Computer Networks

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Agenda

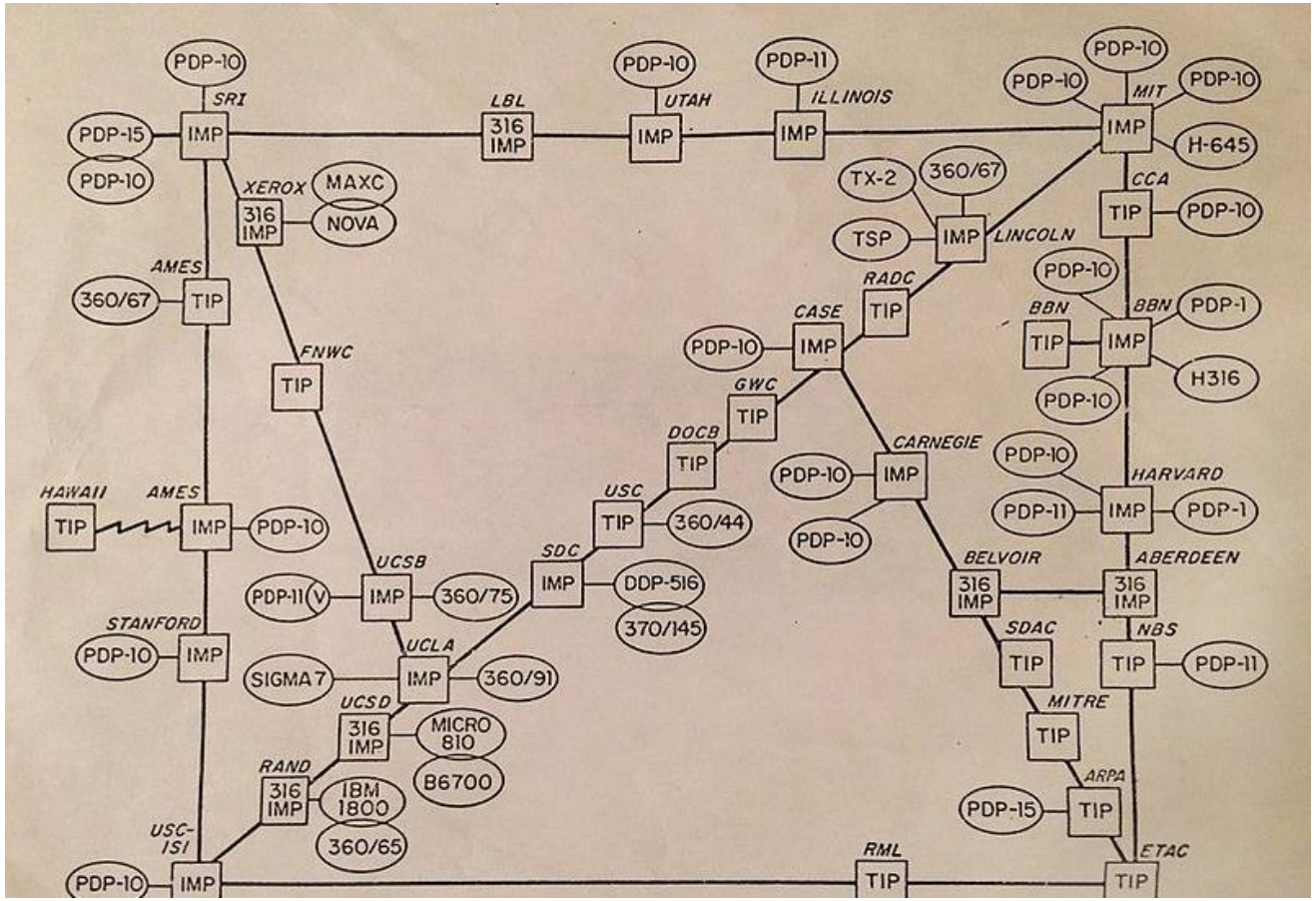
- Computer Network Components
- Device Types
- Protocols
- Topologies
- Internet of Things

Networks

- Devices & Machines are effective/beautiful in isolation…
- Connecting machine/ device to a computer network creates amazing possibilities...
- Key point:
  - Computer networks are no longer only used to connect computers
  - Part of many aspects of everyday life

QI: Arpanet

- US government responds to launch of Sputnik by setting up ARPA, the Advanced Research Projects Agency
- ARPANET created in 1969 connecting computers in UCLA and Stanford
- In 1973, it was called the "internetwork" or "internet" for short

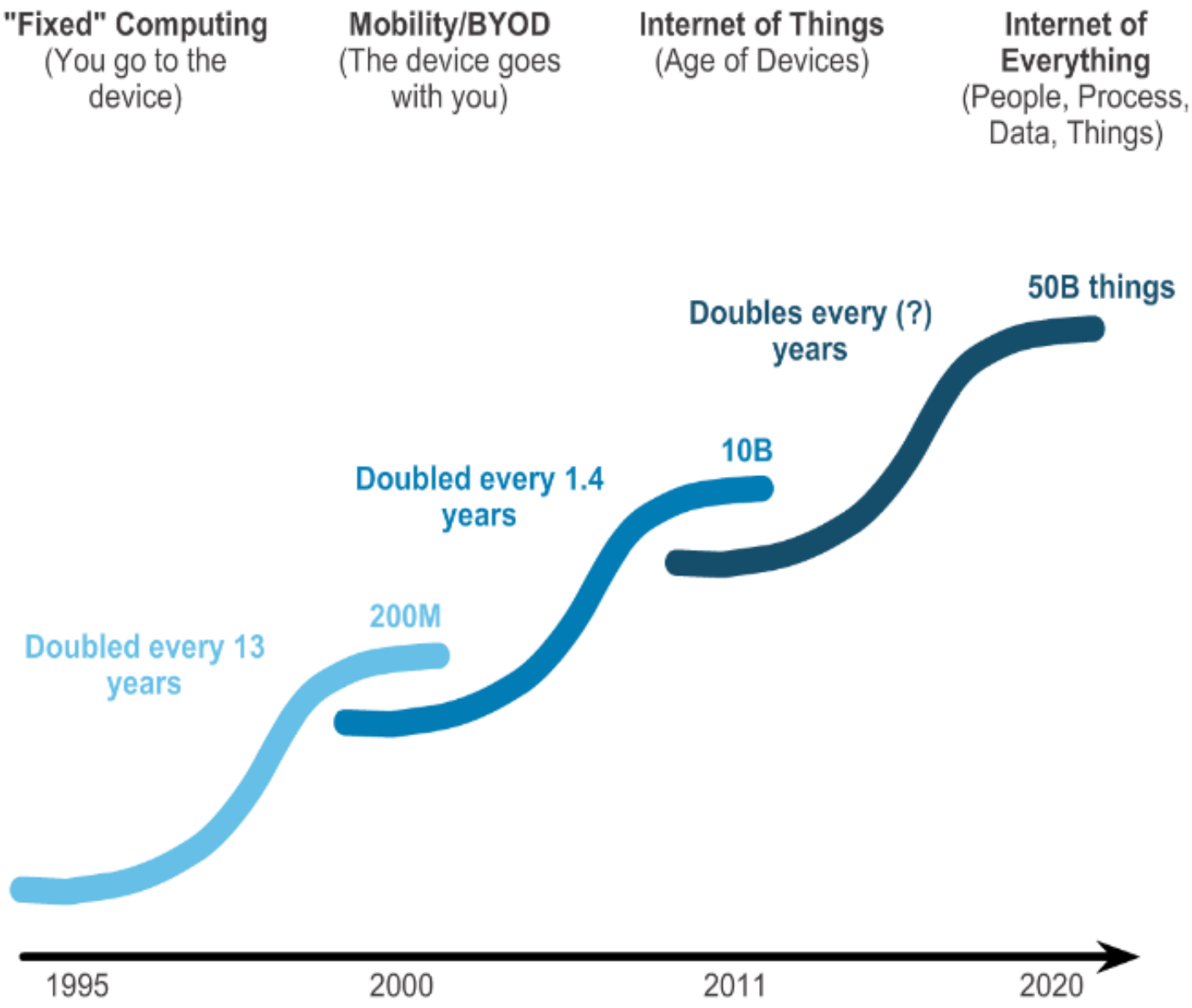


QI: How heavy is the internet?

