The Internet of Things #IoT

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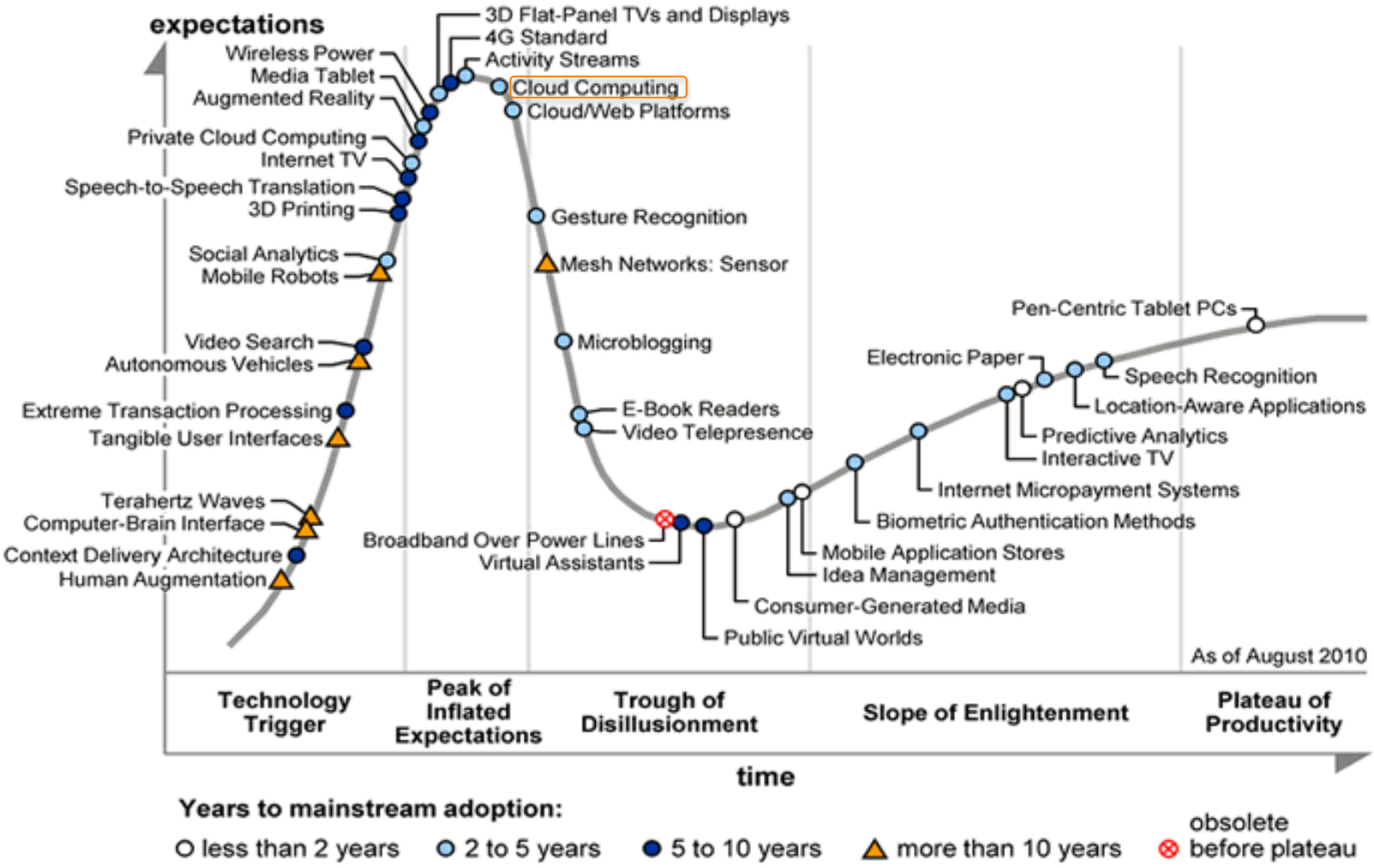
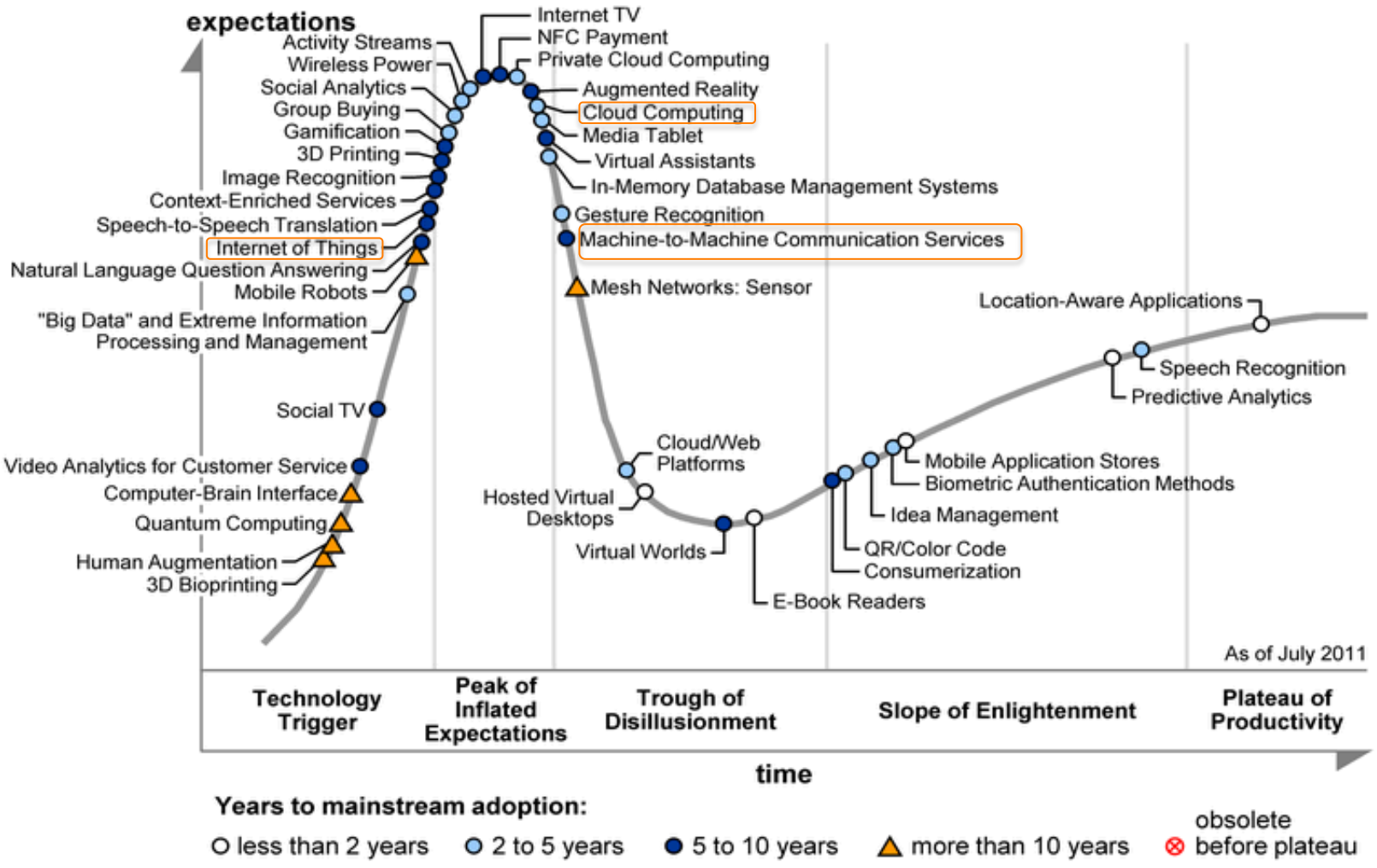
Outline

- Hype cycle 2010 to 2015
- IoT Definition, architecture, and use cases
- System complexity levels
- Communication models
- Cloud computing
  - Infrastructure as a Service (IaaS)
  - Platform as a Service (PaaS)
  - Software as a Service (SaaS)
- Privacy management

