

Computer Network I

Reti di Calcolatori I

Università di Napoli Federico II – Scuola Politecnica e delle Scienze di Base
Corso di Laurea in Informatica

Riccardo Caccavale
(riccardo.caccavale@unina.it)



Services

Internet

- The **Internet** is the ultimate WAN, connecting devices all around the globe.



Internet is network of networks. It is technically huge WAN that allows sub-networks and devices to be connected over different nations and continents

The idea of such “universal” big network was initially theorized by researchers (most notably J.C.R. Licklider) around 1950 and started to become reality almost 10 years later.

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Internet

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- Brief history of Internet:
 - The Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense awarded contracts for the development of the **ARPANET** project (1969).



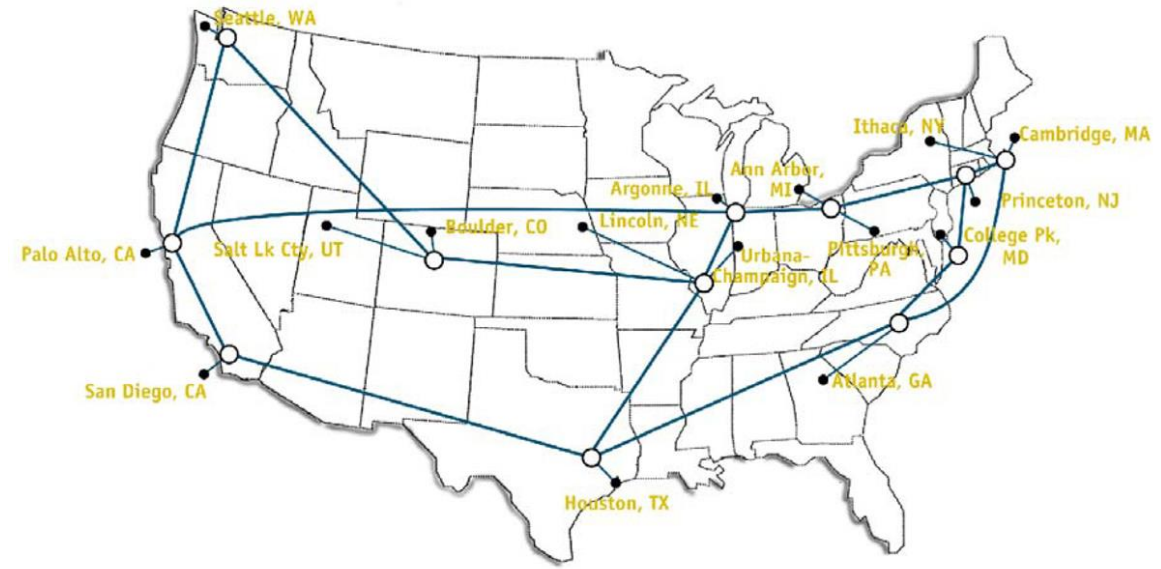
Initial ARPANET having 3+1 nodes: SRI, UCLA, UCSB, and UTAH (1969)

The initial ARPANET was mainly a closed network designed to include universities and research centers. Similar networks were independently created in US and Europe.

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- Brief history of Internet:
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 - R. Kahn (ARPA) and V. Cerf (Stanford) designed the Transmission Control Protocol (TCP) and Internet Protocol (IP), two protocols of the **Internet protocol suite** (1974).
 - The National Science Foundation (NSF) awarded contracts for the **NSFNET** project, a TCP-IP based network (1986).



NSFNET in 1992 (Wikipedia).

The NSFNET and the TCP/IP protocol went toward the idea of a *network of networks*. Both ARPANET and NSFNET carried **commercial restrictions**.

Internet

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- Graphical representation of routing paths for a portion of Internet (Wikipedia)

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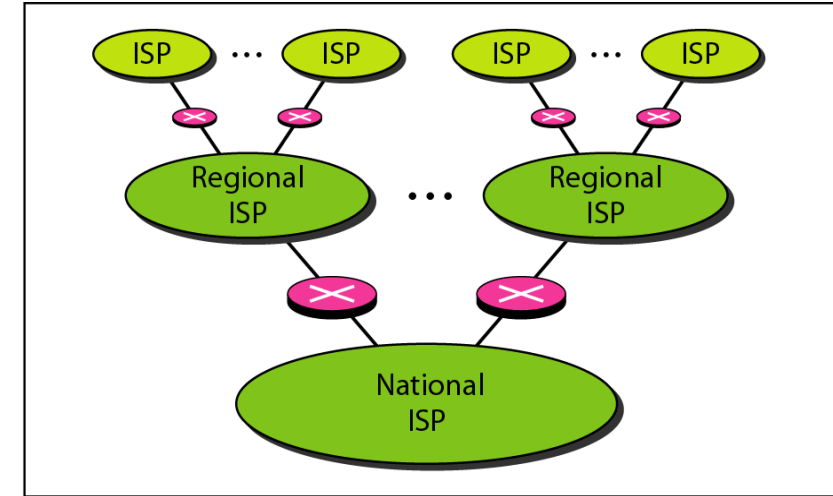
Introduction

- The main role of computer networks is to allow data exchange between multiple devices from different locations, but raw data are just a mean to reach **services** and **resources** provided by the network.
- A network **resource** is a remote “object” we want to have access to (web pages, storage, computation, video or audio files, etc.).
- A network **service** is an “action” that a remote device performs for us (give me the current time, let me send an e-mail, let me store files, etc.).
- The difference between these two definitions is somehow subtle (e.g., let me *see* a *video*, *give* me access to a *web page*, are actions involving objects).
- Entities who offers services on Internet are called **Service Providers**.

