Computer Networks / Retele de Calculatoare

3rd Year students (Romana, Seria A + English)

Lecturer: Prof. Vasile Dădârlat, PhD

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3rd Year students (Seria B)

Lecturer: **Assoc.Prof. Bogdan Iancu, PhD**

Bogdan.Iancu@cs.utcluj.ro

Grading Type: normal, Credits:3

No prerequisite modules required

Basic knowledge in Physics, Mathematics, Computer Architecture – feel free to ask questions anytime

MS Teams – live meetings

TUCN account

*(you were automatically enrolled; if you are not enrolled, send a message in MS Teams to **Bogdan.Iancu@campus.utcluj.ro**)*

https://moodle.cs.utcluj.ro

Rețele de calculatoare / Computer Networks, Sem. 2, 2023/2024

https://moodle.cs.utcluj.ro/course/view.php?id=632

Self-Enrolment key: ***L@b_key2024***

ASSESSMENT

- Lab test (last week) - laboratory
- Written Exam (theory, problems)
- Grading constraints: minimum of 5 (out of 10) for each: ***mid-term (TBD)***, final, lab
- Grade policy

40% Lab + 60% Exam

- Module Credits: 3

Lecture 1

Module Description

Notions of: communications, telecommunications; Communications architecture and protocols; Introduction to computer networks; OSI Model; TCP model; analog and digital transmissions; encoding techniques; transmission media (special focus on fiber optic); synchronous and asynchronous transmissions; digital carriers; multiplexing; circuit and packet switching; Local Area Networks - systems (wired & wireless) & technologies (focus on medium access control techniques); case study: Ethernet LANs; Bridges & Switches; introduction to internetworking & routing; classic IP & IPv6; Transport level protocols; application level services.

Aim of the module

Introductory module on **data & computer communications, case study: LANs**

data comms: signal transmission, transmission media, interfacing, data link control
networking: technologies and architectures of comms networks (LANs, WANs)
computer communications –basic introduction, basic protocols
simple communications networks (LANs) & their protocols
internetworking

<u>This is the first from a sequence of (at least) 2 modules in Computer Networks!</u>

Why this structure?

-no more much difference between data processing (computers) and data communications (transmission & switching equipment)

-no fundamental difference in transmitting data, voice or video

-today's the metanetwork (let's say Internet), makes no difference (reference) to single or multi processor computers, or to PAN, LAN, MAN or WAN (access to any resource is done easily & uniformly)

Fields of Study

-data transmissions: data, signals, transmission systems, techniques (coding, multiplexing, switching)

-general aspects of networks: definition, evolution, generations, further developments; history of Internet; case study: LANs

-topologies: star, ring, bus

-introduction to internetworking

-protocols:

- -Architectures & reference models
- -Lower & higher levels
- -Study for levels 1 to 3: Physical, Data Link, Network
- -Internetworking
- -Transport & Application level services

Bibliography

Main text book for this module:

- **W. Stallings – *Data and Computer Communications*, Prentice Hall, editions 2004 - 2014**
- The 'most available' text book (Romanian) is: Vasile Teodor Dadarlat, Emil Cebuc: *Retele Locale de Calculatoare - de la cablare la interconectare,* Editura Albastra (MicroInformatica), 2005

Also you'll get good knowledge and experience reading:

- L. Peterson, B. Davie – *Computer Networks, Fifth Edition: A Systems Approach*, The Morgan Kaufmann Series in Networking, 2013
- A. Tanenbaum – *Computer Networks,* Prentice Hall, 2002,2005,2010
- D. Comer – *Computer Networks and Internets*, Prentice Hall, 2008, 2014

LAB Activity (compulsory)

TABLE OF CONTENTS

	Week
1	Introduction to Wireshark and Packet tracer
2	Cooper based transmission media and UTP cabling
3	Optical fibers and components
4	Structured Cabling
5	Connectivity to Network: IPv4 subnets and basic router configuration
6	Connectivity to Network: DHCP and IPv4 static routing
7	Connectivity to Network: IPv6 introduction and static routing
8	Transport layer: TCP/UDP and Network Programming using Socket
9	Ethernet, ARP and NDP
10	VLAN, trunking and inter-VLAN routing
11	Layer 2 networks: Spanning Tree Protocol, Link Aggregation and Etherchannel
12	Security threats in computer networks
13	Recap
14	Laboratory test

Standardization bodies

Why standards?

-for unique specifications

-for global uniformity and interoperability

What's now?

-still are proprietary networks (big companies): IBM/SNA, Digital/DECNET, Novell/Netware, Cisco

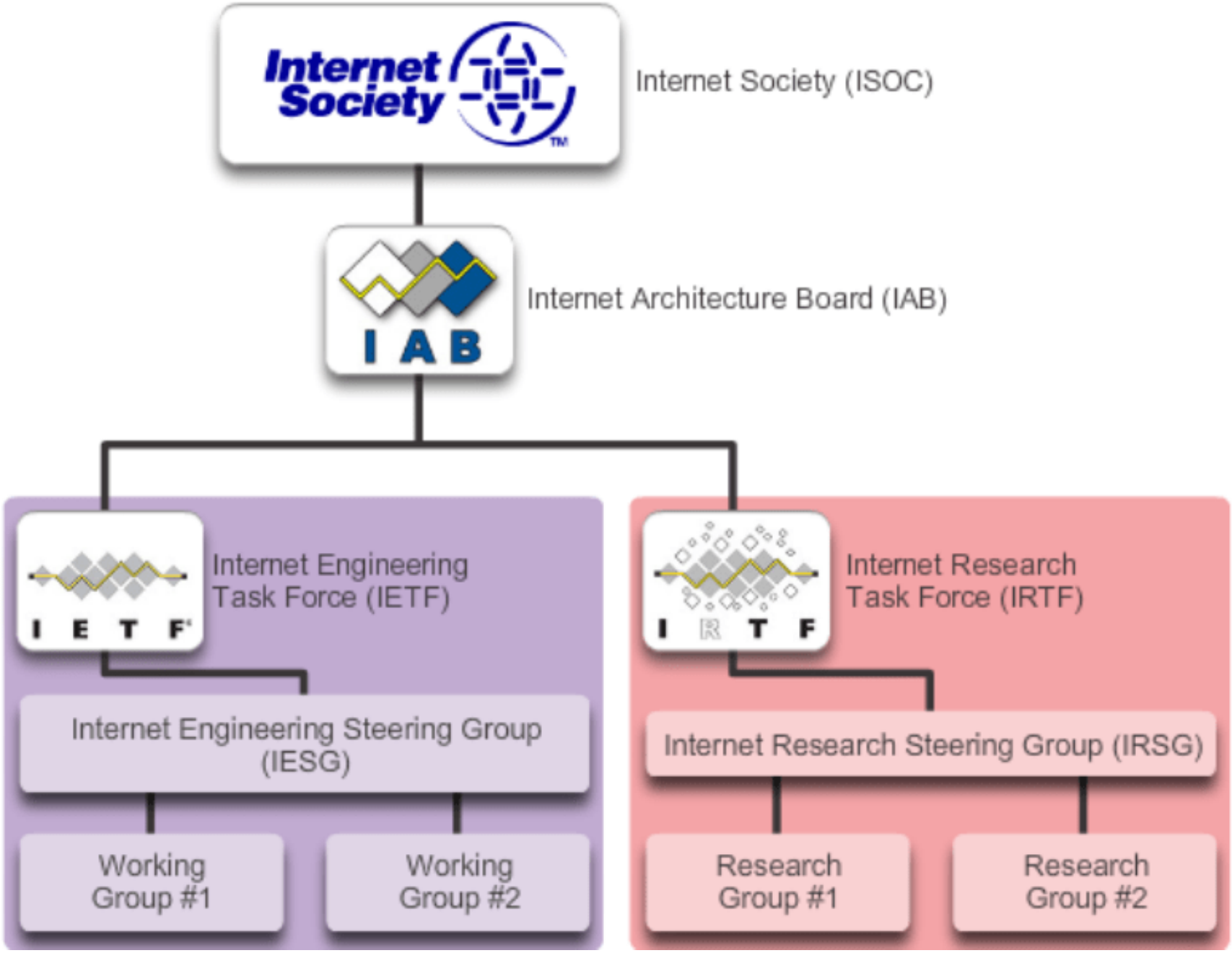
-'de facto' standards: adopted by the market, not yet official standards: TCP/IP protocol suite

