Introduction to Applications based Internet of Things Network

LÊ TRỌNG NHÂN

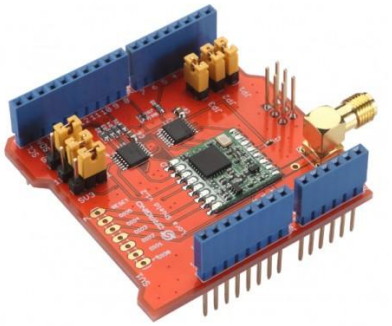
trongnhanle@hcmut.edu.vn
trongnhanle85@gmail.com

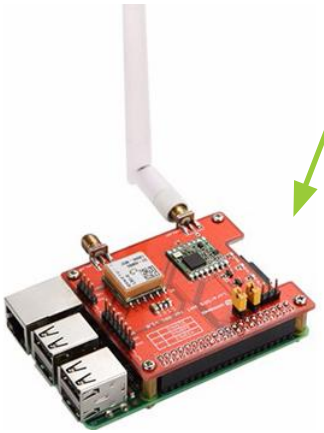
Evaluation

- 20% Mid term exam (MCQs)
- 30% Final term exam (MCQs)
- 40% Lab + 10% Project

Project Structure

- IoT Server
  - Adafruit IO





- Sensor node
  - STM32 Platform (Nucleo, Microbit or ESP32)
  - Temperature and Humidity sensors (2 sensors)
  - Wireless or wired communication
  - Modbus 485

- Gateway
  - **PC** or Raspberry Pi
  - E2E Protocol (MQTT)

- Smartphone App:
  - Unity 3D

Project evaluation

- Group project of 3 students!!!!
- Extra points:
  - Gateway:
    - Implement the gateway on Raspberry PI
    - Implement the **Error Control** for the gateway Implement the NB-IoT for the gateway (SIM7070)
  - Adafruit server:
    - Webhock service

Labs

- Lab1 (1 week): Python and Adafruit server
- Lab 2 (2 weeks) Sensor integration
- Lab 3 (2 weeks) Mobile apps
- Lab 4 (1 week) AI and Extra features

Installed Software

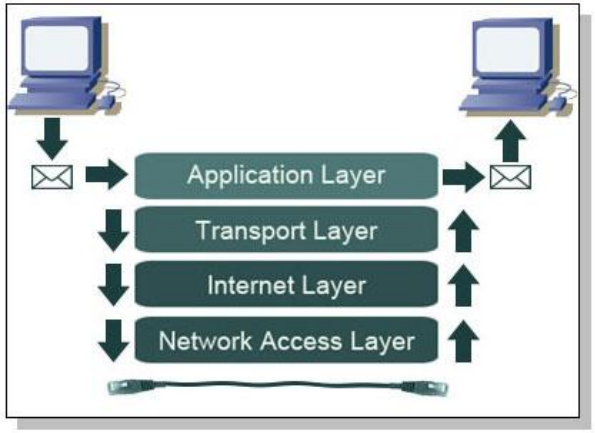
- PyCharm + Python v3.8.5
- Android Studio version 4

- STM32Cube for ARM
- MakeCode for Microbit (or Yolo:Bit) platform

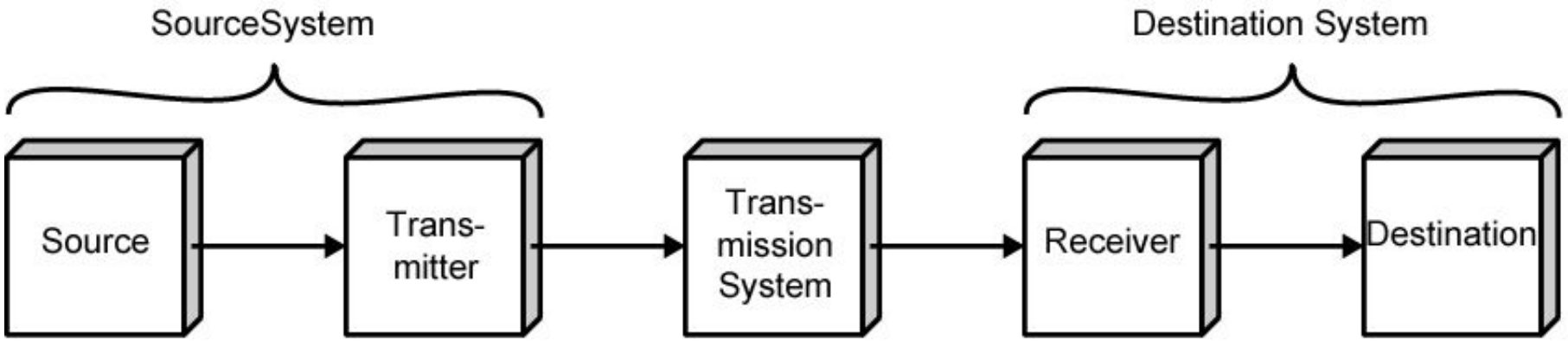
Content

- Introduction
  - Network and Internet and Internet of Things
  - Internet of Things Architecture
  - Edge Computing and Edge AI
  - Demo: Teachable Machine with Google
- Proposed block diagram for IoT Applications
  - Sensing System based on Microcontroller Platform
  - Gateway Processing using Raspberry PI or PC
- Potential Applications based IoT Network
  - Environment Monitoring
  - Smart Street Light
  - Autonomous Robots

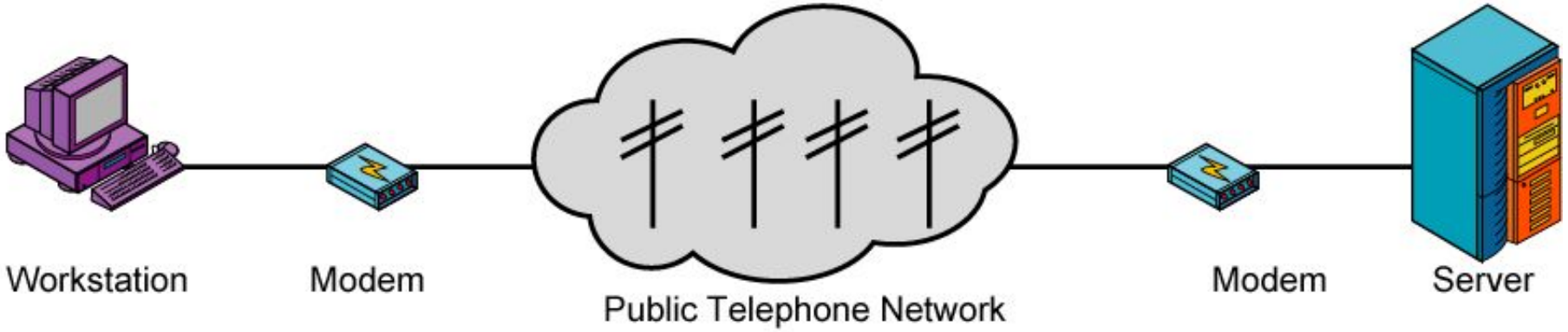
Network, Internet and Internet of Things



Communication Model

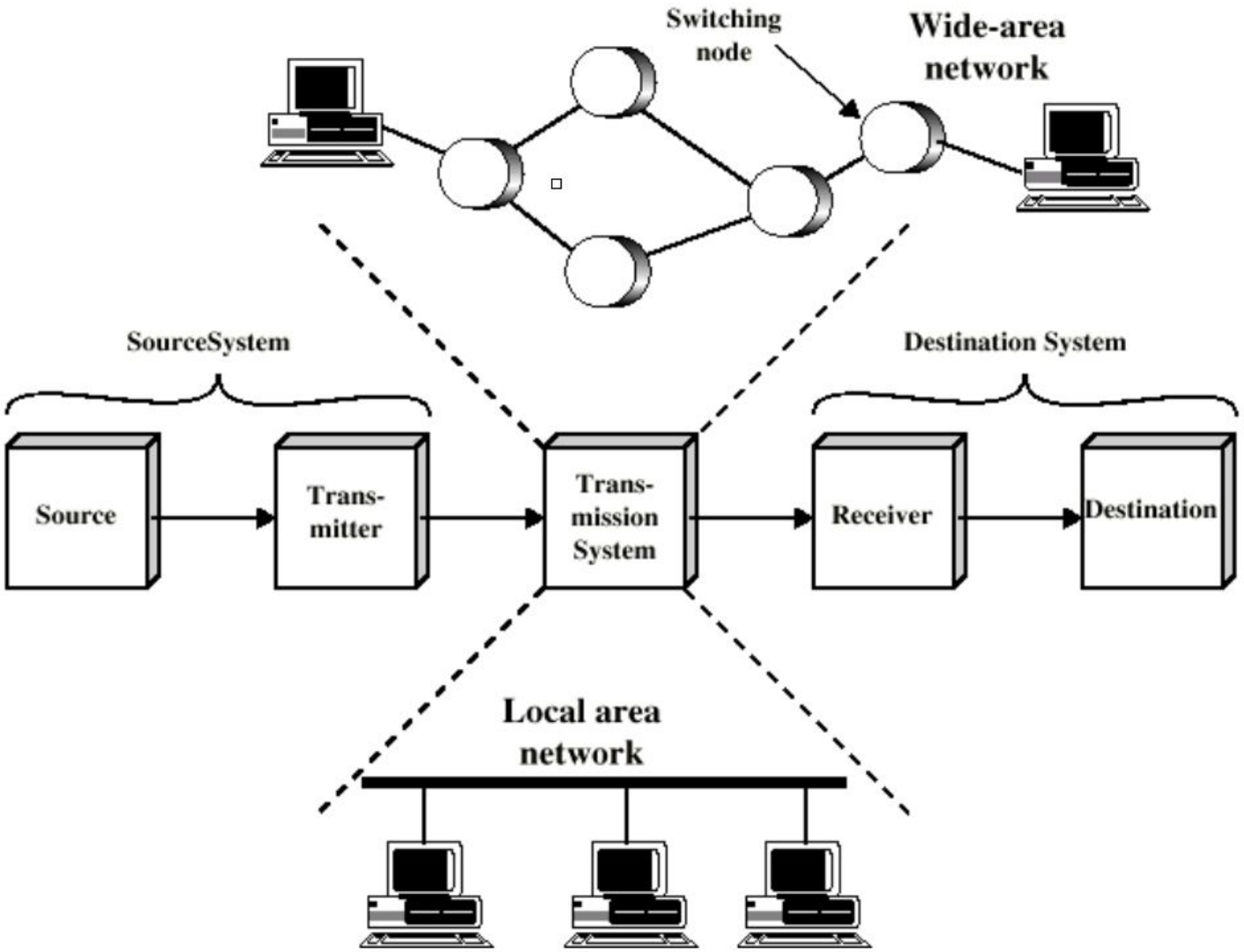


(a) General block diagram



(b) Example

Conventional Communication Networks



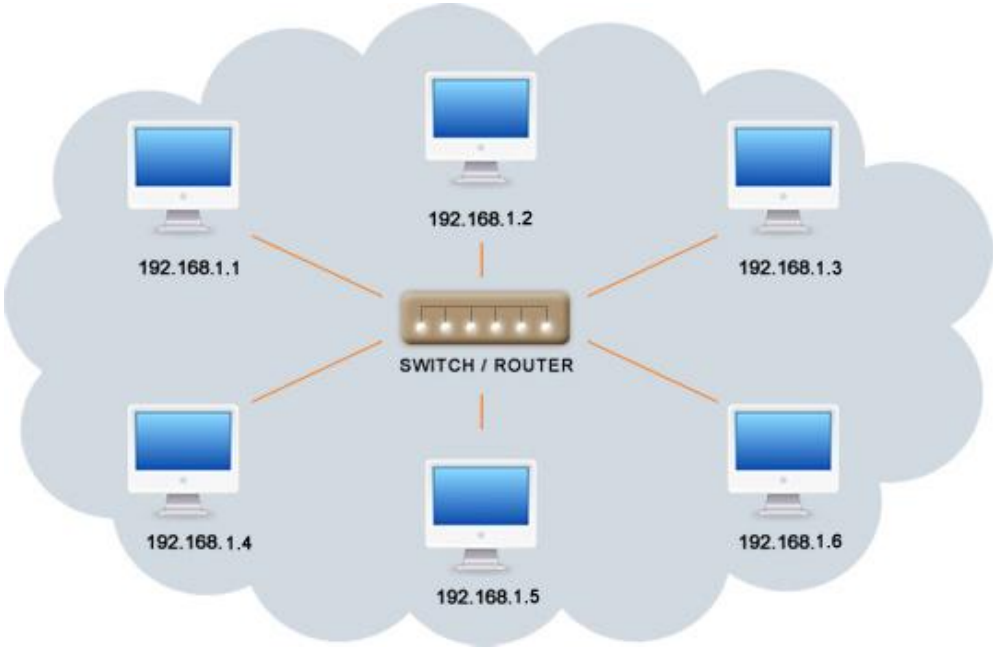
Local Area Networks (LANs)

