



IoT for Smart Living

Bharadwaj Amrutur

Professor

Robert Bosch Centre for Cyber-Physical Systems,

Indian Institute of Science, Bangalore

amrutur@iisc.ac.in



What is IoT



- IoT = Internet of Things
- Anything and Everything becomes accessible via your web browser
- Enabled by incredible advances in Communication, Sensing and Computation
- Metcalf's Law

Power of network grows as square of number of nodes



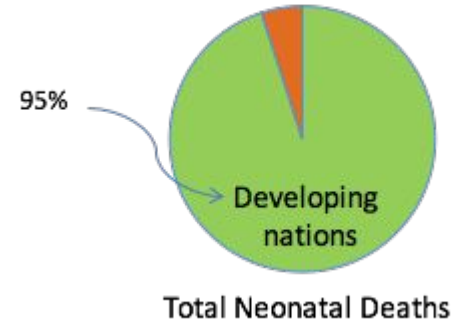
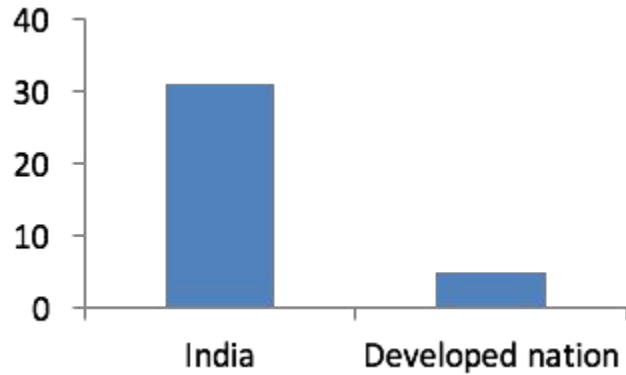
Two applications