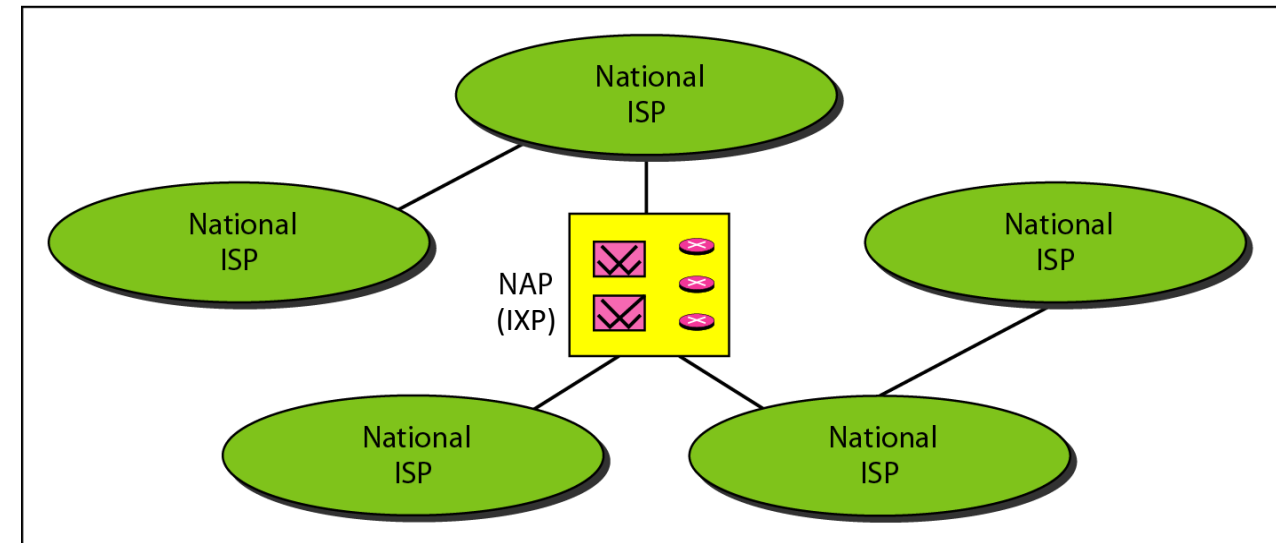
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Internet Service Providers

- **Internet access** is the basic service.
- An **Internet Service Provider (ISP)** is an organization that provides services for accessing, using, or participating the Internet.
- ISPs can be organized as commercial, community-owned, non-profit, or privately owned (e.g., by private companies or universities).
- Different ISPs exchange data through **Network (neutral) Access Points (NAPs)** or **Internet Exchange Points (IXPs)**.



a. Structure of a national ISP

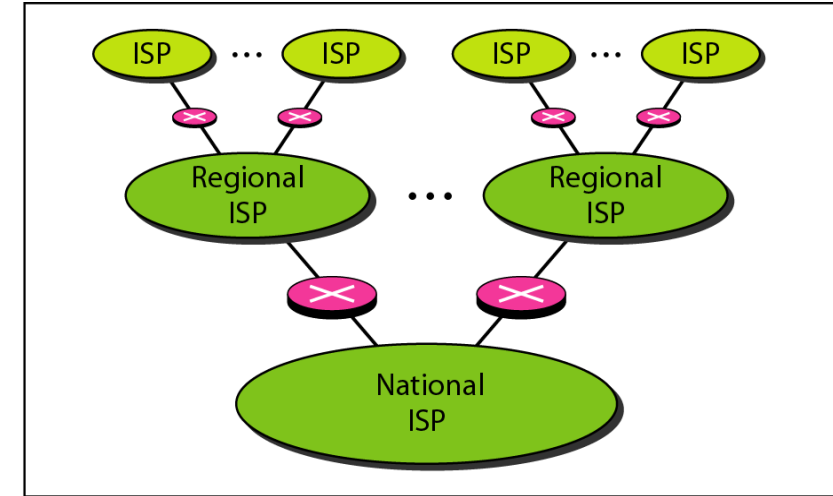


b. Interconnection of national ISPs

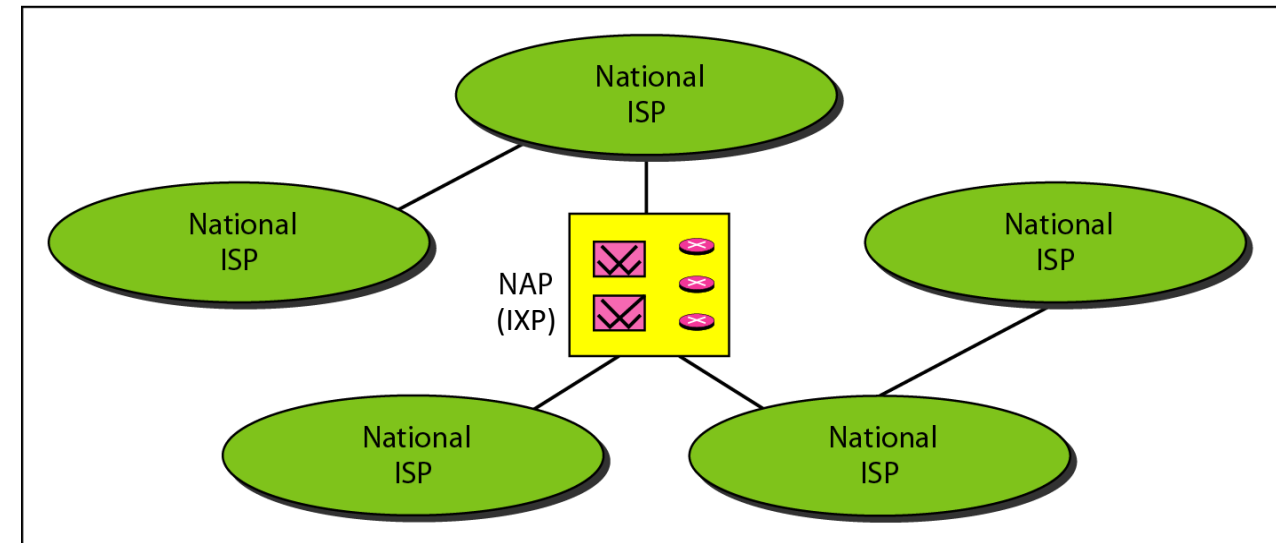
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Internet Service Providers

