Selected Topics in Computer Architecture, Computer Networks, and Distributed Systems
(Internet of Things)
(IN3450)

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About me…

- Ph.D on Grid Scheduling in 2008 from AKCE Research Centre, Anna University-Chennai, India.
- PostDoctoral scientist and Guest Professor of Technical University Munich, Germany.
- Principal Investigator (Ongoing)
  - Two projects
    - Rs. 3.56 crores – IoT Cloud
    - 20000 Pounds with Cardiff University London and IIT-Ropar.
  - Three projects for Institute
    - Rs. 2 crores – SeedFund
    - Rs. 15 lakhs per idea (10 per year) under MSME.
    - DSIR-SIRO status
  - Consultant of BEL, India.
- Principal Investigator (completed)
  - > five funded projects (Rs.17.05 lakhs, Rs. 15.12 L, Rs.4.77 L, Rs.8 L, 10L) – Completed!
  - and two German grants (Rs. 4.5 lakhs and Rs. 2.3 lakhs) – Completed!.
  - DST-NIMAT Entrepreneurial project (Rs. 3 lakhs) – Completed
- Researcher at
  - a TIFAC Core in Network Engineering project (>Rs. 2.5 crore),
  - A German ISAR project (> 5 Partners – LRZ, IBM, MaxPlanc, ParTec).
- Project Coordinator for 6 years at SXCCE, a reg. research centre of Anna University-Chennai.
- Recognized Ph.D supervisor of Anna University-Chennai (Ranked 8 in NIRF ranking) – Produc
  Ongoing: 5 Ph.D candidates at IIIT-Kottayam (an institute of national importance of India).

Indian Institute of Information Technology Kottayam

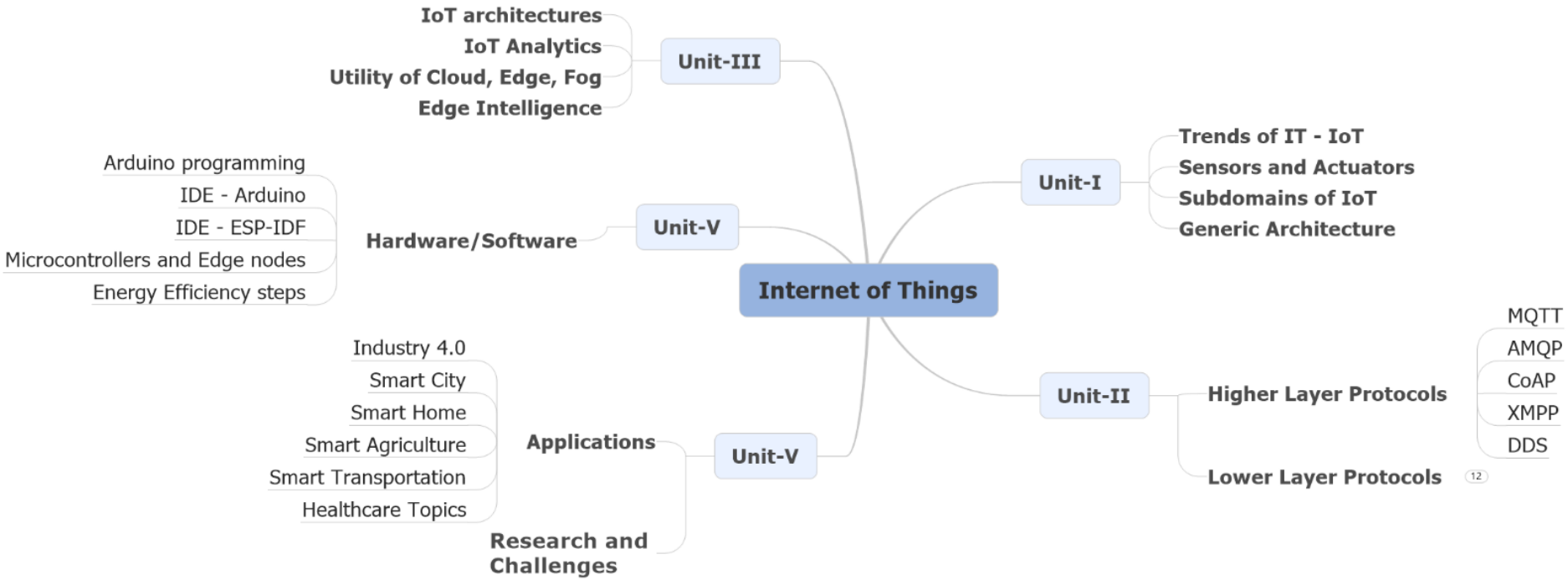
- WELCOME TO

IOT COURSE

Indian Institute of Information Technology Kottayam

www.sbenedictglobal.com

Syllabus


Internet of Things
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Trends of IT - IoT
Sensors and Actuators
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Healthcare Topics
Research and Challenges

Evaluation

- Exam
- Bonus (0.3 credits) for 10-15 minutes of webinars (FCFS) – Topics will be shared.
- NOTE: There is no repetition exam!

History of IoT?

- The phrase “Internet of Things” was first used by Kevin Ashton in the title of a presentation made by him at Procter & Gamble (P&G) in 1999.
- The phrase was used to refer to Radio-frequency identification (RFID) gadgets used for tracking consignments.

IoT

- Future internet may consists of
  - millions of computing devices
  - Billions of personal devices or things
  - Trillions of sensors or digitized objects
- Entrepreneurs, business people, and technical aspirants are working on addressing the emerging problems of the Future Internet.
- Open and industry standards exist.
- IoT leads to smarter computing
  - How human life acts in the year 2050? – Robots!
  - Knowledge-driven society will be enabled.
  - Cognition-enabled machines and expert system will be a common solution.
  - Devices in home, offices, motels, coffee houses, airport, gyms, hospital, and so forth connect, collaborate, and suggest the future activities.

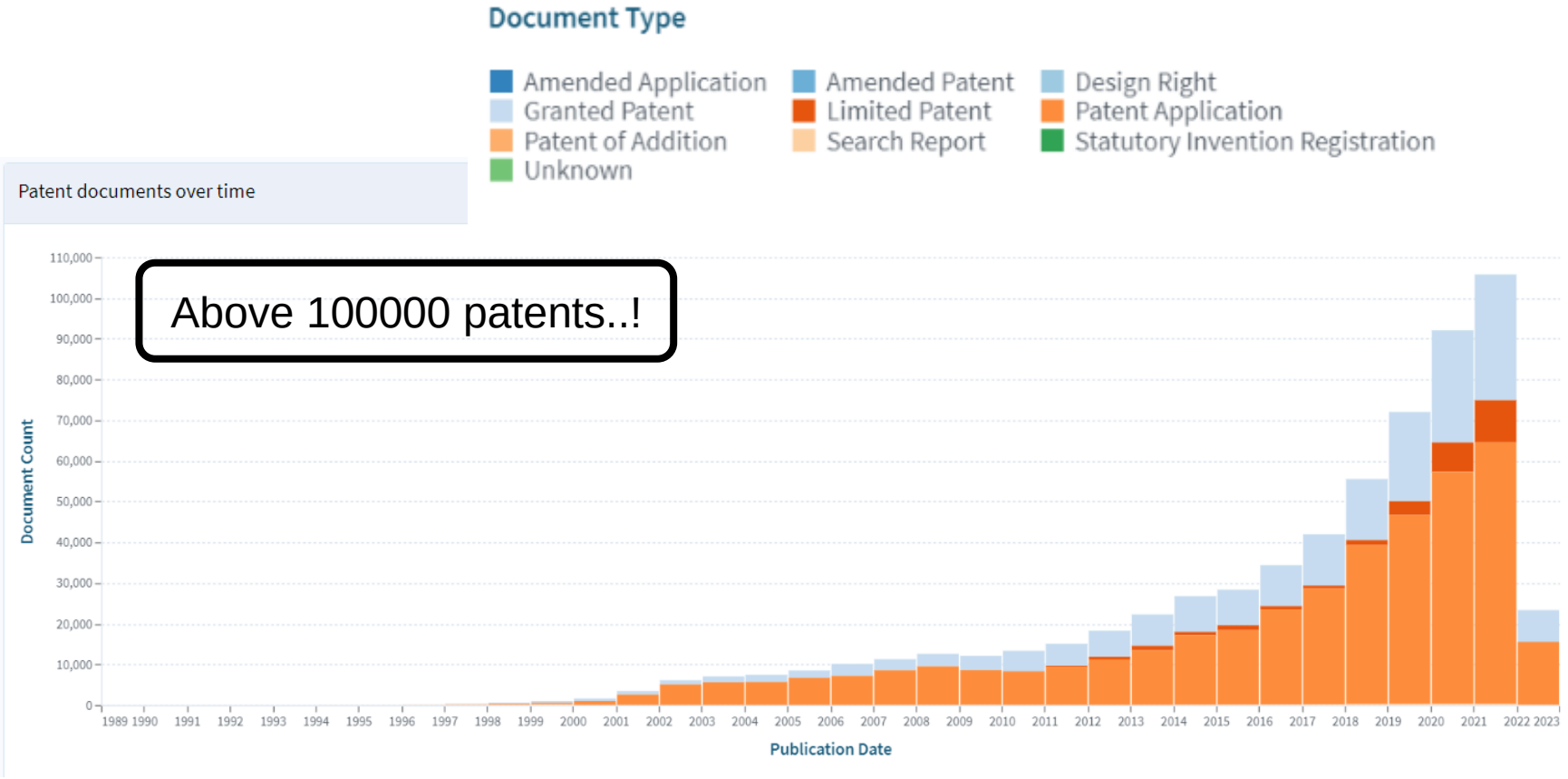
IoT

- IoT delivers smarter environments.
- Living, working and relaxing environments collaborate each other.
- For eg. , If someone wants to print a document, connected things will begin a conversation between the smartphone and a printer; and, the printer automatically prints the document!
- IoT prescribes the shift towards people IT.
- It is considered as disruptive and transformative technologies with the smart synchronization of a galaxy of ICT.