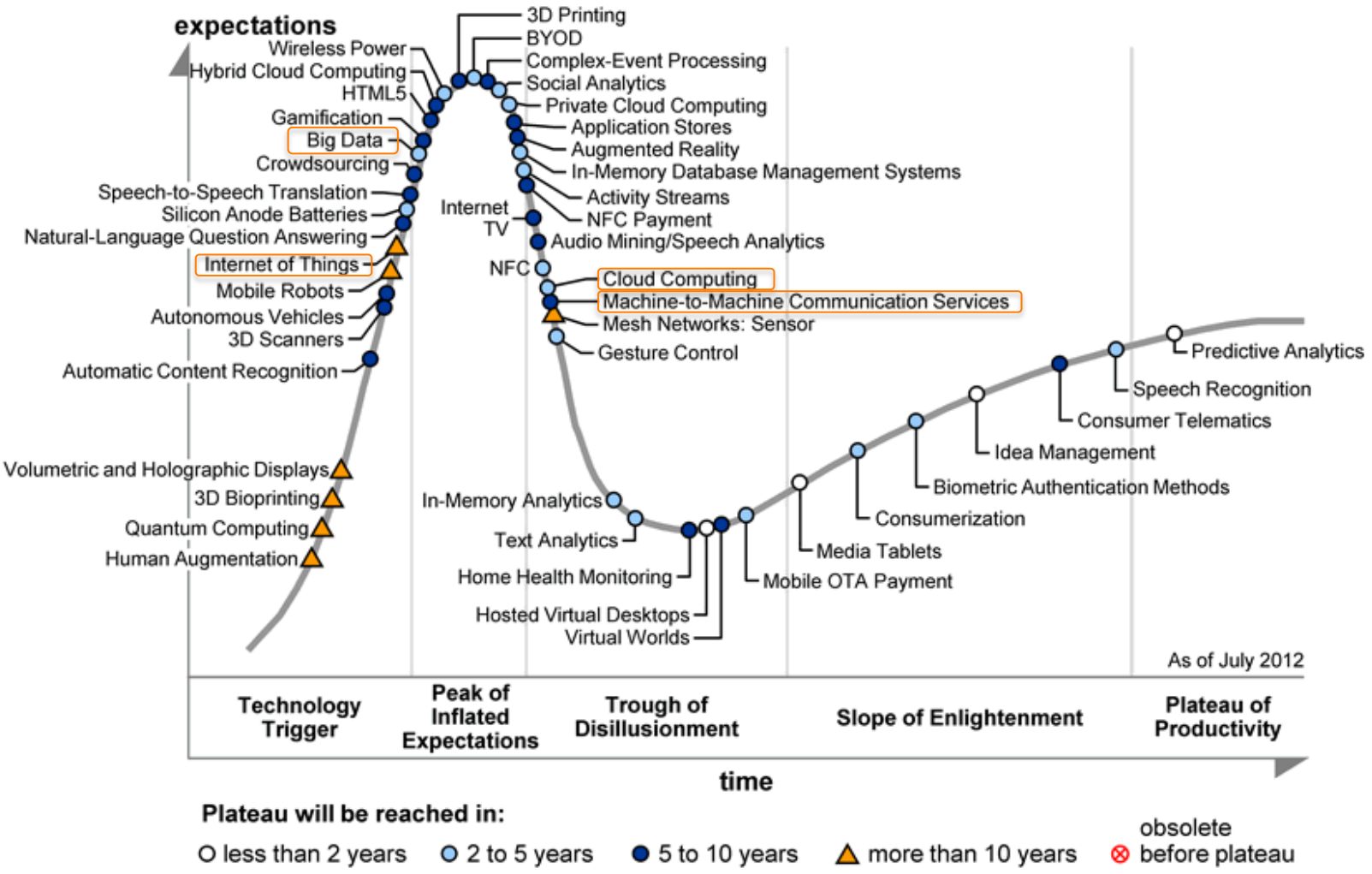
Gartner Hype Cycle 2010



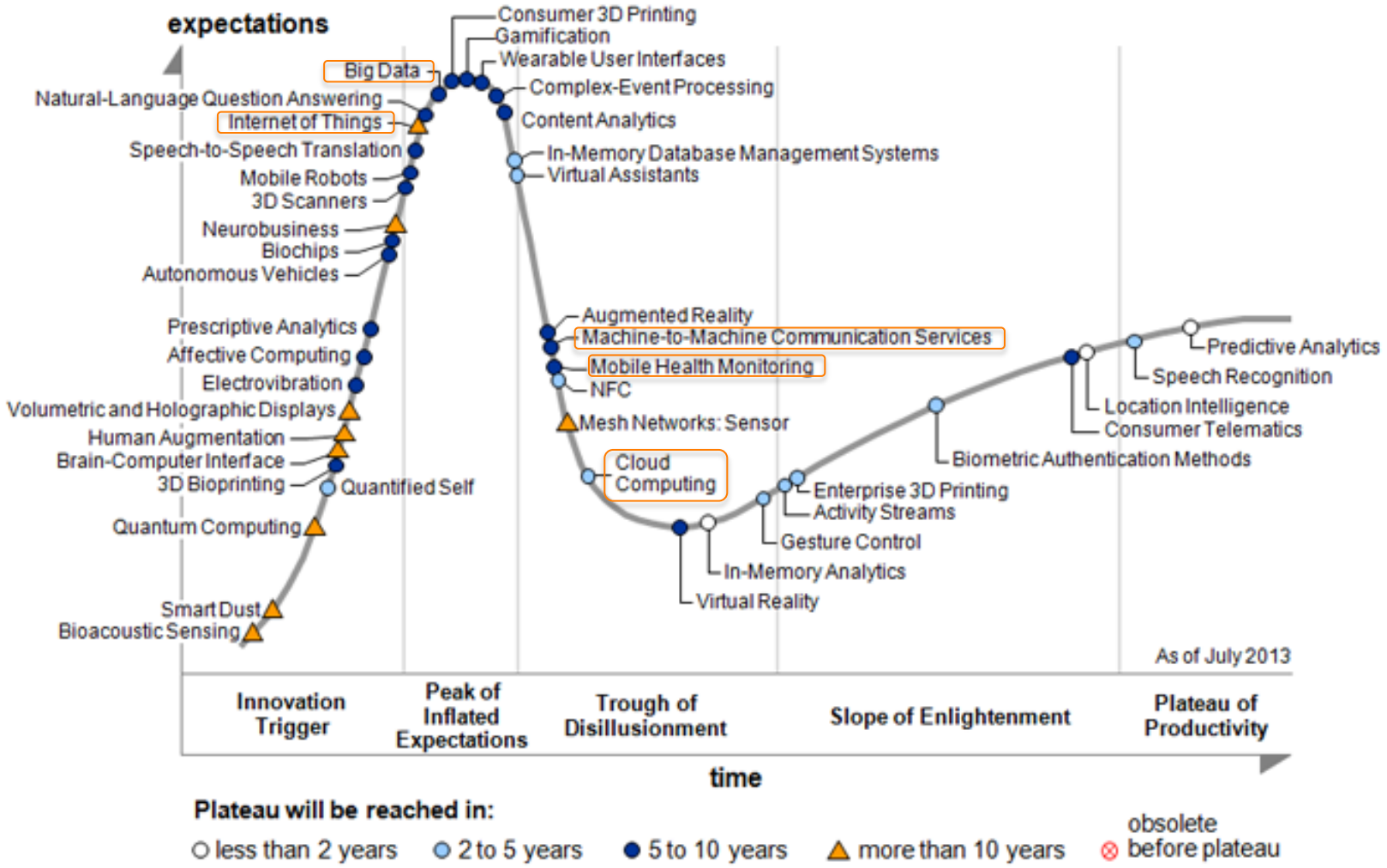
Gartner Hype Cycle 2011



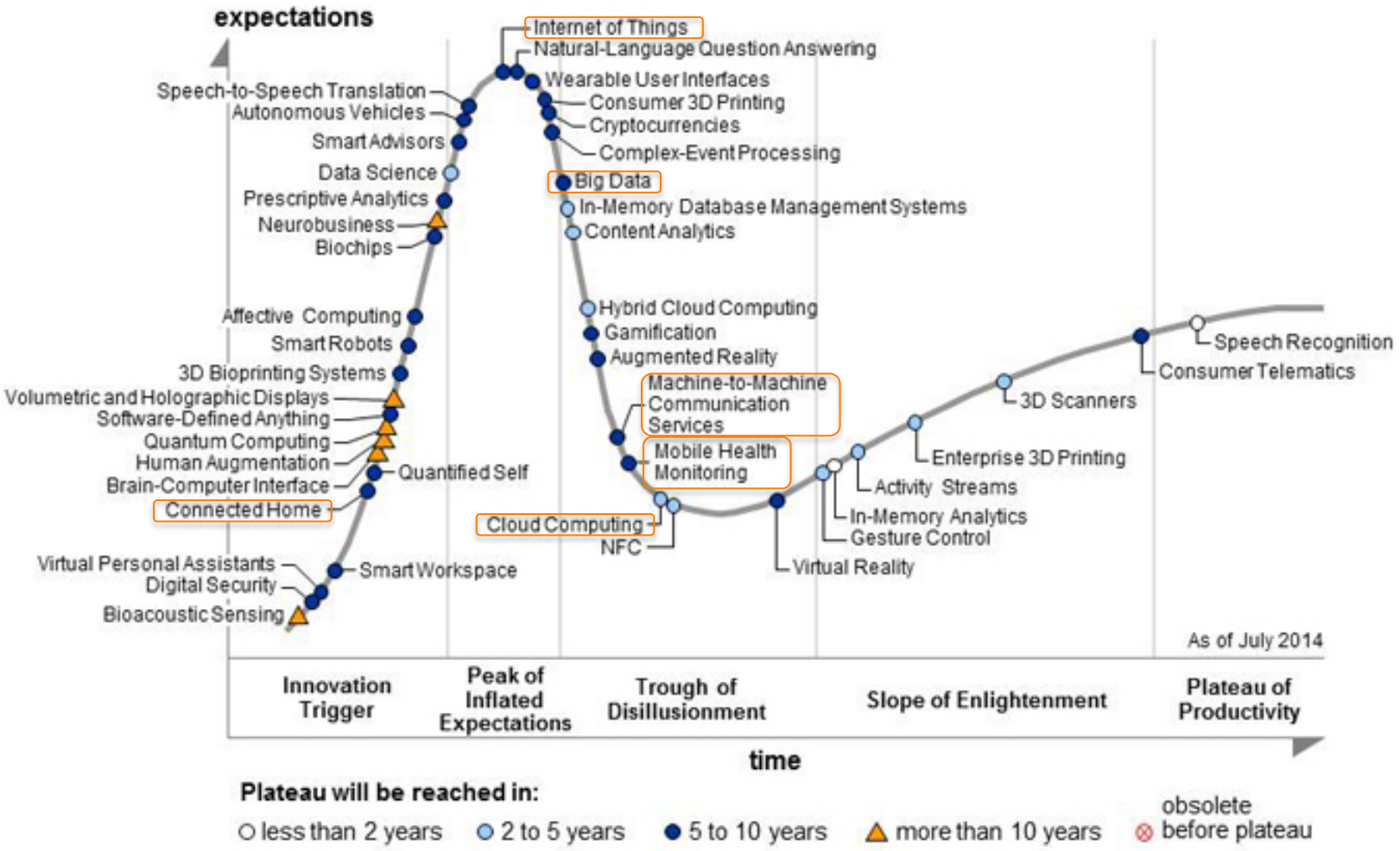
Gartner Hype Cycle 2012



