Introduction to Telecommunications
EN1052

Chathuranga Weeraddana

December 2020

Course Information

- Lecturer: Chathuranga Weeraddanana
  Lectures: Mondays 8.00 – 10.00 a.m.

- Course Website: http://online.mrt.ac.lk/

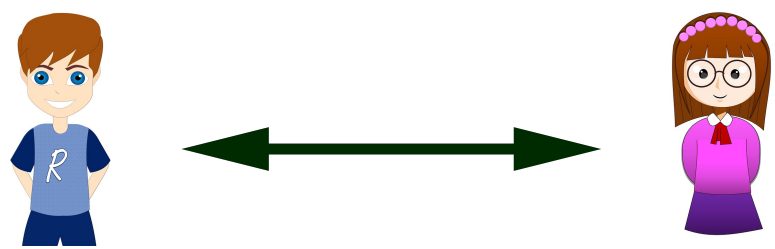
- Textbook :
  - B. P. Lathi, "Modern Digital and Analog Communication Systems", Oxford University Press. (Latest Edition)
  - Computer Networking: A Top-Down Approach Featuring the Internet, James F. Kurose and Keith W. Ross, 3rd Edition, Addison Wesley (Pearson Education)
  - some others ?

- Evaluation of Performance:
  $\underbrace{\text{Assignments, Quizzes, Mid-Exam}}_{\textbf{40\%}}$, & $\underbrace{\text{End Exam}}_{60\%}$

Lecture 1: Introduction

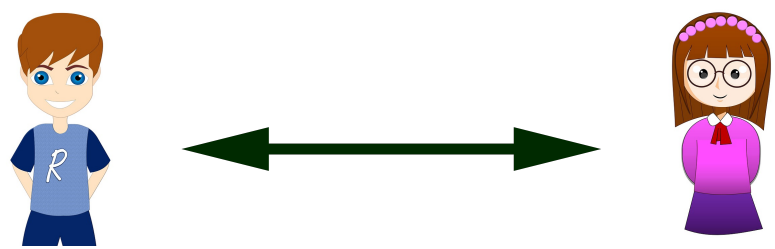
Telecommunication

- tele + communication
- tele: distant
- communication:
  - the act of conveying *meanings* (information)
  - from one entity to another
  - by using mutually understood signs



Very Basic Communication

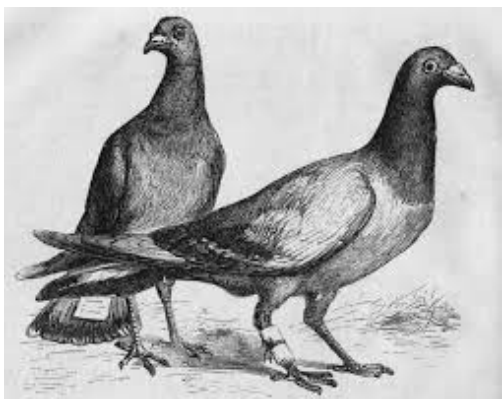
- *information* source: produces a message or sequence of messages
- destination: the person (or thing) for whom the message is intended
- of course, things get more complicated with more sophistications



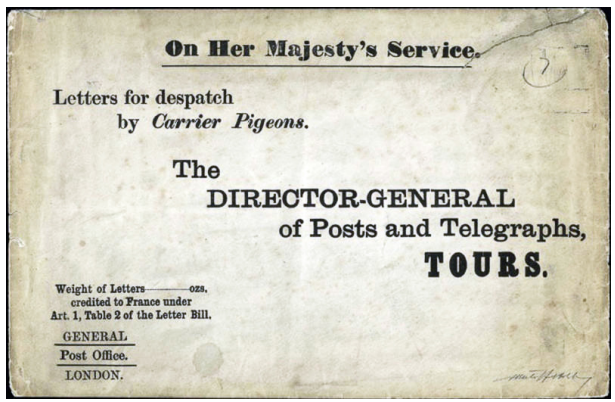
Early Communication Mechanisms

Early Communication Systems

- pigeon post (one of the oldest)
  - uses homing pigeons to carry messages
  - effective as messengers due to their natural homing abilities
  - physical messages are attached to the pigeons





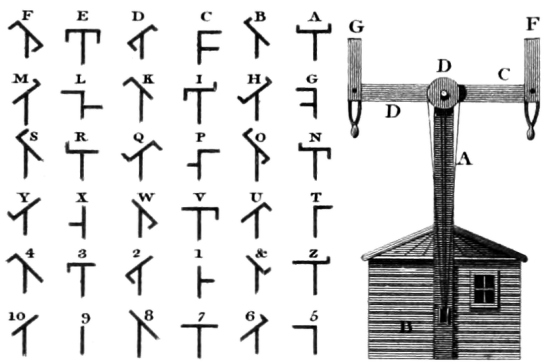


Early Communication Systems

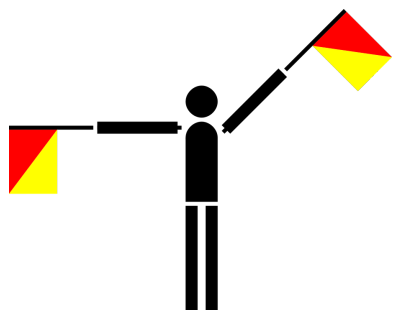
- telegraph
  - long-distance transmission of textual or symbolic messages
  - no physical exchange of an object like in pigeon post
  - optical telegraphs
  - electrical telegraphs

Early Communication Systems

- optical telegraph
  - smoke signals (one of the oldest)
  - beacons (one of the oldest, still used today)
  - semaphore line (18th)
  - reflected light signals (early 19th)
  - flag semaphore (still used today)

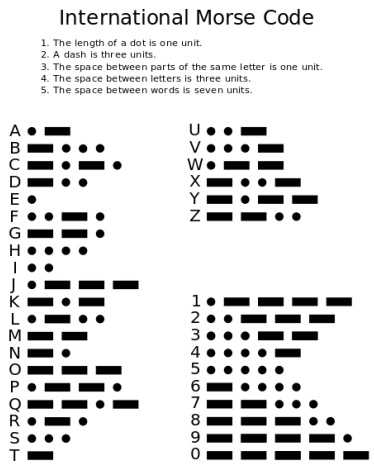


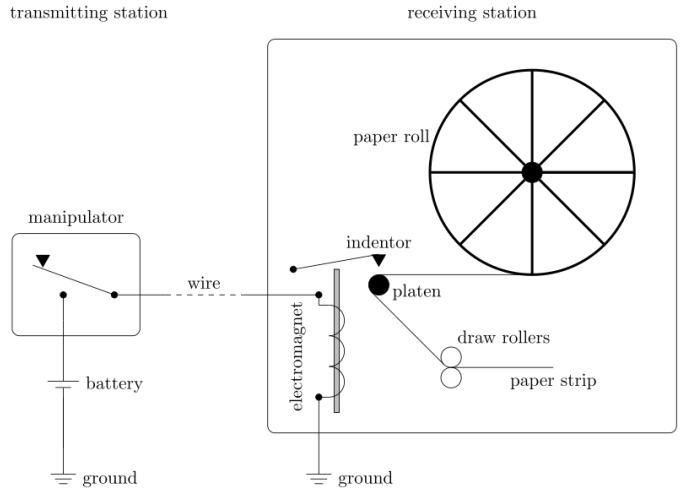




Early Communication Systems

- electrical telegraph: a telegraph that uses electrical signals
  - electro static, electro chemical (late 18th, early 19th)
  - electro-magnetic, e.g., Morse code (early 19th, mid 19th)
  - trans-Atlantic telegraph cable (mid 19th)





