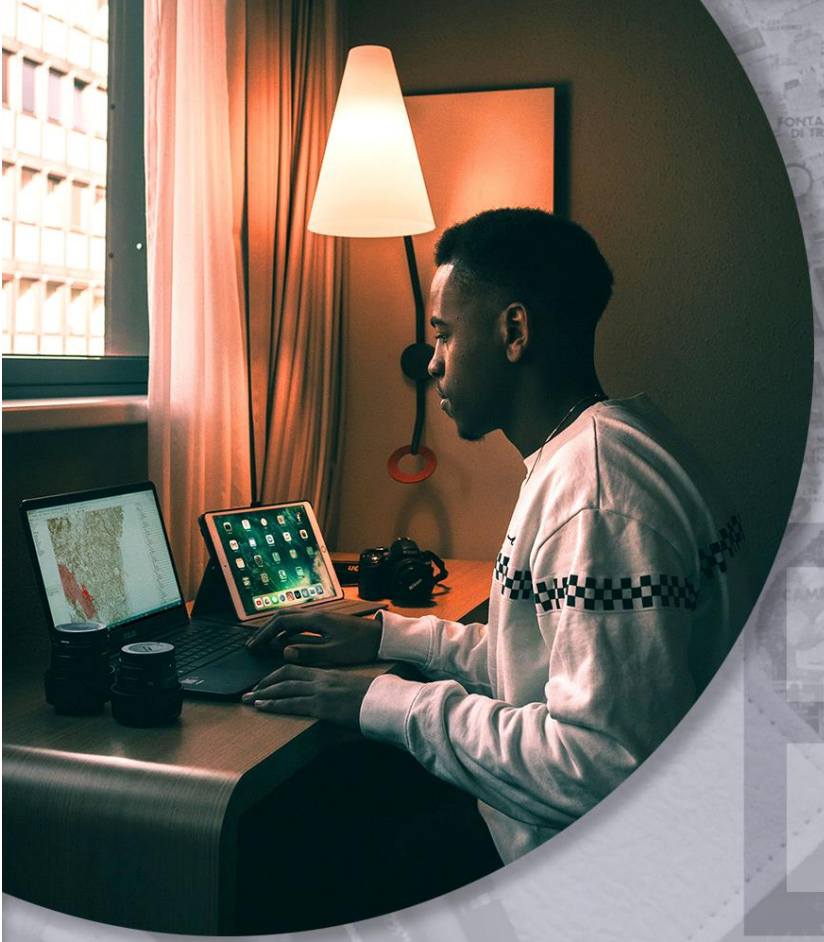

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Sensor Data Standards
April 2025

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Sensor Data Standards

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Learning outcomes

- At the end of this lecture, the learner is expected to be able to
  - Explain core concepts, such as sensors and sensor networks
  - List different types of sensors and their usages
  - Describe the basic principles of accessing standardized sensor networks

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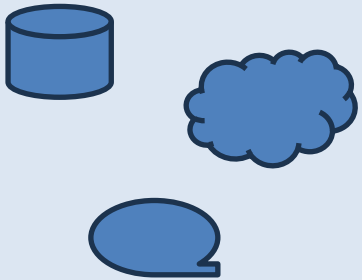
Sensor networks and digital twins

Sources: smhi.se and uppkoppladbygg.se

Figure 1. SmartHelmets and Bluetooth beacons

Data streams, alerts

Data processing



Physical world

Virtual world

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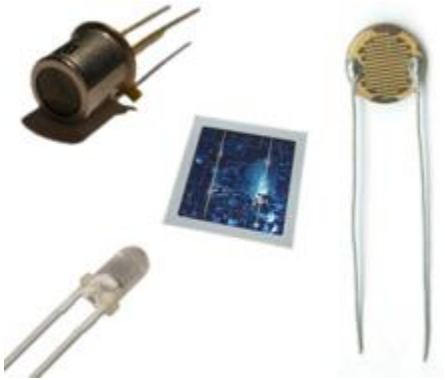
Definition of a sensor

"A sensor is a device, module, machine, or subsystem that detects events or changes in its environment and sends the information to other electronics, frequently a computer processor" (Wikipedia).

More simply: A **sensor** is a device that produces an output signal after having detected an instance of a certain physical phenomenon.