- about the same as a grain of sand...
  - "In terms of data, if every bit of information stored in silicon comprises 40,000 electrons, the total weight of all the information flowing across the internet – books, music, photographs, emails, orders – is two millionths of an ounce"

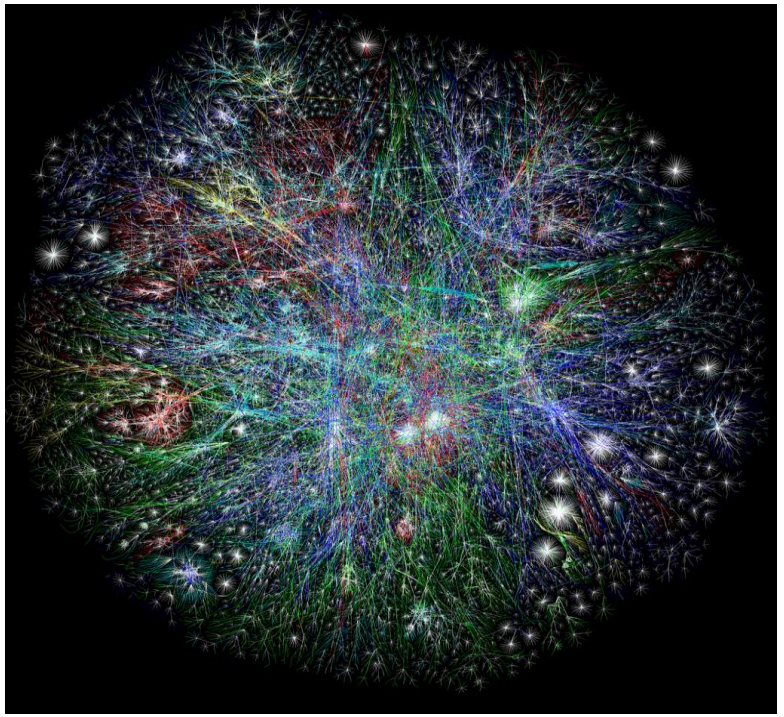
Source: http://discovermagazine.com/2007/jun/how-much-does-the-internet-weigh

Computer Networks Evolution

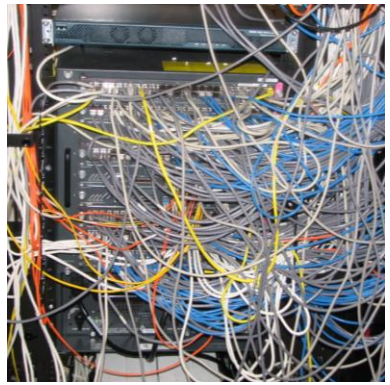


Networks - Under the bonnet

- Inherently Physical:
  - Devices need some form of physical channel to communicate
  - Devices need specific hardware to use that channel (eg. antenna and associated electronics)

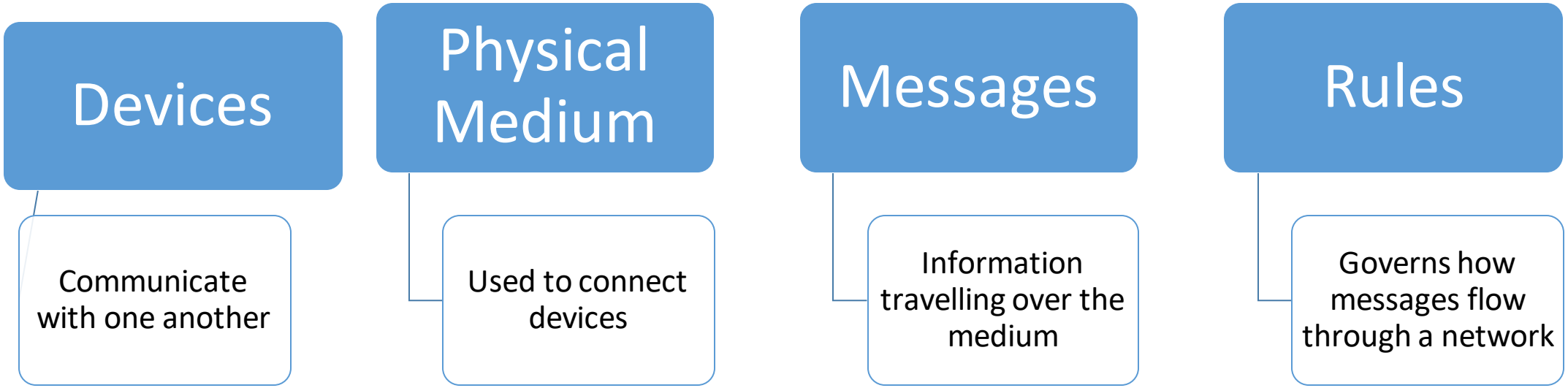


Networks – Under the bonnet



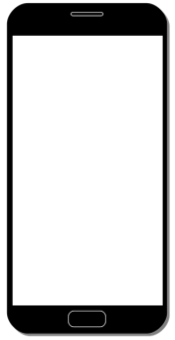
- Once connected, it can get complicated!
- Sophisticated combination of protocols, software, hardware, algorithms, configurations, policies...
- Security, privacy, access, quality of service, wired/wireless...