- An ISP network is hierarchically defined:
 - A **point of presence** (PoP) is a group of one or more routers used by ISPs to reach the customers.
 - **Access** ISPs for local areas.
 - **Regional** ISPs for larger areas.
 - **National** ISPs for nations.
- An **Internet exchange point** (IXP) works as a meeting point between multiple ISPs, typically managed by third parties.



a. Structure of a national ISP



b. Interconnection of national ISPs

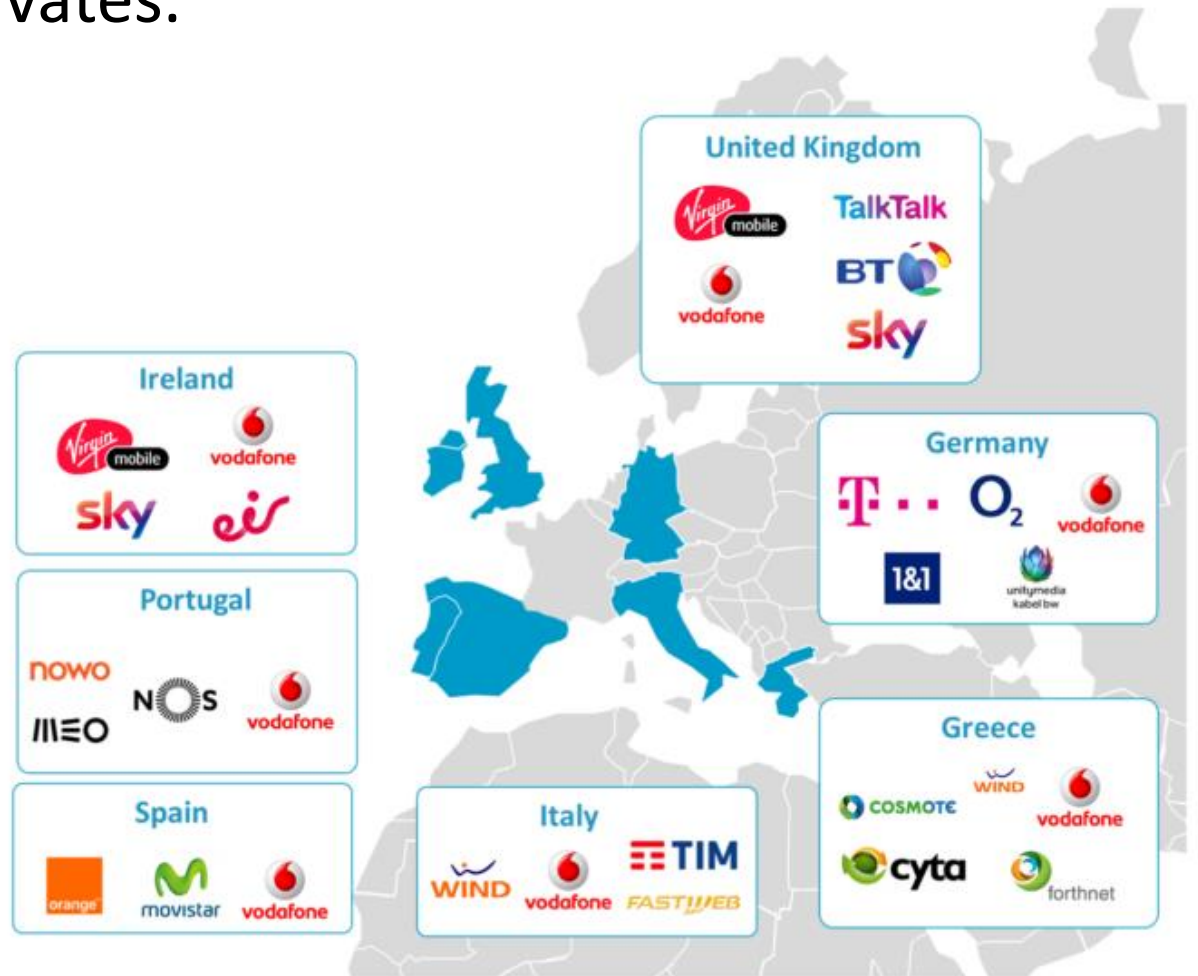
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Example of ISPs

- On a national scale there can be several commercial ISPs which provides internet services to companies and privates.

