

Communications & Controls in IoT

EC5.204

Introductory Class

Instructors: Sachin Chaudhari and Aftab Hussain

Emails: firstname.lastname@iiit.ac.in

Jan. 05, 2023



INTERNATIONAL INSTITUTE OF
INFORMATION TECHNOLOGY

HYDERABAD

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Background: Sachin Chaudhari

- **Academics**

- Associate Professor, SPCRC and SCRC, IIIT Hyderabad (Jul. 2021-onwards)
- Asst Prof., SPCRC, IIIT Hyderabad (Jan. 2015-Jun. 2021)
- Postdoc, Aalto University, Finland (2013-2014)
- PhD, Aalto University, Finland (2007-2012)
- M.E., IISc Bangalore, India (2002-2004)
- B.E., VNIT, Nagpur (1998-2002)

- **Industry**

- Senior Wireless Communication Engineer, Esqube Communications, Bangalore (an IISc start-up) (2004-2007)

- **Research Interests:**

- Signal Processing and Machine Learning for Wireless Communication:
IoT for Smart Cities, 5G/6G, Satellite Communications

- **Research Projects on IoT**

- **DST and PRIF:** IoT Enabled Smart Cities: Pollution Health and Governance
- **CoE on IoT for Smart Cities:** Coordinator
- **India's First *Living Lab* for Smart City Research**

Background: Aftab Hussain

- **Academics**

- Asst Prof., IIIT Hyderabad (2018-present)
- Postdoc Fellow, Harvard University (2016-2018)
- MS+PhD, KAUST, Saudi Arabia (2011-2016)
- B.Tech, IIT Roorkee (2005-2009)

- **Industry**

- Design Engineer, Analog Devices India (2010-2011)

- **Research Interests:** Flexible electronics, sensor systems, smart cities, IoT

- **Research Projects**

- Artificial muscles
- Pressure sensor mat
- 2-wheeler safety
- Water sensors

Outline

- Course Intro
 - Introduction to IoT
 - Motivation and Importance
 - Few of the IoT activities at IIITH
- Course Administration
 - Syllabus
 - Resources
 - Evaluation
 - Tutorials

Introduction and Motivation

Internet of Things (IoT)

- [webopedia] The Internet of Things refers to the ever-growing network of **physical objects** that feature an **IP address** for internet connectivity, and the **communication** that occurs **between** these **objects** and other Internet-enabled devices and systems.

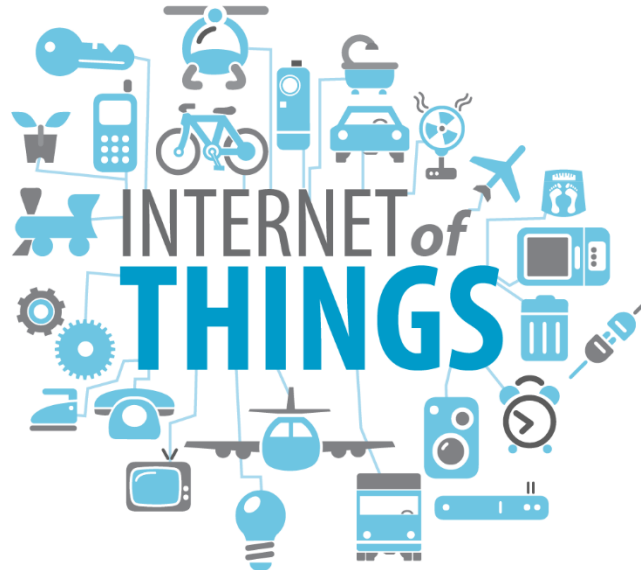


Image: <http://www.meccanismocomplesso.org/en/iot-internet-of-things/>

- IoT extends internet connectivity beyond traditional devices such as computer and smart-phones to a diverse range of devices such as thermostats, cars, lights, vending machine etc.

Differences between Computers and IoT Devices

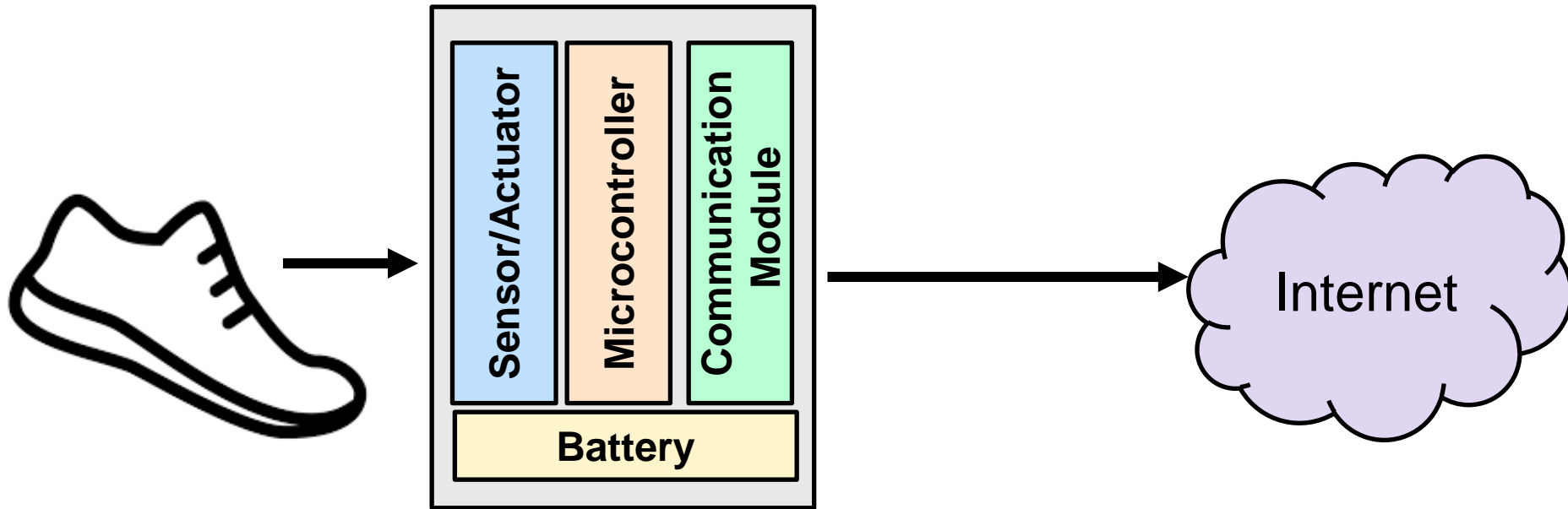
Computers

- Main task is to compute and run programs
- General purpose
- Significant resources
- Expensive
- Example: iPad