Elements of a Network



Device Types

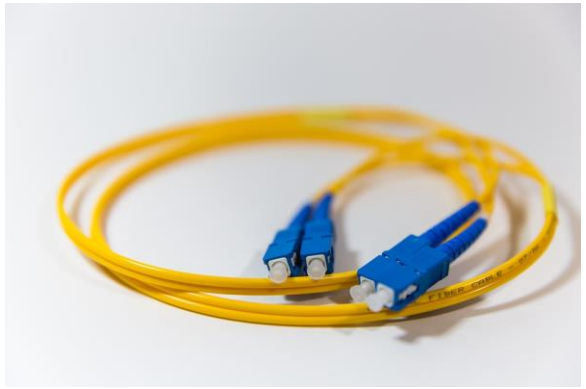
- End Devices



- Infrastructure Devices

Physical Medium

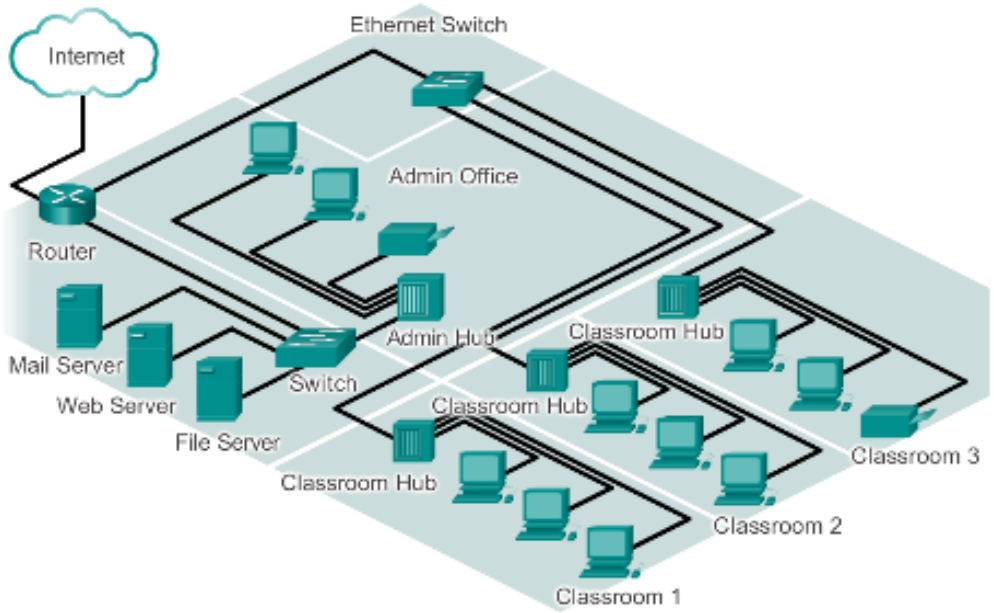
- Wired



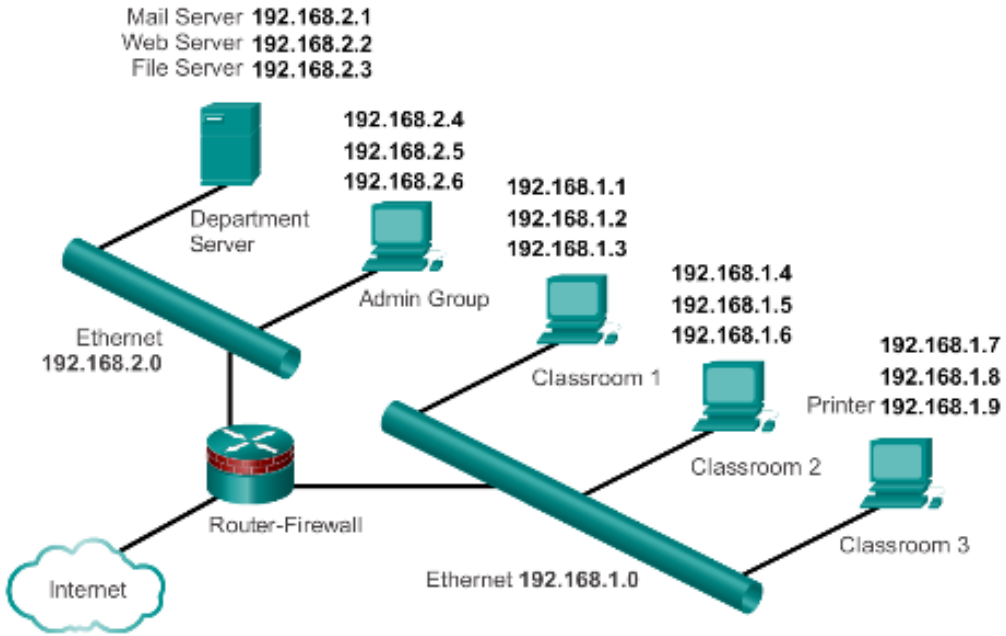
- Wireless

Network Topology

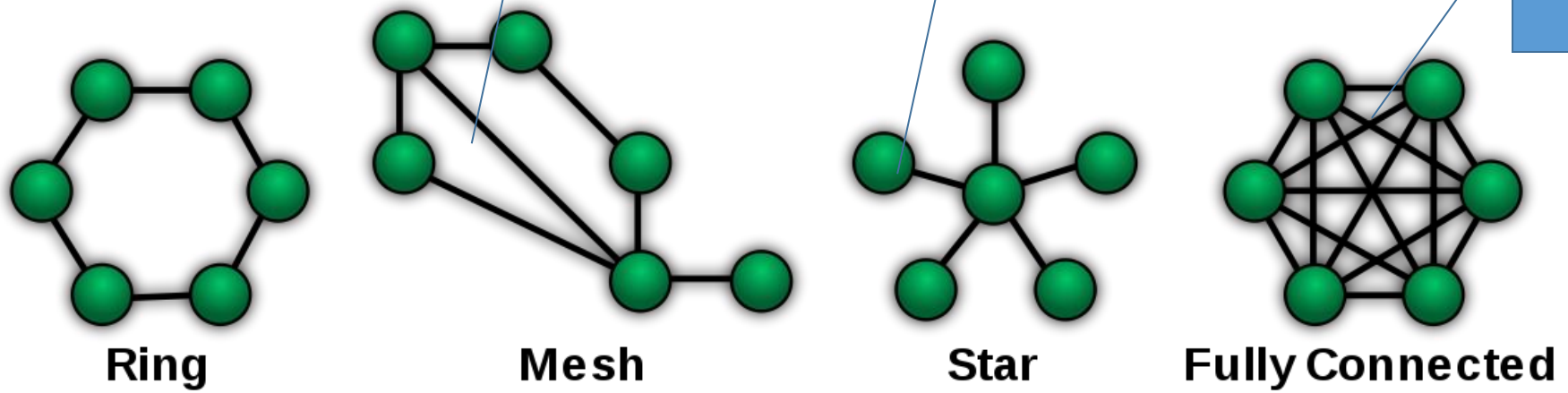
Physical Topology

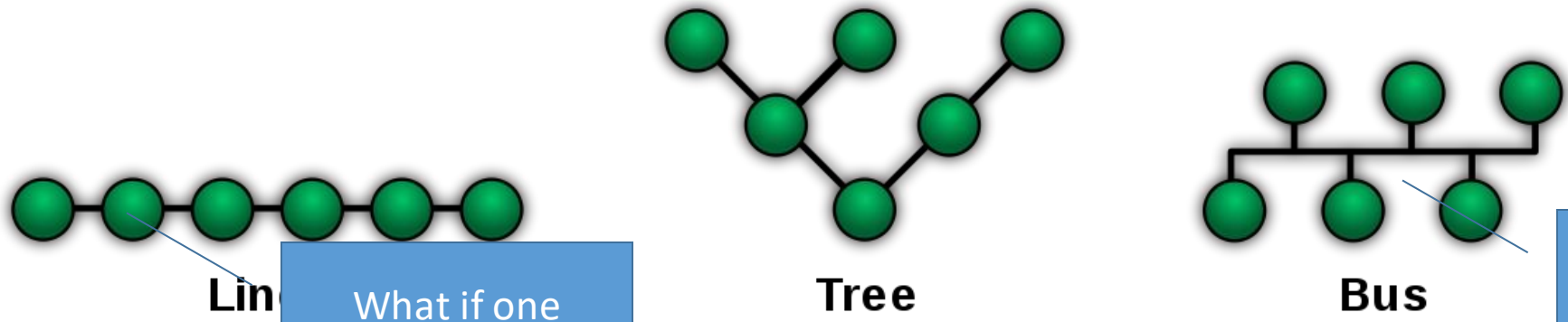


Logical Topology



Network Topology





What connection to use? Unorganised….

Centre is single point of failure

Will not scale well

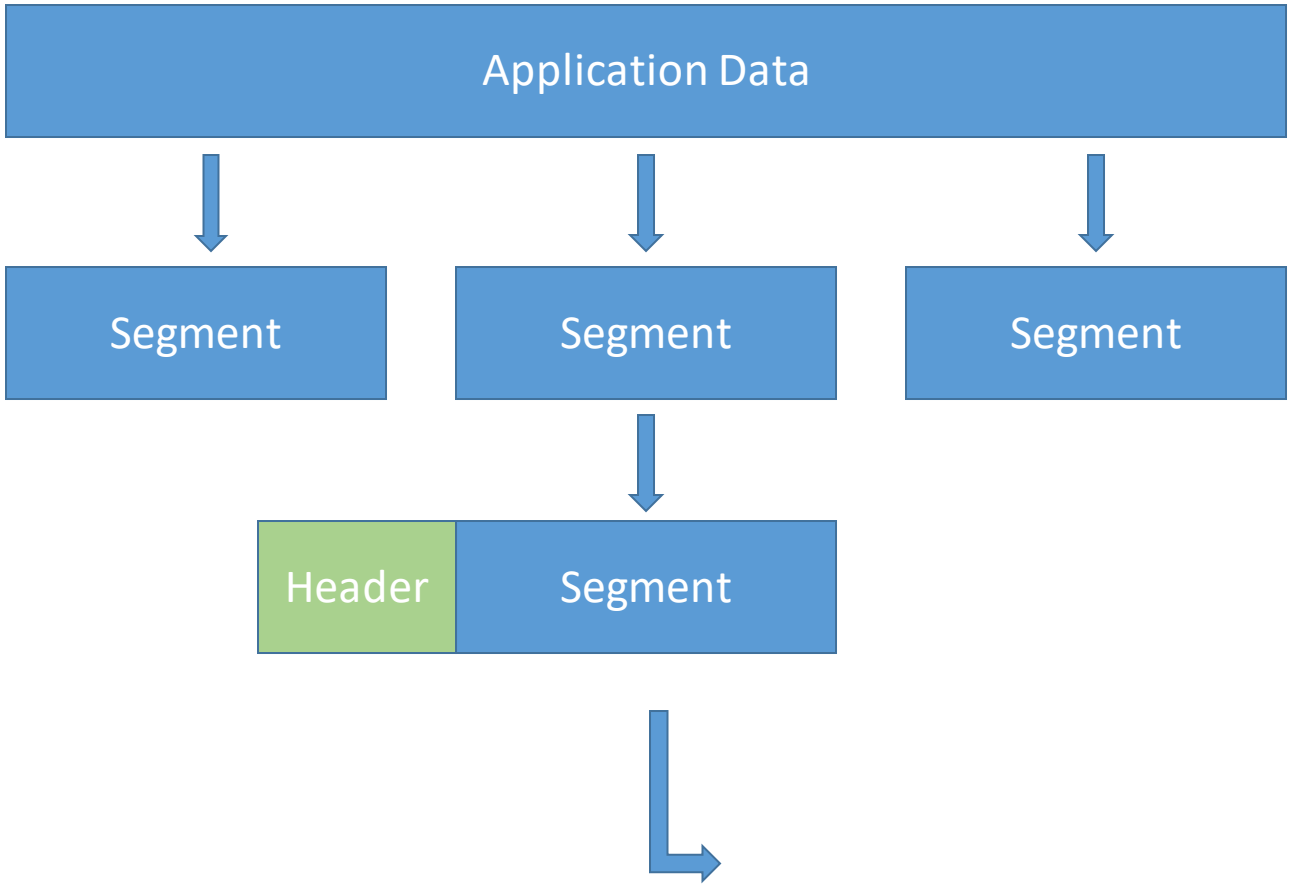
What if one device goes down???