-'de jure' standards: official standard, small market acceptance

-consortiums, forums: mix of companies (product promotion), specification & standardization bodies (standardization in progress):

IEEE 802.x- formal standardization group

Frame Relay Forum, ATM Forum, Internet Engineering Task Force (IETF) – application development, IResearchTF – further development (see structure on next page)


Internet Society
Internet Society (ISOC)
IAB
Internet Architecture Board (IAB)
IETF
Internet Engineering Task Force (IETF)
Internet Engineering Steering Group (IESG)
Working Group #1
Working Group #2
IRTF
Internet Research Task Force (IRTF)
Internet Research Steering Group (IRSG)
Research Group #1
Research Group #2

Standardization bodies (continued)

For proprietary standards, closed systems:
ECMA (European Computers Manufacturers Association)
EIA (European Industrials Association)

For interface standards, multi-vendor systems:
ITU-T (International Telecommunications Union, Telecommunications sector), former CCITT (Comite Consultatif International pour telephone et telegraphe)
ANSI (American National Standards Institute)
IEEE (Institute for Electrical and Electronic Engineers)
ETSI (European Telecom Standards Institute)

For international standards, open systems:
ISO (International Organization for Standardization) – Technical Committee for Information Processing TC 97

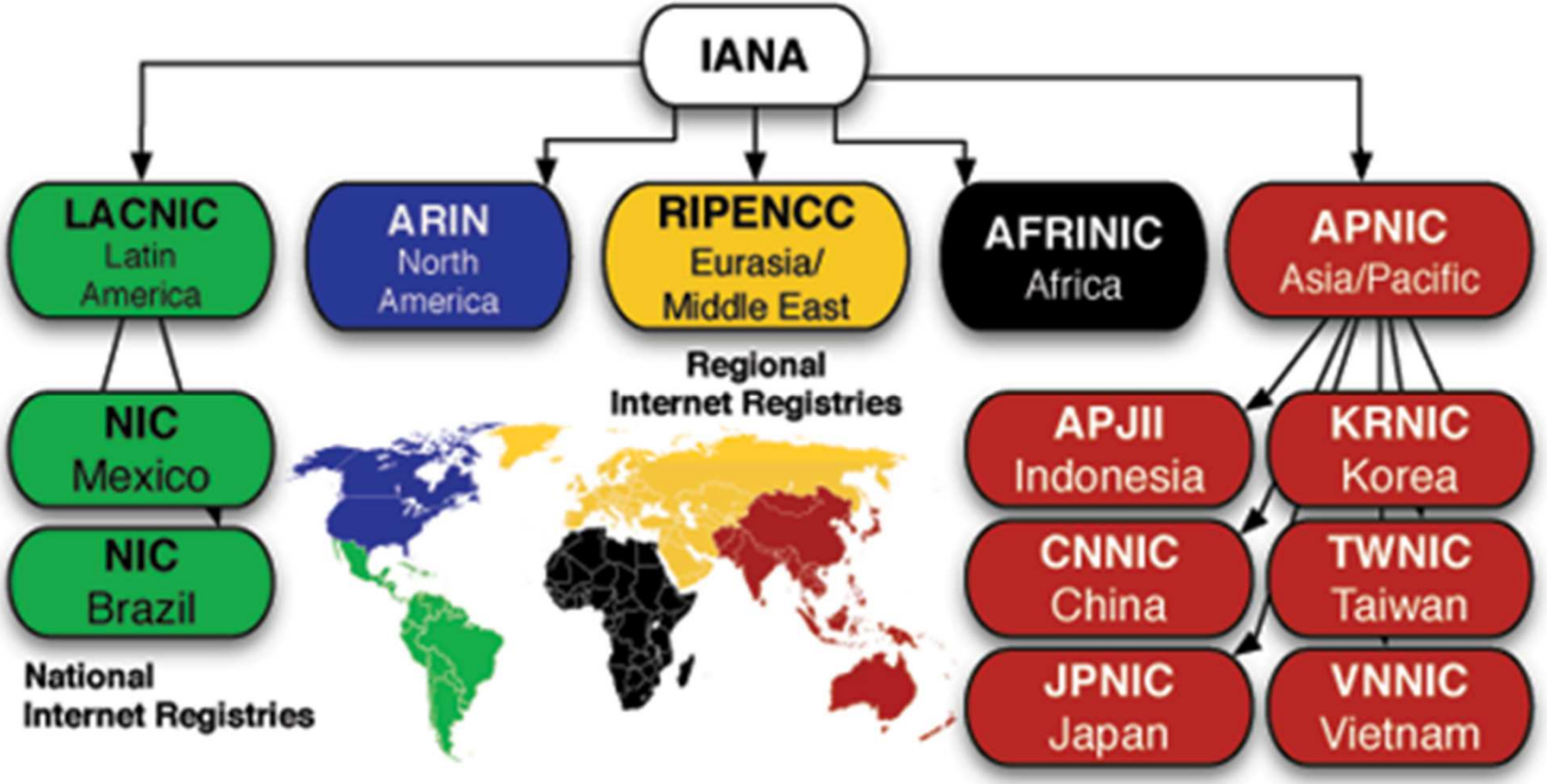
The Intersection of Media Development Principles and Internet Governance

INTERNET GOVERNANCE BODY	PRINCIPLE AT STAKE	TECHNICAL DEBATE
ICANN	**Freedom of Expression**	**Domain Names (gTLDs)** Management of new, generic Top-Level Domains (gTLDs)
IGF Internet Governance Forum	**Media Pluralism**	**Social Media as News Platforms** Algorithms and Media Plurality
ITU	**Access to Information**	**Wireless Internet** 5G Cellular Networks and Unlicensed Spectrum Standards
IETF	**Privacy**	**Web Browsing Privacy** Encryption
IEEE	**Secure Access and Trust**	**Wi-Fi Security** Local Area Networks (LAN) Protocols in Diverse Settings

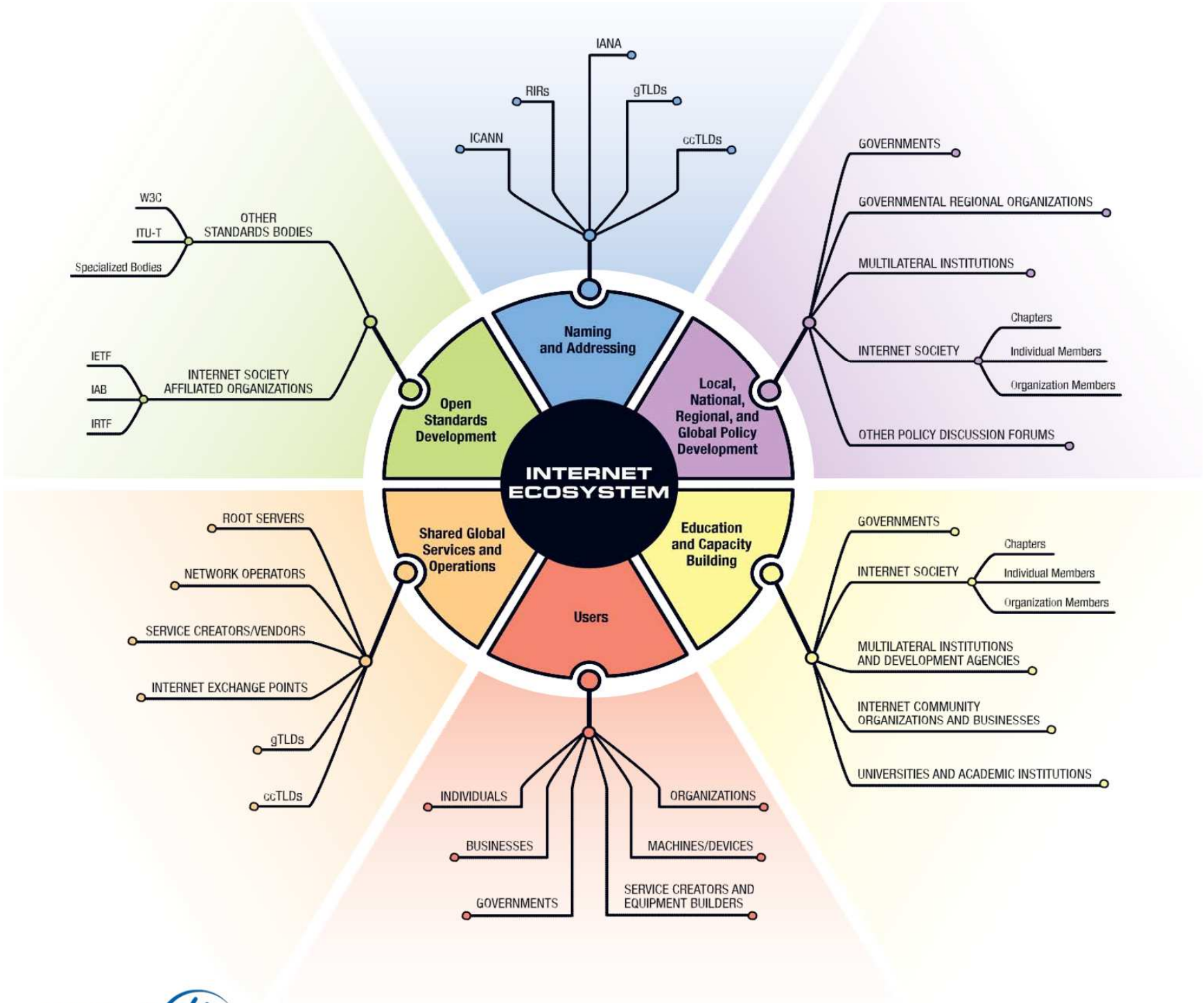
http://www.cima.ned.org/publication/media-development-digital-age-five-ways-engage-internet-governance/