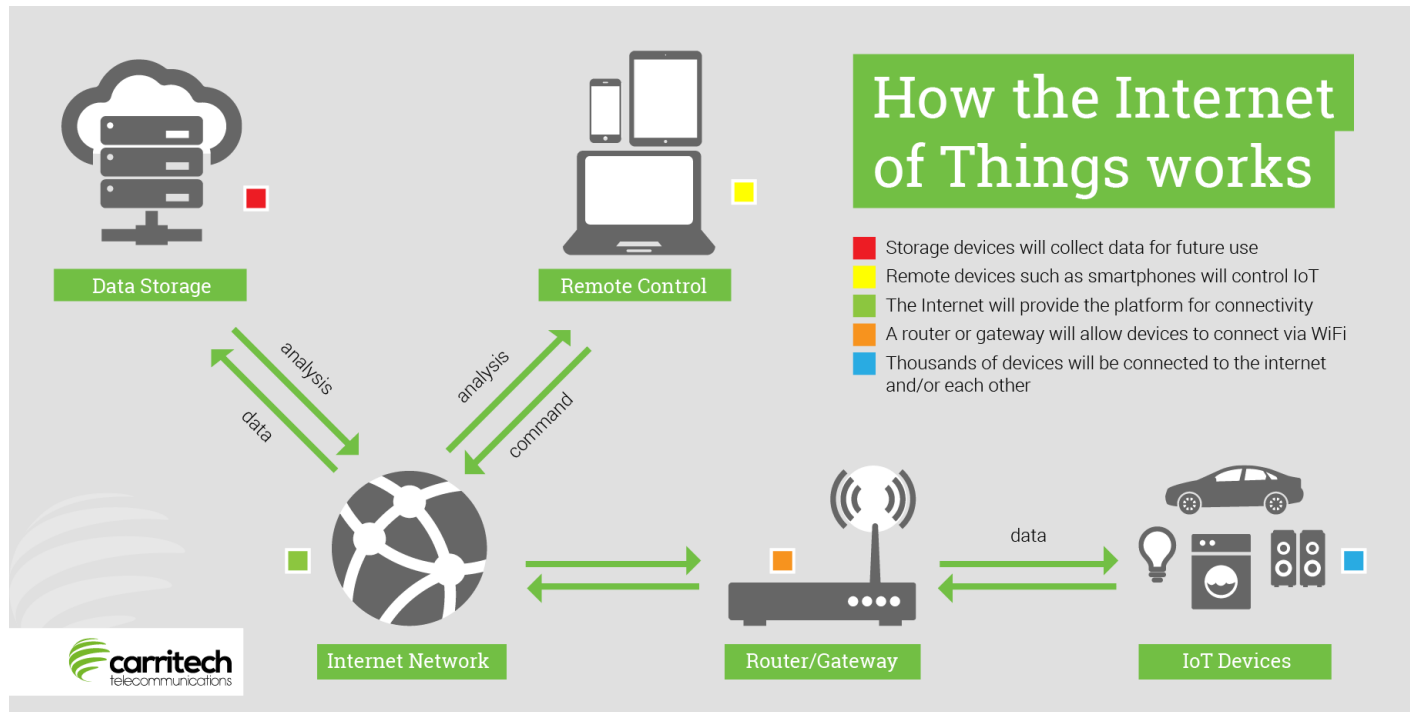
IoT Devices

- Main task is not computing
- Does specific application
- Limited resources
- Cheaper, efficient and faster for one (or very few things)
- Example: Washing Machine

How do you connect a thing to internet?



How does IoT work?



Picture Credit: <http://www.carritech.com/news/internet-of-things/>

Why to connect a *thing* to internet?



