HYBRID SIMULATION

Real application support

- The same applications that run on the real nodes can also run on the simulated nodes

Interaction with real nodes

- Real sensor nodes can participate in the simulation

Advantages

- Enables the use of real traffic from the sensor channel that is currently not well understood and the models are not yet mature
- Validate protocols and applications running on the real nodes by being able to test these applications in large networks
- Study the behavior of sensor network protocols and applications at scale

HYBRID SIMULATION CHALLENGES

Virtual Time Synchronization between ns and external entities

- done between ns and external processes

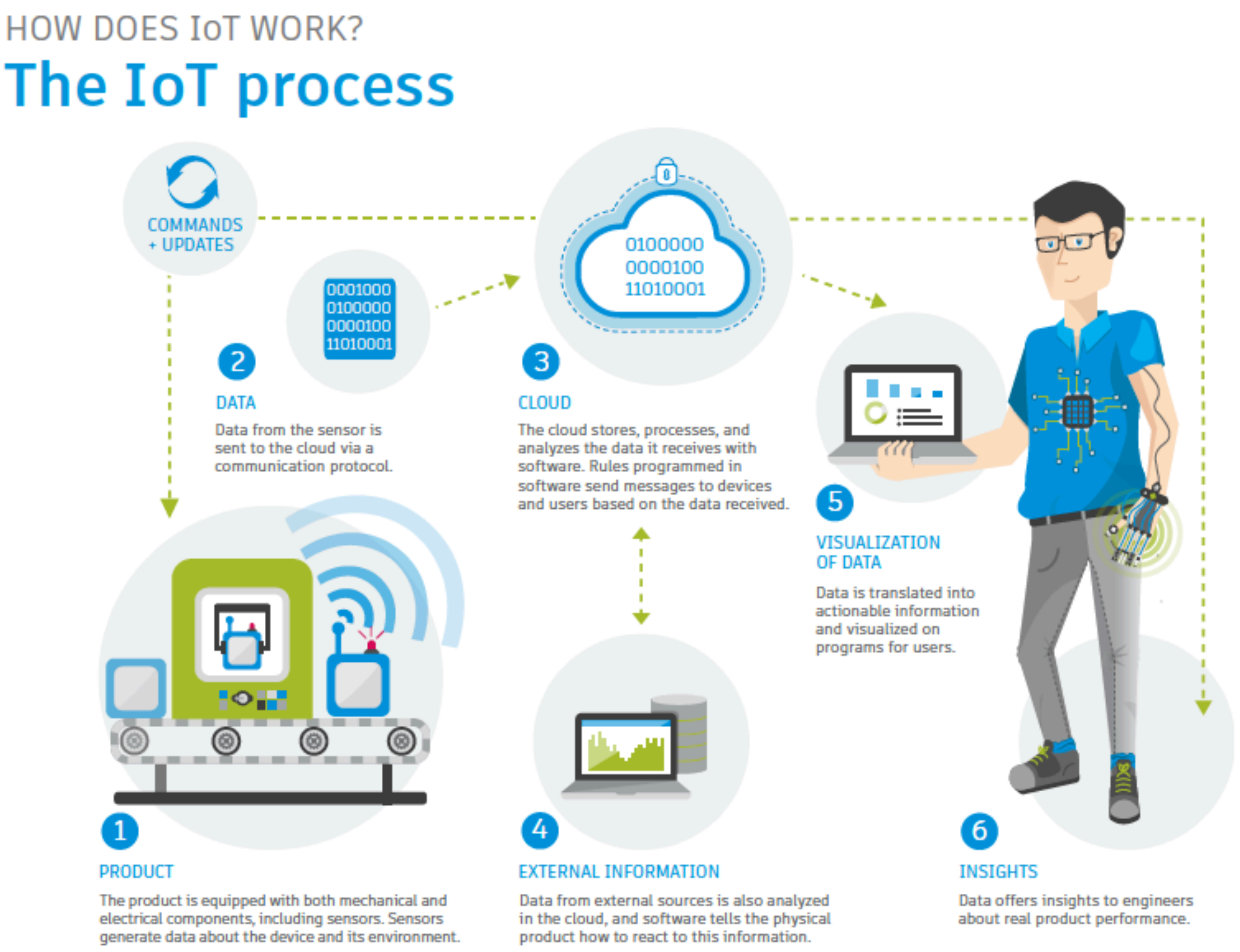
Real and Virtual Time Synchronization

Hybrid Modeling of Wireless Channel

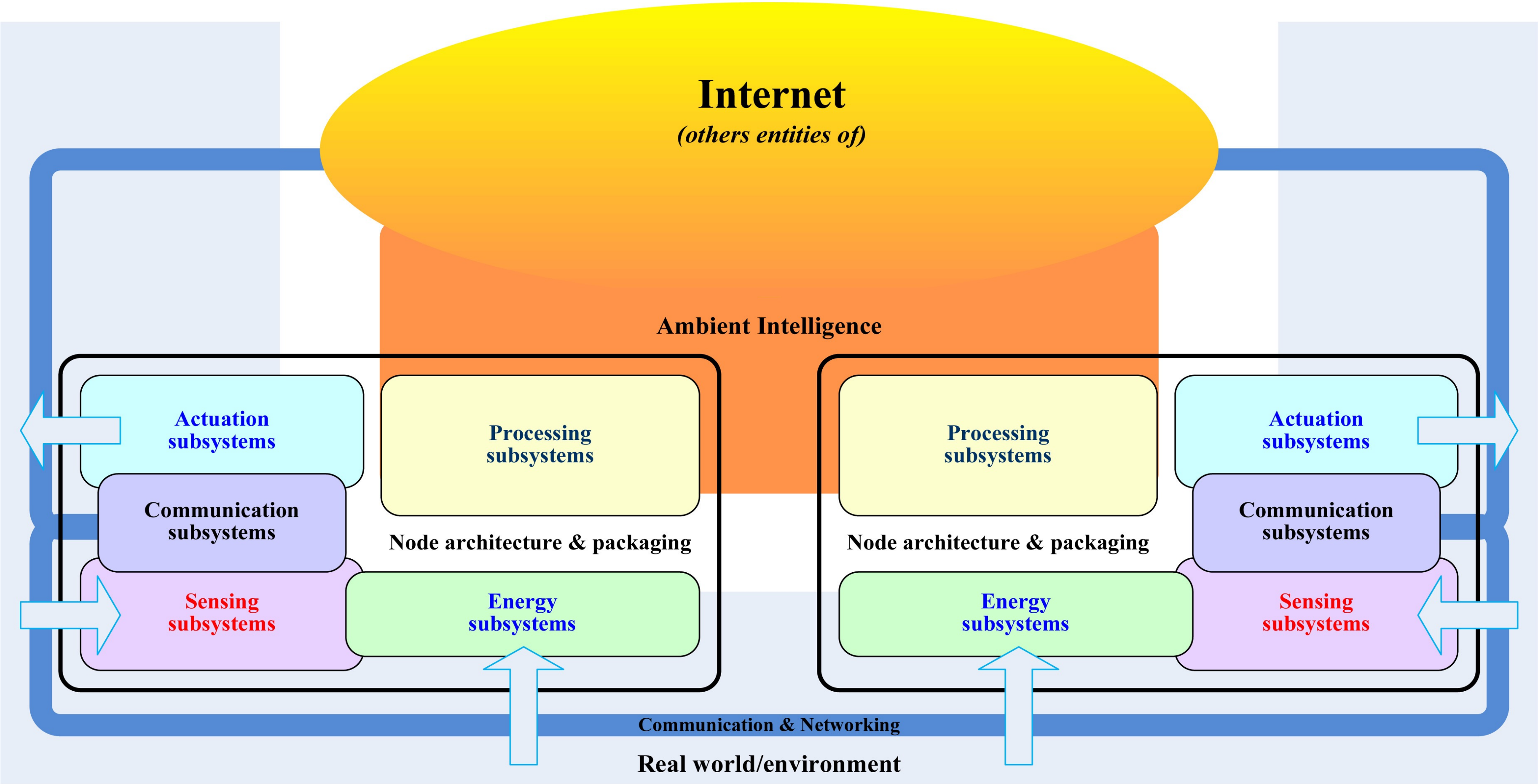
- collision between packets from real and virtual nodes
- Open Problem !