Internet Assigned Numbers Authority

- global coordination of:
  - DNS Root, IP addressing, and other Internet protocol resources



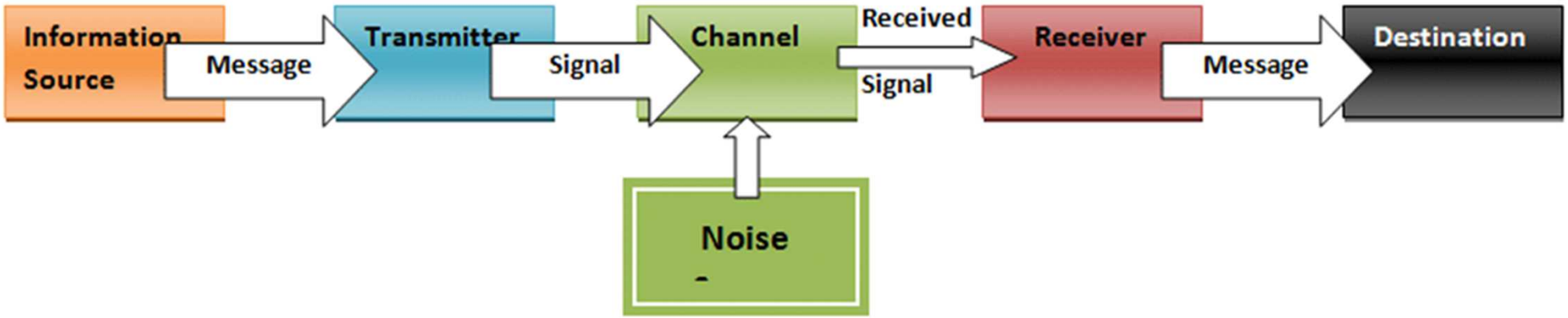
http://www.caida.org/funding/nets-ipv6/nets-ipv6_proposal.xml


INTERNET ECOSYSTEM
Naming and Addressing
IANA
RIRs
gTLDs
ICANN
ccTLDs
Open Standards Development
W3C
ITU-T
Specialized Bodies
OTHER STANDARDS BODIES
IETF
IAB
IRTF
INTERNET SOCIETY AFFILIATED ORGANIZATIONS
Local, National, Regional, and Global Policy Development
GOVERNMENTS
GOVERNMENTAL REGIONAL ORGANIZATIONS
MULTILATERAL INSTITUTIONS
INTERNET SOCIETY
Chapters
Individual Members
Organization Members
OTHER POLICY DISCUSSION FORUMS
Shared Global Services and Operations
ROOT SERVERS
NETWORK OPERATORS
SERVICE CREATORS/VENDORS
INTERNET EXCHANGE POINTS
gTLDs
ccTLDs
Users
INDIVIDUALS
ORGANIZATIONS
BUSINESSES
MACHINES/DEVICES
GOVERNMENTS
SERVICE CREATORS AND EQUIPMENT BUILDERS
Education and Capacity Building
GOVERNMENTS
INTERNET SOCIETY
Chapters
Individual Members
Organization Members
MULTILATERAL INSTITUTIONS AND DEVELOPMENT AGENCIES
INTERNET COMMUNITY ORGANIZATIONS AND BUSINESSES
UNIVERSITIES AND ACADEMIC INSTITUTIONS

Notions of: Communications, Telecommunications

The ‘old’ need to communicate: use of symbols, writing, languages

Claude Shannon’s model of communication



The Communications Model

Source

Generates data to be transmitted (the message)

Sender (transmitter)

Converts data into transmittable signals (ex. modem)

Transmission System

Simply, the **channel** - carries data, using signals; may be affected by noise; from a single transmission line to a complex network connecting the parts

Receiver

Converts received signal into data

Destination

Takes incoming data

Oral communication between two people:
Source & destination: the brain
Sender: transmitting device, the mouth
Channel: medium traversed, the air
Receiver: the receiving device, the ear

Communications

Problems (limitations) with the Shannon's model:
-one way
-no feedback
-not appropriate to group communications
-no explanation for the sending/receiving process

Questions?
-which are the formats a message is delivered?
-which are today's communications methods (radio, TV, papers, phone, Internet): one-way, two-way, multiple, interactive? Which will be preferred in the future?
-what about the teaching process?
-how to make the message secure?

Key Communications Tasks (from en engineering view)

Utilization of the Transmission System: optimal, efficient allocation of existing resources

Interfacing with the Transmission System: electromagnetic signals

Signal generation: for optimal propagation & proper interpretation at receiver

Synchronization between the communication parts

Message exchange management: rules of the conversation

Error detection and correction, flow control: part of the exchange management

Addressing and routing: more devices may share the transmission facilities

Recovery: resume of activity from the point of interruption

Message formatting: bit or character oriented

Security: data received only by intended receivers, and unaltered

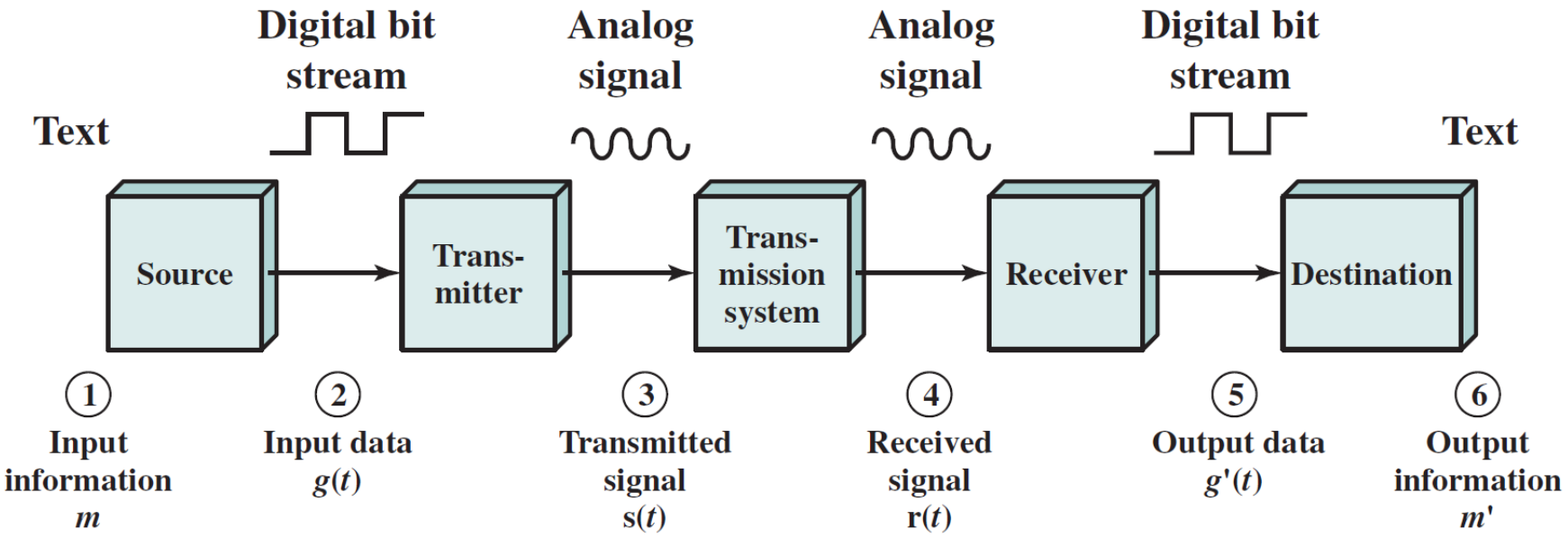
Network Management: configure the system, monitor its status, detect failures & overloads, planning the future growth

Telecommunications

Etymology: communication at a distance, as the *tele* prefix states (see television, teleaction, telecommand, telephony)
Definition: the *information transfer* between *two (or more) points*, usually at a distance, using *media* other, or perhaps including audio.