Speaker+Mic

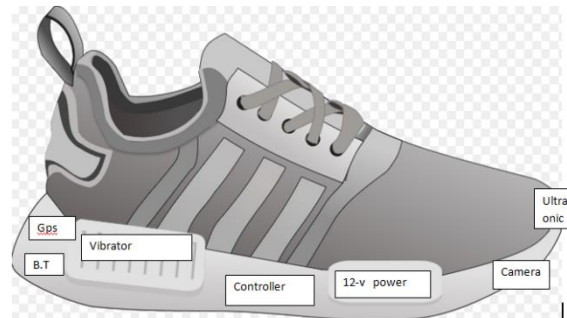


Smart Speakers :
Amazon Echo / Google Home

https://en.wikipedia.org/wiki/Smart_speaker



Shoes



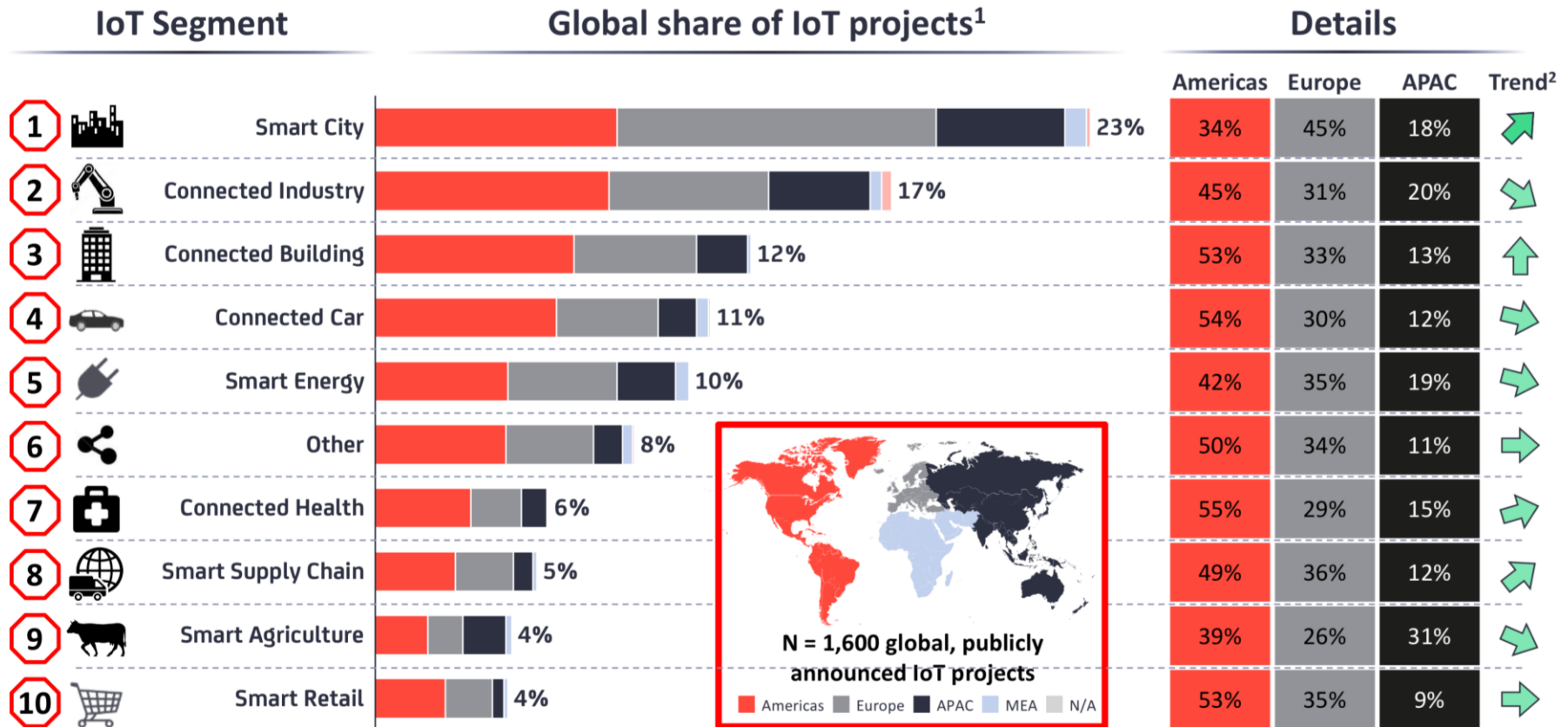
Smart Shoes

<https://innovate.mygov.in/innovation/smart-shoes-for-blind-person/>

Why IoT?

- Adds *smartness* to simple things
 - *To be smart, a thing doesn't need to have super storage or a supercomputer inside of it . All a thing has to do is connect to super storage or to a super computer*
 - <https://www.leverage.com/iot-ebook/what-is-iot>
- Consumers
 - Ease of access from anywhere and anytime
 - Efficient systems and reduced bills
- Companies
 - Real-time monitoring and response
 - Reduction in human errors
 - Increase in productivity
 - Predictive analysis

Applications of IoT



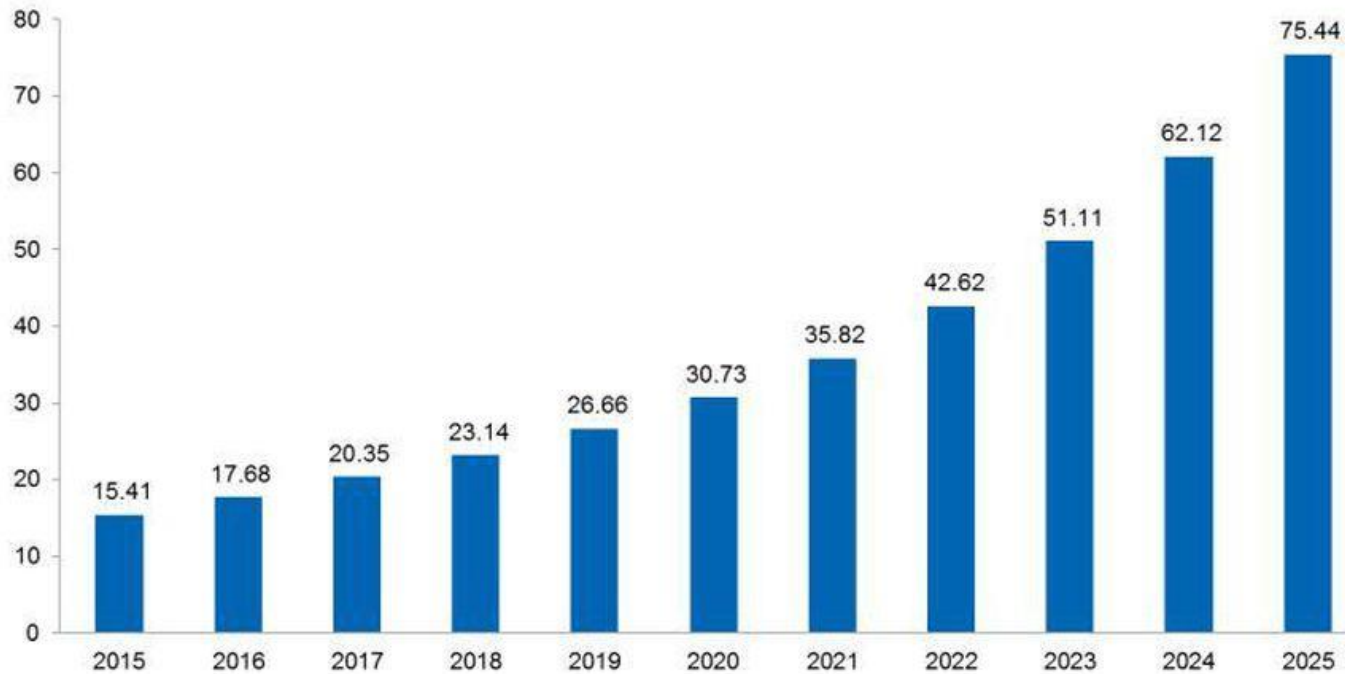
1. Based on 1,600 publicly known enterprise IoT projects (Not including consumer IoT projects e.g., Wearables, Smart Home). 2. Trend based on comparison with % of projects in the 2016 IoT Analytics Enterprise IoT Projects List. A downward arrow means the relative share of all projects has declined, not the overall number of projects 3. Not including Consumer Smart Home Solutions. **Source:** IoT Analytics 2018 Global overview of 1,600 enterprise IoT use cases (Jan 2018)
Source: IoT Analytics, Jan 2018

Source: The Top 10 IoT Segments in 2018 based on 1,600 real IoT projects, [IoT Analytics](https://www.iot-analytics.com/)

Rise of the IoT!