- Some Italian ISPs are:

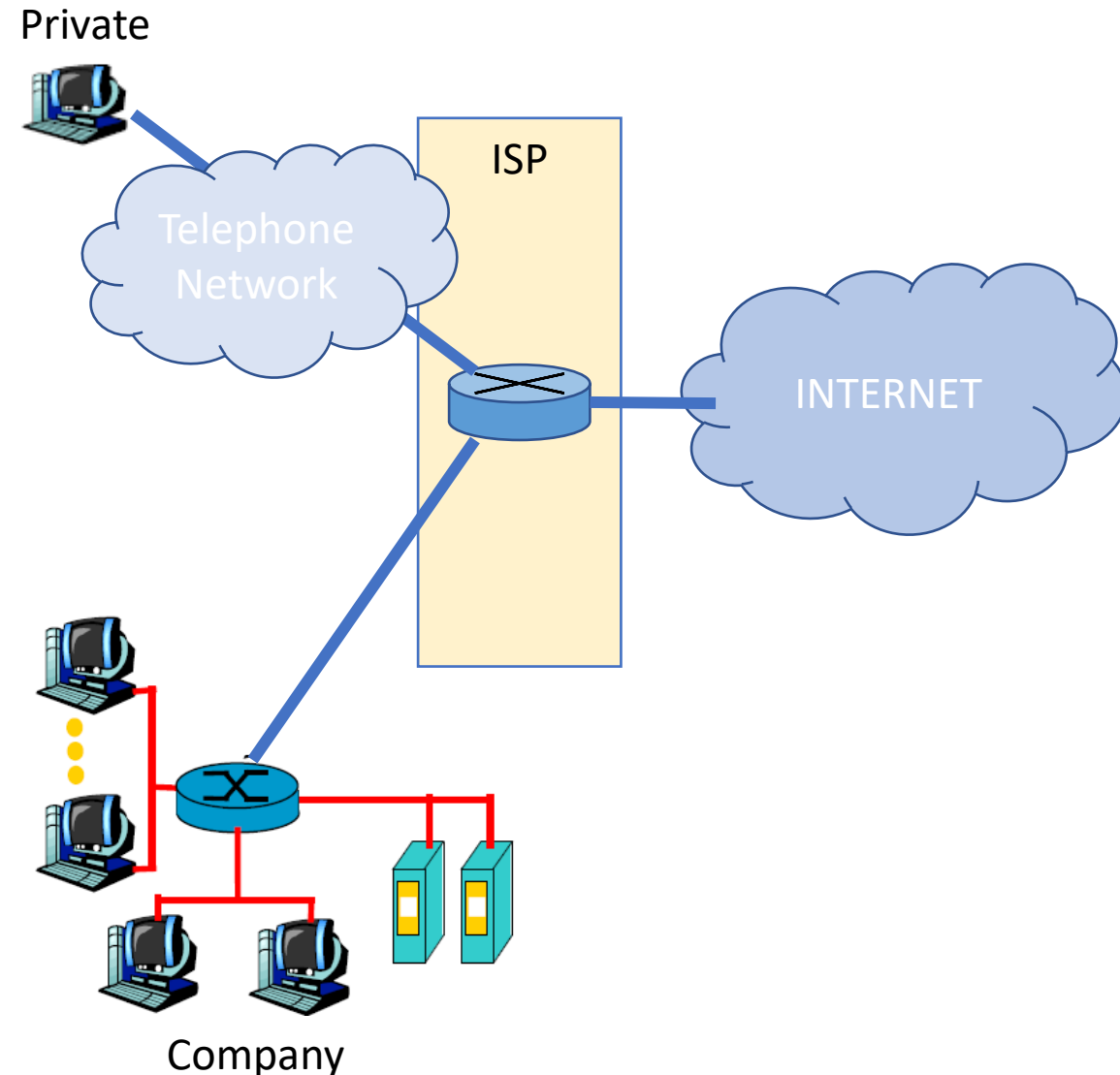
- Telecom Italia.
- Fastweb.
- Vodafone.
- Tiscali.
- ...



Services

Internet Connection

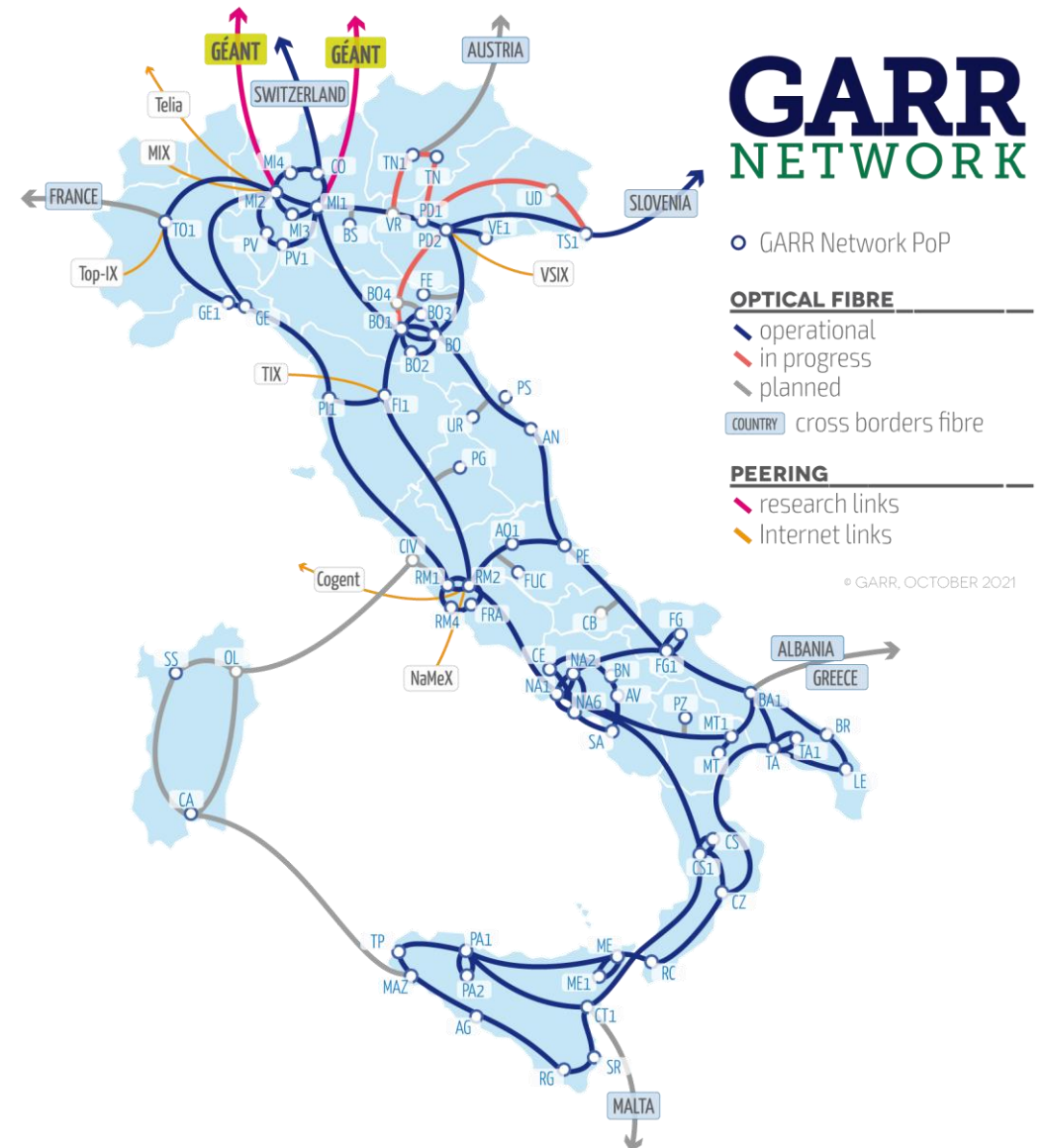
- Private internet connections are established via **Modem** enabled by the telephone network.
 - Analogic (56kbps).
 - Integrated Services Digital Network ISDN (128kbps).
 - Asymmetric Digital Subscriber Line ADSL (1Mbps to 20Mbps).
 - Twisted-Pair Copper Wire (10Mbps to 100Mbps).
 - Optical Fiber (50Mbps to 40Gbps).
- Companies (especially medium/large ones) can have a direct/dedicated connection to the ISP.



