TEXAS STATE UNIVERSITY

The rising STAR *of Texas*

REALITY LAB

Augmented Reality *meets* Internet of Things

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XReality Team

Presentation outline

- The connected Things (IoT)
- Mixed Reality (AR/VR)
- A new paradigm: Virtual Environment of Things (VEoT)
- Demo: Integration of Arduino + Hololens
- Discussion

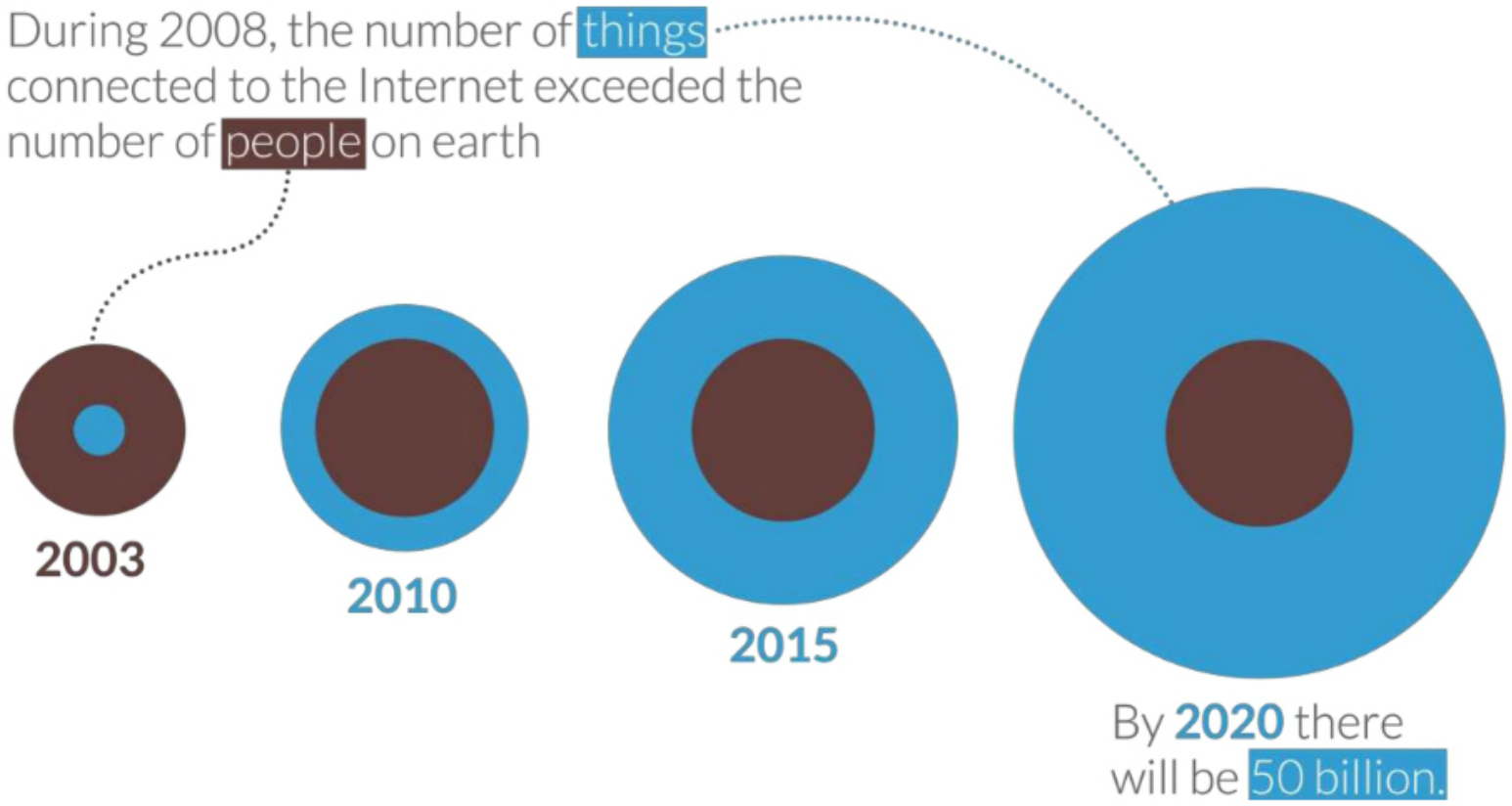
Big Data

- Every day, we create 2.5 quintillion bytes of data, so much that 90% of the data in the world today has been created in the last two years alone.
  *-this data is called **'Big Data'***

- What we expect in the near future…

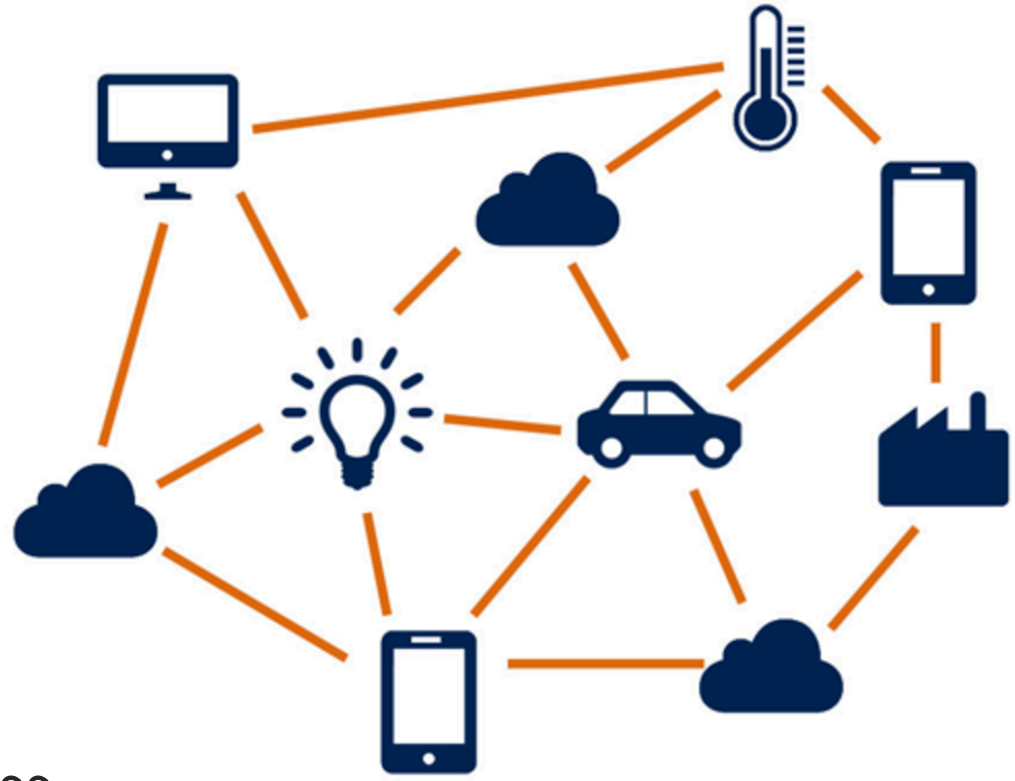
Non-human centric **> human** centric data **by 2020**

Big Things


During 2008, the number of things connected to the Internet exceeded the number of people on earth
2003
2010
2015
By 2020 there will be 50 billion.

Internet of Things

- **Human to Thing interaction anywhere, at any anytime**



- Computing devices are embedded in everyday objects
- Support data and command flow across wireless low data rate networks with low power requirements

IoT Market Dynamics

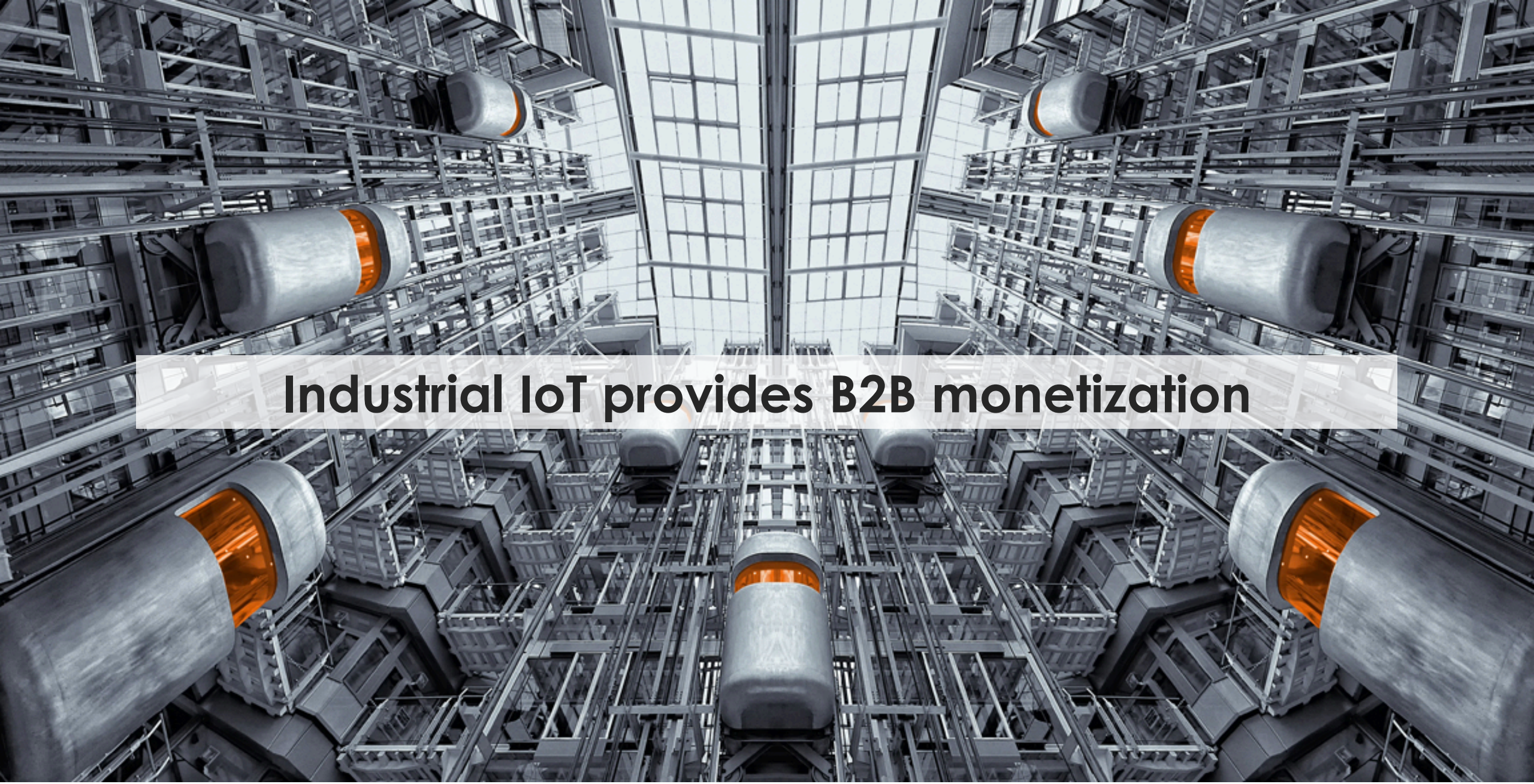
- The global IoT market will grow from $157B in 2016 to **$457B by 2020**, attaining a Compound Annual Growth Rate (CAGR) of 28.5%