Often a sensor is equipped with a controller unit, allowing wifi connection

Different types of light sensors



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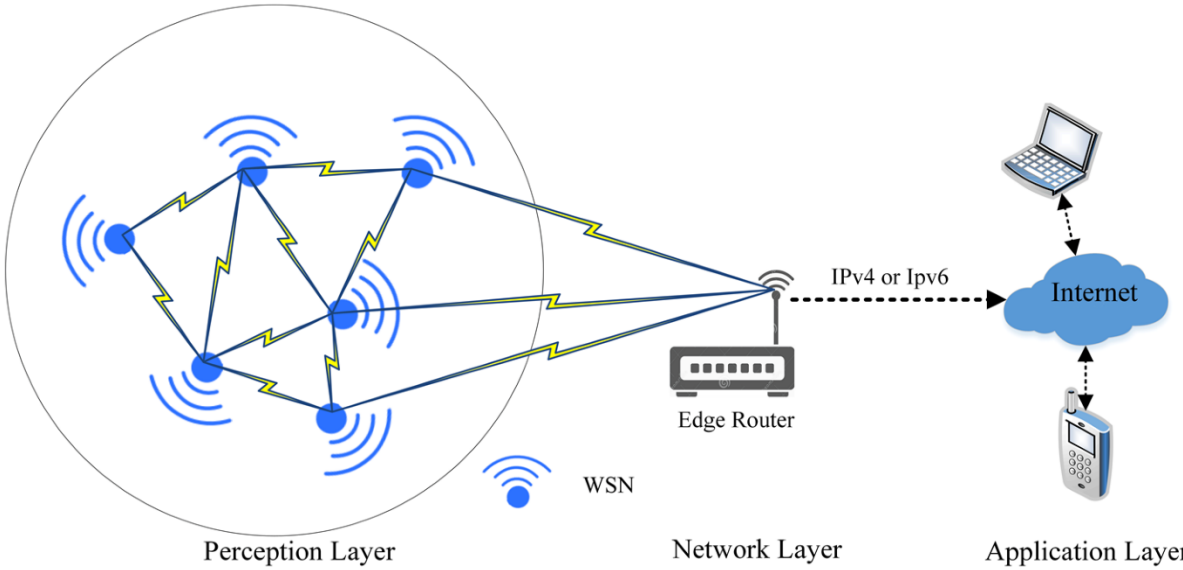
Wireless sensor networks



Source: Ahmad R, Wazirali R, Abu-Ain T. Machine Learning for Wireless Sensor Networks Security: An Overview of Challenges and Issues. *Sensors*. 2022; 22(13):4730. https://doi.org/10.3390/s22134730

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Smart Helmets

Figure 1. SmartHelmets and Bluetooth beacons

- Temperature, accelerometers and gyroscope sensors
- Bluetooth transmission to beacons (sensor controller)
- Beacons connected to the access point of the sensor network by ordinary wifi connection

Source: Rudberg M, Sezer A.A. SmartHelmets and BuildingCloud technologies.
https://www.uppkoppladbygg.se/media/amwgv2ch/ub-white-paper-ncc-scharc-smart-helmets.pdf

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Air Quality Monitoring Stations

- Only PM10 sensor in this specific case
- A/D converter and sensor controller in box
- Usually, GSM connection to the access point of the sensor network

Image: Östra Sveriges Luftvårdsförbund.
https://oslvf.se/matningar_och_vaderstationer/

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Examples of sensors

Smart homes
- Leakages, movements, temperature, energy etc

Environmental sensors
- Air, water, soil, …

Mobile sensors
- Mobile phones, car mounted

Human sensors
- Social media, usage of public resources

Source: ECT News Network, https://www.technewsworld.com/story/the-smart-home-jury-is-still-out-on-matter-ai-could-help-178442.html

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ZigBee standard

High-level communication protocol for IoT, home automation and other applications

- Low power, usually based on batteries. But sometimes batteries are not even needed
- Low data rates (around 250 kbits/sec in 2.4 GHz band)
- Close proximity (around 10-20 meters) Can be expanded by using mesh networks, up to several kilometres.

