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Internet of Things (IoT) → Introduction

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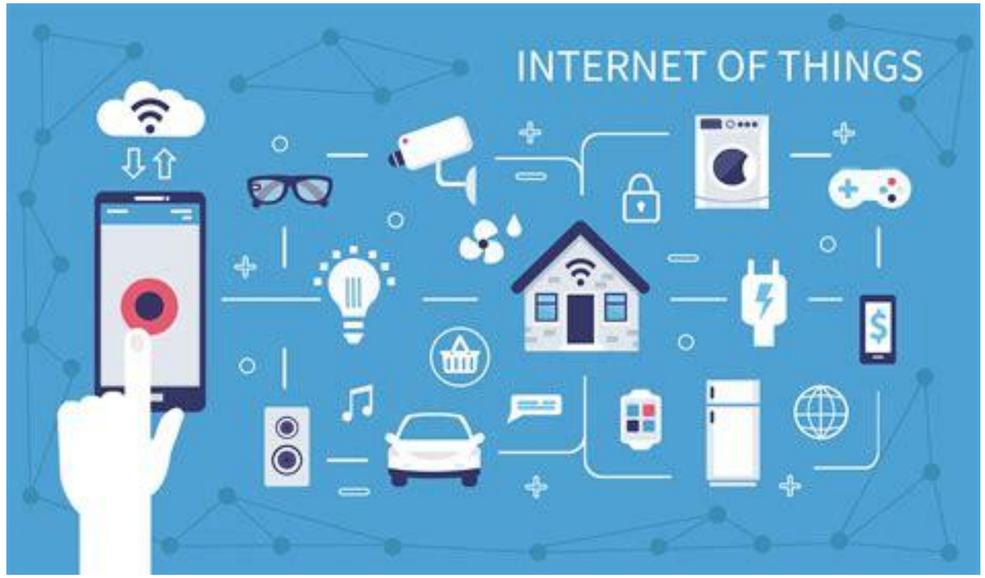
Internet of Things (IoT)

- Cyber-physical objects (both hardware and software)

  often equipped with sensors and/or actuators

  that connect and exchange data via the Internet (or other communication networks)



NOTE: browsers or network infrastructure devices are *not* considered as IoT devices

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IoT Examples

- Smart homes, equipped with smart devices, connected into smart cities, powered by smart grids, interconnected via smart transport systems, providing smart healthcare services, etc...
- Controlled via: smart-phones, smart speaker devices, special-purpose devices & apps
- Industry 4.0 (production lines), Military, ...
- Social IoT (SIoT): devices represent active human users (smart-phones, -watches, bracelets, wearables, etc → more dynamic & unpredictable ; considers social relations
- Several enabling technologies
  - E.g. Embedded systems, sensors and wireless sensor networks, control systems and automates, AI & machine learning, ...

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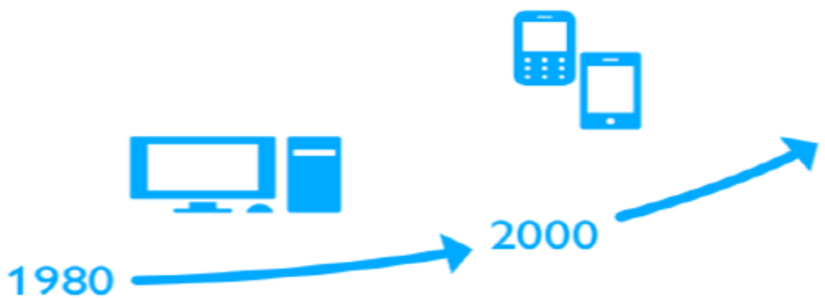
IoT Evolution

- **Mainframes** (1950s): one computer for many users
- **Personal computers** (1980s): one computer per user
- **Smart devices** (2000s): many (mobile) computers per user
- **IoT** (2020s...): “every thing” interconnected