Early Communication Systems

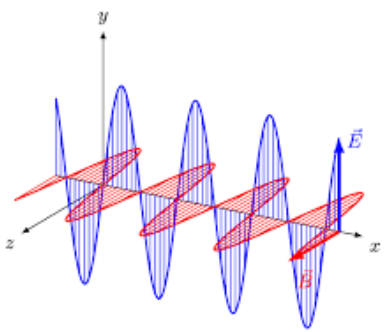
- telephone (late 18th century)
  - device to produce replication of the human voice
  - many inventors... yet credit is for the Alexander G. Bell (1876)
  - 1st telephone services, on both sides of Atlantic (1878-1879)
  - 1879: National Bell Telephone Company formed in the US
  - 1885: American Telephone and Telegraph (AT&T), New York
  - 1st transcontinental telephone call (1915)
  - transcontinental calls for public, *via radio* (1927)
  - 1st transatlantic telephone cable (1956)



Early Communication Systems

- radio
  - from early 1800s-1873, about half century theoretical development
    - the theory of electromagnetism
    - credit goes to James Clerk Maxwell
  - Heinrich Rudolf Hertz experimentally verifies Maxwell's theory (1886s)







Early Communication Systems

- wireless telegraph (late 19th and early 20th century)
  - transmission of electric telegraphy signals without wires (wirelessly)
  - Guglielmo Marconi: first telegraph system based on radio (1897 patented)
  - Marconi demonstrated invention above in 1901 (first transatlantic radio signal)

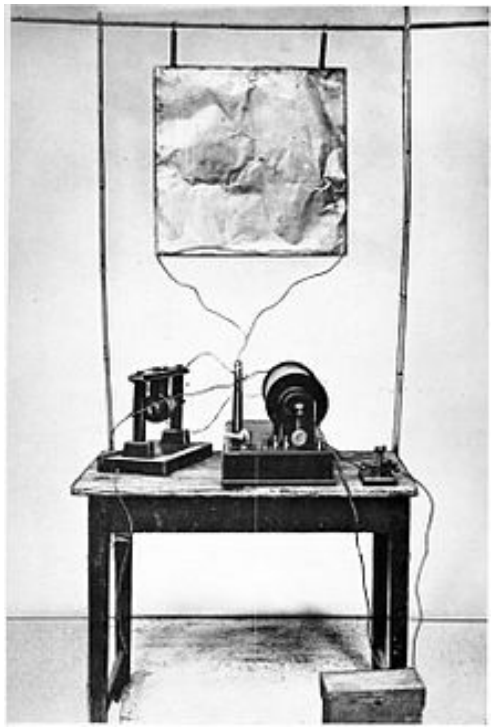


Figure: Marconi's first transmitter

20 th Century

Communication Systems, 20th Century

- 1902-1920:
  - first bidirectional communication across the Atlantic (1902)
  - experiments with AM radio broadcasting
  - multiplexed carrier telephony
  - first voice over radio transmission (1914)
  - H. C. Armstrong $\rightarrow$ superheterodyne radio receiver (1918)

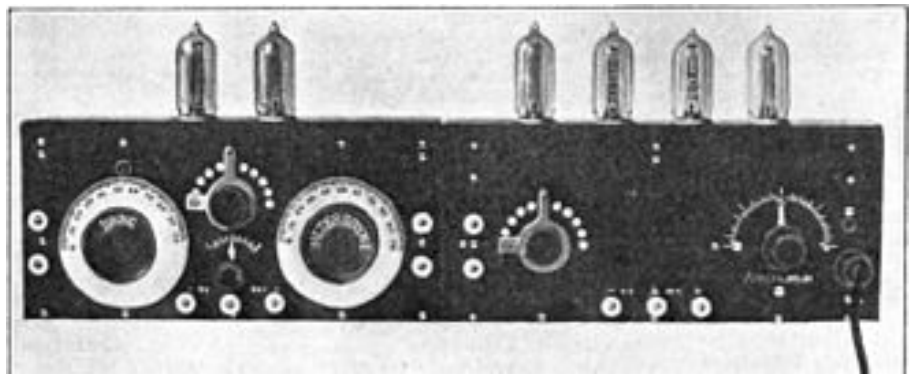


Figure: Prototype of Armstrong's Receiver

Communication Systems, 20th Century

- 1920-1928:
  - Carson
  - Nyquist
  - transmission theory



Figure: Harry Nyquist

Communication Systems, 20th Century

- 1925: John Logie Baird demonstrated the transmission of moving pictures, and television was born
- 1927: public demonstration of TV transmission by wire



Figure: Baird and television receiver

Communication Systems, 20th Century

- 1936: Armstrong $\rightarrow$ FM radio
- 1937: Alec Reeves $\rightarrow$ invention of pulse-code modulation (PCM)