2 devices communicate simultaneously???

Source: wikipedia

Messages

- Data is divided into smaller parts during transmission
  - Segmentation
- The benefits of doing so:
  - Many different conversations can be interleaved on the network(multiplexing)
  - Increases reliability of network communications.
  - The separate pieces of each message need not travel the same pathway across the network from source to destination
- Adds complexity however:
  - Addressing, labeling, sending, receiving.
  - Reassembling
- NEED RULES FOR THIS…

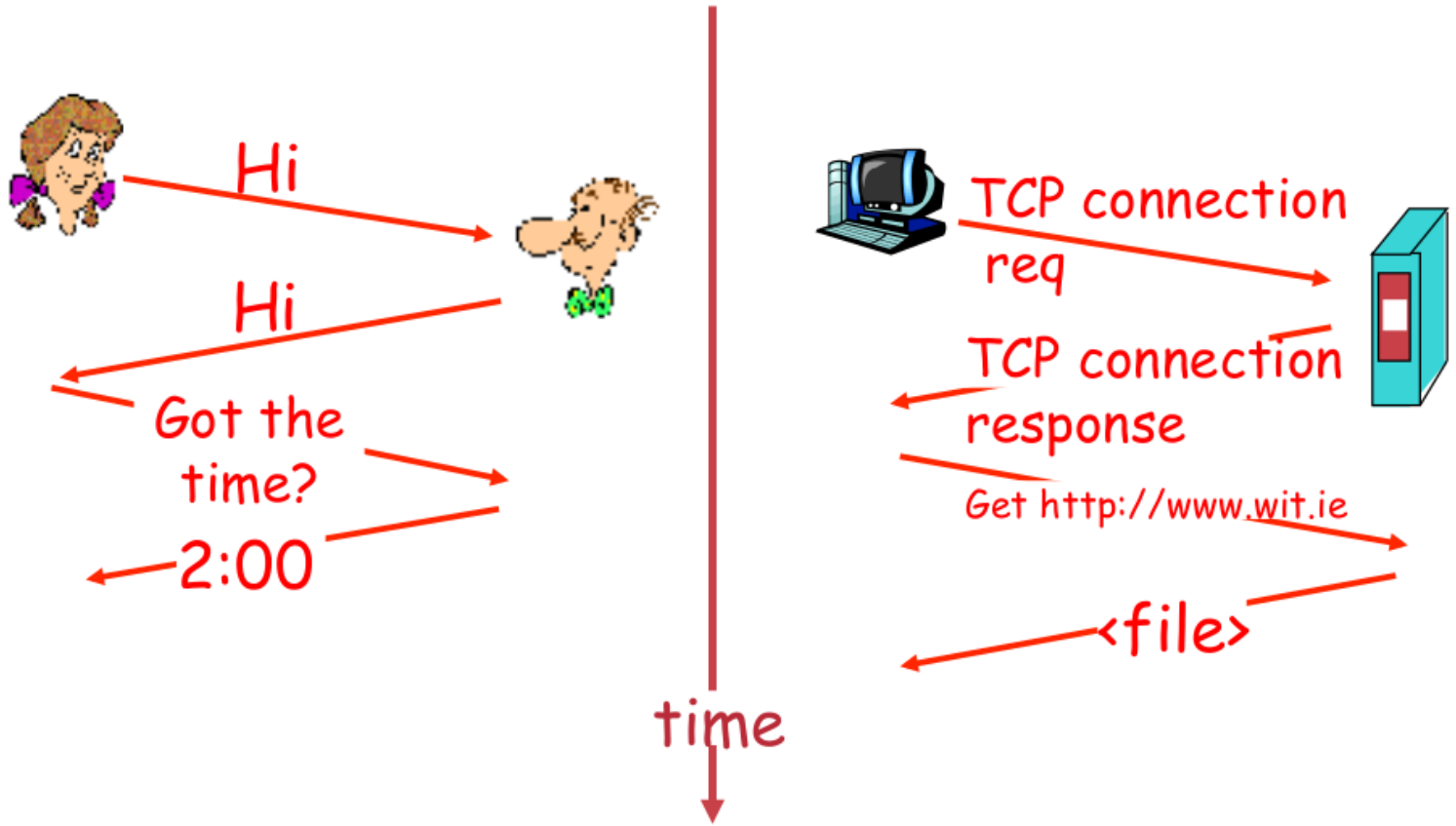


Rules

- Humans have generally accepted protocols for interaction:
  - Identified sender and receiver
  - Agreed upon method of communicating (face-to-face, telephone...)
  - Common language and grammar
  - Speed and timing of delivery
  - Confirmation or acknowledgement requirements
- All communication activity on the Internet is governed by protocols