Example

Communication between two computers exchanging text files, using modems:



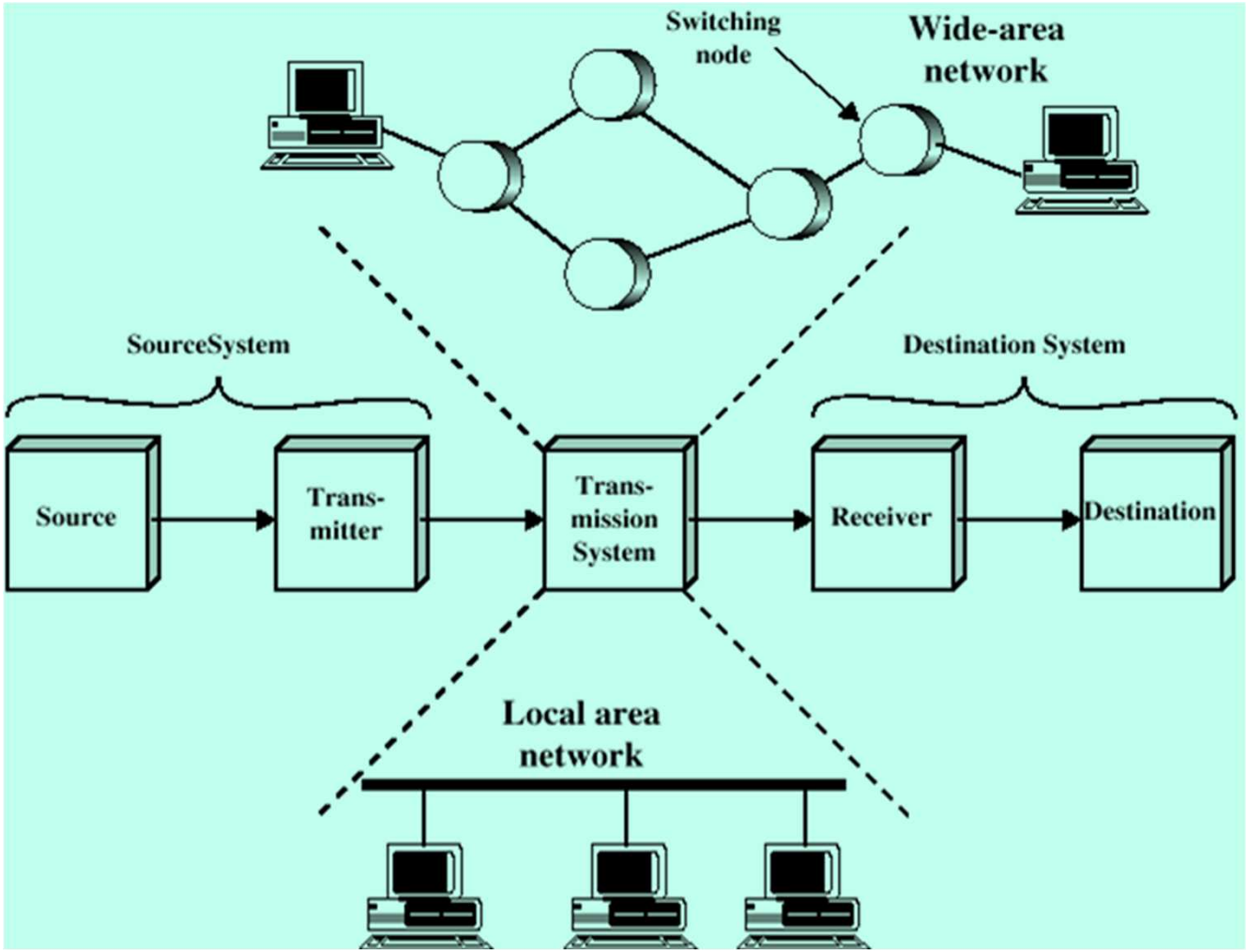
Networking

Point to point communication not usually practical

Devices are too far apart

Large set of devices would need impractical number of connections

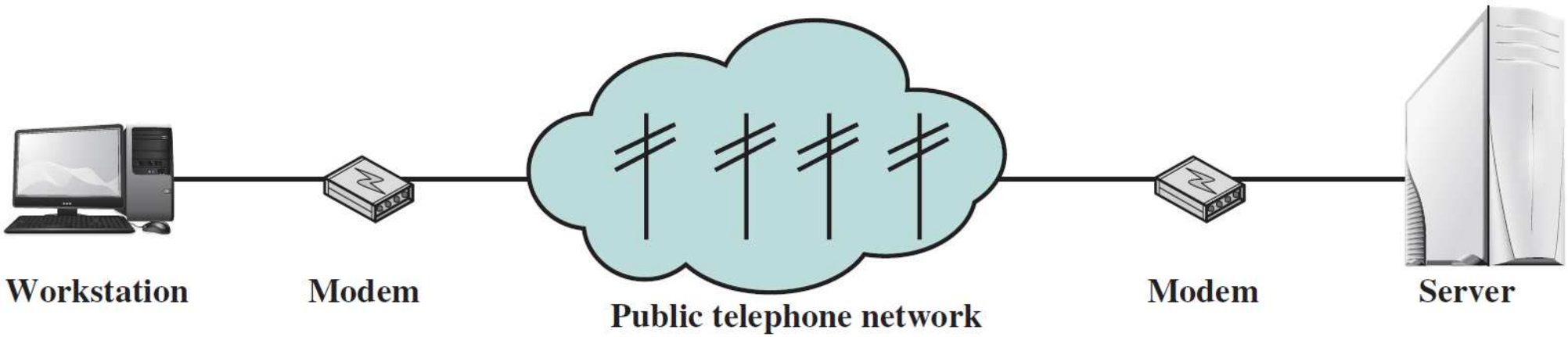
Solution is a **communications network** (see below an example)



Communications Networks

Definition: a mesh of switching nodes and links, enabling one or more 'network hosts' to have access to a telecommunications infrastructure which supports a range of tele-services to the network hosts or between network hosts.

Example: telecommunications connection between a computer and an e-mail server (ISP) – two network hosts – application: e-mail exchange, carrier: PSTN (Public Switch Telephone Network).



Communications Networks continued

Generally all networks are **telecommunications** (data networks, computer networks, telephony networks, mobile cellular networks, TV broadcasting networks).
In the past, a difference : computer networks carry data, telecomm networks operate with voice; no more, today's networks (let's say Internet) carry voice+data+video!

Question?
A lecture is a telecommunication activity and has the structure of a network?

Answer: a lecture has communications attributes, like: point-to-point, simplex or half duplex, symmetric in bandwidth (4KHz), unbalanced, analogue transmission, but is not telecommunication (not at distance) and there is no network (not distance transporting system).