Trends in IT Space

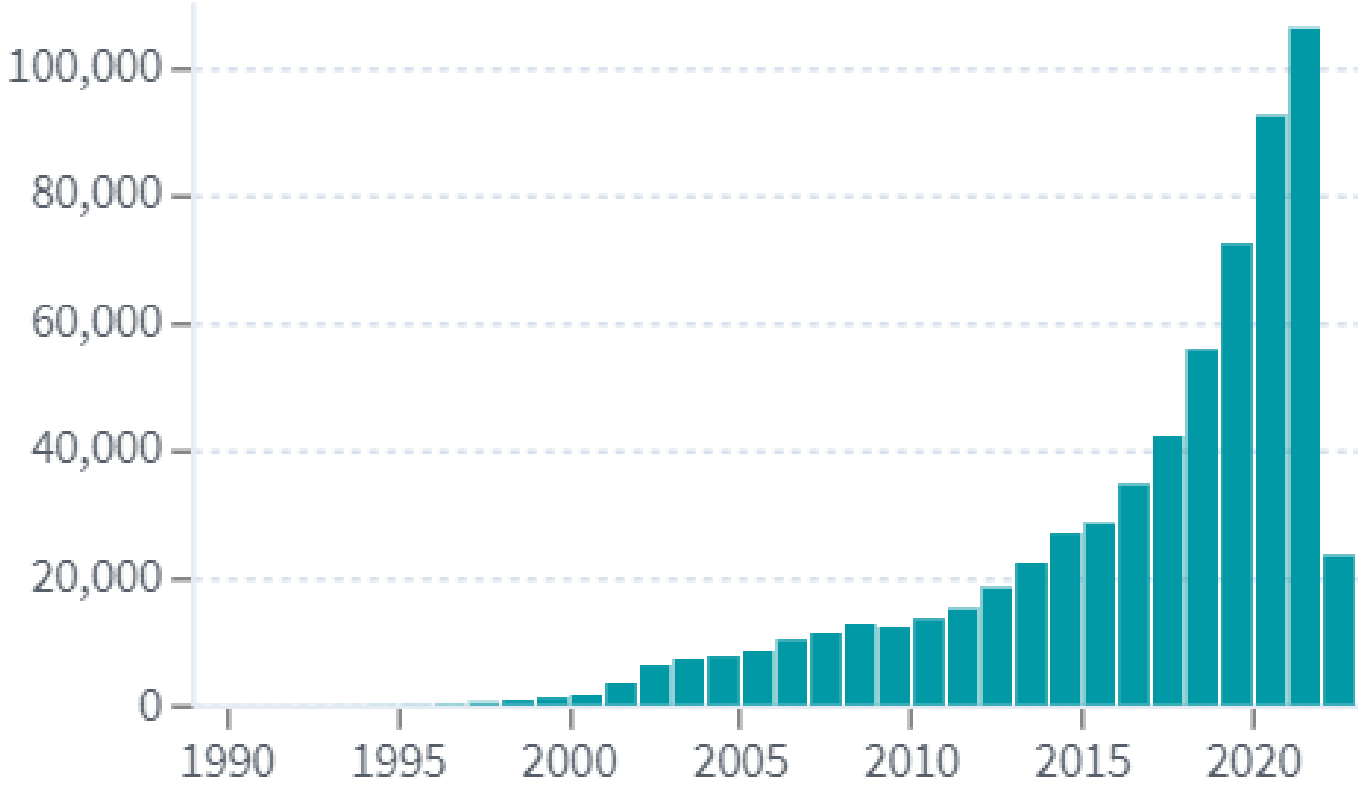
- 20th century was for electricity --:
- 21st century belongs to i) IoT ii) wearable technology, iii) Bigdata, and iv) 3D printing (https://rickscloud.com/tech-trends-in-the-21st-century/).
- There are many transitions happening at IT space
  - Leading to the betterment of IoT

Trends of IoT - Patents



https://www.lens.org/

Trends of IoT - Publications



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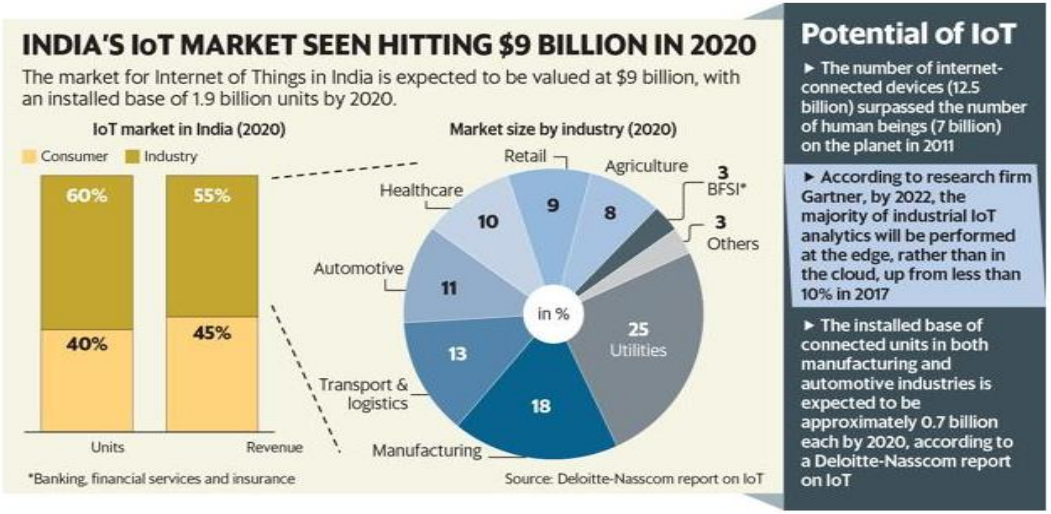
Investors for IoT

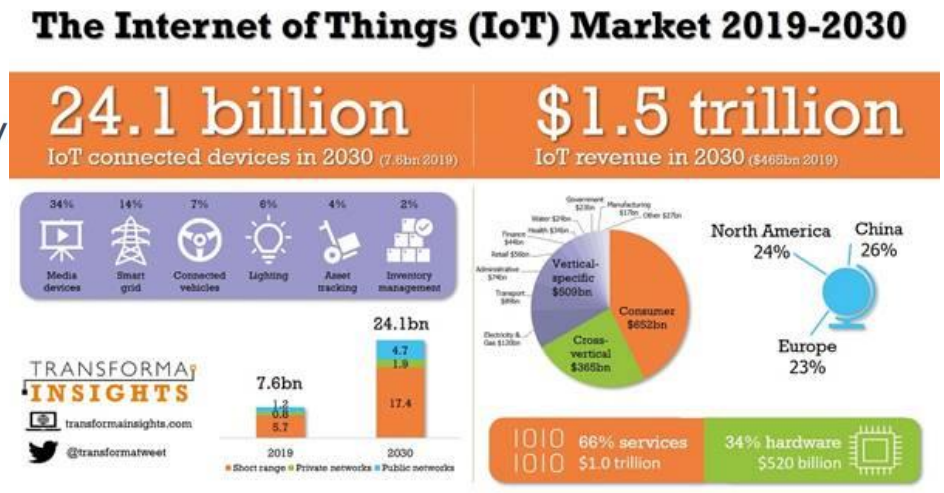


Source: Deloitte-Nasscom report on IoT

RESEARCHANDMARKETS
THE WORLD'S LARGEST MARKET RESEARCH STORE

$169.39 Billion Worldwide IoT Services Industry to 2030 - Identify Growth Segments for Investment