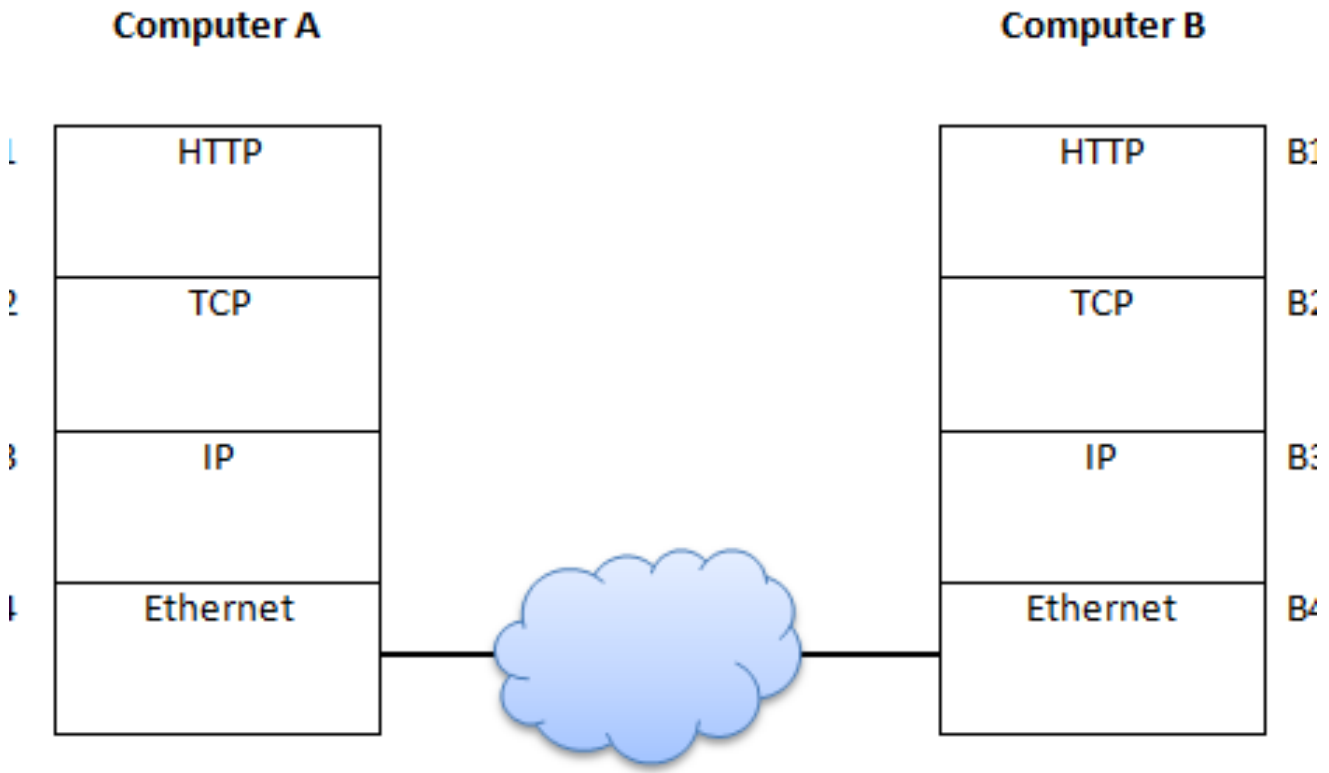
Human Protocol

Network Protocol



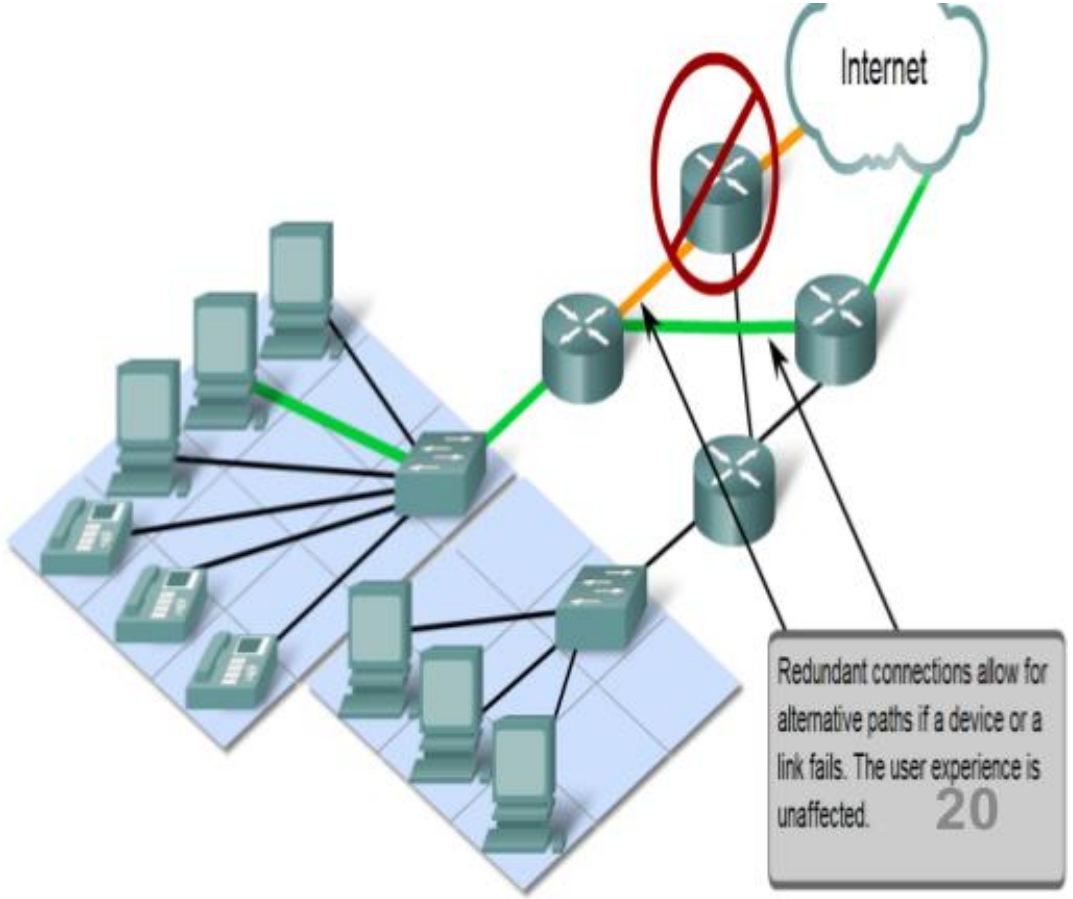
Network Protocols

- Machines rather than humans
- All communication activity in Internet governed by protocols
- Protocols define
  - Format, order of msgs sent and received among network entities
  - Actions taken on msg transmission, receipt

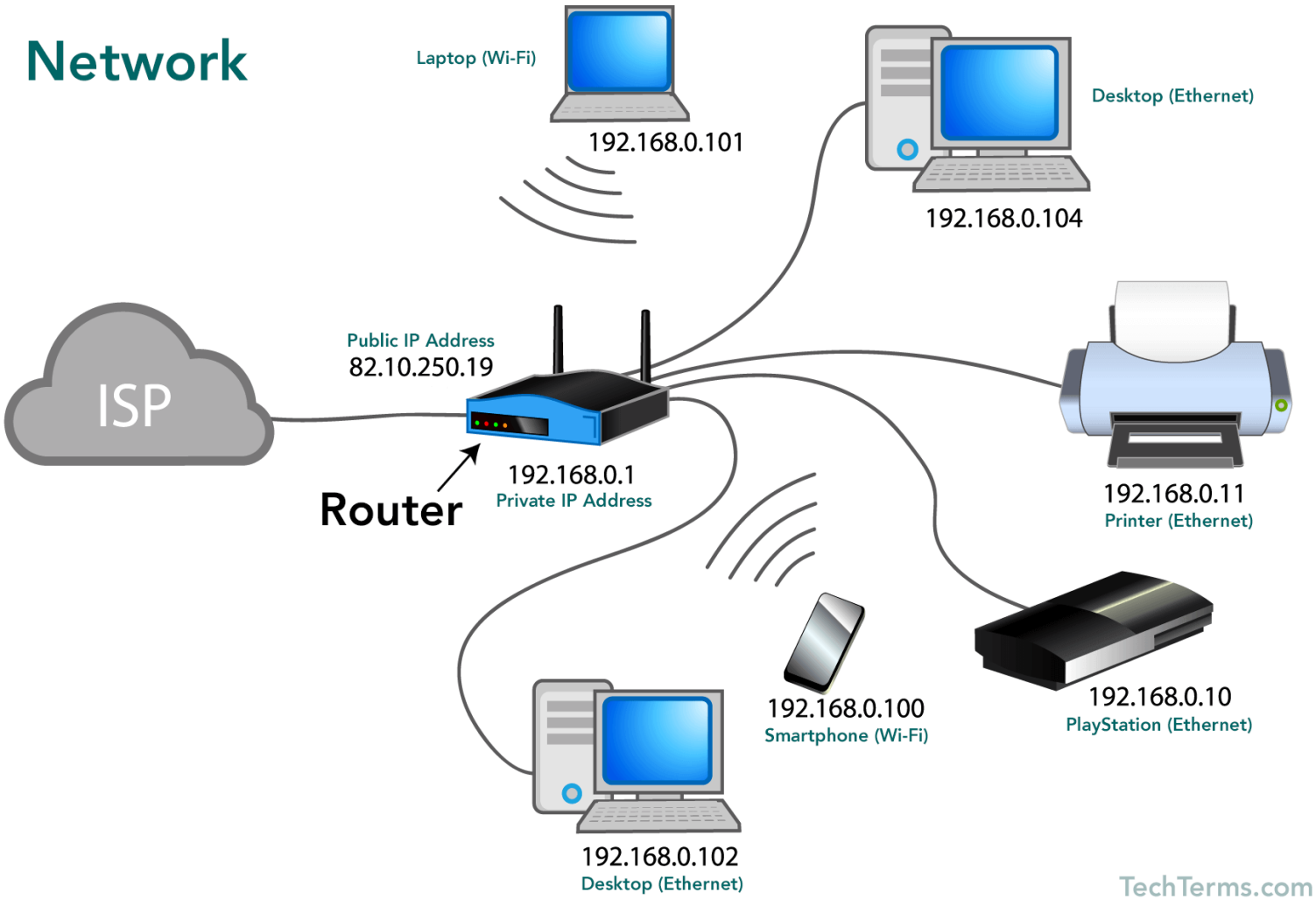


Network Characteristics

- Network architecture refers to:
  - the technologies that support the infrastructure
  - The programmed services and protocols that move the messages across that infrastructure
- 4 general characteristics to meet user expectations
  - Fault tolerance
  - Scalability
  - Quality of service (QoS)
  - Security



Typical Home Network



Source: https://techterms.com/definition/network

Some Networking Vocabulary

- **Network Interface**: any kind of software interface to networking hardware. (e.g. wifi interface and wired interface) A network interface may be associated with a physical device, or it may be a representation of a virtual interface. (e.g. interfaces on your virtual machines)
- **LAN**: Local Area Network refers to a network or a portion of a network that is not publicly accessible to the greater internet.
- **WAN**: Wide Area Network. Much Larger and extensive than a LAN. Often used to refer to the Internet, as a whole.
- **Node:** General term usually for a device on a network. Every node has a unique network address.
- **Media Access Control(MAC):** Used to distinguish specific devices. A unique address that each device is assigned during manufacturing. Used to differentiates it from every other device on the internet. Typically, each network interface has a MAC address.
- **IP:** protocols that allow the internet to work. IP addresses are unique on each network and they allow machines to address each other across a network.