Figure 1. The IoT market will be massive

IoT installed base, global market, billions

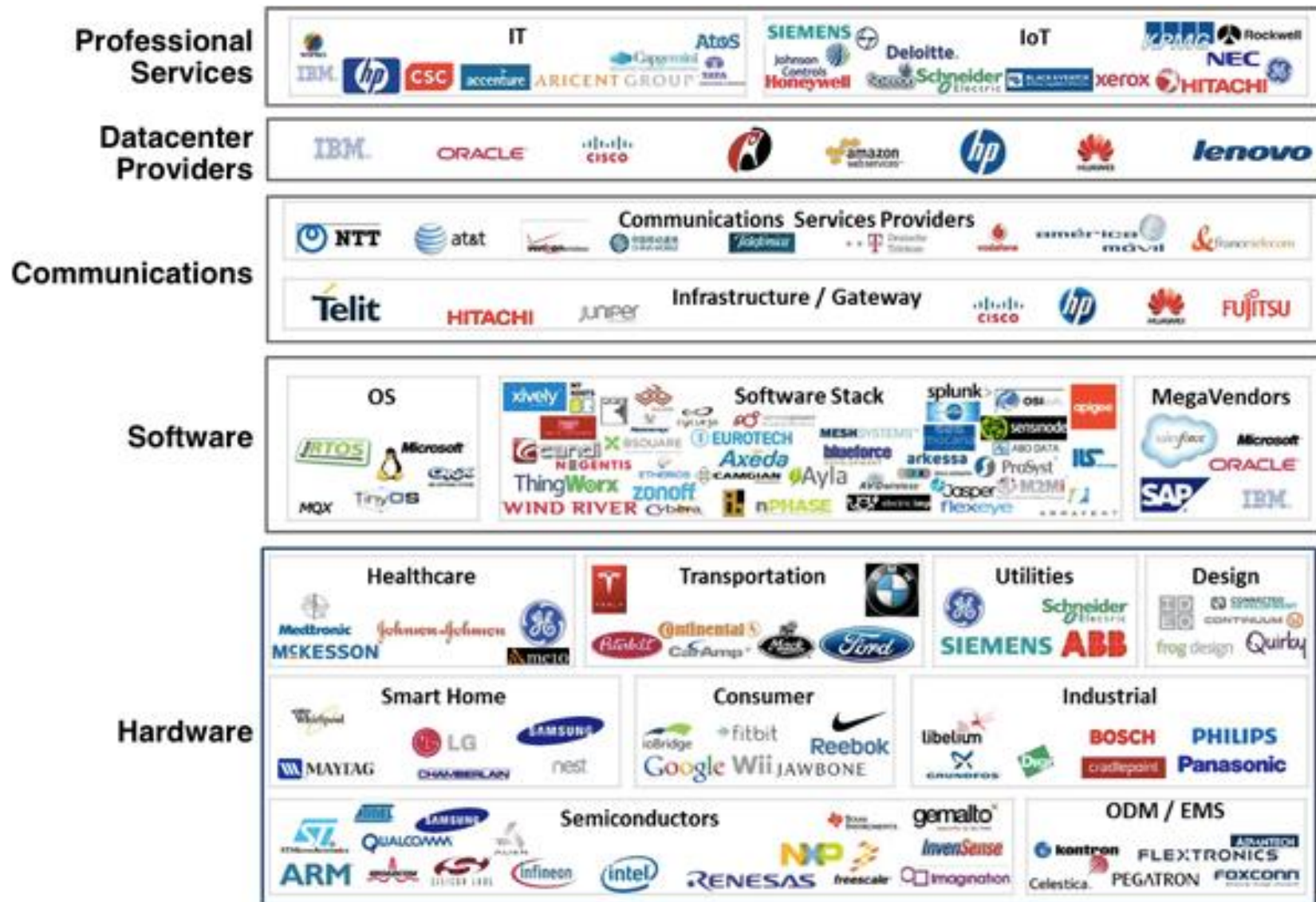


Source: IHS

© 2016 IHS

<https://www.exuberantsolutions.com/iot-training.htm>

Companies in IoT (Only a few shown)



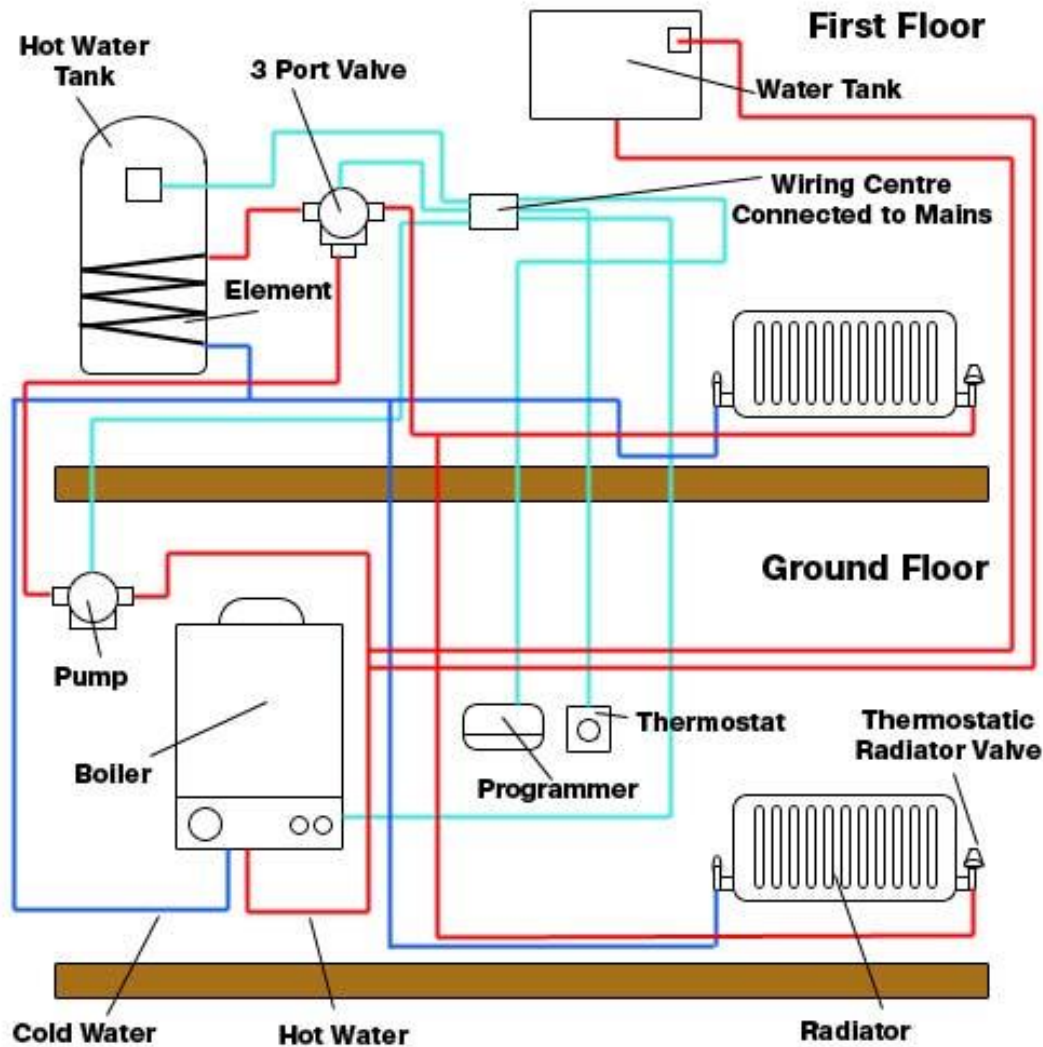
Everybody wants a pie of IoT!!! <https://www.quora.com/What-are-the-top-IoT-companies>

