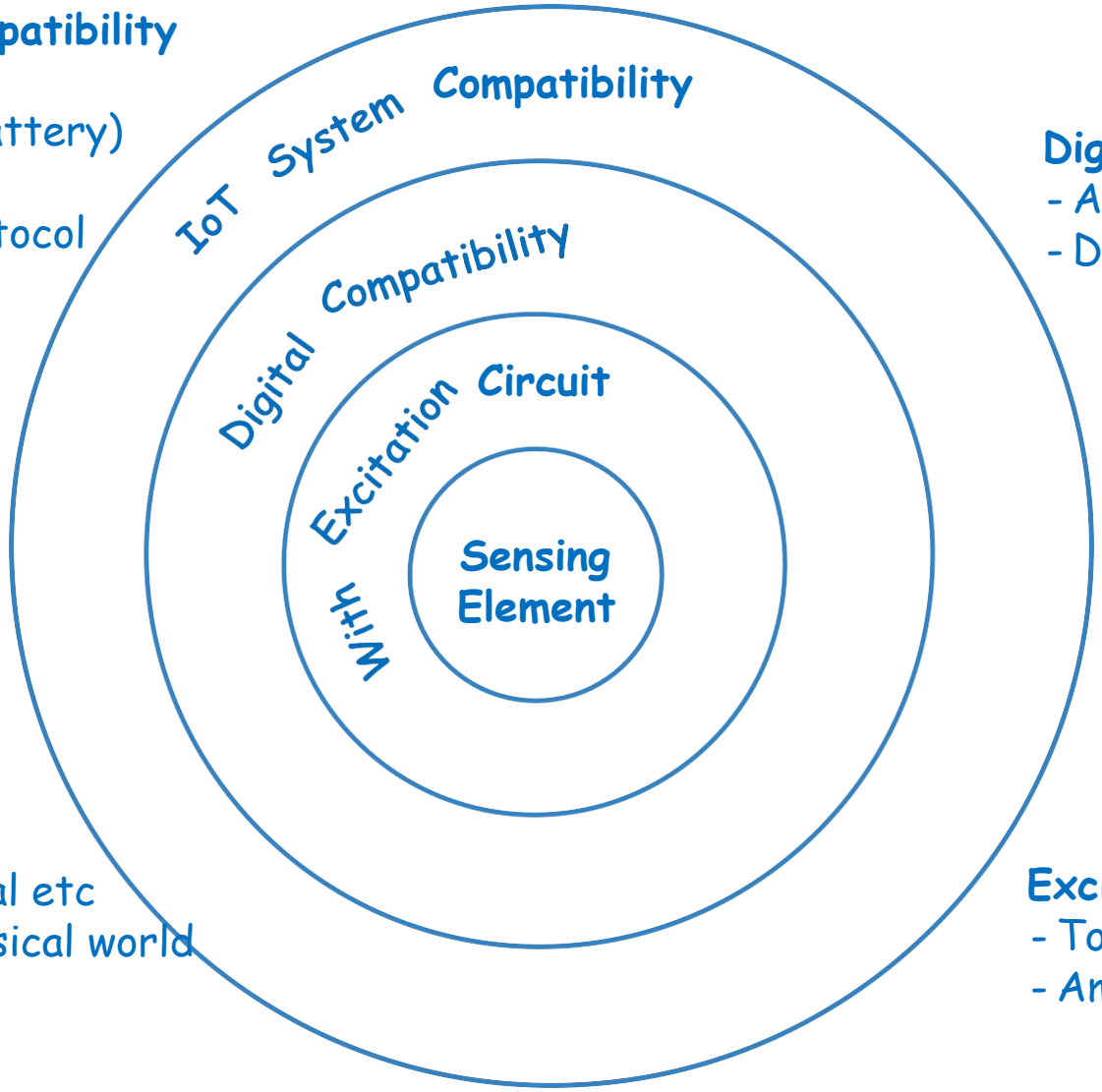
EE5111
SELECTED TOPICS IN INDUSTRIAL CONTROL & INSTRUMENTATION

Recap

A SmartSensor Node for IoT

IoT System Compatibility
- Computation
- Power Mgmt (Battery)
- Wireless
- Data comm. protocol



Digital Compatibility
- Analog to Digital
- Data xfer protocols

Sensing Element
- MEMS / Chemical etc
- Responds to physical world

Excitation Ckt
- To excite electrically
- Amplification etc

Multi Sensor System

- Classical Multi Sensor System
- Multi Sensor Joint System
- Collocated Multi Sensor System

- Important system design coordinates
  - Performance
  - Power
  - Area
  - Cost

- Important for IoT → S.C.A.L.E. !