Source: Wikipedia, https://en.wikipedia.org/wiki/Zigbee#/media/File:ETRX357_ZigBee_module_with_size_ref.JPG

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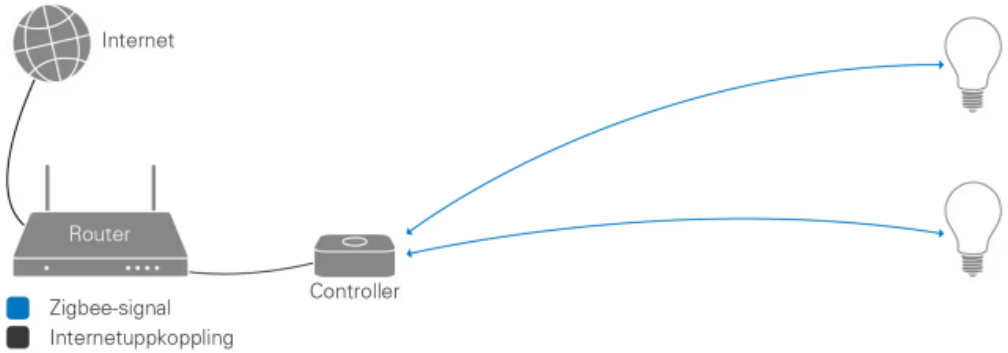
ZigBee networks

ZigBee is a low-power wireless network standard

- Can be applied to mesh networks
- For ZigBee networks, a controller is required, connected to the internet.
- It is only the controller which is connected to the internet, not the sensors themselves.



Source: Kjell & Company, https://www.kjell.com/se/kunskap/hur-funkar-det/smarta-hem/fjarrstyrning/zigbee

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Accessing Sensor networks

- HTTP (Hypertext transfer protocol is the foundation of data communication for the World Wide Web
- HTTP GET is the most used HTTP requests. It is used for retrieving data. The request may be initiated by a mouse click on a hyperlink.
- There are also other HTTP requests, for instance POST, PUT, DELETE etc.
- A HTTP GET request can easily be issued using Python

```
import request

# The API endpoint
url = ”https://mySensorNetowork.com/sensors”

# A GET request to the API
respone = requests.get(url)
```

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Web API's

- Remote Procedure Calls (RPC)
  - OGC Sensor Observation Standards
  - url=http://myAccessPoint?service=SOS&version=2.0.0& …
- Representational State Transfer (REST)
  - OGC SensorThings Standards
  - url=http://myAccessPoint/sensor
- Simple Object Access Protocol (SOAP)
  - Submitting complex messages using XML

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Open Geospatial Consortium

- Develops industry standards for the GI sector
- Established in 1994
- Consists of private companies, public authorities and academic institutions
- Developing and testing new standards are among its core activities

- Examples of standards
  - Web Map Service (WMS/WMTS)
  - Web Feature Service (WFS)
  - Catalogue Service for the Web (CSW)
  - Geography Markup Language (GML)

  - Sensor Web Enablement (SWE)
  - OGC SensorThings API

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OGC Sensor Web Enablement Services

- Sensor Observation Services (SOS)
  - Web service interface which allows querying observations, sensor metadata, as well as representations of observed features.
- Sensor Planning Services (SPS)
  - provide information about the capabilities of a sensor and how to task the sensor.
- Sensor Model Language (SensorML)
  - defining processes and processing components associated with the measurement and post-measurement transformation of observations
- SWE Service Model Implementation Standard
  - Data types for common use across SWE services
- SWE Common Data Model Encoding Standard
  - Low level data standards for exchange of sensor related data

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OGC Sensor Observation Services

- Primarily designed to provide access to sensor observations
- For access to and inserting new sensor observations and sensor metadata
- Based on RPC (HTTP GET) and SOAP (optional) (HTTP POST)
  - RPC syntax: http://serviceUri?kvp1&kvp2&kvp3&...
- Three basic operations defined
  - *GetCapabilities* - provide metadata and detailed information about the operations being available by an SOS server.
  - *DescribeSensor* – enables querying of metadata about the sensors and sensor networks available by an SOS server
  - *GetObservation* – provide access to observations by allowing spatial, temporal and thematic filtering through key value pairs

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HTTP GET request example

```
#            procedureID = sensorID

sosEndPoint = ”https://OurApiEndpoint?”
swesCommon = "service=SOS&version=2.0.0&"
getObservationString = "REQUEST=GetObservation&procedure="
+ procedureID + "&responseFormat=application/json"

sosUrl = sosEndpoint + swesCommon + getObservationString
response = requests.get(sosUrl)
```

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OGC SensorThings API

baseUri/sensor
baseUri/datastream
baseUri/observation
baseUri/thing
baseUri/location
…

response = requests.get(“baseUri/sensor”) -> All sensors in JSON

response = requests.get(“baseUri/sensor(43)”) -> Sensor with id=43 in JSON

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Handling sensor networks in QGIS

- There is currently no support for SWE services in QGIS
  - Python scripting required
  - Pre-analysis of service metadata required
- Plug-in for SensorThings API available in QGIS
  - Very few such services exists

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