Use Case: Nest Learning Thermostat

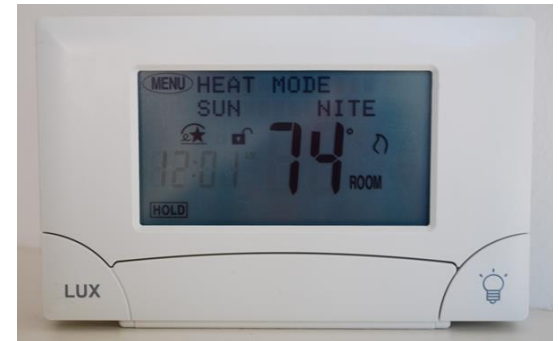


- Founded in 2010 by former Apple engineers
- Learns what temperature you like and builds a schedule around yours
- <https://www.youtube.com/watch?v=HhqD-ljcD6I>
- Google acquired Nest Labs for \$3.2 billion in cash in Jan. 2014

Thermostat?



Centralized Heating



Thermostat

Use Cases: Amazon Dash



https://en.wikipedia.org/wiki/Amazon_Dash

- Started in 2015
- Replenishment services
 - <https://www.youtube.com/watch?v=-OgPTC0EB48>
- Discontinued in 2019
 - Alexa
 - Subscriptions

Use Cases: Agriculture

- IoT based Soil-Crop-Atmosphere Screening
 - monitor pH level, temperature, airflow, water, manure, fertilizers, precipitation, nutrients and light
 - ML based algorithms to solve problems
- Objectives
 - Better crop selection and planning
 - Optimized inputs, Irrigation and Fertigation Schedule
 - Real time detection of diseases
 - Pest control and enhanced yield



Use Cases: Industrial IoT



<https://altizon.com/what-is-iiot-and-its-benefits/>

- IoT refers to consumer IoT while IIoT refers to Industrial IoT
 - IoT: simple and low-risk applications, low-cost sensors
 - IIoT: sophisticated high-risk applications, precision sensors
- Applications for industrial IoT
 - aerospace, defense, healthcare and energy
 - Improving productivity, safety, reliability

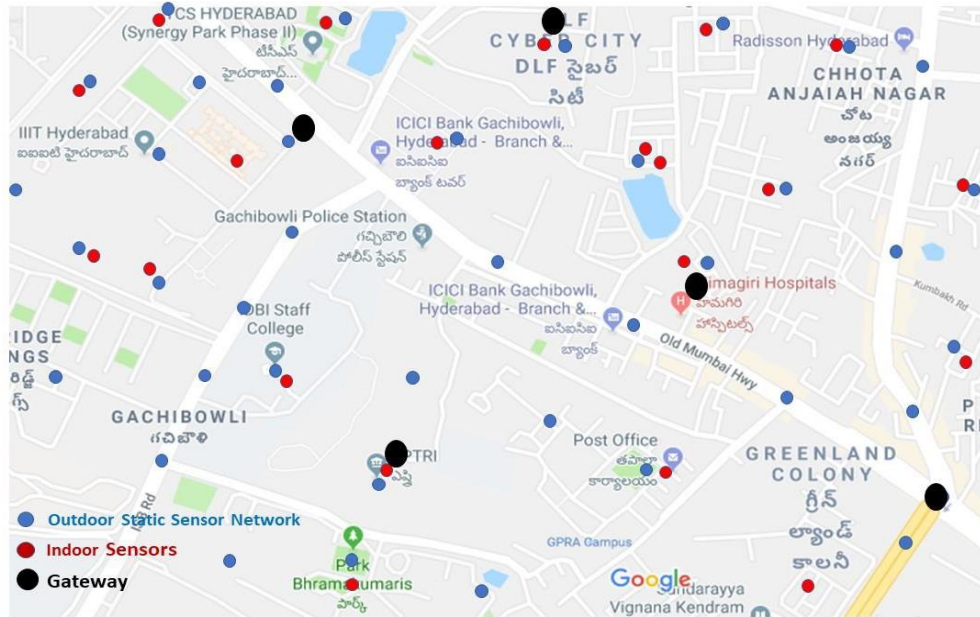
IoT: Necessity in Times of Covid

- Health
 - Remote monitoring
 - Telemedicine
 - Compliance
- Getting manufacturing back on track
 - Remote monitoring and control

What thing will you connect to the Internet?

Few of the IoT Activities at IIITH!!!

IoT Enabled Smart Cities: Pollution, Health and Governance



DST and PRIF-Funded project

Sachin Chaudhari (PI)