Calibration

- Why is calibration required ?
- What is calibration ?
- What are the ways to calibrate inertial sensors ?
- What is the outcome of calibration process ?
- How is calibrating one sensor different from calibrating a sensor array (or multi-sensor system) ?

Calibration Illustrated

Following is the observation made while calibrating a weighing scale

Standard Weight	Weighing Balance's Reading
0.5 Kg	0.55 Kg
1.0 Kg	1.0 Kg
2.0 Kg	1.9 Kg
3.0 Kg	2.8 Kg

Weighing balance
(To be calibrated)

Q: Write equation for calibration compensation.

Q: What is the actual weight of an object which is measured as 1.225 Kg by this weight scale?

Standard weights
(Standard reference)

Image source: Internet

Revisiting IoT System Overview

IoT System Design

What is the Internet of Things?

- Start with a traditional device

- Add computational intelligence to improve the functions

- Add a network connection to further enhance functions – IOT fridge

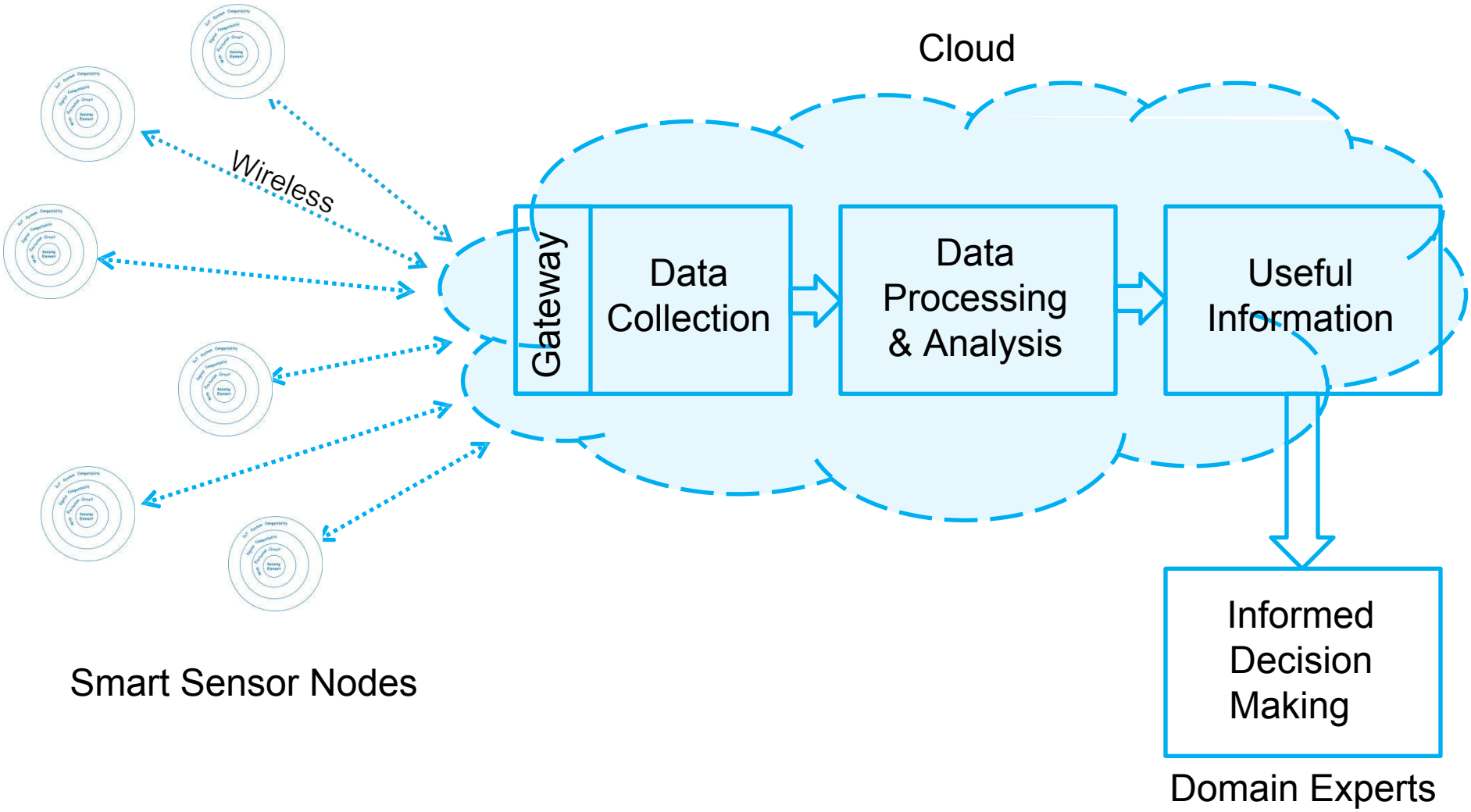
What is the Internet of Things?