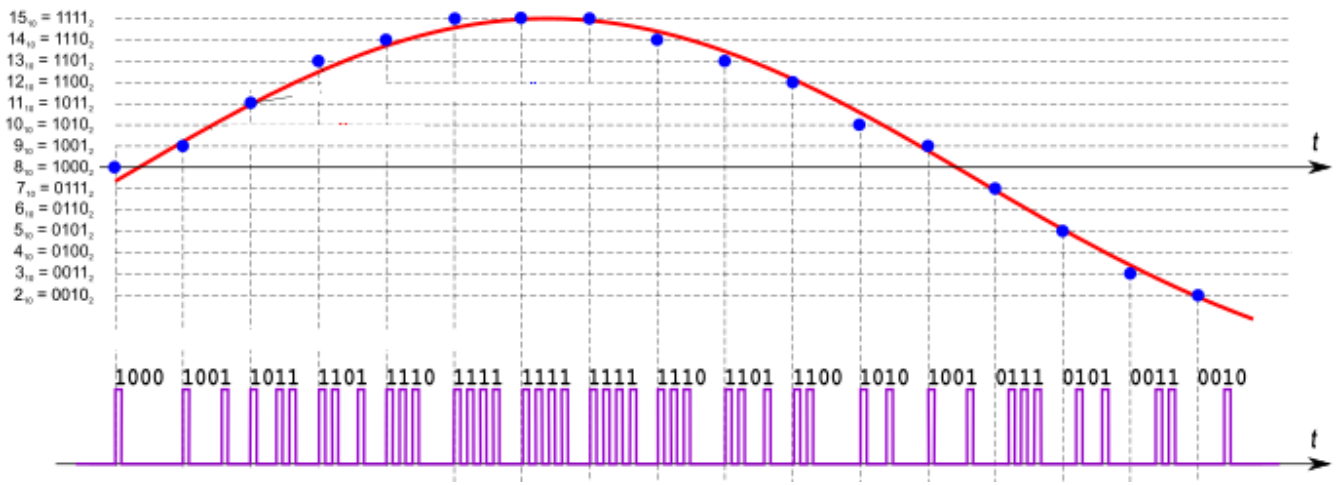


Figure: Pulse Code Modulation

Communication Systems, 20th Century

- 1936: first coaxial cable installed between New York and Philadelphia for multi-channel telephone systems
- 1940: broad band carrier systems are introduced allowing for simultaneous calls over a single pair of wires
- 1945: Arthur C. Clarke introduces the concept of using satellites for communications

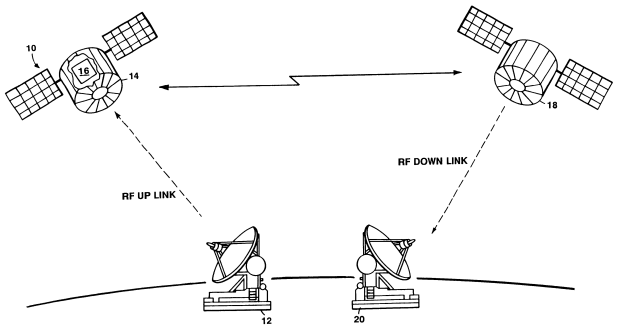


Figure: satellite communication

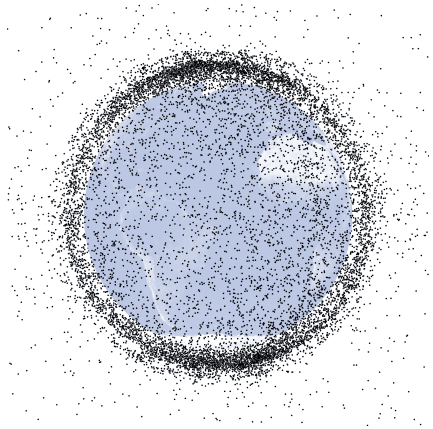


Figure: satellite junk

Communication Systems, 20th Century

- 1938–1945: radar and microwave systems (world war II)
- 1944–1947: mathematical representations of noise and statistical methods for signal detection

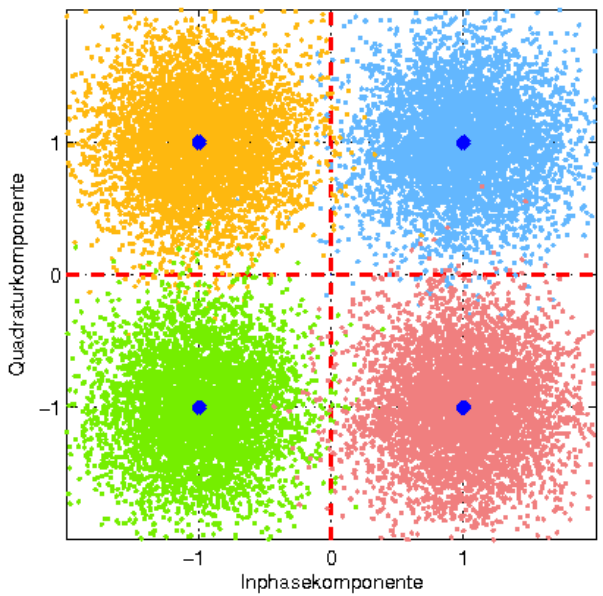


Figure: Noise at the Receiver

Communication Systems, 20th Century

- 1948–1950: C. E. Shannon
  $\rightarrow$ founding papers on information theory
- entropy: amount of information in a transmitted message
- channel capacity: rate at which information can be reliably transmitted

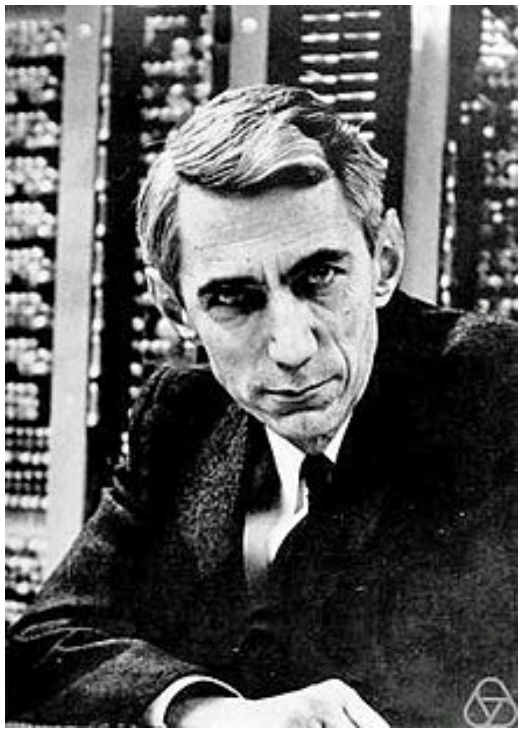


Figure: C. E. Shannon

Communication Systems, 20th Century

- 1962-1965:
  - first int. telecommunication sat (Telstar)
  - INTELSAT with 11 countries
  - the first commercial comm. satellite, Early Bird
  - The first Soviet comm. satellite, Molniya 1 (TV programs)





Communication Systems, 20th Century

- 1967: Bell Laboratories: a wireless telephone extension
- 1968: first computer network with packet switching: the Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory

- 1969:
  - Bell Labs creates the UNIX operating system
  - ARPANET: first network to implement the protocol suite TCP/IP

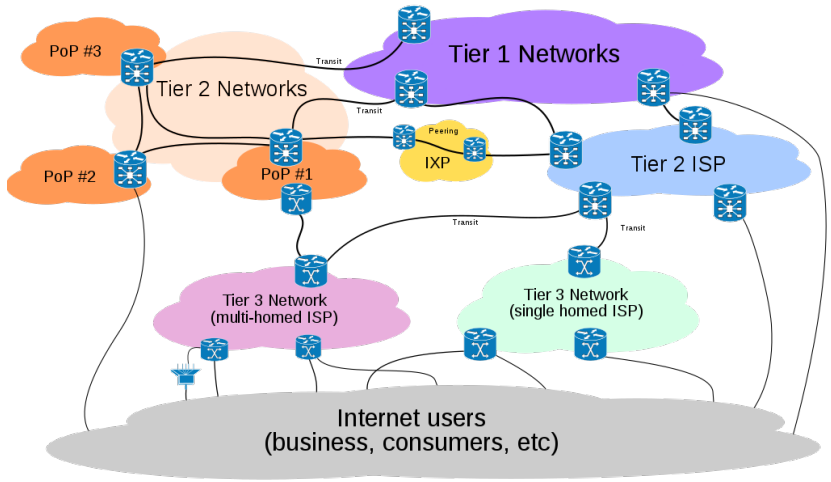


Communication Systems, 20th Century

- 1973:
  - development of a common Internetwork Protocol
  - the first "Mobile Phone" (DynaTAC 8000x, prototype) call by Motorola