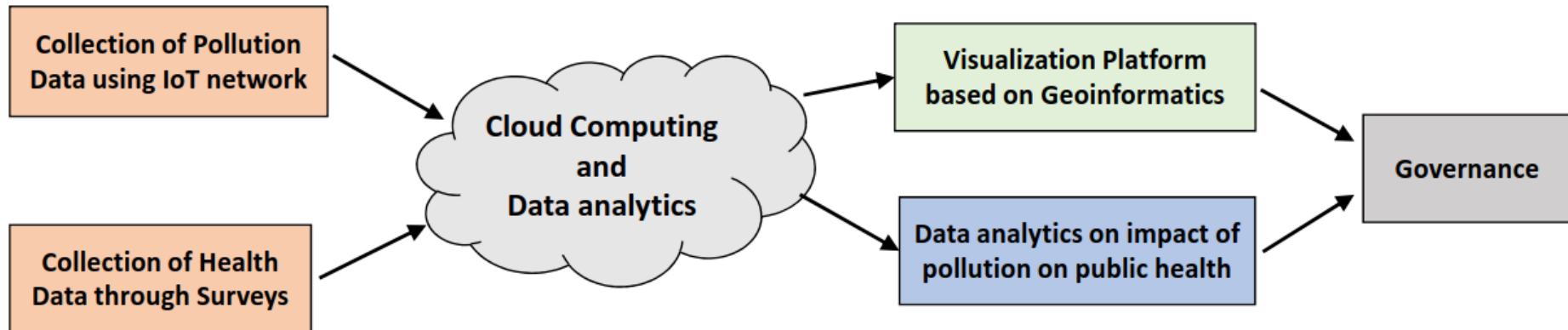
Aftab Hussain

Kavita Vemuri

K. Rajan

Dr. Shailaja Tetali

6 papers published and
one patent filed

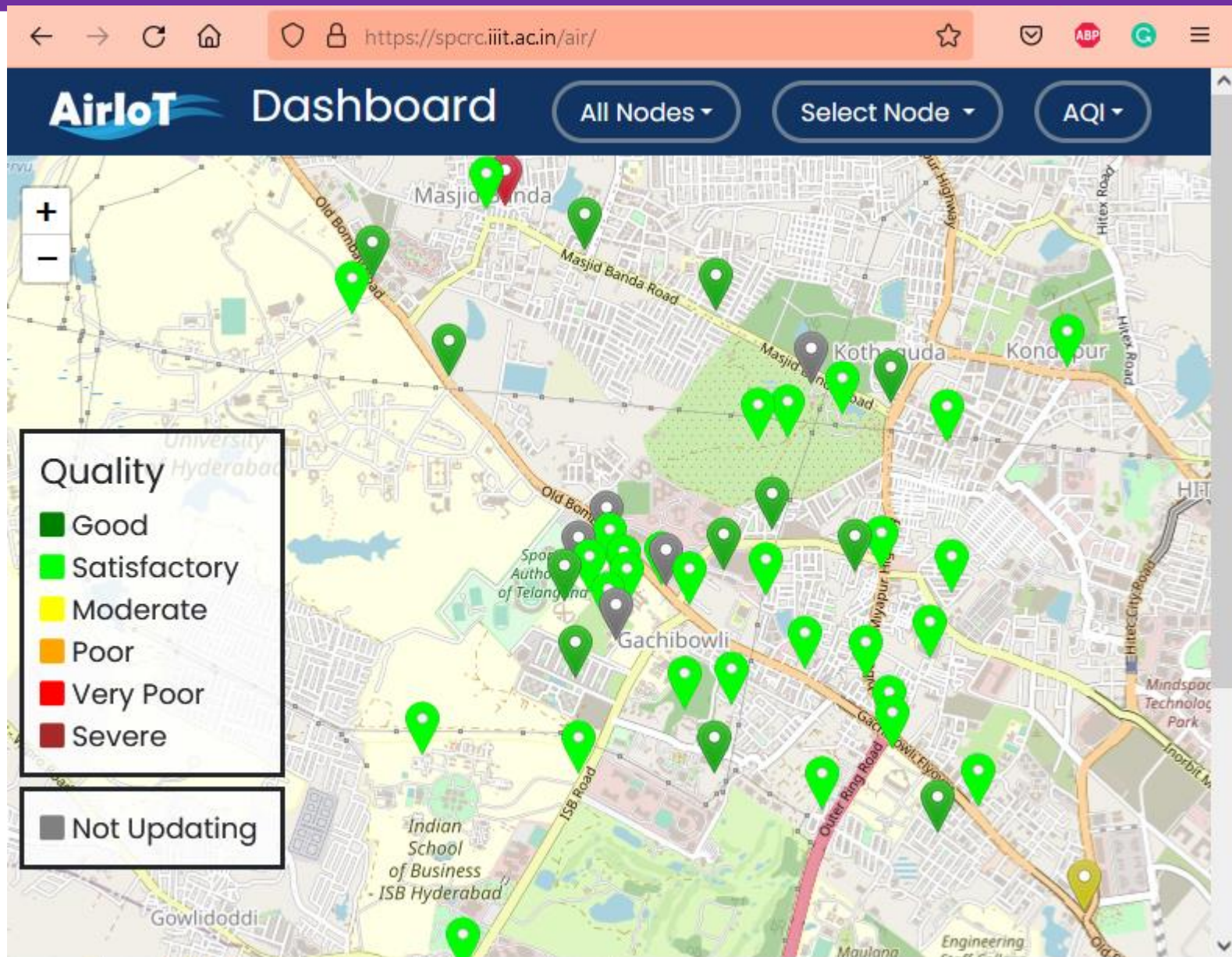


Development for APM

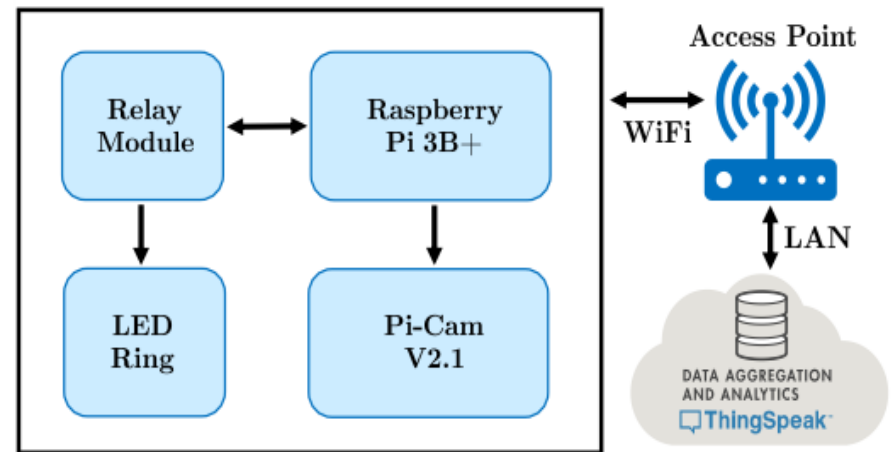
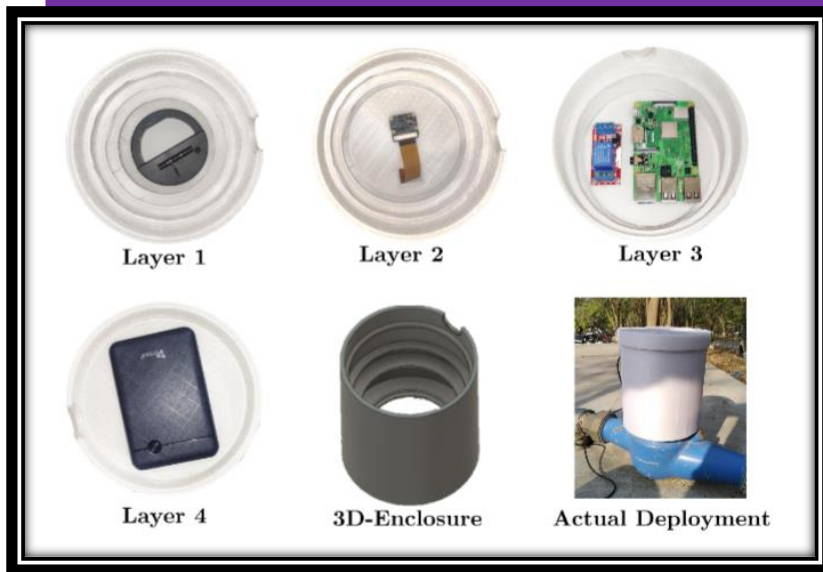


- Developed a product quality low-cost pollution node
- Patents filed
- Deployed 40 more nodes in Gachibowli region (extended IIITH region)
- Deployed 3 mobile nodes on GNITS buses
 - Plan to deploy 7 mobile nodes in collaboration with easyCommute and GNITS buses
- ML based calibration of PM sensors done
- Experiment with Gas sensors and their calibration going on

Web-based Dashboard



Making Analog Water Meters Smart!