Global Telecommunications Networks

Today we speak about **Global Networks**

Issues:

-fixed or mobiles

-application driven networks

-integrated telecommunication networks (carry data, voice, video)

-convergence of networks (in terms of access interfaces, packet size, service supply)

-seamless (network of networks, metanetwork)

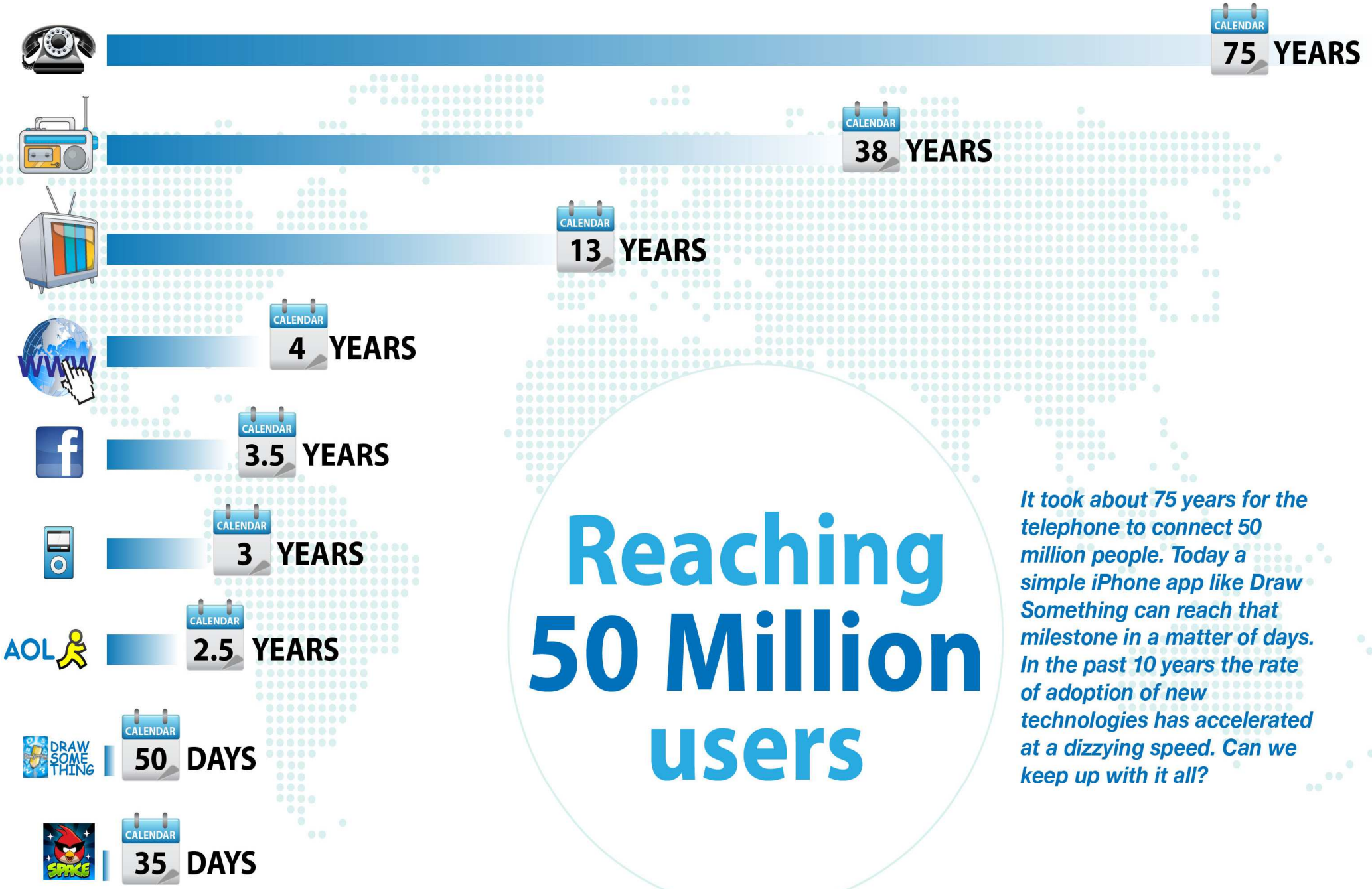
-increased number of services

-need for an ordered development, based on **reference models**

Some Milestones for Communications Networks evolution

(concerning offered services)

1850: Telegraphy
1890: Telephony
1930: Radio, Television, Facsimile, Branch Exchange
1970: Color TV, Stereo radio, low-speed data transmissions(Kbps), remote computing
1990: ISDN, medium & high speed data transmissions (Mbps), multimedia, LANs, WLANs, video…
2000: Very high speed transmissions (Gbps), mobile, home access, security, virtual reality, teleworking, banking ……..
2010: Mobile communications, cloud computing, High Performance computing …


CALENDAR
75 YEARS
CALENDAR
38 YEARS
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13 YEARS
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3 YEARS
CALENDAR
2.5 YEARS
CALENDAR
50 DAYS
CALENDAR
35 DAYS
AOL
DRAW SOME THING
SPACE
Reaching
50 Million
users
It took about 75 years for the telephone to connect 50 million people. Today a simple iPhone app like Draw Something can reach that milestone in a matter of days. In the past 10 years the rate of adoption of new technologies has accelerated at a dizzying speed. Can we keep up with it all?
by G. Kofi Annan / @gkofiannan / gkofiannan.com

2/28/2024

Introduction to Computer Networks

Computer Networks are an interconnection of computers.

Two computers are said to be interconnected if they are able to exchange information (data).

The main reasons why computers are networked are:

•to share hardware resources – higher reliability (files, printers, modems, fax machines)

•to share application software (MS Office)

•to save money – downsizing process: from mainframes to a lot of small intelligent computers spread around

•to increase productivity (make it easier to share data among various users)

Types of computer networks

Different criteria:

-public (ex. educational WANs) or private (company owner)

-geographical location (coverage): Personal Area Networks (PAN), Local Area Networks (LANs), Metropolitan Area Networks (MANs), Wide Area Networks (WANs)

-type of transmission media: hard-wire (copper based wire or fiber optic), soft-wire (radio, satellite, infrared)

- topologies: mesh, star, ring, bus

- transmission type: broadcast/multicast, point-to-point, peer-to-peer

- classes of reliability

- application domains (ex. multimedia applications)

-way in which nodes exchange information: broadcast (LANs, Wireless), switched (circuit switching, packet switching (datagrams, virtual circuits))

Internet Evolution

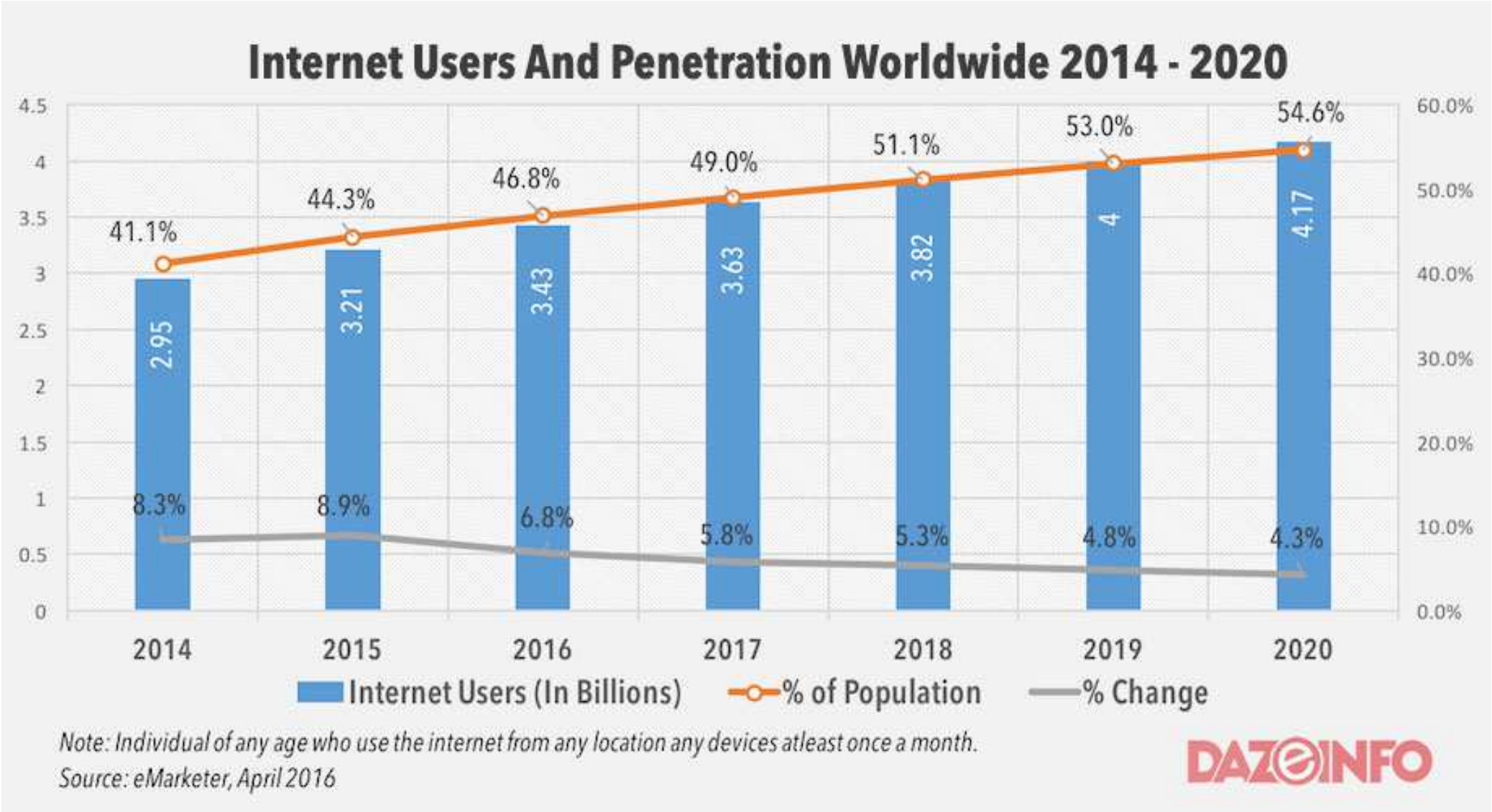
"The best predictor of future behavior is past behavior“ (Dr. Phil)