- 1974: the term *Internet* is adopted

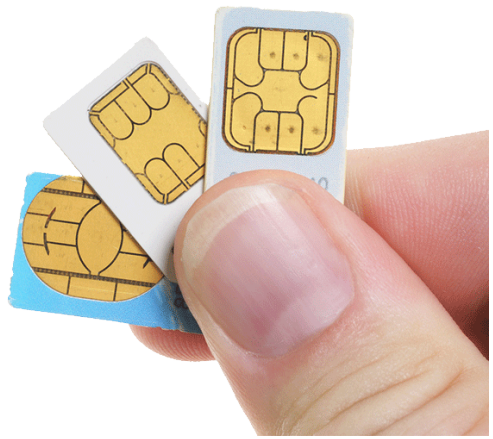


Communication Systems, 20th Century

- 1976: first digital switch, AT&T
- 1978: trials of AMPS, an analog system, Bell Labs
- 1983:
  - AMPS (1G), 1st cellular (analog) network standard in the US
  - UN declares 1983 as the World Communications Year

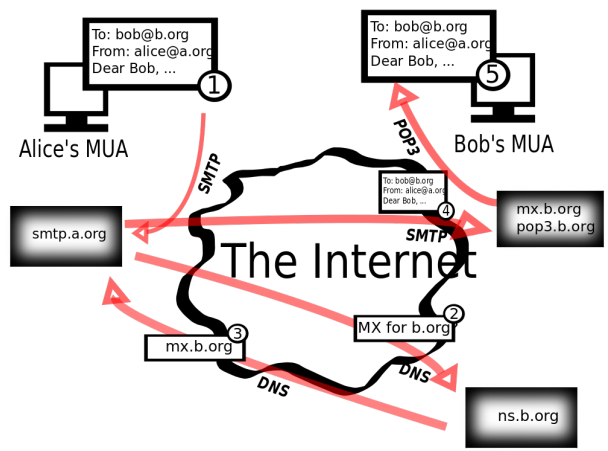
Communication Systems, 20th Century

- 1987: GSM (2G), 1st digital cellular network standard, Europe
- 1988: 1st transatlantic fiber optic cable between USA and England/France, 40000 channels
- 1991-1992: CDMA (2G), 1st digital cellular system from the US
- 1993: 1st web browser, Mosaic, by University of Illinois Urbana-Champaign, USA



Communication Systems, 20th Century

- 1995:
  - e-mail protocols SMTP, POP3 and IMAP were standardised
  - start of the dot-com bubble, the period of extreme growth in the usage and adaptation of the Internet
- 1999:
  - business via World Wide Web
  - 1st release of UMTS (3G) standards



21 th Century

Communication Systems, 21th Century

- 2000: 1st 3G/UMTS call
- 2001: 1st commercial WCDMA 3G mobile network, NTT DoCoMo, Japan
- 2002: 1st commercial CDMA2000 3G mobile network, SK Telecom, Korea



Communication Systems, 21th Century

- 2000-2009:
  - 3G networks begin rollout (2003)
  - Blackberry smartphone (2003)
  - Skype (2003)
  - Facebook (2004), even more mobile support (2007)
  - Twitter (2006)
  - 1st iPhone (2007)
  - 1st Android smartphone (2009)













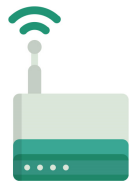
Communication Systems, 21th Century







- 2010-:
  - tablets (2010)
  - 4G networks begin rollout (2012)



  - offload traffic exceeded cellular traffic, e.g., prevalence of Wi-Fi hotspots (2015)
  - 4G traffic surpassed 3G traffic (2015)

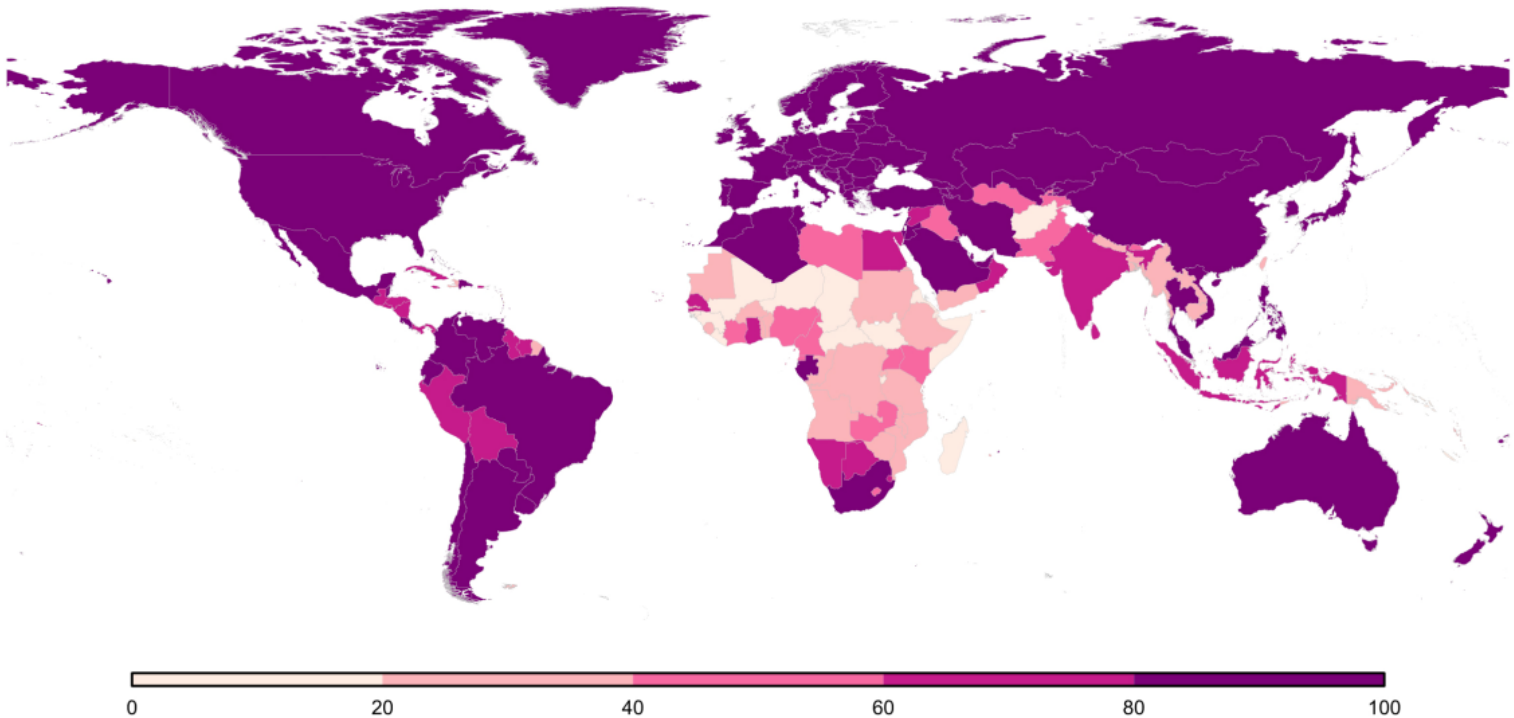


Statistics by ITU

Current Statistics (source ITU, 2017)