- Characteristics
  - Smaller scope
    - Building or small campus
  - Usually owned by same organization as attached devices
  - Data rates much higher

Token- Ring

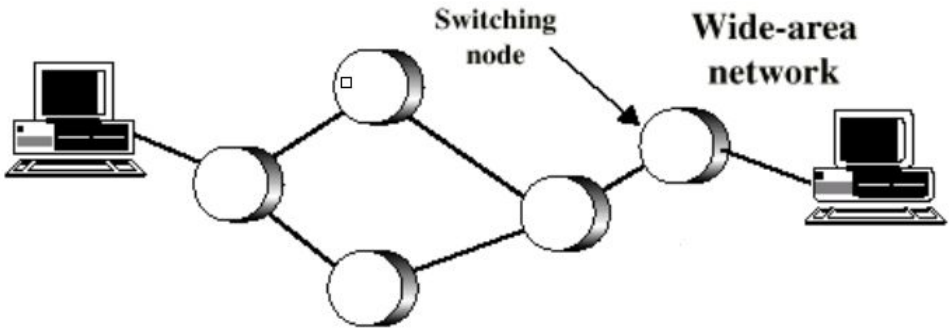
- Categories
  - Switched LANs
    - Ethernet
  - Wireless LANs
  - ATM LANs

(Asynchronous Transfer Mode)



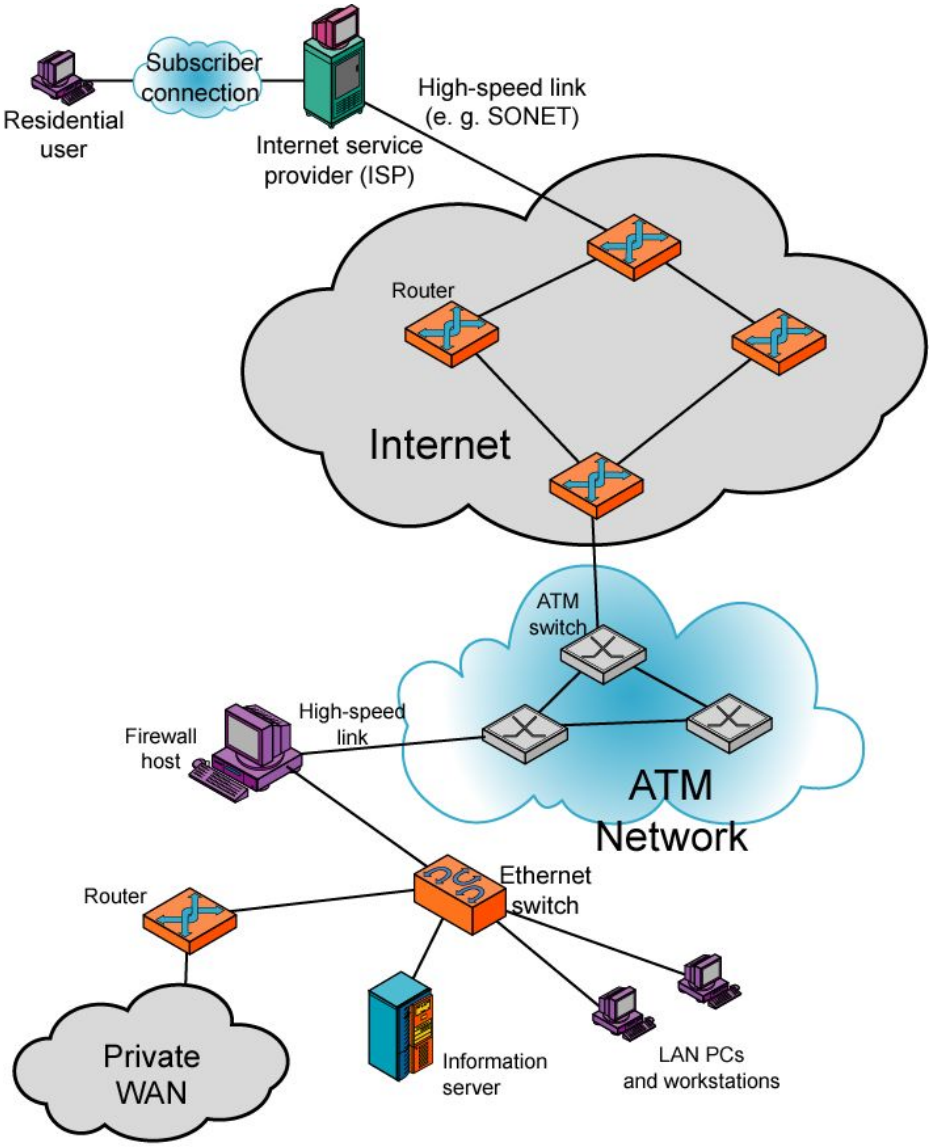
Wide Area Networks (WANs)

- Characteristics
  - Span a large geographical area
  - Cross public rights of way



- Technologies used include:
  - Circuit switching
  - Packet switching
  - Frame relay
  - Asynchronous Transfer Mode (ATM)

Internet Network



TCP/IP Architecture

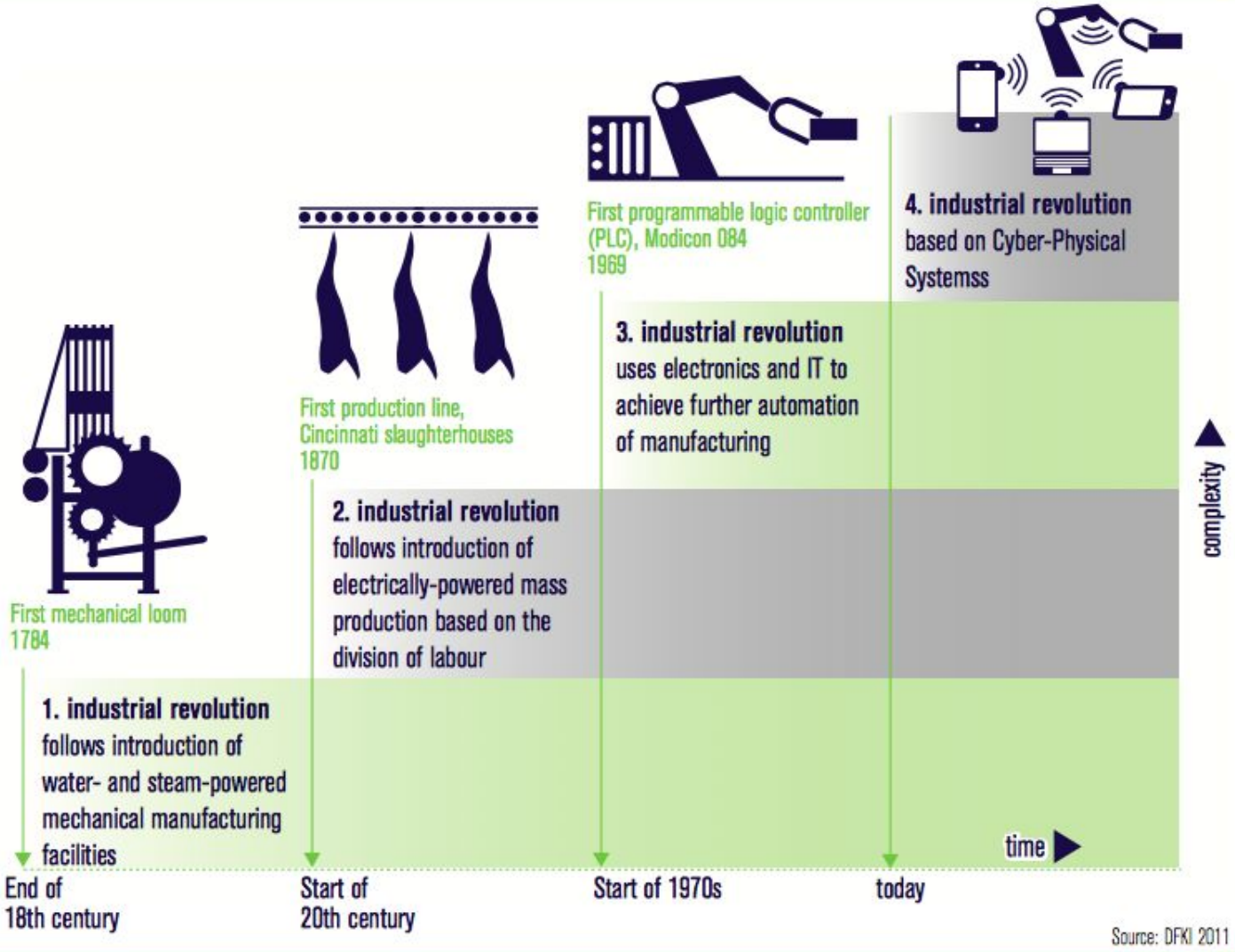
- Application
- Transport
- Internet
- Data Link
- Physical

Internet of Things (IoTs)

Internet of Things (IoT)