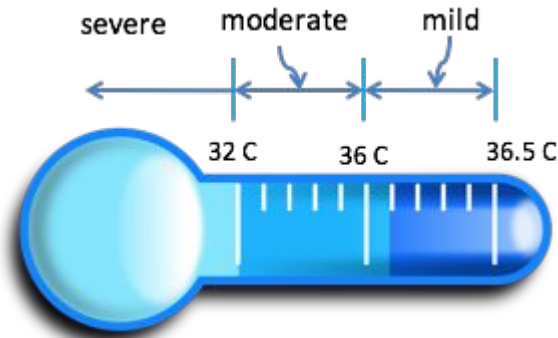
- Rural Health
- Smart Cities



Neonatal Mortality



Hypothermia: Leading indicator of Morbidity and Mortality





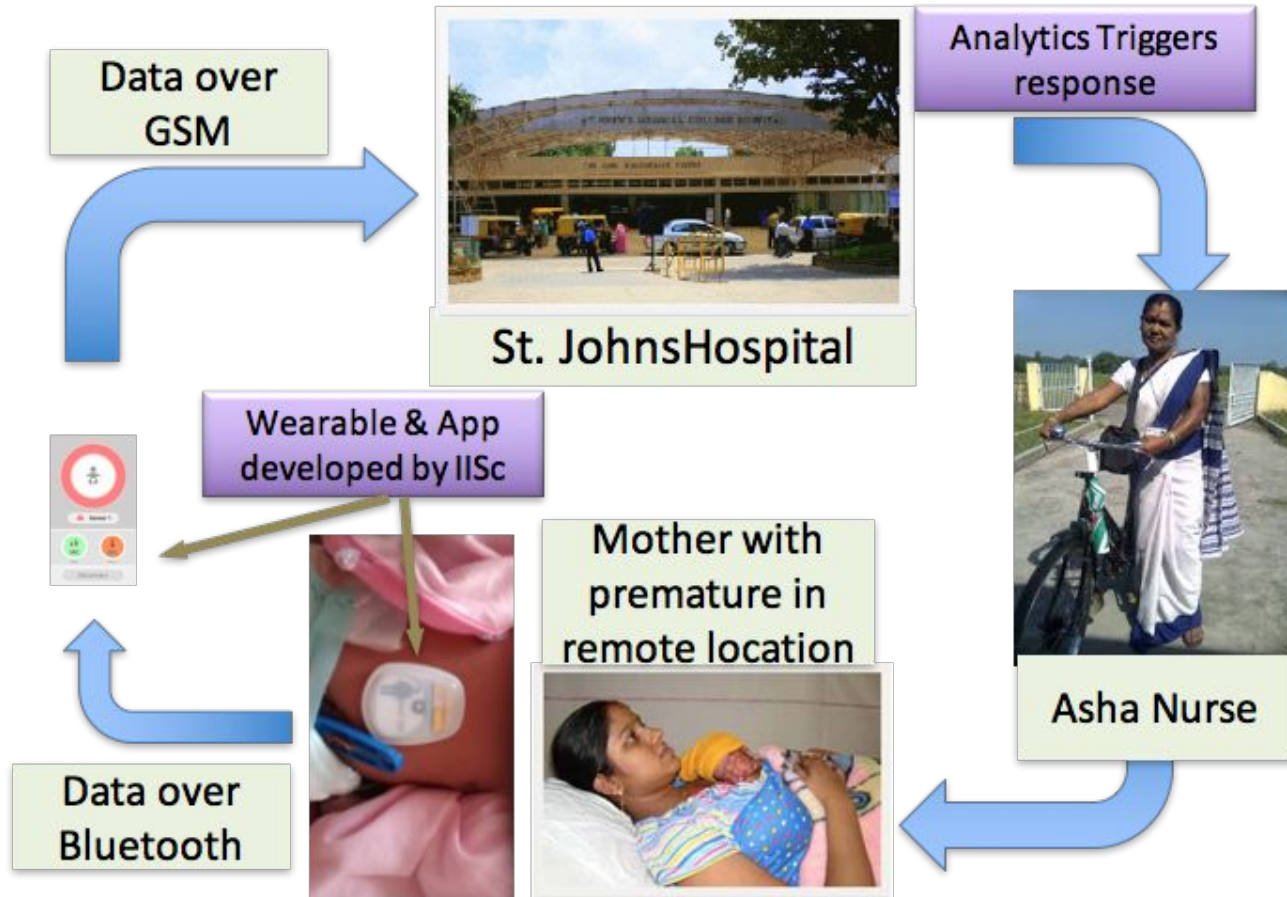
Affluent versus Deprived



If baby can't come to NICU, can we take the NICU to the baby?



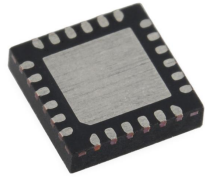
Connected Kangaroo Mother Care System



KMC IoT Device



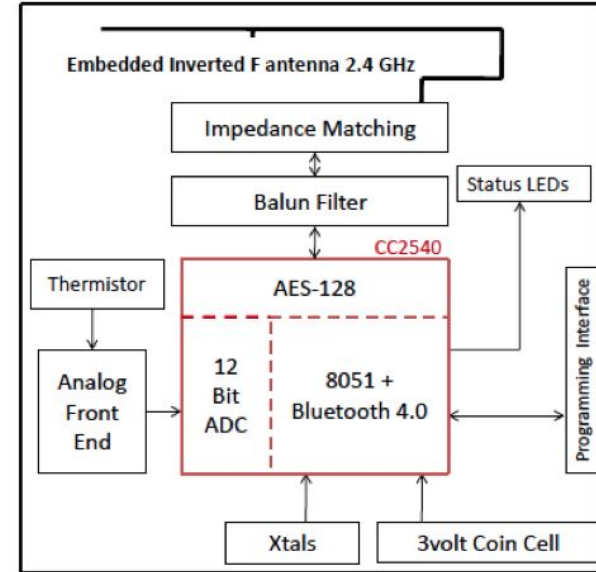
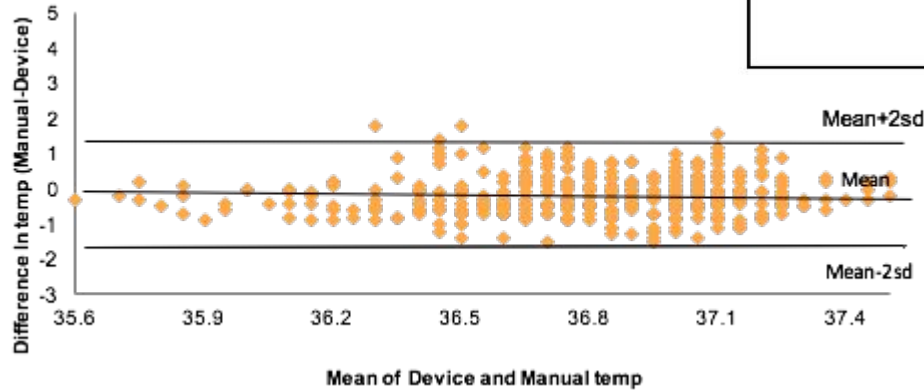
x 2



x 1

Capacitance
Touch
Sensor

x 2





IoT for Smart Cities



Smart City Component	Devices
Transit Operations Systems (Maintenance and tracking)	Crowd sensors (cameras /phones/pressurepads), Bus ID and Location sensor (cameras/rfid/gps), Bus Bay Sensor (magnetometer/camera), Signage Actuators, Various other Asset Sensors (doors/lights/humidity/temperature)
Smart parking system	Parking sensors (Magnetometers/ Cameras)
Area based traffic control	Traffic density sensors (camera /laser/magnetometers/cell tower records/phones), Signal sensors (LDR), Signal actuators (Light Controllers), Crowd sensors,
GPS tracking and optimisation of routes of garbage trucks	GPS sensors, other locationing sensors (UWB, WiFi, LoRa, CellTower Triangulation)
LED Streetlight lighting	LDR sensor, LED Control Actuator, Power Supply Sensor
Traffic analysis or roads and video surveillance inside bus using CCTV surveillance	Cameras , crowd sensing
Fleet management system	Vehicle ID and Locationing Sensors (GPS, and other radio triangulation based sensors, RFID/BLE beacon based sensors)
Automatic fare collection system (transport)	Smart card readers and actuators/ smart phone (NFC) based devices/Biometric sensors
Pedestrian Infra	Camera sensors



What questions can you answer?



Commuters:

- Does this bus which is coming now to the stop go to place XYZ?
- When will bus XYZ arrive at this stop?
- Give me a route where I can get seating.
- Alert me when my bus comes within a km

Transit Centers:

- Which platforms are getting congested?
- What is the movement pattern of commuters?
- Alert me if there is unusual activity



Key elements of these problems



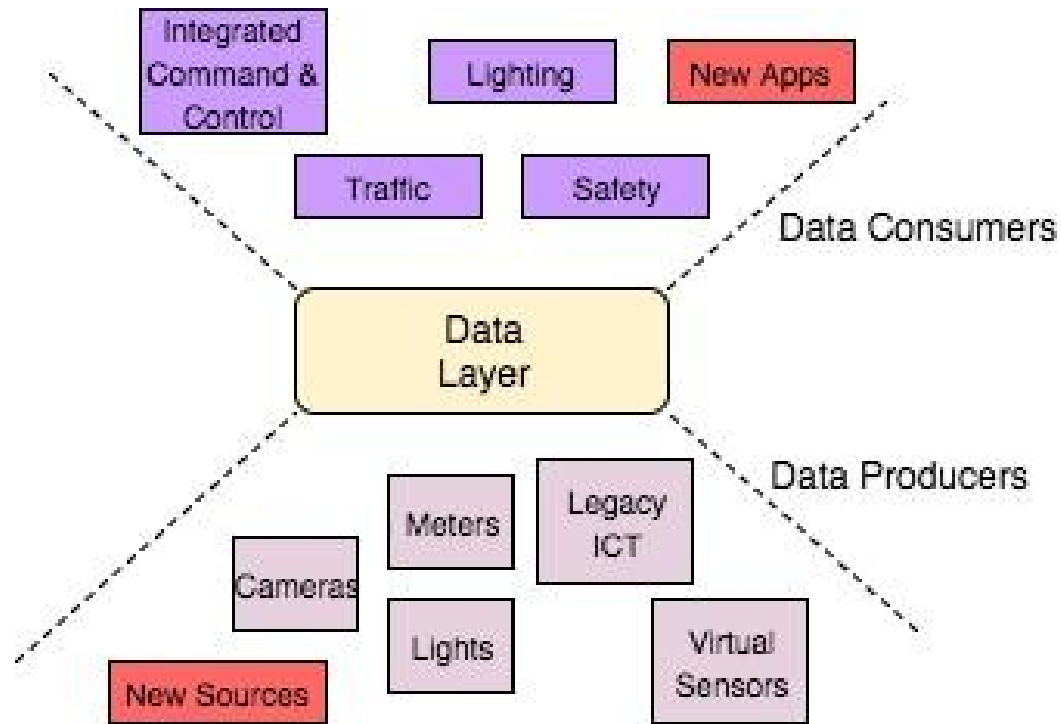
- Need interplay of different elements
 - Camera, Citizen, Bus Locations, Public Address management, Congestion Sensors, BMTC Route Database, Traffic police/Security, Augmented Reality,.....
- Need to correlate or **connect** different information pieces.
- Need real-time (for some of them)
- Need to support new applications of the future



Platform Approach to Smart City IoT Framework

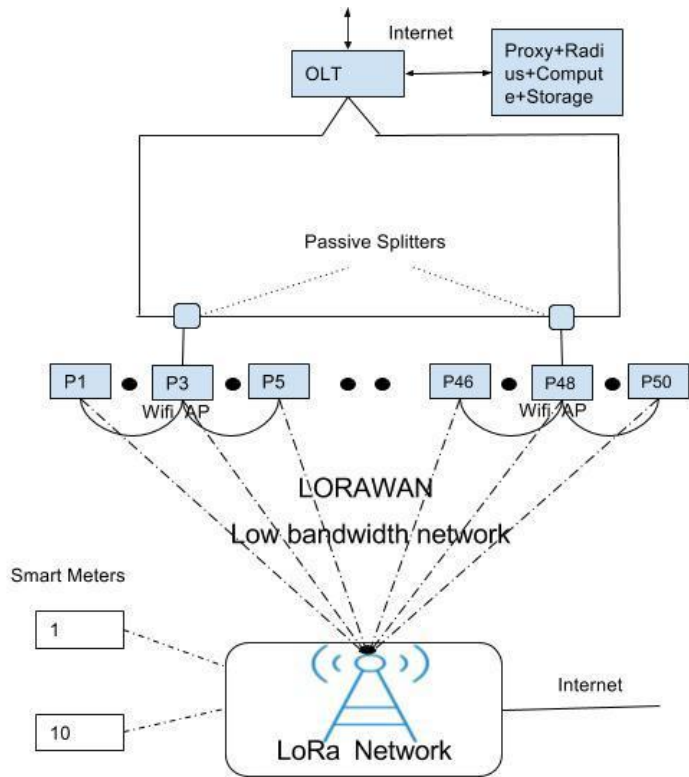
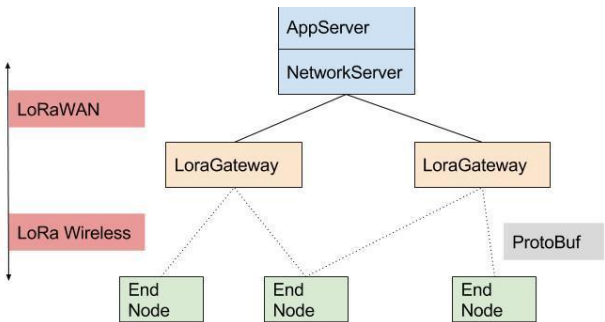
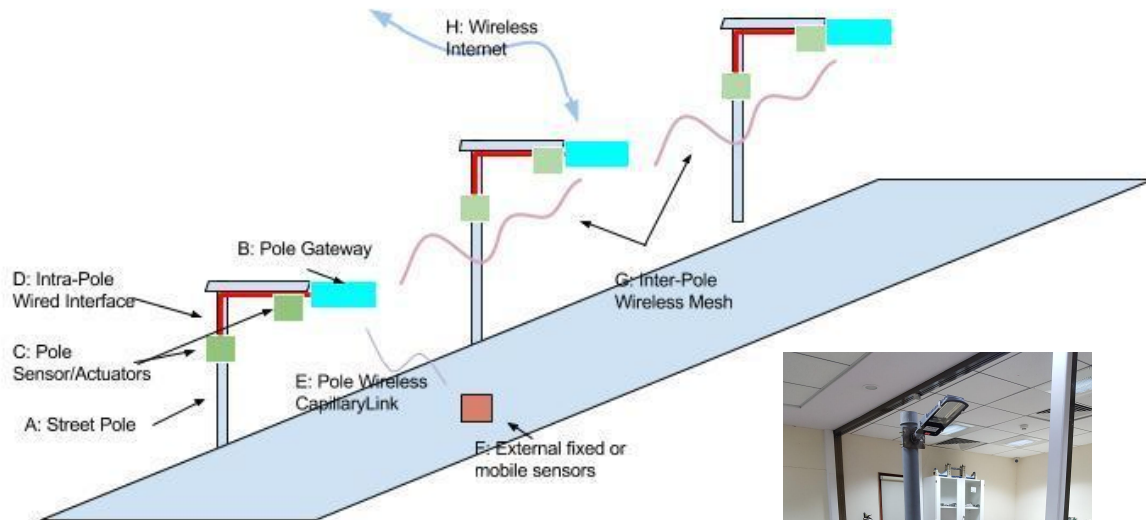


- Focus on Data & APIs
- Extensible & Scalable
- Secure & Privacy preserving
- Sustainable & Maintainable
- Enable new cross-domain (real-time) applications
- Application & Device portability





Test Bed





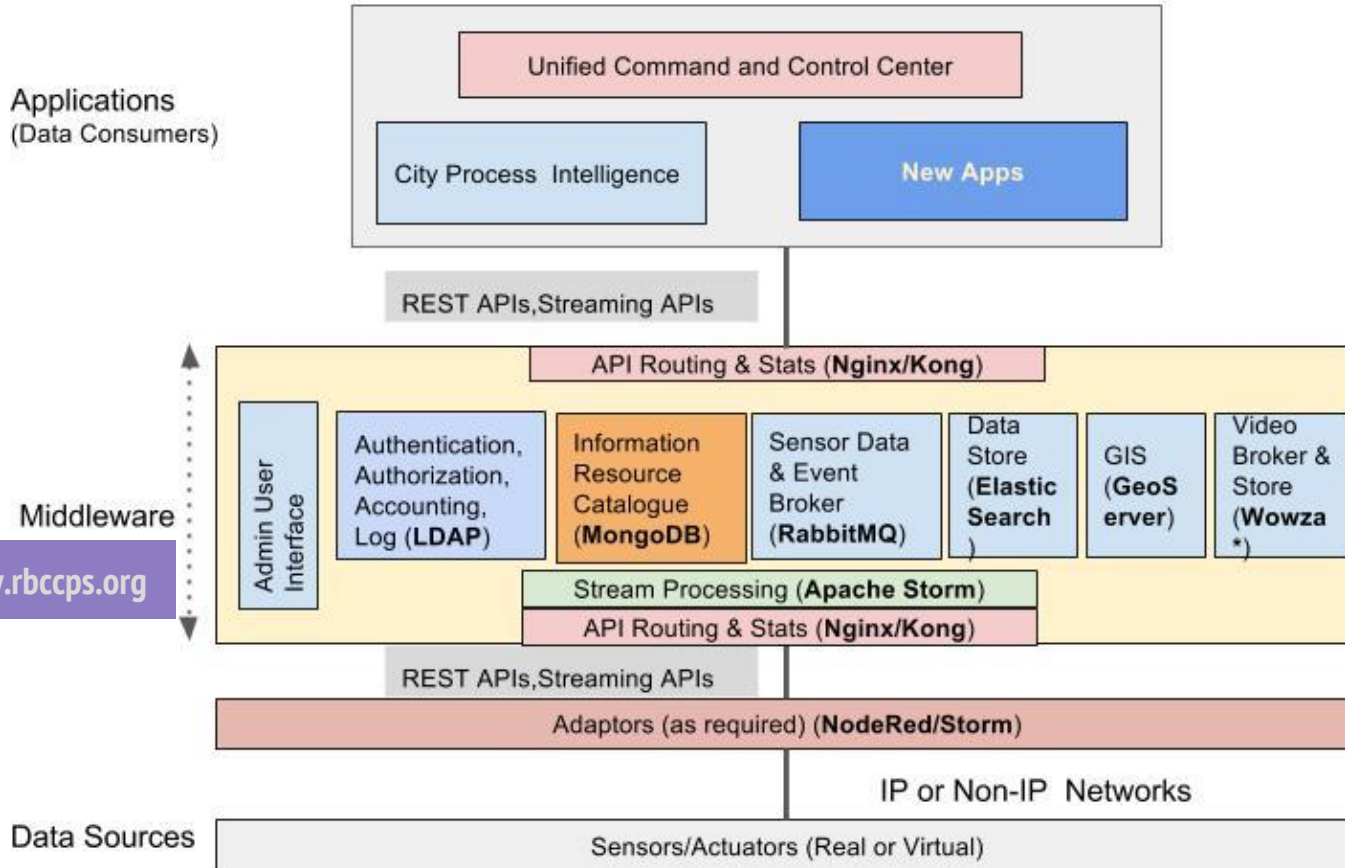
Ultra Sound LoRa Connected Water Level Sensor



LoRa Enabled LED Streetlight



Data Middleware Platform





Catalog Item: Streetlight - 1



```
"item-metadata": [
  {
    "refCatalogueSchema": "generic_iotdevice_schema.json",
    "id": "70b3d58ff0031de5",
    "resourceSchemaVersion": "1.0.0",
    "resourceType": "streetlight",
    "tags": [
      "onstreet",
      "Energy",
      "still under development!"
    ],
    "latitude": {
      "value": 13.0143335,
      "ontologyRef": "http://www.w3.org/2003/01/geo/wgs84_pos#"
    },
    "longitude": {
      "value": 77.5678424,
      "ontologyRef": "http://www.w3.org/2003/01/geo/wgs84_pos#"
    },
    "owner": {
      "name": "IISC",
      "website": "http://www.iisc.ac.in"
    },
    "provider": {
      "name": "Robert Bosch Centre for Cyber Physical Systems, IISC",
      "website": "http://rbccps.org"
    },
    "geoLocation": {
      "address": "CV Raman Road, Bangalore, 560012"
    },
    "accessMechanism": {
      "requestAccessSite": {
        "describes": "URI for getting permissions to access the device",
        "value": "http://rbccps.org/middleware/requestAccess"
      },
      "accessEndPoint": {
        "value": "https://smartcity.rbccps.org/api/0.1.0/db",
        "describes": "End point to access the archived values (database access endpoint)"
      },
      "subscriptionEndPoint": {
        "value": "http://smartcity.rbccps.org/api/0.1.0/subscribe",
        "describes": "End point for subscribing to LIVE data"
      },
      "updateEndPoint": {
        "value": "http://smartcity.rbccps.org/api/0.1.0/update",
        "describes": "End point for subscribing to LIVE data"
      },
      "resourceAPIInfo": {
        "value": "https://rbccps-iisc.github.io/",
        "describes": "Information on how to use various APIs (access, update, cat) associated with this resource"
      }
    }
  ]
}
```



Catalog Item: Streetlight - 2



```
"data_schema": {
  "type": "object",
  "properties": {
    "dataSamplingInstant": {
      "type": "number",
      "description": "Sampling Time in EPOCH format",
      "units": "seconds",
      "permissions": "read",
      "accessModifier": "public"
    },
    "caseTemperature": {
      "type": "number",
      "description": "Temperature of the device casing",
      "units": "degreeCelsius",
      "permissions": "read",
      "accessModifier": "public"
    },
    "powerConsumption": {
      "type": "number",
      "description": "Power consumption of the device",
      "units": "watts",
      "permissions": "read",
      "accessModifier": "public"
    },
    "luxOutput": {
      "type": "number",
      "description": "lux output of LED measured at LED",
      "units": "lux",
      "permissions": "read",
      "accessModifier": "public"
    },
    "ambientLux": {
      "type": "number",
      "description": "lux value of ambient",
      "units": "lux",
      "permissions": "read",
      "accessModifier": "public"
    },
    "targetPowerState": {
      "type": "string",
      "enum": [
        "ON",
        "OFF"
      ],
      "units": "dimensionless",
      "description": "If set to ON, turns ON the device. If OFF turns OFF the device. Writeable parameter. Writeable
red for authorized apps",
      "permissions": "read-write",
      "accessModifier": "protected"
    },
  },
}
```




Catalog Item: Streetlight - 3



```
"targetBrightnessLevel": {
  "type": "number",
  "description": "Number between 0 to 100 to indicate the percentage brightness level. Writeable only allowed for authorized apps",
  "units": "percent",
  "permissions": "read-write",
  "accessModifier": "protected"
},
"targetControlPolicy": {
  "enum": [
    "AUTO_TIMER",
    "AUTO_LUX",
    "MANUAL"
  ],
  "units": "dimensionless",
  "permissions": "read-write",
  "description": "Indicates which of the behaviours the device should implement. AUTO_TIMER is timer based, AUTO_LUX is ambient light based and MANUAL is controlled by app. Writeable only allowed for authorized apps",
  "accessModifier": "protected"
},
"targetAutoTimerParams": {
  "type": "object",
  "permissions": "read-write",
  "properties": {
    "targetOnTime": {
      "type": "number",
      "description": "Indicates time of day in seconds from 12 midnight when device turns ON in AUTO_TIMER. Writeable only allowed for authorized apps",
      "units": "seconds",
      "accessModifier": "protected"
    },
    "targetOffTime": {
      "type": "number",
      "description": "Indicates time of day in seconds from 12 midnight when device turns OFF in AUTO_TIMER. Writeable only allowed for authorized apps",
      "units": "seconds",
      "accessModifier": "protected"
    }
  }
},
"targetAutoLuxParams": {
  "type": "object",
  "permissions": "read-write",
  "properties": {
    "targetOnLux": {
      "type": "number",
      "description": "Indicates ambient lux when device turns ON in AUTO_LUX. Writeable only allowed for authorized apps",
      "units": "lux",
      "accessModifier": "protected"
    }
  }
}
```