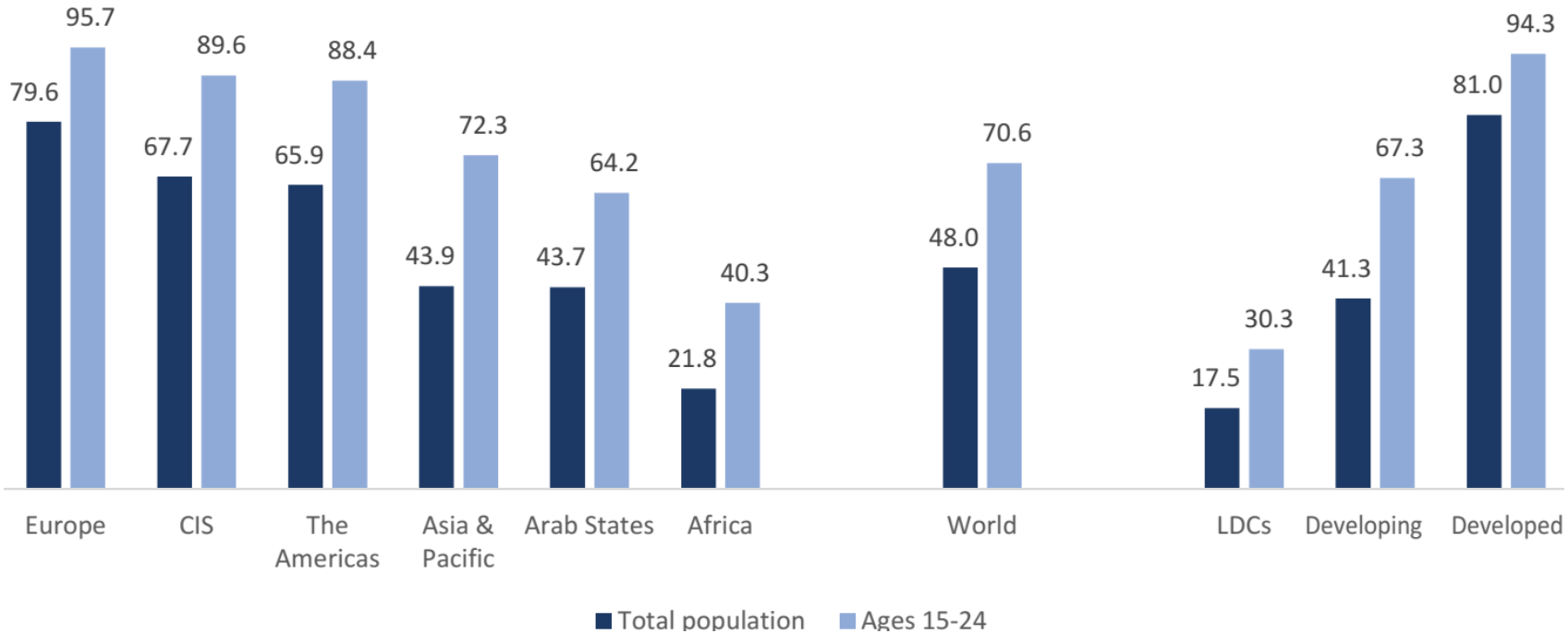
- 70% of the world's youth being online
- spread of mobile-broadband services drives ICT development
- growth of mobile broadband $\ggg$ growth of fixed broadband
- mobile-broadband prices $\downarrow$ 50% on average over the last 3 yrs
- $1/2$ of world's population are online
- broadband services become available at much higher speeds

Youth (15-24) Using the Internet, 2017



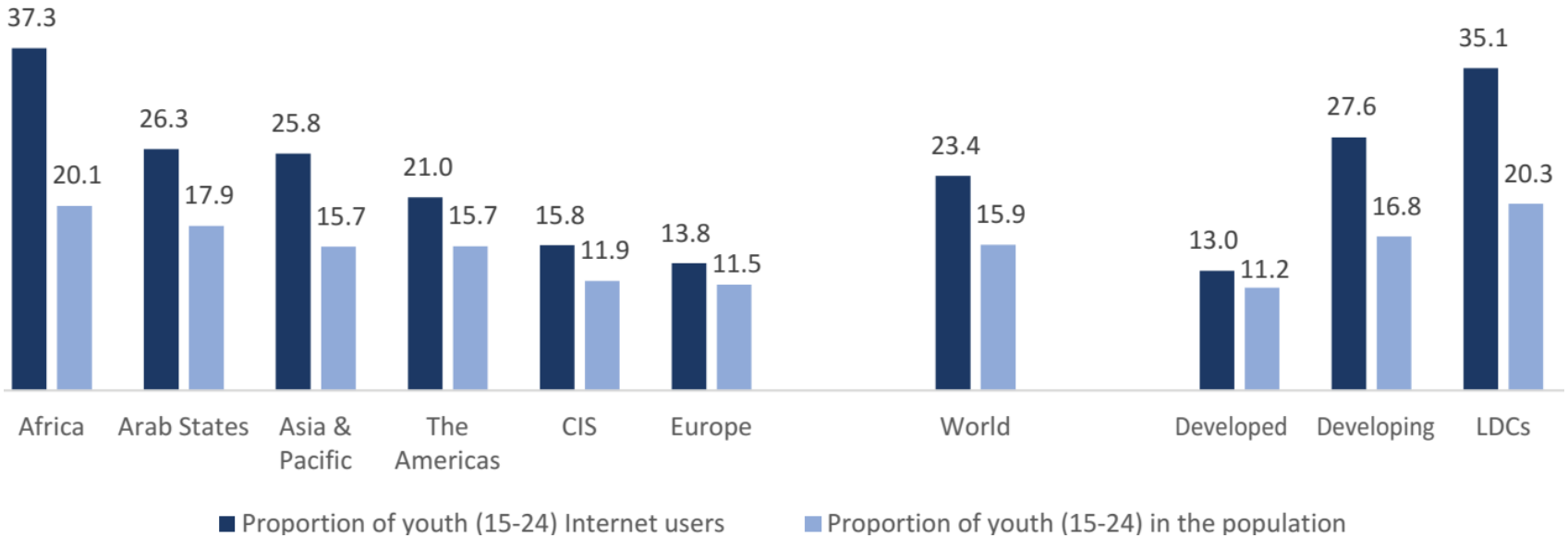
- 104 countries: more than 80% of the youth population are online