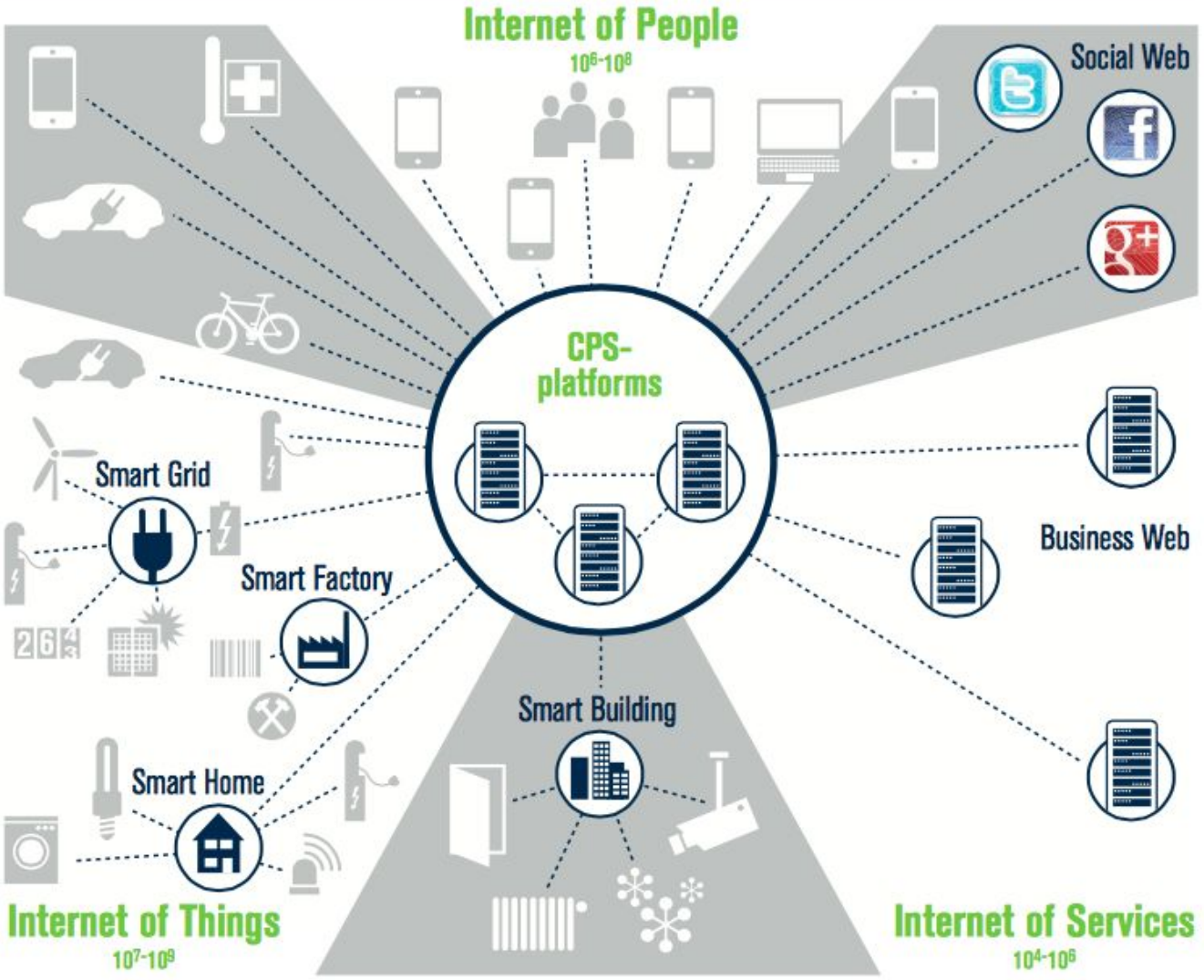
Industry 4.0

Figure 1:
The four stages of
the Industrial Revolution



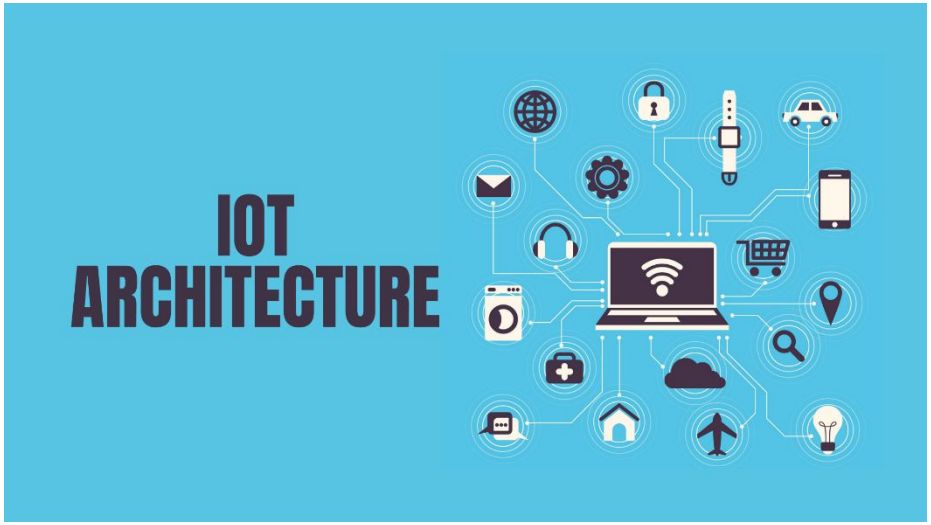
IoTs and Services

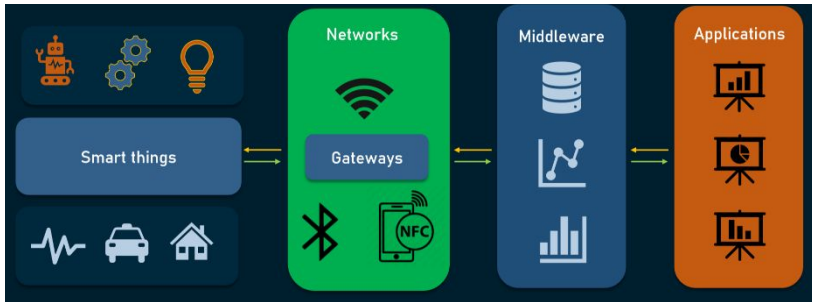
Figure 4:
The Internet of Things and Services – Networking people, objects and systems



Source: Bosch Software Innovations 2012

Internet of Things Architecture





https://www.altexsoft.com/

Internet of Things (IoT)

(Timothy Chou)

Do

Learn

Collect

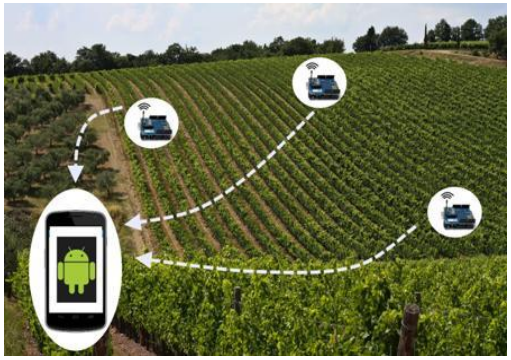
Connect

Things

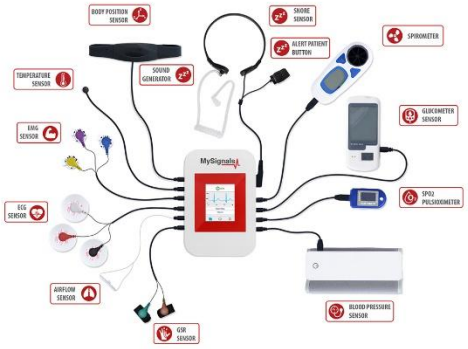
Things Layer

- Sensors are selected according to the applications:
  - Easy configuration
  - Low cost - Long lifetime
  - **Camera is used as a sensor**
- Actuators [MQTT Protocol]:
  - Remote control
  - Low latency

Smart Agriculture

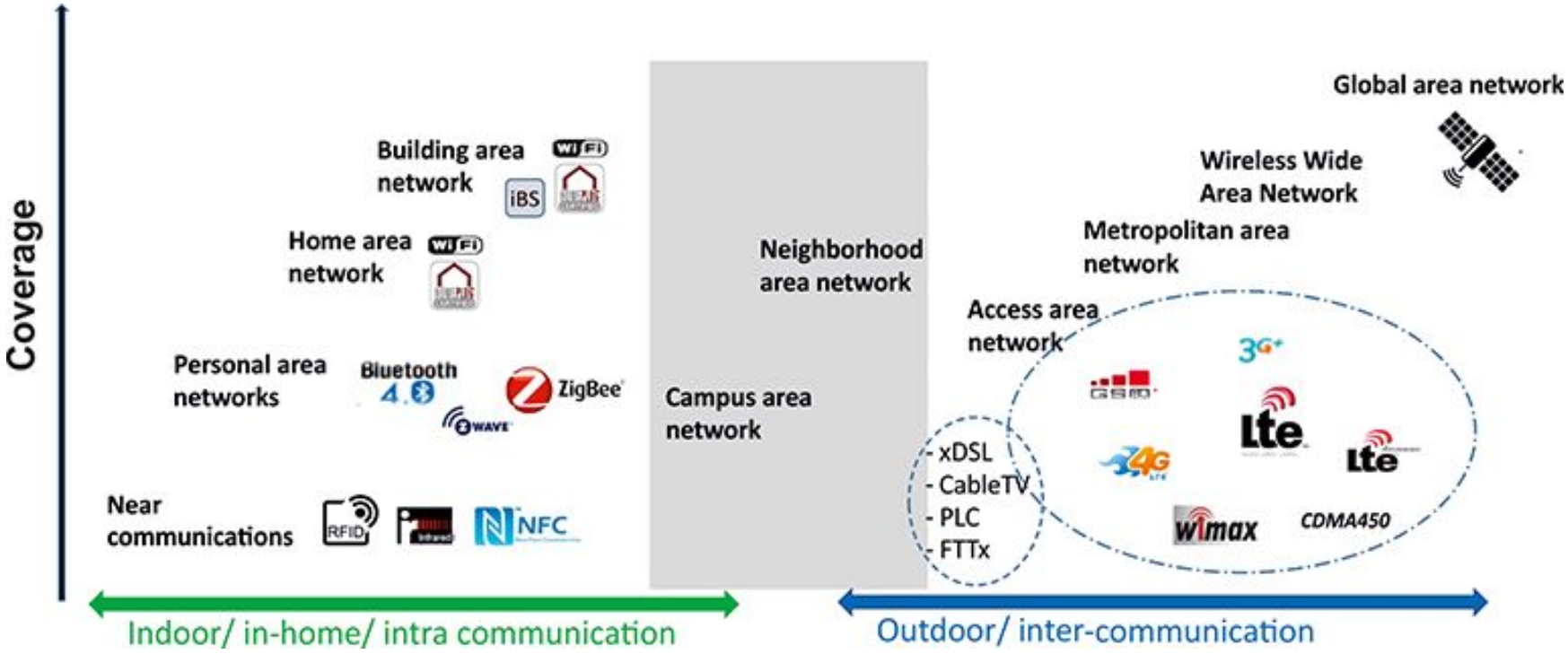


eHealth



Water Quality

Connect Layer

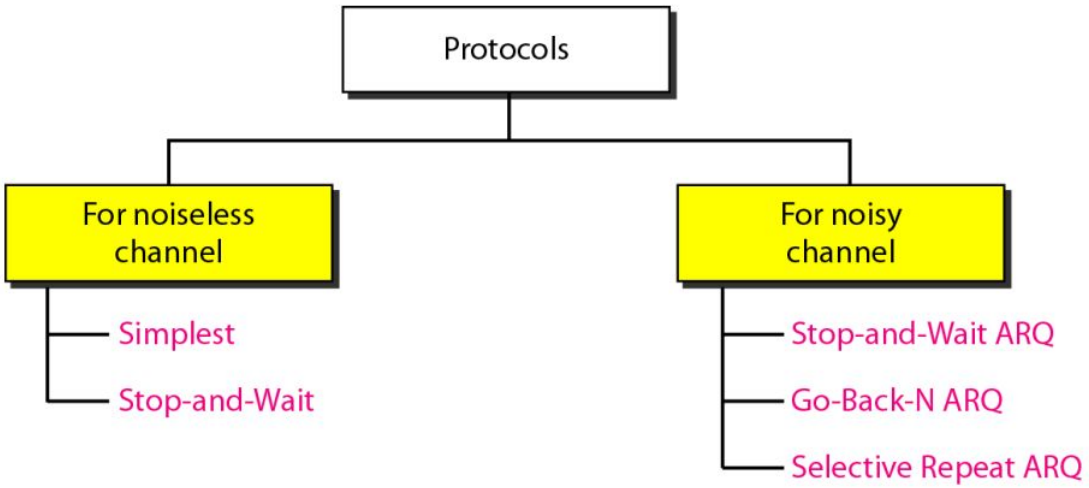


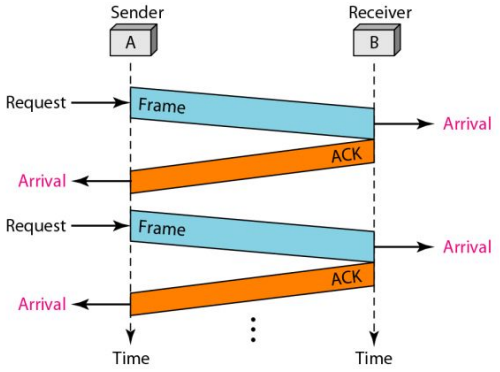
- More than 60 protocols are proposed every year
- Mobility network