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Example of the GARR Network

- The internet access of Italian universities is managed by GARR.
- GARR (Gruppo per l'Armonizzazione delle Reti della Ricerca) is the Italian national computer network for universities and research.
- The GARR network is connected to other national research and education networks in Europe and the world, is an integral part of the global Internet.



Services

Sharing Services and Resources

- The main goal of computer networks (and internet) is **to share services or resources** between different devices (and users beyond devices).
- There is a variety of **services** enabled by computer networks:
 - **File sharing**: moving, reading, copying files from remote hosts over the network.
 - **E-mails**: sending/receiving electronic mails.
 - **Instant messaging**: sending/receiving messages on-line.
 - **Video telephony**: organize and participate to calls.
 - **Web pages**: watching/showing hypertextual pages.
 - **Hardware management**: remote control (printing, surveillance, domotic systems, etc.).
 - **Hardware sharing**: using/providing hardware (CPU, memory, etc.) of/to remote hosts.
 - **Application sharing**: using/offering applications of/to remote hosts.
 - ...

Services

Sharing Services on Local Networks

- Resources can be **private** and locally available: for instance, in local networks, there can be devices (printers, air conditioners, etc.) that offer services and devices (tablet, laptop, smartphone) that uses them.
- It could be possible to use such services (for instance, printing a document or turning on air conditioning) even **without internet access**.
- However, most of today's services are **public** and provided through Internet by Service Providers.



Services

Service Providers Beyond Connectivity

- There are several famous companies whose main business is to provide services over Internet:

- Amazon (AWS),
- Google,
- Microsoft (Azure),
- IBM,
- Oracle,
- Aruba,
- Alibaba,
- ...

