Rangkaian IoT

W3 – Interactions - Reza Diharja, S.Si., M.T.

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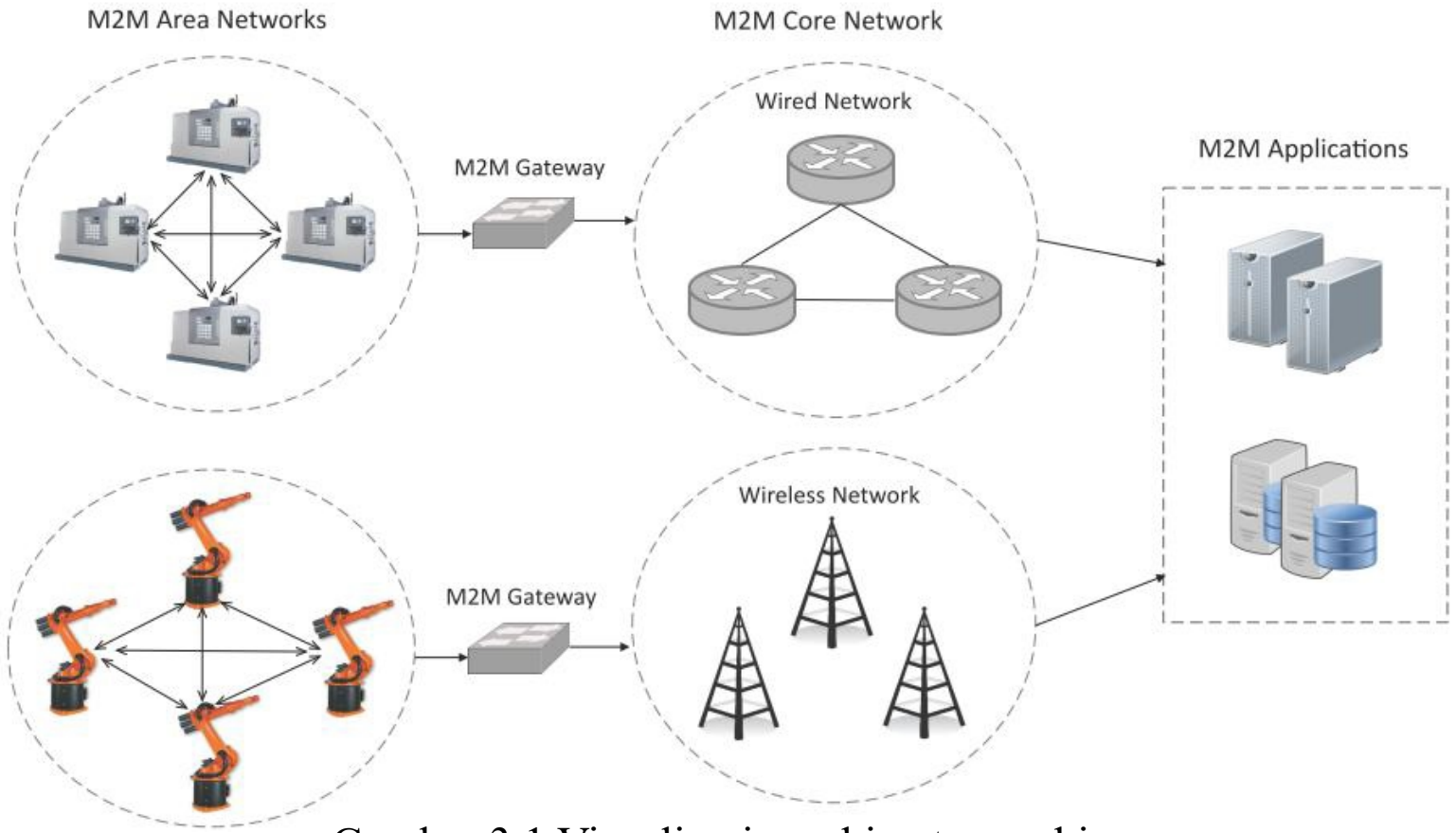
Machine to machine (M2M)

IoT is not a construct that has appeared suddenly or without precursors. Technological forerunners and various conceptualizations exist prior to the relatively new "IoT" label, for example, machine-to-machine (M2M) communications.