Gartner Hype Cycle 2013



Gartner Hype Cycle 2014



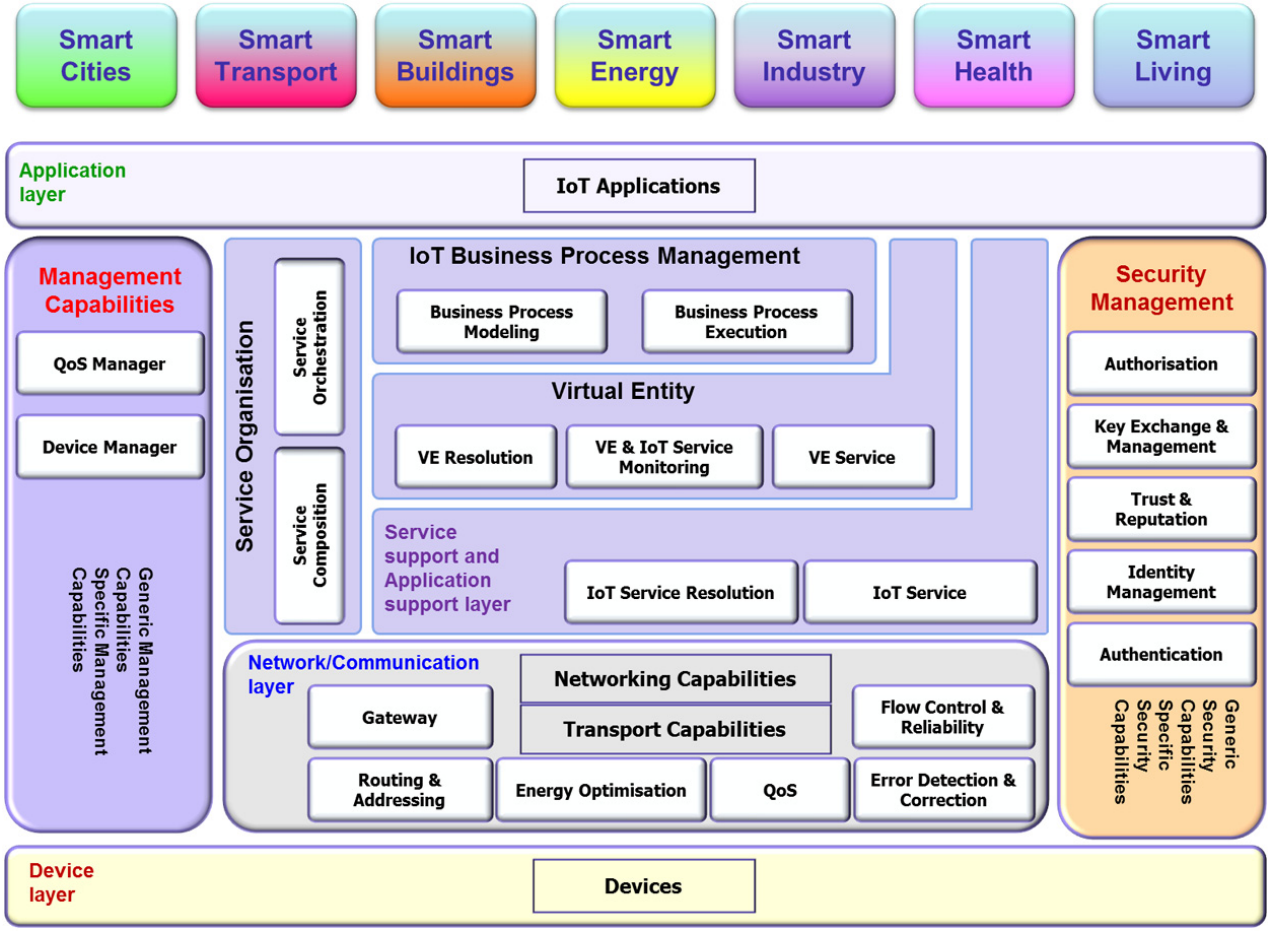
Gartner Hype Cycle 2015

IoT Definition by ITU-T

A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things”

