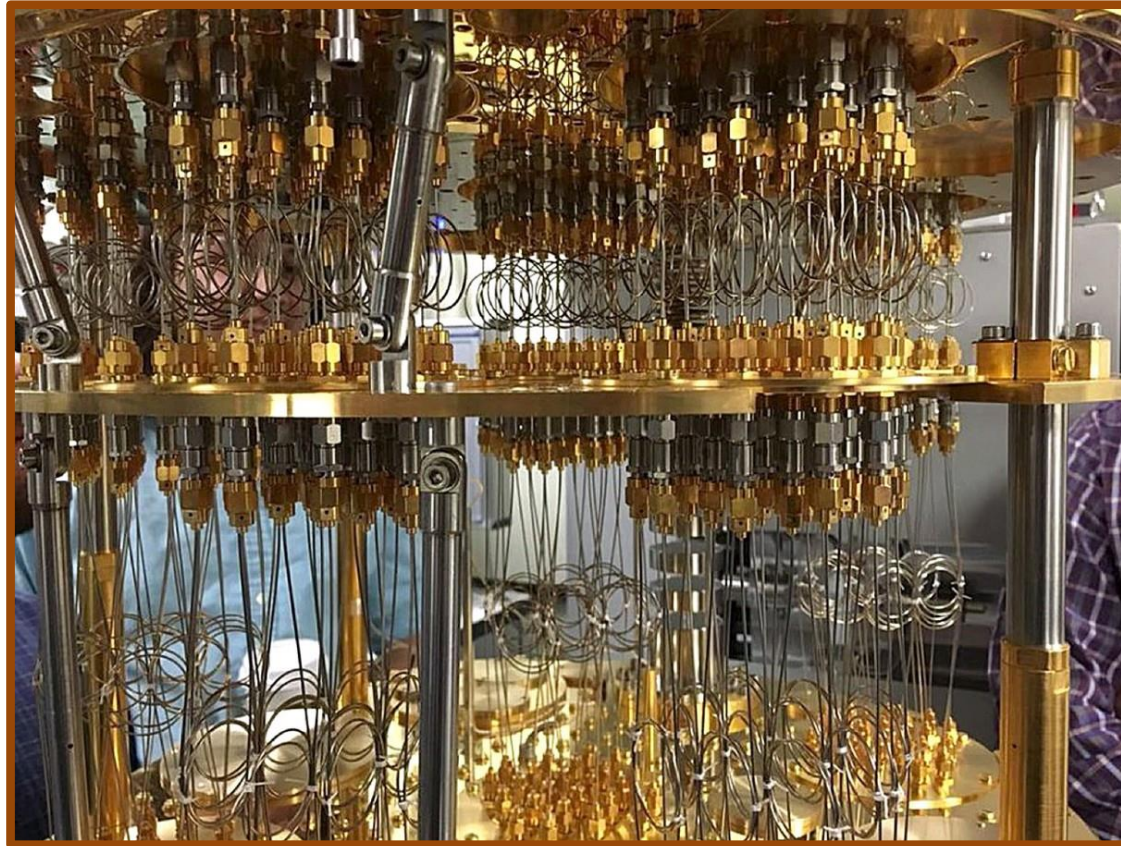
March 2, 2019

Plan

- Reflection from last session
- Advances in computing
- Advances in communication
- Midterm evaluation

Reflection

- Network effect
- Economies of scale
- Economies of scope
- Approaches to digital transformation policies
 - Government-led vs private sector led (examples)
 - Top-down vs bottom-up (examples)
 - Innovation vs regulation (examples)



Advances in Computing

Evolution of computing power

- 1st computers – little capacity for memory and information retrieval
 - *arithmetical benefit*
- Development of magnetic core memories
 - *non-arithmetical benefit: lower marginal cost of reproducing information*
- Thermionic technology
- Semiconductor technology
- Microprocessor (*a computer on a chip*)

Computing power growth

- Moore's Law of Productive Technology
 - G. Moore - former chairman of Intel, one of the founding fathers of the chip industry
 - available computing power quadruples every 30 months
- Computing power as measured in MIPS (*million instructions per second*)
- Expression of computing power growth: 2 to the power of n where n is the current year minus 1986
 - 1987: $2^1 = 2$ MIPS (1987 – 1986)
 - 1997: $2^{11} = \text{over } 2 \text{ BIPS}$ (1997 - 1986)
- Next steps - quantum computing

Physical limits of computing



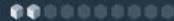
Quantum computing

The three known types of quantum computing and their **applications, generality, and computational power.**



A very specialized form of quantum computing with unproven advantages over other specialized forms of conventional computing.

DIFFICULTY LEVEL



Quantum Annealer

The quantum annealer is least powerful and most restrictive form of quantum computers. It is the easiest to build, yet can only perform one specific function. The consensus of the scientific community is that a quantum annealer has no known advantages over conventional computing.

APPLICATION
Optimization Problems

GENERILITY
Restrictive

COMPUTATIONAL POWER
Same as traditional computers



The most likely form of quantum computing that will first show true quantum speedup over conventional computing. This could happen within the next five years.