- *M2M communications refers to direct wired or wireless communication between devices using any communications channel that does not necessarily require direct human intervention.*
- *M2M communication can include industrial production facilities, enabling a sensor or meter to communicate the data that it records to application software that can further process them.*

- ***IoT accommodates*** *the same devices/ assets/machines as M2M applications, but also very small (low-power), personal, and inexpensive devices with sometimes very limited functionality that might not be able to justify a dedicated M2M hardware module.*
- ***Traditional M2M*** *solutions typically rely on point-to-point communications using embedded hardware modules and dedicated protocols.*
- *In contrast,* ***IoT solutions depend predominantly on IP-based networks*** *to interface device data to a cloud or middle ware platform primarily using common/open protocols.*

Machine-to-Machine (M2M) refers to networking of machines (or devices) for the purpose of remote monitoring and control and data exchange.



Gambar 3.1 Visualisasi machine to machine

- *An M2M area network comprises of machines (or M2M nodes) which have embedded hardware modules for sensing, actuation and communication. Various communication protocols can be used for M2M local area networks such as ZigBee, Bluetooh, ModBus, M-Bus, Wirless M-Bus, Power Line Communication (PLC), 6LoWPAN, IEEE 802.15.4, etc.*
- *The communication network provides connectivity to remote M2M area networks.*
- *The communication network can use either wired or wireless networks (Ipbased).*
- *While the M2M area networks use either proprietary or non-IP based communication protocols, the communication network uses IP-based networks.*