- Have identities, physical attributes, and virtual personalities
- Use intelligent interfaces
- Are seamlessly integrated into the information network
- Often communicate data associated with users and their environments

IoT Architecture by ITU-T



http://www.internet-of-things-research.eu/documents.htm

IoT Use Cases by oneM2M

1 Agriculture

2 Energy

2.1 Wide area energy related measurement/control system for advanced transmission and distribution automation

2.2 Analytics

2.3 Smart meter reading

2.4 Environmental monitoring of remote locations to determine hydropower

2.5 Oil and gas pipeline cellular/satellite gateway

3 Enterprise

3.1 Smart building

4 Finance

IoT Use Cases by oneM2M

5 Healthcare

5.1 M2M healthcare gateway

5.2 Wellness services

5.3 Secure remote patient care and monitoring

6 Industrial

7 Public services

7.1 Street light automation

7.2 Devices, virtual devices and things

7.3 Car/bicycle sharing services

7.4 Smart parking

7.5 Information delivery service in the devastated area

IoT Use Cases by oneM2M

8 Residential

8.1 Home energy management

8.2 Home energy management system (HEMS)

8.3 Plug-in electrical charging vehicles and power feed in home scenario

8.4 Real-time audio/video communication

8.5 Event triggered task execution

8.6 Semantic home control

8.7 Semantic device plug and play

9 Retail

IoT Use Cases by oneM2M

10 Transportation

10.1 Vehicle diagnostic and maintenance report

10.2 Remote maintenance services

10.3 Traffic accident information collection

10.4 Fleet management service using digital tachograph (DTG)

IoT Use Cases by oneM2M

11 Other

11.1 Extending the M2M access network using satellite

11.2 M2M data traffic management by underlying network operator

11.3 Optimized M2M interworking with mobile networks (optimizing *connectivity* management parameters)

11.4 Optimized M2M interworking with mobile networks (optimizing *mobility* management parameters)

11.5 Sleepy node

11.6 Collection of M2M system data

11.7 Leveraging broadcasting/multicasting capabilities of underlying networks

11.8 Leveraging service provisioning for equipment with built-in M2M device

Complexity Levels of IoT Systems

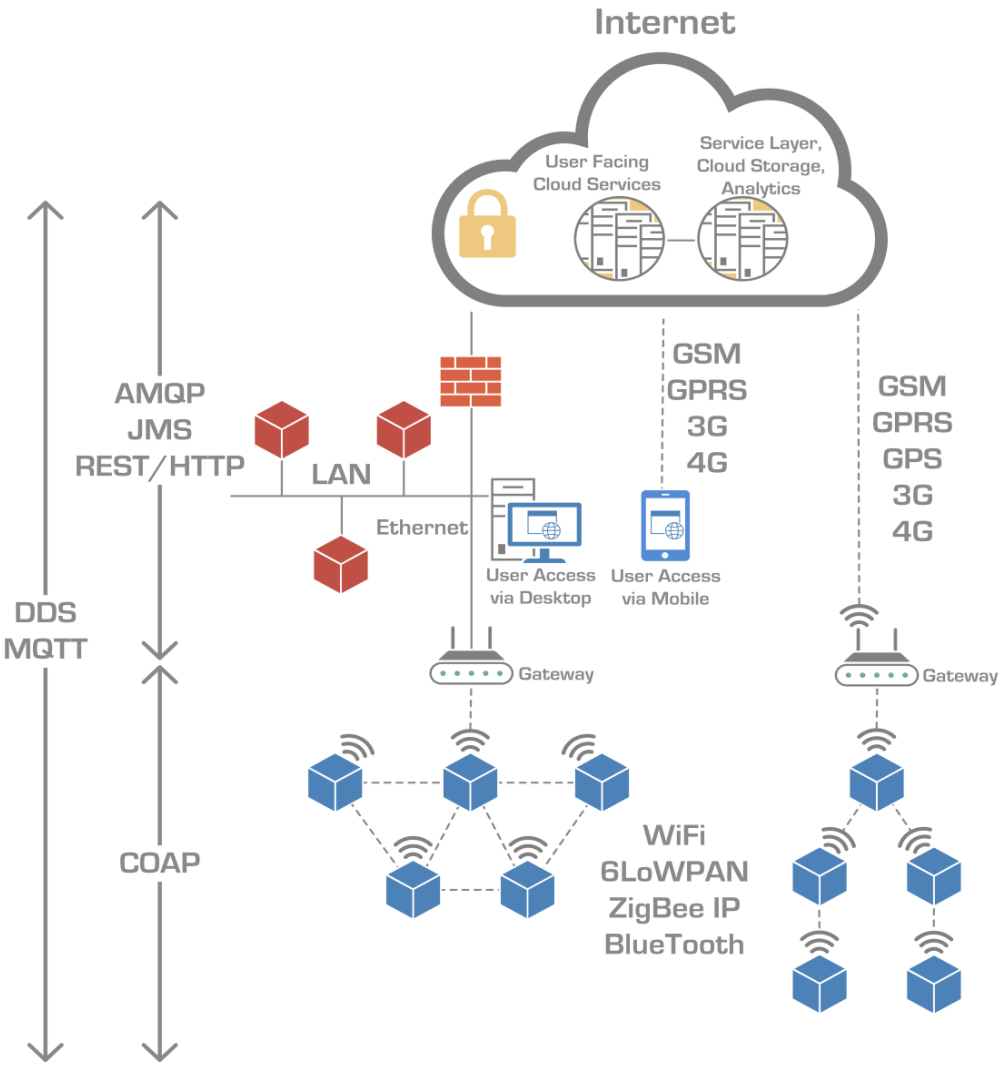
Level	Node	Analysis	Storage	Example
1	Single	Local	Local	Home Automation
2	Single	Local	Cloud	Smart Irrigation
3	Single	Cloud	Cloud	Vibration Monitoring
4	Multiple	Local	Cloud	Noise Monitoring
5	Multiple + Coordinator	Cloud	Cloud	Forest Fire detection
6	Multiple + Centralized Controller	Cloud	Cloud	Weather Monitoring

