IoT Architecture

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CS698T, Lecture 2

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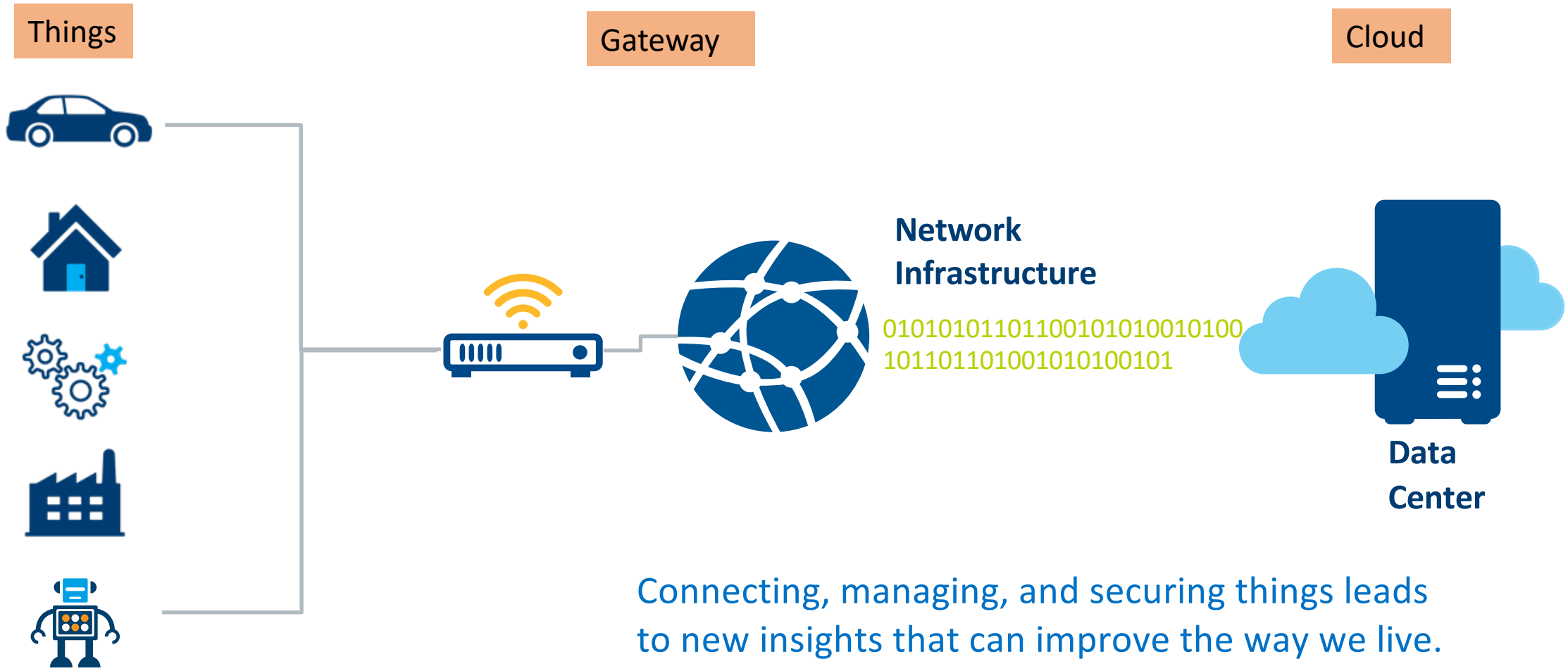
IoT Overview

83B devices will be connected to the Internet by **2024**[1]



Connecting, managing, and securing things leads to new insights that can improve the way we live.