March 01, 2022 06:23 ET | Source: Research and Markets

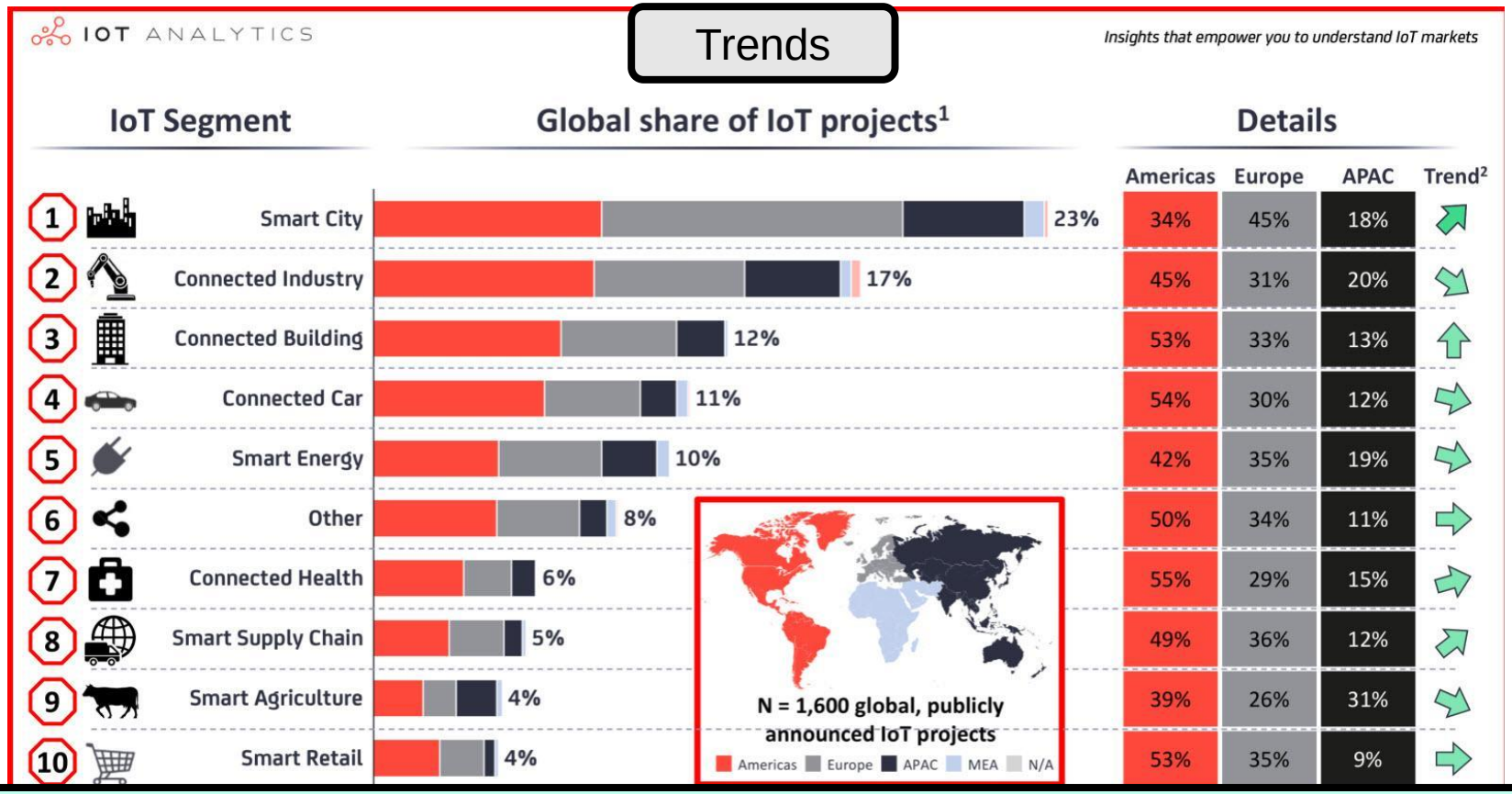


Source: iot-now.com

Future Investors

- Bosch is investing Rs1,700 crore in India as it focuses on IoT and artificial intelligence.
- Tata Communications is investing about $100 million in IoT, with a focus on smart cities, utilities and people safety.
- Reliance Jio Infocomm has launched an NB-IoT (narrow-band IoT) network, with commercial network available in Mumbai, while Bharti Airtel Ltd is in talks with US telco Verizon for a broad partnership around IoT.
- Constantly watch: https://www.iottechexpo.com/europe/ (Upcoming in Sep 2022 in Amsterdam)

Global Scenario of IoT

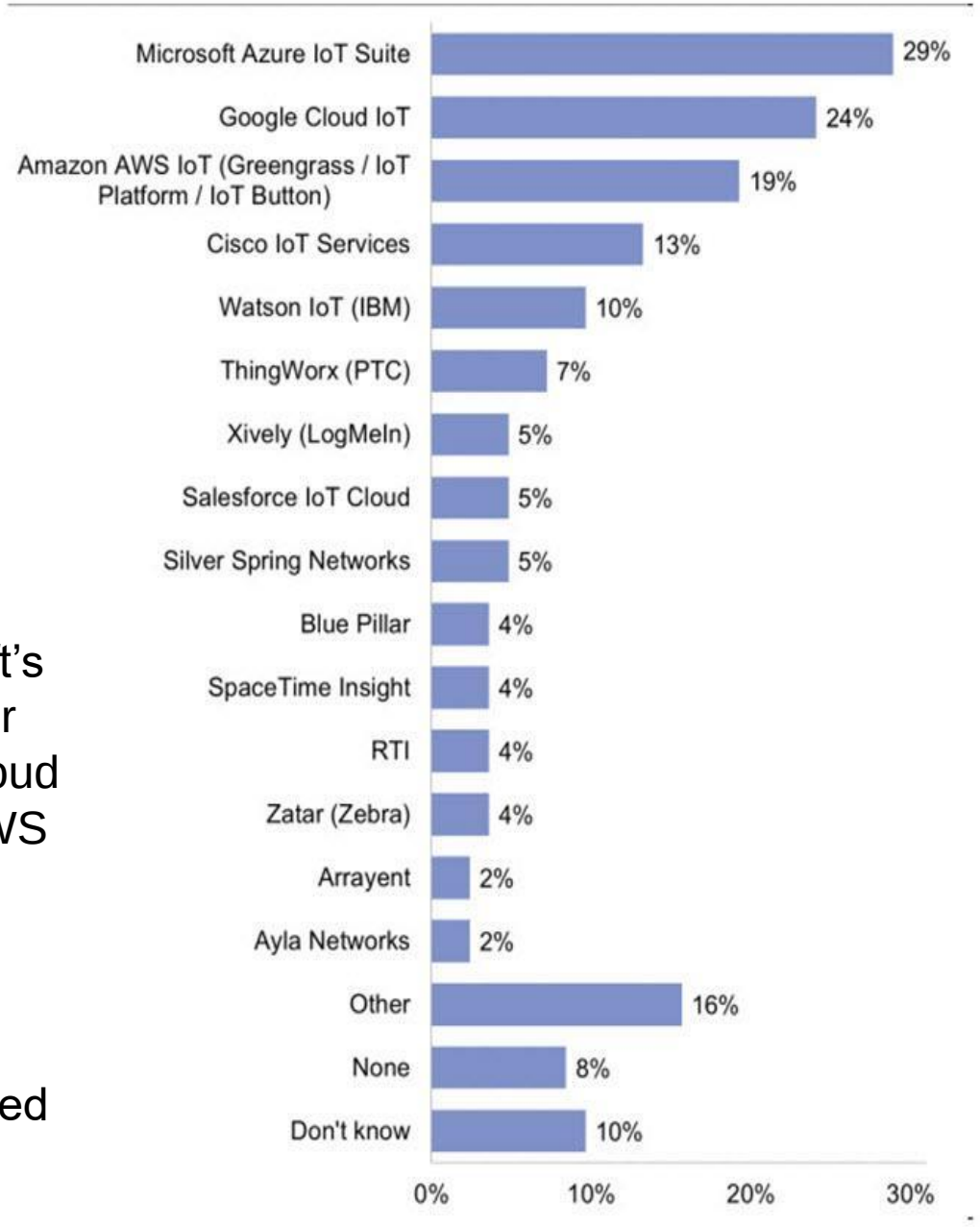


https://www.forbes.com/

Leading Global Project Domains

- Smart Cities (23%), Connected Industry (17%) and Connected Buildings (12%) are the top three IoT projects (in progress).
- The chart shows that nearly half of the Smart City projects (45%) are in Europe, while the Americas lead in the area of Connected Health, with 55% of global projects…
- There are variations in this chart depending on the flow of funds and industrial interests.