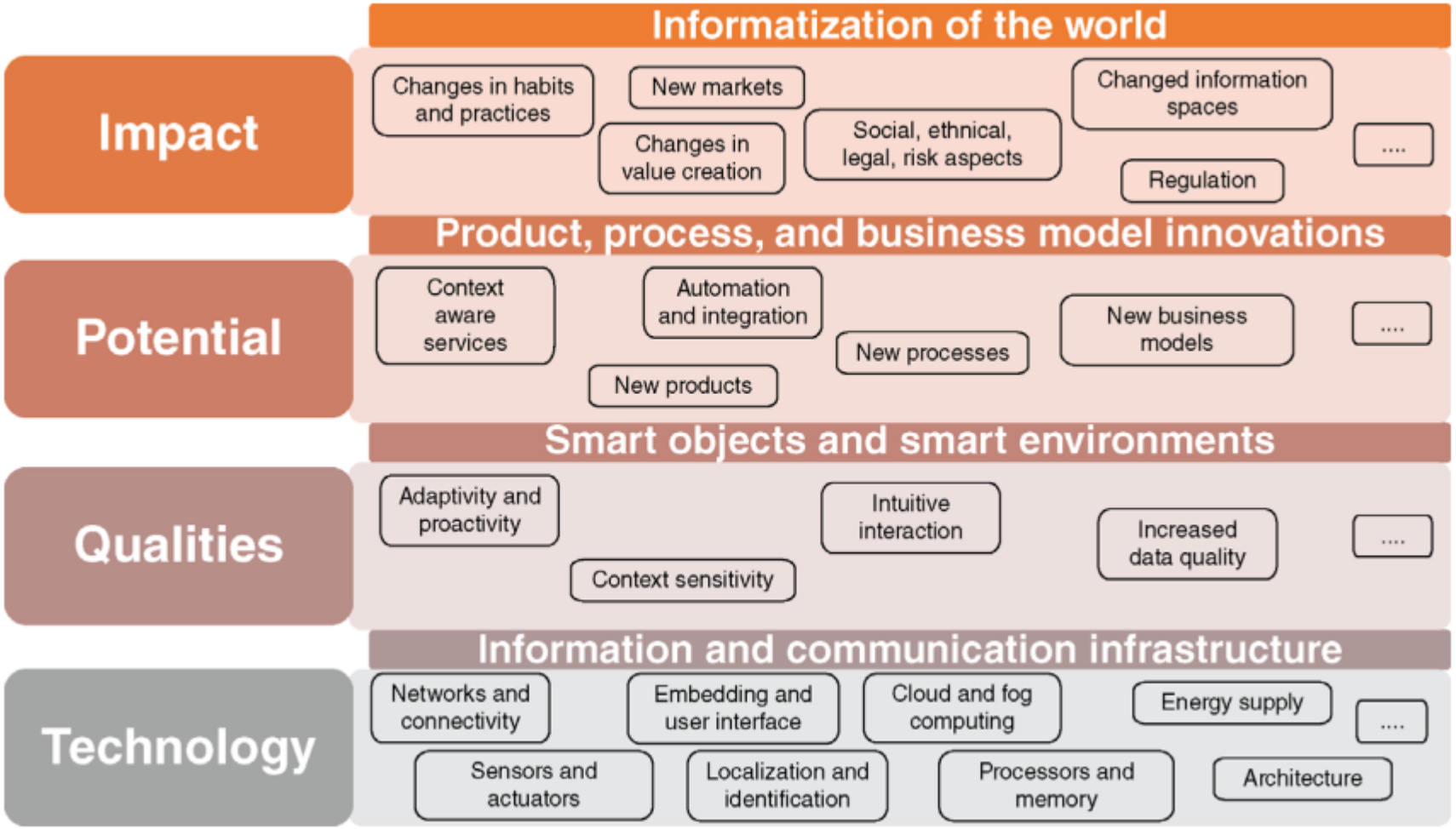
Industrial Internet and Industry 4.0

A broad segmentation of IoT comprises:

1. ***A consumer-oriented perspective**, including smart phones, connected automobiles, smart TVs, and wearables;*
2. ***An industrial perspective**. The latter includes, for example, power grids and power plants, transportation, wind turbines, and industrial equipment.*

The straightforward analogy is to translate objects within an industrial (production) context into smart objects. Production facilities, such as tools, conveyors, and even the products to be manipulated or built will become smart objects as conceptually defined.