2020

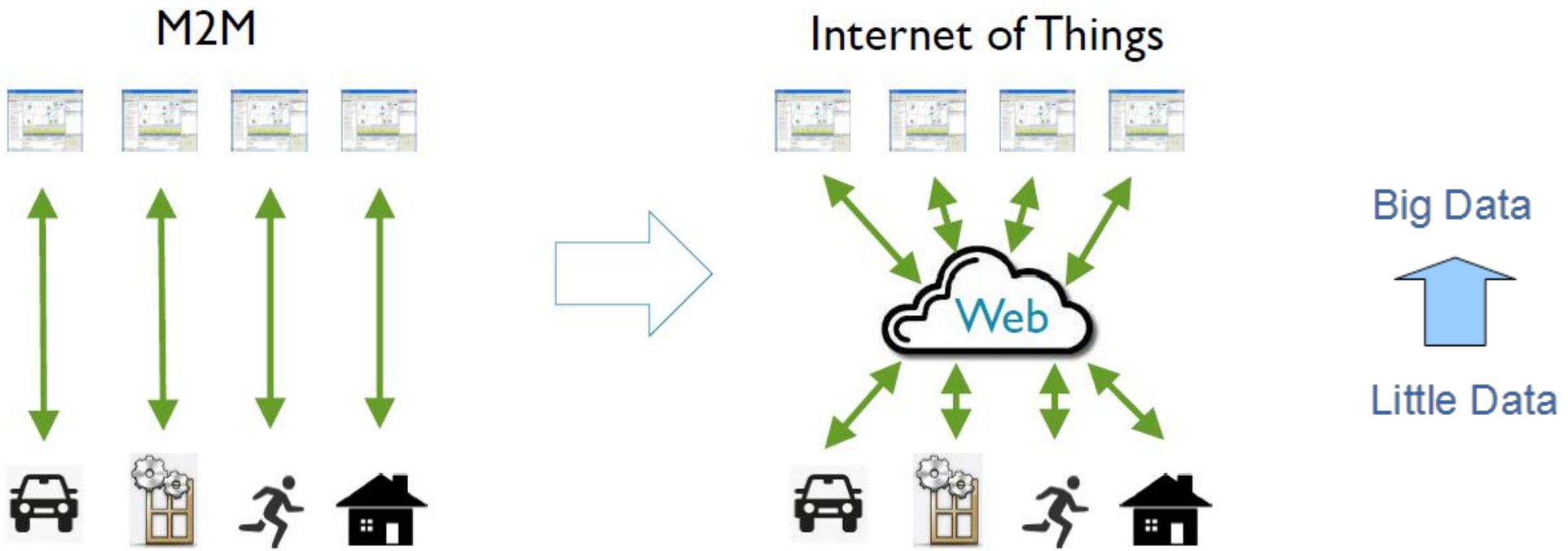


→ Scalability of integration

Machine to Machine (M2M) vs IoT

- M2M tends to be proprietary & application-specific → vertical data silos
- IoT integrates cross-applications, including back-end and cloud systems

  → Need for large-scale messaging



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Risks of IoT

- New issues of privacy, security, safety,... with all further implications
- Need for official standards, regulations, guidelines,...

  ...and informal norms and culture.

E.g.: https://data.london.gov.uk/blog/**the-trouble-with-the-internet-of-things/**

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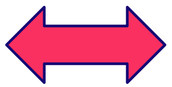
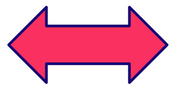
IoT Architecture(s)

- Objects ←connected to → Cloud Systems ←connected to→ Client Apps





Things: smart devices, sensors, actuators, ...

Cloud Systems (control apps, models, machine learning, data analytics, ...)

Clients: web apps, mobile apps, ...

