第零讲
物联网概念
Lecture 0
Basic Concepts of IoT

明玉瑞 Yurui Ming

yrming@gmail.com

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概念
Disclaimer

- 物联网是指连接设备的网络，以及建立设备与云之间、设备本身之间通信的技术。由于廉价计算机芯片和高带宽电信网络的演进，我们现在有数十亿台设备连接到互联网。

  The term IoT, or Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. Thanks to the advent of inexpensive computer chips and high bandwidth telecommunication, we now have billions of devices connected to the internet.

- 物联网的发展得益于多种技术的融合，包括普适计算、商用传感器、日益强大的嵌入式系统和机器学习技术。嵌入式系统、无线传感器网络、控制系统、自动化（包括家庭和楼宇自动化）等传统领域独立地和共同地使用物联网，组成了物联网应用的各个生态。

  Due to the convergence of multiple technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems, and machine learning, the field of IoT has evolved quickly in recent years. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), independently and collectively enable the Internet of things, supporting one or more common ecosystems in applications.

历史
History

- 在上世纪80年代和90年代，便一直有在讨论向日常物品添加传感器和智能的想法，但除了一些早期项目—包括联网自动售货机—因为技术还没有准备好，进展缓慢。其时芯片太大太笨重，物体也无法有效通信。在最终达到连接数十亿台设备的成本效益之前，需要便宜且省电、扔掉也不觉可惜的处理器。RFID标签—可以无线通信的低功耗芯片—的采用解决了这个问题，同时宽带互联网和蜂窝和无线网络的可用性也越来越高。IPv6的采用—为世界上可能需要的每台设备提供足够的IP地址—也是物联网扩展的必要步骤。凯文·阿什顿在1999年创造了“物联网”一词，尽管新技术至少需要十年才能赶上这一愿景。

  The idea of adding sensors and intelligence to basic objects was discussed throughout the 1980s and 1990s. But apart from some early projects -- including an internet-connected vending machine -- progress was slow simply because the technology wasn't ready. Chips were too big and bulky and there was no way for objects to communicate effectively. Processors that were cheap and power-frugal enough to be all but disposable were needed before it finally became cost-effective to connect up billions of devices. The adoption of RFID tags -- low-power chips that can communicate wirelessly -- solved some of this issue, along with the increasing availability of broadband internet and cellular and wireless networking. The adoption of IPv6 – which provides enough IP addresses for every device the world is ever likely to need -- was also a necessary step for the IoT to scale. Kevin Ashton coined the phrase 'Internet of Things' in 1999, although it took at least another decade for the technology to catch up with the vision.

历史
History

- 如上所述，为昂贵的设备上添加RFID标签以帮助跟踪其位置是最早的物联网应用之一。但从那时起，为物体添加传感器和互联网连接的成本持续下降，从而几乎可以将所有东西连接到互联网。最初商业和制造业对物联网最感兴趣，它的应用有时被称为机器对机器 (M2M)，但现在智能设备几乎填充我们的家庭和办公室，物联网几乎转变为与每个人都相关。对互联网连接设备的早期建议包括“blogjects”（将有关自己的数据发布到互联网上的博客对象）、泛在计算（或“ubicomp”）、隐形计算和普适计算，现在更多叫物联网。

  As mentioned above, adding RFID tags to expensive pieces of equipment to help track their location was one of the first IoT applications. But since then, the cost of adding sensors and an internet connection to objects has continued to fall, making it possible to connect nearly everything to the internet. The IoT was initially most interesting to business and manufacturing, where its application is sometimes known as machine-to-machine (M2M), but the emphasis is now on filling our homes and offices with smart devices, transforming it into something that's relevant to almost everyone. Early suggestions for internet-connected devices included 'blogjects' (objects that blog and record data about themselves to the internet), ubiquitous computing (or 'ubicomp'), invisible computing, and pervasive computing. Now, Internet of Things is a more popular term.