Internet of Things Framework



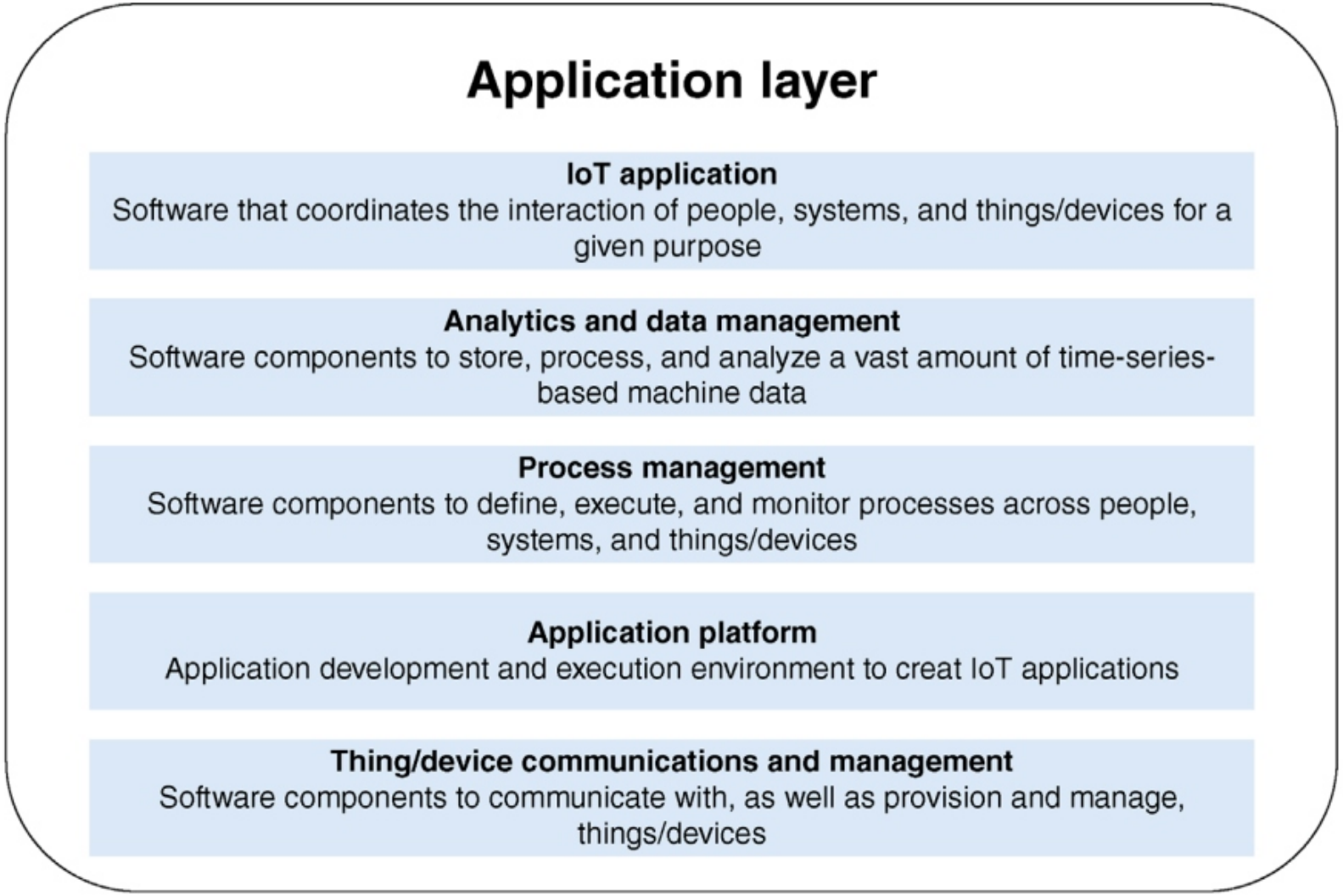
Gambar 3.2 Framework Internet of Things

Infrastructure and Communication Technology

- *The layer "Technology" describes the building blocks of an information and communication technology (ICT) infrastructure for the computerization of the (everyday) world.*
- *These building blocks include multiple software and hardware components, as well as highly developed and novel technologies;*
- *They are used to connect virtual information about or from things to the physical real world;*
- *These include technologies for computing, storage, embedding, and mobile and wireless networking, as well as sensors and actuators.*

The building blocks of the technology layer, which are a foundational dimension of IoT in the next slides.

Architecture and Reference Models



Connectivity layer

Network communication
Protocols that enable communication between things/devices, backbone infrastructure, and/or the cloud

Things/device layer

Thing/device Software
Embedded software that runs on the physical thing to manage and operate its functionality

IoT components
Embedded sensors, actuators, processors, and connectivity ports/antennas

Thing/device hardware
Core hardware components

Networks and Connectivity

- *Network technologies connect objects that are equipped with information technology, and can be located in different locations. A large number of network technologies are available for this purpose, depending on the application.*
- *An application-related distinction feature is the scaling of the range. It ranges from global networks (satellites) over regional and local networks to so-called personal, body, and intra body area networks.*
- *In contrast to PCs, smartphones, and similar devices, loT devices are normally constrained regarding memory space, access to a continuous power supply, and processing capacity.*