Introduction

- "All Science Is Computer Science"

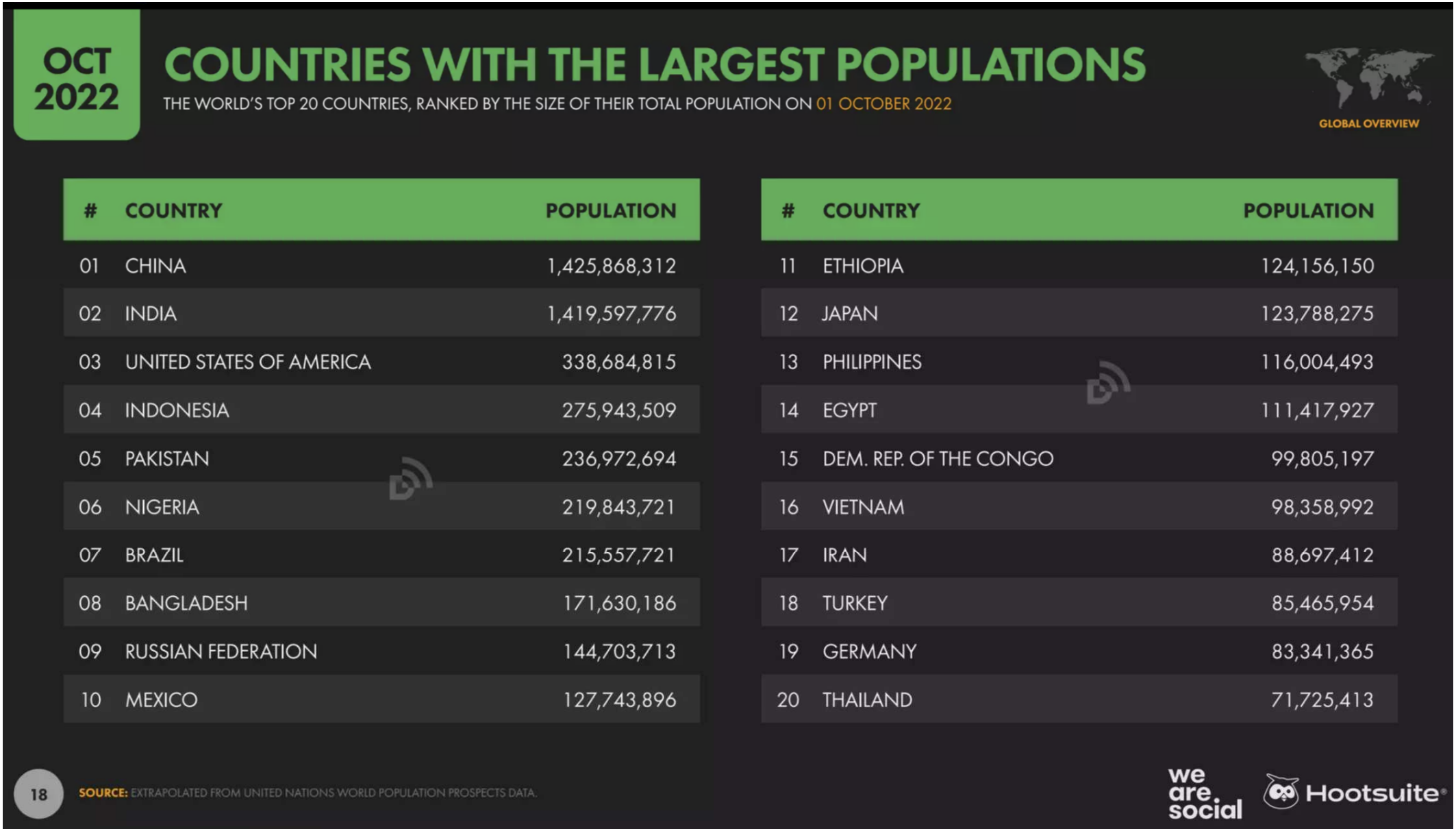
(New York Times, 2001)

- The Internet
  - global network connecting millions of computers
  - network of networks, a networking infrastructure