IOT: TECHNOLOGY, SYSTEM AND NETWORK

WORKING PRINCIPLE

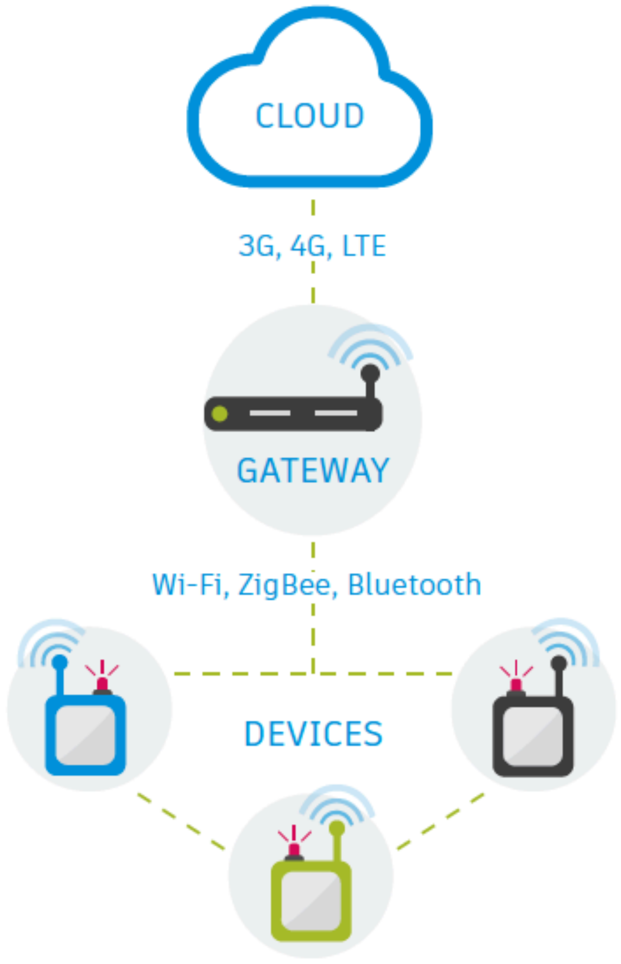


ABSTRACTION

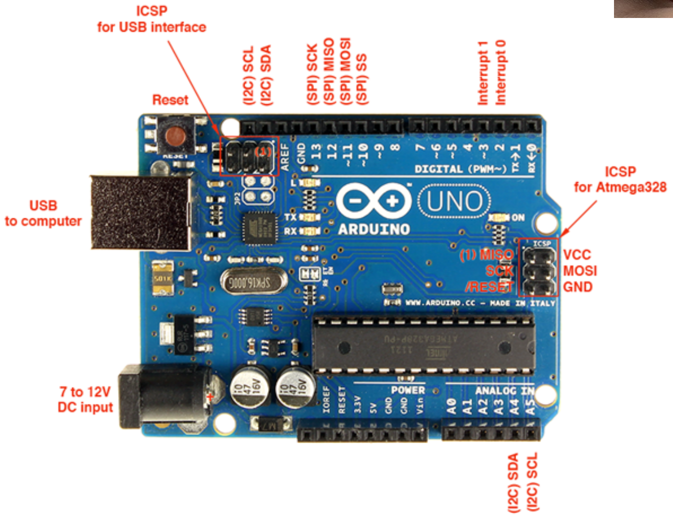


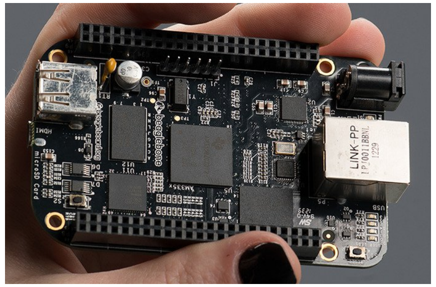
CONNECTIVITY

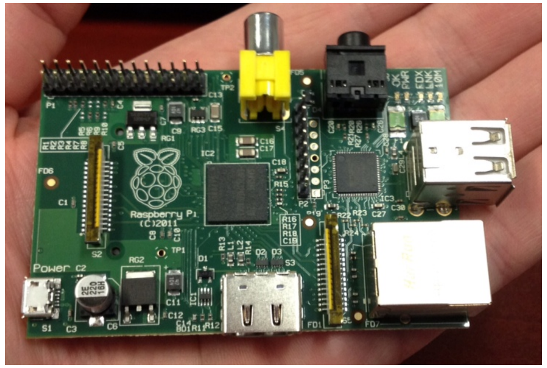
- Many communication technologies exist, this includes ones such as WiFi, Bluetooth, ZigBee and 2G/3G/4G cellular,
- but there are also several new emerging networking options such as Thread as an alternative for home automation applications, and Whitespace TV technologies being implemented in major cities for wider area IoT-based use cases.
- Depending on the application, factors such as range, data requirements, security and power demands and battery life will dictate the choice of one or some form of combination of technologies.