IoT Platforms

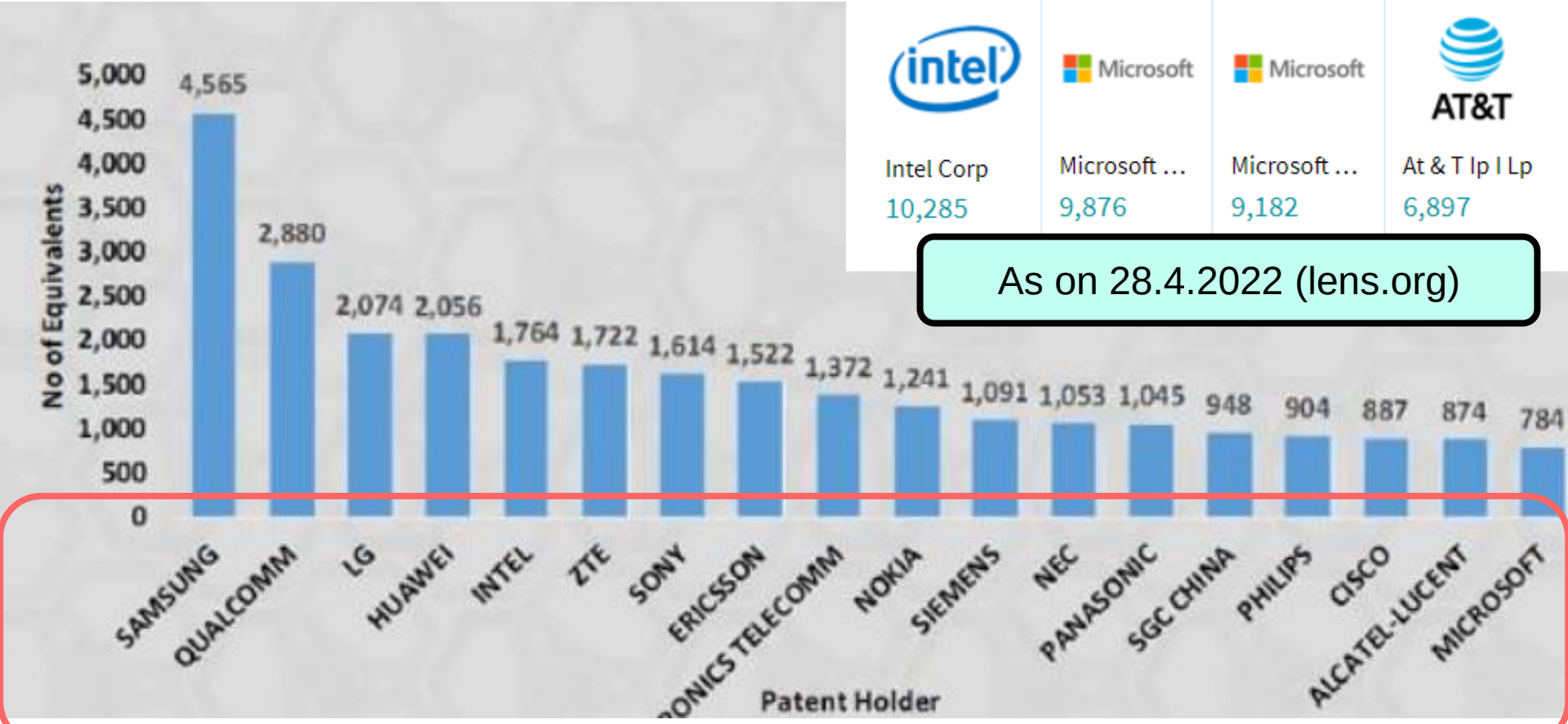


- 29% of developers favor Microsoft's Azure IoT Suite as the platform for their IoT projects, with Google Cloud IT second (24%), and Amazon AWS IoT third (19%).
- AWS was more popular with respondents from smaller organizations.
- Googe's Cloud IoT is being adopted more by employees in larger companies.

IoT Patents

Qualcom…	Samsung …	Ibm	Ericsson T…
29,623	25,762	19,106	10,666
Intel Corp	**Microsoft …**	**Microsoft …**	**At & T Ip I Lp**
10,285	9,876	9,182	6,897

As on 28.4.2022 (lens.org)



https://blogs-images.forbes.com/louiscolumbus/files/2018/06/IoT-Patent-Map.jpg

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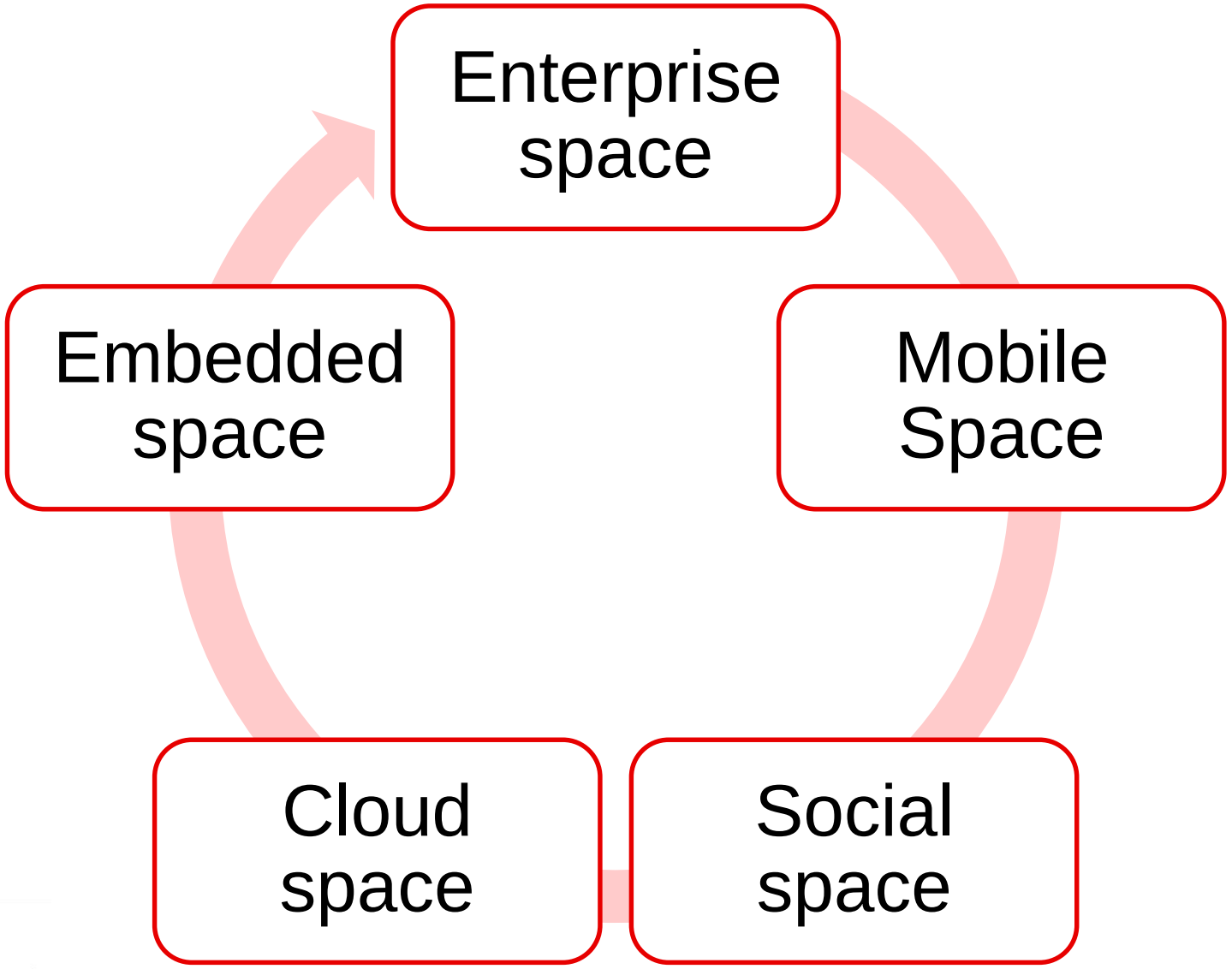
How IT contributed to IoT?