Communication Protocol

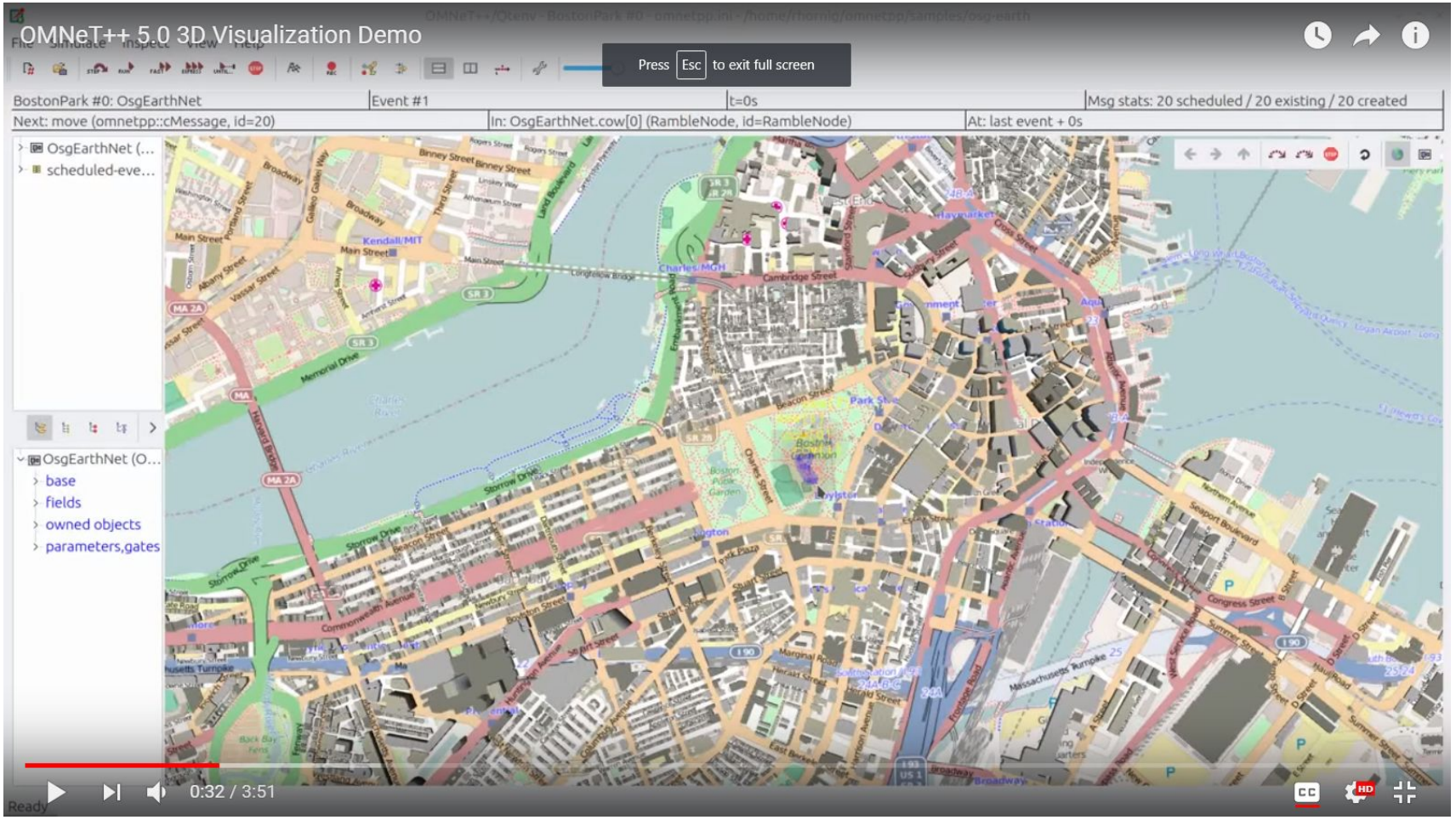
- The combination of **framing**, **flow control**, and **error control** to achieve the delivery of data from one node to another.

- The protocols are normally **implemented in software** by using one of the common programming languages.

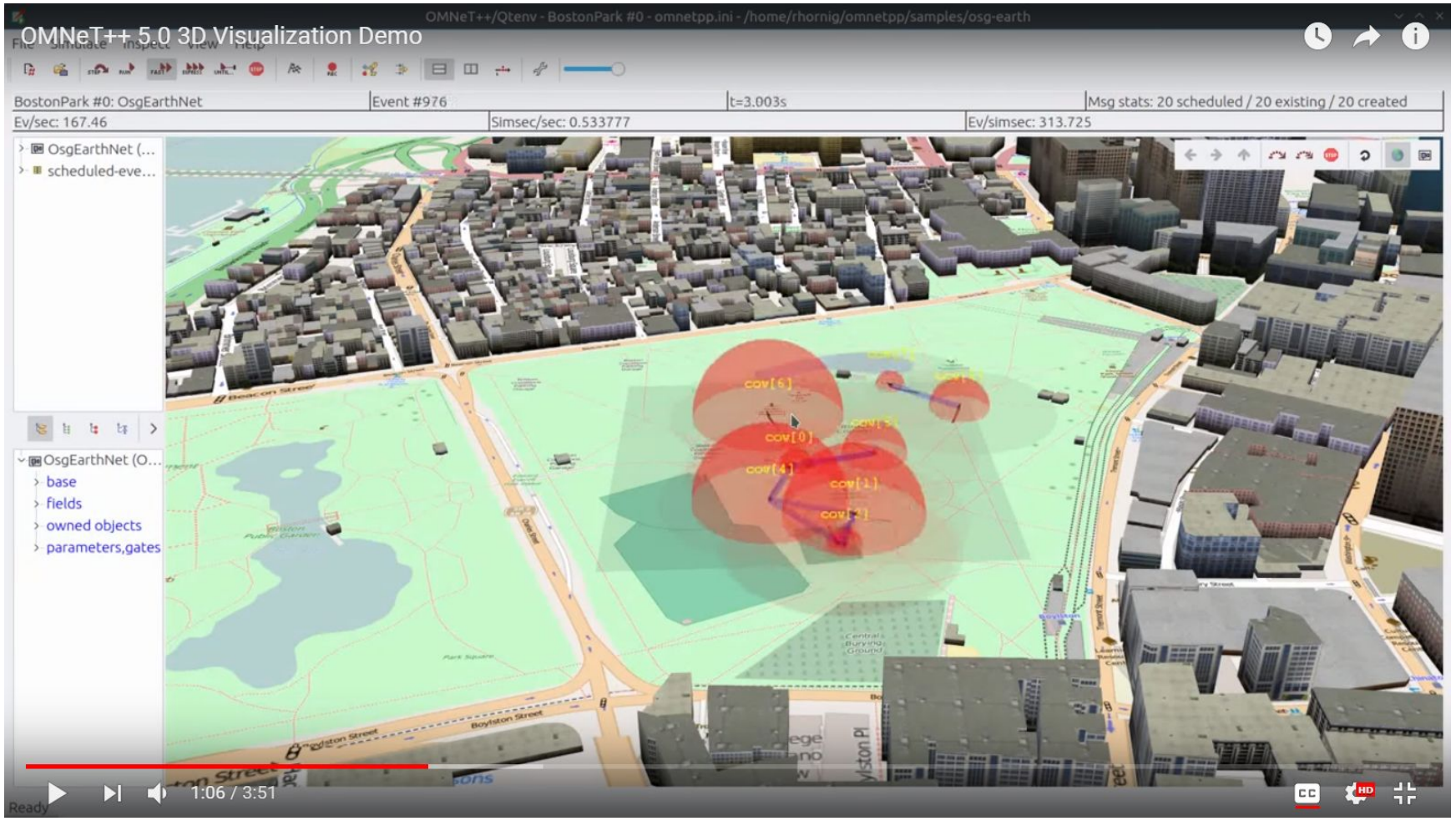




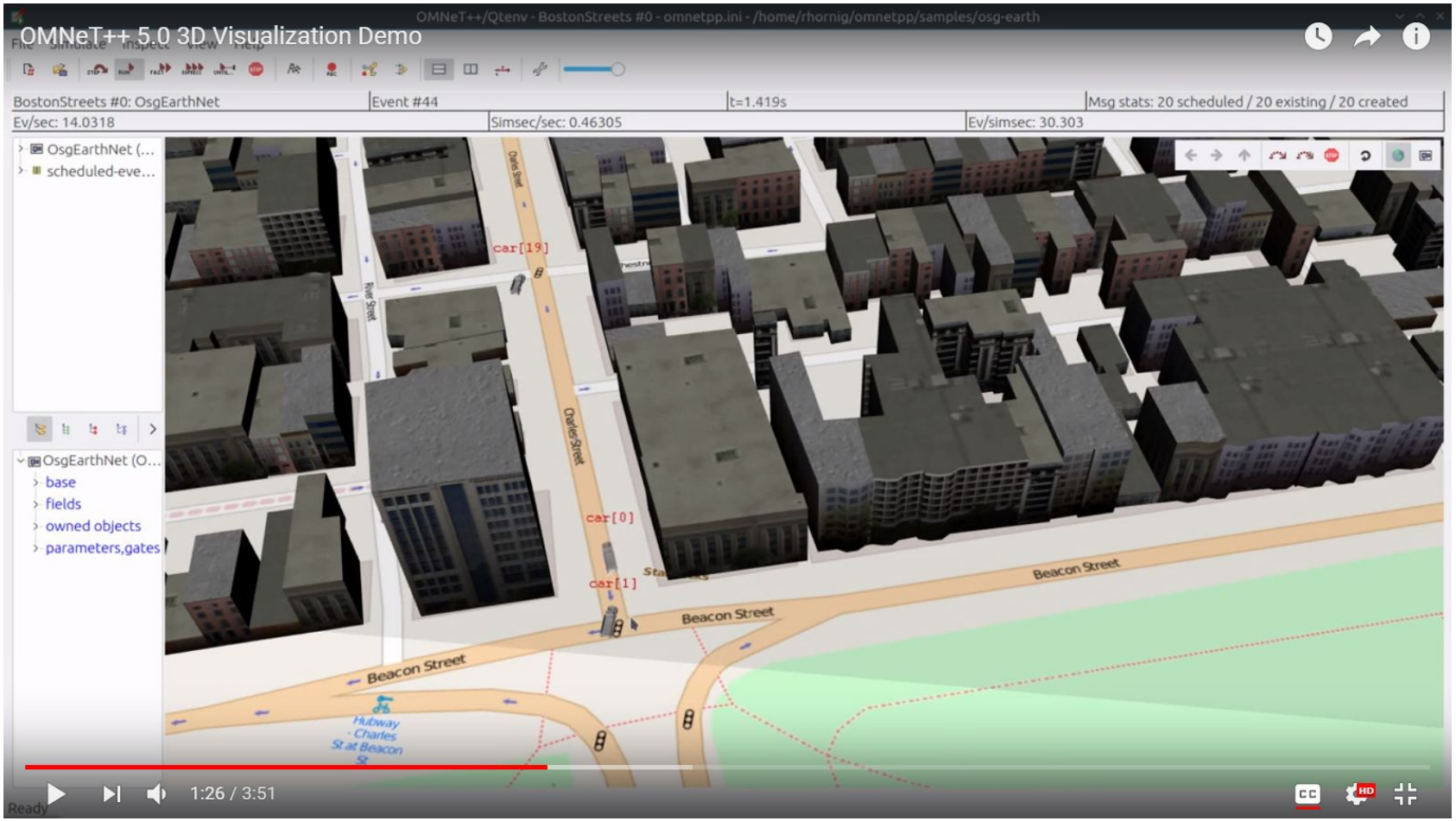
OMNeT++ 5.0


OMNeT++ 5.0 3D Visualization Demo
Press Esc to exit full screen
BostonPark #0: OsgEarthNet
Event #1
t=0s
Msg stats: 20 scheduled / 20 existing / 20 created
Next: move (omnetpp::cMessage, id=20)
In: OsgEarthNet.cow[0] (RambleNode, id=RambleNode)
At: last event + 0s
OsgEarthNet (...
scheduled-eve...
OsgEarthNet (O...
base
fields
owned objects
parameters,gates
0:32 / 3:51
Ready