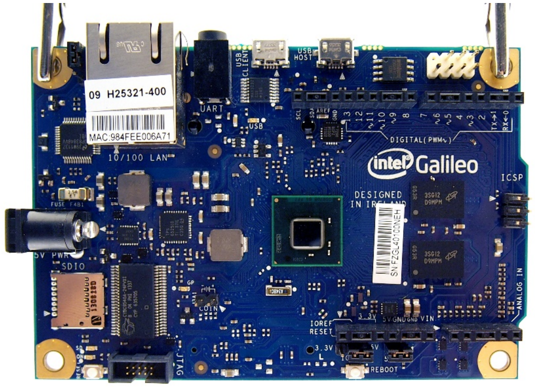


TECHNOLOGIES

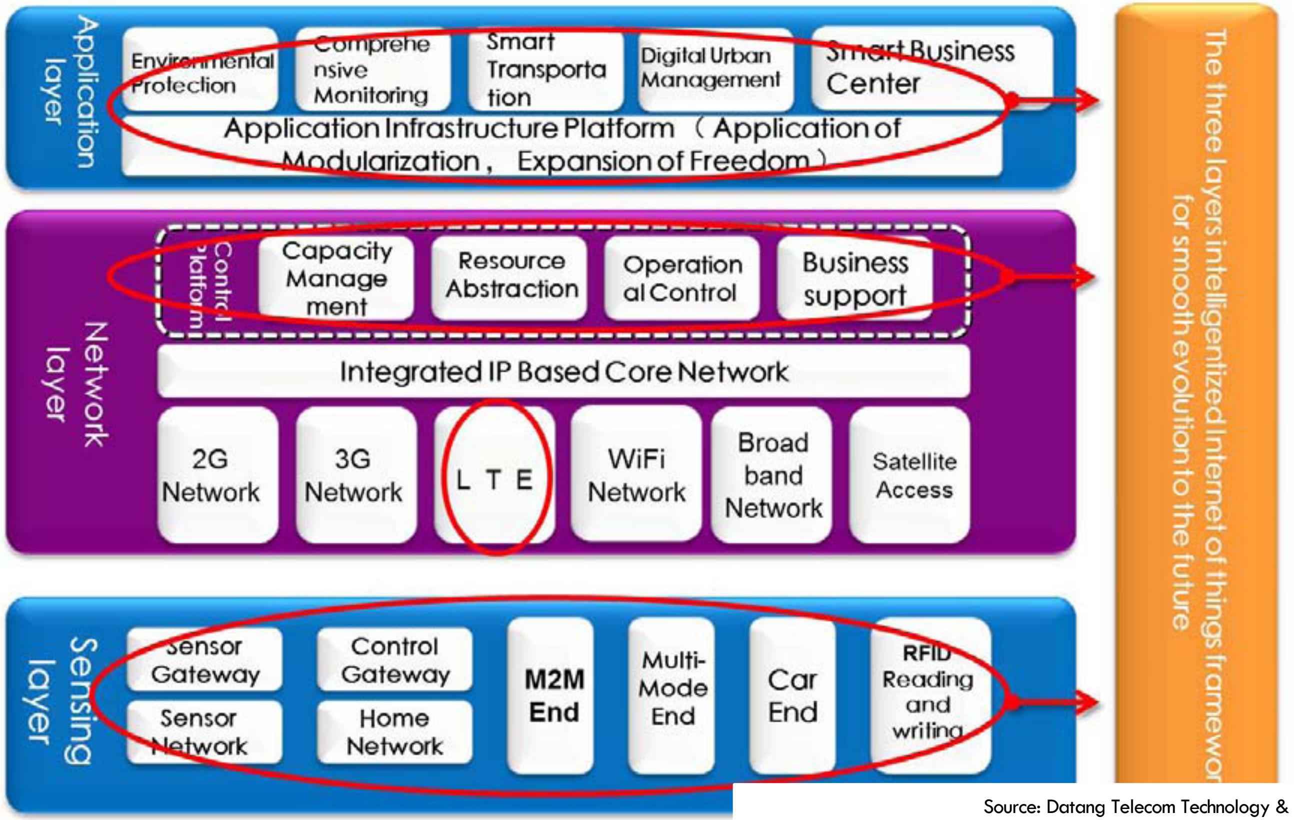






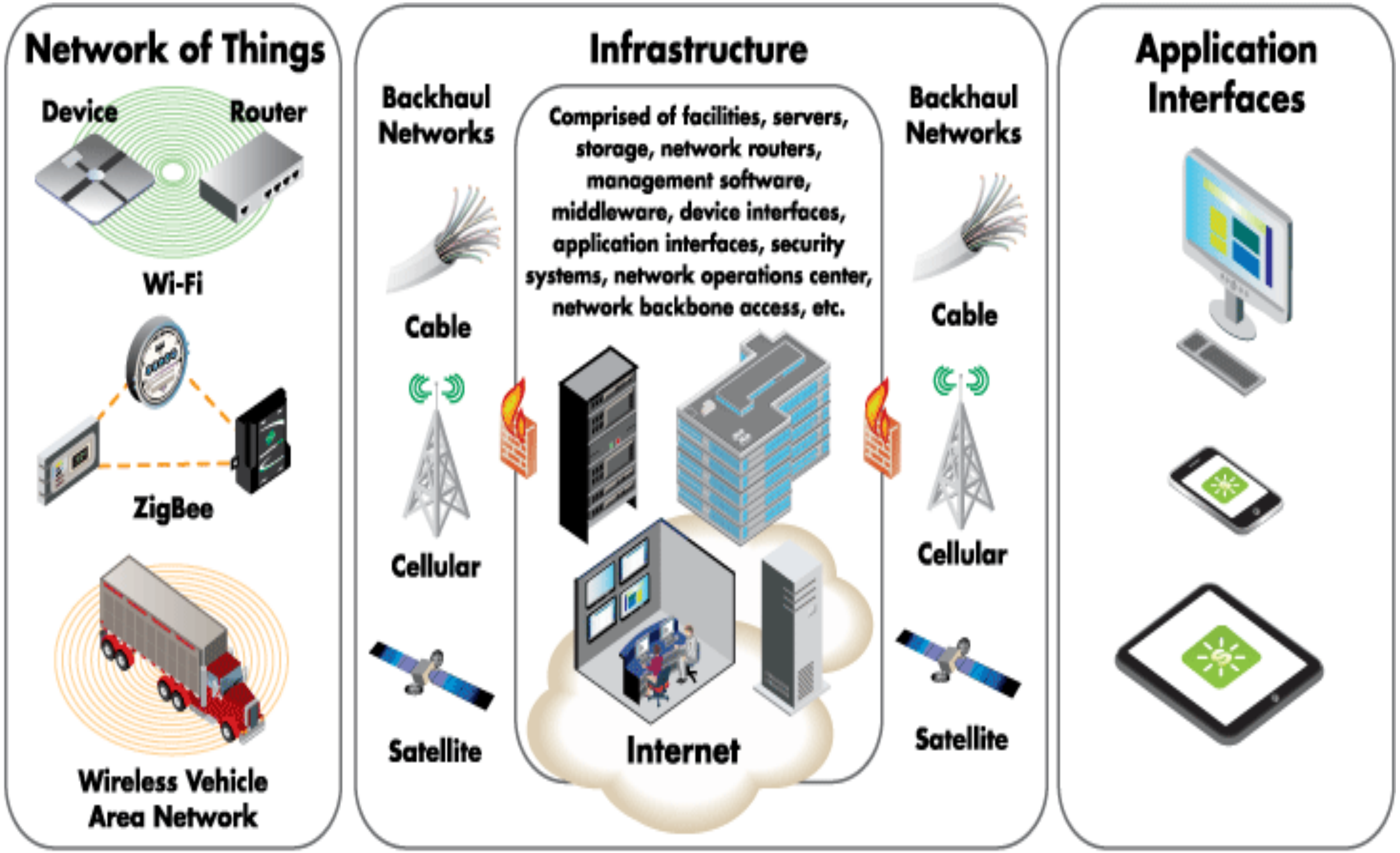


IOT ARCHITECTURE

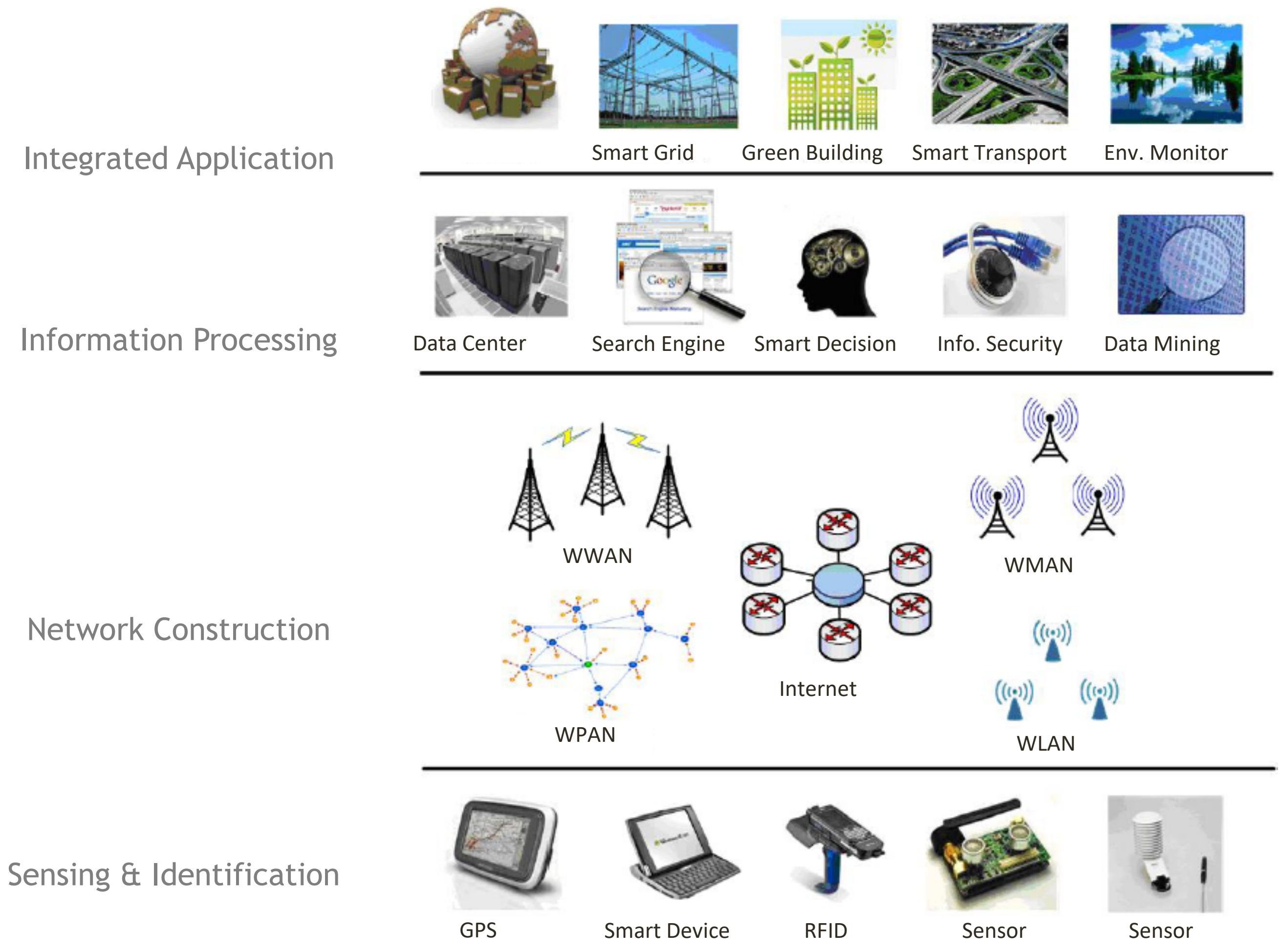


Source: Datang Telecom Technology & Industry Group

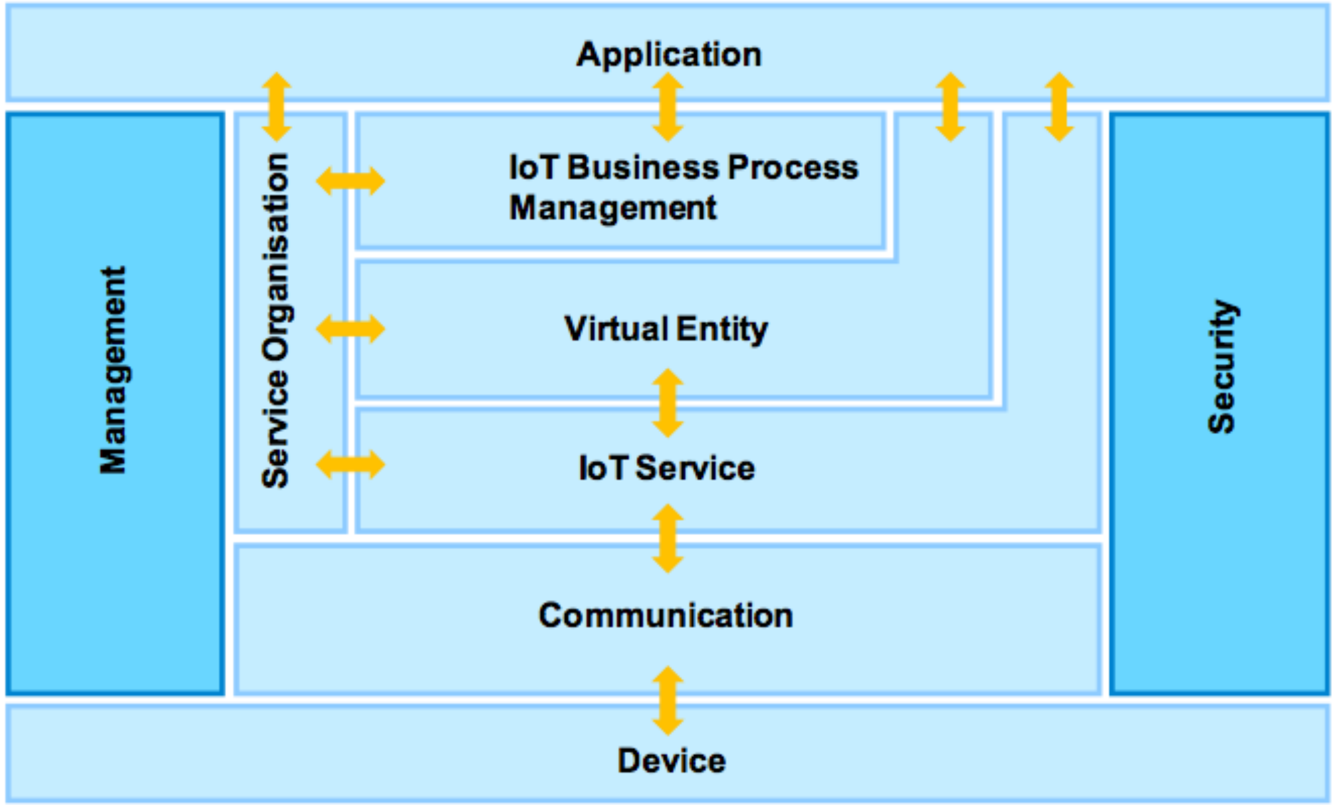
IOT ARCHITECTURE



IOT ARCHITECTURE

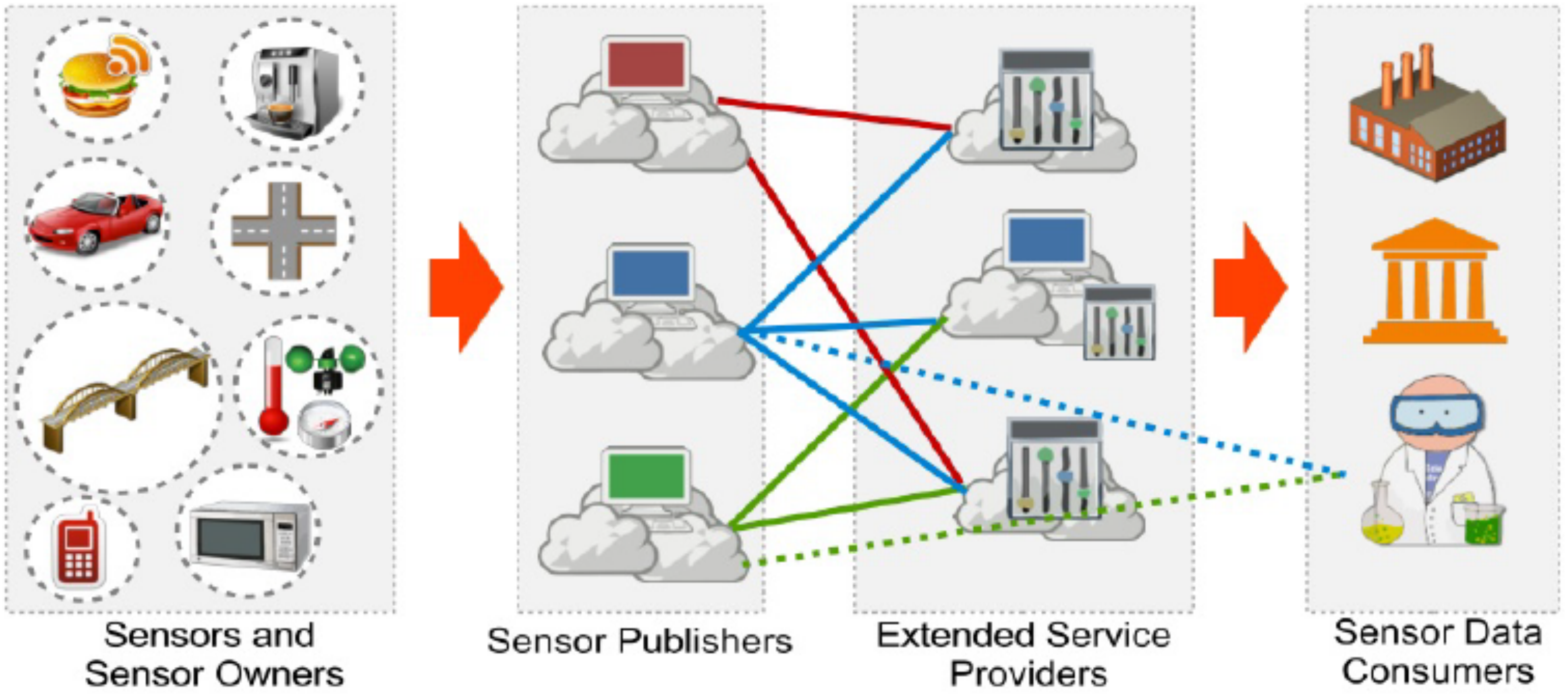


IOT ARCHITECTURE



Source: IoT-A