Table 3.1 Examples for IoT reference architectures

Reference model	Founders	Latest release	IoT domain(s)	Viewpoints[a)]	Brief description
Internet of Things—Architecture (IoT-A)	NEC, CFR, ALBLF, SAP UniS, HEU, HSG, CEA, SIEMENS, ALUBE, FhG IML, and CATTID,	July 2012	Any	Functional and information	The "Internet of Things Architecture" (IoT-A) is an EU project. Based on a system requirement process, the outcomes cover a detailed architecture including the definition of a range of key components. It centers on a functional and an information perspective. http://www.meet-iot.eu/deliverables-IOTA/D1_3.pdf
Industrial Internet Reference Architecture (IIRA)	AT&T, Cisco, General Electric, IBM, and Intel	January 2017	Manufacturing	Business, usage, implementation, and functional	The IIRA is a standards-based architectural template and methodology. It is meant to enable Industrial Internet of Things system architects to design their own systems based on a common framework and concepts. http://www.iiconsortium.org/IIC_PUB_G1_V1.80_2017-01-31.pdf
Reference Architecture Model Industrie 4.0 (RAMI 4.0)	The German Electrical and Electronic Manufacturers' Association, and its partners	July 2015	Manufacturing and Logistics	Business, functional, information, communication, integration, asset, lifecycle/value chain, and hierarchy	The RAMI 4.0 is a reference architecture taking into account particularities of Industrie 4.0/smart factories, which started in Germany and today is driven by all major companies and foundations in a large number of industry sectors. The RAMI 4.0 consists of a three-dimensional coordinate system that describes aspects of Industrie 4.0. www.zvei.org/en/association/specialist-divisions/automation/Pages/default.aspx
Cisco's Internet of Things Reference Model	Cisco	June 2014 (Draft)	Any	Any	The proposed IoT reference model is comprised of seven levels standardizing the concept and terminology surrounding IoT. From physical devices and controllers at level 1 to the collaboration and processes at level 7, the reference model sets out the functionalities required and concerns. http://cdn.iotwf.com/resources/71/IoT_Reference_Model_White_Paper_June_4_2014.pdf

Table 3.2 Overview of communication technologies and standards for IoT

Bluetooth BLE	2.4 GHz	1–100 m >100 m	Headsets, wearables, sports and fitness, health care, proximity, automotive	IEEE 802.15.1[a)] Bluetooth SIG [b)]
EnOcean	315 MHz, 868 MHz, 902 MHz	300 m outdoor, 30 m indoors	Monitoring and control systems, building automation, transportation, logistics	ISO/IEC 14543-3-10[c)]
GSM, LTE, LTE-M	Europe: 900 MHz and 1.8 GHz, USA: 1.9 GHz and 850 MHz		Mobile phones, asset tracking, smart meters, M2M	3GPP[d)]
6LoWPAN	2.4 GHz	10–30 m	Automation and entertainment applications in home, office, and factory environments	Adaption layer for Ipv6 over IEEE802.15.4[e)]
LoRa	Sub 1 GHz ISM band	2–5 km urban; 15 km suburban; 45 km rural	Smart city, long-range M2M	LoRaWAN[f)]
NB-IoT (narrow-band-IoT)	700–900 MHz	10–15 km rural deep indoor penetration	Smart meters, event detectors, smart cities, smart homes, industrial monitoring	3GPP LTE Release 13[g)]
NFC	13.56 MHz	Under 0.2 m	Smart wallets, smart cards, action tags, access control	ISO/IEC 18092[h)] ISO/IEC 14443-2,-3,-4[i)]
NWave	Sub 1 GHz ISM band	Up to 10 km	Agriculture, smart cities, smart meters, logistics, environmental	Weightless[j)]
RFID	120–150 kHz (LF), 13.56 MHz (HF), 2450–5800 MHz (microwave), 3.1–10 GHz (microwave)	10 cm to 200 m	Road tolls, building access, inventory, goods tracking	ISO 18000[k)]

DASH7	433 MHz (UHF), 865–868 MHz (Europe), 902–928 MHz (North America) UHF	0–5 km	Building automation, smart energy, smart city logistics	
SigFox[l)]	900 MHz	3–10 km urban 30–50 km rural	Smart meters, remote monitoring, security	
Weightless	470–790 MHz	Up to 10 km	Smart meters, traffic sensors, industrial monitoring	Weightless[m)]
Wi-Fi	2.4 GHz, 3.6 GHz, 4.9–5 GHz	Up to 100 m	Routers, tablets, smartphones, laptops	IEEE 802.11[n)]
Z-Wave	ISM band 865–926 MHz	100 m	Monitoring and control for homes and light commercial environments	Z-Wave[o)]; recommendation ITU G.9959[p)]
ZigBee	2.4 GHz; 784 MHz in China, 868 MHz in Europe, and 915 MHz in USA and Australia	10–20 m	Home and building automation, WSN, industrial control	IEEE 802.15.4[q)]