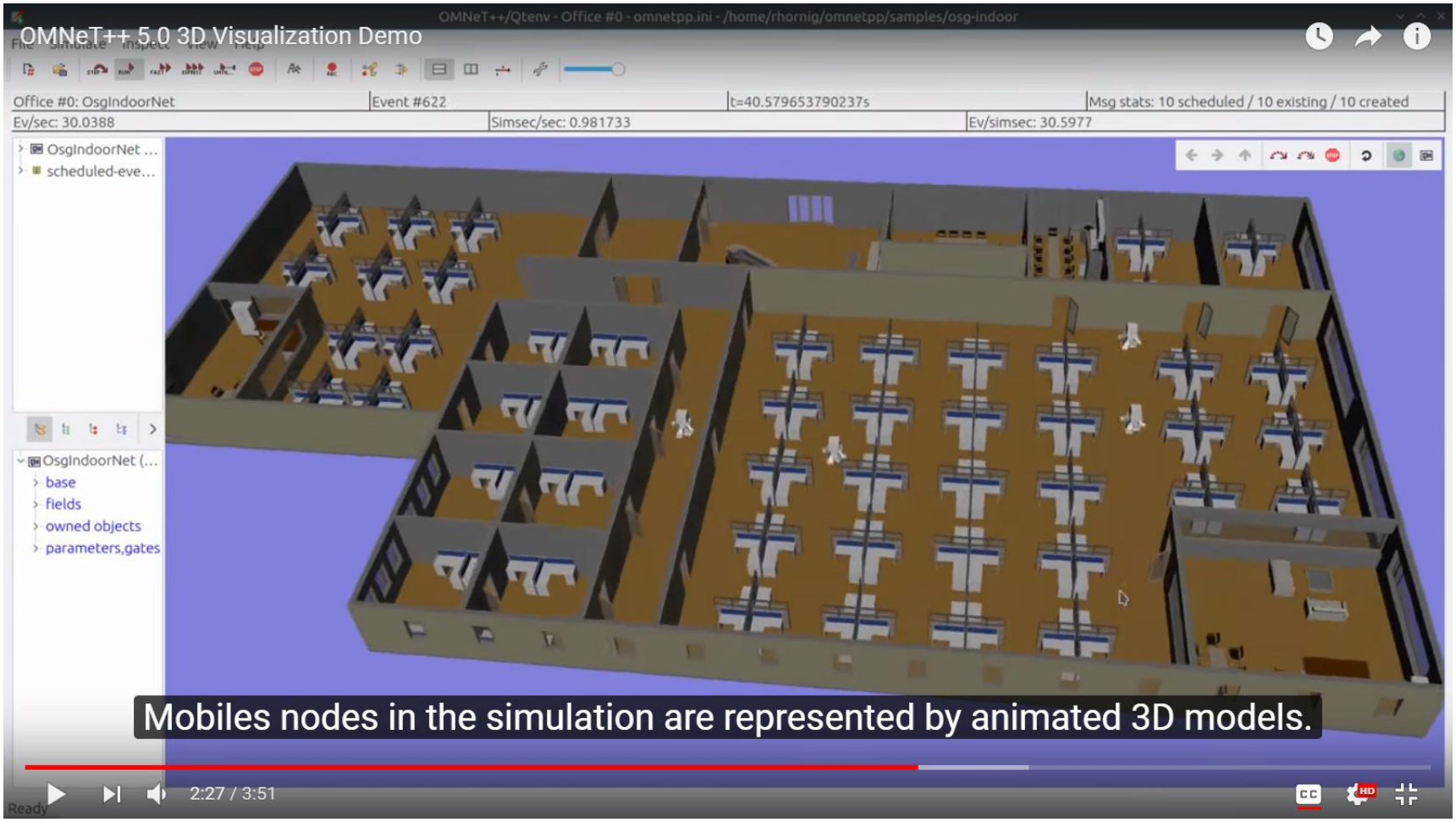
OMNeT++ 5.0


OMNeT++ 5.0 3D Visualization Demo
OMNeT++/Qtenv - BostonPark #0 - omnetpp.ini - /home/rhornig/omnetpp/samples/osg-earth
BostonPark #0: OsgEarthNet
Event #976
t=3.003s
Msg stats: 20 scheduled / 20 existing / 20 created
Ev/sec: 167.46
Simsec/sec: 0.533777
Ev/simsec: 313.725
OsgEarthNet (...
scheduled-eve...
OsgEarthNet (O...
base
fields
owned objects
parameters,gates
cov[6]
cov[0]
cov[4]
cov[1]
cov[2]
Beacon Street
Boylston Street
1:06 / 3:51
Ready

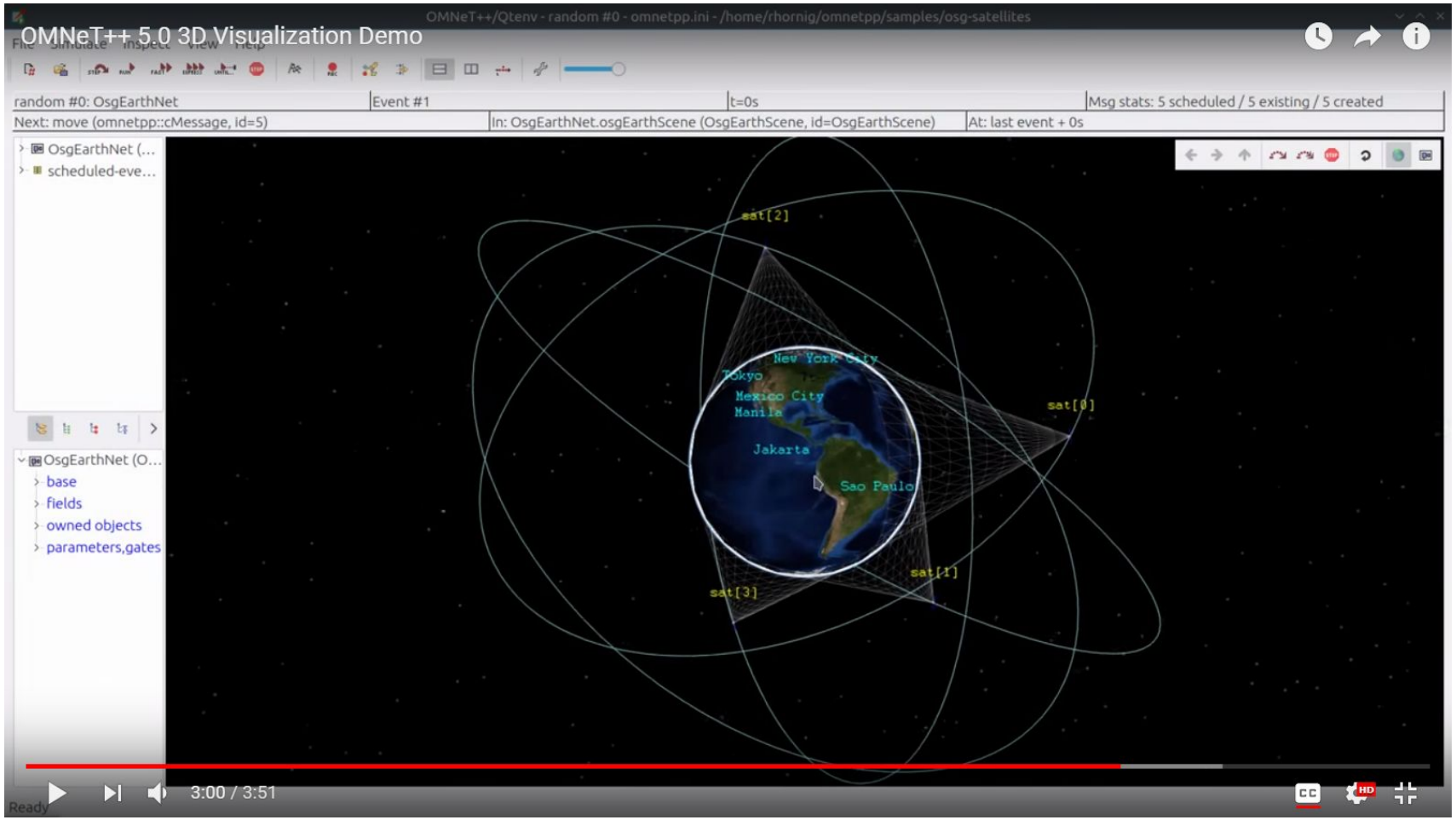
OMNeT++ 5.0


OMNeT++ 5.0 3D Visualization Demo
OMNeT++/Qtenv - BostonStreets #0 - omnetpp.ini - /home/rhornig/omnetpp/samples/osg-earth
BostonStreets #0: OsgEarthNet
Event #44
t=1.419s
Msg stats: 20 scheduled / 20 existing / 20 created
Ev/sec: 14.0318
Simsec/sec: 0.46305
Ev/simsec: 30.303
OsgEarthNet (...
scheduled-eve...
OsgEarthNet (O...
base
fields
owned objects
parameters,gates
car[19]
car[0]
car[1]
Charles Street
Beacon Street
Beacon Street
Beacon Street
Hubway - Charles St at Beacon St
1:26 / 3:51
Ready

OMNeT++ 5.0

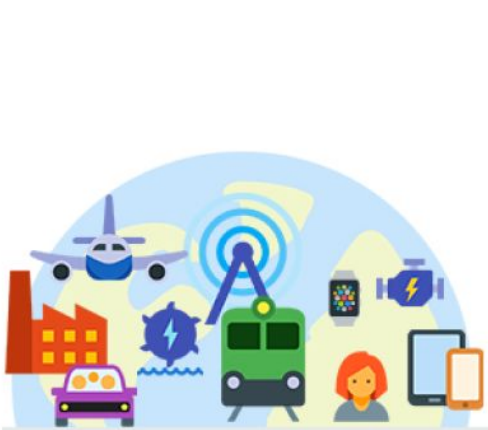

OMNeT++ 5.0 3D Visualization Demo
OMNeT++/Qtenv - Office #0 - omnetpp.ini - /home/rhornig/omnetpp/samples/osg-indoor
Office #0: OsgIndoorNet
Event #622
t=40.579653790237s
Msg stats: 10 scheduled / 10 existing / 10 created
Ev/sec: 30.0388
Simsec/sec: 0.981733
Ev/simsec: 30.5977
OsgIndoorNet ...
scheduled-eve...
OsgIndoorNet (...
base
fields
owned objects
parameters,gates
Mobiles nodes in the simulation are represented by animated 3D models.
2:27 / 3:51
Ready

OMNeT++ 5.0


OMNeT++ 5.0 3D Visualization Demo
OMNeT++/Qtenv - random #0 - omnetpp.ini - /home/rhornig/omnetpp/samples/osg-satellites
random #0: OsgEarthNet
Event #1
t=0s
Msg stats: 5 scheduled / 5 existing / 5 created
Next: move (omnetpp::cMessage, id=5)
In: OsgEarthNet.osgEarthScene (OsgEarthScene, id=OsgEarthScene)
At: last event + 0s
OsgEarthNet (...
scheduled-eve...
OsgEarthNet (O...
base
fields
owned objects
parameters,gates
sat[2]
sat[0]
sat[1]
sat[3]
New York City
Tokyo
Mexico City
Manila
Jakarta
Sao Paulo
3:00 / 3:51
Ready

Edge Computing in Internet of Things Applications

Edge Computing



Operations Technology

Information Technology

THE EDGE

The Things

- Wearables
- Cars
- Motors
- Buildings
- Mobile Devices
- Meters
- Robotics
- Generators