- **Discrete Manufacturing, Transportation, and Utilities will lead** all industries in IoT spending by 2020, averaging $40B each

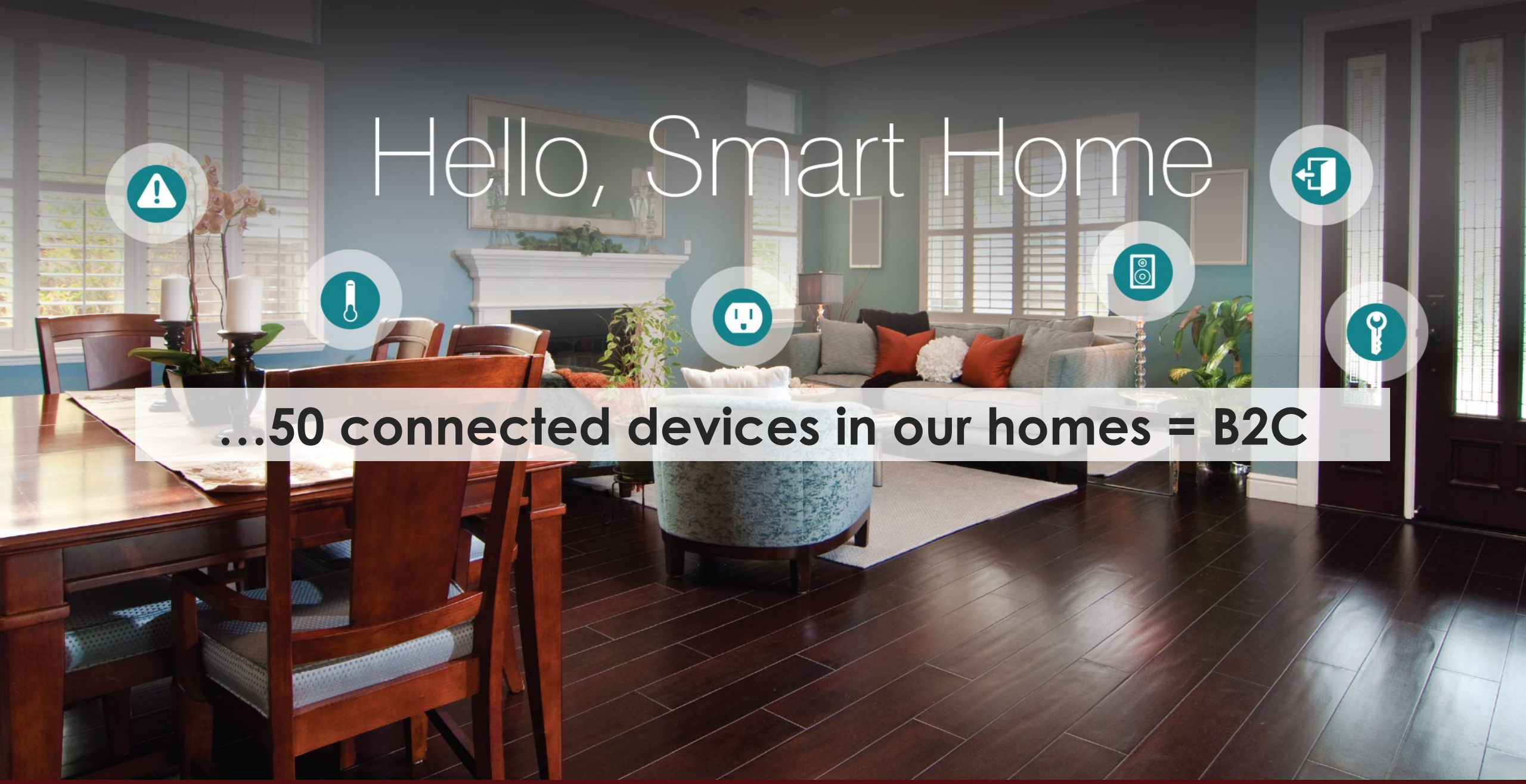
- B2B IoT segments will generate more than $300B annually by 2020, including about $85B in **the industrial sector**