- 1950s car with electro-mechanical control

- 21st century car – computer based control systems for fuel injection, anti-lock braking

- IOT cars? Currently enhanced by smart phones for traffic conditions, routing, car-sharing.

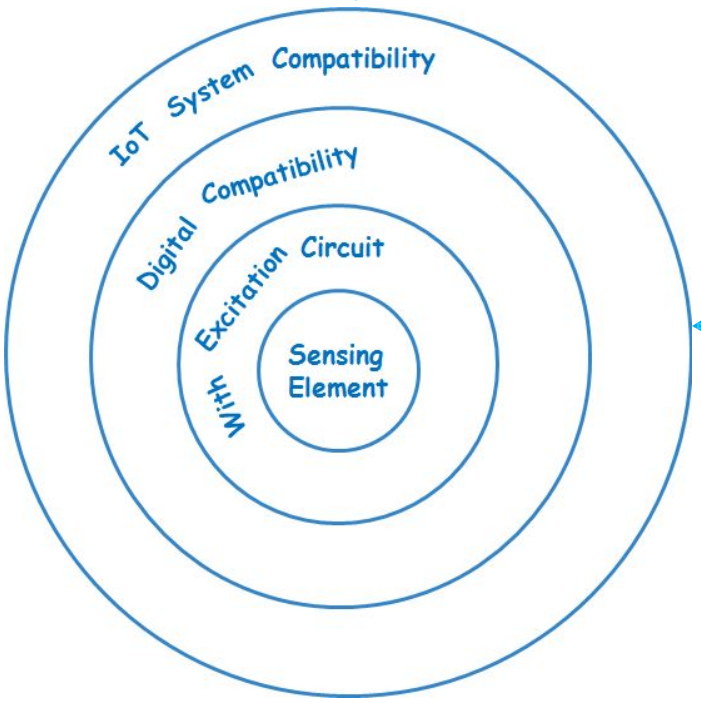
IoT System with Smart Sensors



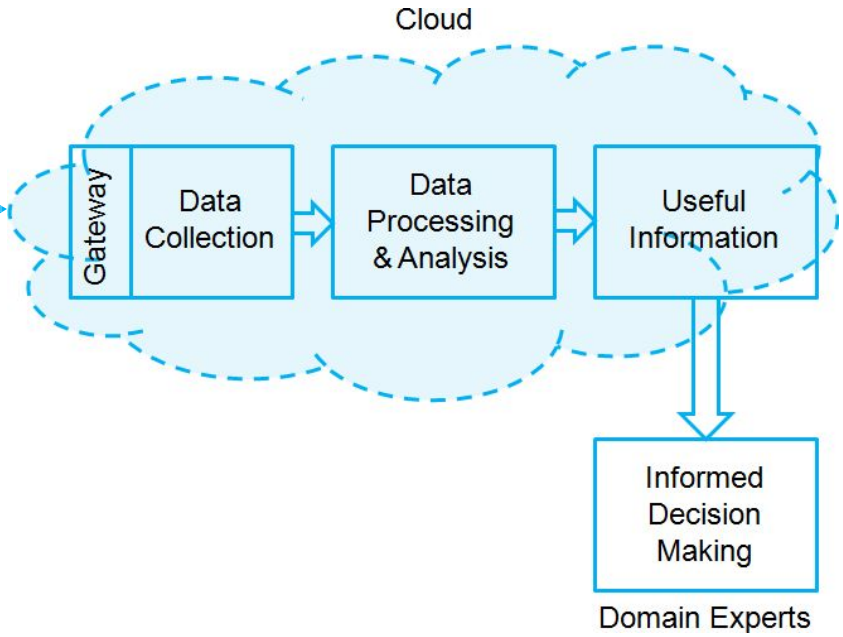
Distribution of Computation

Low level of computation

High level of computation / analysis



Wireless



Desirable

- Increased capabilities at the local node
- Reduced requirements on the connectivity
- Providing the back-end with high level information
- Simplified data interface

Case Study: Shoe-mounted PDR Sensor

Realtime Monitoring Application

Path construction (PDR) on application platform

Positioning w/o GPS !