DATA GENERATION

Sensors & Actuators

DATA SENSING

Data Aggregation & Gateways

DATA COLLECTION AGGREGATION

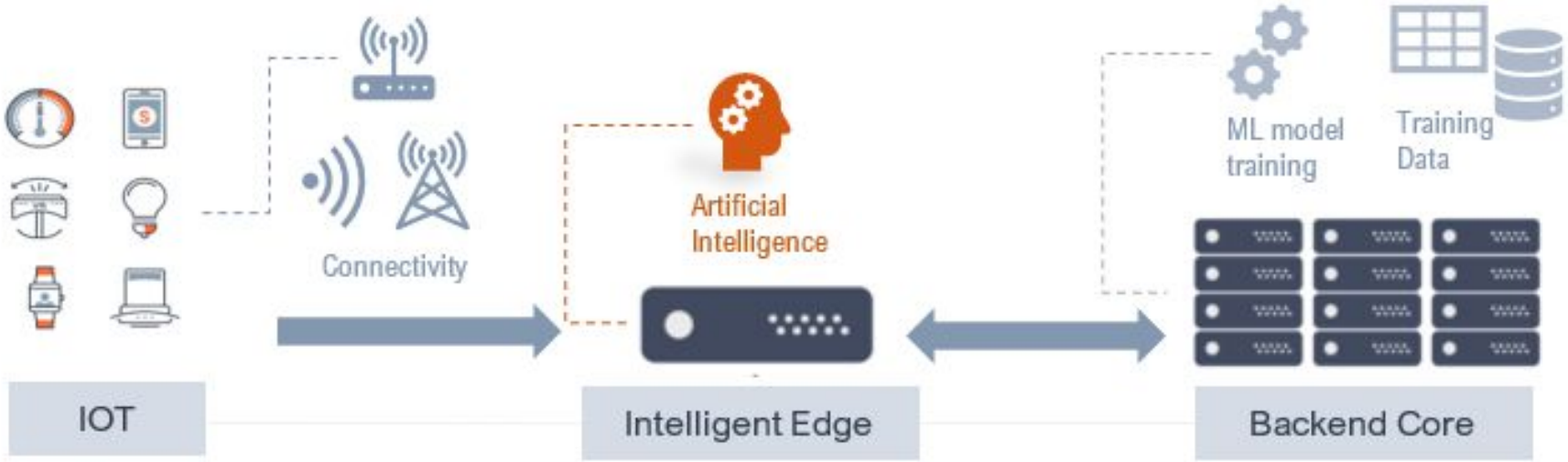
Edge IT

EARLY DATA ANALYTICS

Data Center & Cloud IT

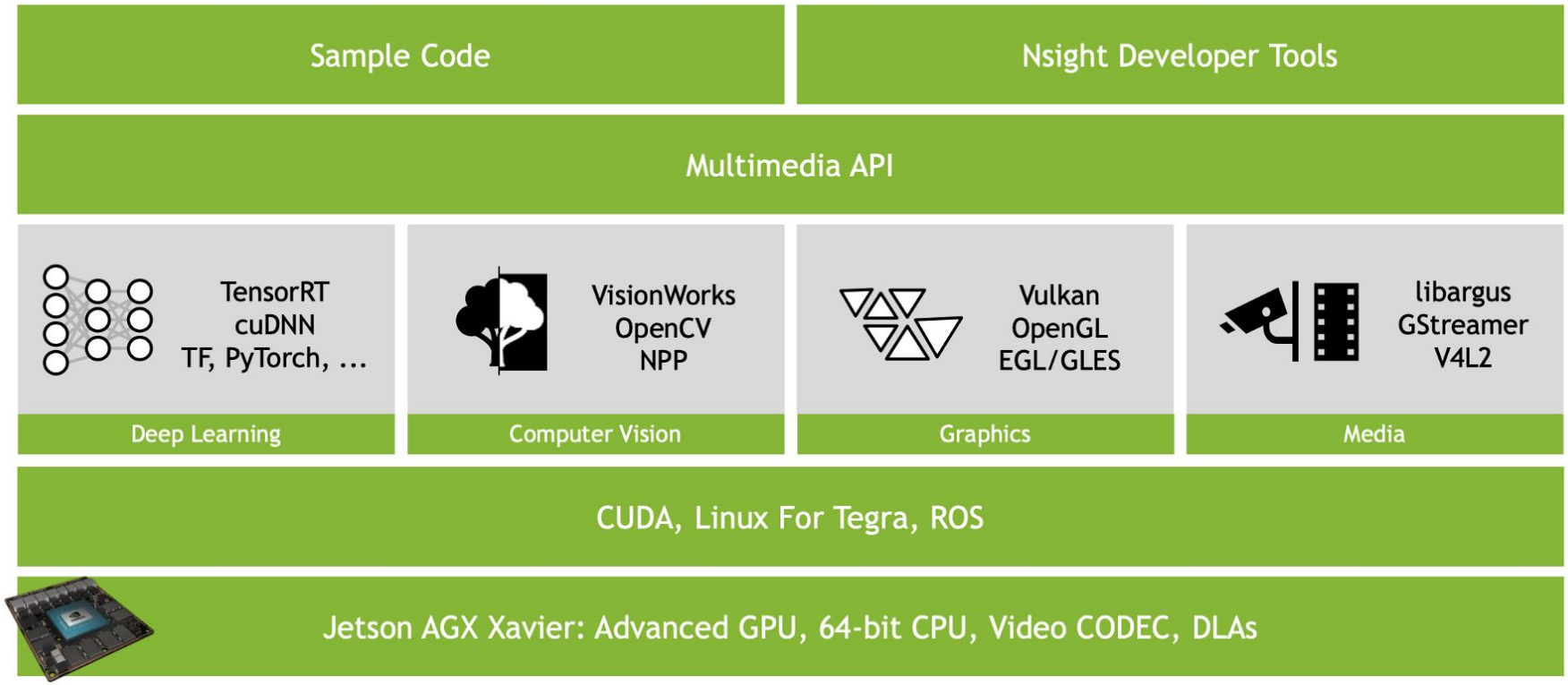
DEEP DATA ANALYTICS

Combine it with AI = Edge AI



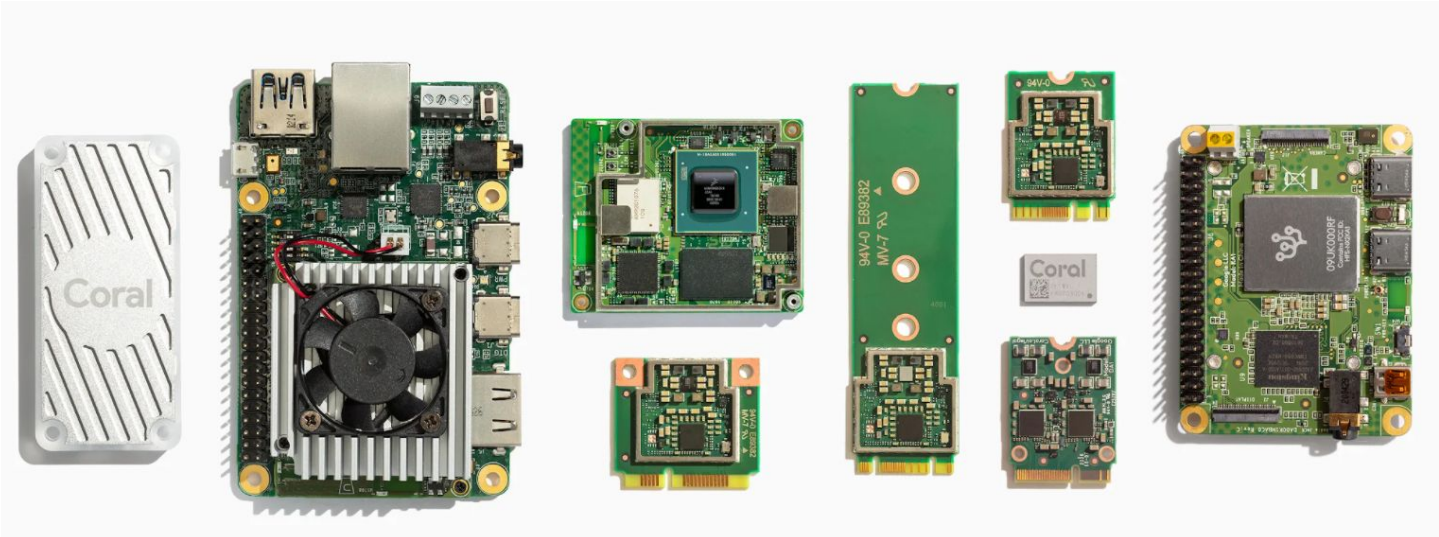
- Edge AI overcomes the latency of data and **complex computations:**
  - Increase in levels of Automation
  - Digital Twins for Advanced Analytics
  - Real-Time Decision Making
  - Edge Inference and Training

Edge AI on Embedded Platform



384 NVIDIA CUDA cores and 48 Tensor Cores

PyCoral [https://coral.ai/products/]



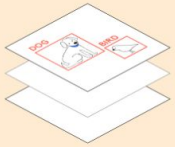
Models

Trained TensorFlow models for the Edge TPU

Image classification

Models that recognize the subject in an image, plus classification models for on-device transfer learning.

→ See models



Object detection

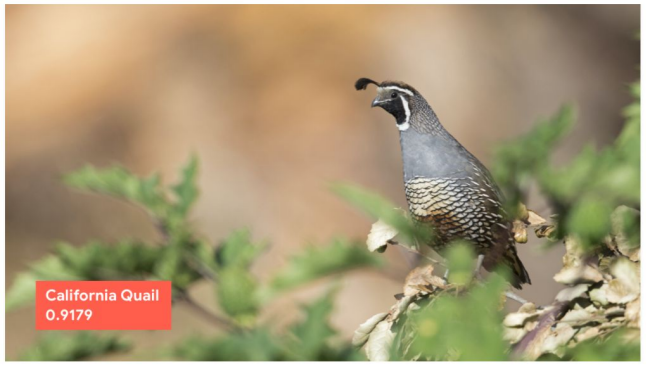
Models that identify multiple objects and provide their location.

→ See models

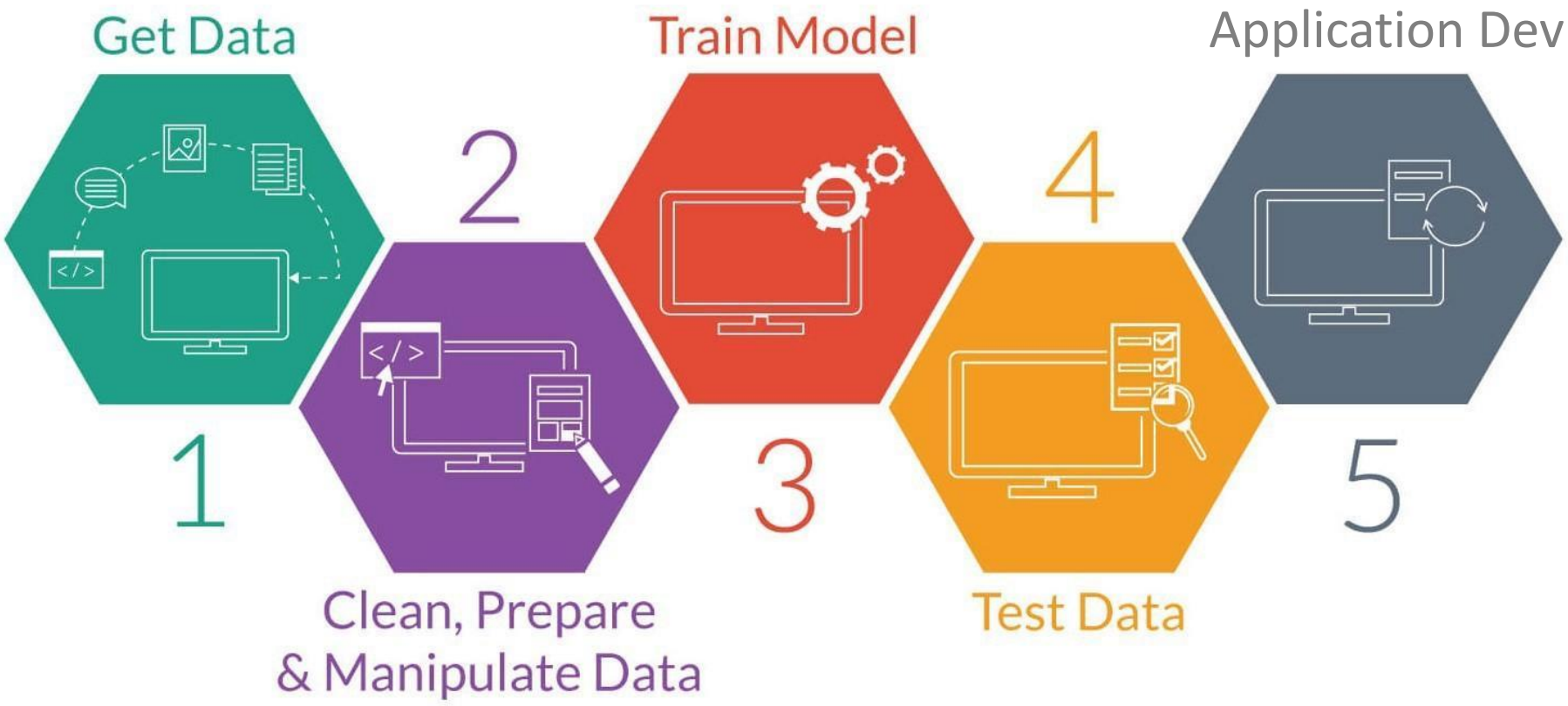
Semantic segmentation

Models that identify specific pixels belonging to different objects.