技术
Technologies

- 如前所述，虽然物联网的想法已经存在了很长时间，但一系列不同技术的最新进展使其变得实用：
  - 低成本、低功耗的传感器技术：经济实惠且可靠的传感器使物联网技术为更多制造商提供了可能。
  - 连接性：大量的互联网网络协议使得将传感器连接到云和其他“事物”变得容易，以实现高效的数据传输。
  - 云计算平台：云平台可用性的提高使企业和消费者都可以访问他们需要扩展的基础设施，而无需实际管理所有基础设施。
  - 机器学习和数据分析：随着机器学习和数据分析的进步，以及对存储在云中的各种海量数据的访问，企业可以更快、更轻松地收集洞察力。这些相关技术的出现继续推动物联网的前沿发展，物联网产生的数据也为这些技术提供了支持。
  - 对话式人工智能 (AI)：神经网络的进步为物联网设备（例如数字个人助理Alexa、Cortana和Siri）带来了自然语言处理 能力，并使其具有吸引力、价格合理且适合家庭使用。

技术

Technologies

- As aforementioned, while the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies has made it practical.
  - Access to low-cost, low-power sensor technology. Affordable and reliable sensors are making IoT technology possible for more manufacturers.
  - Connectivity. A host of network protocols for the internet has made it easy to connect sensors to the cloud and to other “things” for efficient data transfer.
  - Cloud computing platforms. The increase in the availability of cloud platforms enables both businesses and consumers to access the infrastructure they need to scale up without actually having to manage it all.
  - Machine learning and analytics. With advances in machine learning and analytics, along with access to varied and vast amounts of data stored in the cloud, businesses can gather insights faster and more easily. The emergence of these allied technologies continues to push the boundaries of IoT and the data produced by IoT also feeds these technologies.
  - Conversational artificial intelligence (AI). Advances in neural networks have brought natural-language processing (NLP) to IoT devices (such as digital personal assistants Alexa, Cortana, and Siri) and made them appealing, affordable, and viable for home use. 。

架构
Architecture

- 物联网系统架构是有一定争议的话题。从简单的角度来看，可认为物联网由三层组成：
- 第1层：设备，包括联网的各种设备，例如物联网设备中的传感器和执行器，特别是那些使用Modbus、蓝牙、Zigbee或专有协议等协议连接到边缘网关的设备。
- 第2层：边缘网关，由传感器数据聚合系统组成，这些系统提供例如数据预处理、保护与云的连接、基于WebSockets的系统、事件中心等功能，甚至在某些情况下，涵盖边缘分析或雾计算。边缘网关层还需要为上层提供设备的通用视图，以便于管理。
- 第3层：云，包括使用微服务架构为物联网构建的云应用程序，这些架构通常是多语言的，本质上是使用HTTPS/OAuth安全的。它包括存储传感器数据的各种数据库系统，例如使用后端数据存储系统（例如Cassandra、PostgreSQL）的时间序列数据库或资产存储。大多数基于云的物联网系统中的云层具有事件队列和消息传递系统，可处理在所有层中发生的通信。

架构
Architecture

- There are some dispute over the IoT system architecture among experts. In its simplistic view, IoT consists of three tiers:
- Tier 1: Devices, which include networked things, such as the sensors and actuators found in IoT equipment, particularly those that use protocols such as Modbus, Bluetooth, Zigbee, or proprietary protocols, to connect to an Edge Gateway.
- Tier 2: the Edge Gateway. This layer consists of sensor data aggregation systems that provide functionality, such as pre-processing of the data, securing connectivity to cloud, using systems such as WebSockets, the event hub, and, even in some cases, edge analytics or fog computing. Edge Gateway layer is also required to give a common view of the devices to the upper layers to facilitate in easier management.
- Tier 3: the Cloud. This final tier includes the cloud application built for IoT using the microservices architecture, which are usually polyglot and inherently secure in nature using HTTPS/OAuth. It includes various database systems that store sensor data, such as time series databases or asset stores using backend data storage systems (e.g. Cassandra, PostgreSQL). The cloud tier in most cloud-based IoT system features event queuing and messaging system that handles communication that transpires in all tiers.