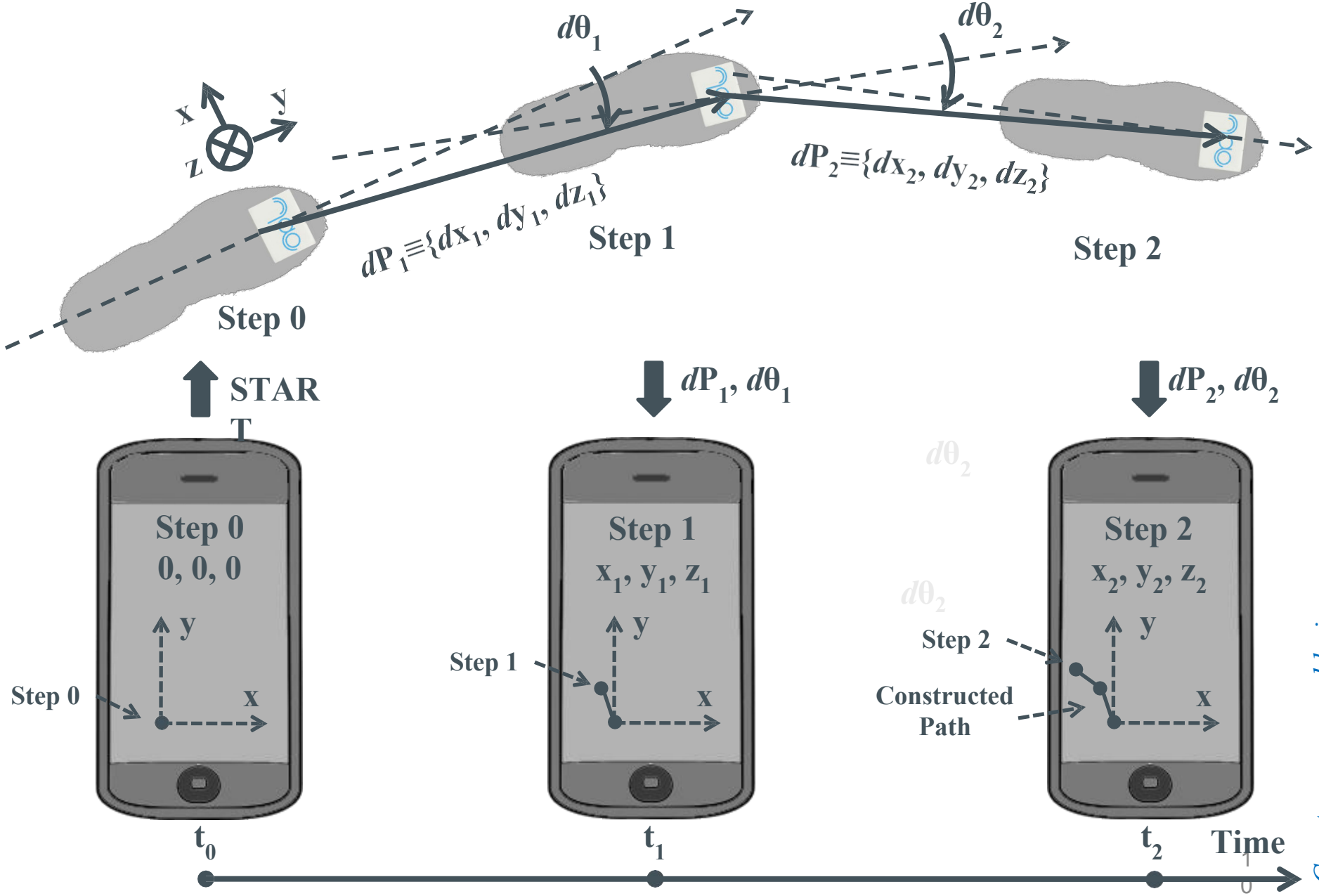
Wireless Transmission

Inside the sensor: Calibration compensation, sensor fusion and navigation equation

Shoe Sensor proving high level information

Courtesy: www.oblu.io

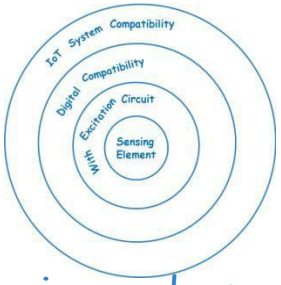
Extremely Simplified Interface!



Courtesy: www.oblu.io

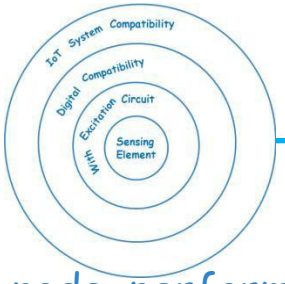
Types of IoT Systems

Level 1



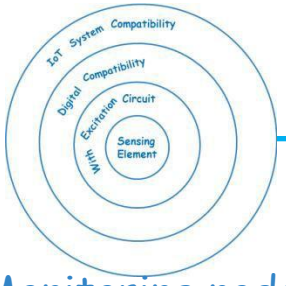
Monitoring node, performs analysis, stores data