src: Forbes, 2017 Roundup Of Internet Of Things Forecasts

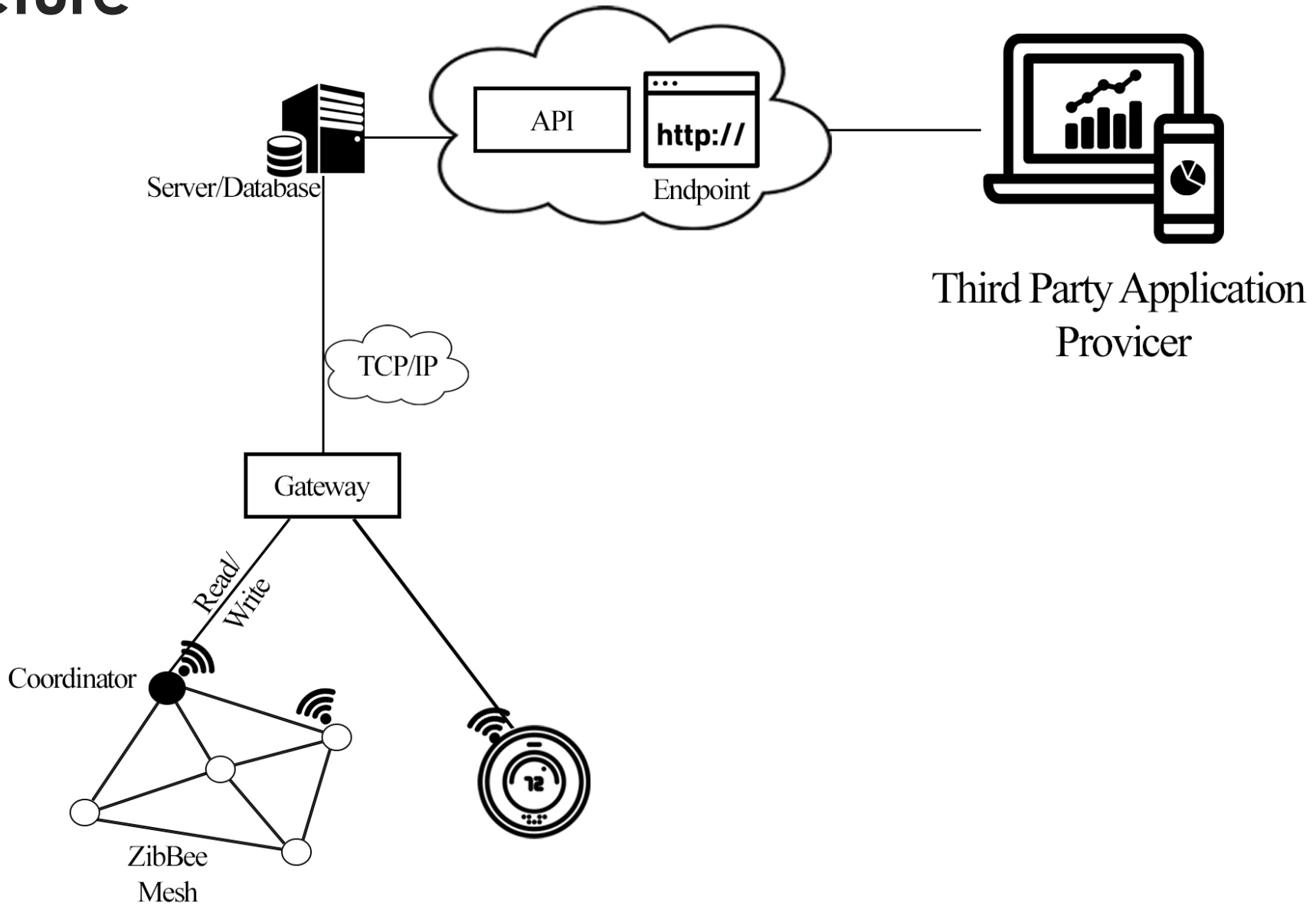
Smart City is a key driver for IoT, B2G



Industrial IoT provides B2B monetization

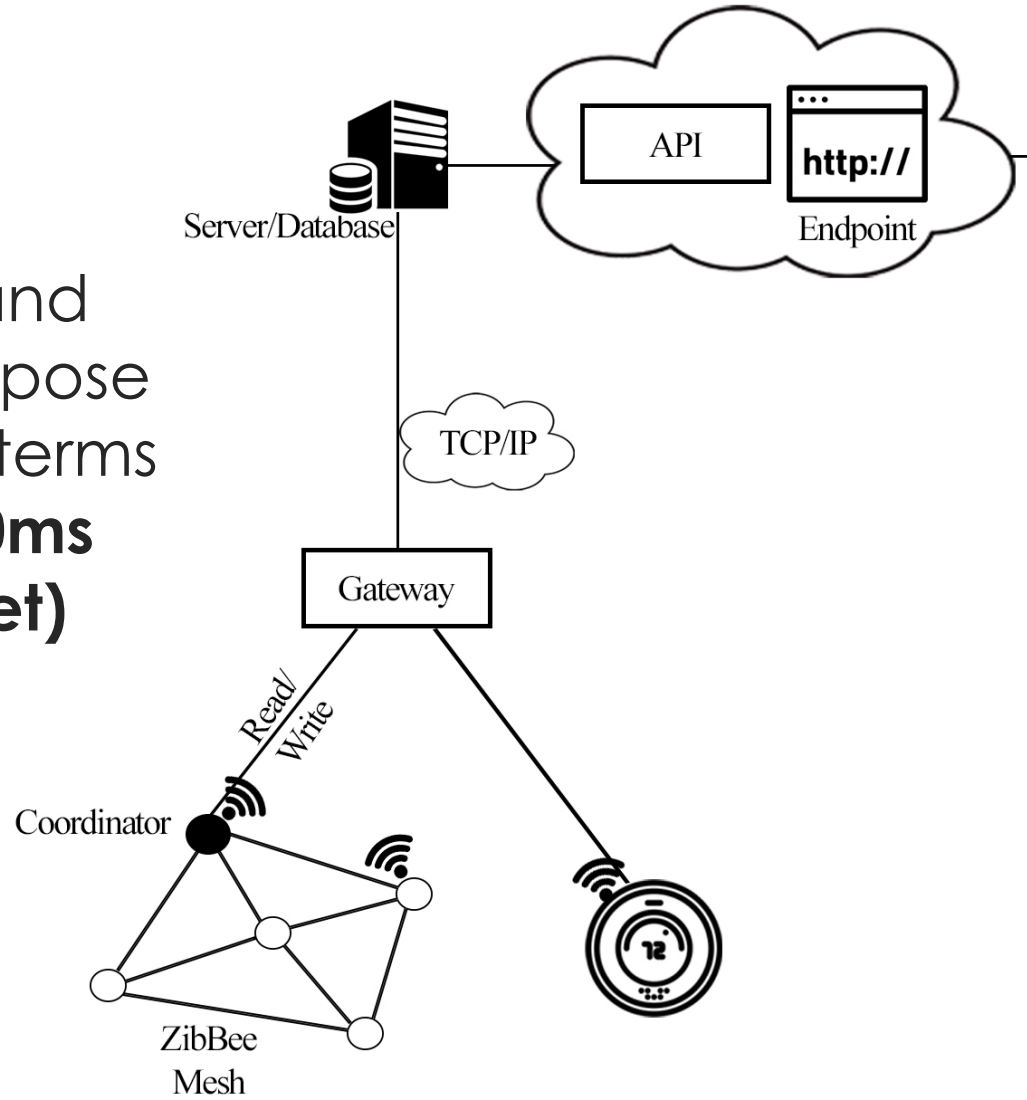

Hello, Smart Home
...50 connected devices in our homes = B2C

IoT Architecture



Latency <10ms (Tactile Internet)

Industrial applications and modern UX impose challenges in terms of **latency <10ms (Tactile Internet)**

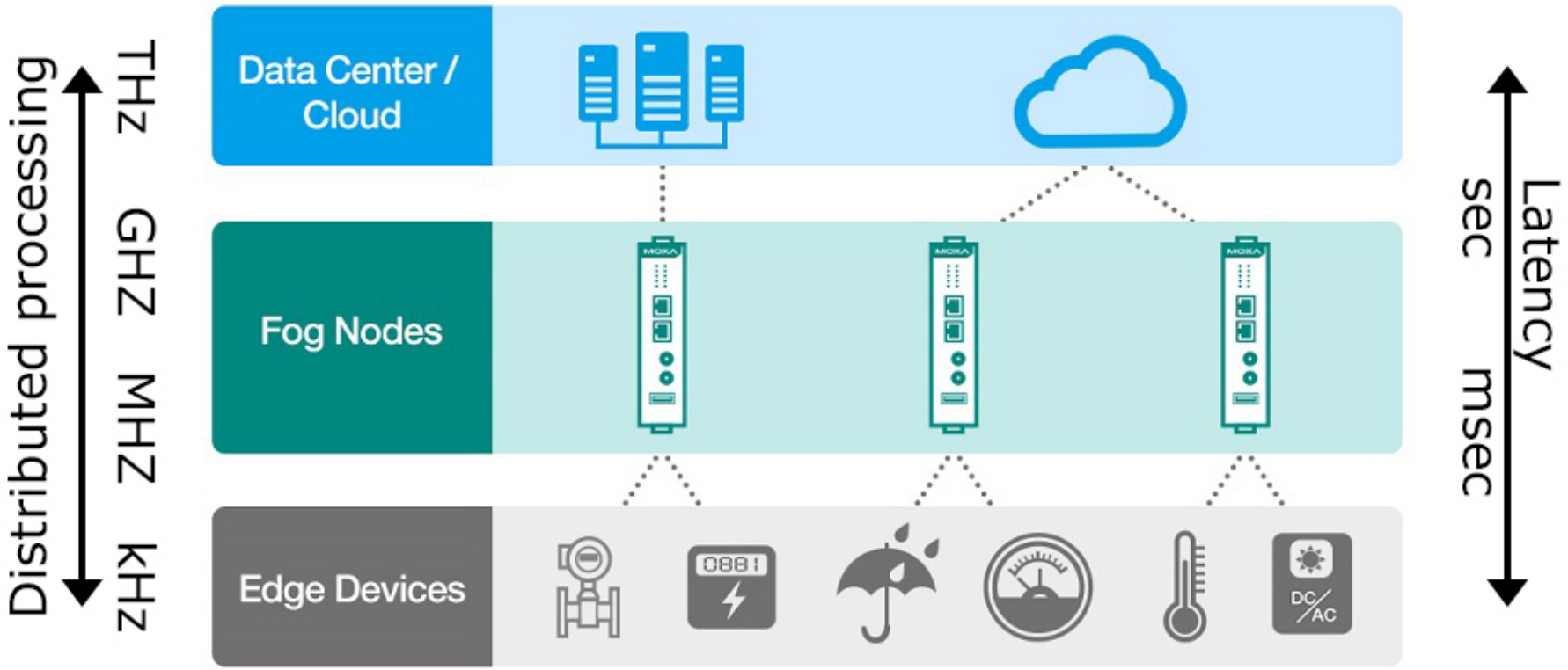


Third Party Application Provicer

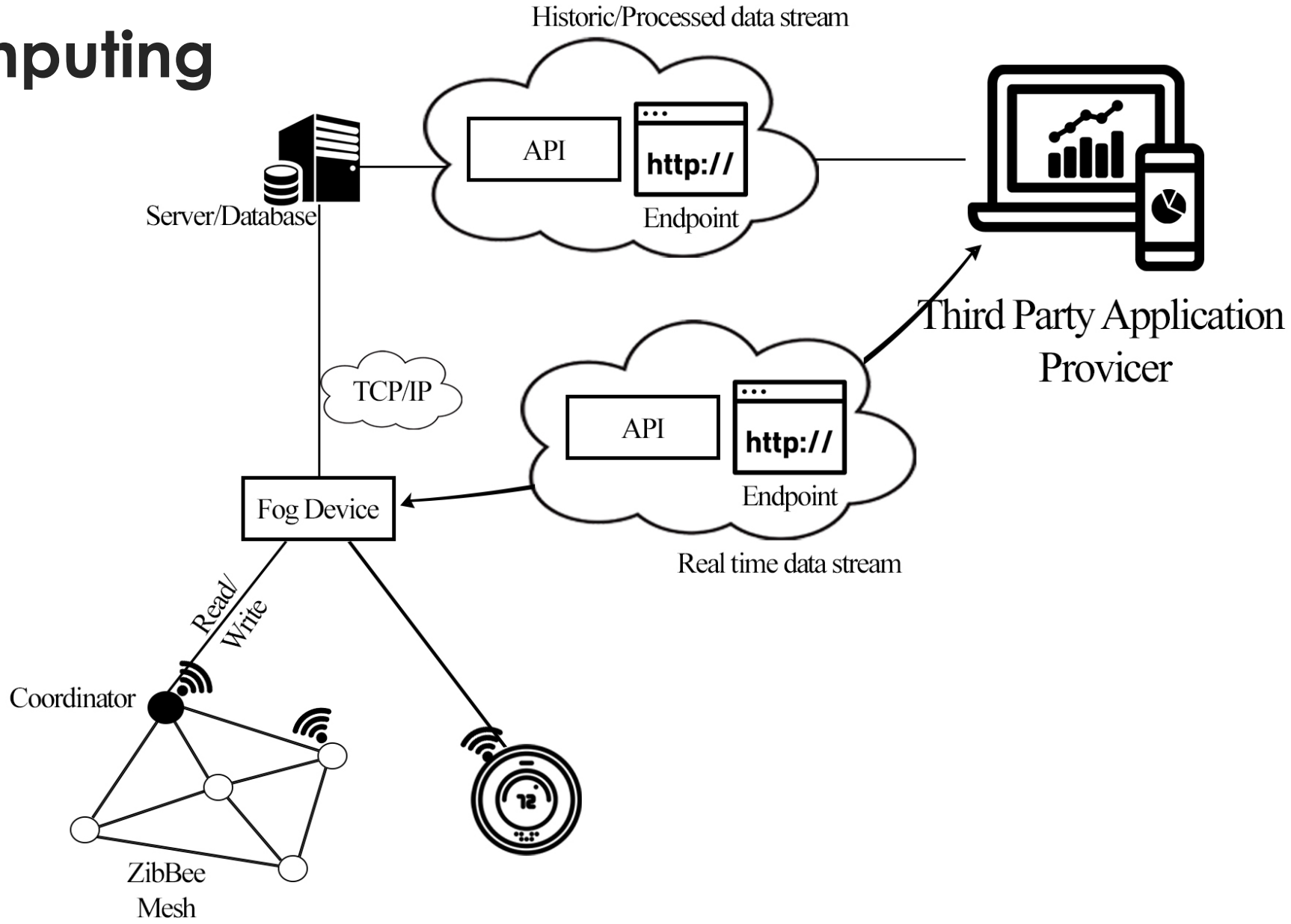
$$T = \sum_{i=1}^{N} (t_d^i + t_c^i) + \sum_{j=1}^{M} t_p^j$$