IOT TECHNOLOGIES : CLOUD (SENSING AS-A-SERVICE MODEL)



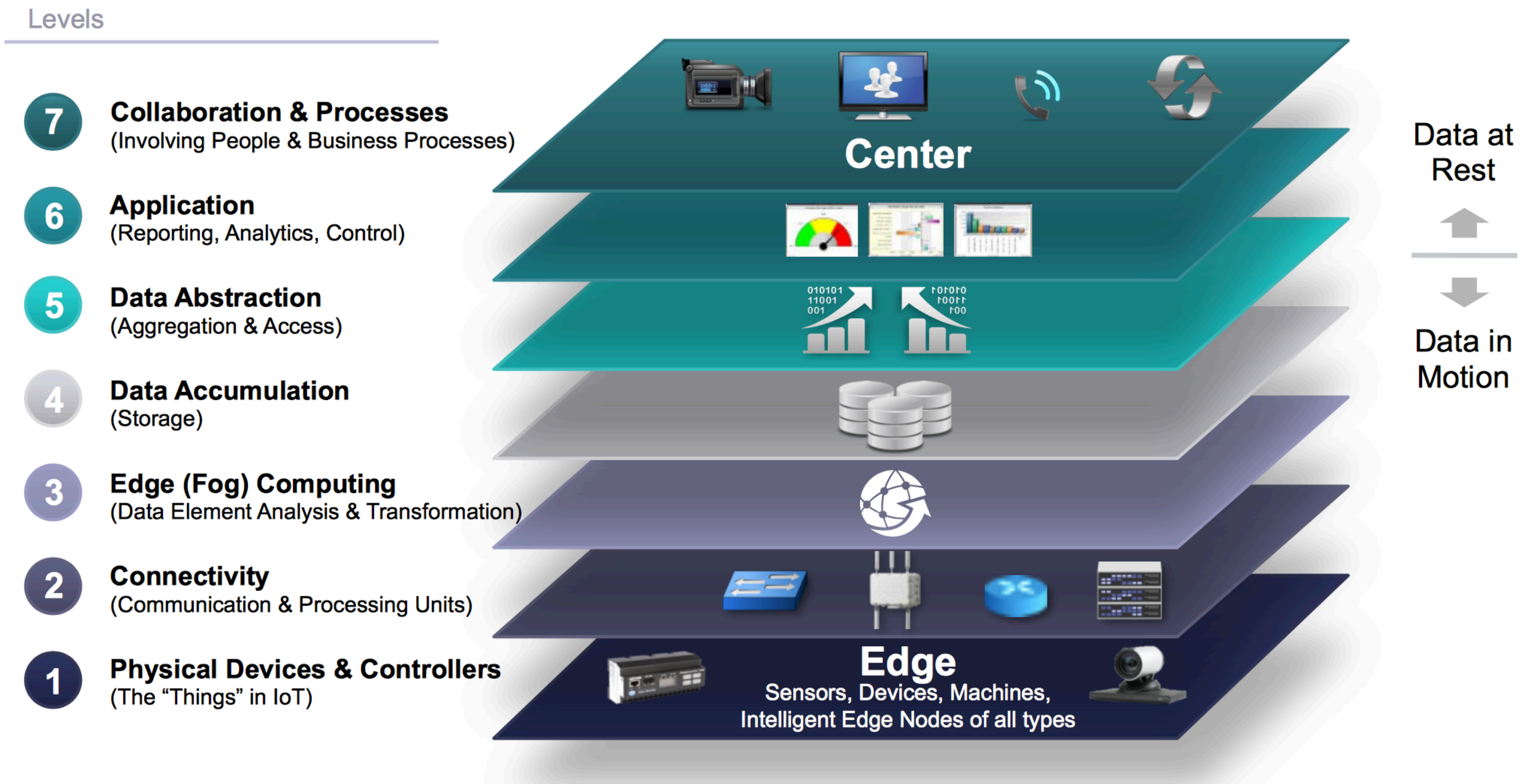
IOT REFERENCE MODEL

IOT REFERENCE MODEL

The purpose of a reference model is to provide clear definitions and descriptions that can be applied accurately to elements and functions of IoT systems and applications. Main benefits include:

- Simplification: As it helps break down complex systems so that each part is more understandable.
- Clarification: Where it provides additional information to precisely identify levels of the IoT and to establish common terminology.
- Identification: It identifies where specific types of processing is optimized across different parts of the system.
- Standardization: It provides a first step in enabling vendors to create IoT products that work with each other (interoperability).