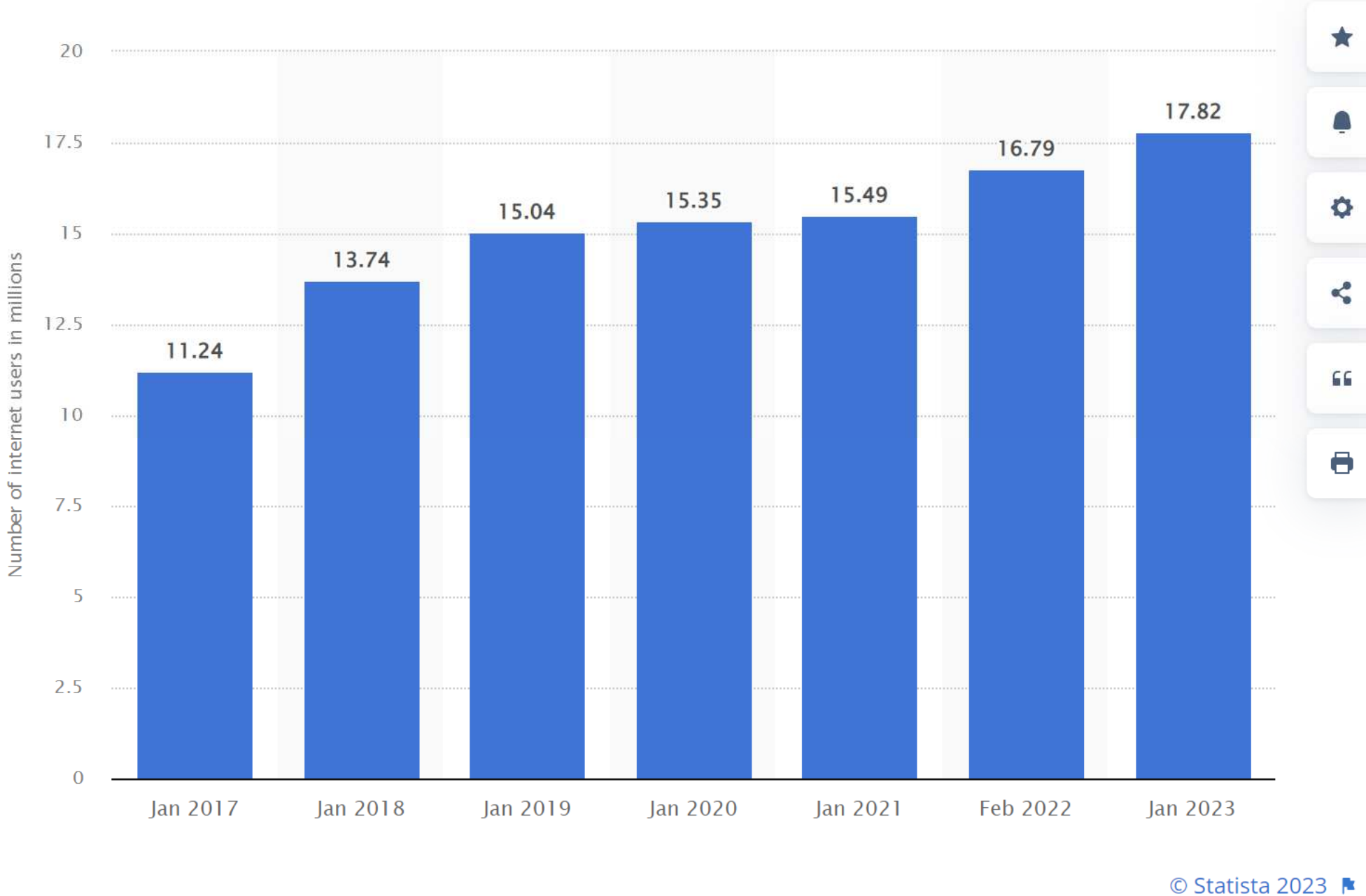

Internet Users And Penetration Worldwide 2014 - 2020
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
41.1%
44.3%
46.8%
49.0%
51.1%
53.0%
54.6%
2.95
3.21
3.43
3.63
3.82
4
4.17
8.3%
8.9%
6.8%
5.8%
5.3%
4.8%
4.3%
2014
2015
2016
2017
2018
2019
2020
Internet Users (In Billions)
% of Population
% Change
Note: Individual of any age who use the internet from any location any devices atleast once a month.
Source: eMarketer, April 2016
DAZEINFO

Internet Users in 2021

https://www.websitepulse.com/blog/internet-in-numbers-2021

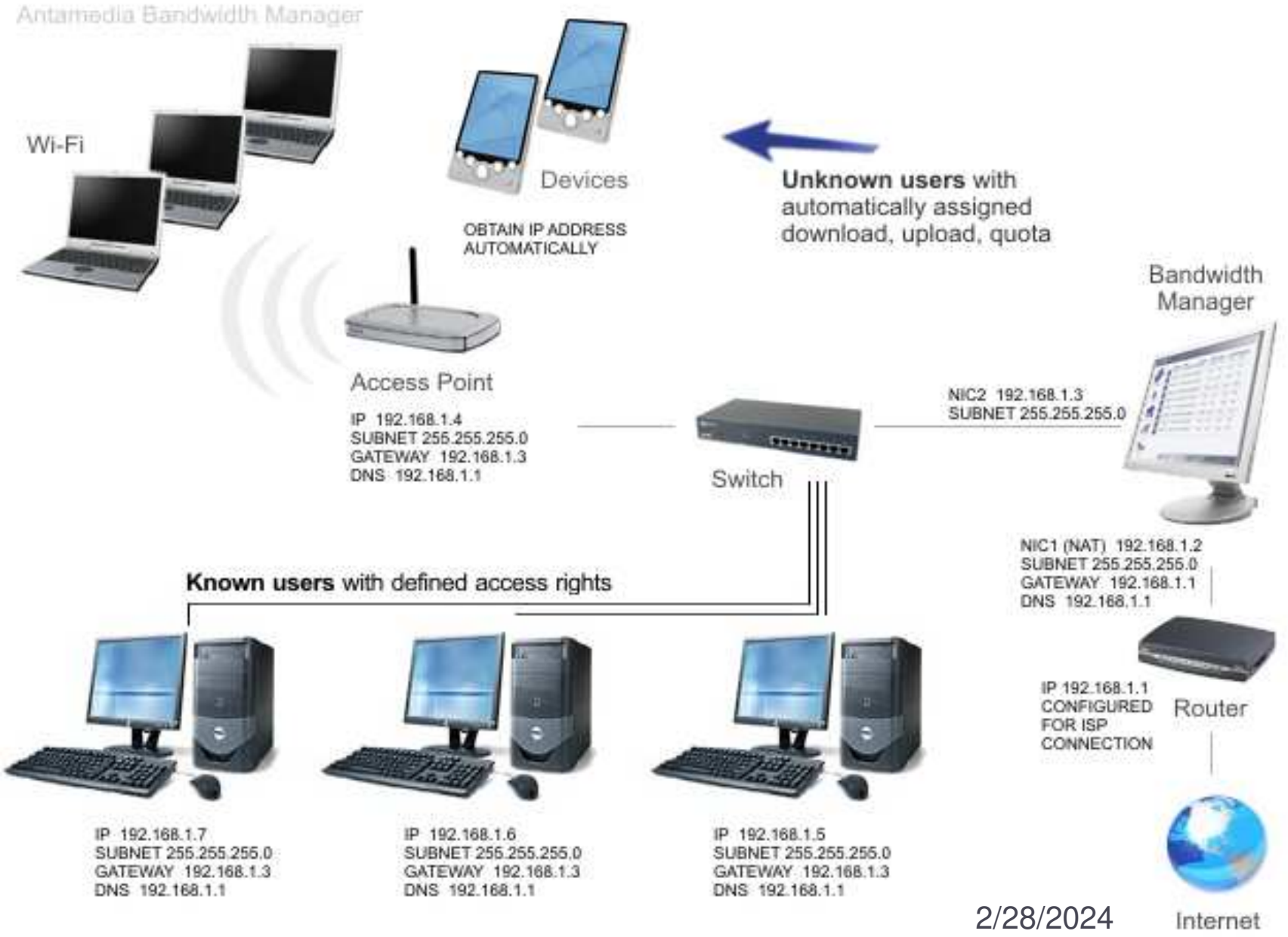

OCT 2022
COUNTRIES WITH THE LARGEST POPULATIONS
THE WORLD'S TOP 20 COUNTRIES, RANKED BY THE SIZE OF THEIR TOTAL POPULATION ON 01 OCTOBER 2022
GLOBAL OVERVIEW
COUNTRY POPULATION
01 CHINA 1,425,868,312
02 INDIA 1,419,597,776
03 UNITED STATES OF AMERICA 338,684,815
04 INDONESIA 275,943,509
05 PAKISTAN 236,972,694
06 NIGERIA 219,843,721
07 BRAZIL 215,557,721
08 BANGLADESH 171,630,186
09 RUSSIAN FEDERATION 144,703,713
10 MEXICO 127,743,896
COUNTRY POPULATION
11 ETHIOPIA 124,156,150
12 JAPAN 123,788,275
13 PHILIPPINES 116,004,493
14 EGYPT 111,417,927
15 DEM. REP. OF THE CONGO 99,805,197
16 VIETNAM 98,358,992
17 IRAN 88,697,412
18 TURKEY 85,465,954
19 GERMANY 83,341,365
20 THAILAND 71,725,413
18
SOURCE: EXTRAPOLATED FROM UNITED NATIONS WORLD POPULATION PROSPECTS DATA.
we are social
Hootsuite

Romania Internet Usage



Computer Network Devices

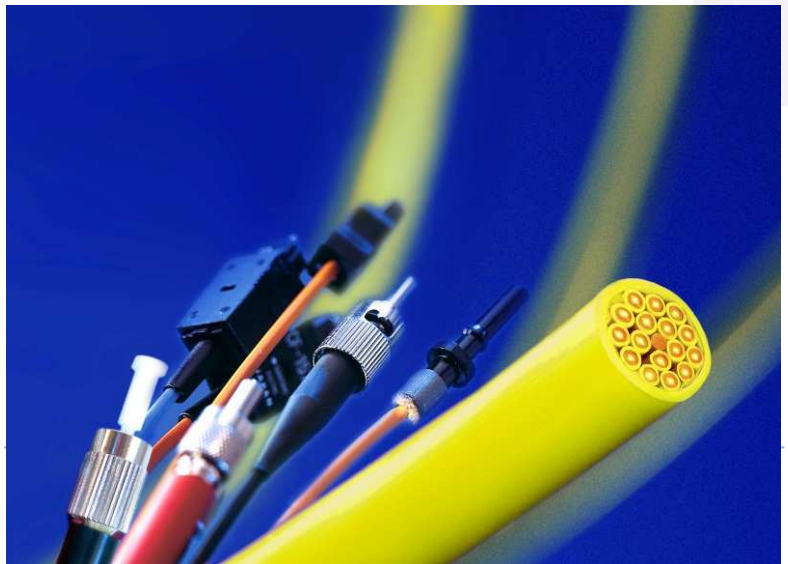
Topologies and network devices



Physical Layer

- Wireless
  - RF
  - Infrared
  - Microwave

- Wired
  - Copper: UTP, FTP, STP
  - Optical fiber



Data link Layer

- Connecting devices in a LAN

- Wireless
  - AP (Access Point)
- Wired
  - Switch

- MAC address
  - unique identifier assigned

to network interfaces (48 bits)