t_d_propagation delay
t_c_channel delay
t_p_processing delay

Edge/Fog computing



Edge/Fog computing



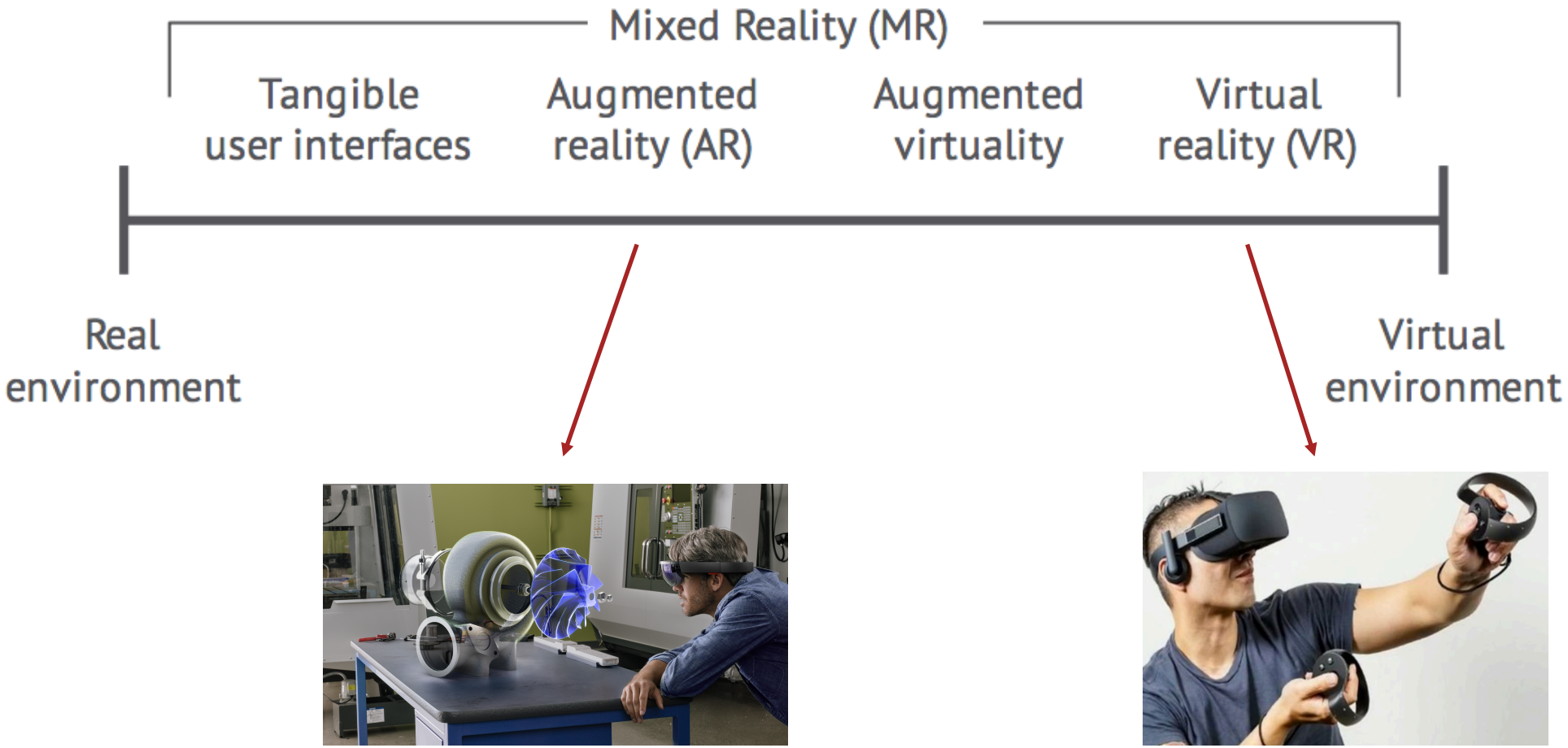
A key challenge: Thing-to-Human interface

touch

dashboard

voice

Mixed Reality



Augmented Reality

Augmented Reality (AR) is a view of the physical real-world filled with augmented objects through immersive devices.

Computer generated 3D objects projected in physical spaces, to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment

Virtual Environment of Things

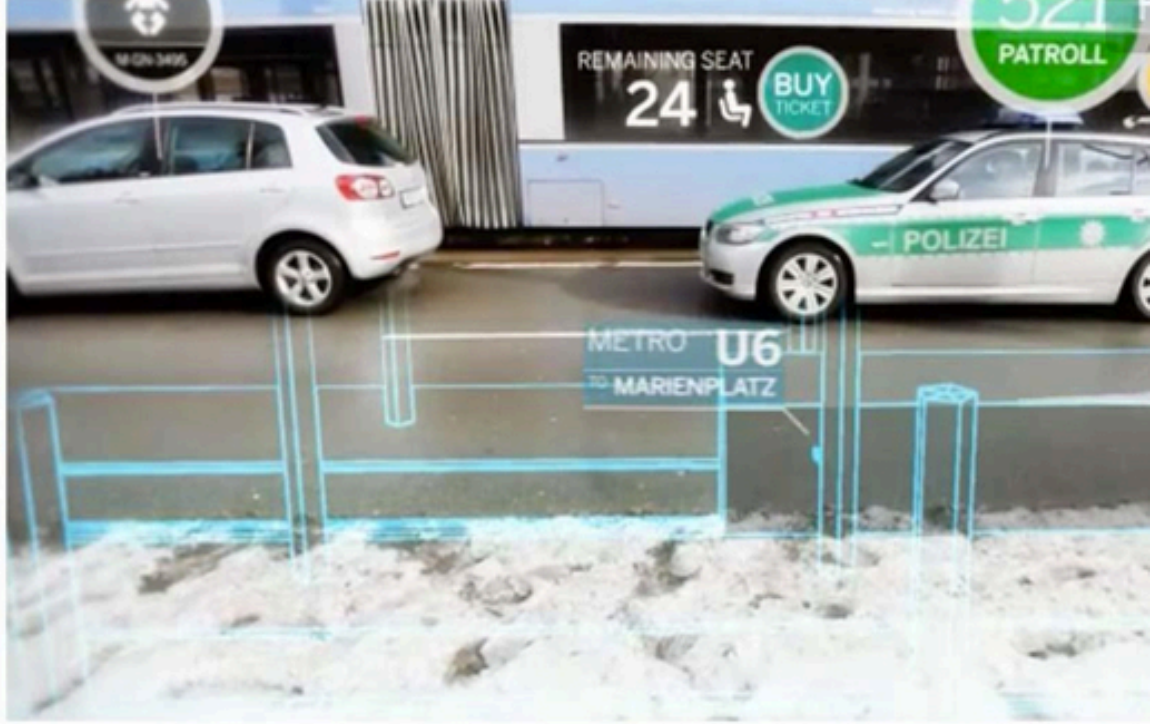
VEoT: Integrating real-world smart things and virtual-world avatars/holograms in a computer generated virtual environment so that entities in either worlds can interact with one another in a real-time manner

VEoT Health

VEoT Agriculture

VEoT Industrial

VEoT Smart City



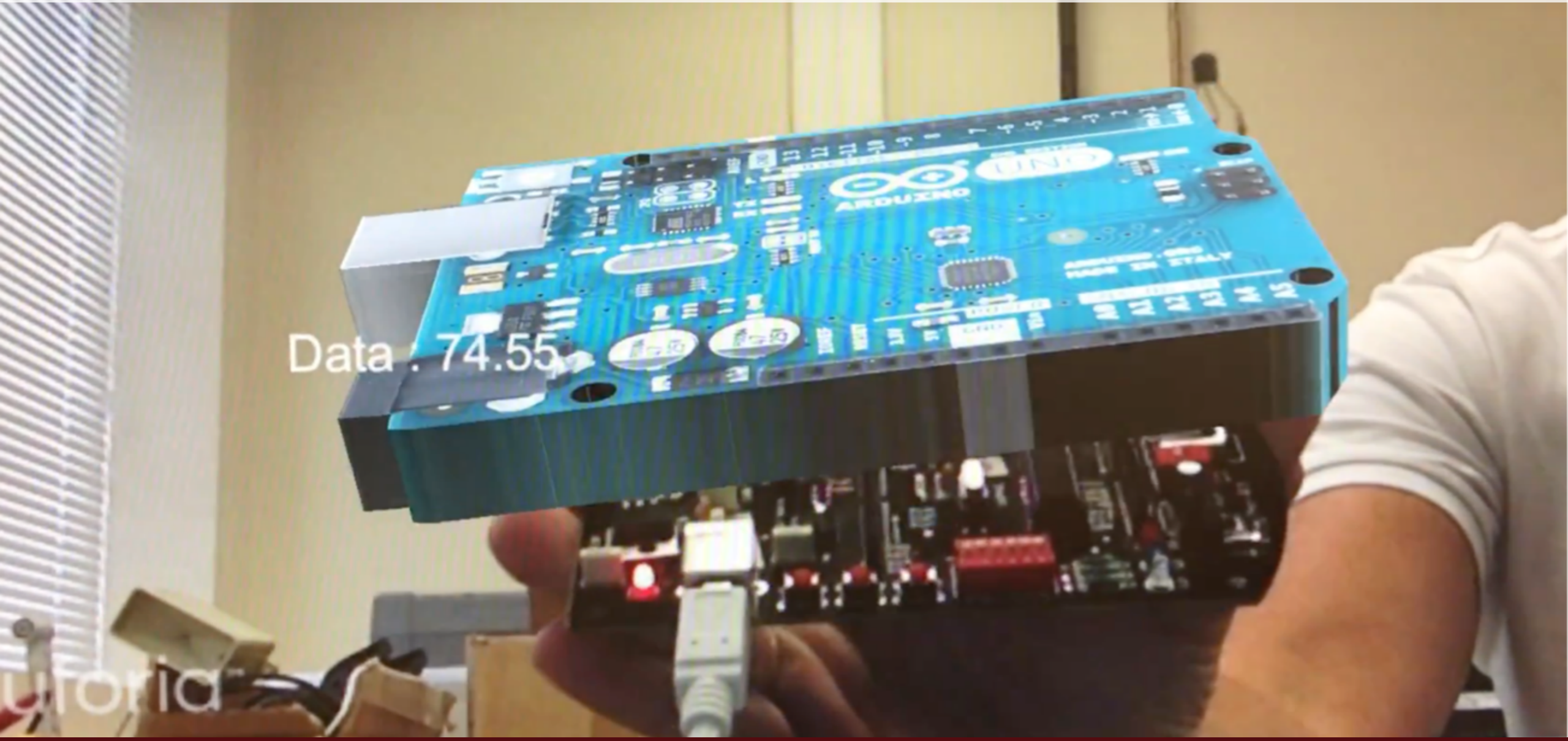
VEoT Simulations

XReality Research Group at Texas State

- Develop **lightweight APIs** to enable the integration of IoT devices and AR applications
- Provide Low Latency <10ms (Tactile Internet) by implementing **Edge/Fog computing** principles
- Develop an interactive visual communication strategy for enhanced UX (**IoT Virtual Twin**)
- Focus on **industrial applications** (Civil Eng, Networking, Health)