Internet of Things Reference Model



Cisco

1 **Physical Devices & Device Controllers**
(The "Things" in IoT)

IoT "devices" are capable of:

- Analog to digital conversion, as required
- Generating data
- Being queried / controlled over-the-net

2 **Connectivity**
(Communication & Processing Units)

Connectivity includes:

- Communicating with and between the Level 1 devices
- Reliable delivery across the network(s)
- Implementation of various protocols
- Switching and routing
- Translation between protocols
- Security at the network level
- (Self Learning) Networking Analytics

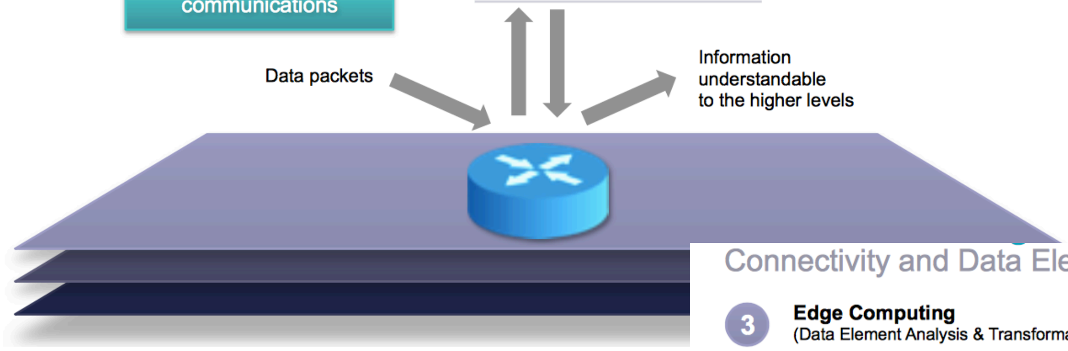
Level 2 functionality focuses on East-West communications

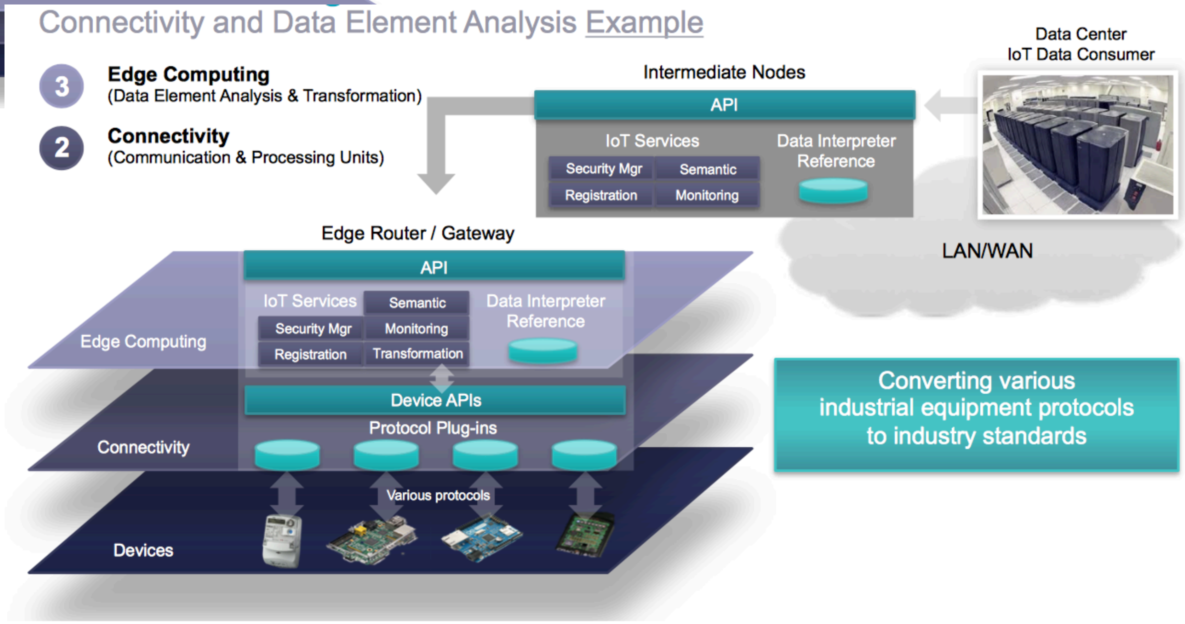
3 Edge (Fog) Computing
(Data Element Analysis & Transformation)

Level 3 functionality focuses on North-South communications

Include;

- Data filtering, cleanup, aggregation
- Packet content inspection
- Combination of network and data level analytics
- Thresholding
- Event generation





Converting various industrial equipment protocols to industry standards

4 Data Accumulation (Storage)

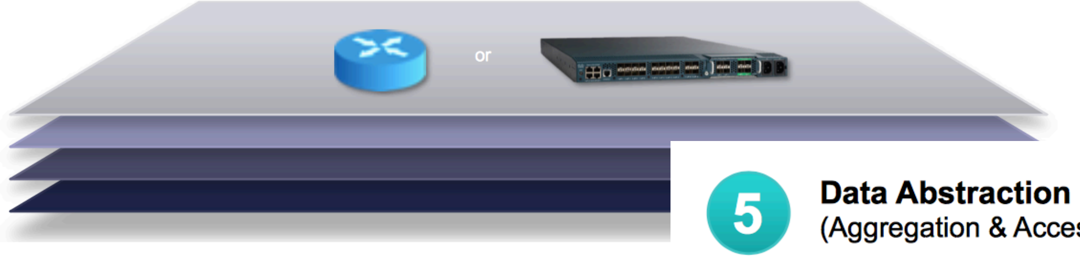
- Event filtering/sampling
- Event comparison
- Event joining for CEP
- Event based rule evaluation
- Event aggregation
- Northbound/southbound alerting
- Event persistence in storage

Query Based Data Consumption

Event Based Data Generation

Making network data usable by applications

1. Converts data-in-motion to data-at-rest
2. Converts format from network packets to database relational tables
3. Achieves transition from 'Event based' to 'Query based' computing
4. Dramatically reduces data through filtering and selective storing