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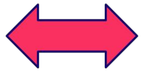
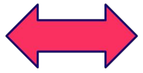
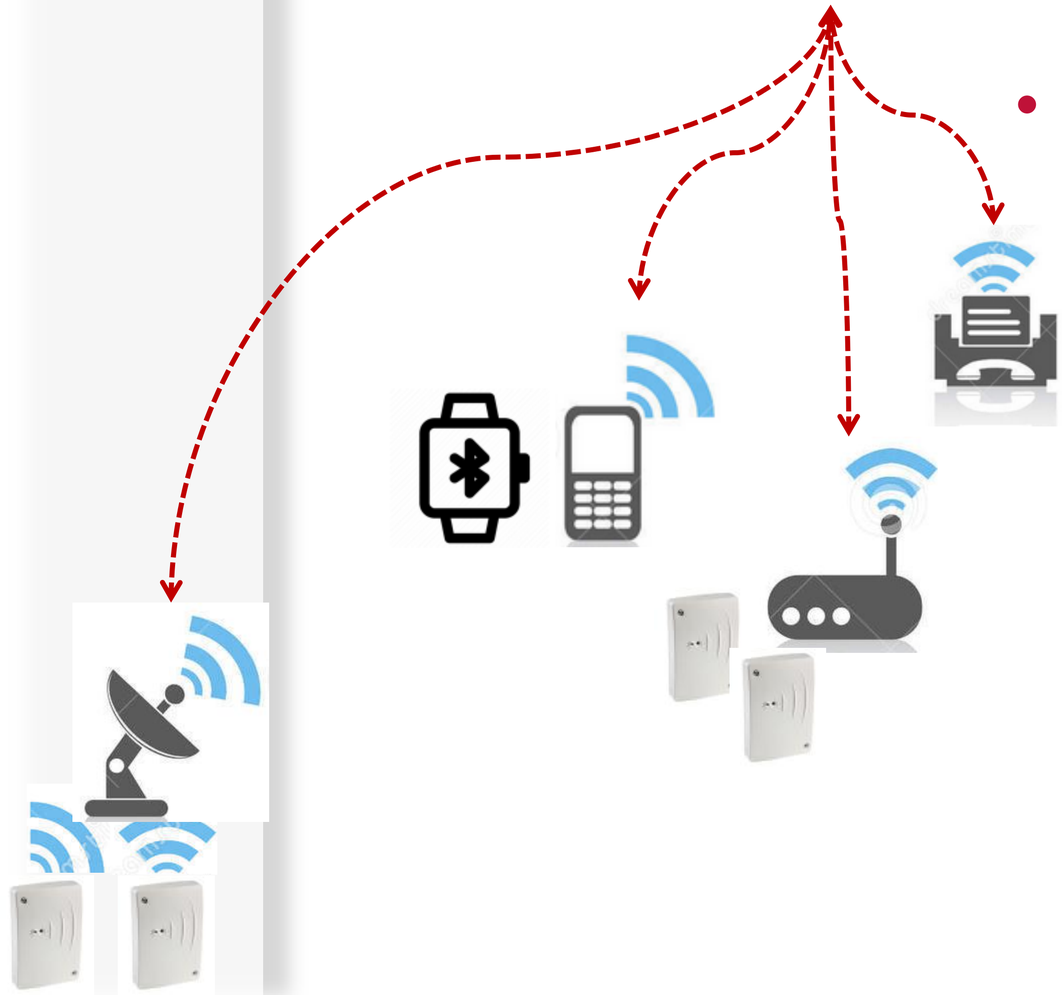
IoT Architecture(s) → Connectivity







- Connections (especially Objects ←→ Cloud)

  may rely on various media:

  - Directly to the Internet: via WiFi, 3G, 4G, 5G, ...
  - Indirectly via a Smart-Phone, Tablet, ...
  - Indirectly via a specific Gateway (Zigbee, Thread, BLE,...)
  - Indirectly via proprietary solution (GSM, SigFox, LoRa, ...)

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IoT Architecture → Characteristics & Requirements

- High heterogeneity → need for interoperability
  - Devices (hardware, software, ...) → wide range of resources, autonomy, ...
  - Networks (wired, wireless, ...) → different bandwidth, speed, reliability, ...
- Large scale
- Highly decentralised, dynamic and unpredictable
- Availability expectations (24/7), privacy, security, ...

- → need suitable communication protocols (among other building blocks)
- no suitable off-the-shelf middleware

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Existing Protocols suitable to IoT (Internet-based)

- **MQTT (63% ↗)**
- **HTTP (54% ↗)**
- **HTTP/2 (25% ↗)**
- **CoAP (22% ↘)**
- **AMQP (18% ↗)**
- **DDS (5% ↗), XMPP (4% ↘), etc.**

- **Survey Results 2018: show predominance of MQTT and HTTP (Rest)**
  - https://blog.benjamin-cabe.com/2018/04/17/key-trends-iot-developer-survey-2018

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MQTT:
- Publish/subscribe, asynchronous
- Over TCP (MQTT-SN for others)
- Simple
- Lightweight (low memory, CPU, down to 2bytes/msg)
- Performance and QoS management
- Binary format

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HTTP:
- Client / Server, synchronous
- Over TCP
- Not designed for IoT
  - → Large headers
  - → No QoS
  - → Text format

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HTTP/2 (since 2015):
- Compatible HTTP1
- Lower latency: header compression
- Server may Push data to clients
- Multiplexing several requests via single TCP connection

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AMQP:
- Publish/Subscribe (v0.9.1), Asynchronous
- Over TCP
- QoS management
- Heavier than MQTT (+60 bytes / message)

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QUESTIONS?

THANK YOU !