→ See models

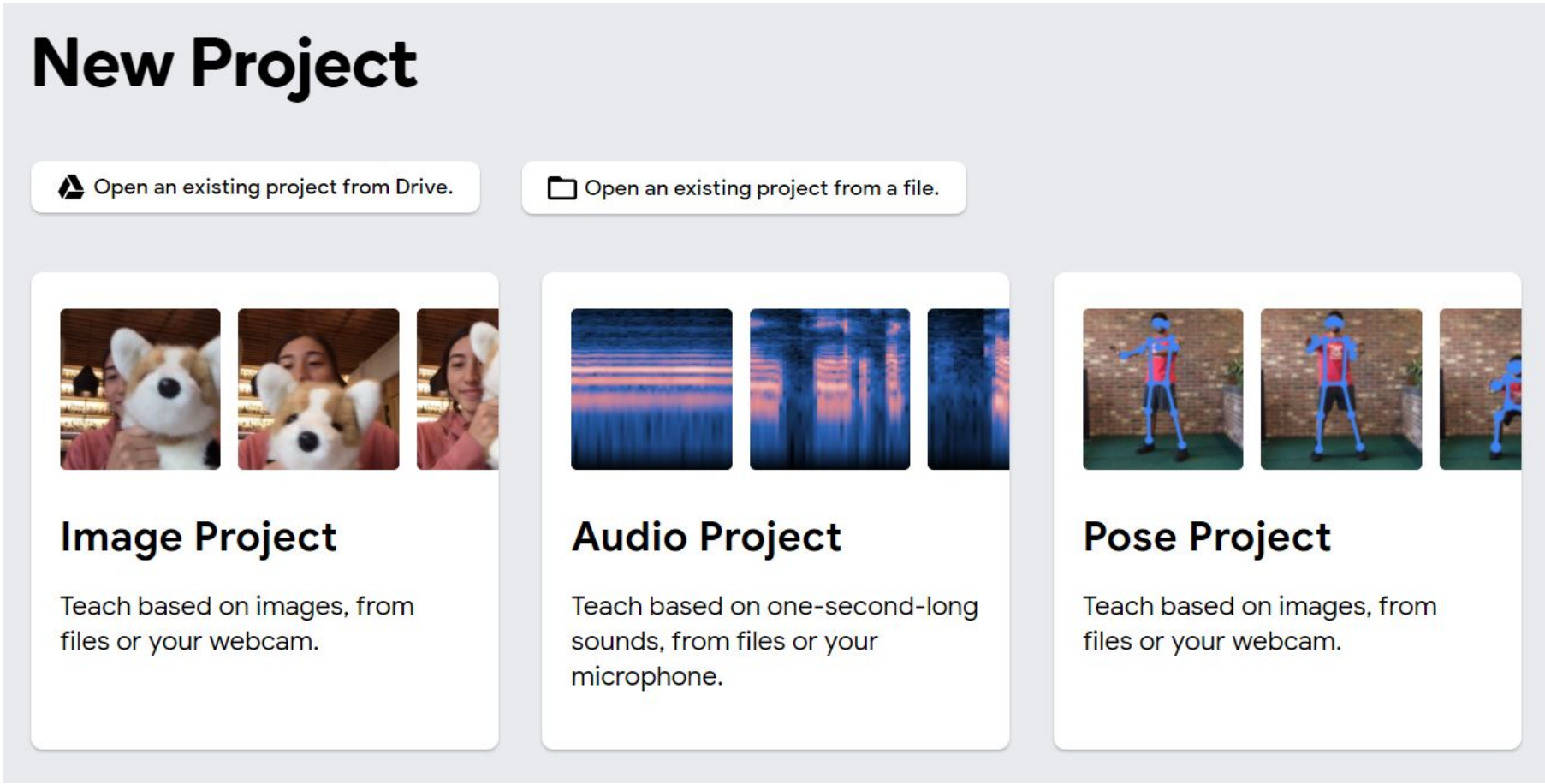


Train an AI Model



Demo with Google TM

- https://teachablemachine.withgoogle.com/train

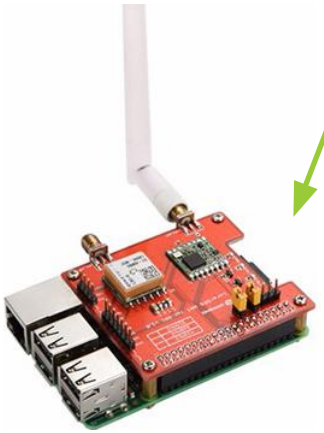


System Architecture

- IoT Server
  - Adafruit IO
  - Thingsboard

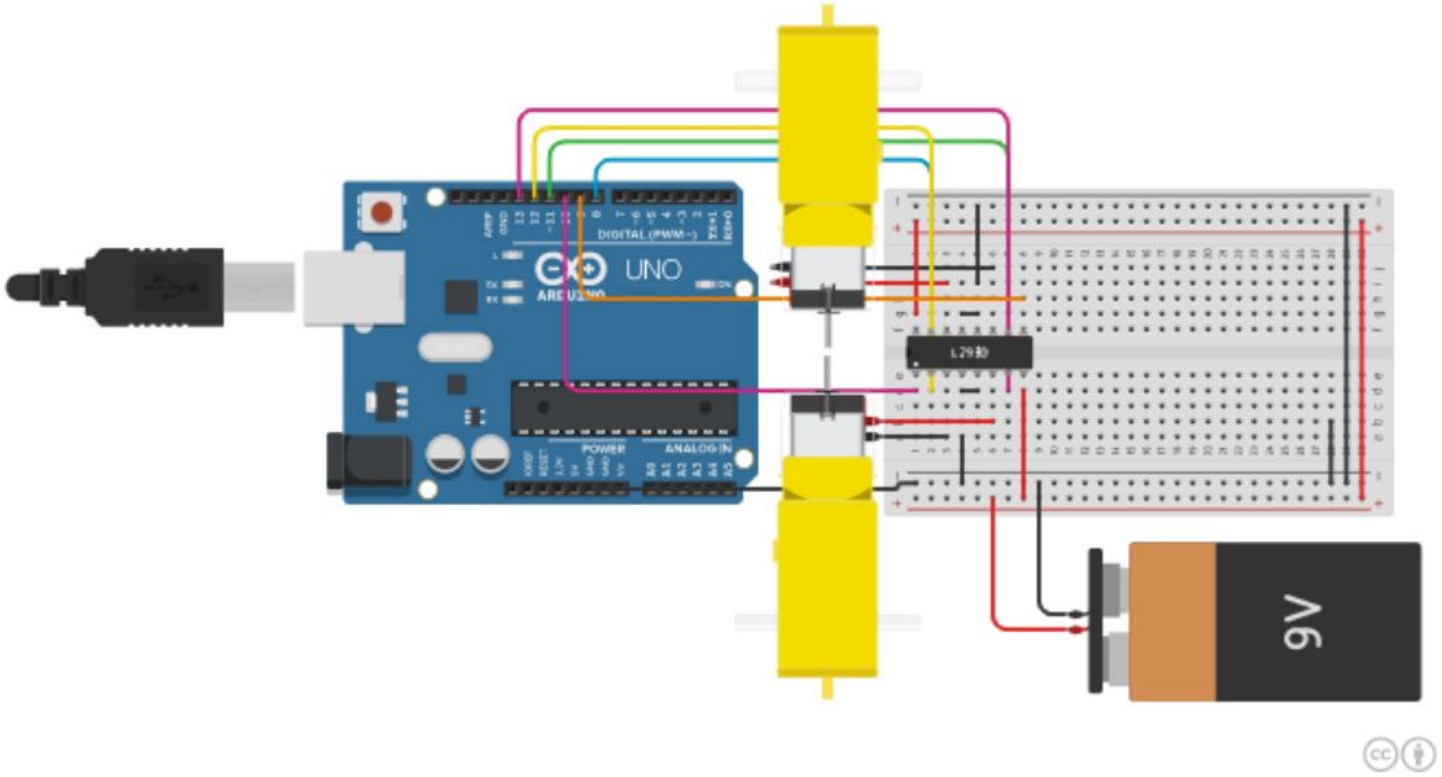
- Smartphone:
  - Android

- Sensor node
  - Arduino Uno
  - Temperature sensor
  - Wireless or wired communication



- Gateway
  - Raspberry Pi
  - E2E Protocol (MQTT)
  - Internet connection

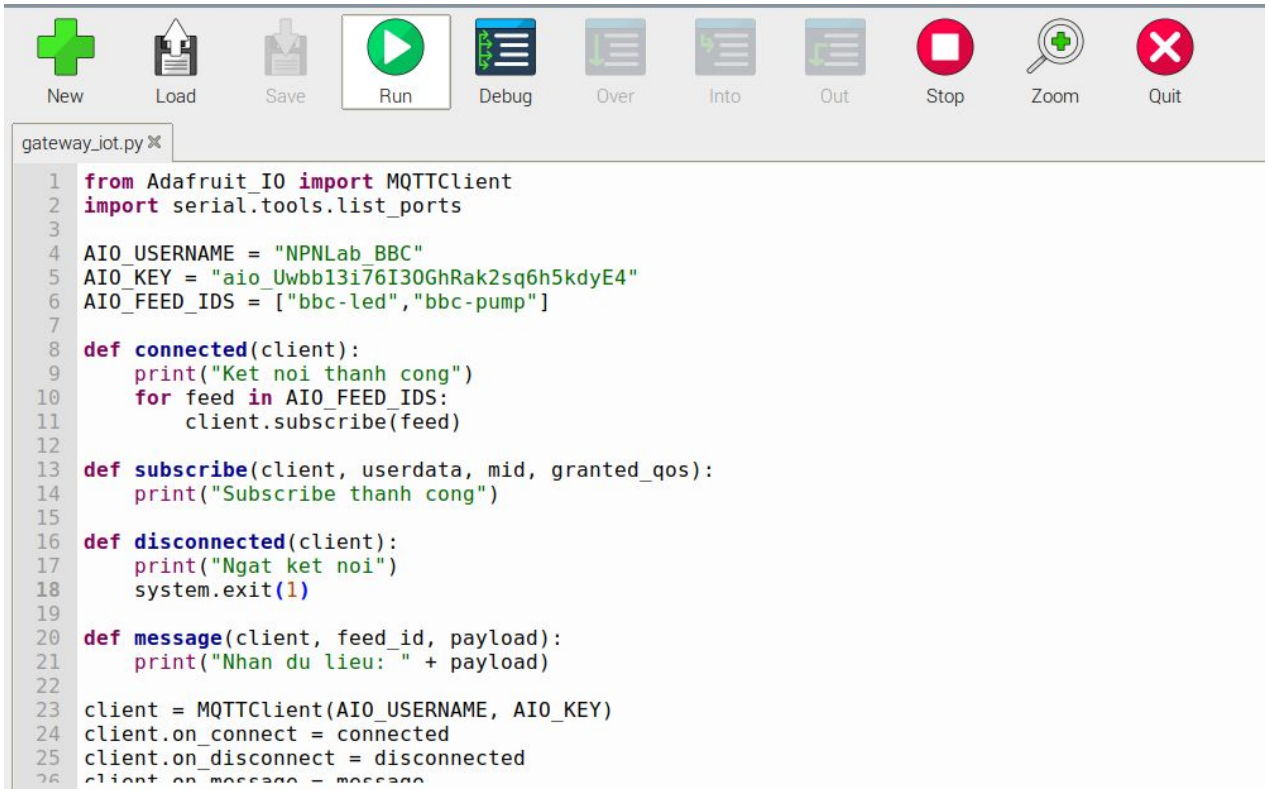
Sensing System based Arduino



- Microcontroller platform:
  - Device drivers are supported
  - Low cost
  - Open source

ONLINE SIMULATIONS!!!

Gateway using Raspberry PI



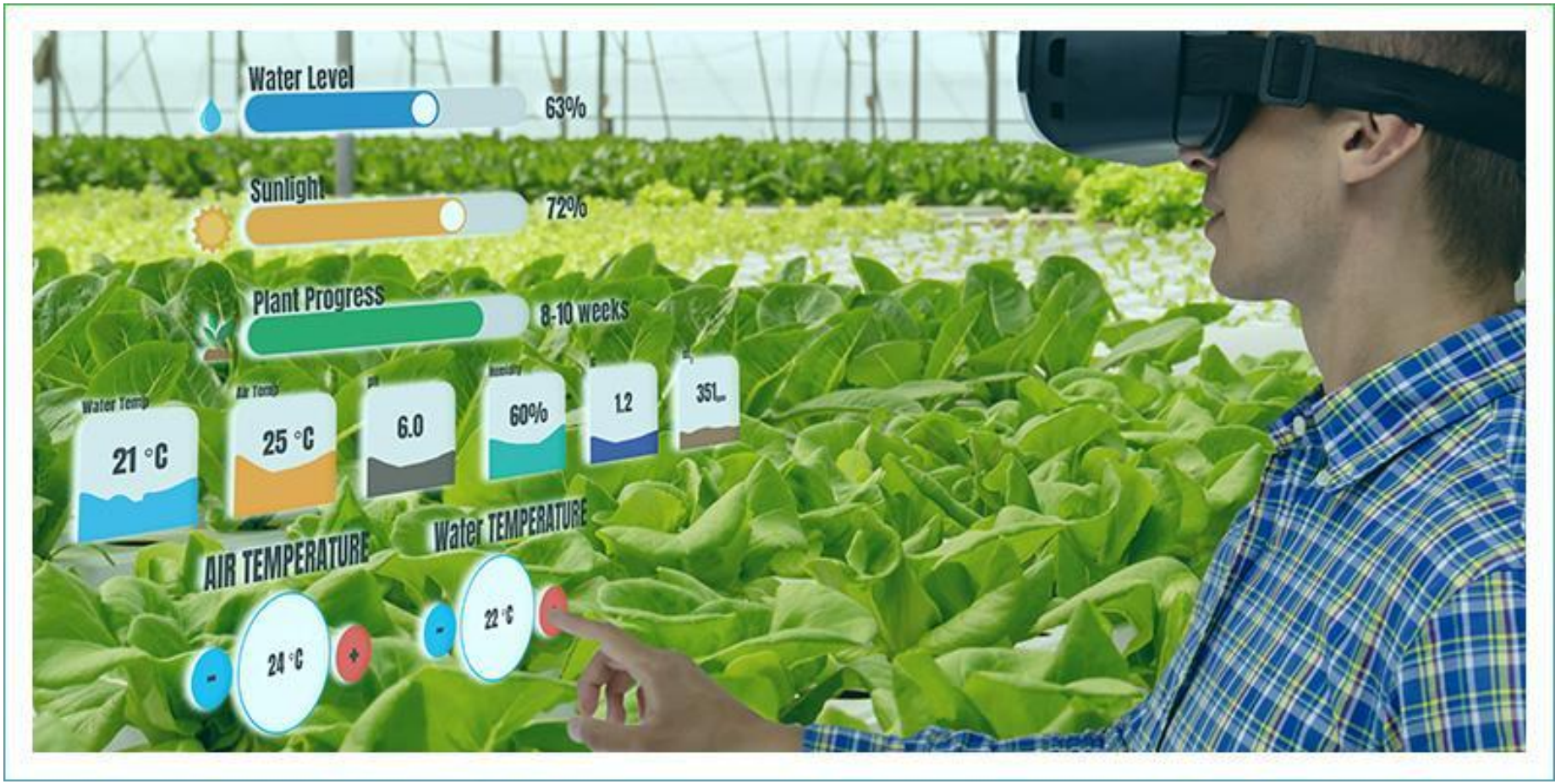
- Micro processor platform:
  - Network connection
  - IoT services are supported