1. https://www.saftbatteries.com/energizing-iot/how-iot-world-shaping-2021-and-what-trends-will-influence-future-iot-infographic

IoT Architecture – 3 Layered Approach

Application Layer

Network or Connectivity or Communication Layer

Perception or Physical Layer

Perception or Physical Layer

- Contains sensors, actuators and edge devices
  - Sensors – temperature, humidity, camera, light, hall effect, piezo-electric, sound, touch, soil moisture sensor, EEG sensor, ECG sensor, pulse oximeter
    - Transforms analog signal into digital signal using sensors
  - Actuators – stepper motor, electric motor, infusion pump, temperature valves
    - Transforms digital signals into analog forms using actuators
  - Edge devices – Arduino, Raspberry-pi, Edison
    - Connect to sensors/actuators
- Interacts with the environment to sense the surrounding, collect data and send it to the gateway

Network/Connectivity Layer

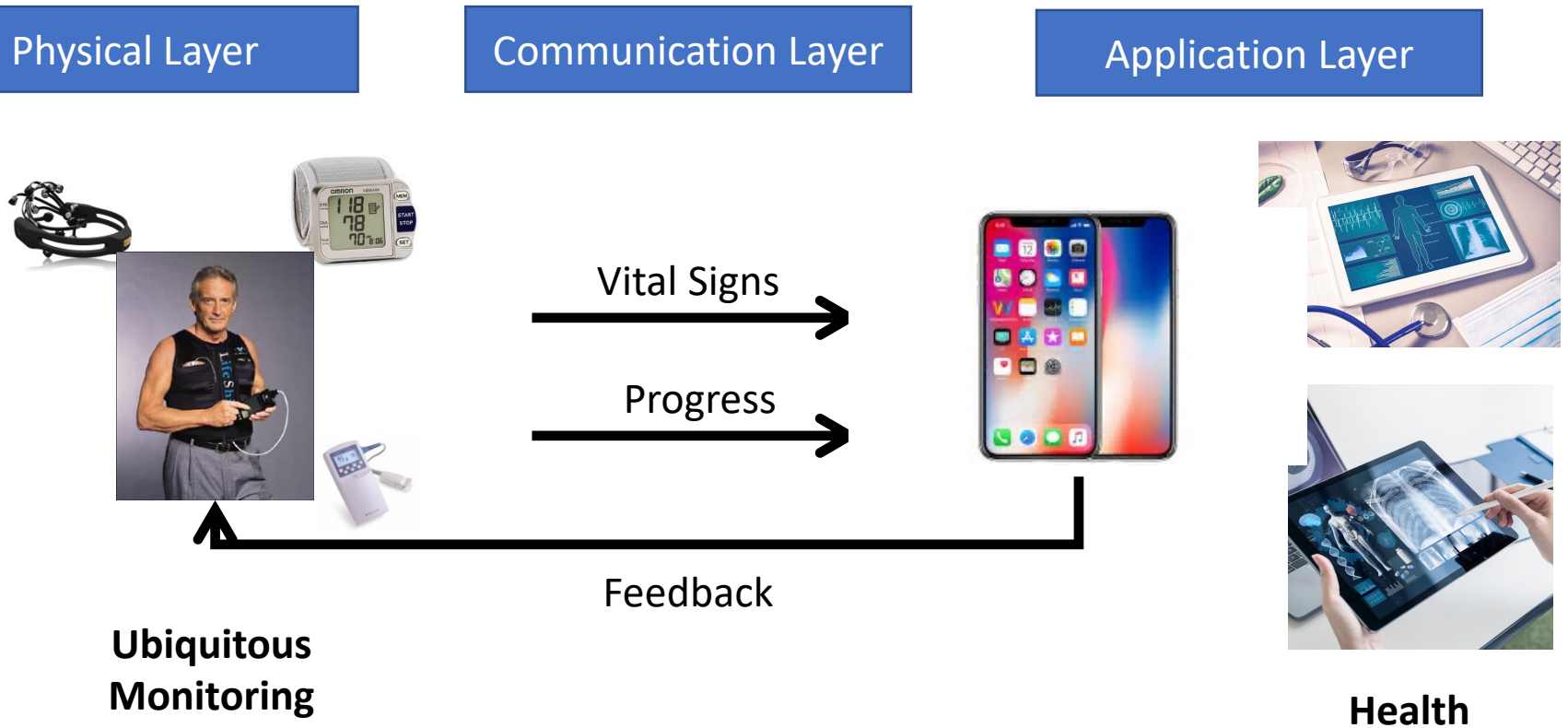
- Transmits the data collected by the perception layer to servers, gateways or cloud and vice versa
- Communication protocols
  - Wifi, ethernet, Bluetooth, Zigbee, LoRA, MQTT, Cellular networks,