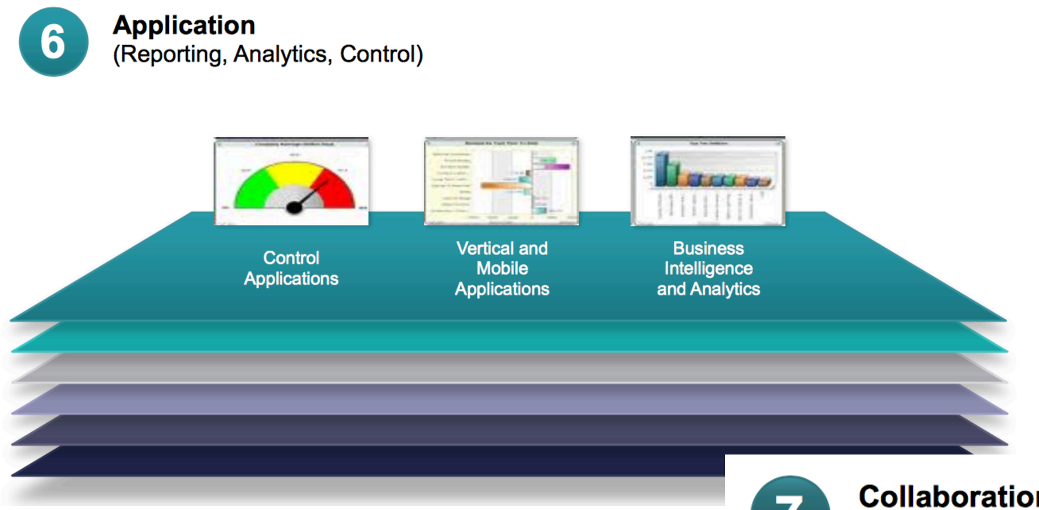


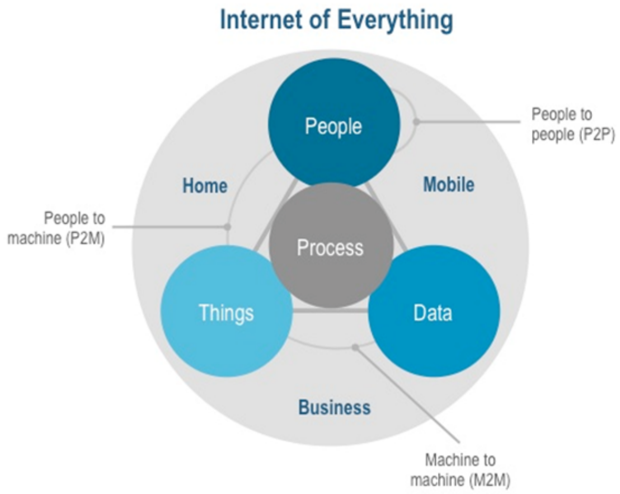
5 Data Abstraction (Aggregation & Access)

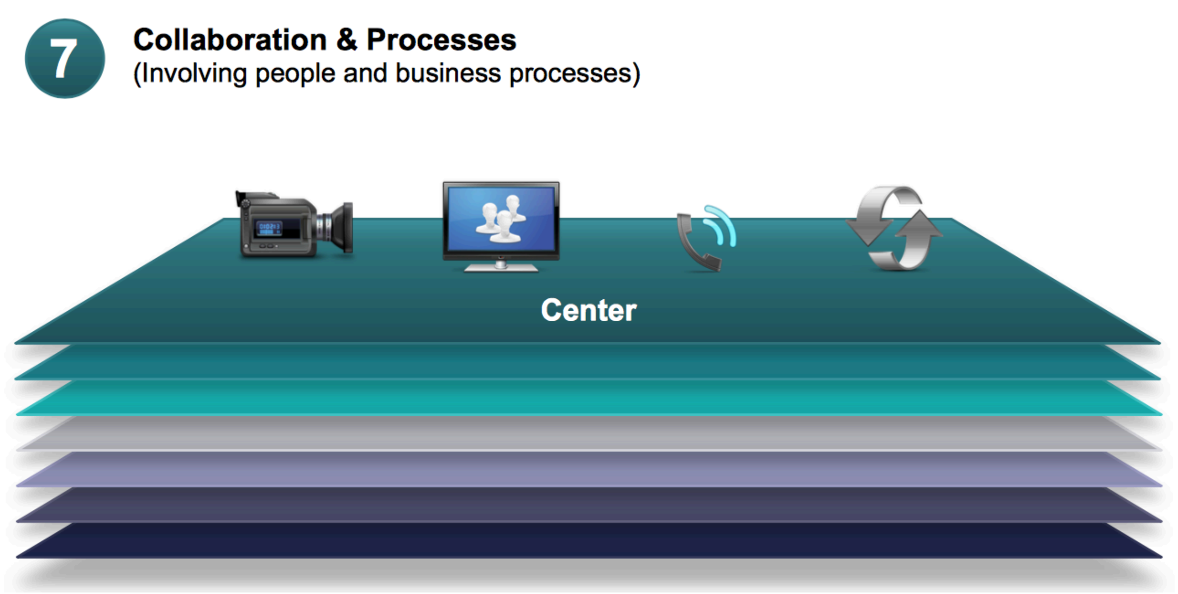
Abstracting the data interface for applications

Information Integration

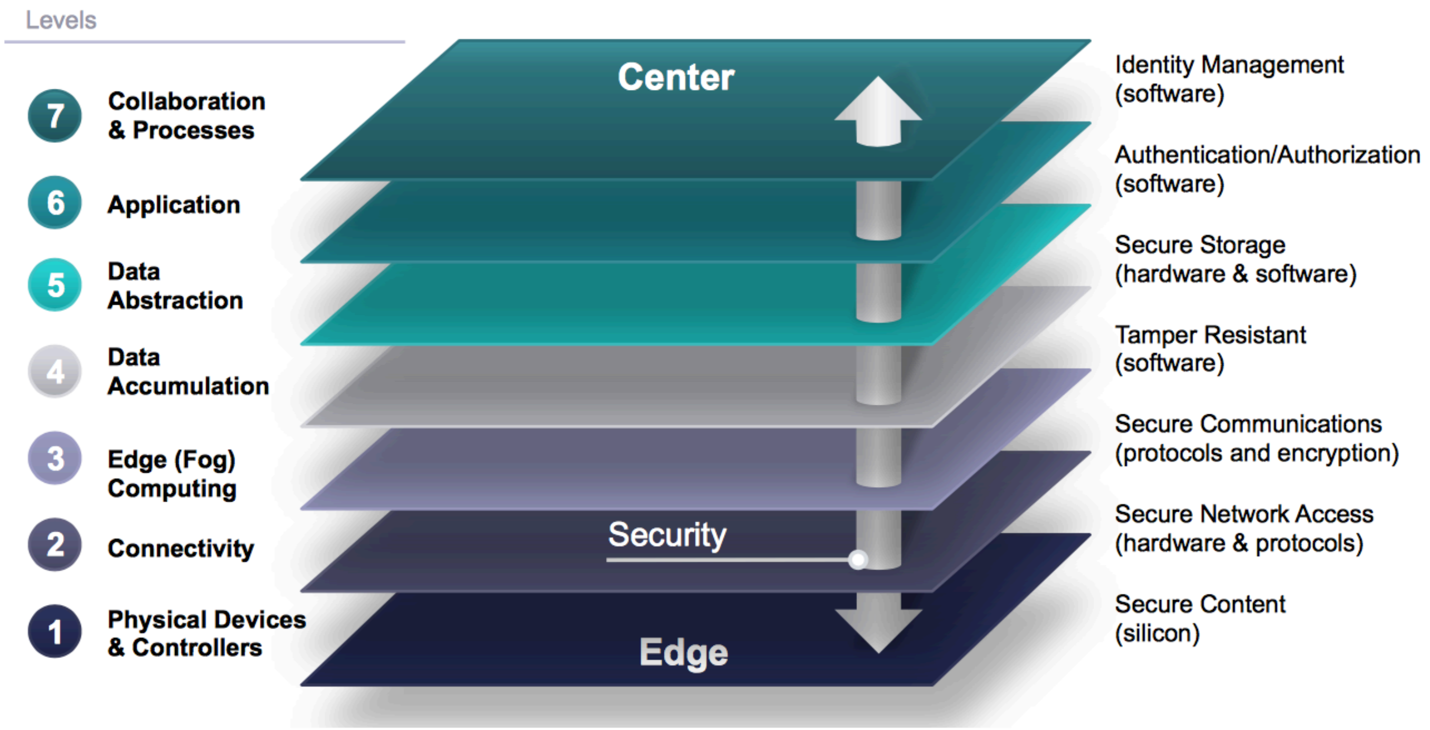
1. Creates schemas and views of data in the manner that applications want
2. Combines data from multiple sources, simplifying the application
3. Filtering, selecting, projecting, and reformatting the data to serve the client applications
4. Reconciles differences in data shape, format, semantics, access protocol, and security