Individuals Using the Internet, 2017



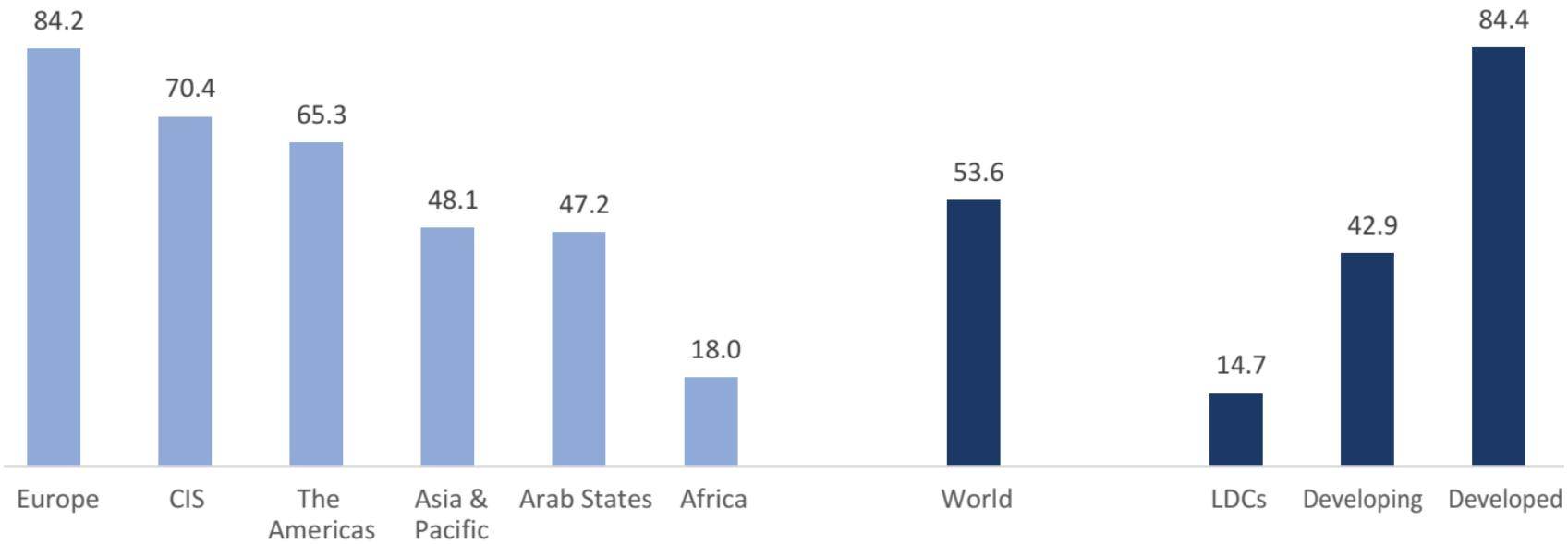
- 71% of young people (15-24 yrs) are using the Internet
- 48%of the total population are using the Internet

Youth Internet Users, 2017



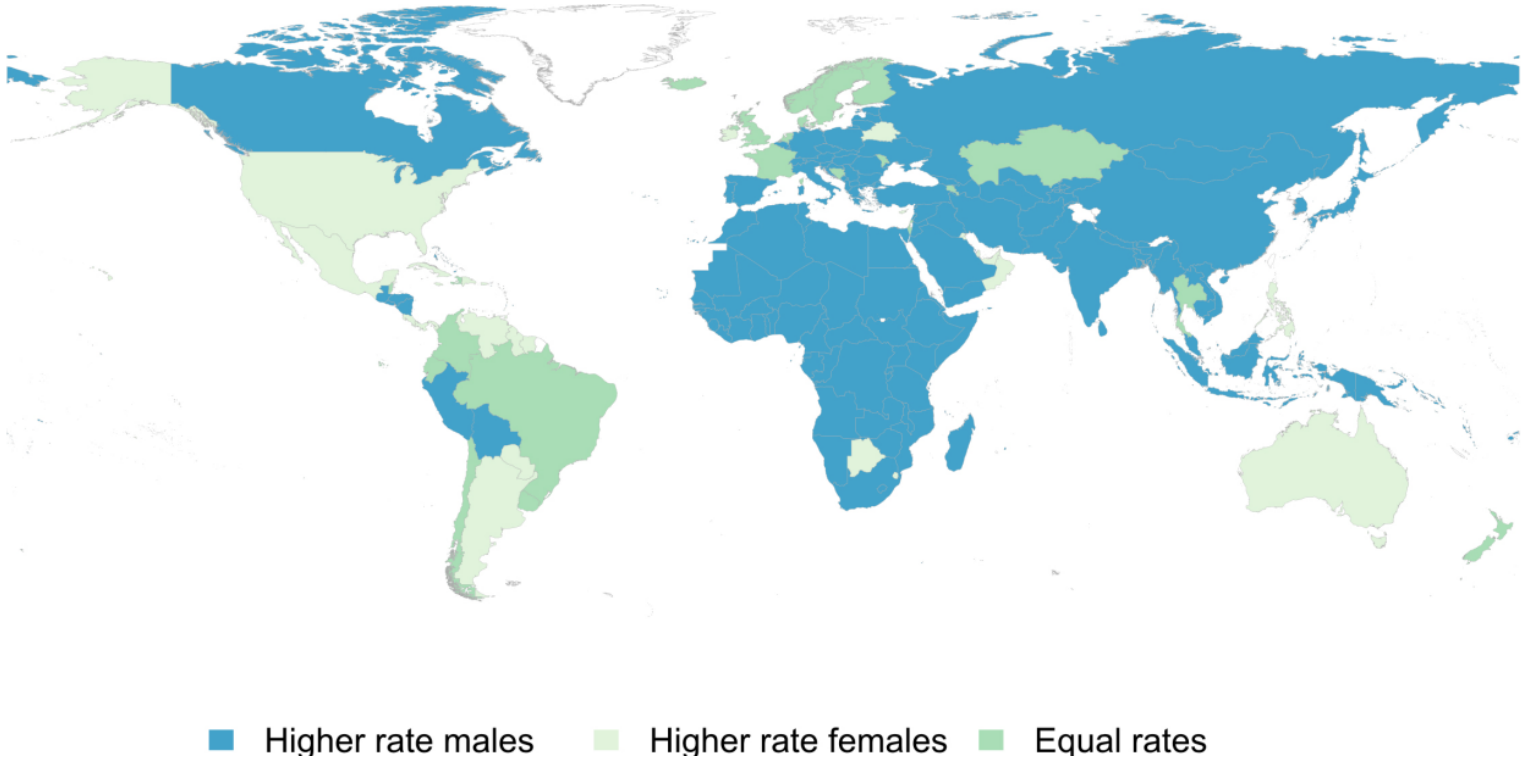
- young people represent almost 25% of the total Internet users
- yet they are only 16% of the total population