Application Layer

- Provides API to monitor, analyze, visualize and control IoT systems (edge devices/gateways)
- Revolutionizes various vertical markets to address their business needs by supporting mobile applications, different use cases etc

IoT architecture – healthcare use case

- Care any place and any time



IoT Architecture – 5 Layered Approach

- Business Layer
- Application Layer
- Processing Layer
- Network or Connectivity or Communication Layer
- Perception or Physical Layer

Processing Layer

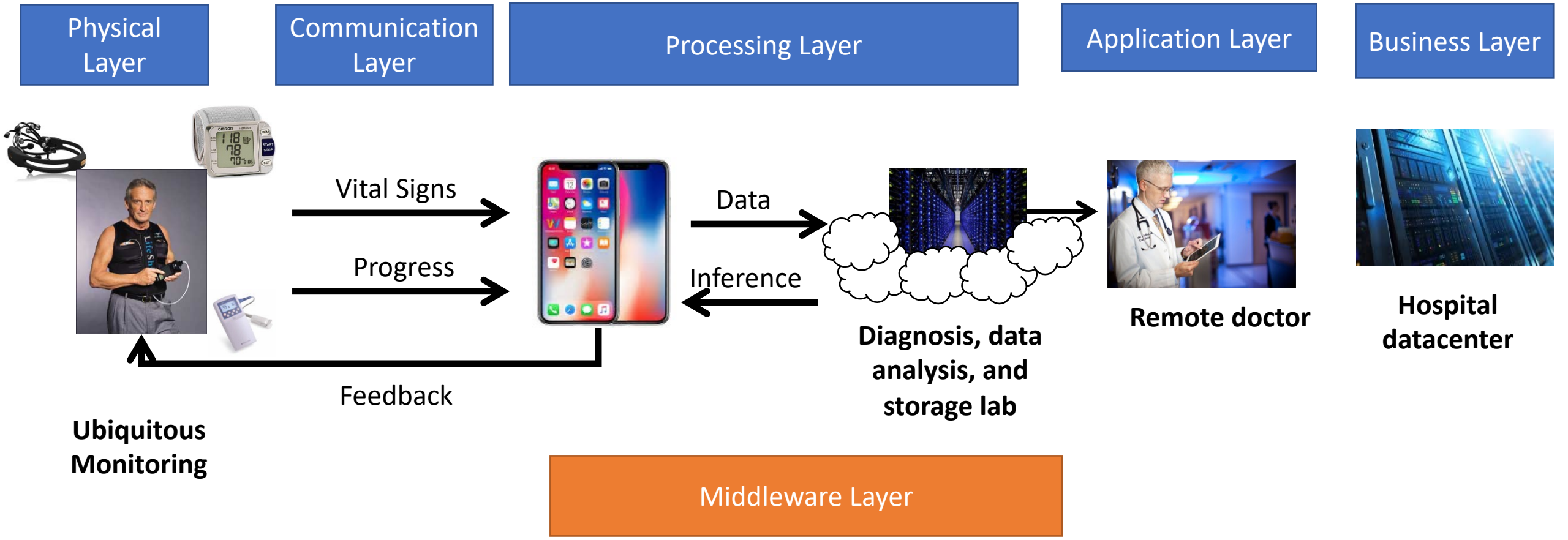
- A software that provides APIs to devices/sensors to connect to gateways
- Analyzes data collected from the perception layer to provide meaningful insights before it gets send to the cloud i.e. computation at the edge

Business Layer

- Uses data from previous layers to take business decisions such as increase in productivity or efficiency or profit
- Makes decisions by analyzing large data from various IoT systems or instances of IoT systems using machine learning techniques