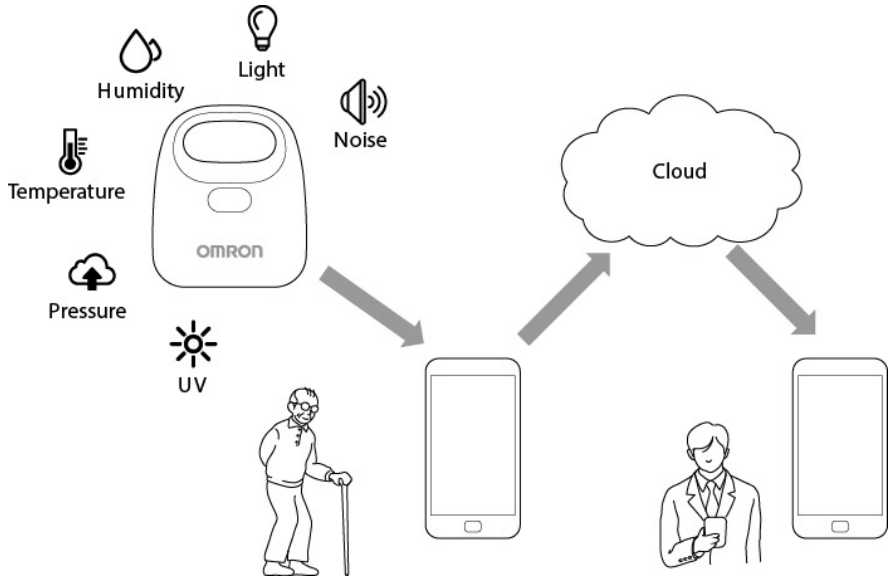
Sensors and Actuators in the IoT World

- *Sensors are technical components for the qualitative or quantitative measurement of certain chemical or physical variables and properties, for example, temperature, light (intensity and color), acceleration, electricity, and so on.*
- *The recorded measured values are usually converted into electronic signals.*
- *When a sensor is employed together with a processor (controller), a power supply, and a unit for data transmission, this is referred to as a sensor node.*
- *A sensor node's primary function is to collect, preprocess, and transmit sensor data from its environment to other sensor nodes or a base station.*

- Examples of sensor categories include (Baras and Brito, 2017) the following:
  - Location: GPS, GLONASS, Galileo

  - Biometric: fingerprint, iris, face

  - Acoustic: microphone
  - Environmental: temperature, humidity, pressure
  - Motion: accelerometer, gyroscope