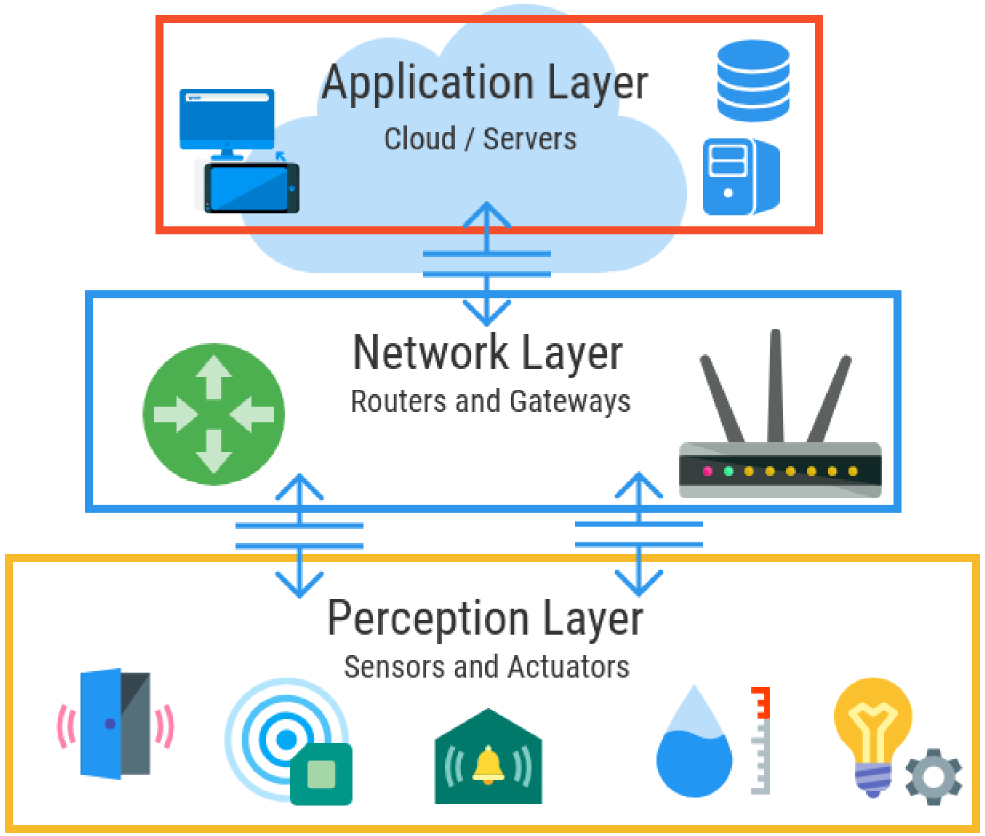
架构 Architecture

- 一些专家将物联网系统中的三层称为边缘层、平台层和业务层，它们分别通过局域网络、接入网络和服务网络连接。

  Some experts classified the three-tiers in the IoT system as edge, platform, and enterprise and these are connected by proximity network, access network, and service network, respectively.

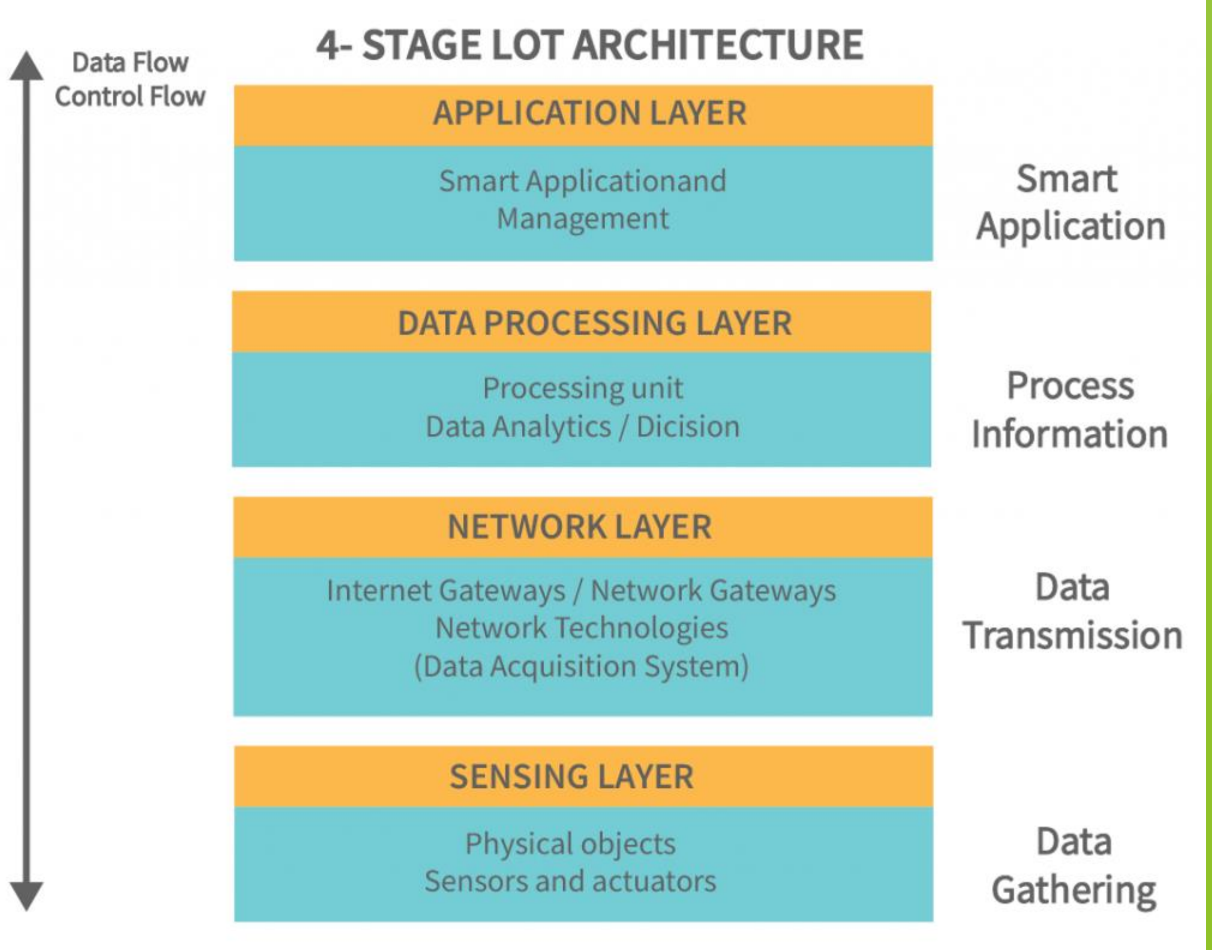
- 同样是三层架构，另一些专家将物联网系统中的三层称为感知层、网络层和应用层，而这些称谓与上面说法没有实质的差别，但实践中却更常用。