Households with Internet Access, 2017



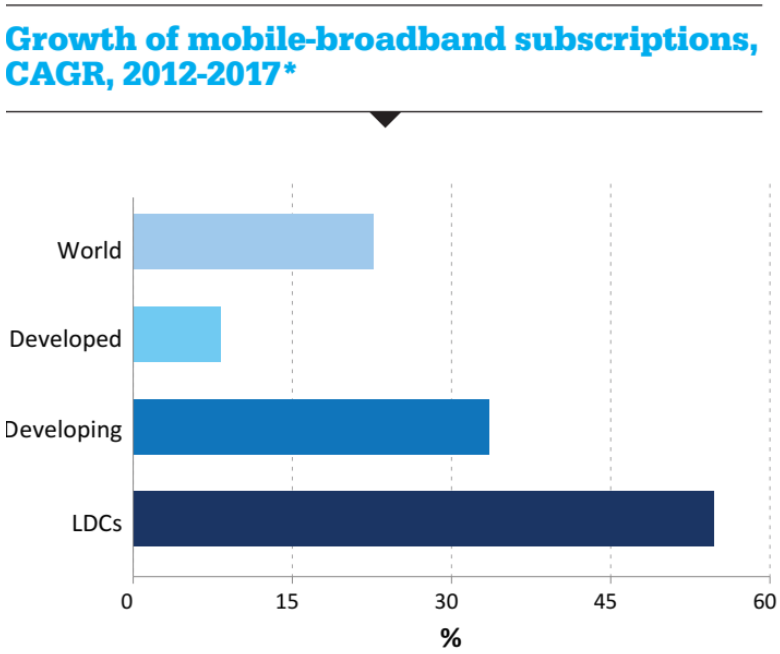
- developed countries, twice as high as in developing countries

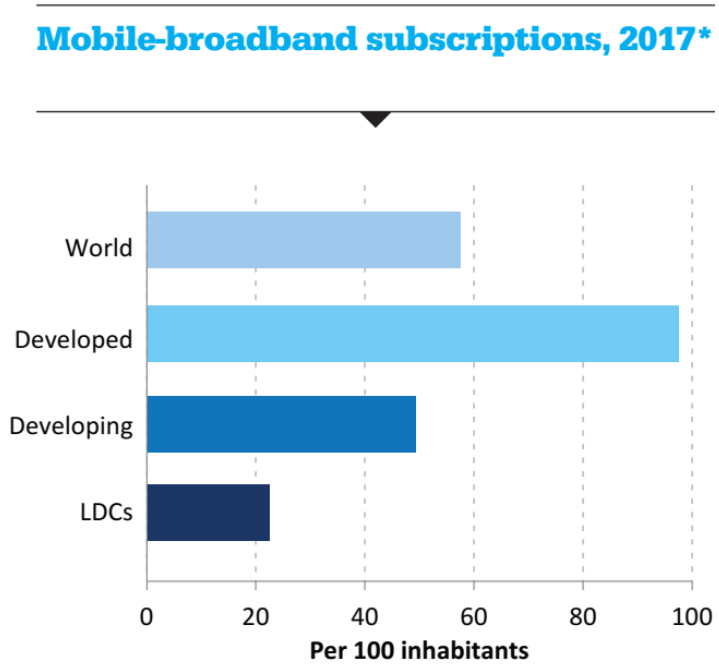
Internet Usage by Gender, 2017



- 2/3 of countries men use Internet more than the proportion of women
- gender parity in tertiary education and gender parity in Internet use are highly related

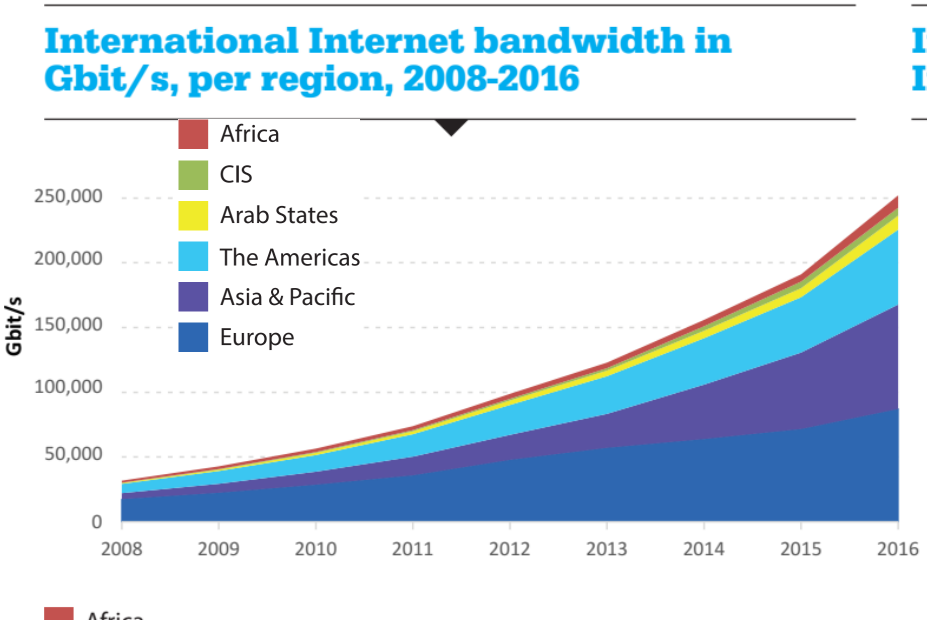
Mobile Broadband Subscription, 2017

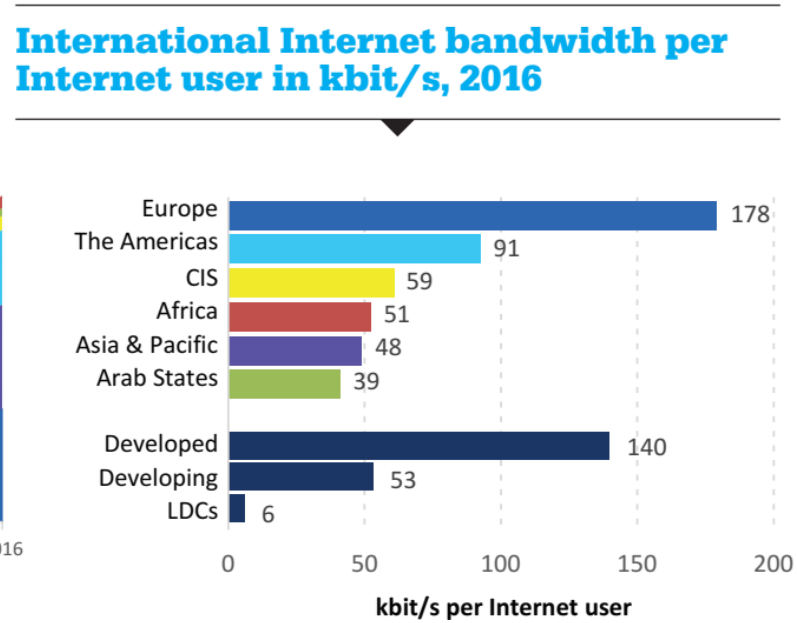




- mobile-broadband subscriptions have grown more than 20% annually in last 5 years
- in developed countries there are many mobile-broadband subscriptions (per 100 inhabitant) compared to others countries