Level 2



Monitoring node, performs analysis

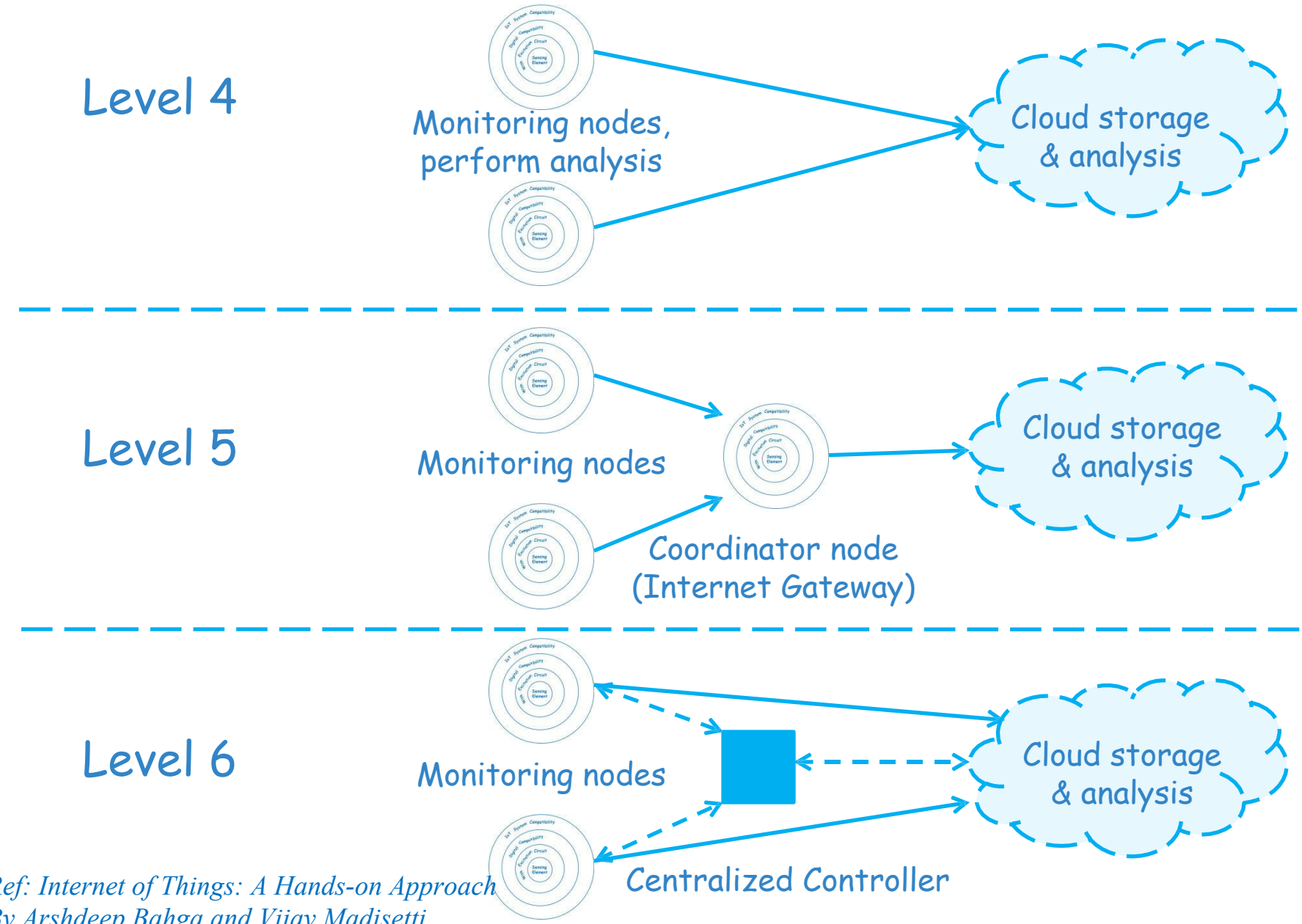
Level 3



Monitoring node

Ref: Internet of Things: A Hands-on Approach
By Arshdeep Bahga and Vijay Madisetti

Types of IoT Systems



Ref: Internet of Things: A Hands-on Approach
By Arshdeep Bahga and Vijay Madisetti

Examples of IoT Systems

Level	Example
1	Oblu (shoe-mounted tracking sensor) sending PDR data to local application platform which hosts Xoblu app for constructing path and visualizing.
2	Xoblu in the above example synchronizes data with cloud for analyzing person's gait / movement behavior over a period of time.
3	Oblu sending PDR data directly to cloud for real time monitoring of a person from remote location.
4	Oblu used for tracking multiple people simultaneously who are at different sites, from a remote location.
5	Network of gas sensors on an industrial site. One node collects data from all the other nodes and sends to cloud.
6	(4) with a centralized control unit which could send remote commands to all the oblus in blanket or selectively.

Ref: Internet of Things: A Hands-on Approach By Arshdeep Bahga and Vijay Madisetti

Capturing Real World

- What attributes of a system you would like to capture?
  - System's state and immediate surrounding

- How would you monitor a moving machine? Say, a robot.
  - By attaching sensor devices

What if you have to monitor humans?

- How is monitoring (sensing) of humans different from robots?

- Human Behavior
  - Different abstraction level
  - Hard to completely capture by a machine