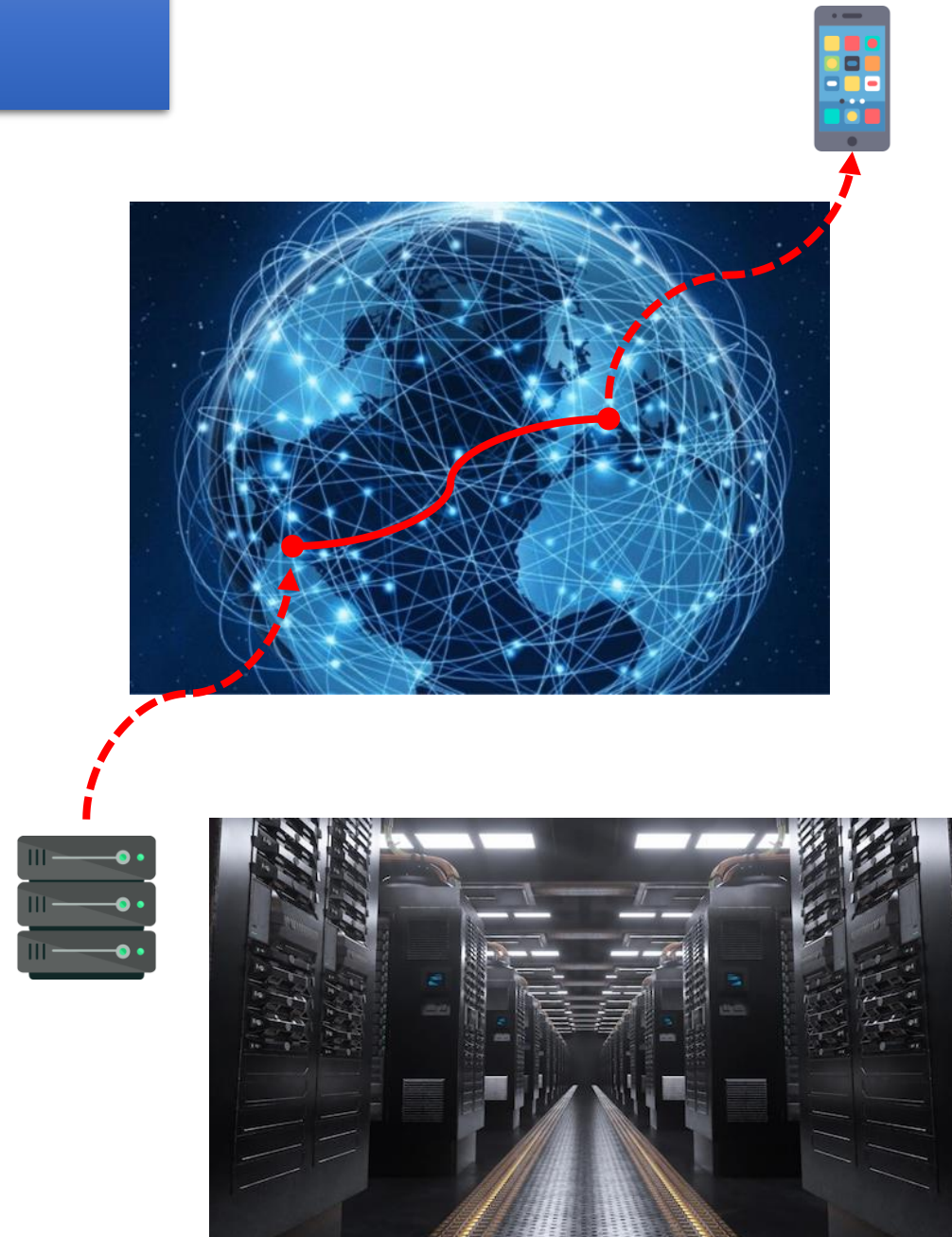


- There are different ways of providing services.

Services

Dedicated Servers

- Resources and services can be public and provided by distant **servers**.
 - A **server** is a special host designed to provide one or multiple **services**.
- For example, a web server (web pages) or an e-mail server may be on the other side of the world, but we are *almost unaware of this distance*.
- Moreover, there could be multiple servers cooperating to provide services and we would be again *unaware* of that.



Services

Grid Computing

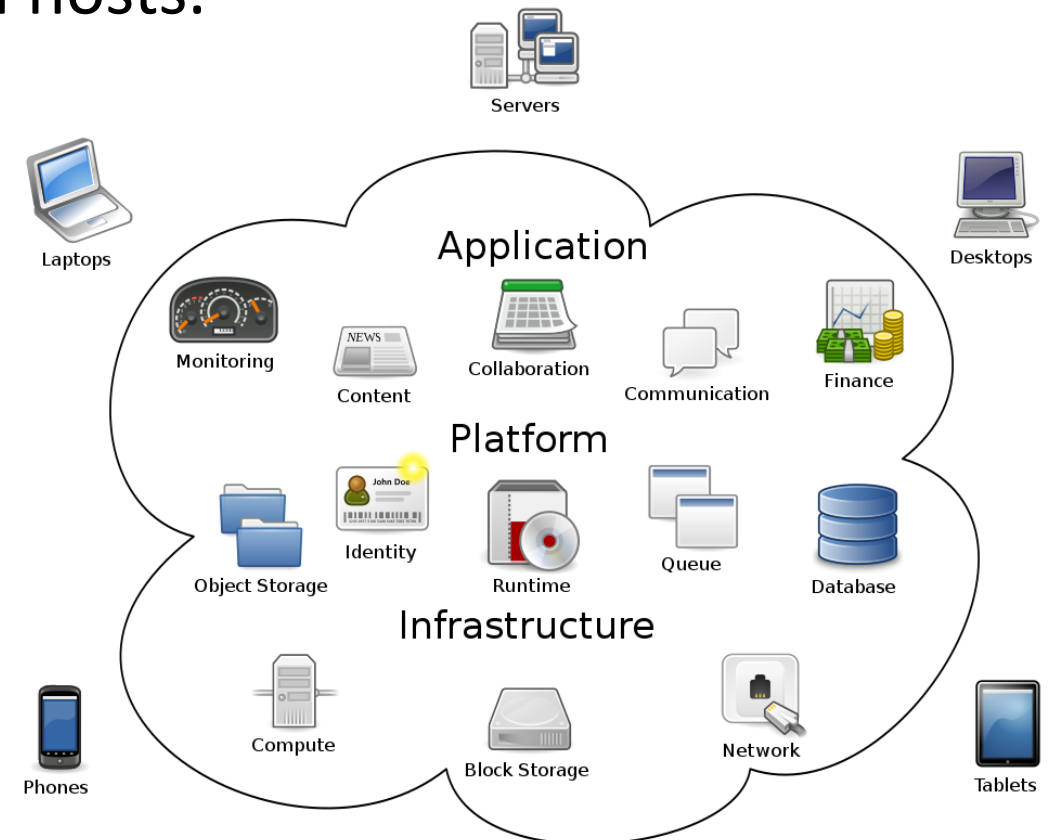
- The **grid computing** is a decentralized resource-sharing infrastructure that typically combines hardware (resources) from different hosts in different geographic locations to achieve a common goal:
 - to perform complex calculations.
 - to store big quantities of data.
- A famous example is **SETI** (Search for Extra-Terrestrial Intelligence - 1999).
- The **SETI@home** project allows PCs all over the world shares resources to analyze radio signals from space, searching for extraterrestrial intelligence.