http://www.internet-of-things-book.com/

IoT Protocols

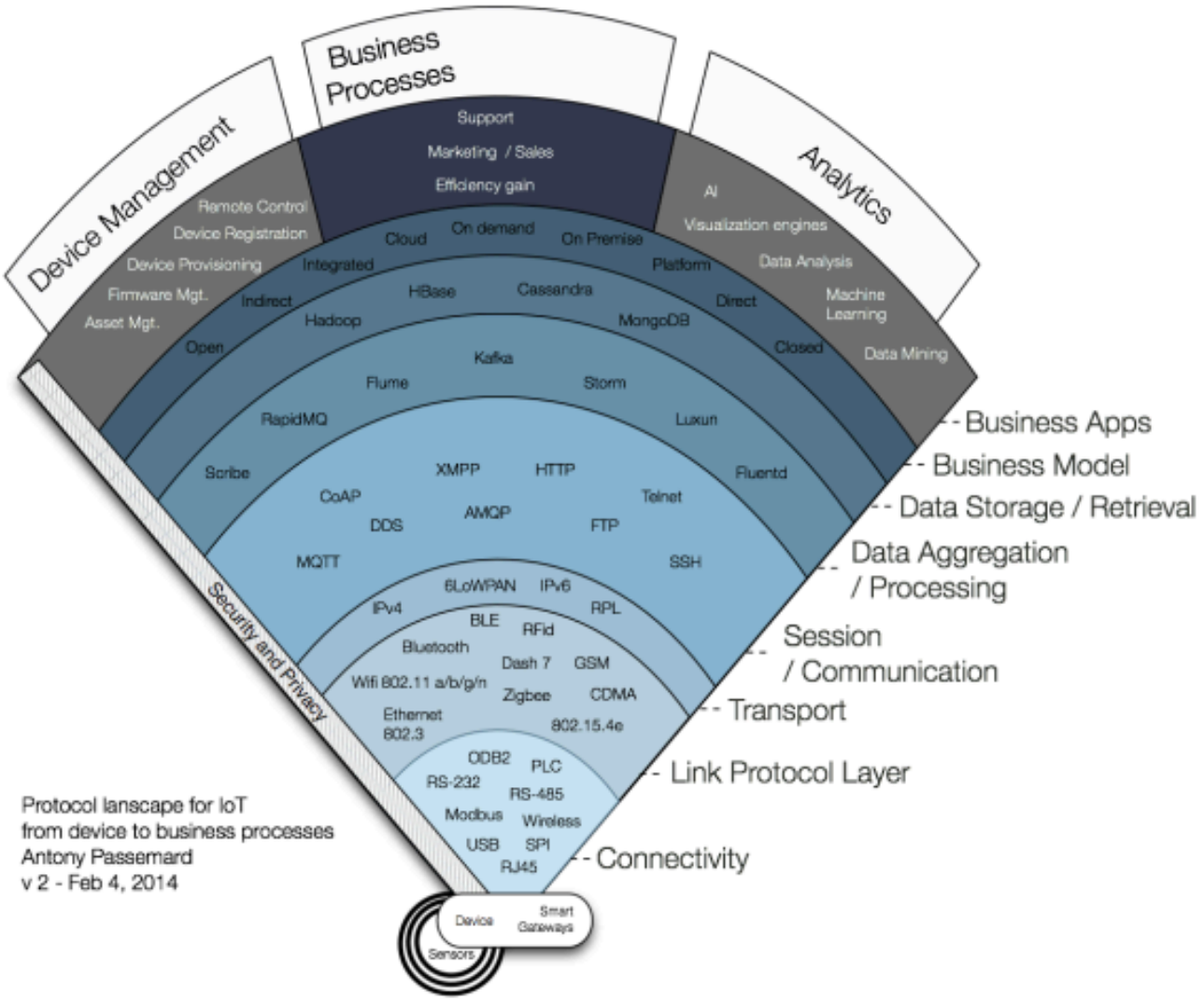
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks
AMQP	Advanced Message Queuing Protocol
CoAP	Constrained Application Protocol
DDS	Data Distribution Service
HTTP	Hypertext Transfer Protocol
JMS	Java Message Service
MQTT	Message Queue Telemetry Transport
REST	Representational State Transfer
WAMP	Web Application Messaging Protocol (over WebSocket)
XMPP	Extensible Messaging and Presence Protocol

IoT Connectivity Protocols



http://www.prismtech.com/download-documents/1561

IoT Protocols

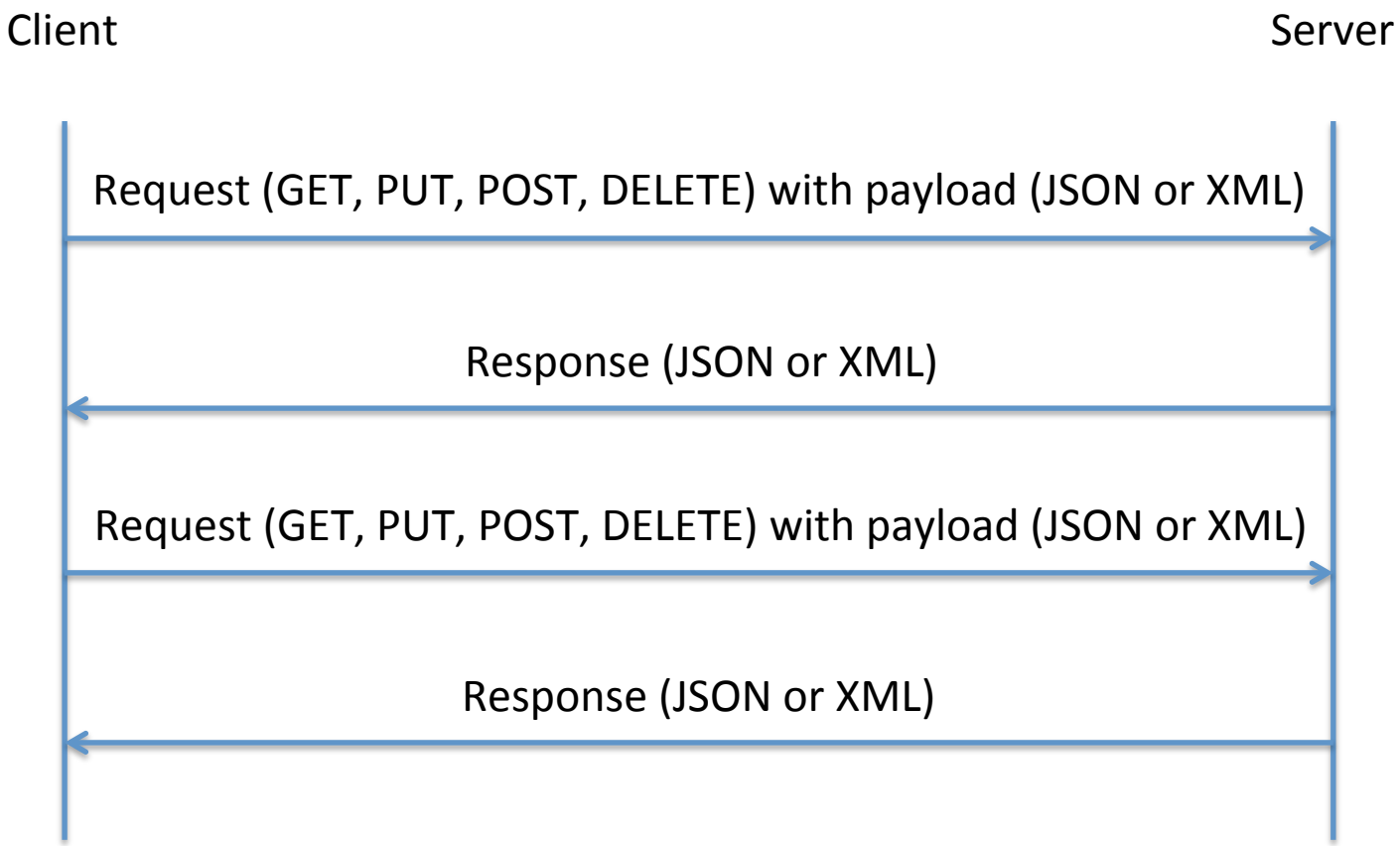


https://entrepreneurshiptalk.wordpress.com/2014/01/29/the-internet-of-thing-protocol-stack-from-sensors-to-business-value/