Potential Applications

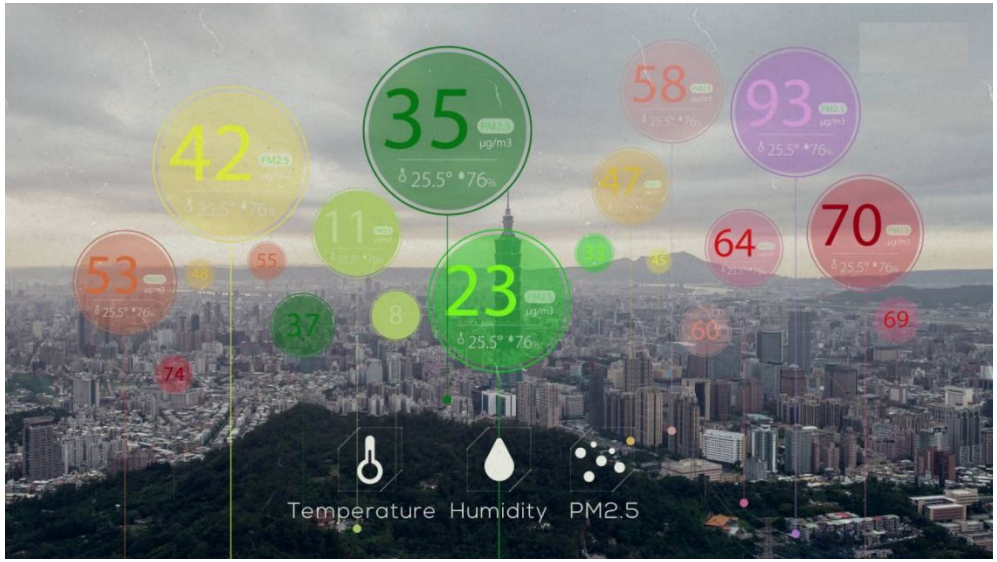
Smart Agriculture

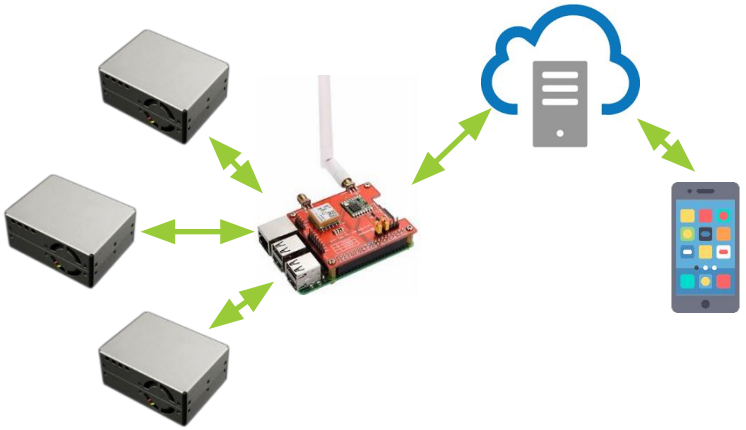
- Temperature and Humidity
- pH, EC
- Light intensity
- Pump controllers

Monitoring system based AR/VR



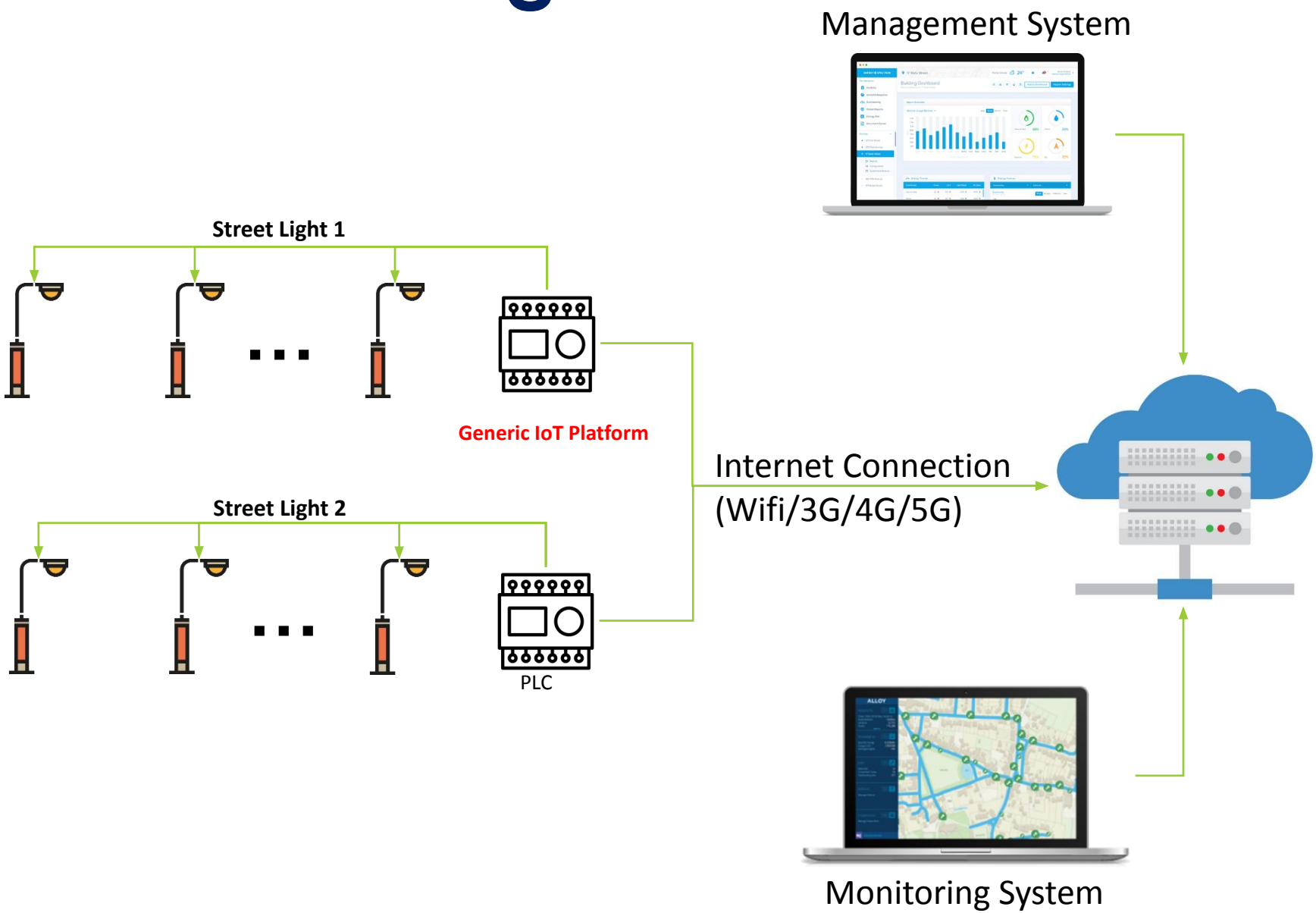
Air Quality Monitoring



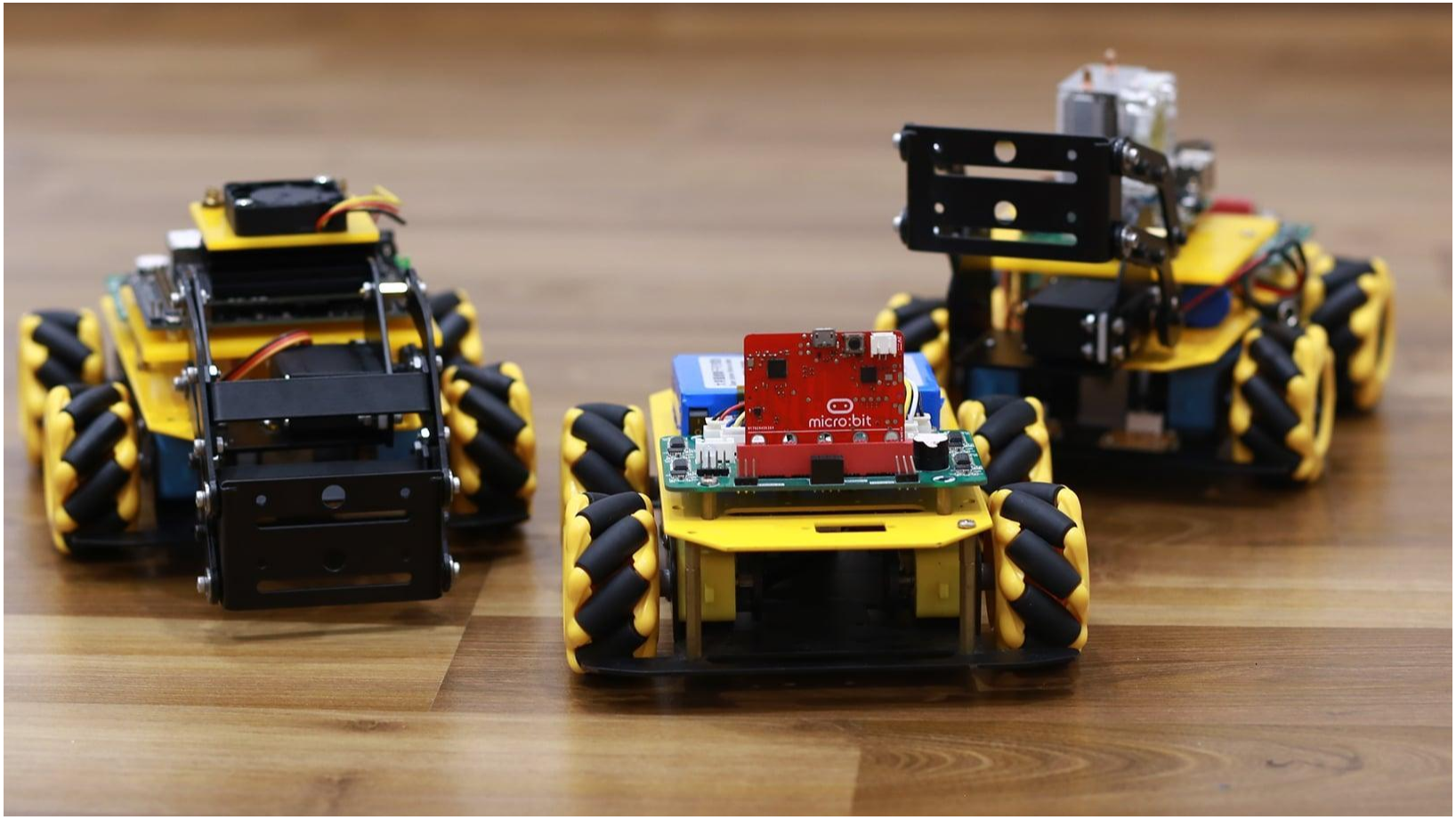


- Air quality monitoring program assists us in improving and **developing air pollution control programs** to reduce the effect of air pollution.
- **PM2.5, PM10, CO2, CO**

Smart Street Light



Autonomous Robots



- Smart warehouse applications