Services

Cloud Computing

- The **cloud computing** is centralized architecture in which resources (hardware and software), typically managed by companies (service providers), are offered on-demand as services to external hosts.
- In a cloud architecture several services can be offered:
 - Applications for productivity, games, communication, social networks, etc.
 - Storage, shared databases, web servers, etc.
 - Virtual machines (with specific configurations), servers, firewalls, etc.



Services

Cloud Computing

- A widely used definition of cloud computing is provided by the **NIST** (U.S. National Institute of Standards and Technology).
- **Cloud computing** is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- This cloud model is composed of five essential characteristics:
 1. On-demand self-service.
 2. Broad network access.
 3. Resource pooling.
 4. Rapid elasticity.
 5. Measured service.

Services

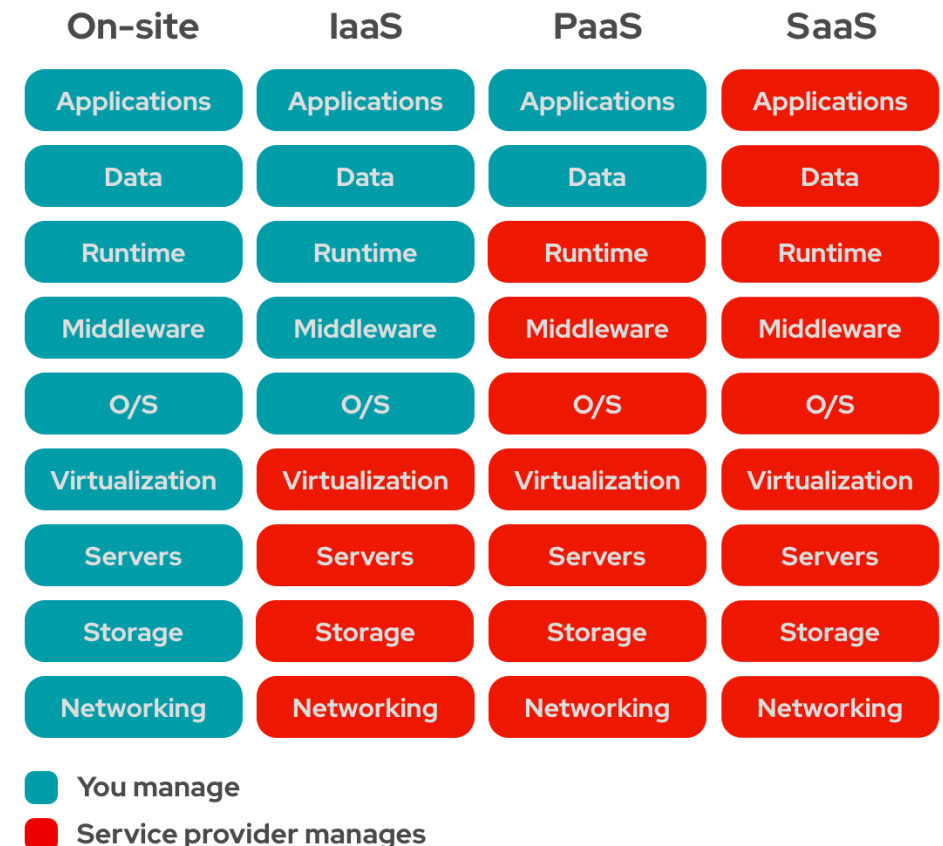
Cloud Computing

1. **On-demand self-service.** A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
2. **Broad network access.** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
3. **Resource pooling.** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
4. **Rapid elasticity.** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
5. **Measured service.** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service. Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

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Cloud Computing: Service Models

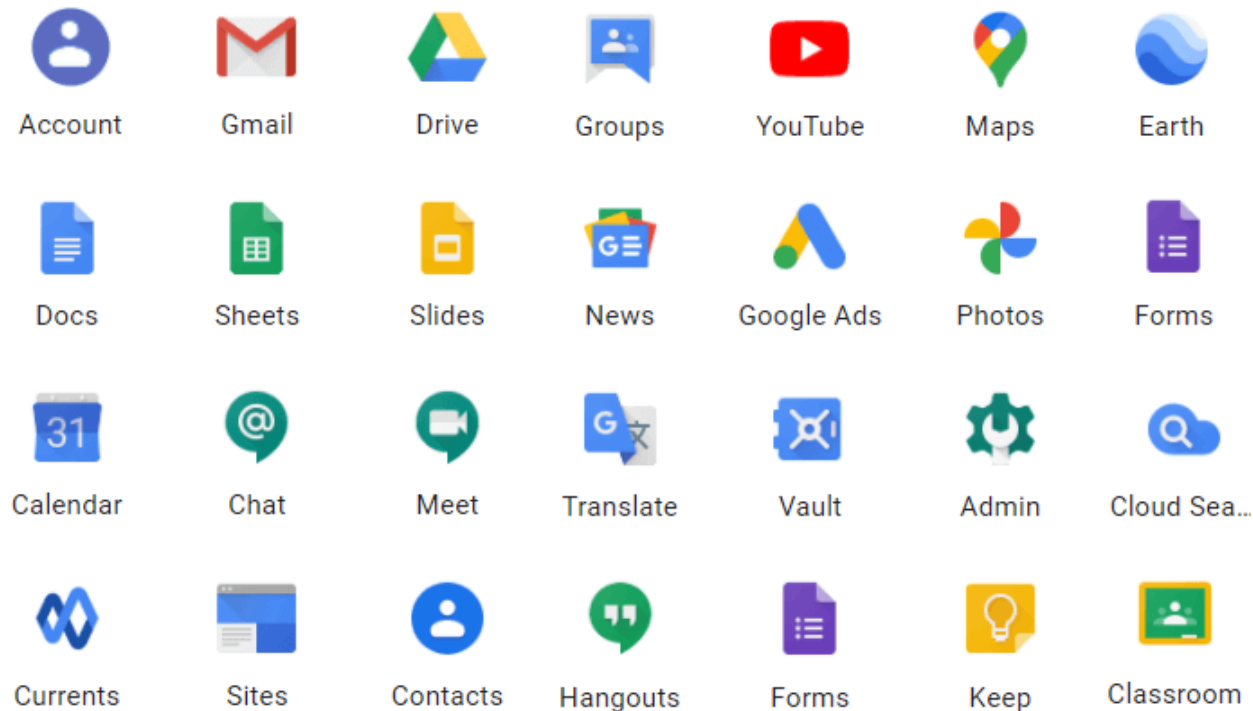
- The NIST grouped services provided by a cloud computing architecture in 3 categories (**service models**) depending on how much of the computing infrastructure is managed by the service provider.
- **Software as a Service (SaaS)**: whole applications provided along with software/hardware components needed to run them.
- **Platform as a Service (PaaS)**: working platforms provided with specific configurations (e.g., OS, APIs, etc.).
- **Infrastructure as a Service (IaaS)**: mainly the hardware is provided.