IoT architecture – healthcare use case

- Care any place and any time



Middleware Layer

- A software that provides APIs to devices/sensors to connect to gateways and vice versa irrespective of the mode of communication
- Creates an abstraction of the hardware for ease of programming
- Establishes communication with low level hardware as well as cloud
- Device discovery and management
- Scalability
- Big data and analytics
- Security and Privacy
- Context detection

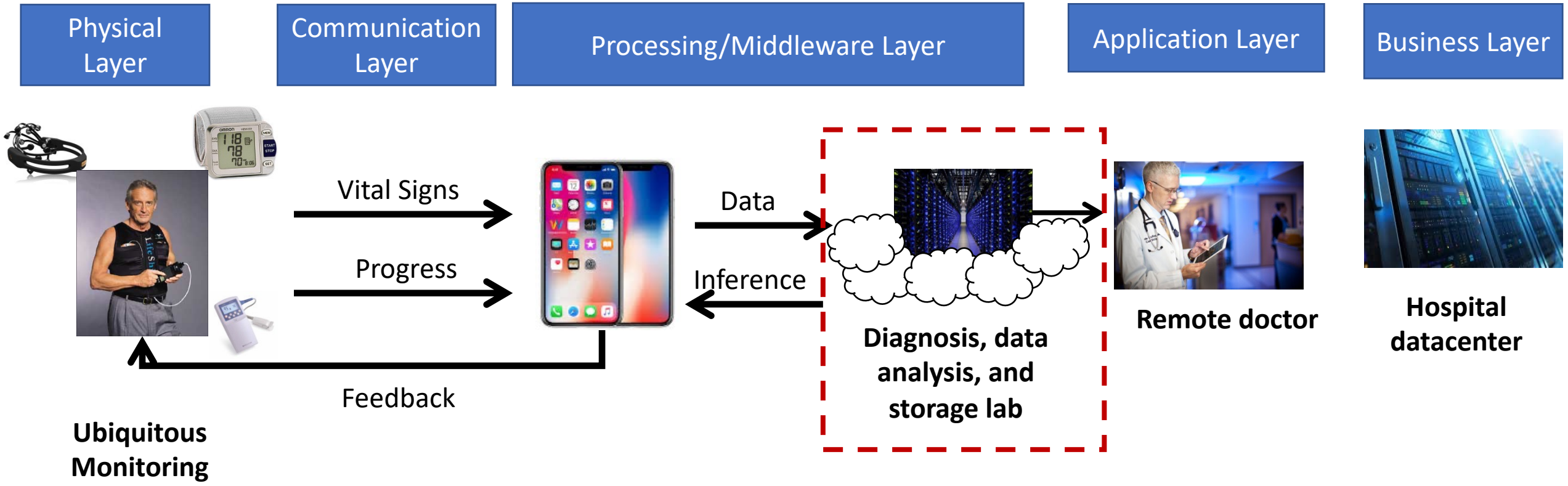
Middleware Layer

- Middleware Classification
  - Event based – e.g. publish/subscribe architecture
  - Service oriented – HYDRA[1] - supports dynamic configuration and self-management
  - Database oriented – considers IoT device network as virtual relational database
  - Semantic – supports various communication protocols
  - Application specific – Trustworthy data manager for healthcare devices, TDM[2]

1. Eisenhauer, Markus, Peter Rosengren, and Pablo Antolin. "Hydra: A development platform for integrating wireless devices and sensors into ambient intelligence systems." In *The Internet of Things*, pp. 367-373. Springer, New York, NY, 2010.
2. Bagade, Priyanka, Ayan Banerjee, and Sandeep KS Gupta. "Rapid evidence-based development of mobile medical iot apps." In *2016 IEEE International Conference on Pervasive Computing and Communication Workshops (PerCom Workshops)*, pp. 1-6. IEEE, 2016.