- Trends in IT space that contributed IoT domain,
  - Enterprise transformation
    - New business model
  - Many solutions are service-enabled ones…
  - BigData is becoming a crucial insight…
  - Software defined cloud environments…
  - Support for the diversity of data sources
    - Wearables, open/web data, media, industrial control data

IoT Working Space / Domains



IoT – Key Drivers for enterprise transformation

- Infrastructure optimization
- Process excellence
- Architecture modernization
- Technology adaption and adoption
- Leverage data toward actionable insights
- Device ecosystem
  - create slim device
  - Integrate with cloud
    - Eg. Thinkspeak, www.idigi.com
- Digitization and distribution
- Extreme and deeper connectivity

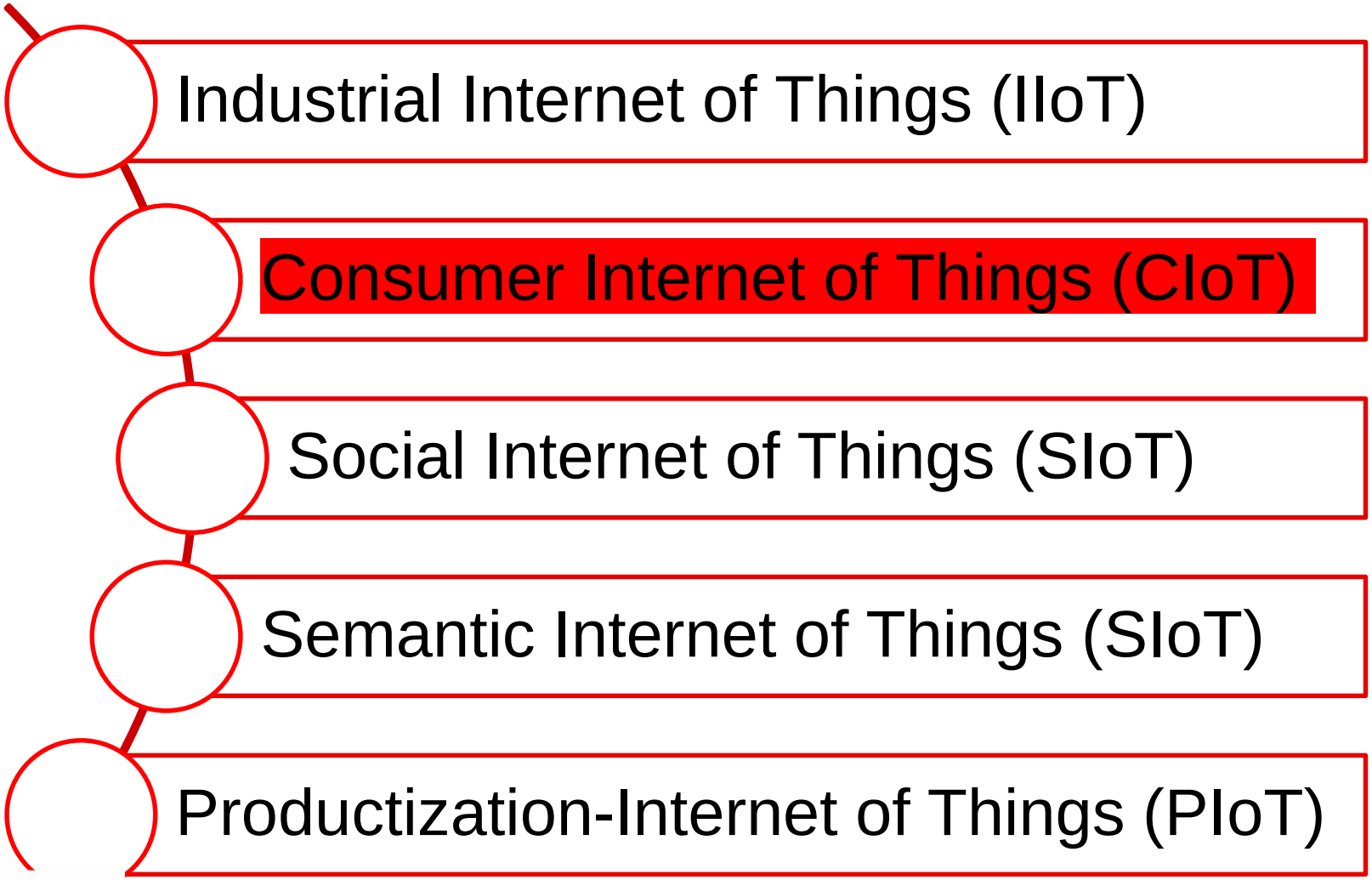
Popular M2M applications

- Smart Energy
- Smart Health Care
- Smart HomeSecurity
- Smart cargo handling
- Smart Traffic management
- Smart inventory and management
- Smart cash payment
- Smart tracking
- Smart displays
- Smart manufacturing
- Smart Asset Management
- Smart Retailing – a distribution process

IoT Challenges and Research Domains

- Challenges
  - How to handle large volume of data? (DATA)
  - How to address a large number of devices/things?
  - Elasticity in compute servers, storage and network connectivity. (i.e., scalable INFRASTRUCTURE)
  - How to improve the energy efficiency of batteries?
- Research Domains / Topics
  - Energy efficient device architectures
  - Elastic IoT infrastructures
  - Highly optimized communication protocol design
  - Data duplication and compression techniques
  - Data reliability
  - Data security

Subsets of IoT Domain



Industrial IoT (IIoT)

- IIoT applies embedded intelligence and network connectivity of IoT devices to improve systems or products.
- Few industrial sectors
  - Eg. Car manufacturing,
  - 3D printing companies,
  - Manufacturing sector
  - Smart buildings
  -
- Case study @ Cognizant:
- https://www.youtube.com/watch?v=SkaNBfUzov0

Industry 4.0

- How the system of industry is changing? – Automation
  - Industry 4.0 is the name given to the current trend of automation and data exchange in manufacturing technologies.
- Industry 4.0 is based on Germany
- Industrial Internet is based on the USA.
- Industry 4.0
  - Fourth industrial revolution
  - First three revolution
    - First (18th century)– water and steam power engines revolutionized production
    - Second (Early19th century) – electrical engines/power revolutionized production (eg. Belt conveyors powered by electricity)
    - Third (Mid 19th century) – Electronics and IT (Programmable controllers)
    - Fourth industrial revolution via. IoT connections (Eg. Siemens)

Challenges of Existing Manufacturers

Siemens captured opinions from 40 manufacturers around 11 countries to understand the challenges of existing manufacturers. They are…

- Digital skills – digital production or maintanence.
- Access to finance for the scale of businesses
- Creating a culture of collaboration.
- Data and cyber security.
- Specialized strategic management and planning capabilities.

Industry 4.0

- In the future, industrial businesses will build global networks to connect their machinery, factories, and warehousing facilities – known as Cyber-Physical-Systems (CPS).

- CPS will take shape of smart factories, smart machines, smart storage facilities, smart supply chains.

- Labors are monitored using sophisticated wearables.

Use case…

- Predictive maintenance
  - Based on the identifiable sensor values, machines are predicted and prevented.

- Spare-Parts replacement
  - Availability of spares

Industry 4.0 for Customers vs. Industries

- For customers
  - Customized solution at affordable prizes
- For industries
  - Highly flexible mass production based on market changes.
- In the future, the product life cycle will be smaller than imagined today due to Industry 4.0

Benefits Industry 4.0 promises for SME

SME – Small to Medium Enterprise benefits from Industry4.0 via.

- Succeeding in competitions
- Increased productivitiy
- Increased revenue
- Optimization of manufacturing processes
- Development of exponential technologies (ie. IoT, RFID,…)
- Delivery of better customer service.

Building blocks of Industry 4.0

- BigData and Analysis
- Autonomous robots
- Simulation
- Horizontal and vertical integration
- Internet of Things
- Cyber-security
- Cloud computing
- Additive manufacturing (ie. 3D printing for prototypes)
- Augmented reality (eg. For maintenance procedures)

Consumer IoT (CIoT)

- Wearables, gadgets, portables, implantables, handhelds, consoles, appliances, instruments and utensils are the IoT products in this category.
- Nest's CamSurveillance create safer home.
  - We are entering into the connected era!
- Challenge:
  - How to bind several heterogeneous devices from different manufacturers?
- Kaa project (www.kaaproject.org) is an opensource IoT middleware platform for managing, collecting, analyzing, and acting on the connected devices.