Network Layer

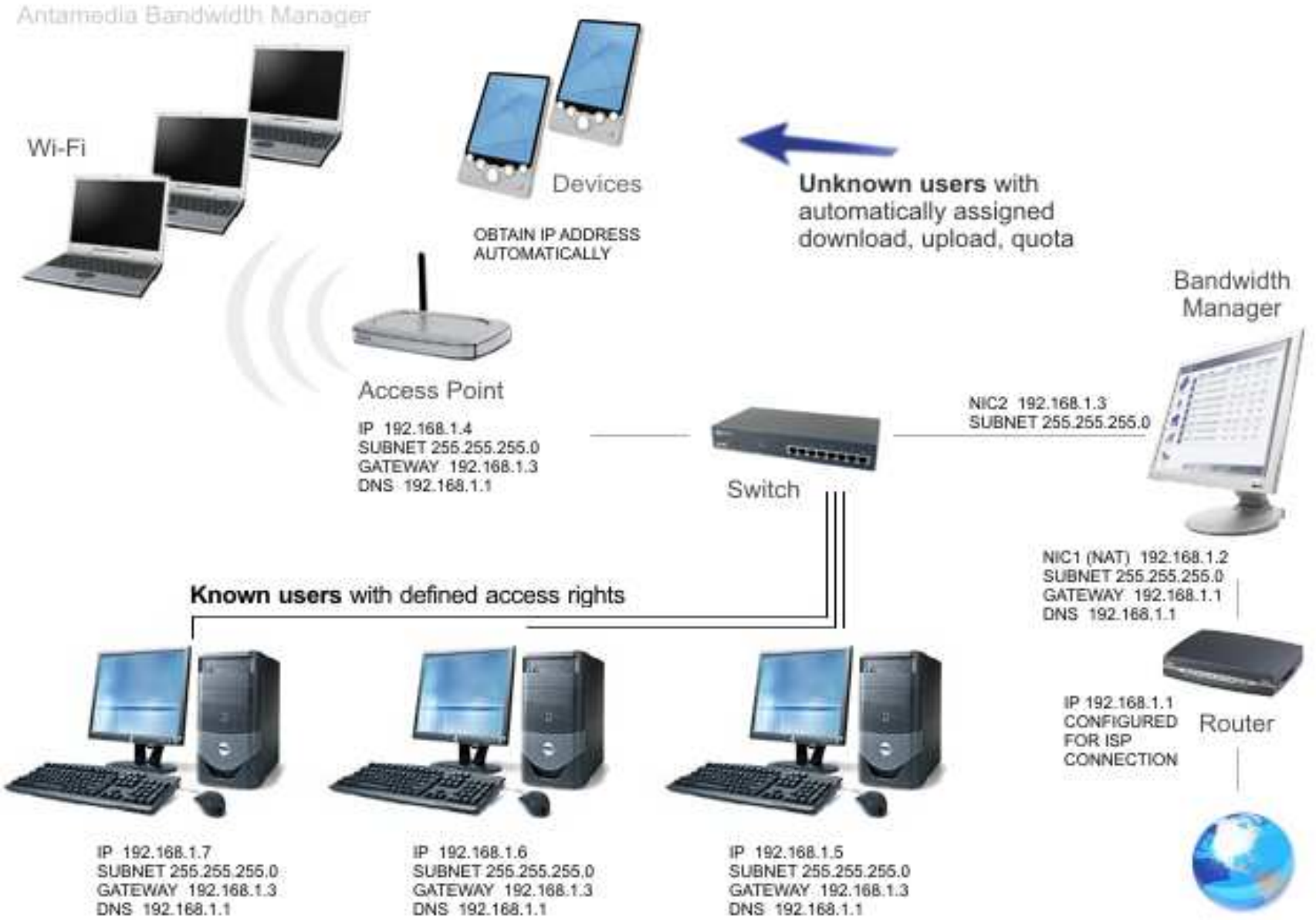
- Connecting different LANs

- Wireless
  - Wireless Router
- Wired
  - Router

- IP address
  - Version 4 (32 bits)
  - Version 6 – auto-configuration (128 bits)

    (2001:0db8:3c4d:0015:0000:0000:abcd:ef12)

Topologies and network devices



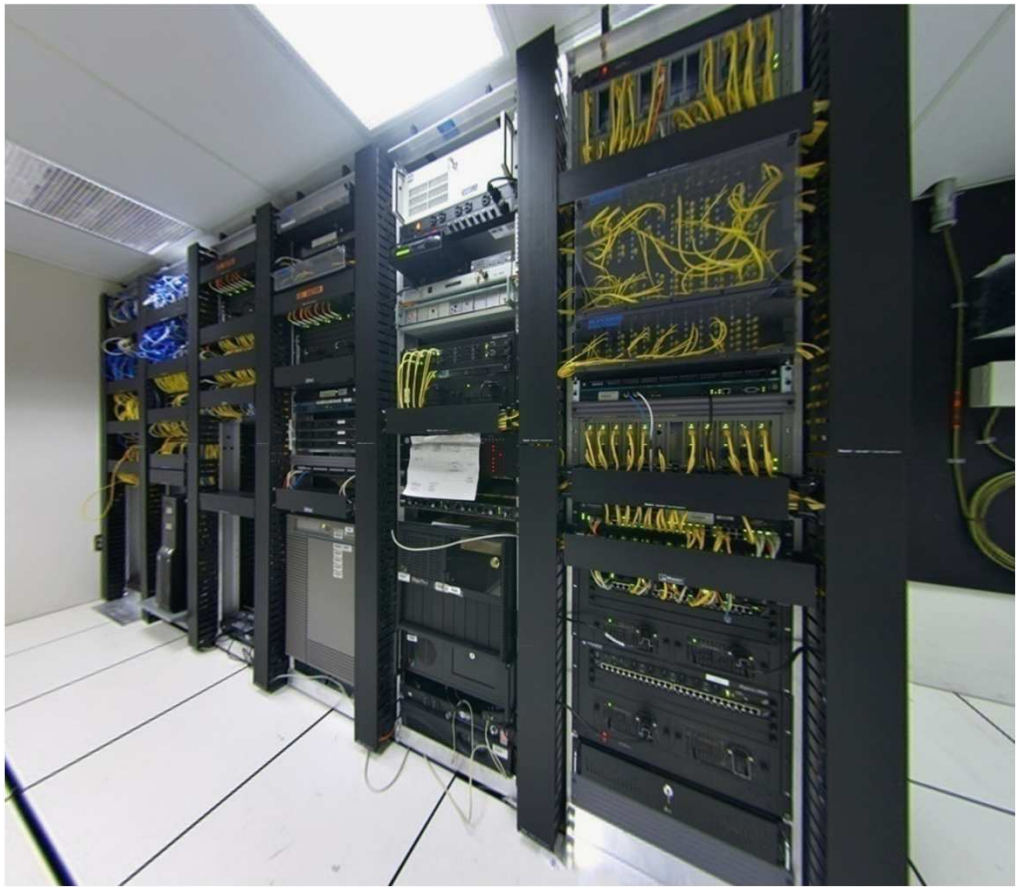
Internet and Computer Networks Evolution

Traditional solution

- **Requirements:**
  - Office space
  - Servers
  - Cooling
    - UPS
  - Operating systems, softwares, upgrades, patches
  - Firewalls, Intrusion prevention systems, spam control, …
  - Failover
  - Disaster recovery
  - Team of experts

Traditional solution disadvantages

- Time consumption
- Higher costs
- Slow scaling



Evolution

Timeline: