INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

Engineering IoT Systems: Through the Lens of Smart City Living Lab

SMARTCITY RESEARCH CENTER

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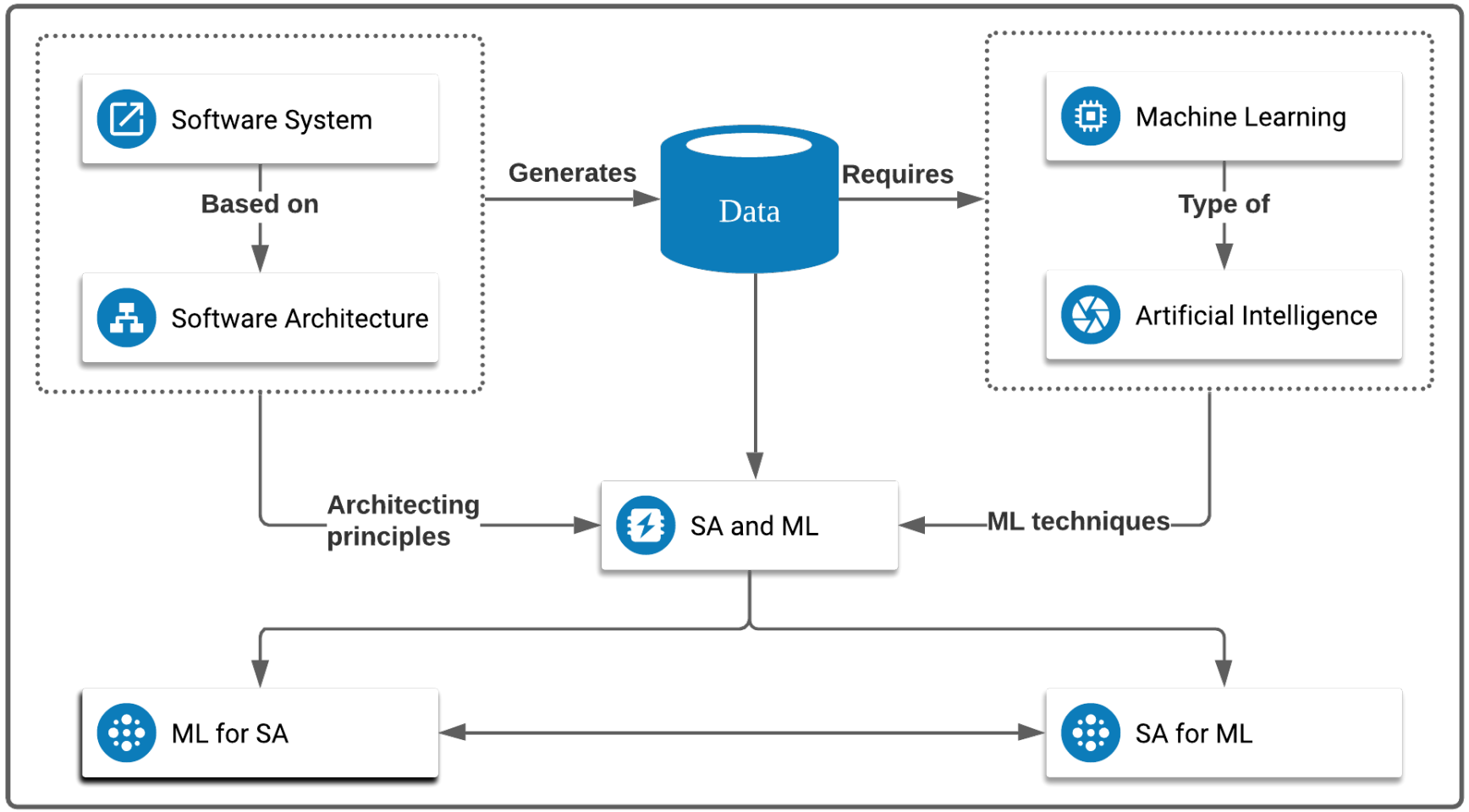
SERC
Software Engineering Research Centre

My Research



Areas: Self-adaptive architectures, software architecture, ML-enabled systems, MLOpS,..

Domains: microservice systems, IoT systems, CPS,..

Smart Cities

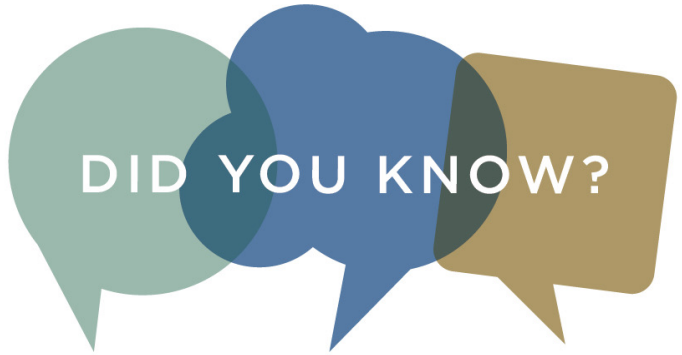
What is a Smart City?

A smart city is a municipality that uses **information and communication technologies (ICT)** to increase **operational efficiency**, share **information with the public** and **improve** both the **quality** of government services and citizen welfare

Source: techtarget

Engineering Smart City: Key Challenges

1. IDC – Global spending on smart city projected to reach 158 billion USD
2. UN - By 2050, 68% of the world's population is expected to live in urban areas
3. Smart City technologies can reduce energy consumption in buildings by 30%
4. Traffic congestion can be reduced by 30% through smart parking systems
5. Green house emission reduction by 15%
6. ….

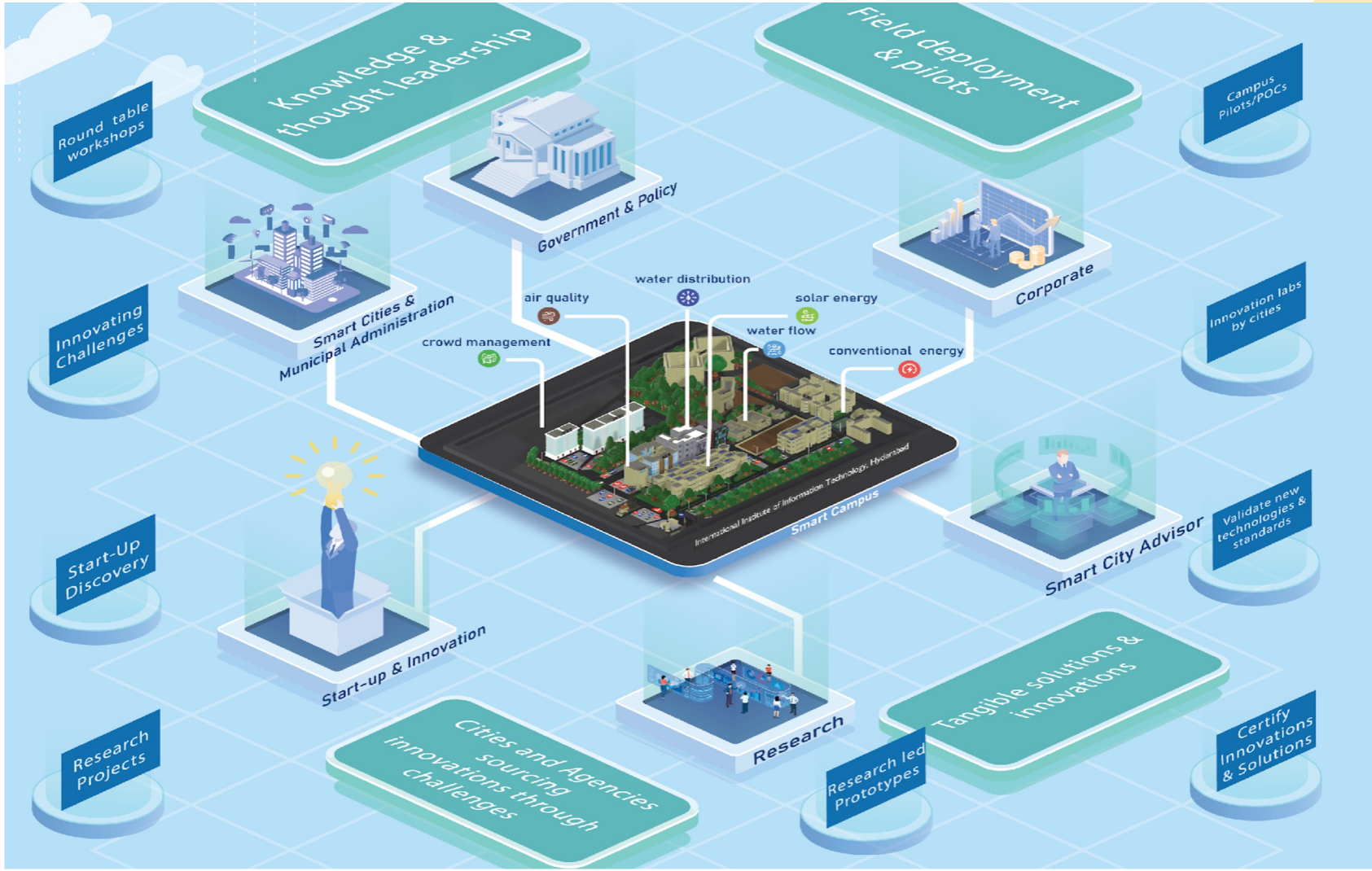


But..How to get Started?

Living Lab Model

The Living Lab Model

- Campus a “live” lab to seed, test and prove innovation before taking them into cities
- Connect. Share. Discover.
- A place for all stakeholders to meet and converse on possibilities, challenges and solutions
- IIITH Living Lab setup by Meity, Smart cities mission and Govt of Telangana
- With knowledge support from EBTC and AIA



The Big Challenge: Interoperability and Heterogeneity

Sensor Verticals and requirements

Weather

Air Quality

Water Quality and Quantity

Energy Monitoring

Smart House

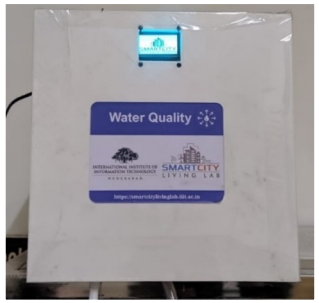
Crowd Monitoring

Smart Lamp

Engineering Smart City: Key Challenges

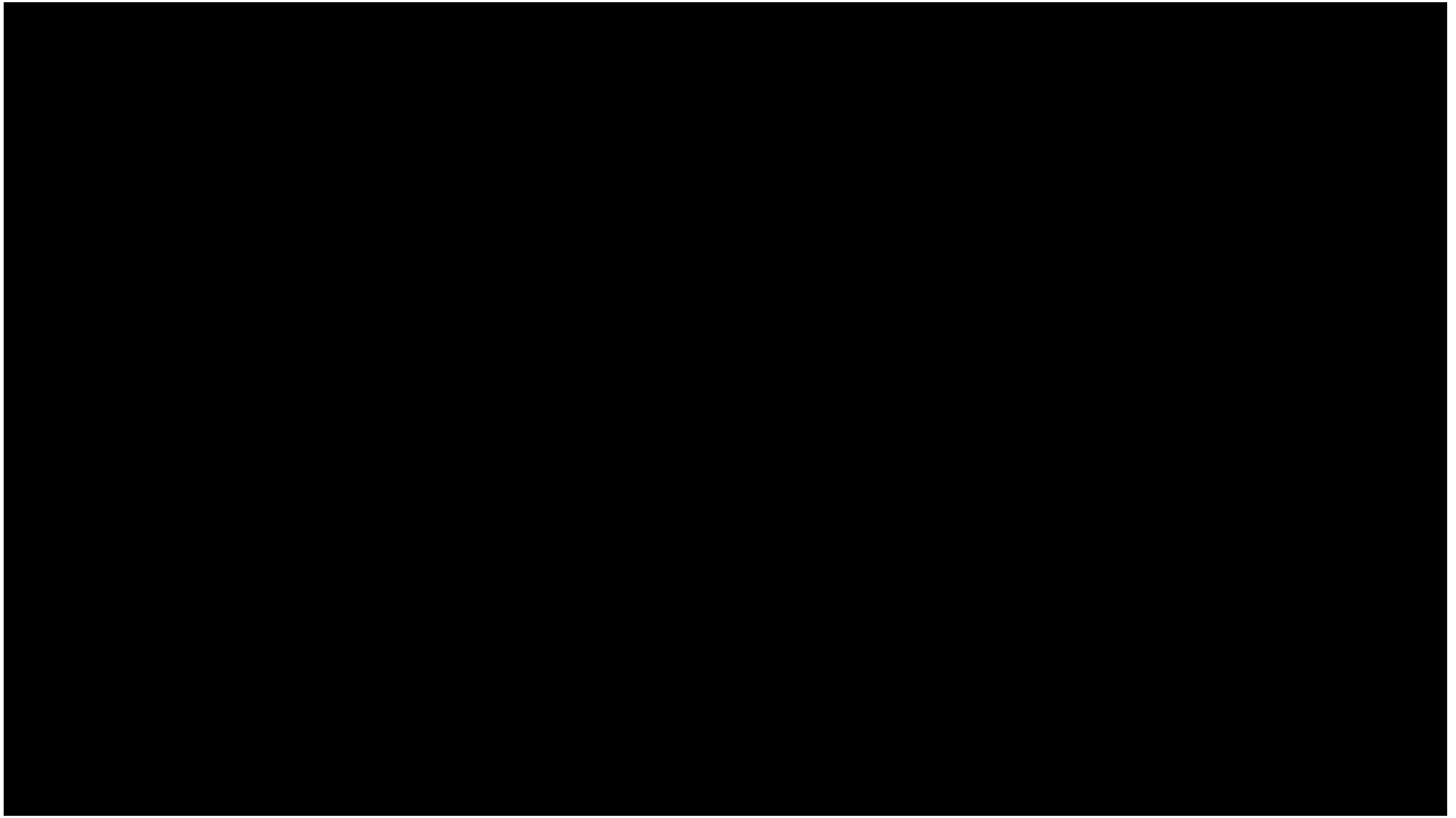
1. Each Sensor nodes may use different protocol – MQTT, HTTP, COAP,..
2. Support for different communication channels – Wifi, 4G, LoRA, etc.
3. Nodes may fail - Hardware issues or software issues
4. Adding new node should be a hassle-free process
5. Near-real time visualizations, data also needs to be sent to multiple stakeholders

Sensor Nodes



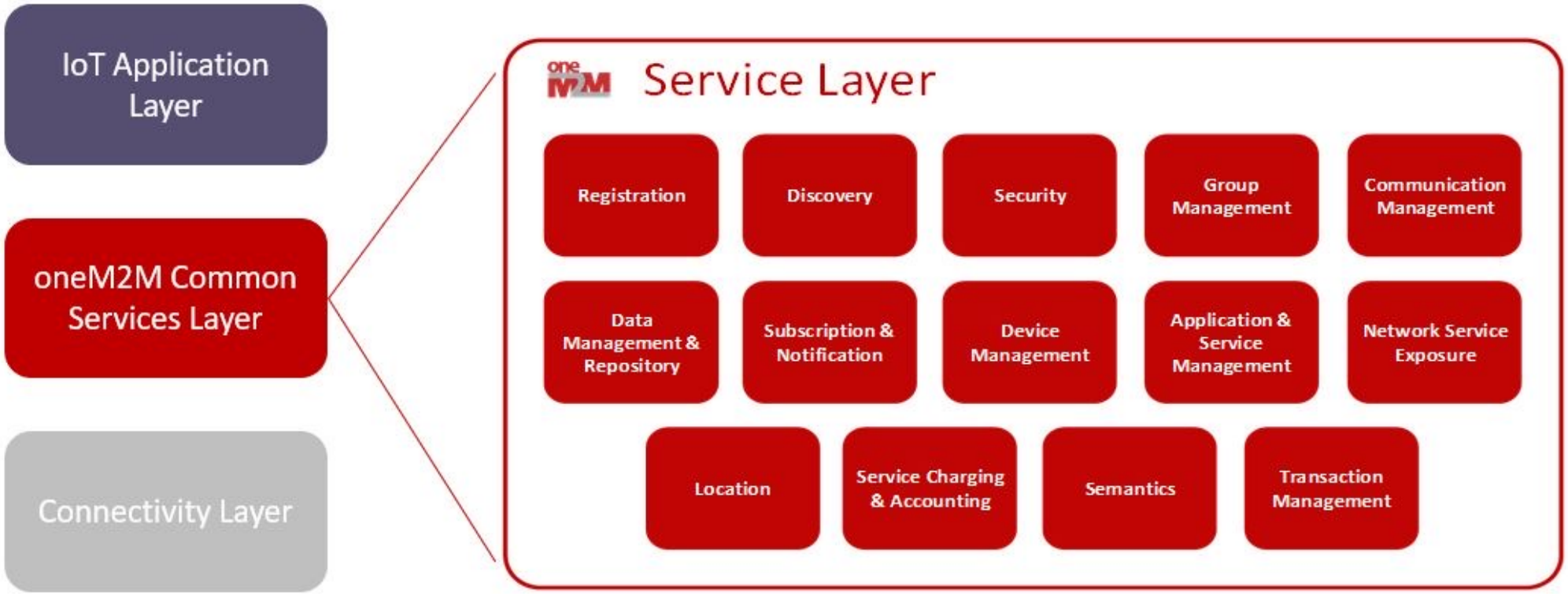
Framework for Interoperability

The OneM2M Standard



Source: onem2m.com

The OneM2M Standard



Standard defined and maintained by body consisting of members from US, Japan, Europe, India, Korea, China, etc

Source: onem2m.com

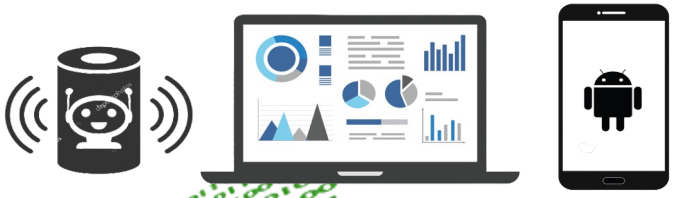
Putting it Together

Smart Campus Overview

Weather

Air Quality

Water Quality and Quantity

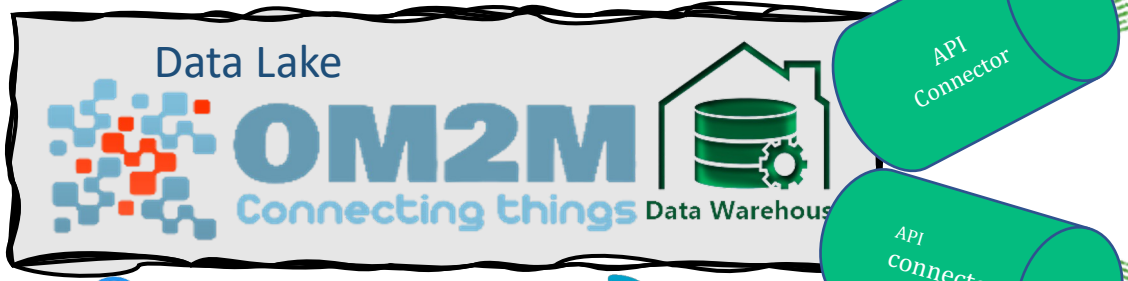


Energy Monitoring

Smart House

Crowd Monitoring

Smart Lamp

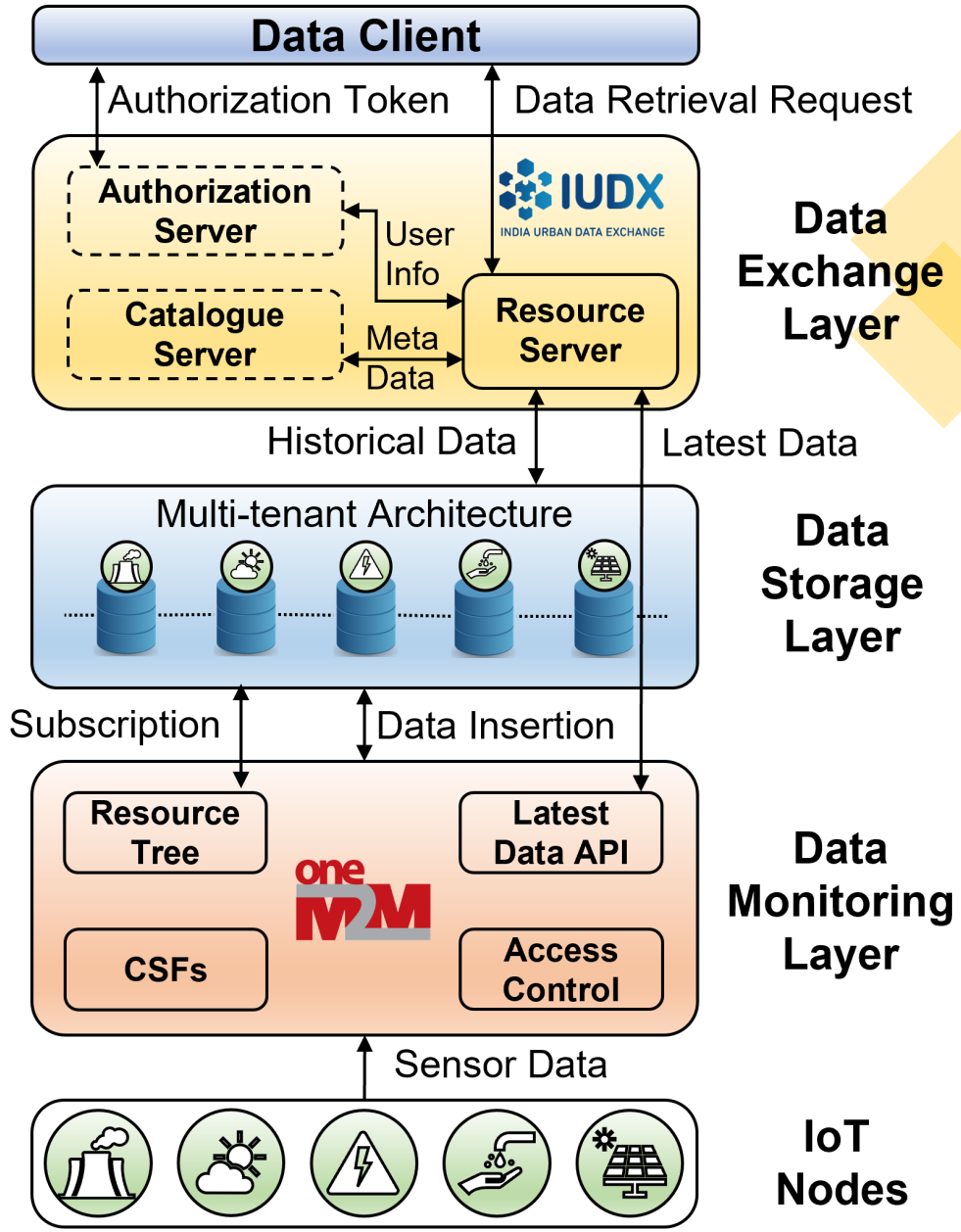


Zooming in Further

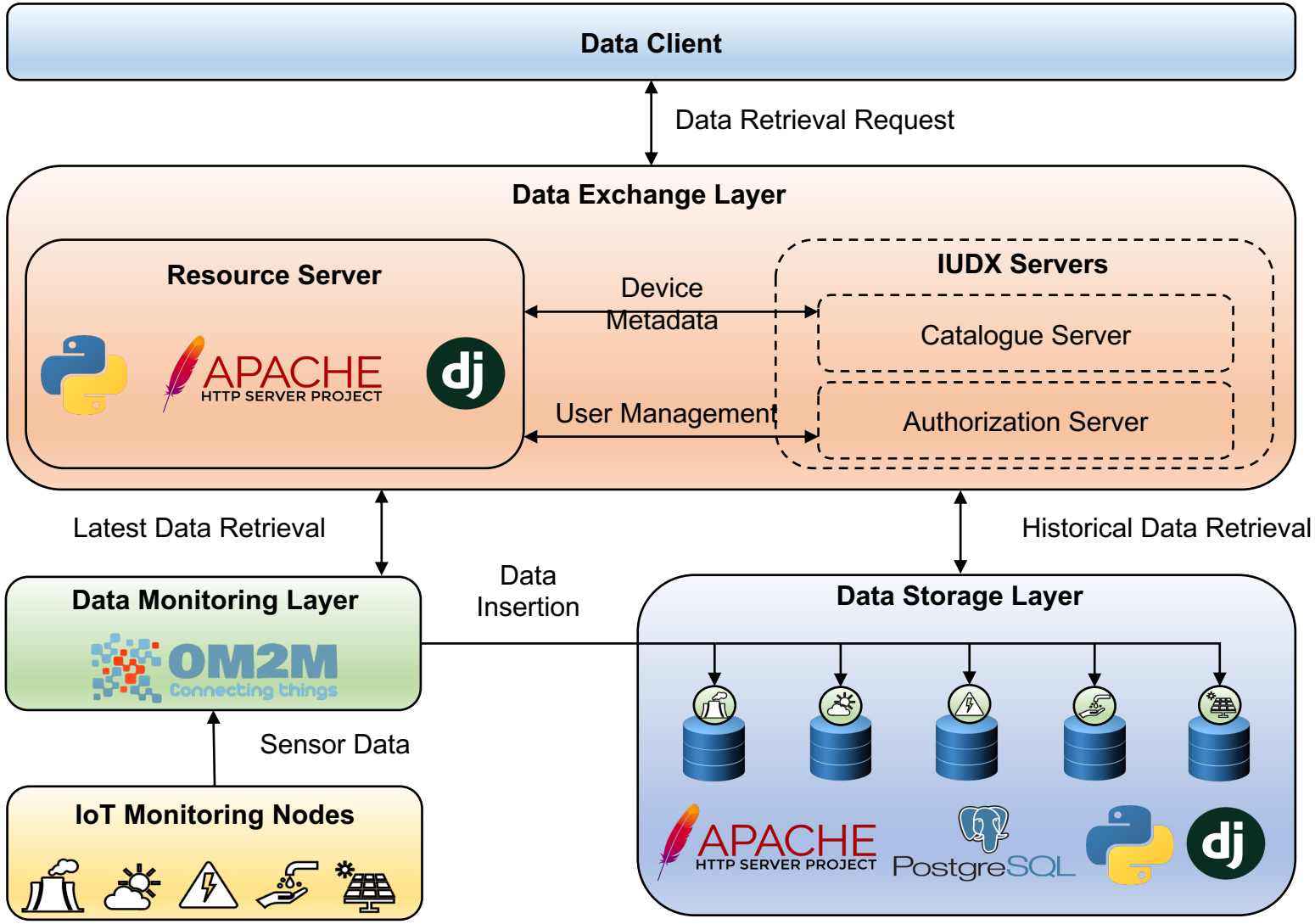
- Multiple IoT nodes post data to the **Data Monitoring Layer (DML)** at predefined intervals depending on the parameters being monitored

- The DML forwards this data using the subscription-notification CSF of oneM2M to the **Data Storage Layer (DSL)**

- The data can be subsequently accessed by registered clients through the APIs in **Data Exchange Layer (DEL)**



Zooming in Further



Visualization

Data Visualization Features

Fetch periodic data from onem2m cloud

Display nodes deployed and vertical parameters

Web frontend and mobile app to view locations on map and relevant sensor data

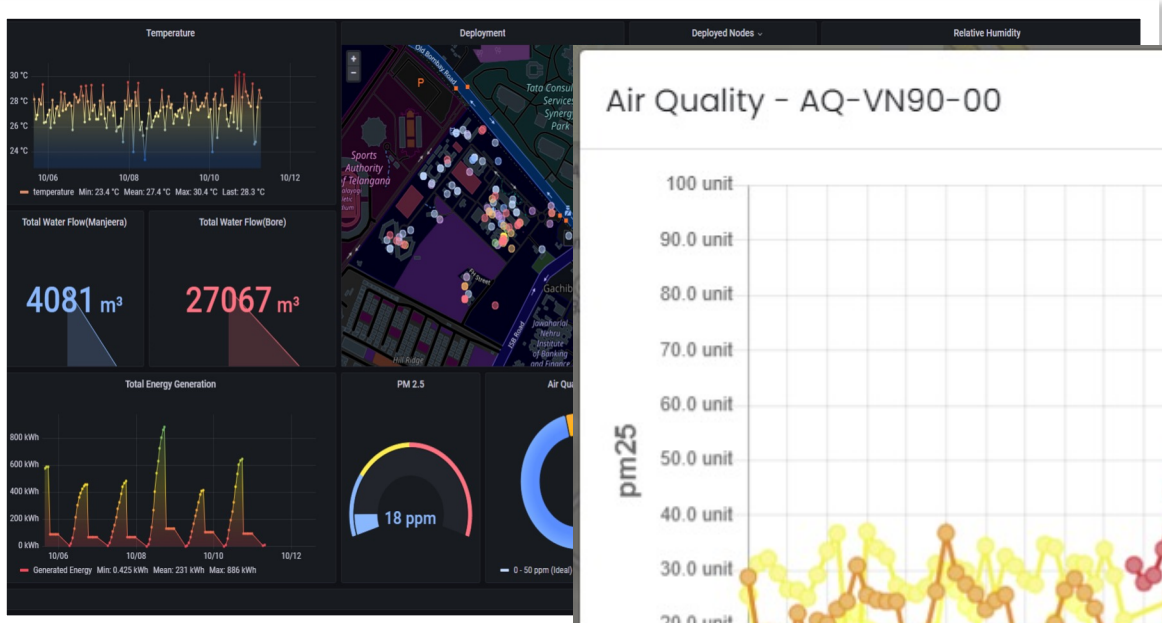
Backend to store and process nodes and vertical data

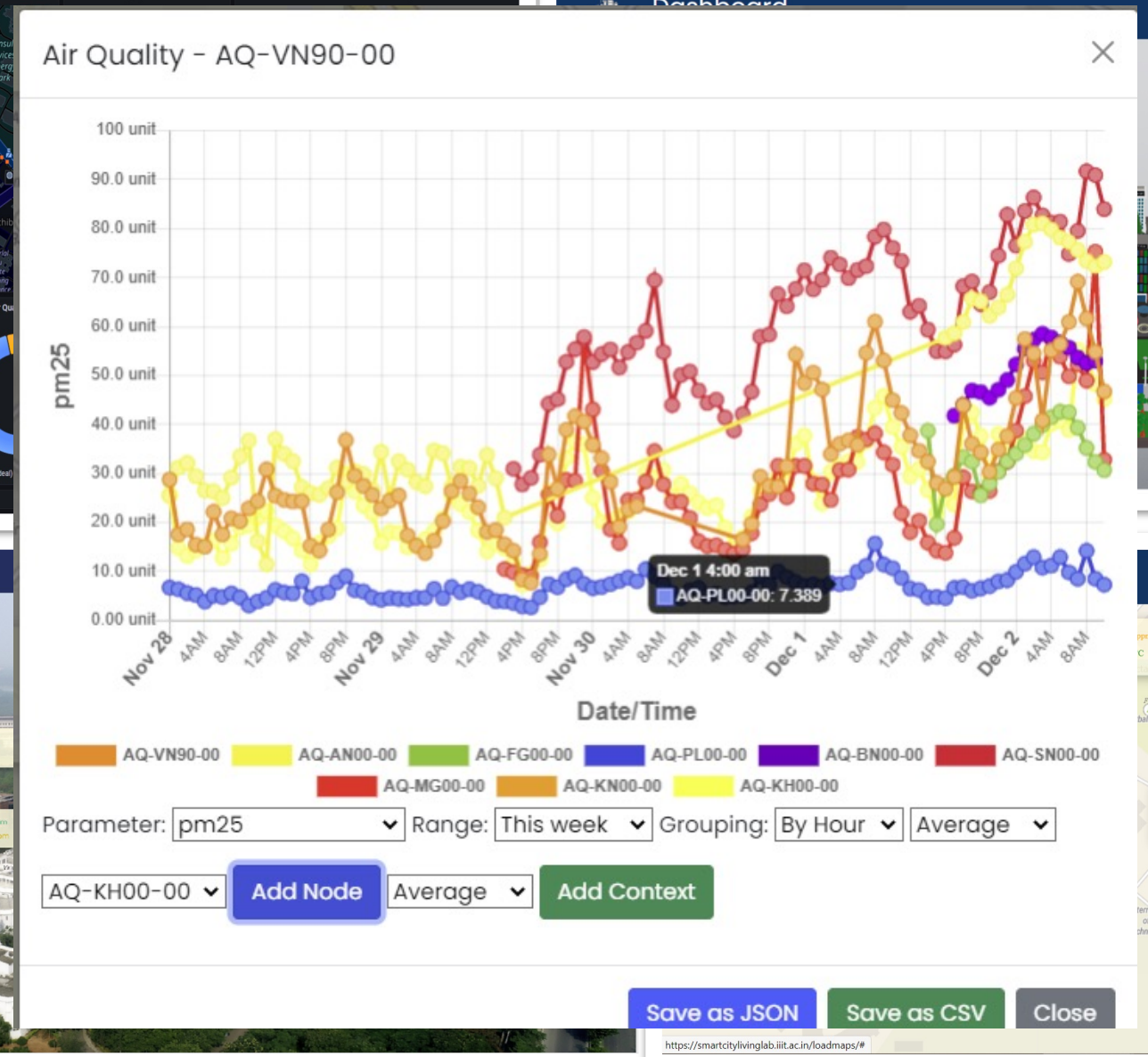
Run analytics on the data captured

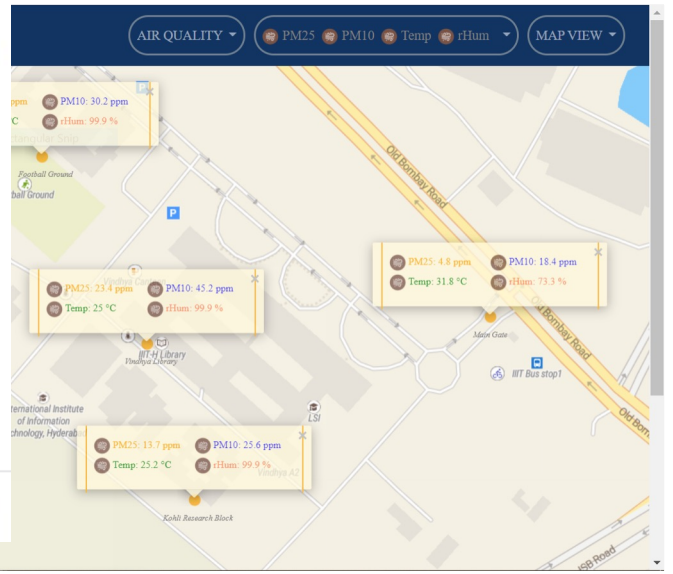
Generate visualization diagrams and graphs

Provide summary view, 3D view and Map view with Analytics for easy visualization

Data Visualization

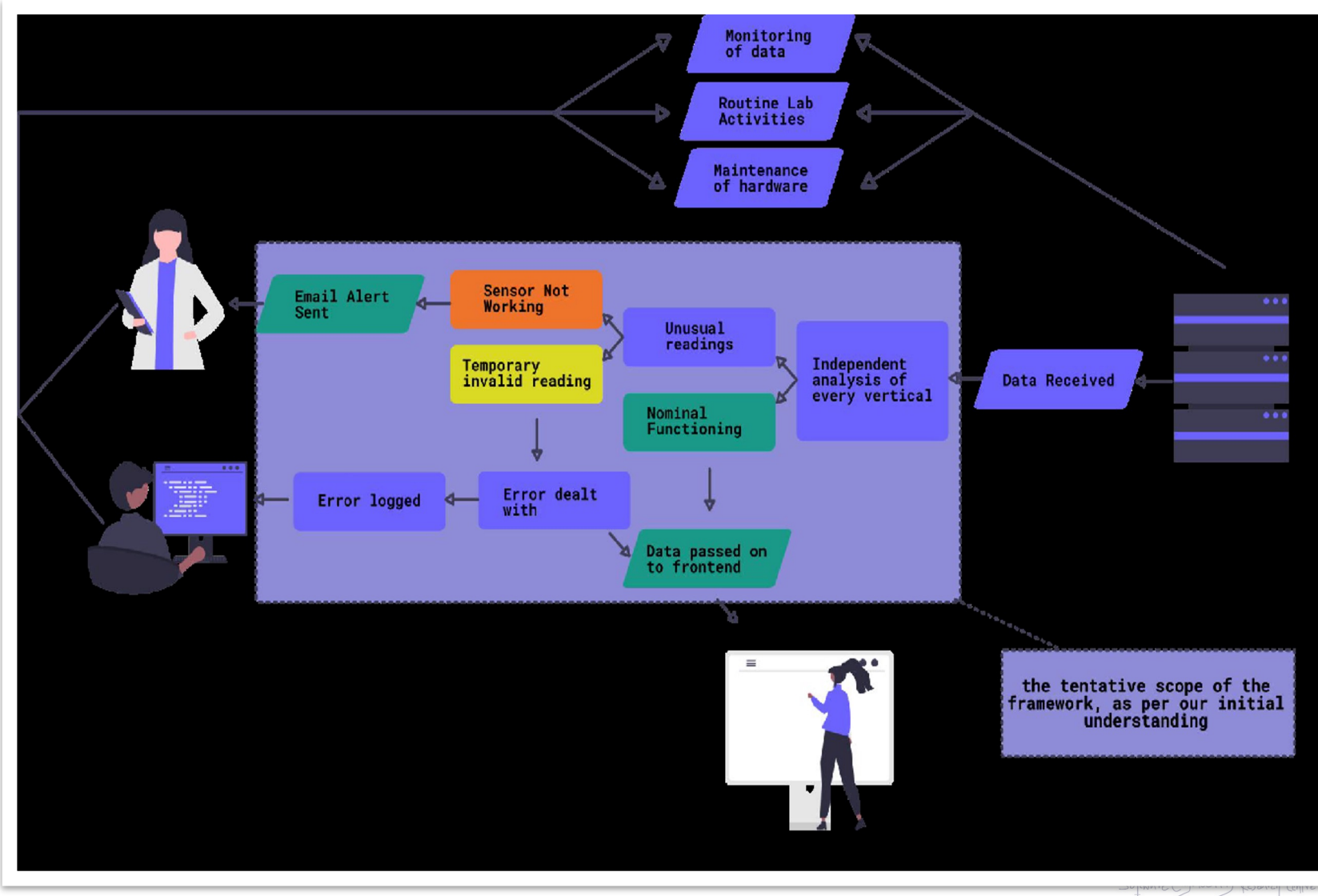






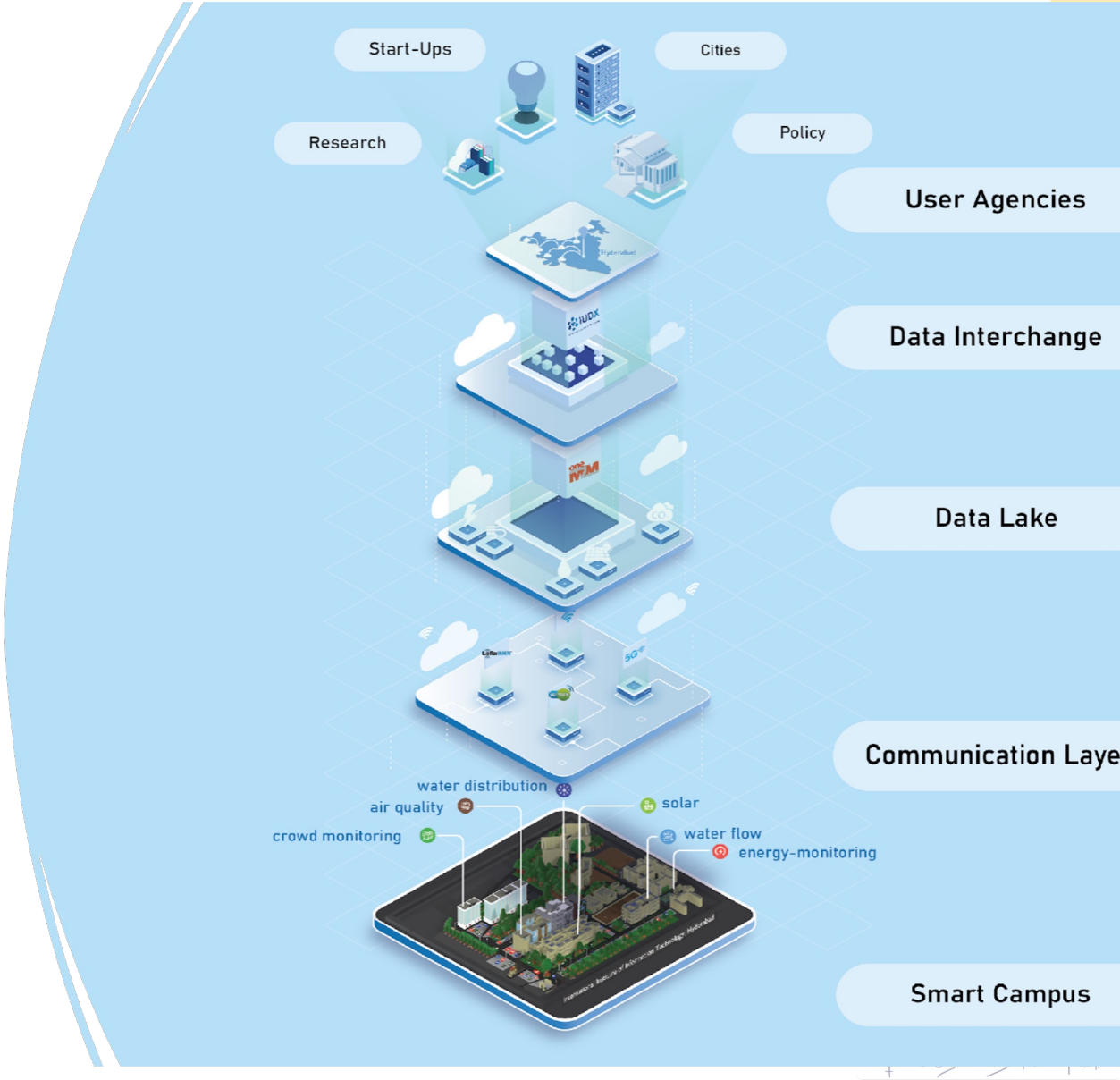
Node Maintenance – Handling uncertainties

- Data quality validation, outlier detection, and systematic reporting
- Send an email to respective authority to report the node health
- Validation of the subscription resource and notification
- To assess the servers' status and notify



Reference Stack Built

- Water, Energy, Solar, Pollution, Weather, Occupancy/crowd management sensor Data
- Multiple communication networks
- OM2M layer, a horizontal M2M service platform
- Data lake comprising of OM2M and Data warehouse
- Standard Data and Information models with IUDX as a data interchange layer
- Standardized view of all sensor data
- Data availability to multiple stakeholders including Research, Govt etc.



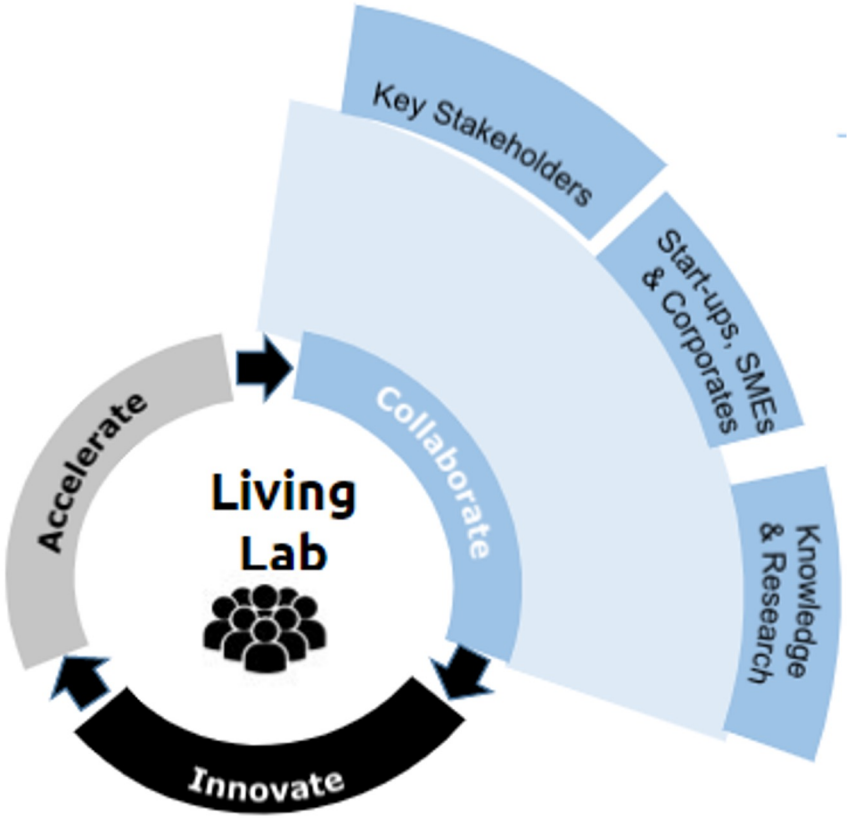
Looking into the Future

Ongoing and Future Works

1. Migration of architecture to support larger scale - Self-adaptation
2. Integration of 5G – Crowd Management and water quality management
3. Digital Twins – Water Center of Excellence with Hyderabad
4. Maintenance dashboard and alerting system development
5. Interoperability layer analysis
6. WiSun Deployment with Silicon Labs
7. Many more core research works on water, Air, Smart Energy, …..

Partners and Leadership

Founding Partners, In-Place and Engaged



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Key Stakeholders

Start-ups, SMEs & Corporate partners

Knowledge & Research

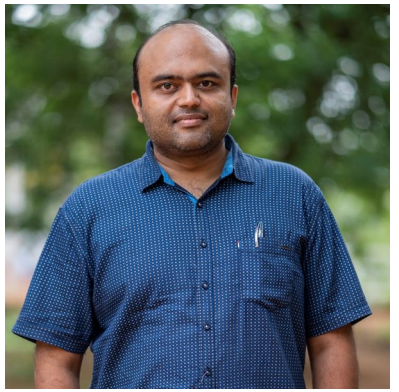
Network partners

Leadership Team

Aftab Hussain

Ramesh Loganathan

Vishal Garg



Sachin Chaudhari

Anuradha Vattem

Deepak Gangadharan

Karthik Vaidhyanathan

Prakash Yalla

Publications & Patents

Publications

• Sai Usha Nagasri Goparaju, SVSLN Surya Suhas Vaddhiparthy, Pradeep C, Anuradha Vattem, Deepak Gangadharan "Design of an IoT System for Machine Learning Calibrated TDS Measurement in Smart Campus", accepted in WF-IoT 2021
• S. Deb, C. Rajashekar, S. Chaudhari, K. Vemuri, K. S. Rajan, "IoT Network-Based Analysis of Variations in Particulate Matter Due to COVID-19 Lockdown", accepted in CONECCT 2021
• C. Rajashekar, S. Chaudhari, "Hierarchical Clustering based Spatial Sampling of Particulate Matter Nodes in IoT Network", accepted in WF-IoT, 2021
• I. Patwardhan, S. Sara, S. Chaudhari, "Comparative evaluation of new low-cost particulatematter sensors", accepted in FiCloud 2021
• G. Ihita, S. Viswanadh. S. Yelishetty, S. Gaur, S. Chaudhari, "Security Analysis of Large Scale IoT Network for Pollution Monitoring in Urban India," accepted in WF-IoT 2021.
• A. Lall, A. Khendelwal, R. Bose, N. Bawankar, A. Dwivedi, N. Nitin, S. Chaudhari, "Low Cost Retrofitting of Analog Water Meter for Digitization," accepted in FiCloud 2021.
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• Shubham Mante, Ruthwik Muppala, D Niteesh, Aftab M Hussain "Energy Monitoring Using LoRaWAN-based Smart Meters and oneM2M Platform", accepted in Sensors 2021
• Deeksha Devendra, Shubham Mante, D. Niteesh, Aftab M. Hussain "Electric Vehicle Charging Station using Open Charge Point Protocol (OCPP) and oneM2M Platform for Enhanced Functionality", accepted in TENCON 2021
• Shubham Mante, Nathalie Hernandez, Aftab Hussain, Sachin Chaudhari, Deepak Gangadharan and Thierry Monteil "5D-IoT, a Semantic Web Based Framework for Assessing IoT Data Quality", accepted in 37th ACM/SIGAPP Symposium On Applied Computing (SAC), 2022
• Md Anam Raihan, Kuntal Chattopadhyay, Aviruch Bhatia, Vishal Garg, Aftab M Hussain "Energy analysis of semi-transparent building integrated photovoltaic window in Hyderabad, India using automated parametric simulations", accepted in ICSREE 2021
• Shubham Mante, SVSLN Surya Suhas Vaddhiparthy, Muppala Ruthwik, Deepak Gangadharan, Aftab M Hussain, Anuradha Vattem "A Multi Layer Data Platform Architecture for Smart Cities using oneM2M and IUDX", accepted in WF-IoT 2021
• Sai Usha Nagasri Goparaju, SVSLN Surya Suhas Vaddhiparthy, Pradeep C, Anuradha Vattem, Deepak Gangadharan "Design of an IoT System for Machine LearningCalibrated TDS Measurement in Smart Campus", accepted in WF-IoT 2021
• A. Kumar Lall, A. Khandelwal, N. Nilesh, S. Chaudhari "Improving IoT-based Smart Retrofit Model forAnalog Water Meters using DL based Algorithm", accepted in FiCloud 2022
• Rishikesh Bose, Ayu Parmar, Harsha Narla, Sachin Chaudhari "Comparative Evaluation of Low-Cost CO2 Sensorsfor Indoor Air Pollution Monitoring", accepted in WF-IoT 2022
• A. Kumar Lall, A. Khandelwal, R. Bose, N. Bawankar, N. Nilesh, A. Dwivedi, S. Chaudhari "Making Analog Water Meter Smart usingML and IoT-based Low-Cost Retrofitting", accepted in FiCloud 2021

Patents

• "Low cost retrofit for digitisation of analog water meter," Rishikesh Bose, Nilesh Bawankar (Under Review (3rd level verification))
• "Air quality monitoring device for monitoring an air-quality with less energy consumption," Prof. Sachin Chaudhari, Rajashekar Reddy Chinthalapani, Ayu Parmar, Ayush Dwivedi, Niranjan Keesara, Mahesh Murty (Applied for all India patent)

Thank you

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