- https://www.reply.com/en/content/innovative-start-ups-focused-on-iot-and-wearable-technologies

Popular Wearable Applications in Healthcare

- Prevention of diseases and maintenance of health
  - Fall identification and prevention
  - Mental status monitoring (stress patterns of children or employees)
  - To check hypertension or blood pressure.
- It can suggest medical decision making processes.
  - For diabetic patients, cancer patients, stroke patients, and so forth.
- Weight control applications
  - Suggesting physical exercise (apt ones)
- Physical activity monitoring
  - For athletes, to suggest training pattern.
  - Textiles that warm up during chilly days (e.g. Polar Seal)
- Improves the quality of patient monitoring

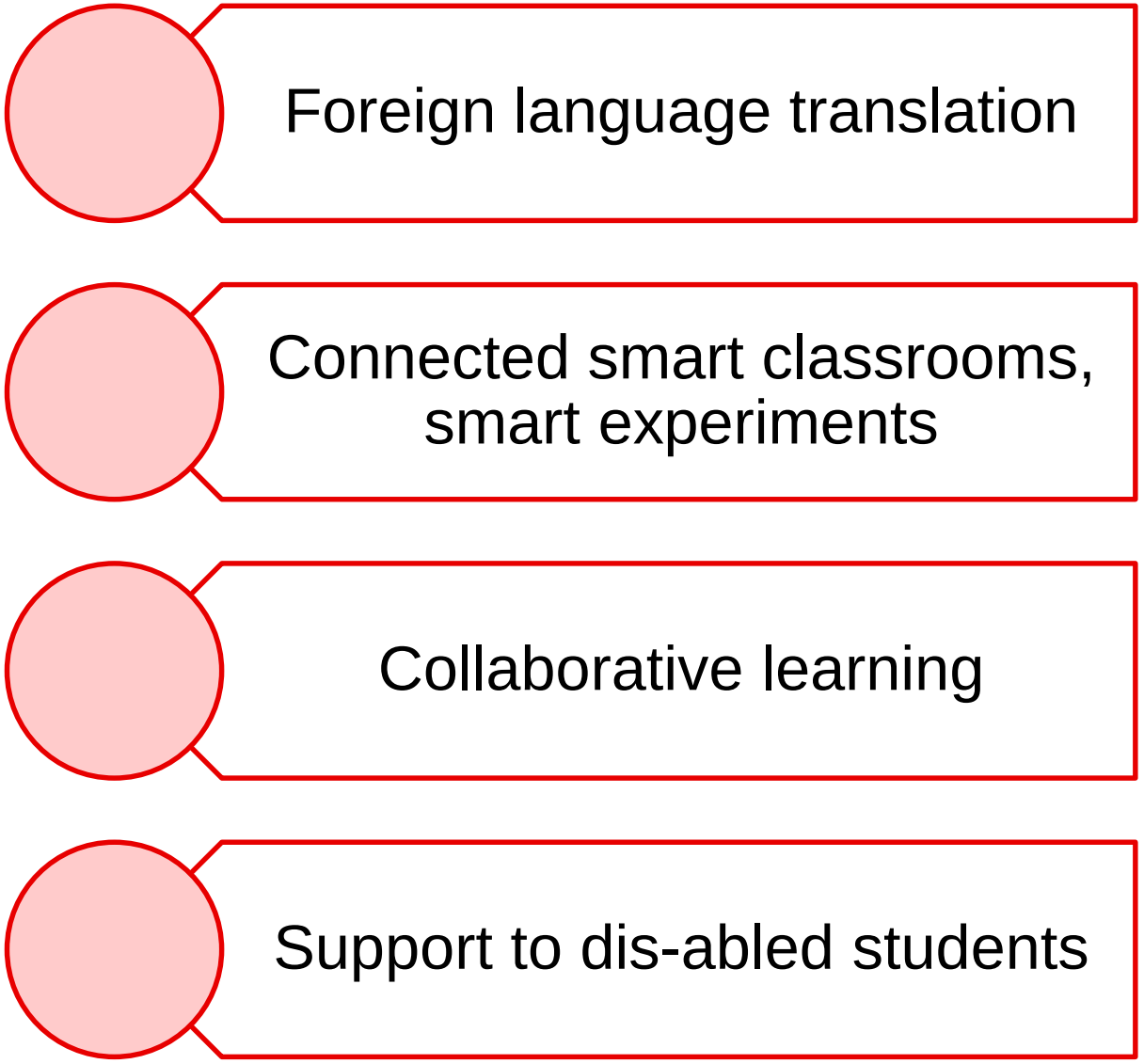
Wearable Devices

- Wearable devices can be attached to shoes, eyeglasses, earrings, clothing, gloves and watches.
- Skin-attachable devices
- A smartphone is typically used to collect information and transmit it to a remote server for storage and analysis.

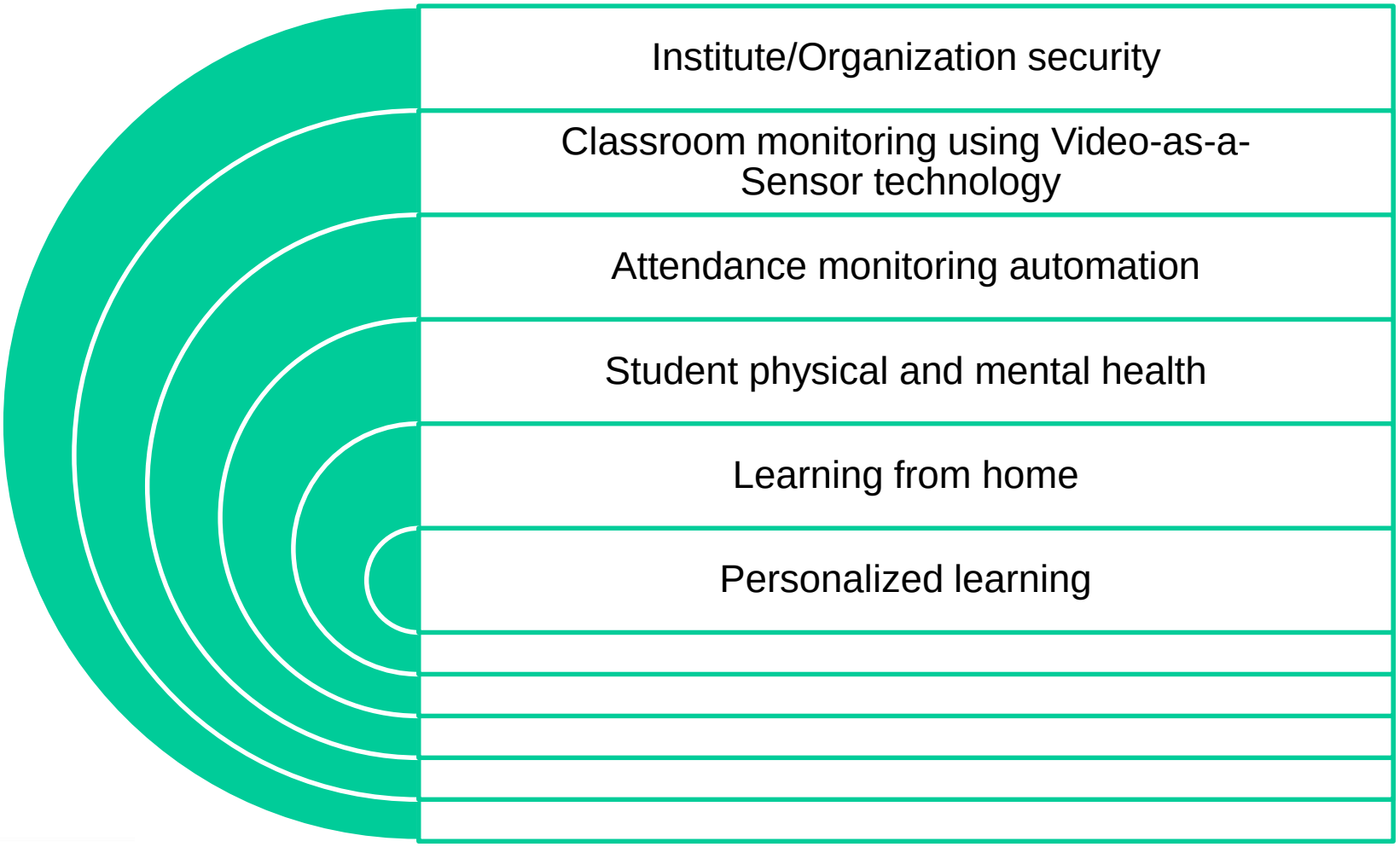
Social/Semantic/Productization

- Social IoT
  - It addresses the establishment of social relationships among interacting objects.
  - Web2.0 sites such as Facebook, Google+, LinkedIn, and so forth are popular social internet of things.
  - These sites extract our likes, dislikes, updates, and interactions.
- Semantic IoT
  - Semantics are applied within connected devices.
  - Defining, modifying and interpreting data
  - (Deals with the language and syntax of metadata)
  - (contextualized, Personalized, Tailor-made solutions)
- Productization IoT
  - Deals with the customization of the sensor applications.
  - Preferably, using 3D printers and solutions.