- Developed an IoT and Learning (ML/DL)-based low-cost retrofit mechanism to digitize analog water meters to make them smart.
 - Low-Cost (we are working on making it optimized in terms of looks, cost, and robustness)
 - Retrofit model
 - ML based algorithm converts images to digits and send data to server
 - Patent Filed, Papers Published, Planning a start-up
- UG students enthusiastically worked and published an international conference and filed patent on this
 - Won the Water Challenge by the Telangana State Government

IoT Enabled E-bike chargers



- PI: Aftab Hussain
- Patent filed
- We have developed an E-bike charging system based on globally recognized OCPP and OneM2M standards
- It is compact, and low-cost specifically focused on 2-wheeler charging
- In the process of being commercialized through a partner company

Flexible pressure sensor array

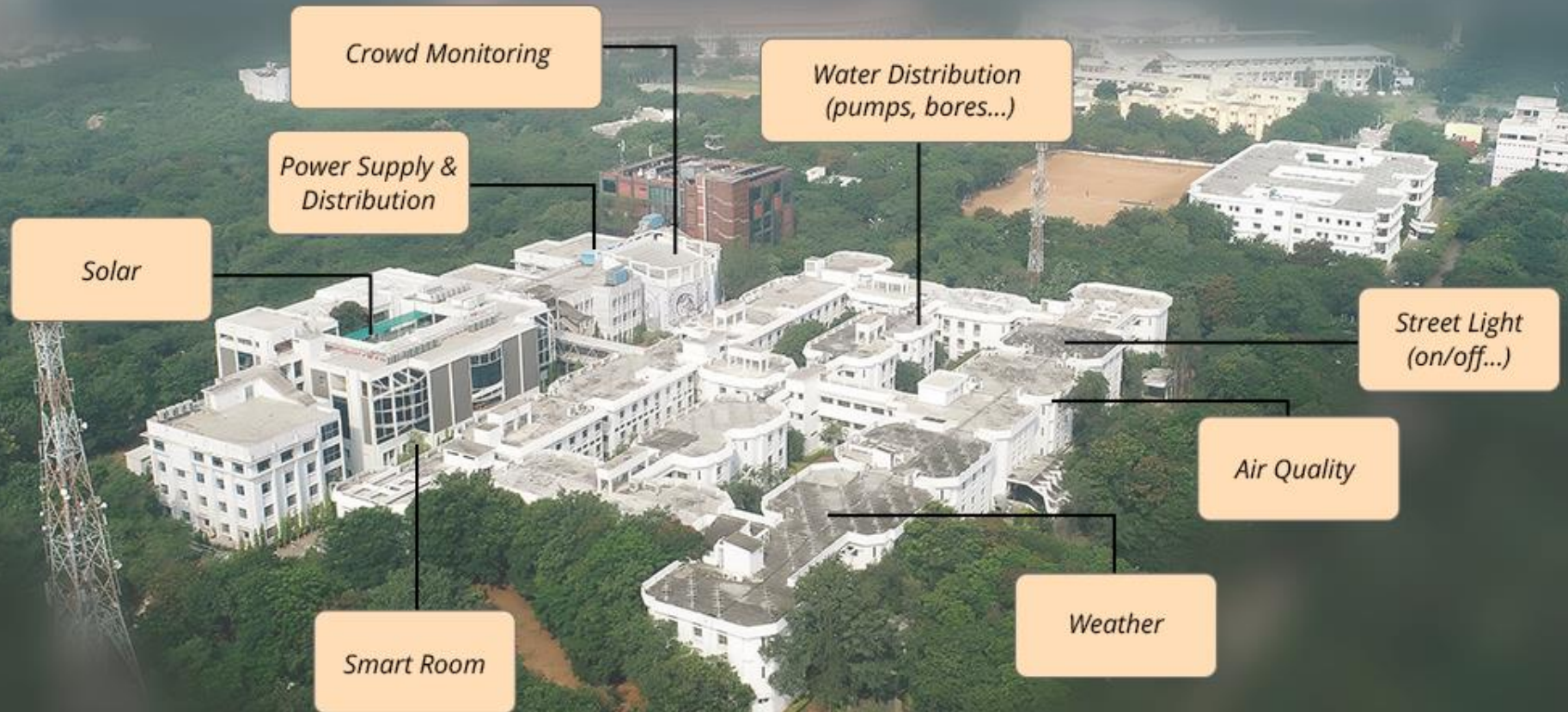


- PI: Aftab Hussain
- Patent filed
- Flexible pressure sensor: We have developed a flexible pressure sensor array that can provide real-time pressure distribution over a large area
- We have incorporated a startup for commercialization of the product

CoE on IoT for Smart Cities

- Started Jan. 2019
- Supported by India-EU collaboration on ICT Standardization, TSDSI and ETSI
- Faculty involved
 - S. Chaudhari (Coordinator), A. Hussain, R. Loganathan, V. Garg, D. Gangadharan, K. Vemuri, K. Rajan
- Activities Supported
 - **Knowledge initiatives:** Tutorials, Hackathons, Workshops
 - **Research collaboration** with LAAS-CNRS and INSA (Toulouse, France), Bordeaux metropole, NTNU (Norway), LTU (Sweden) and IITG
 - **Resulted in Living Lab project and Smart City Research Center**