  For the three tiers perspective, another experts term the layers as perception layer, network layer, and application layer, which is more common in practice.



架构
Architecture

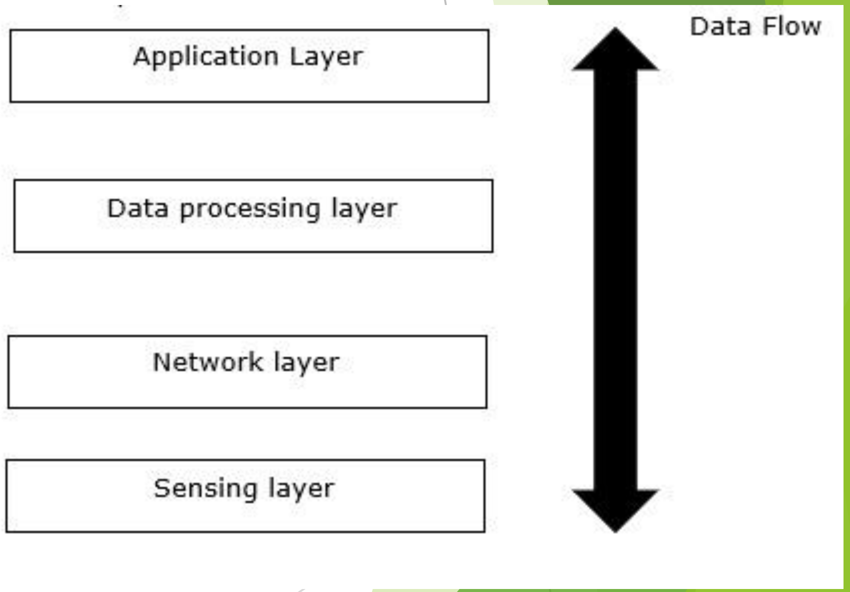
- 另外一种流行的观点是从数据流的角度，将物联网架构分为四层：
- 传感层—物联网的第一阶段，包括传感器、设备、执行器等，它们从物理环境中收集数据，对其进行处理，然后通过网络发送。
- 网络层—物联网的第二阶段，包括网络网关和数据采集系统。DAS将模拟数据（从传感器收集）转换为数字数据。它还执行恶意软件检测和数据管理。
- 数据处理层—物联网的第三阶段，是最重要的阶段。在这里，对数据种类进行了预处理并相应地进行了分离，然后被发送到数据中心。Edge IT在这里开始起作用。
- 应用层—物联网的第四阶段由云/数据中心组成，其中数据由农业、国防、医疗保健等具体应用程序管理和使用。