Demo 1: Object identification

View video ➔ https://youtu.be/jeEM5w0aKMU

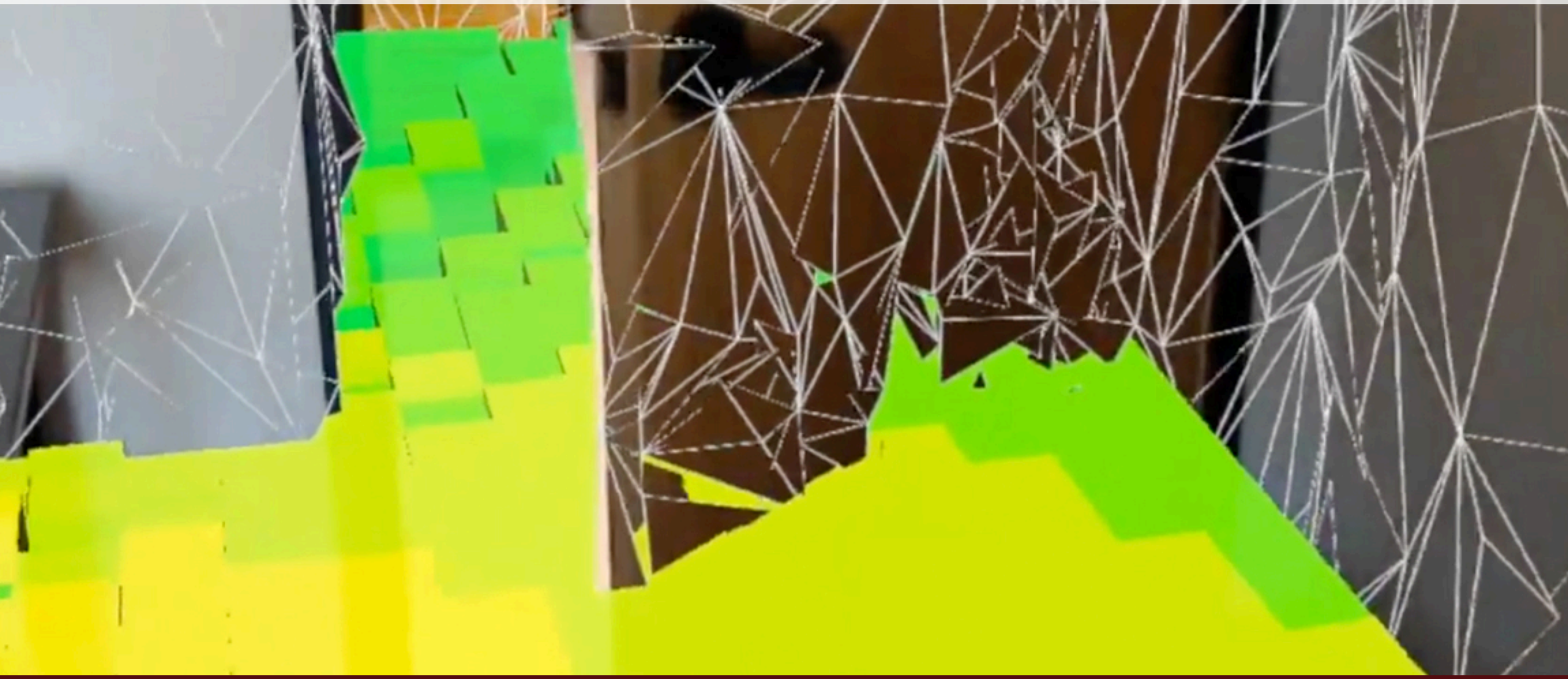


Demo 2: IoT / AR Interaction

View video ➔ https://youtu.be/XHGtIbU-TBE

Demo 3: Network propagation visualization

View video ➔ https://youtu.be/npcdQPvOb6o

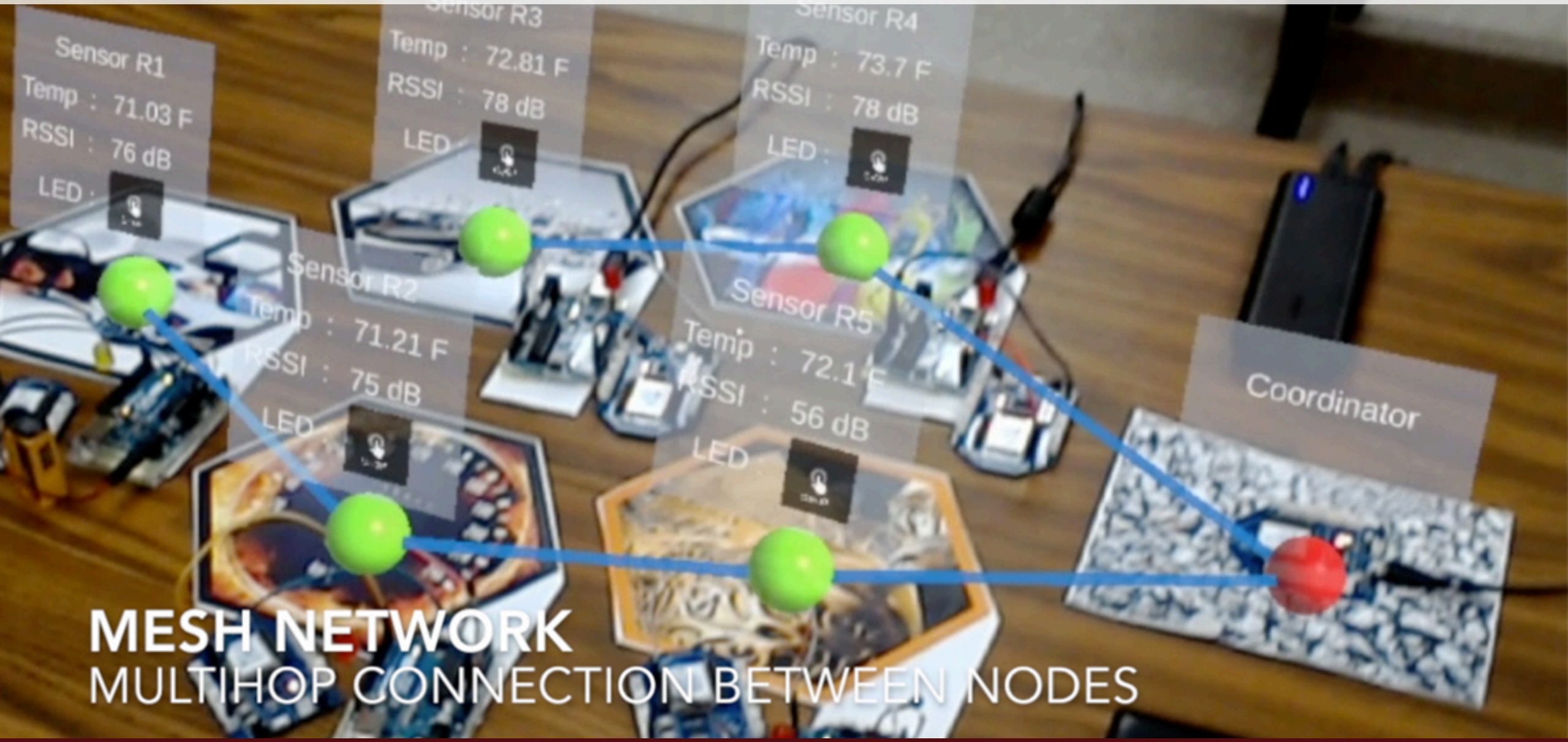


Demo 4: First Responders

View video ➔ https://youtu.be/HKcNgCU6Wa0

Demo 5: Network visualization

View video ➔ https://youtu.be/GEB9C4mVQ4Q



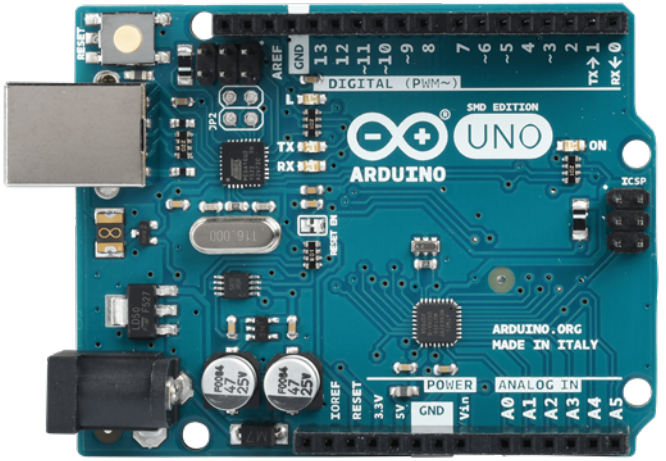
Devices and Hardware

Augmented Reality

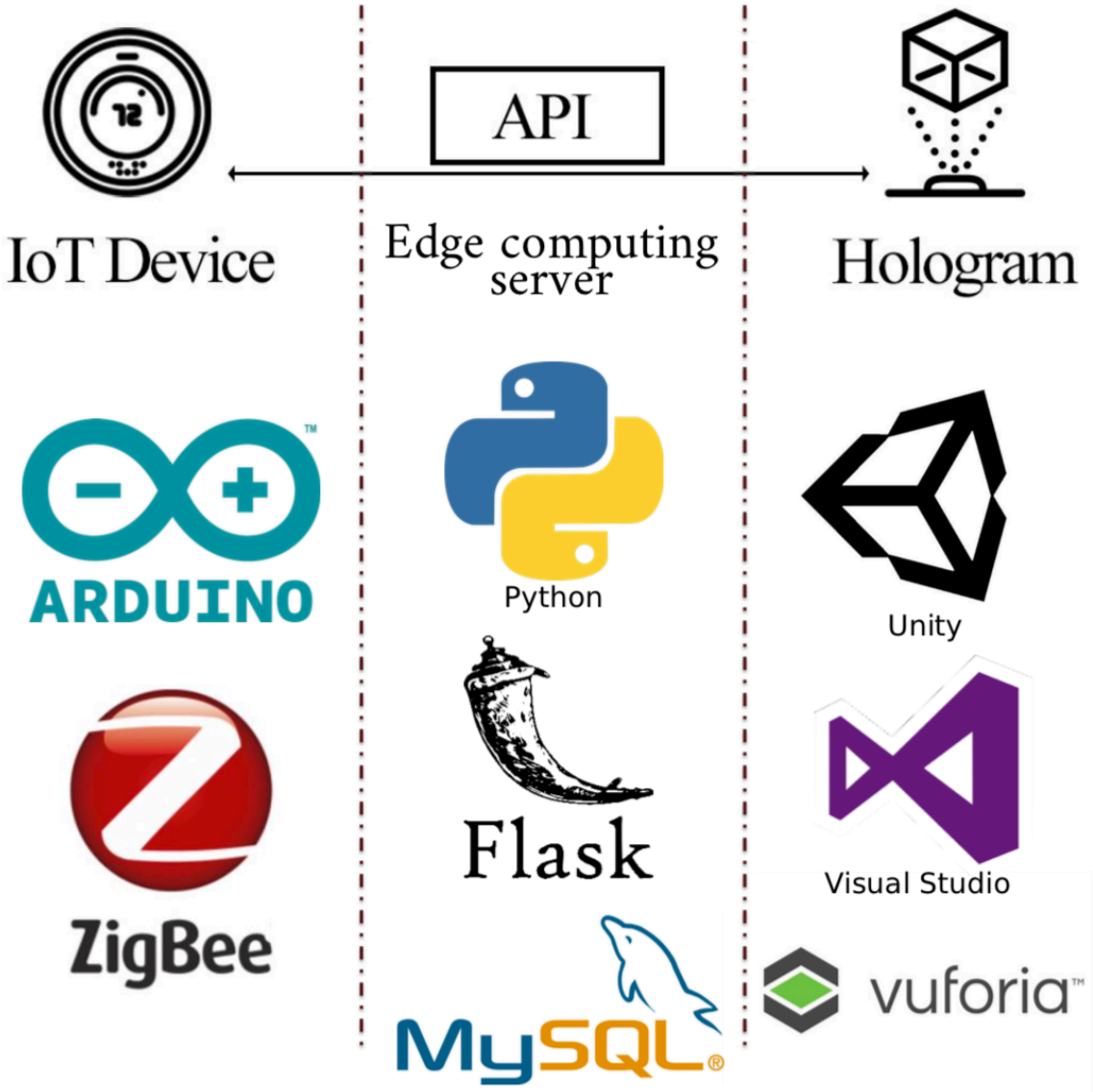
- Microsoft Hololens VR headgear

Internet of Things

- Arduino Uno R3
- ZigBee XBee S2D
- Raspberry Pi (Edge computing)



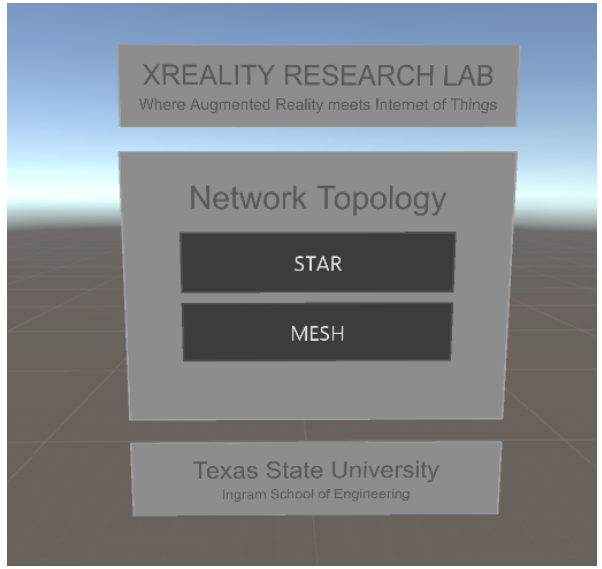
Technologies