6
Application
(Reporting, Analytics, Control)
Control Applications
Vertical and Mobile Applications
Business Intelligence and Analytics


Internet of Everything
People
Process
Things
Data
Home
Mobile
Business
People to people (P2P)
People to machine (P2M)
Machine to machine (M2M)


7
Collaboration & Processes
(Involving people and business processes)
Center

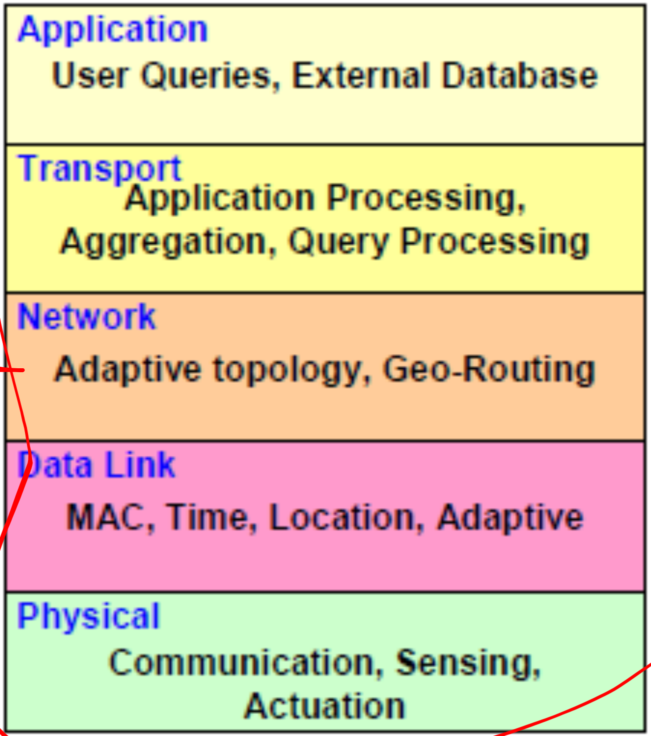
Internet of Things Reference Model: Security

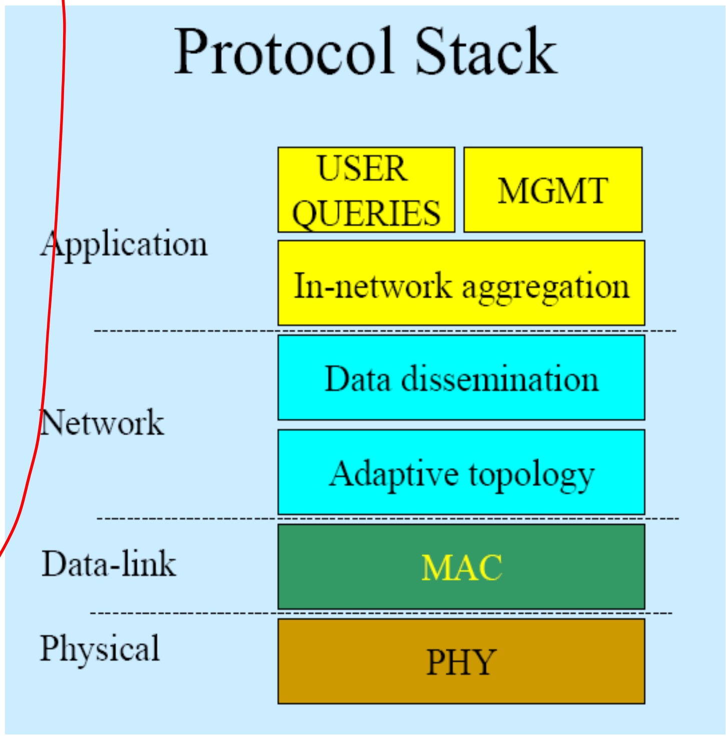


NETWORK ABSTRACTION

LOGICAL LAYERS

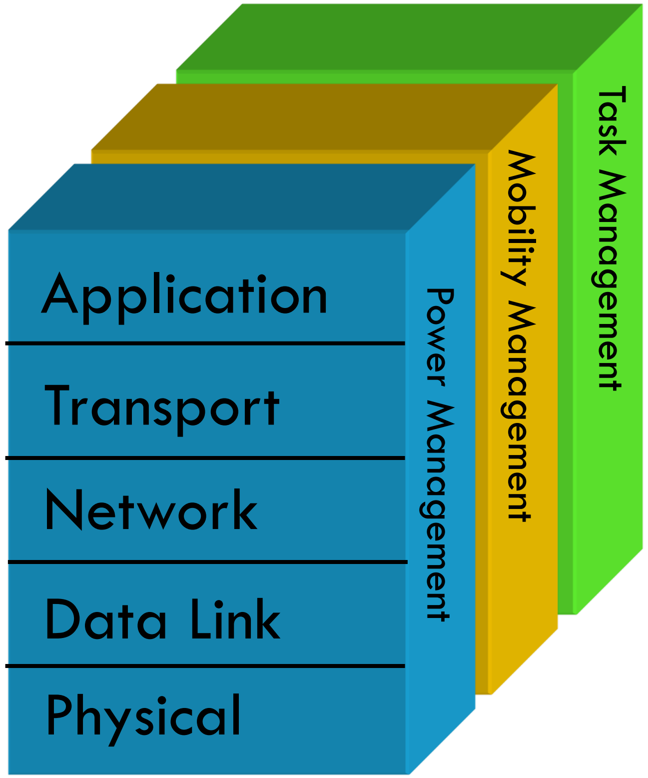
- **Coordinating to minimize duty cycle and communication**
  - Adaptive Topology
  - Routing
  - Adaptive MAC
- **In-network processing**
  - Data centric routing
  - Programming models





SENSOR NETWORK PROTOCOL STACK

- Power Management – How the sensor uses its power, e.g. turns off its circuitry after receiving a message.
- Mobility Management – Detects and register the movements of the sensor nodes
- Task Management – Balances and schedules the sensing tasks given to a specific



PHYSICAL LAYER

COMPONENTS OF A DIGITAL COMMUNICATION SYSTEM.