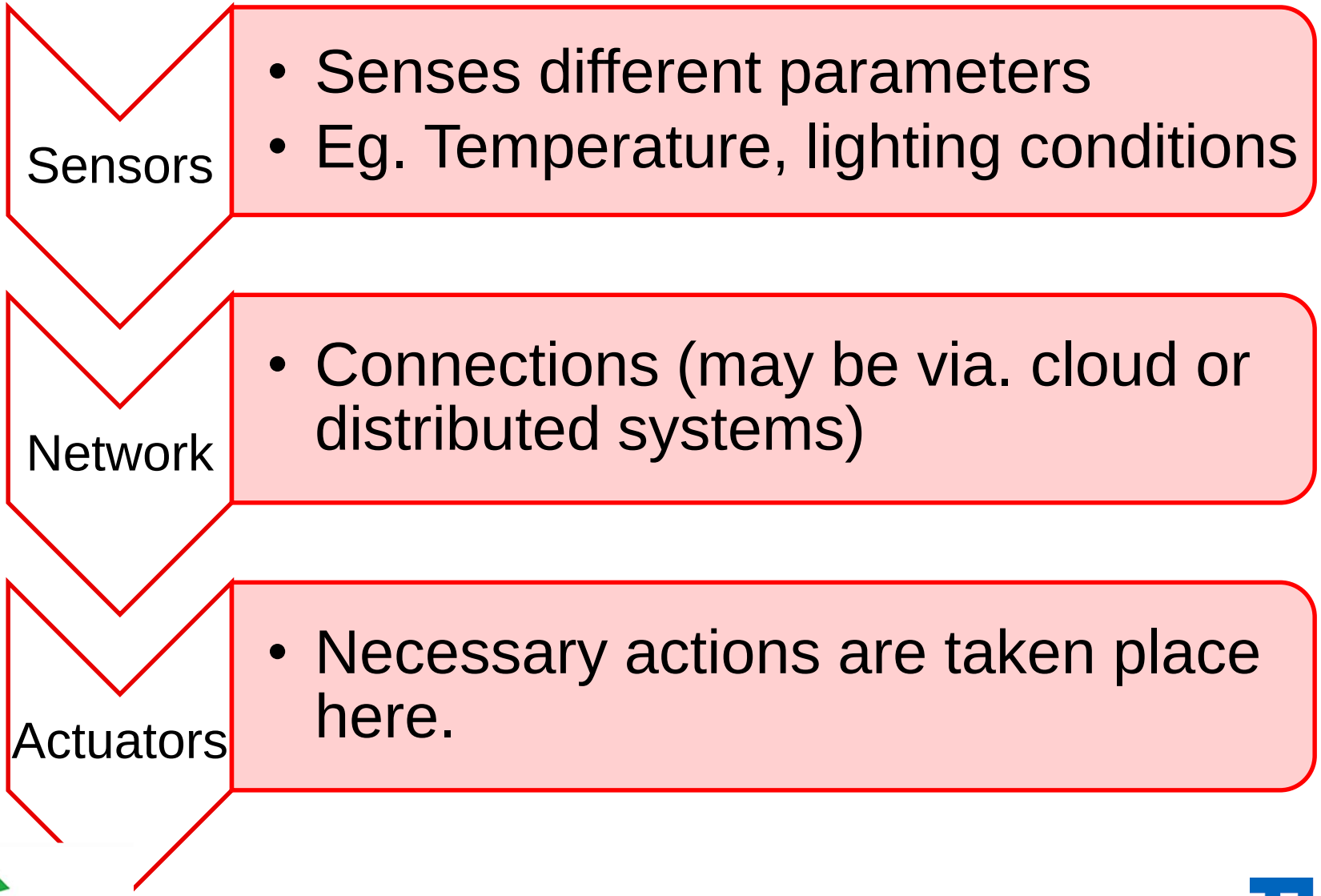
IOT for Education



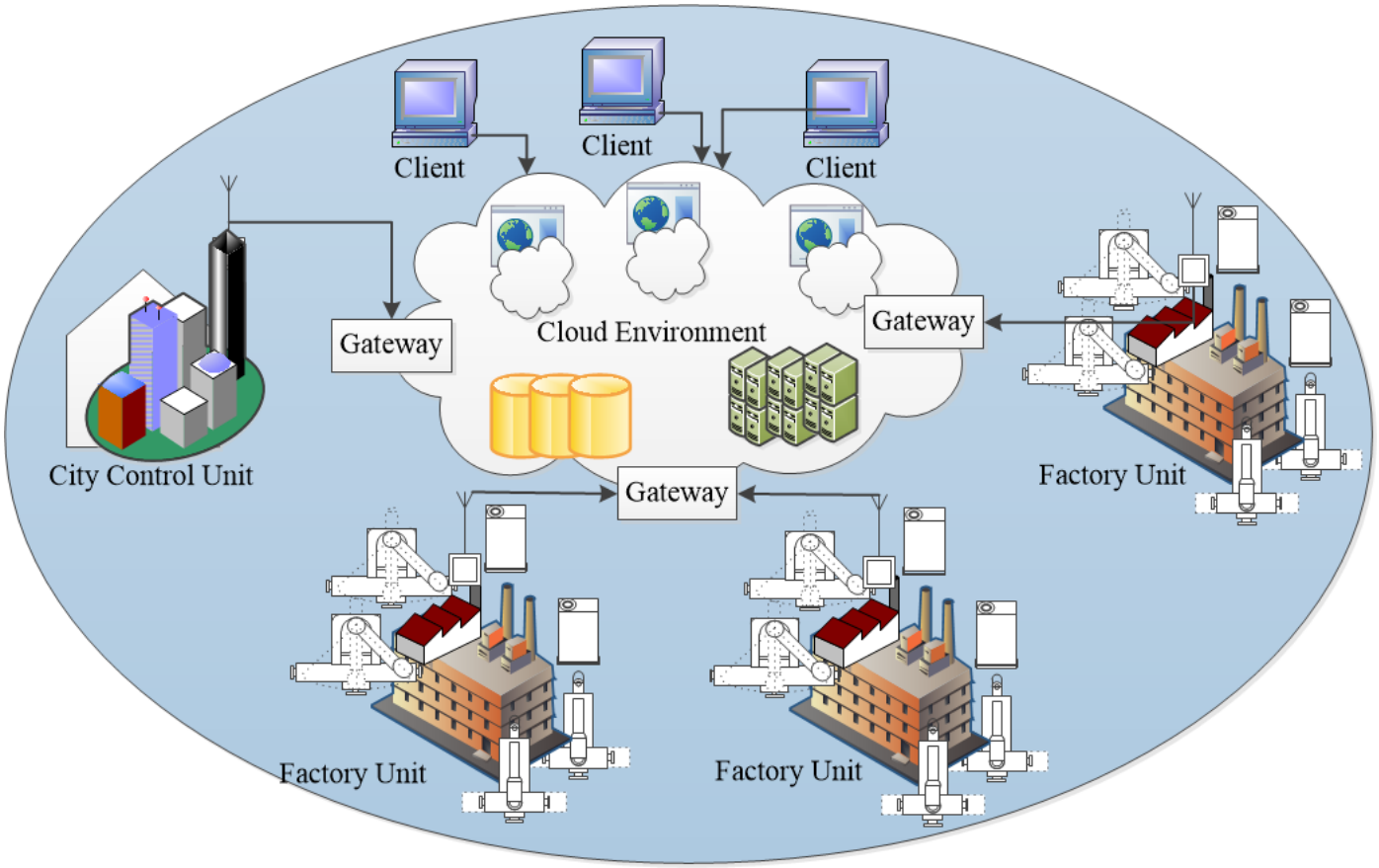
IOT for Education (Indirect)



Three Basic Building blocks of IoTs

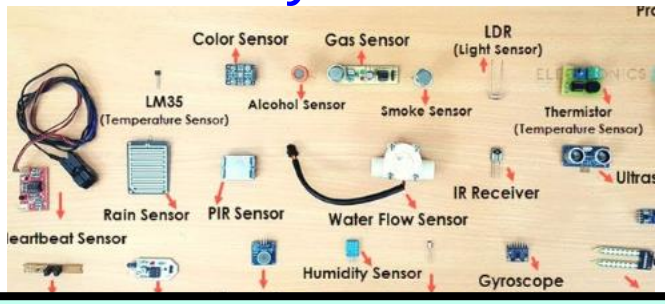


IoT – Air-Quality Monitoring Architecture



Sensors

- A device which detects or measures a physical property and records, indicates, or otherwise responds to it is called as sensors – Oxford dictionary
- A few sensors
  - Obstacle detection sensors
  - Camera detection sensors
  - Smoke detection sensors



Electronicshub.org

- Sensors can be of
  - different shapes and sizes (big or small) and
  - Different properties (chemical or mechanical or electrical or electronic or light…)
- Designing sensors and fabricating them are tougher than applying sensors for different applications.
- Sensors convert a form of input to the other form of energy. Eg. Sound sensor converts sound to electrical

Features of a sensor

Sensors are sensitive to the measurable property.

They are immeasurable to the other measurable properties.

i.e., a temperature sensor does not sense light energy.