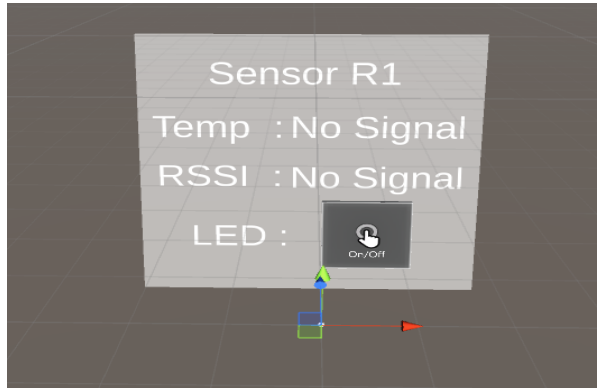


Unity (AR Design)

Unity

- Unity is a multipurpose game engine that supports 2D and 3D graphics, drag-and-drop functionality and scripting using C#
- Unity supports building to 27 different platforms.
- Support for Holographic App building.



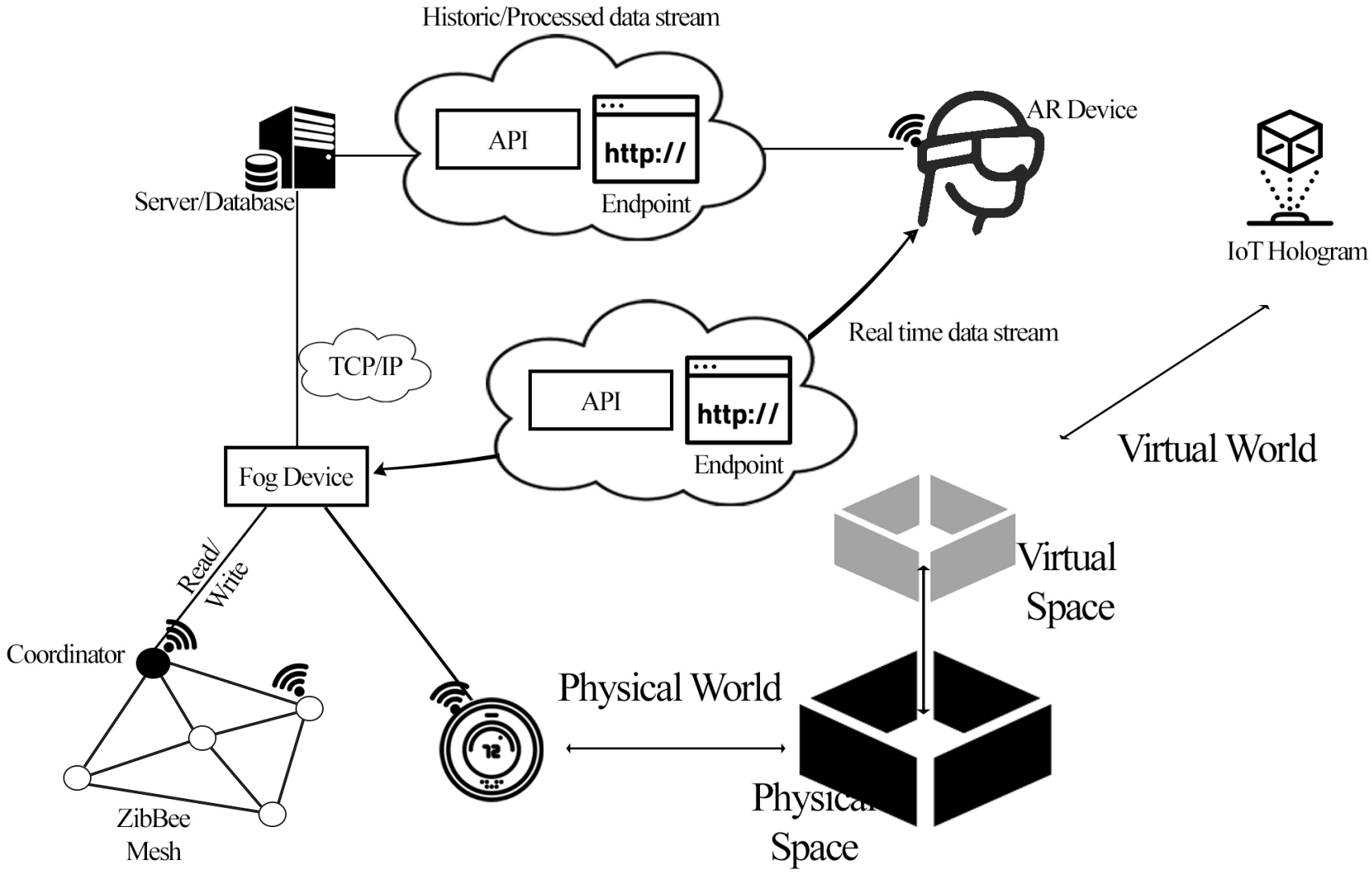


Vuforia (Object Recognition SDK)

Vuforia

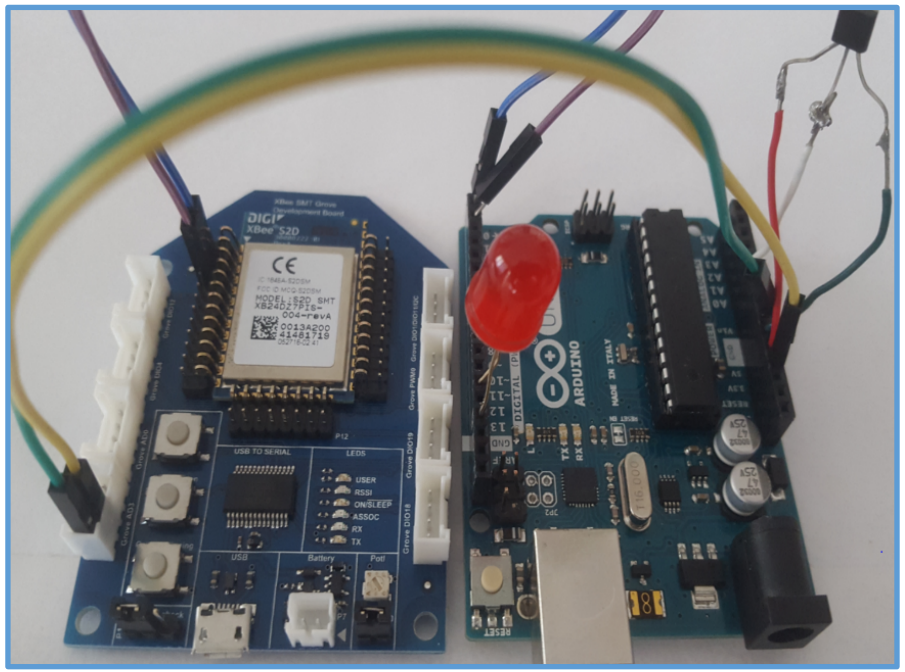
- It is a Software Development Kit (SDK) which enables Augmented Reality apps.
- Computer Vision Technology
- **Marker** and **markerless** object tracking.
- It provides support for application development through an extension to the Unity Game Engine.
- Object to be detected are scanned and processed then formulated into unity asset package.