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Analog Quantum

The analog quantum computer will be able to simulate complex quantum interactions that are intractable for any known conventional machine, or combinations of these machines. It is conjectured that the analog quantum computer will contain somewhere between 50 to 100 qubits.

APPLICATIONS
Quantum Chemistry
Material Science
Optimization Problems
Sampling
Quantum Dynamics

GENERILITY
Partial

COMPUTATIONAL POWER
High



The true grand challenge in quantum computing. It offers the potential to be exponentially faster than traditional computers for a number of important applications for science and businesses.

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Universal Quantum

The universal quantum computer is the most powerful, the most general, and the hardest to build, posing a number of difficult technical challenges. Current estimates indicate that this machine will comprise more than 100,000 physical qubits.

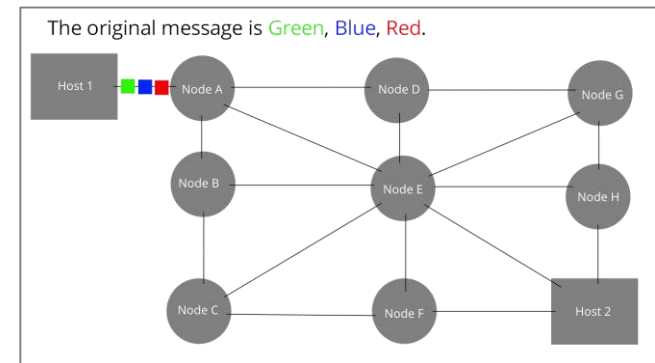
APPLICATIONS
Secure computing
Machine Learning
Cryptography
Quantum Chemistry
Material Science
Optimization Problems
Sampling
Quantum Dynamics
Searching

GENERILITY
Complete with known speed up

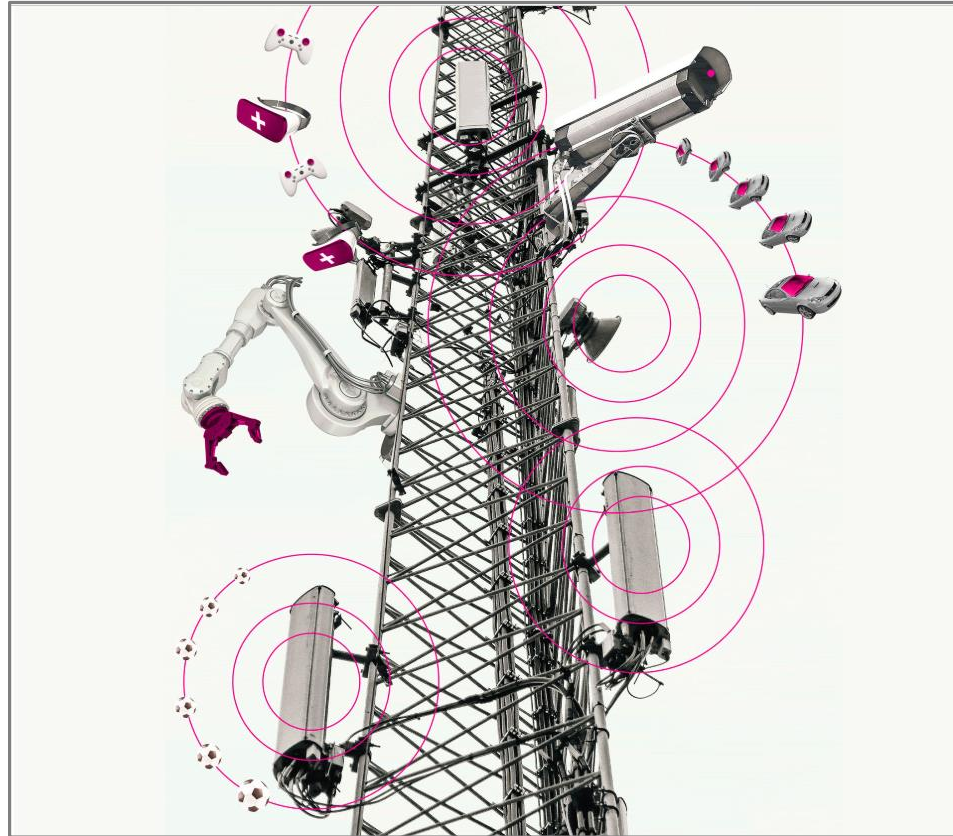
COMPUTATIONAL POWER
Very High

Computers' effect on economy

- Limited communication between computers = limited effect on the economy
- Key inventions of 1960-70s
 - packet switching to break & re-assemble messages
 - TCP/IP - defines internet communication
- Browsers and search engines layered on top of TCP/IP
 - increased collection and use of data