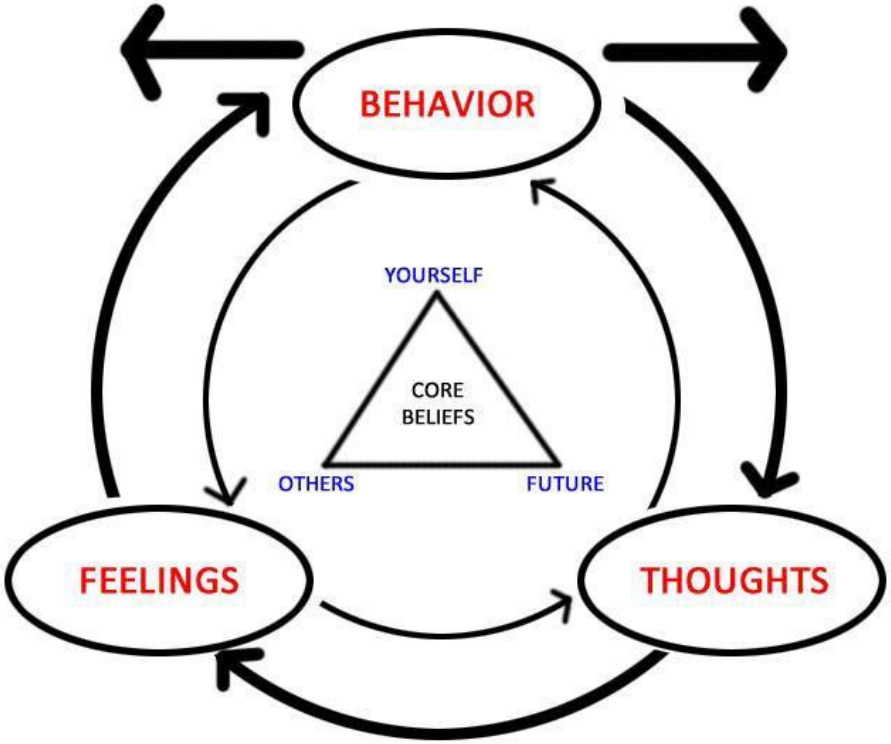


Image source: wikipedia.org

How toMonitor Humans?

...and super humans

Image source: costumekart.com

How toMonitor Humans?

...and super humans

Get them a smartphone!

Image source: costumekart.com

Smartphone – A Sensor Hub

What is a sensor ?

- Touchscreen
- Light
- WiFi
- Wind speed
- Bluetooth
- GPS
- Proximity
- Barometer
- Tilt
- Magnetometer
- Accelerometer
- Gyroscope
- Temperature
- Humidity

Image source: Internet

How to Monitor Humans?

...and super humans

Image source: costumekart.com

How to Monitor Humans?

...and super humans

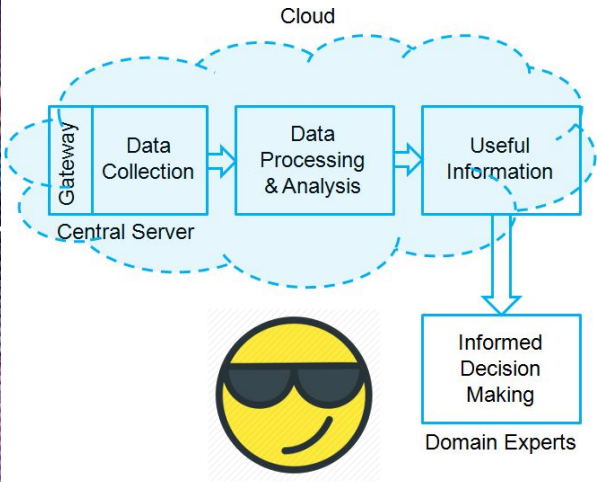


Image source:

Image source: dailymail.co.uk

Download my App and allow me to monitor you!

Special discount on placing order from our app!

Download my app and get discount on your first transaction!