Architecture



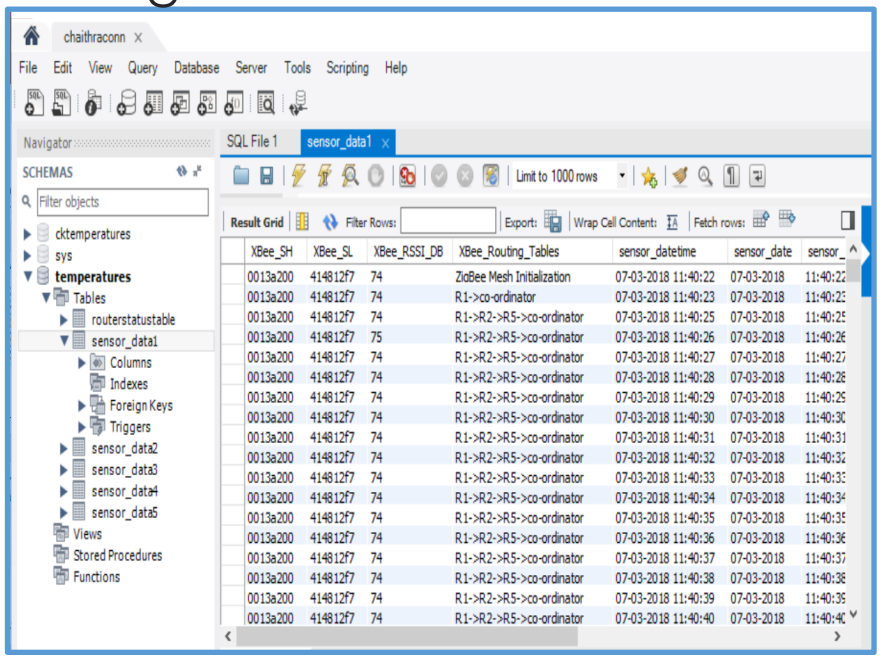
Network setup

- Sensor are paired with respective Arduino boards.
- ZigBee is used as a communication protocol between the sensor nodes
- LM35 precision temperature sensor
- LED on/off can be controlled from the network management portal
- Series2 XBee modules(Mesh Networking)
- Xbee shield connected to Arduino- Routers
- Xbee shield connected to base station- Coordinator
- Coordinator has information of all the routers.
- XCTU software is a graphical user interface which helps in interacting with xbee modules
- Multiple Digi modules can be configured on XCTU
- XCTU helps in analyzing the network view and visualize the topology

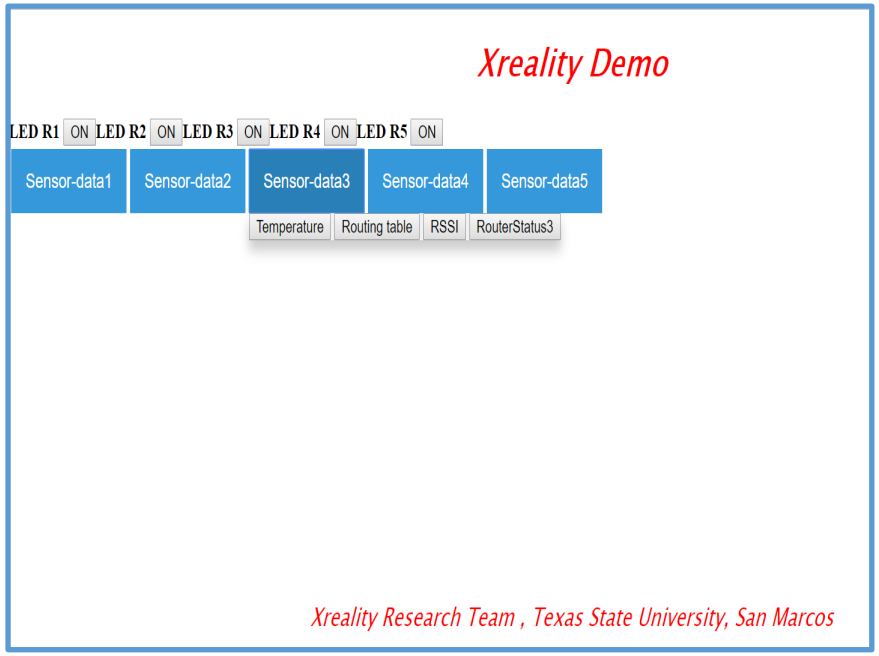


Network Management Portal

- Python scripting is used to decode the data from the coordinator.
- Decoded data is hosted on to MySQL Database
- Flask-python web development
- HTML webpage –where a user will have a manual control over the data, choose the network topology that needs to be accessed from the Network Management Portal.
- ngrok is used to host the data into cloud



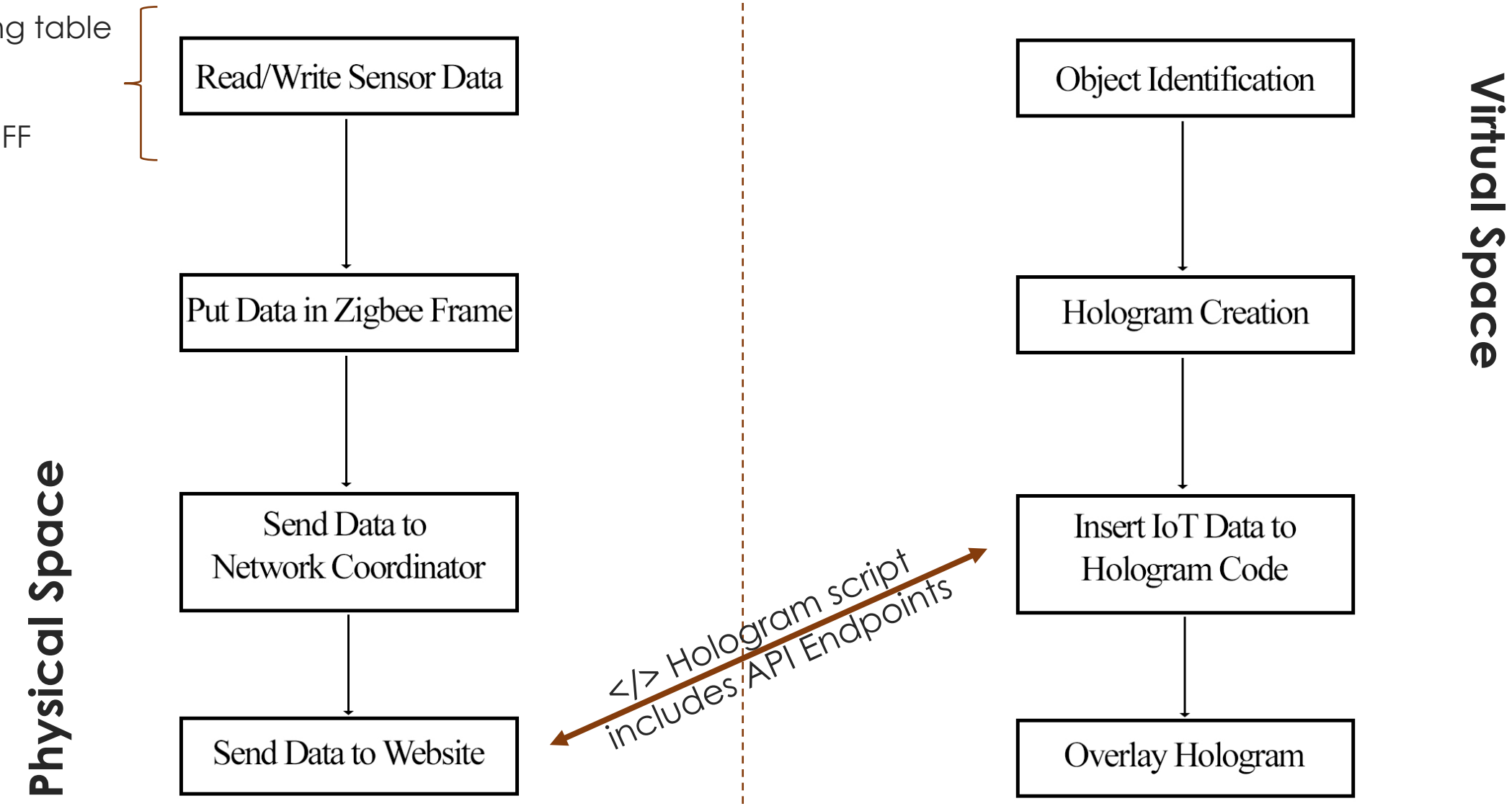
MySQL database



Network Management Portal

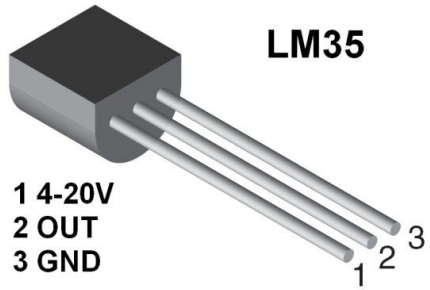
Process flow

- Routing table
- Temp
- RSSI
- ON/OFF



Reading Temperature Sensor

- LM35 Sensor
- Reading Sensor data at pin A0
- Converting sensor data into Fahrenheit
- Sending temperature value as payload to coordinator




```
int sensor = A0;

void loop()
{
  String string_payload = "";
  digitalWrite(LED_pin, LOW);
  temp = analogRead(sensor); // read LM35 sensor output
  tempc = temp*0.0048828125*100; //convert sensor data into centigrade
  tempf = tempc*9/5+32; //convert centigrade to fahrenheit
  dtostrf(tempc, 3, 3, tempxbee); //convert float data to string
  for (int i = 0; i < sizeof(tempxbee); i++)
  {
    string_payload += tempxbee[i];
  }
```

Coordinator Function

- Receive payload
- Decode data package
- Create MySQL table and insert temperature data

```
# Decode Sensor data from XBee frame
def sensordatadecode(decodedData):
    list_of_rfdata = decodedData[1].split(",")
    sensordatatemp = [decodedData[0]]
    sensordatatemp += list_of_rfdata
    return sensordatatemp
```

```
# Insert sensor data into the MySQL database
def sensordatainsertmysql(decodedData, config,
                          sensordata_decoded, SensorTablesName, temperature_value):
    cnx = mysql.connector.connect(**config)
    cursor = cnx.cursor()
    i = 0
    while (str(decodedData[0][0:16]) != SensorSHSLAddress[i]):
        i += 1
    else:
        add_sensor_count = "INSERT INTO " + SensorTablesName[
            i] + " (temperature) VALUES ( %(temperature)s)"
    data_sensor_count =
    {
        'temperature': temperature_value,
    }
    cursor.execute(add_sensor_count, data_sensor_count)
    cnx.commit()
    cursor.close()
    cnx.close()
    print 'Sensor data have been written to MySQL database'
    print '-----------------'
```

Flask Server Function

- Rendering HTML page
- Reading data from MySQL Database
- Host data on HTML
- Flask Server is the Integrator