Request-Response by REST(ful) API

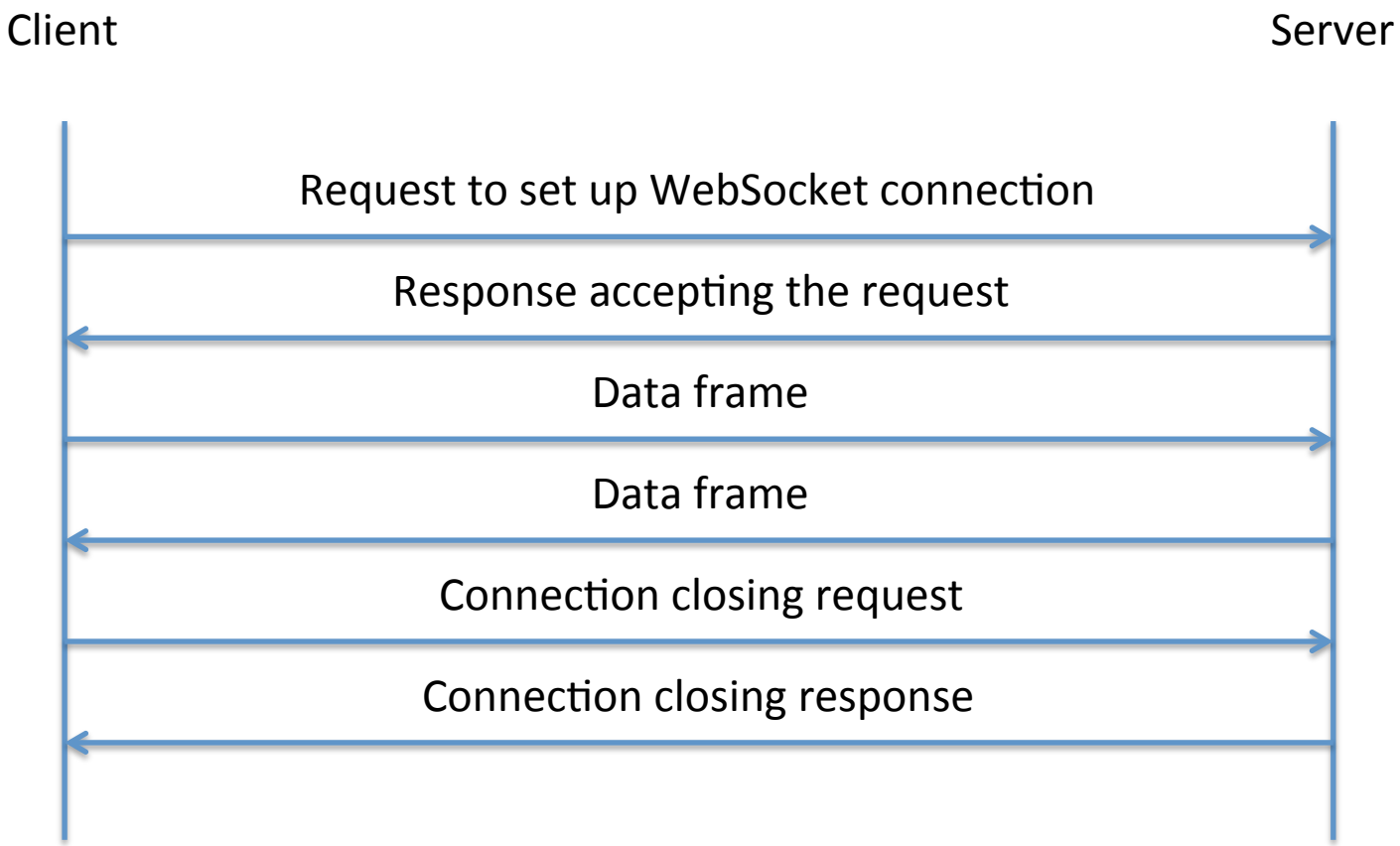
REST: Representational State Transfer

API: Application Programming Interface

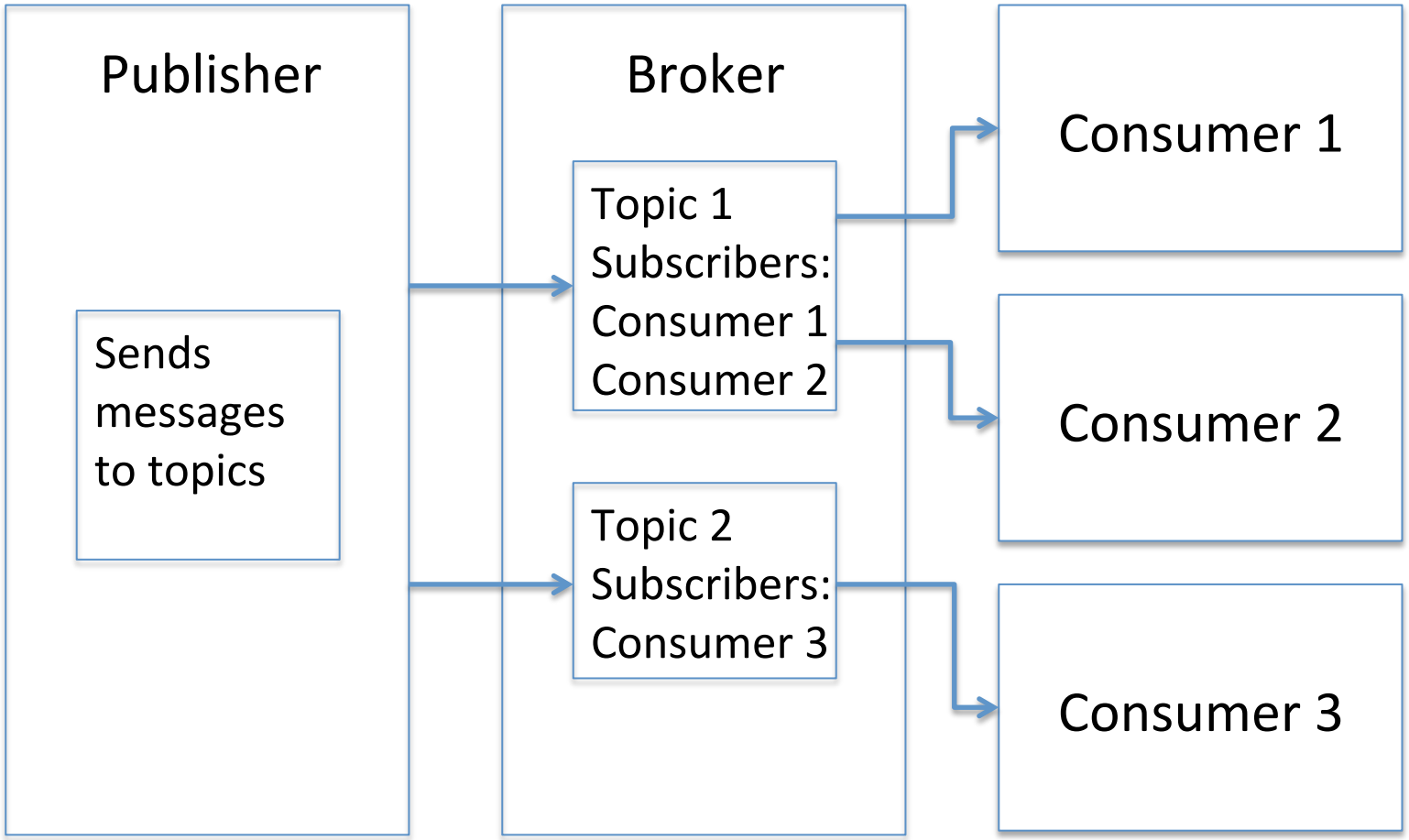


Exclusive Pair by WebSocket API

for Low-Latency or High-Throughput Requirements



Publish-Subscribe Communication



What is an API?

- API is a set of routines, protocols, and tools for building software applications
- It specifies how software components interact and are used when programming graphical user interface (GUI) components
- Example: Django REST framework

```
/lighting
    controller.py
    db.sqlite3
    /lighting
        settings.py
        urls.py
    manage.py
    /myapp
        admin.py
        models.py
        serializers.py
        /templates
            /myapp
                index.html
        views.py
```

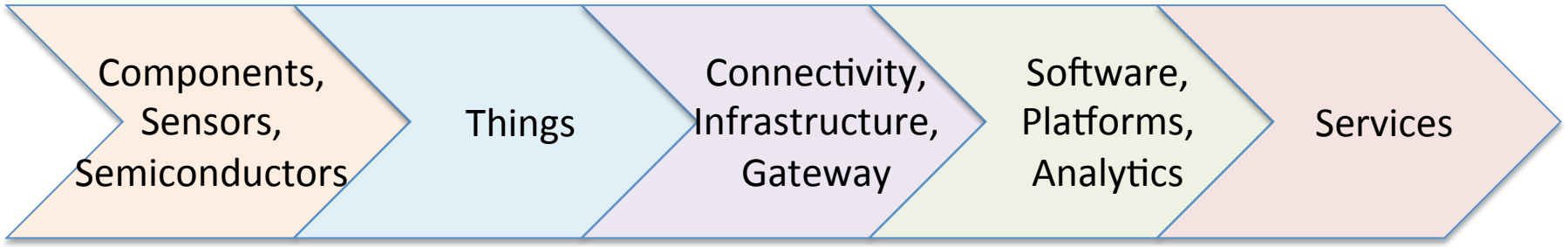
Demonstration

- Raspberry Pi, breadboard, wires, Python, and Django
  - Smart lighting: LED, light-dependent resistor (LDR), 1kΩ/10kΩ resistors, analog-to-digital converter (ADC, *e.g.*, MCP3008), and SQLite3
  - Smart parking: Ultrasonic sensor (*e.g.*, HC-SR04), 1kΩ resistor, and MySQL