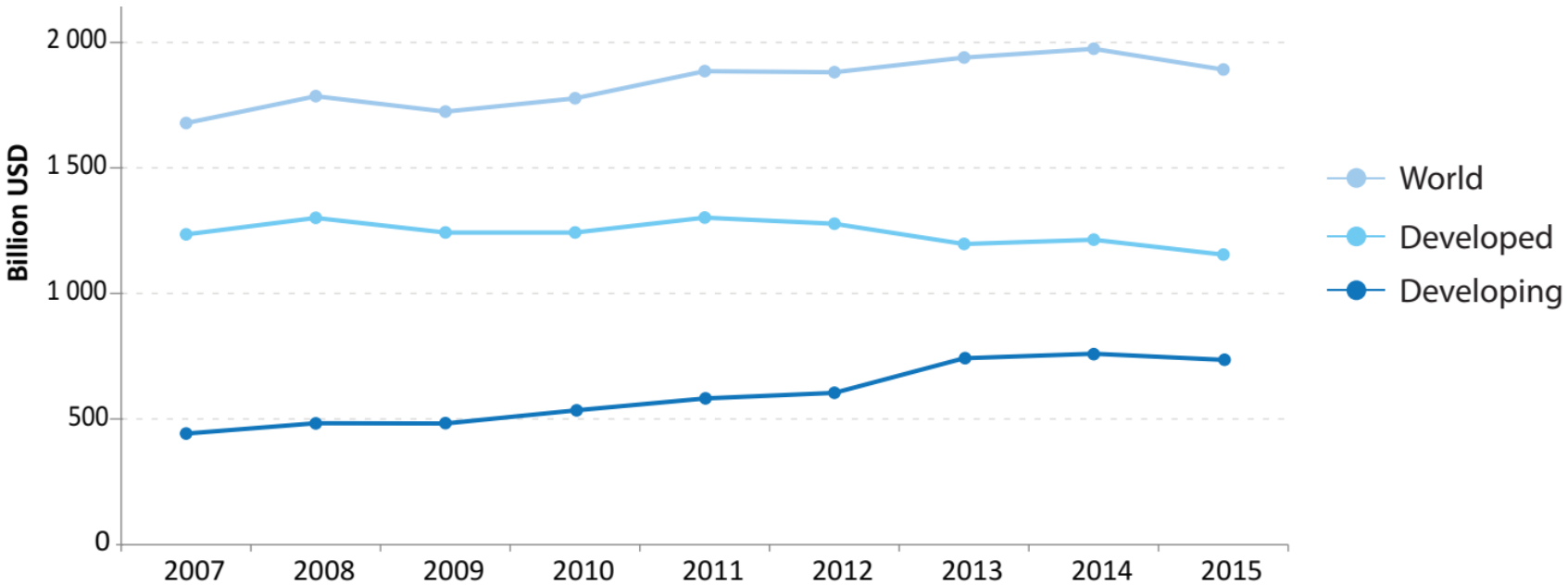
Internet Bandwidth, 2017





- international Internet bandwidth grew worldwide by 32% between 2015 and 2016
- in developed countries, bandwidth per internet user is significantly larger than that of other countries

Telecommunication Revenues



- even though the bandwidth is up, revenue has gone down

Trends

ITU Concerns

- exponential development of advanced ICTs
  - AI
  - big data
  - cloud
  - IoT



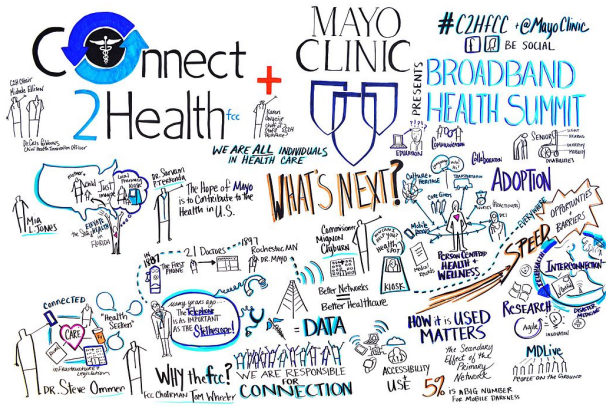


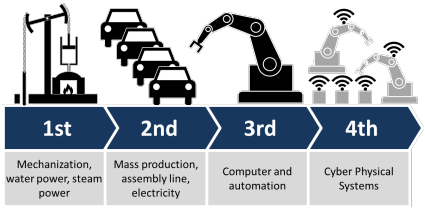


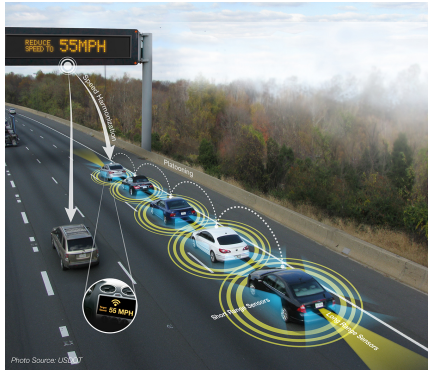


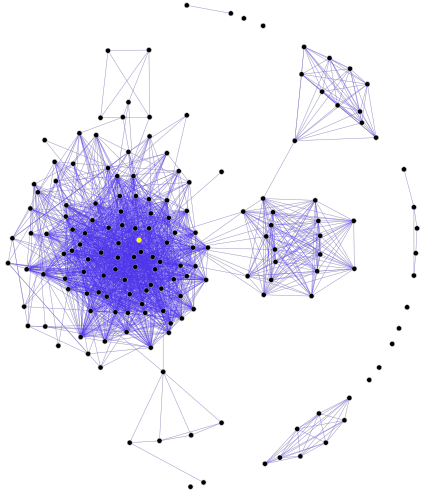
ITU Concerns

- emerging ICT ecosystem
  - health
  - automotive
  - networking
  - logistics/transport
  - industry











Trends in Telecommunications

- connecting the IoT
- cloud computing
- carrier-grade WiFi
- 5G wireless
- integration with content

Trends, Roughly Speaking

- the data requirements, amount, speed, etc. are unimaginable
- telecommunication plays a crucial role here
- so, lets get some glimpses of related ideas, technicalities