Key Points so far

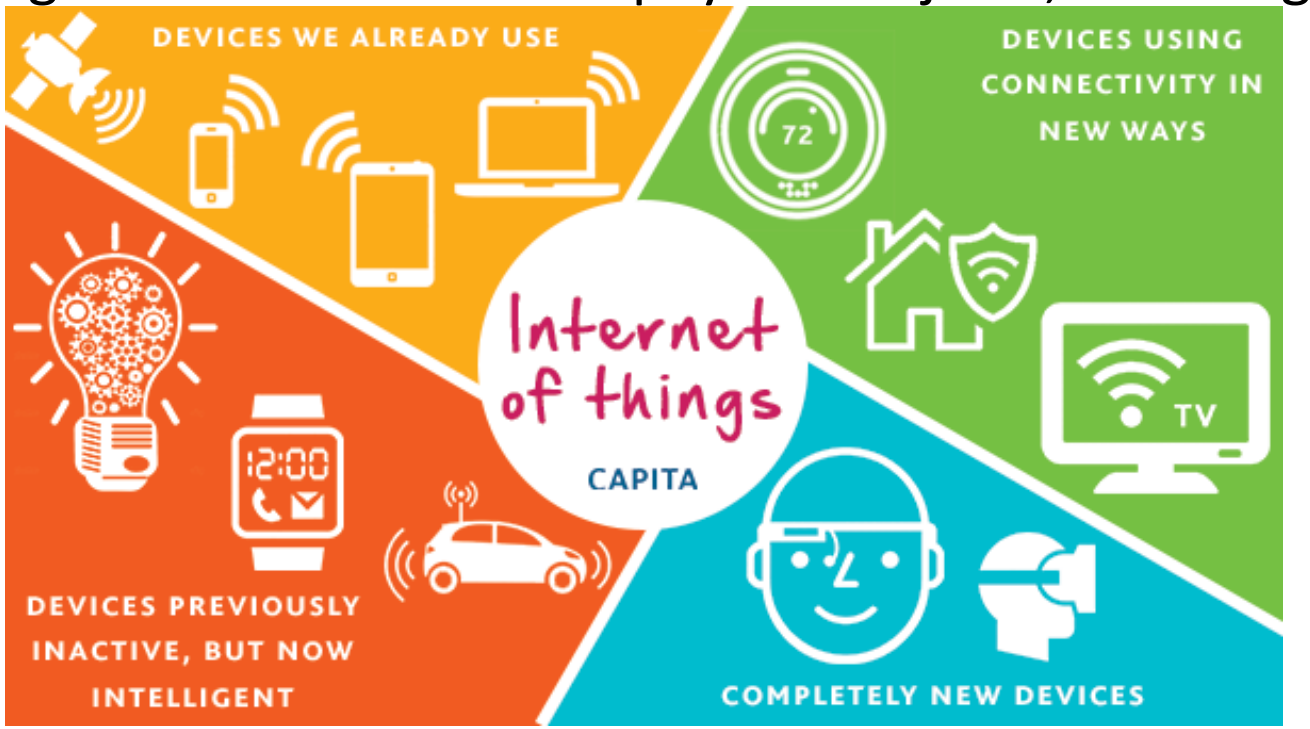
- Networks are everywhere
- 4 Components of every network
  - Devices
  - Medium
  - Protocols (Rules)
  - Messages (Data)
- Networks are connecting everything (not just for PCs/Laptops)
- Networks have a Topology
- Some key characteristics of a network

Internet of Things

- Internet → The worldwide network of interconnected computer networks, based on a standard communication protocol (TCP/IP).
- Thing → An object not precisely identifiable.
- Internet of Things (IoT) → A worldwide network of interconnected objects uniquely addressable, based on standard communication protocol.

What's the difference…

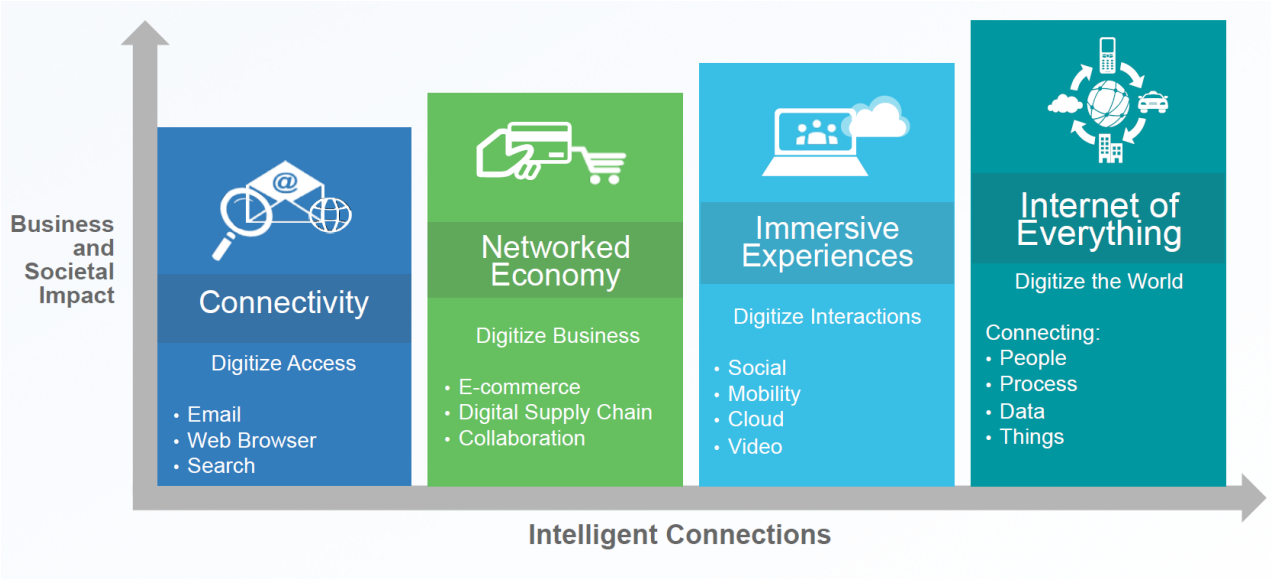
- Extending the current Internet and providing connection, communication, and inter-networking between devices and physical objects, or "Things," (even biological things!)



https://www.capitatranslationinterpreting.com/the-internet-of-things/

IoT Evolution

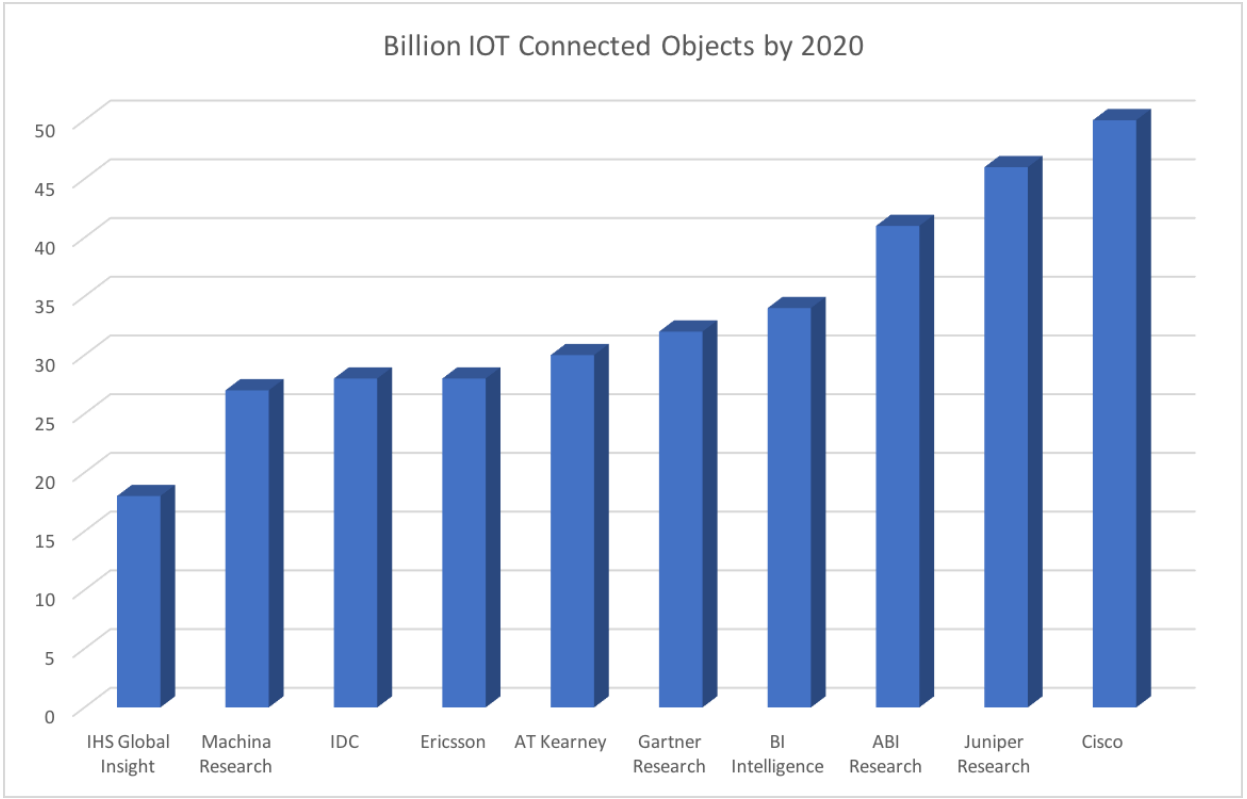
- Started with connectivity among people for sharing information.
- Led to a “flat-world” where everyone across the world is connected.
- Advancement in cloud computing and immersive experience led towards universal accessibility of data.
- Combination of immersive experiences, connectivity and advancement in electronics further leading to Internet of Everything (IoE)