Cloud Computing

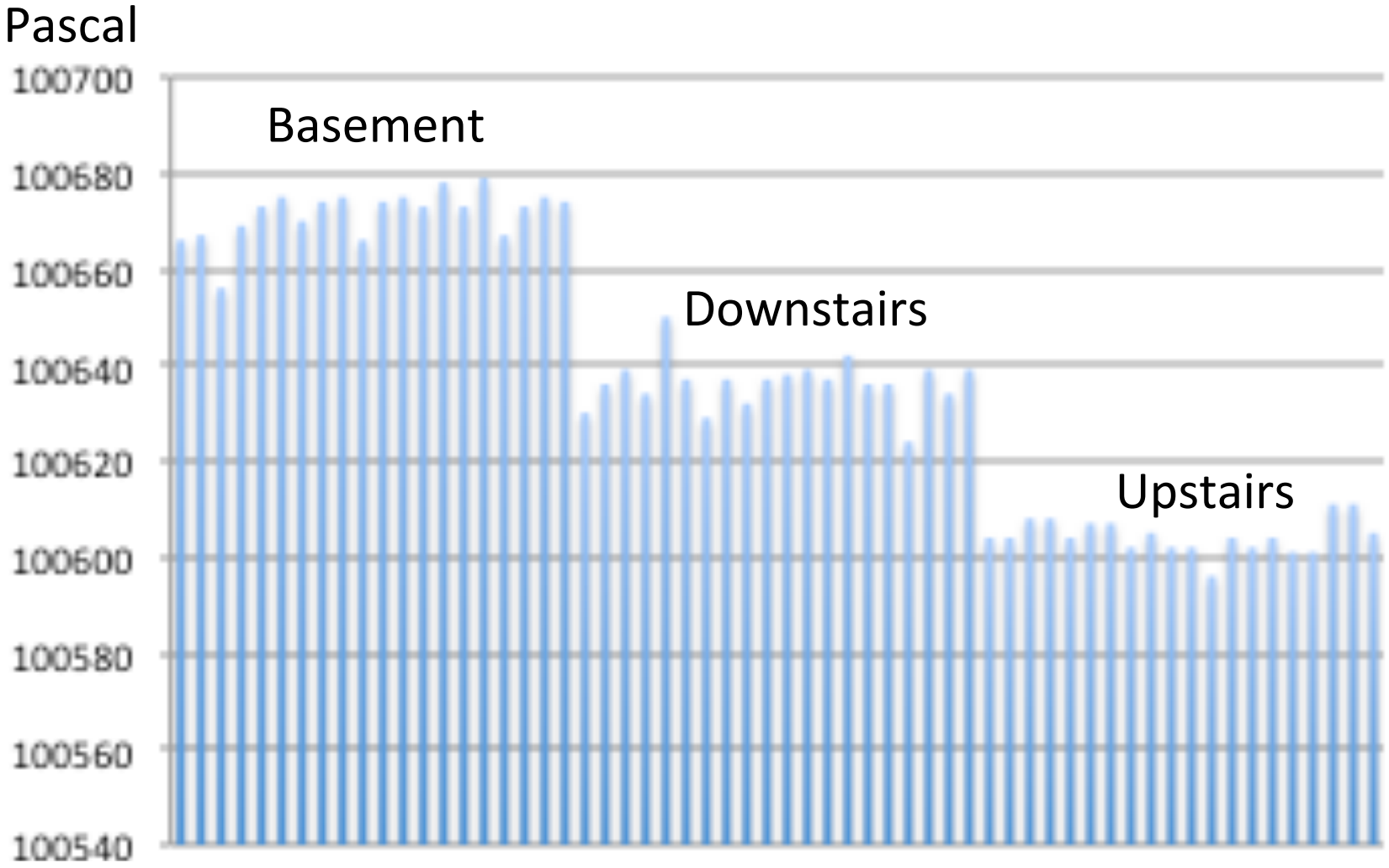
- IaaS (Infrastructure as a Service)
  - Amazon Web Services (AWS), Google Compute Engine, Microsoft Azure, DigitalOcean, *etc*.
- PaaS (Platform as a Service)
  - Beebotte, Carriots, GroveStreams, ThingSpeak, Xively, *etc*.
- SaaS (Software as a Service)
  - Automatic, Cardiio, Hue, Nest, SmartThings, *etc*.

IoT Value Chain and Business Case

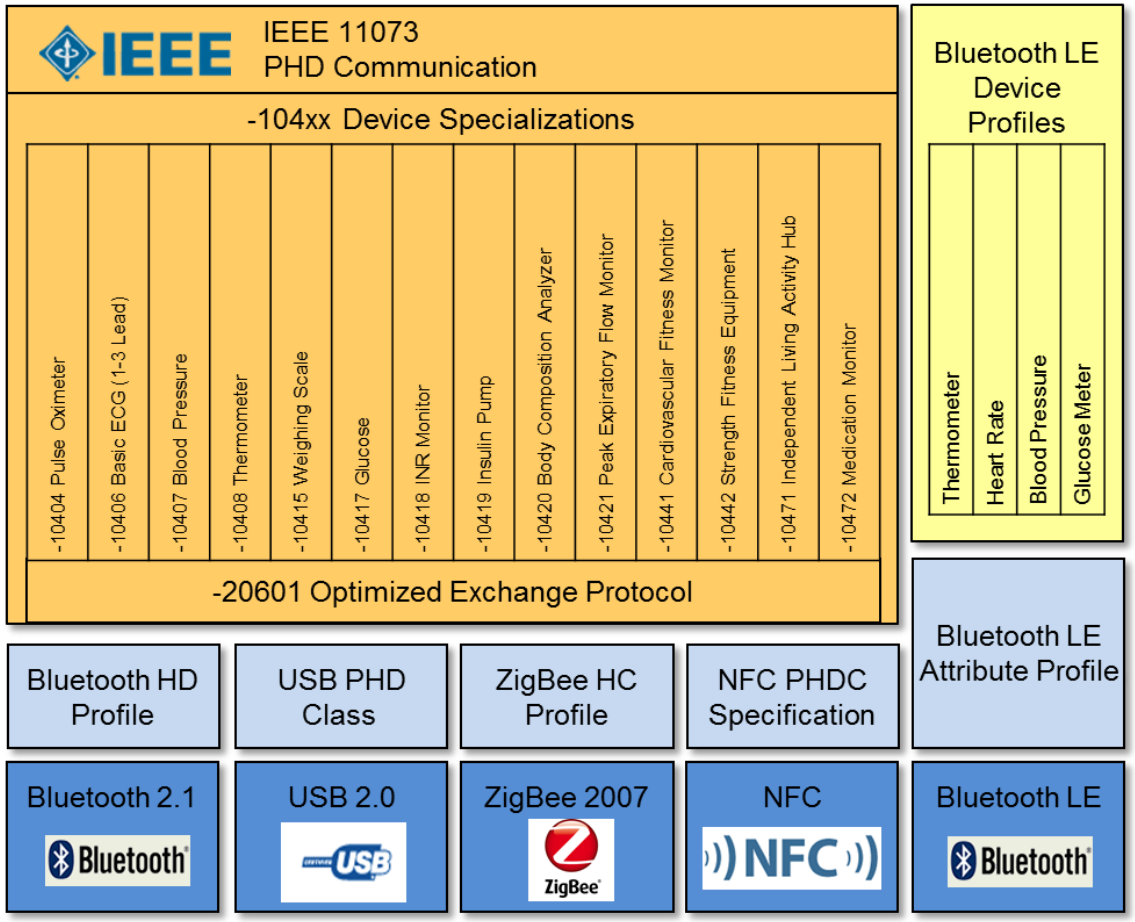


- The IoT can enable transformation of business and industry
- Enterprises can experiment with small-scale projects to gauge benefits while also monitoring what is happening in other industries, as a source of ideas
- A compelling business case and justifications must be developed, quantified, and articulated before large-scale deployment can happen
- Source: Jim Tully, Gartner, Inc.