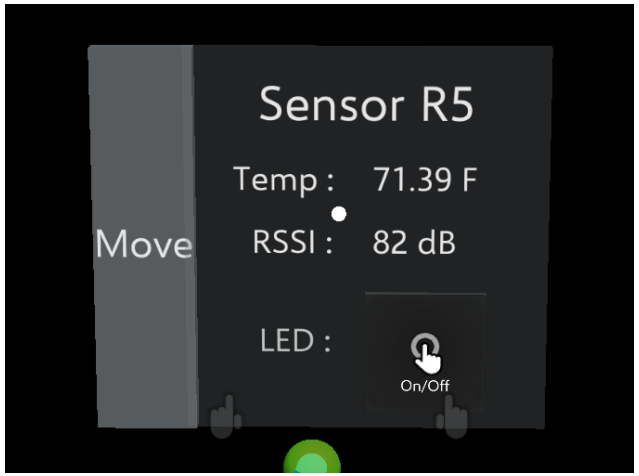
```
@app.route('/sensor-data/temperature-json/')
def temperature_json():
    alltemp = []

    connection = MySQLdb.connect(host='localhost',
                                 user='admin',
                                 passwd='password',
                                 db='temperatures'
                                 )
    cur = connection.cursor()

    sensor_number = request.args.get('number')
    cur.execute("SELECT temperature   FROM sensor_data" + sensor_number
    temp = cur.fetchall()
    i = 0
    if len(temp) > 0:
        for row in temp:
            alltemp.append(row[0])
    return jsonify(alltemp)
```

Unity Sensor UI Panel

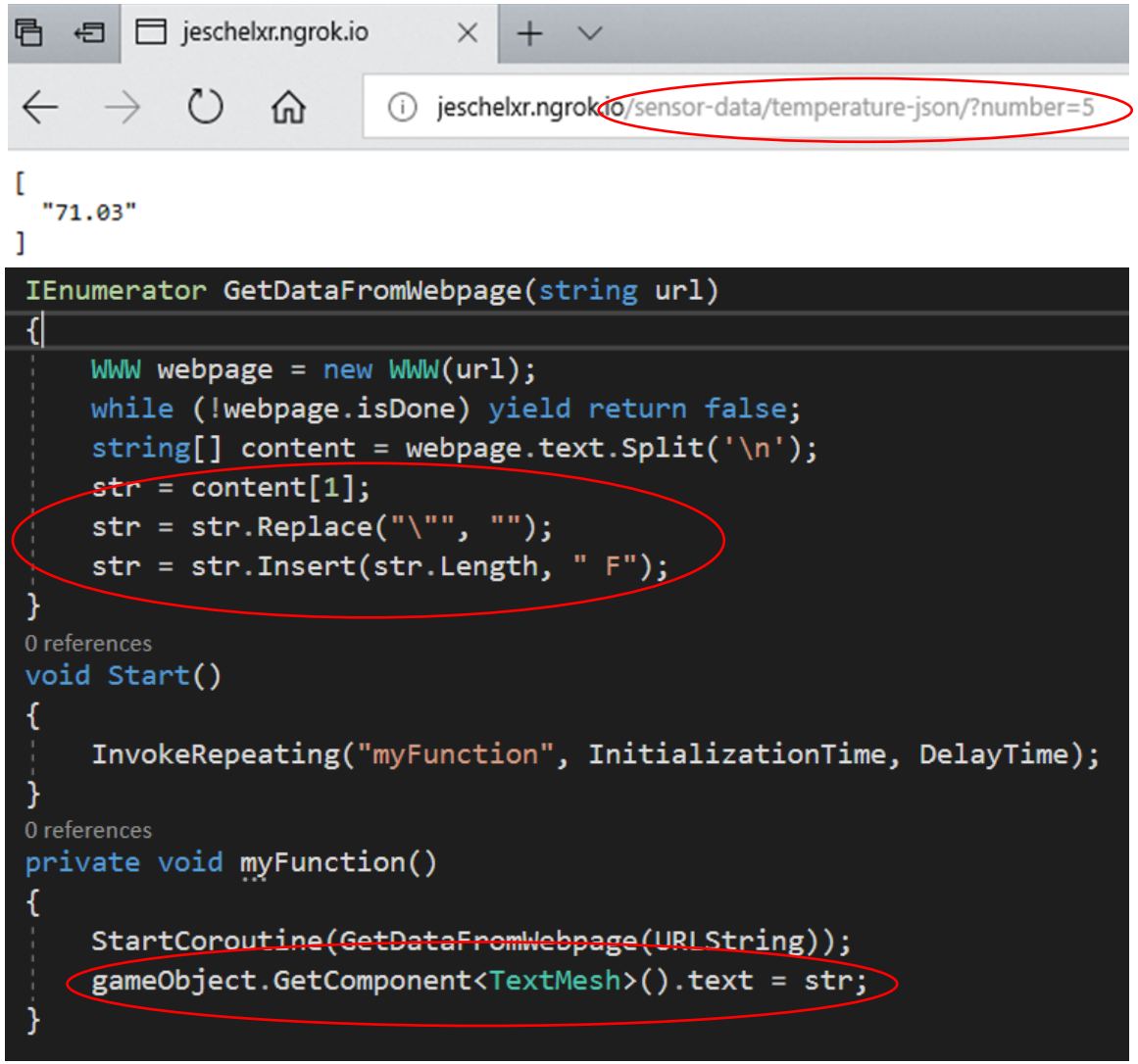
- When UI panel (GameObject) is active, the embedded scripts are activated
- When scripts are activated, its corresponding URL Requests are made to the Flask Hosted HTML page for information.




```
------------------
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/rssi-json/?number=1 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/temperature-json/?number=3 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/temperature-json/?number=1 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/rssi-json/?number=2 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/rssi-json/?number=5 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/temperature-json/?number=2 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/temperature-json/?number=5 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/temperature-json/?number=4 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/rssi-json/?number=3 HTTP/1.1" 200 -
127.0.0.1 - - [11/Apr/2018 17:21:17] "GET /sensor-data/rssi-json/?number=4 HTTP/1.1" 200 -
decodedData is ['0013a20041680c8f', '71.39,52', 'rx_explicit', '11-04-2018 17:21:18', 1523485278103.0, '7693']
Nw topo: {'0013a20041680c8f': 'fffe'}
sensordatadecoded is ['0013a20041680c8f', '71.39', '52']
Writing Sensor data to MySQL database...
Sensor data have been written to MySQL database
------------------
```

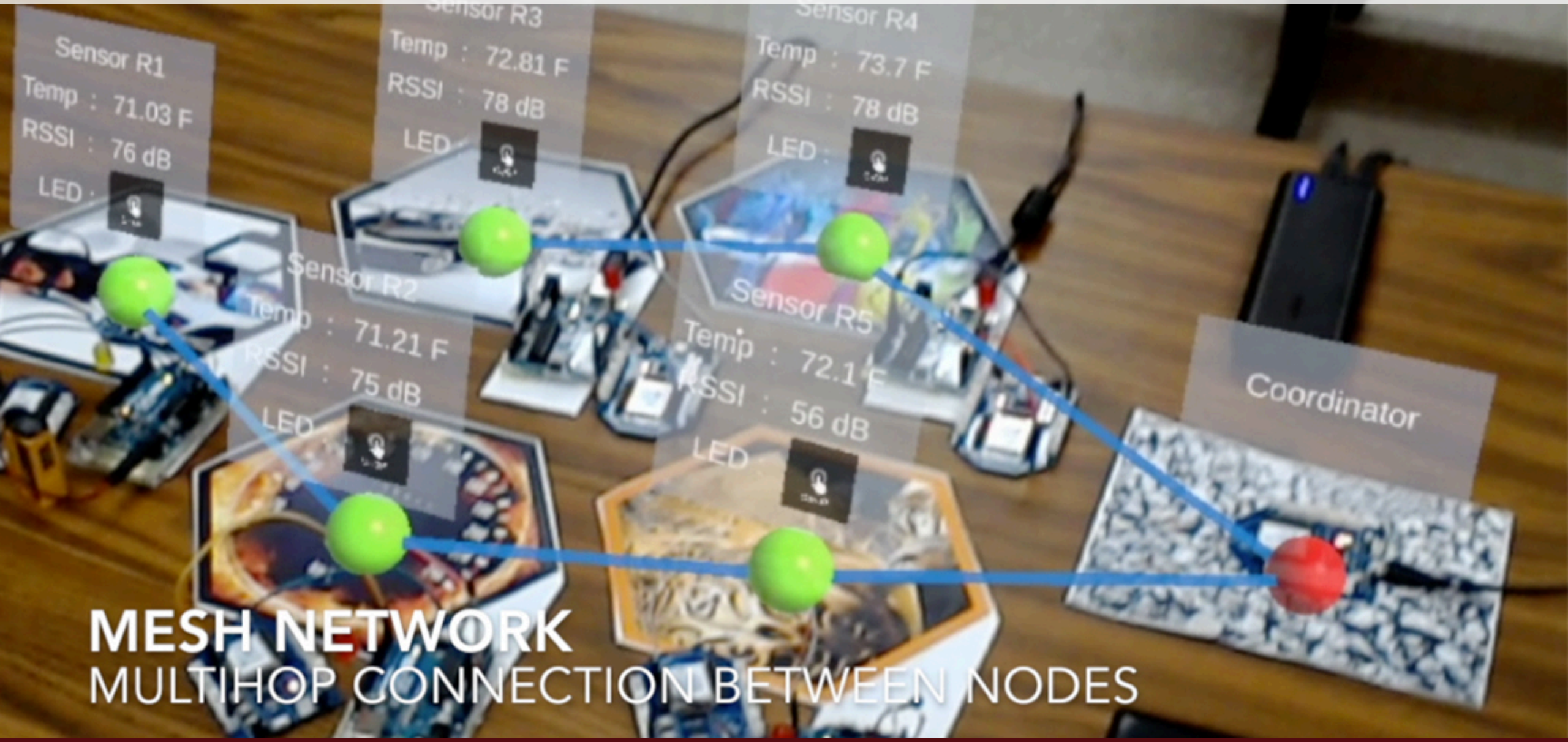
Unity Sensor UI Panel

- Data from the HTML is saved into a string
- The data from the string is tailored to appear in the UI Panel "Temp:"



Demo 5: Network visualization

View video ➔ https://youtu.be/GEB9C4mVQ4Q



Future work: Holoportation

Opportunities

- Differentiate by creating state of the art applications and products
- Raise research funding
- Commercialize new ideas
- Write joint publications in peer reviewed journal and conference proceedings
- Ride the wave of AR+IoT innovation

Thank you!

XReality Research Group

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