IoT cloud centric architecture – healthcare use case

- Care any place and any time

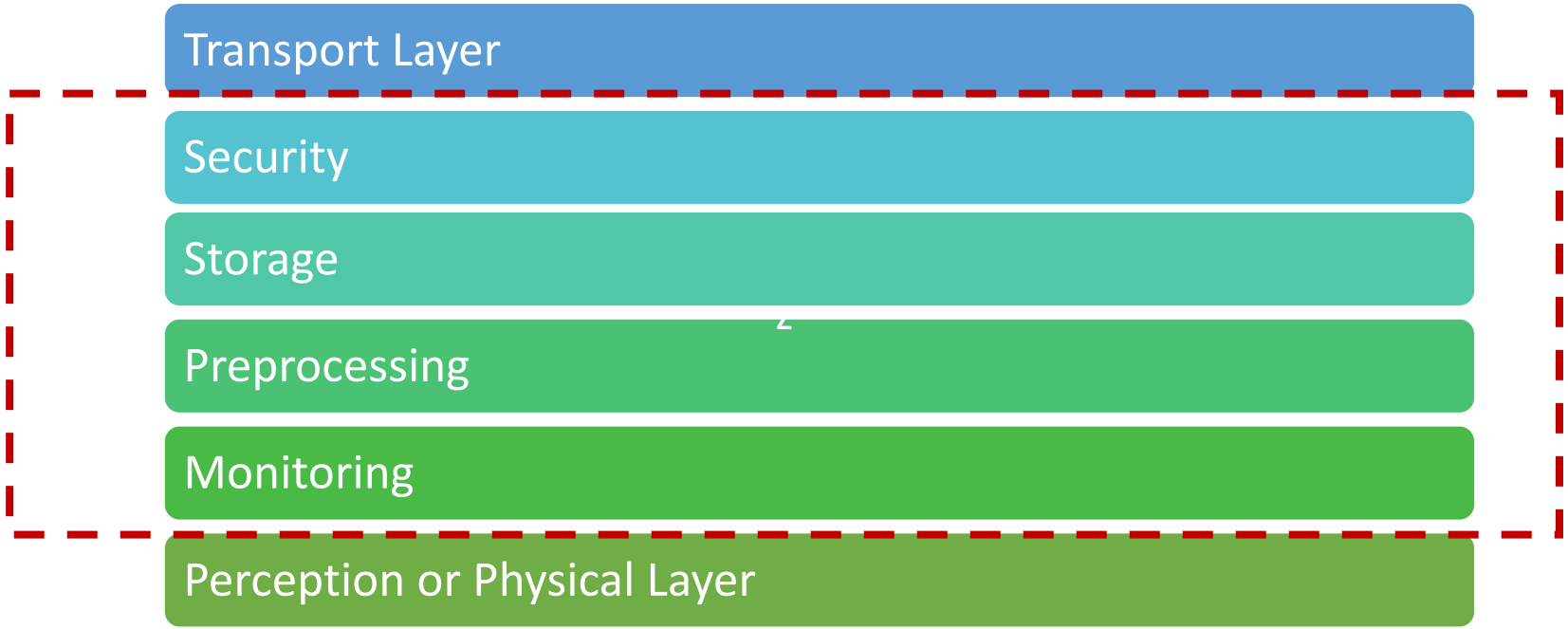


Fog Computing

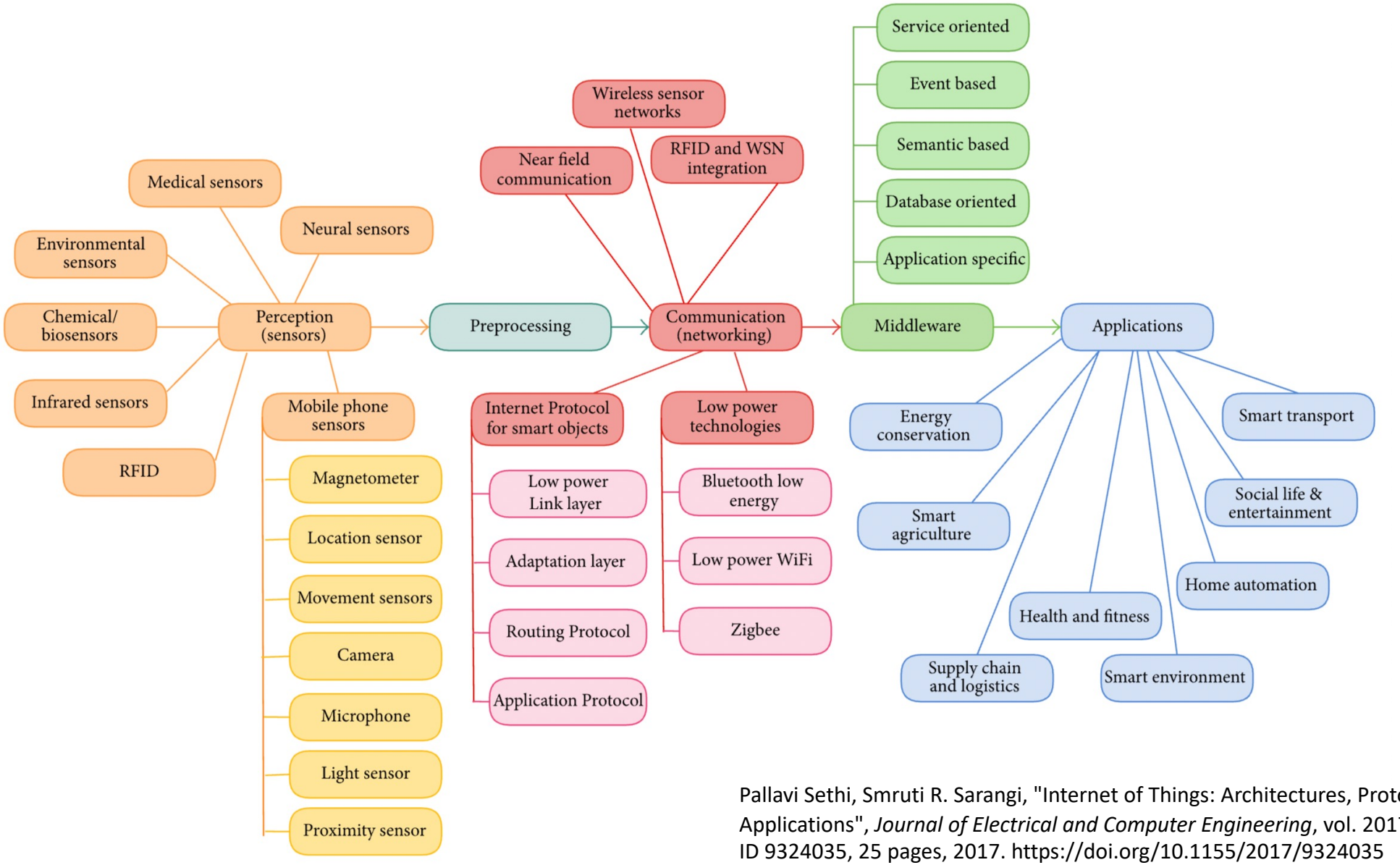
- Also known as edge computing.
- Challenges with communicating and processing data on the cloud
  - Mobility – network connection interruptions
  - Reliable and real time actuation - data latency
  - Scalability – more device, more latency
  - Power constraints – small IoT devices

Fog Computing

- Collects, analyzes and stores data from the perception layer before sending it to the cloud
- Same as computing on the smartphone in our current healthcare example



IoT Taxonomy



Pallavi Sethi, Smruti R. Sarangi, "Internet of Things: Architectures, Protocols, and Applications", *Journal of Electrical and Computer Engineering*, vol. 2017, Article ID 9324035, 25 pages, 2017. https://doi.org/10.1155/2017/9324035

Reading Material

- Pallavi Sethi, Smruti R. Sarangi, "Internet of Things: Architectures, Protocols, and Applications", *Journal of Electrical and Computer Engineering*, vol. 2017, Article ID 9324035, 25 pages, 2017. https://doi.org/10.1155/2017/9324035
- Kumar, Nallapaneni Manoj, and Pradeep Kumar Mallick. "The Internet of Things: Insights into the building blocks, component interactions, and architecture layers." *Procedia computer science* 132 (2018): 109-117.

Questions?