India's First Living Lab for Smart Cities



Started April 2020

Living Lab: Team



Living Lab: Objectives



Research on IoT
for Smart Cities



Data for AI/ML



Test-bed for
smart city
deployments



Promote start-
ups

Living Lab: Themes



Water Monitoring and
Distribution

Non-revenue water
Quality



Safety and Security

Crowd monitoring
Street Lights
Structural health of buildings



Health

Air Pollution + Weather
Social Distancing



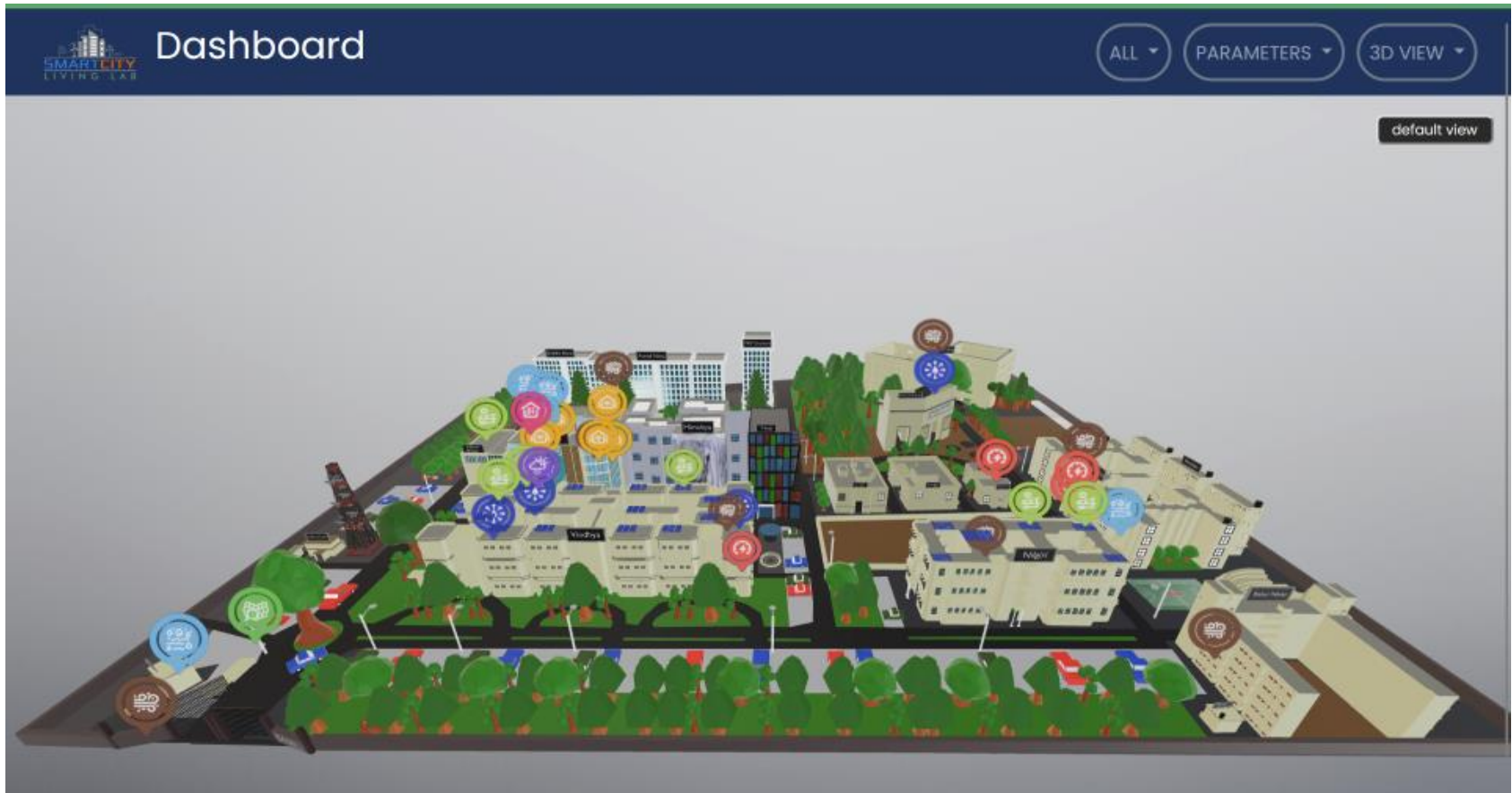
Energy

Building Energy Efficiency
Solar energy
Smart rooms

Living Lab: Dashboard



Living Lab: Dashboard



IoT Courses at IIITH

IoT Workshop (MTech CASE)

Introduction to IoT (2nd Semester CSE)

Embedded System Workshop (3rd Semester CSE)

Communication and Controls in IoT (4th Semester ECE)

Talent Sprint: <https://iiit-h.talentsprint.com/iot/> (for professionals)

Importance of this subject

- Solve relevant problems in Indian Smart Cities
- Opportunity to work in Smart City Research Center (SCRC)
 - Sachin Chaudhari (SPCRC)
 - Aftab Hussain (CVEST)
 - Deepak Gangadharan (CSG)
 - Karthik Vaidyanathan (SERC)
- Startups!
 - CIE
 - Product lab
- Much more fun than theoretical subjects!

Course Details/ Logistics

Syllabus (Tentative)

- Introduction to IoT
- Sensing and Actuation
- Microcontroller based Embedded System Design
- Interfacing of Sensors and Actuators
- Basics of Networking
- Communication Protocols: WiFi/Bluetooth/Zigbee/LoRaWAN/NB-IoT,
- Data Protocols: MQTT/CoAP
- Sensor Networks, *Edge, Fog and Cloud Computing*,
- Interoperability in IoT
- Smart City Applications

Resources

BOOKS

- P. Lea, *Internet of Things for Architects*, Packt, 2018
- Raj Kamal, *Internet of Things*, McGraw Hill, 2018
- O. Hersent, D. Boswarthick, O. Elloumi, *The Internet of Things*, Wiley, 2016
- D. Norris, *The Internet of Things*, McGraw Hill, 2015
- A. Bahga and V. Madisetti, *Internet of Things*, University Press, 2016

VIDEOS

- National Programme on Technology Enhanced Learning (NPTEL) and SWAYAM
 - Introduction to Internet of Things, Sudip Misra, IITK
 - https://swayam.gov.in/nd1_noc19_cs65/preview
- Research papers and online content

Course Portal

MOODLE: <https://courses.iiit.ac.in/>

Under Spring 2023

If you still need to get enrolled, email us.

- News
- Discussion Forum
- Projects

Projects

- Themes:
 1. Mobile air pollution
 2. Smart agriculture
 3. 2-wheeler safety
 4. Water sensors
- Team of 4 students
 - TAs will circulate a form, please make your own teams
- Funded project
 - Teams will be reimbursed till maximum of Rs. 10 K per team for the components purchased
 - Check with lab if those components are already available
 - Please consult the faculty before purchasing the project specific sensors
 - Bills should be proper and in the name of IIIT Hyderabad.
 - Students will send soft-copy of bills to the faculty in advance.
 - Note that the reimbursement bills must be submitted by 15 Feb. 2023.

Teaching Assistants

- Rishabh Agarwal
- Vayur Shanbag
- Kirti Vignan Reddy
- Ivin Kuriakose

Exams and Evaluation

- Mark Distribution
 - First Quiz (20)
 - Final (50) : (MidSem as this a half course)
 - Project (30)
- Grading: Relative (TBD)

Questions?

- That's all for today!
- Next class on **Monday!**