Source: Cisco

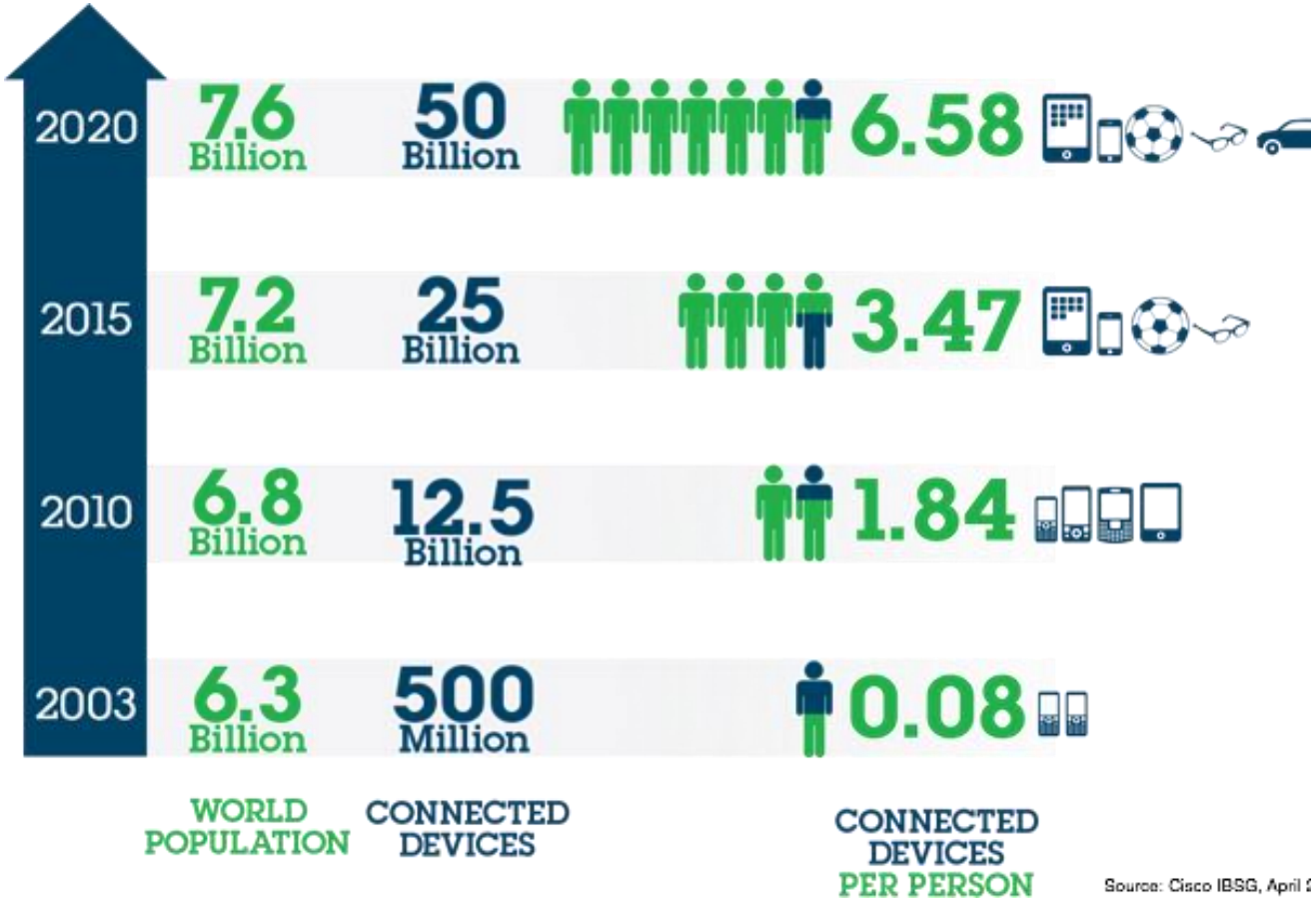
IoT Market

- As of 2015, 25 billion IoT units
- Expected to grow to 50 billion IoT devices by 2020



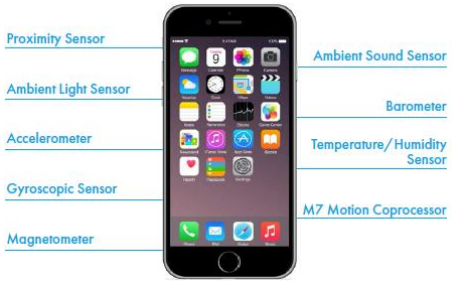
IoT Potential

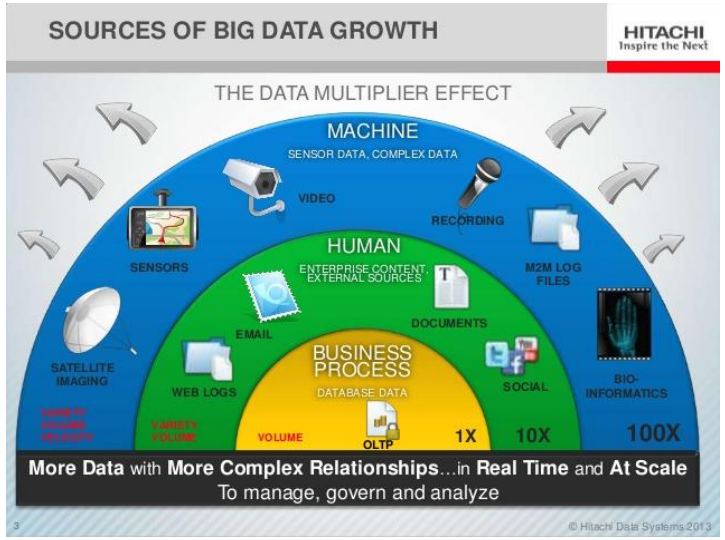
- Conservatively → 20 billion newly connected devices will be deployed.
- First public website went live at CERN in 1990.
  - It took 15 years to reach 1 billion people on earth over the internet.
  - IoT is looking to add 6 billion connected devices per year.
- Economic impact
  - New revenue streams
  - Reducing costs
  - Reducing time to market
  - Improving supply chain
  - Reducing production loss
  - Increasing productivity