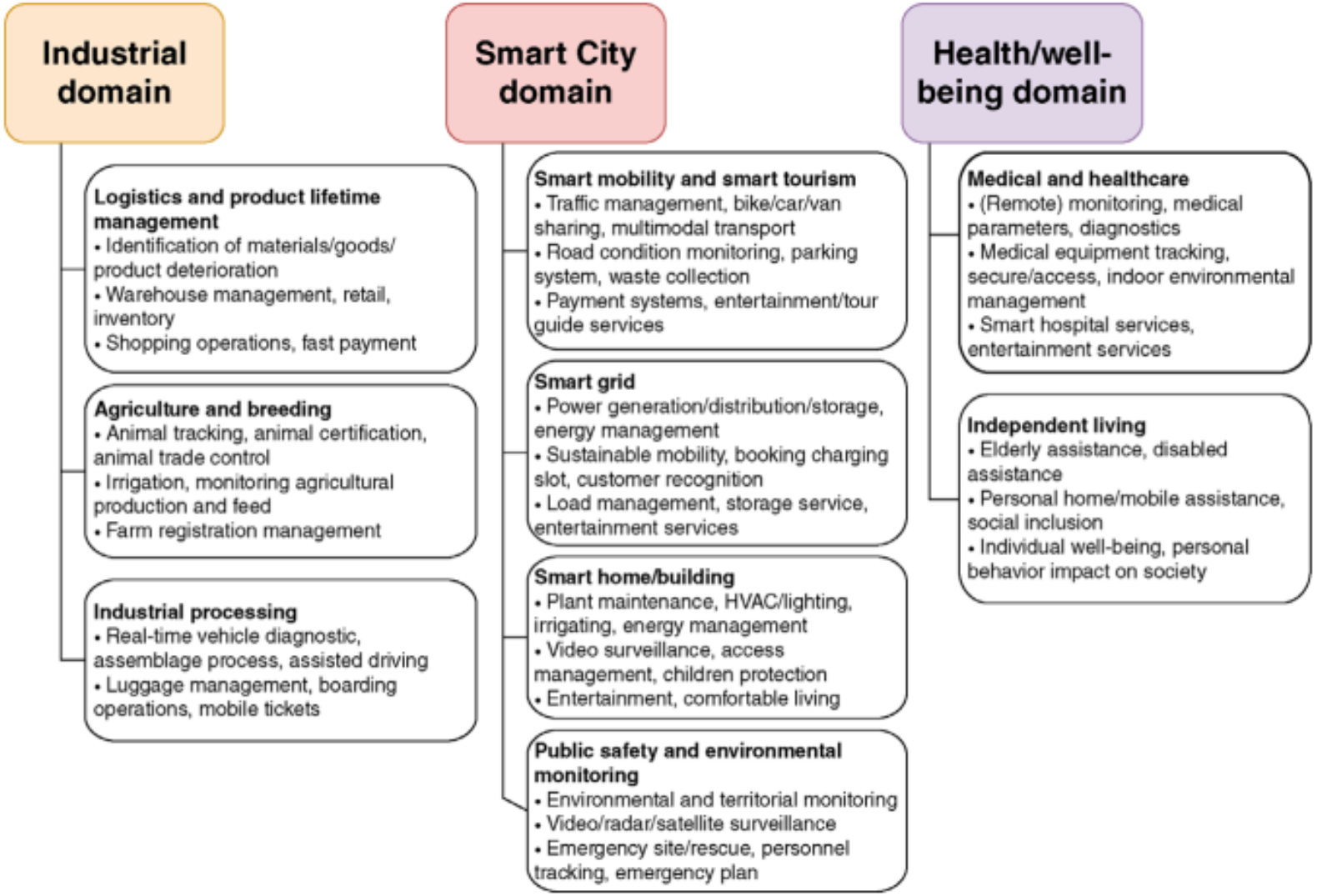
Actuators (Refresh)

- *Actuators convert electrical signals (e.g., commands emanating from the control computer) into mechanical motion or other physical variables (e.g., pressure or temperature), and thus actively intervene with the control system and/or set variables.*
- *In the field of measurement and control engineering, actuators are the signal-related counterparts to sensors.*
- ***Types of actuators include hydraulic, pneumatic, electric, mechanical, and piezoelectric**. They convert signals or setting and regulation specifications of a control into (mostly) mechanical work.*

Cloud Computing and Fog Computing

- *In order to meet data management challenges, 32 cloud and fog computing are among the most important approaches to cope with IoT data management issues.*
- *Cloud computing is a concept in which computing performance, storage, software, and other services are provided as a group of virtualized resources over a network, primarily the Internet.*
- *In addition to this,* ***the "Cloud" of resources can be accessed at any time from any connected device and site****. In principle, Cloud computing achieves excellent results in terms of networking resources and storing and accessing data related to or derived from connected things.*
- *Cloud computing may possess some limitations—especially when millions of devices are to be handled in a time-critical manner.*

- *Fog computing, as a highly virtualized platform, provides computing, storage, and networking services between end devices and traditional cloud computing data centers that are typically, but not exclusively,* ***located at the edge of a network****.*
- *Focusing more on the "edge of the network," however, implies a number of characteristics that make fog computing a nontrivial extension of cloud computing.*
- *Fog computing is expected, for example,* ***to deal with widely distributed and mobile deployments in which very large numbers of nodes are involved****,* ***for example, fast-moving and large groups of vehicles along highways or large-scale sensor networks to monitor the environment.***
- *Since its conceptual inception just some years ago, fog computing has achieved remarkable interest in academia and industrial research.*



Gambar 3.3 IoT application domains and related applications.