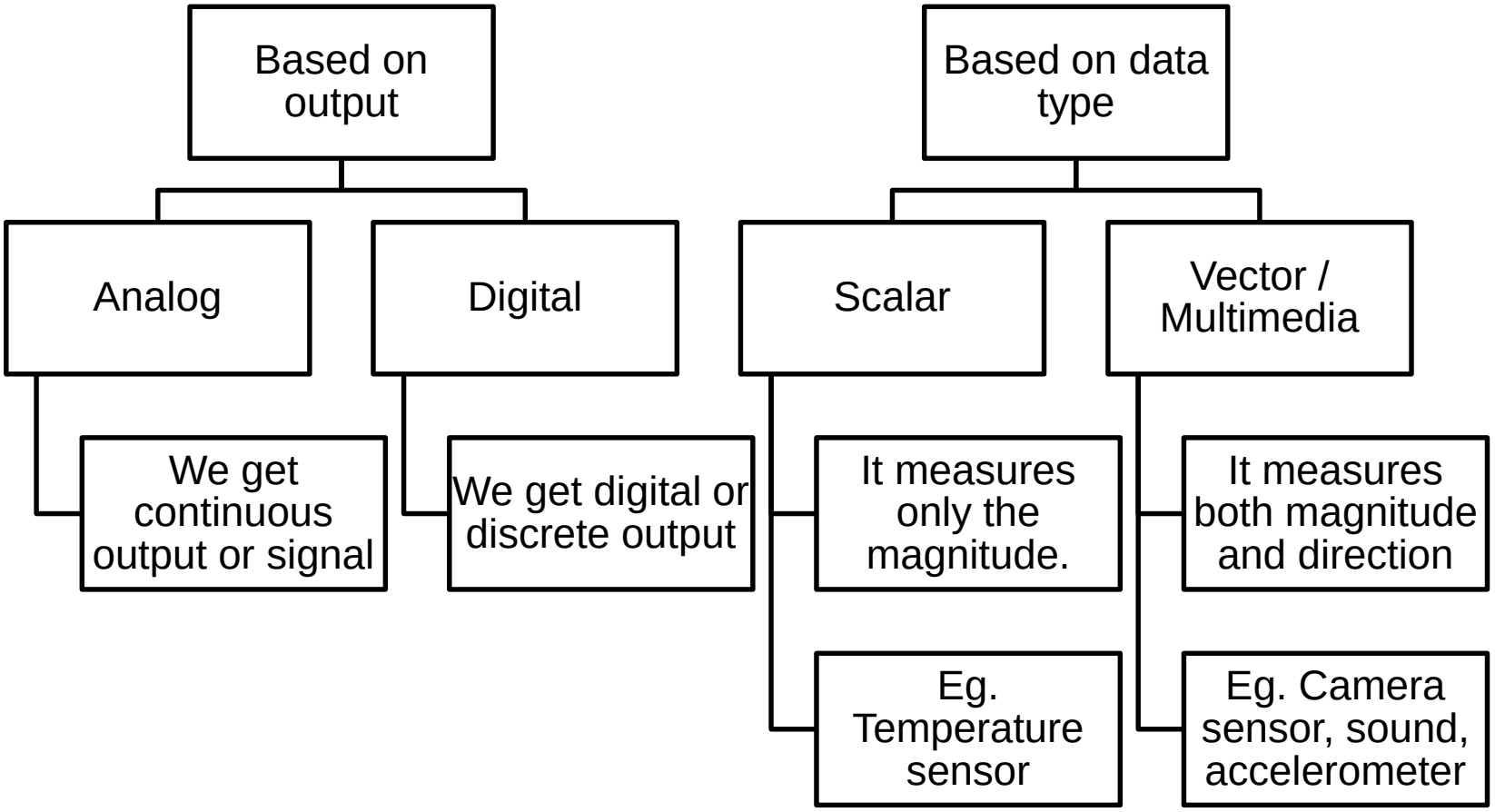
They do not influence the measured property.

i.e., a temperature sensor does not increase the temperature of a room.

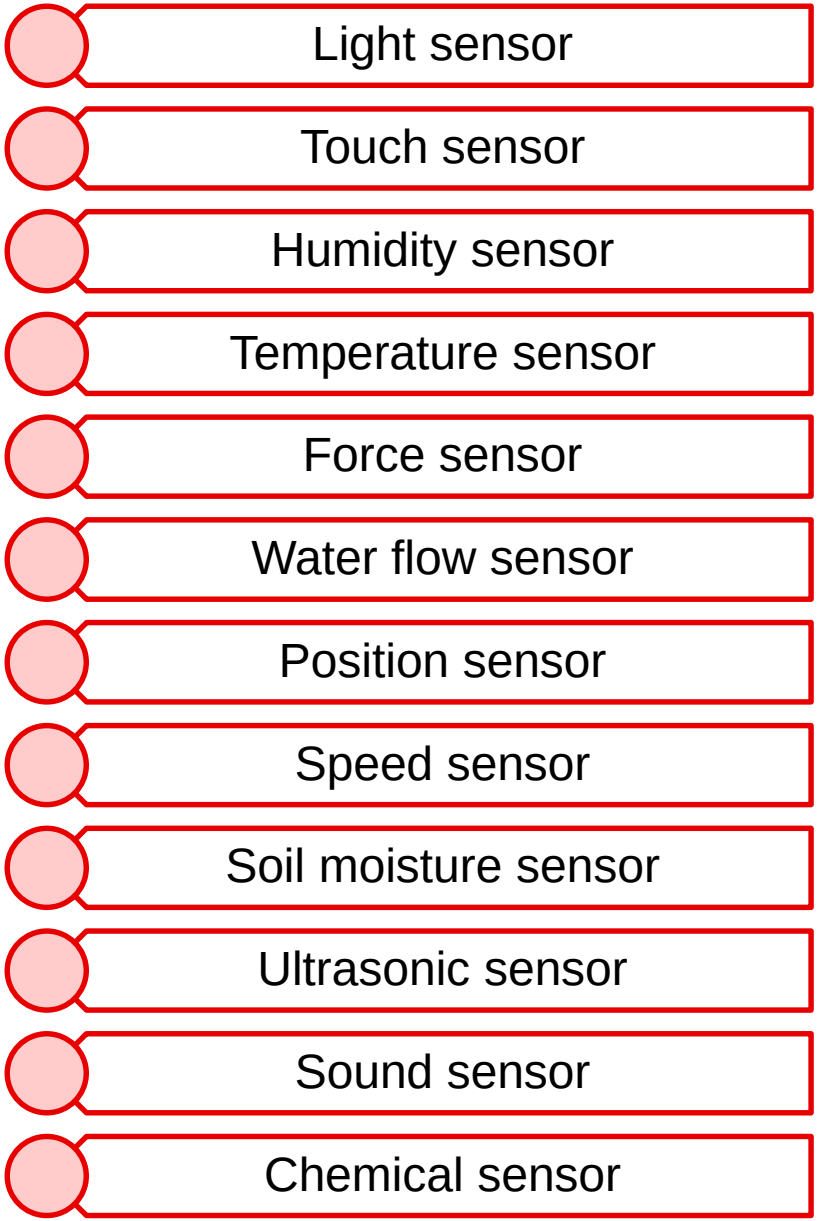
Resolution of a sensor

- The resolution of a sensor is the smallest change that a sensor can detect while measuring its property.
- More the resolution --- More the accuracy or precision

Classes of Sensors



Types of sensors



Sensor Deviations

- Deviations are prone to sensors.
- Hence, there is a maximum and minimum value for any measurable property.
- The sensitivity of a sensor under real conditions may differ from the value specified – named as SENSITIVITY ERROR.
- If the output signal differs from the correct value by a constant, the sensor has an OFFSET ERROR or BIAS.

Linear vs. Non-Linear Transfer function

- Sensors, generally, have a linear behavior (ie. Transfer function w.r.t input and output).
- Non-linearity is the deviation of the sensors' transfer function.
- If the output signal of a sensor slowly changes over time (over months or years), it is termed as a *DRIFT*.
- DRIFT is caused due to the malfunction of sensors.
- NOISE is a random deviation of the signal that varies in time.
- HYSTERISIS ERROR are error due to the impact of the previous measured values (ie. Historical errors are accumulated in the recent values).

Actuators

- Actuators perform actions.
  - Eg. Relay switch – an electromechanical switch (for powering On or OFF)
  - Eg. Solenoid – controls the flow of water / liquid.
- Actuator is a component that moves or controls the mechanism of a system.
- An actuator requires a control signal to act on an environment.

- 2types : Linear vs. Rotary actuators
  - Linear – moves in a linear direction.
  - Rotary – moves in a circular motion.
- https://www.youtube.com/watch?v=OKyZFuc4WKI

Types of actuators

- Hydraulic actuators
  - Hydraulic power is utilized to perform mechanical action.
- Pneumatic actuators
  - Air is utilized to perform mechanical action
- Electric actuators
  - Electric power is utilized to perform actions
  - Eg. Electric signal to control solenoid valves.
- Thermal or magnetic actuator
  - Thermal or magnetic energies are utilized to perform mechanical actions.
- Mechanical actuators
  - Mechanical power is utilized…