Streetlight Observation & Control Data



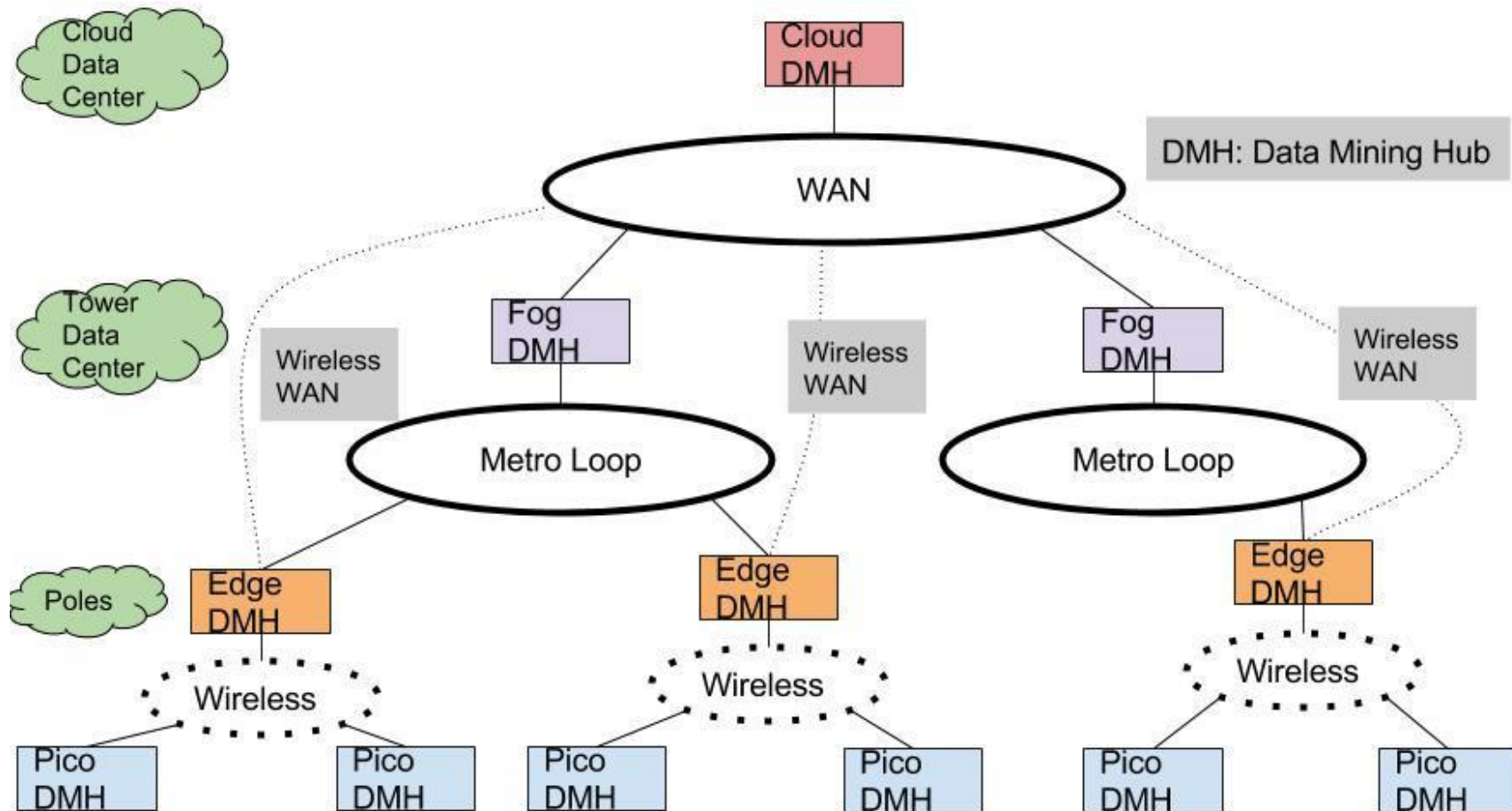
```
{  
  "dataSamplingInstant": 77475,  
  "caseTemperature": 21,  
  "powerConsumption": 0,  
  "luxOutput": 781,  
  "ambientLux": 546  
}
```

```
{  
  "dataSamplingInstant": 138321,  
  "caseTemperature": 21,  
  "powerConsumption": 21,  
  "luxOutput": 36,  
  "ambientLux": 24  
}
```

```
{  
  "targetBrightnessLevel": 70,  
}  
  
{  
  "targetControlPolicy": "AUTO_TIMER",  
  "targetAutoTimerParams": { "targetOnTime":  
343434, "targetOffTime": 606400},  
}
```



Data Mining Architecture





Challenges



- Develop “Standards” for common IoT devices (Streetlights, Parking sensors,)
 - Data Schemas, Interfaces
- Develop “Standards” for API access to Data and enable Data Marketplace
 - Security-Administration, Northbound (App Access) and Southbound (Device access)
- Network as a Service - with API access to allow customizing the network in real-time
- Distributed Data Mining especially for video
 - Software Runtime, Development and Debugging Framework
- Develop Information models/Knowledge structures to capture “Cities” to enable Intelligent apps

IoT Technology is now easily accessible for anyone to experiment with.

Build very interesting applications to solve real world problems



Thank You!