Services

Example of Cloud Service Provider

- Google is an example of Cloud Service Provider (CSP).
 - The most popular services are offered through the Google Workspace (mostly SaaS).
 - Additional services are available as part of the Google Cloud infrastructure (100+ available services).



Google Workspace

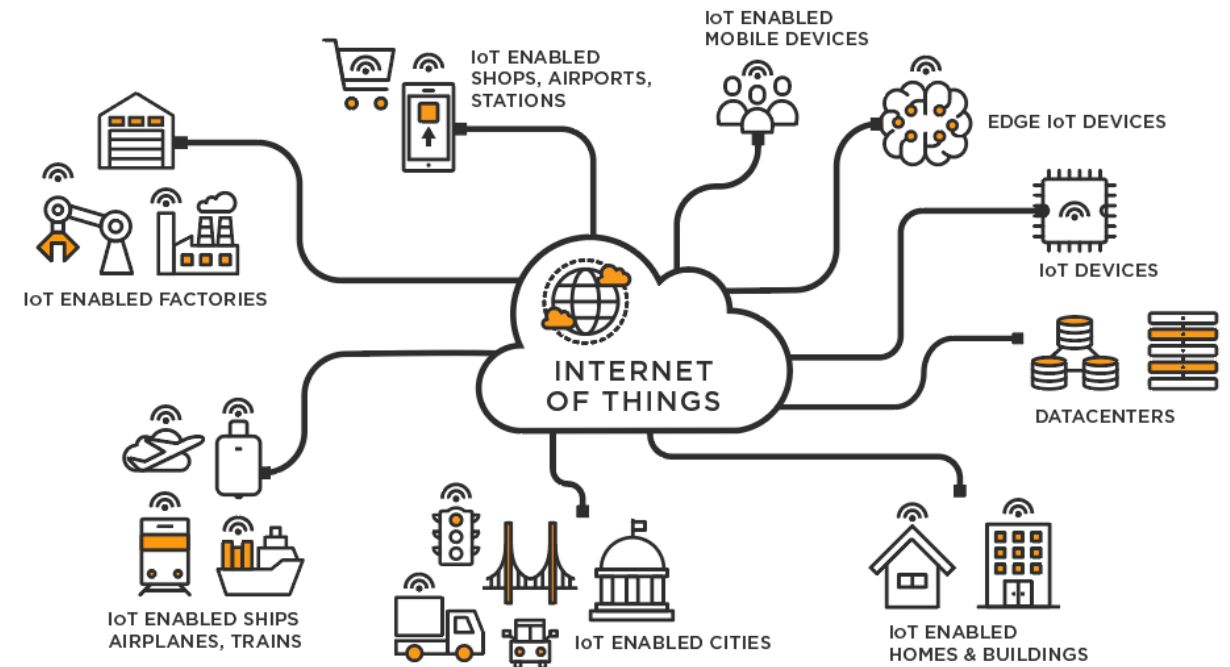


Groups of Google Cloud services

Services

Internet of Things

- The **internet of things** (IoT) is the approach of endowing simple devices (smart devices) with sensors, processing units, connectivity, etc. in order to control/monitor them remotely over internet.
- IoT can be used in combination with cloud computing to:
 - On-line manage devices using graphical user interfaces (GUIs) and remote applications.
 - Store data and information from devices.
 - Elaborate information by means of predictive algorithms or machine learning techniques.

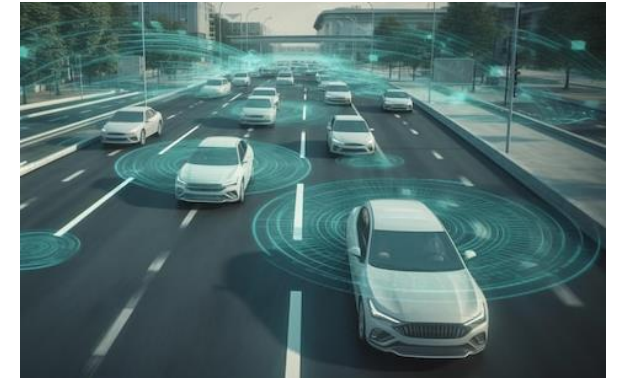


Services

Internet of Things

- Several “things” that are capable of internet connection have already been integrated in our lives:

- Smartphones
- Smartwatches
- Home Assistants
- Smart TV
- Smart Cars
- ...



- Connected things particularly emphasize issues about *privacy* and *security*.