IoT and Big Data

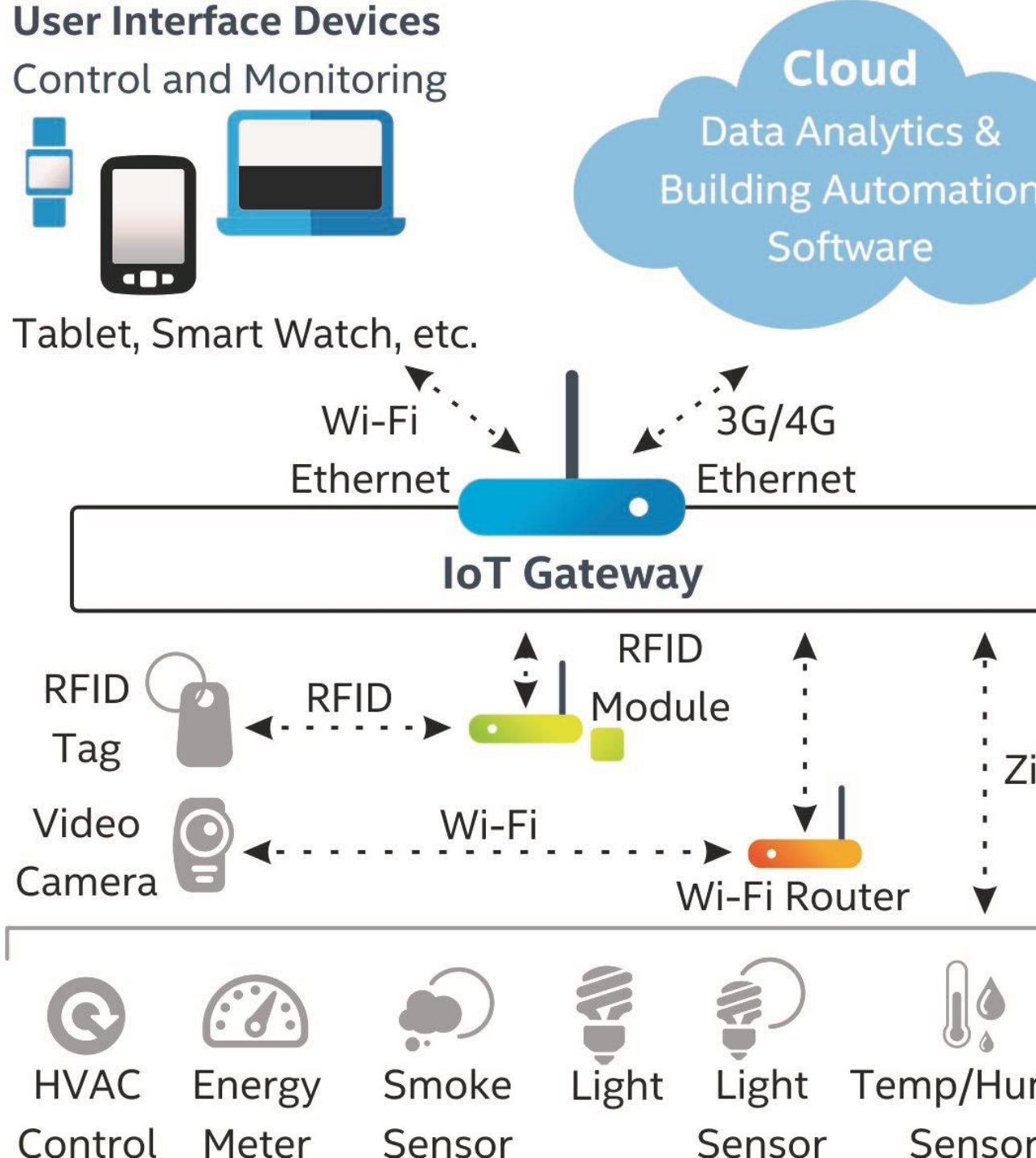
- A full 90% of all the data in the world has been generated over the last two years.
- Sources
  - Physical Environment
  - Smartphones & wearables
  - Online presence





Building Blocks of an IoT System

- Sensing
- Connectivity
- Gateways
- Processing
- Software
- Power



Where does networking come in…

- The Role of Communications
  - Providing a data link between two nodes
- Communication type:
  - Wireline (e.g. copper wires, optical fibers)
  - Wireless (e.g. RF, IR). RF-based communication is the most popular choice
- Popular RF-based communication solutions:
  - IEEE 802.15.4
  - IEEE 802.11 (or Wi-Fi)
  - Bluetooth
  - Near Field Communication (NFC), e.g. RFID

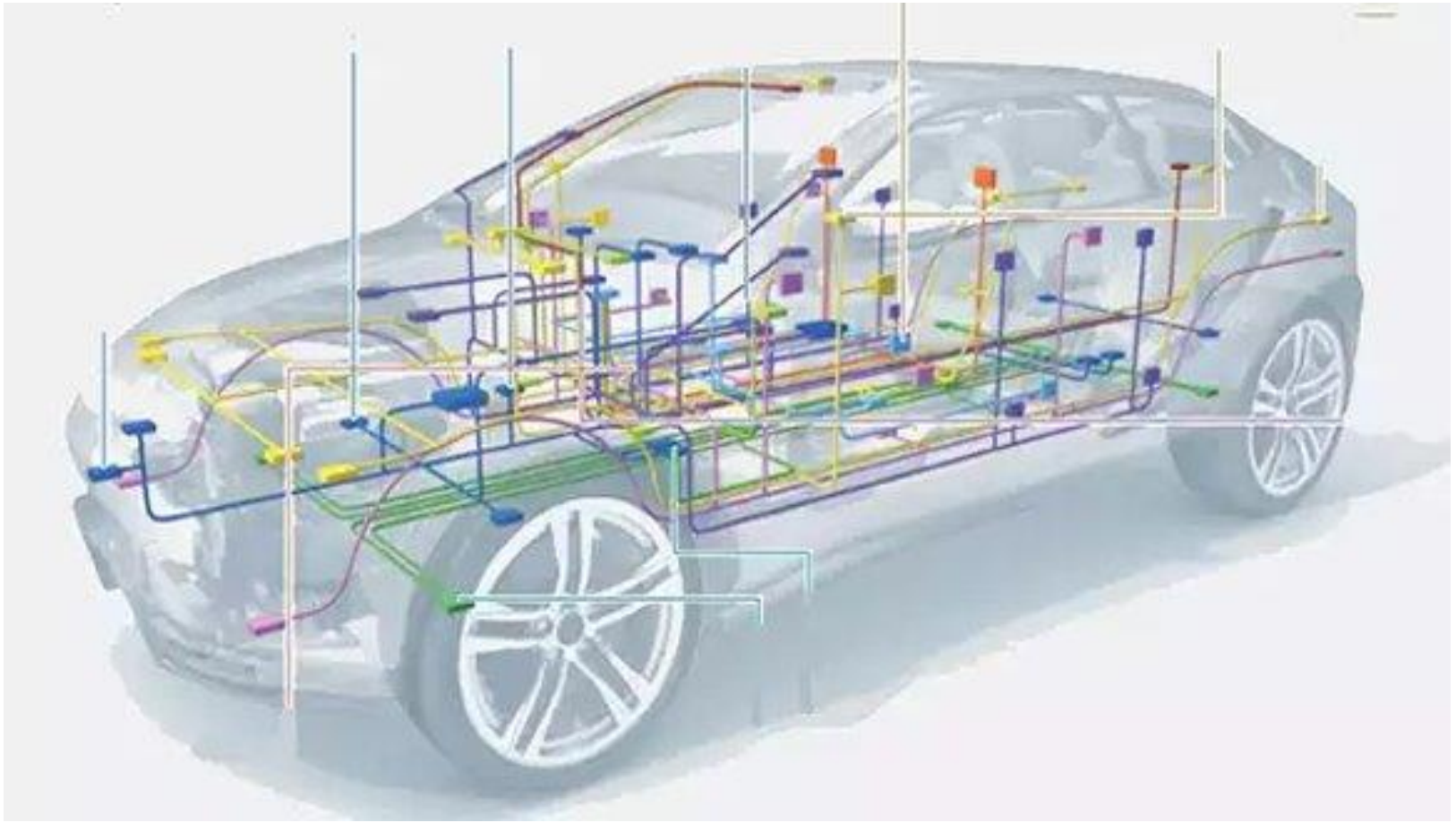
Networking and IoT

- The Roles of Networks
  - Managing connected devices (discovery, join, leave, etc).
  - Relaying data packets from the source to the destination node in the network.

- IoT is a distributed system. All nodes need to perform networking related tasks.
- Main concerns as before: Reliability, Performance, Security, QOS, Scalability

http://www.psemi.com/markets/industrial/internet-of-things

Connected Car



Learning about Networks/IoT

- Can't create complex networks at home however you can create "virtual networks"
  - Virtualbox hypervisor
  - Vagrant
- Can use programmable, multi-channel, prototyping device to investigate different mediums, protocols, IoT etc.
  - Raspberry Pi has bluetooth, Wifi, Ethernet, SPI, I2C...