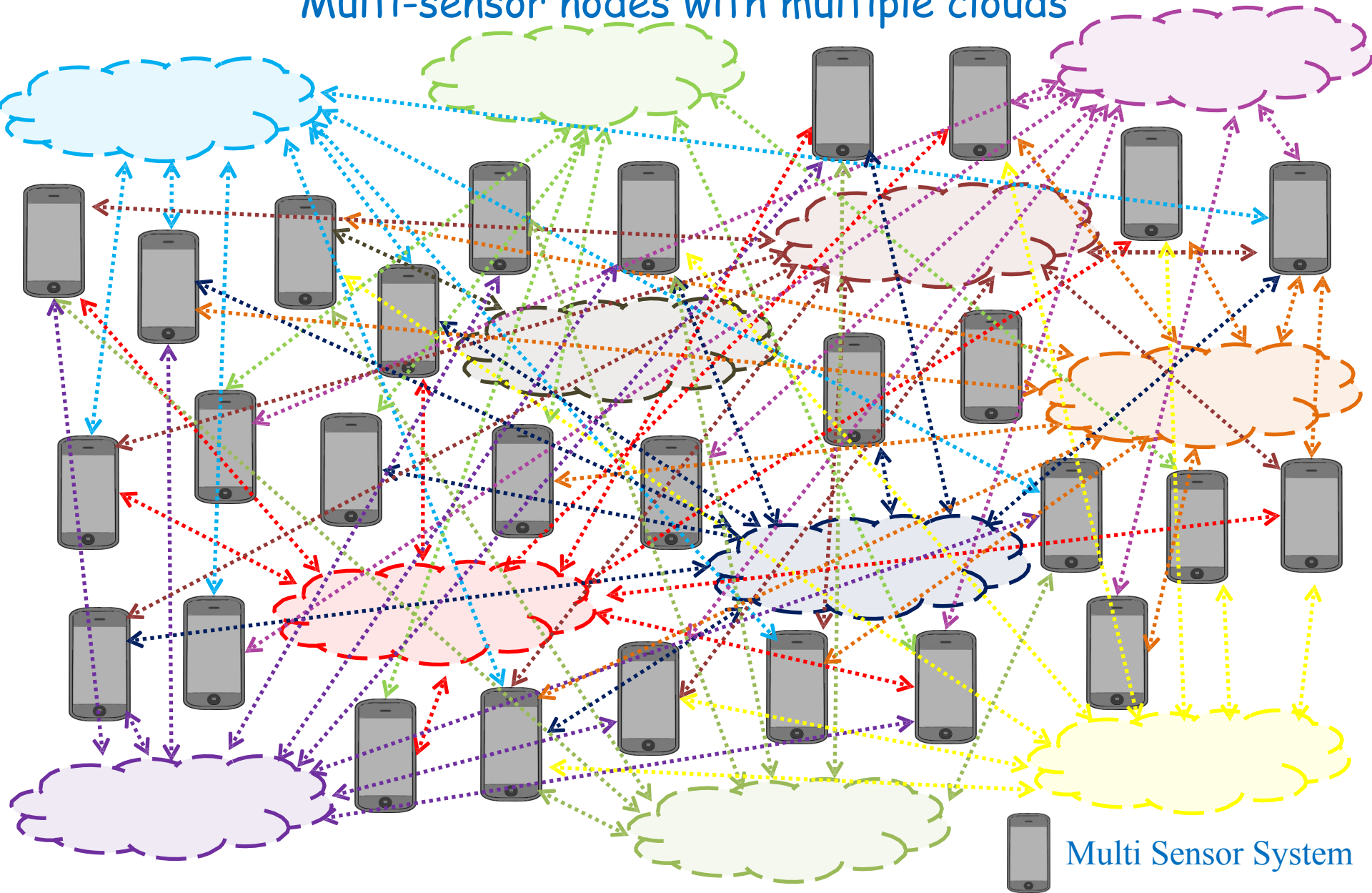
Download my app. Forever free services!

Download my app. Please…

Image source: igdigital.com

A Gigantic IoT System

Multi-sensor nodes with multiple clouds



Discussion

- What is the cost which user pays for hosting "active" App
  - Tangible cost?
  - Intangible cost?
- Demo of IoT Dashboard

http://mesh-systems.com/interactive-demo

Thank You

Understanding Economics of an "active" App

Q: Compute the per annum power cost of hosting an "active" App. Given following

- Battery capacity of a smartphone: 3000 mAH
- Typical battery terminal voltage: 3.7V
- Completely charged battery lasts for 1.5 days
- Efficiency of a battery charger: 80%
- Assumption: An "active" App consumes 2% of total phone's power
- Power rate: Rs 6 per KWH

Further Readings

References:
1. Harvard IoT course (https://software.intel.com/en-us/articles/harvard-iot-course)
2. Internet of Things (https://ocw.cs.pub.ro/courses/iot) prepared by Alexandru Radovici and Alexandru Vaduva
3. IoT System by Amit Kr Gupta and Amey Karkare (IIT)