iStockphoto

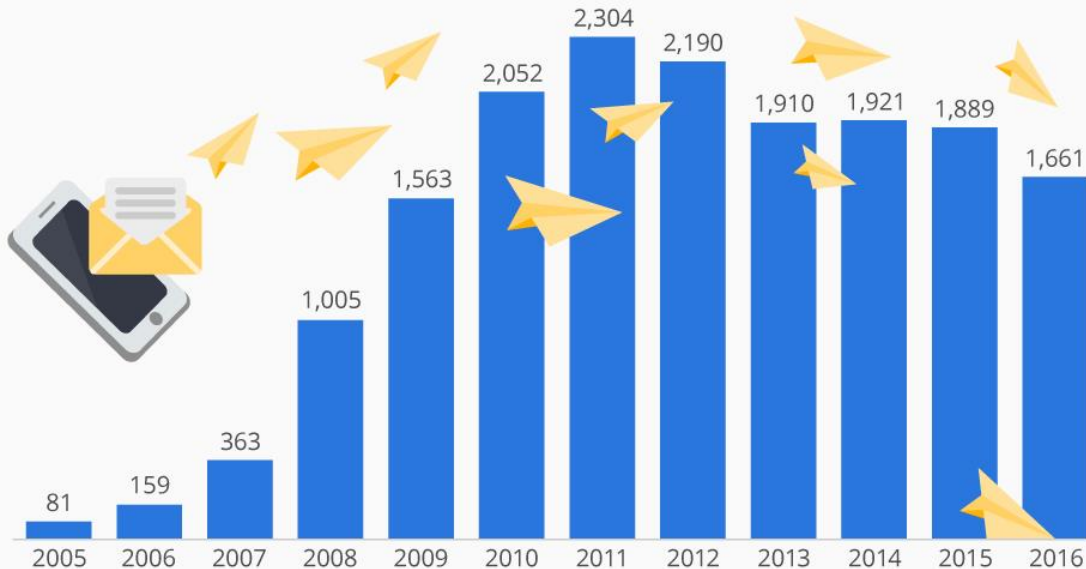


Advances in Communication

Evolution of communication

Texting Turns 25 But Is Clearly Past Its Prime

Annual number of SMS messages sent in the United States (in billions)



@StatistaCharts Source: CTIA

statista



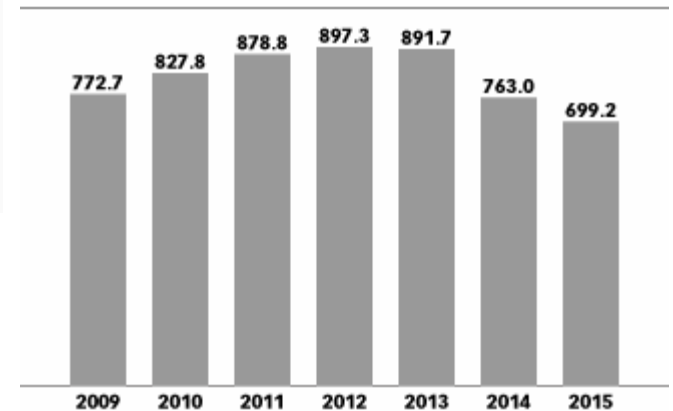
Orbitel-901

Released: 1992

Display: LCD

Weight: 2,1kg

Text Messages Sent in China, 2009-2015



Source: Ministry of Industry and Information Technology (MIIT) - People's Republic of China, Jan 21, 2016

160792

www.eMarketer.com



Motorola-Micro 1989

Price tag: \$3000

Communication as economic enabler

- The mobile web
 - 2014 mobile data traffic increased by 81%
 - PC activities are moving to mobile devices
- Geospaciality
 - Web surfing is now augmented
- Internet of Things
 - Possibility for exponential change in business model innovation

Communication as enabler – cont.

- The Cloud
 - Internet as global computer on which human activity *creates value*
 - For companies - decreases costs and increases integration
 - Software as a Service (SaaS): users log into a service or program without having to install (examples: Amazon, Google, Oracle Cloud)
- OVERALL: **decentralization of internet activity**

Net neutrality

- Internet service provider should treat all data in the same way
 - regardless of *provider*
 - regardless of *content*
 - (*internet service provider vs internet content provider*)
- Companies cannot pay an internet service provider to have faster speeds
 - Netflix pays the same to send a gigabyte of data to one of their customers as a small startup would pay to send data to the same customer.

3G vs 4G vs 5G in in everyday life

Downloading an hour-long playlist
from Spotify - music streaming service

<https://www.wsj.com/graphics/how-fast-5g-mobile-internet-feels/>



3G vs 4G vs 5G in in everyday life

Downloading 'Bird Box' for offline viewing on Netflix

<https://www.wsj.com/graphics/how-fast-5g-mobile-internet-feels/>



3G vs 4G vs 5G in in everyday life

Downloading 'Fortnite' for iOS

<https://www.wsj.com/graphics/how-fast-5g-mobile-internet-feels/>



Midterm evaluation

- Your feedback on
 - the course and my teaching
- Your ideas are important to me
- I am serious about improving the course and your learning
- Format
 - low-stakes - anonymous