Value of Barometric Pressure Data



Personal Health Device Communication (PHDC)



ECG: Electrocardiograph
INR: International Normalized Ratio

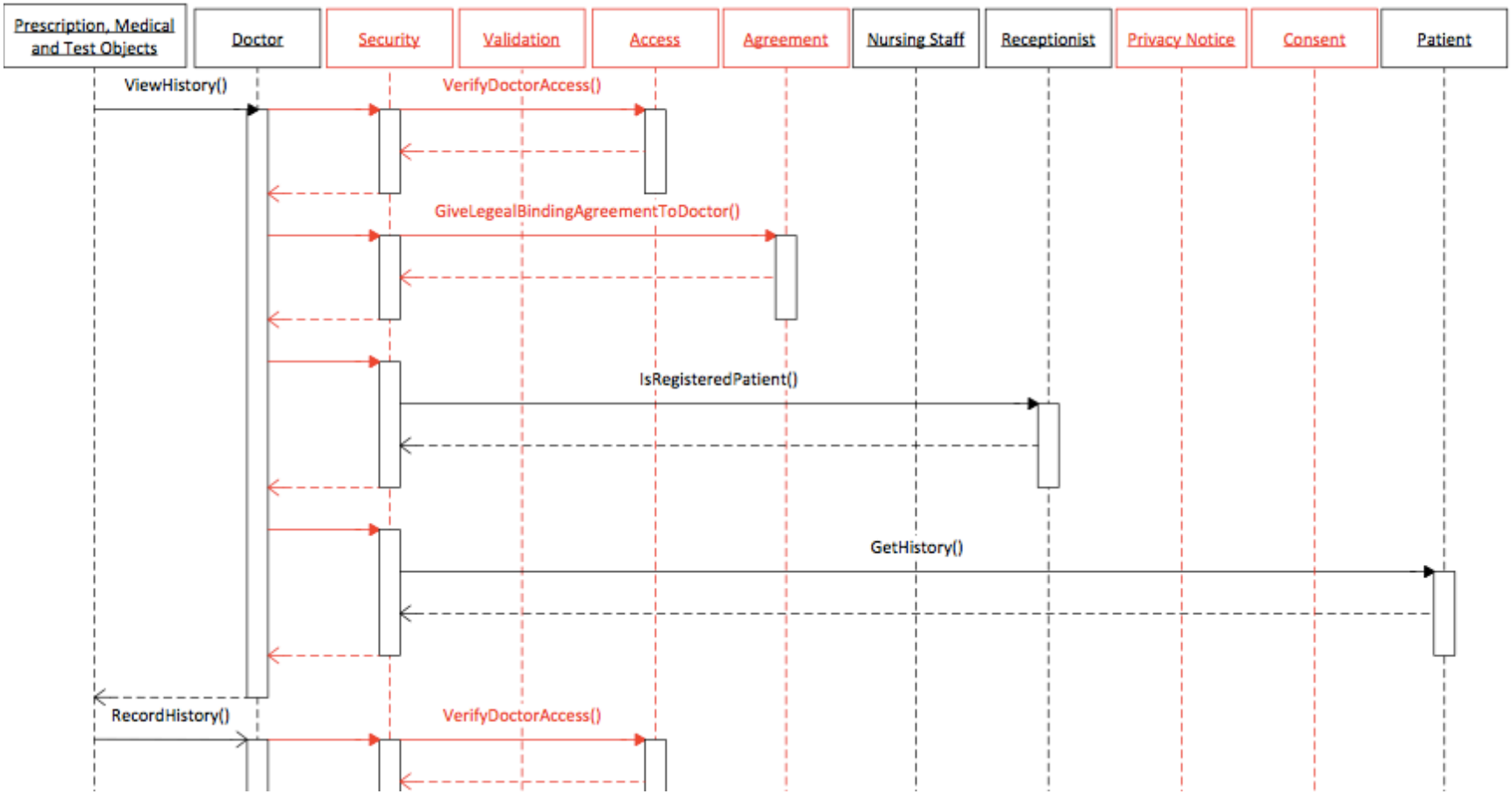
LE: Low Energy
NFC: Near Field Communication

Privacy Management

Fair and authorized processing of Personally Identifiable Information (PII)

- Collection, storage, use, organization, recording, alignment, combination, disclosure by transmission, consultation, erasure, destruction, alteration, *etc.*
- Any data that identifies an individual or from which identity or contact information of an individual can be derived

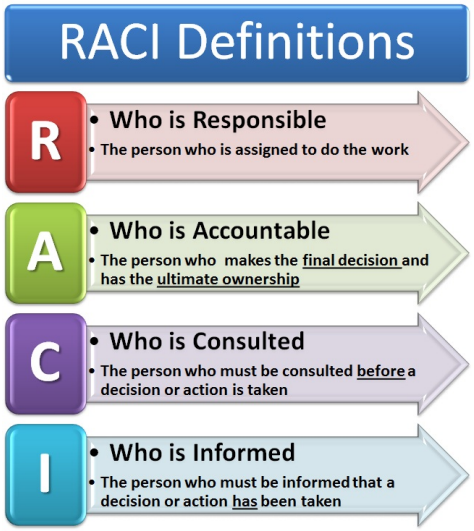
Privacy Management Sequence



Privacy by Design

OASIS

OASIS Privacy by Design Documentation for Software Engineers (PbD-SE) TC



RACI Chart for OASIS PbD-SE Methodology (WIP)

PbD-SE Methodology Step	Documented Activity	Software Engineer	Privacy Resource	Project Mgmt.	Mgmt.	Third Party	User
3.1 Assess Organization-al Readiness	Document Privacy Policy Document	C I	R A C I	C I	A C I	I	C I
	Document Privacy Roles/Training Program in Organization	I	R A C I	C I	A I	I	I
3.2 Scope Privacy Requirements & Reference Architecture	Document Functional Privacy Requirements & hooks to Reference Architecture	R A	R A C I	A C I	A I	R A I	C I
3.3 Conduct Risk Analysis on Use Cases	Document Business Model with Personal Data Flows	C I	R A C I	C I	A C	C I	-
	Document Risk analysis (incl. threat models, PIA)	C I	R A C I	C I	A C I	C I	-
3.4 Identify Privacy Resource Allocation	Document privacy resource allocation to SE team	I	R A C I	R I	A I	I	-
3.5 Create RACI for Producing Artifacts	Document RACI assignment to artifact production	R C I	C I	R A C I	A I	-	-
3.6 Customize Privacy Architecture	Document Privacy Architecture	R A	A C I	A C I	A I	I	-
3.7 Conduct Periodic Review	Document Review of Artifacts throughout the PDLC	R A	C I	R A C I	A I	-	-
3.8 Execute Code Testing & Privacy Evaluation	Document testing and evaluation for privacy usability - **metrics**	R A	R C I	R A C I	A I	-	C
3.9 Create Retirement Plan	Document plan for retirement of software solution	C I	R A C I	R A C I	A C I	I	I
3.10Sign-off	Document sign off with checklist	R A C I	R A C I	R A C I	A C	-	-

OASIS: Organization for the Advancement of Structured Information Standards

Summary

- IoT is not about adding connectivity to all things
  - Not all data sent to the cloud
- IoT is about how sensors, devices, things, and services can be integrated to create value
- Value is extracted by making sense of data, turning it into knowledge and meaningful action
- Access to data shall have differential restrictions