架构

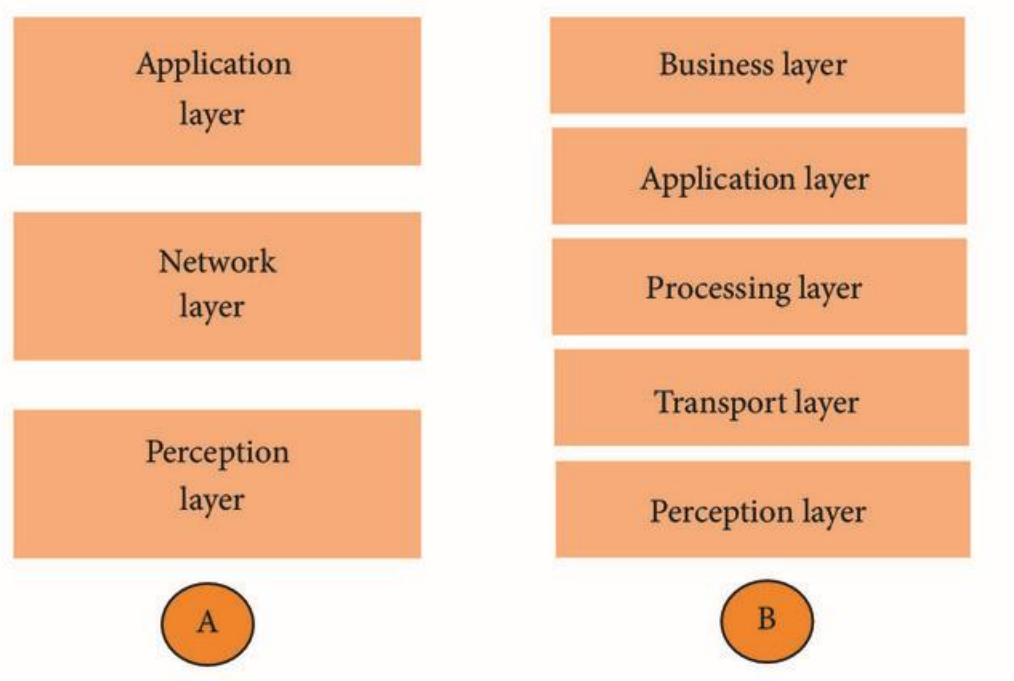
Architecture

- One popular viewpoint is from the data flow perspective, which architects the IoT into four layers:
- Sensing Layer − The first stage of IoT includes sensors, devices, actuators etc. which collect data from the physical environment, processes it and then sends it over the network.
- Network Layer − The second stage of the IoT consists of Network Gateways and Data Acquisition Systems. DAS converts the analogue data (collected from Sensors) into Digital Data. It also performs malware detection and data management.
- Data Processing Layer − The third stage of IoT is the most important stage. Here, data is pre-processed on its variety and separated accordingly. After this, it is sent to Data Centres. Here Edge IT comes into use.
- Application Layer − The fourth stage of IoT consists of Cloud/Data Centres where data is managed and used by applications like agriculture, defence, health care etc.



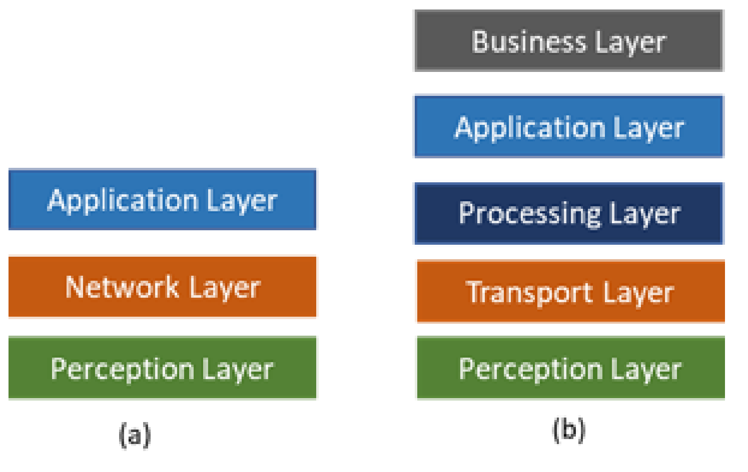
架构
Architecture

- 除此之外，还有一种流行的五层架构，其除了三层架构模型中的感知层和应用层外，还包括传输层（代替网络层）、处理层和业务层。
- 传输层：该层描述了感知层和处理层中的传感器通过各种网络进行的数据传输。
- 处理层：有时称为中间件层，它存储、分析和预处理来自传输层的数据。 在现代软件应用程序中，这通常位于云边缘以实现低延迟通信。
- 业务层：这一层通常被称为商业智能层。业务层位于比应用程序层更高的级别，描述了与利益相关者有关的一切。 决策将根据在应用层找到和使用的数据在这里完成。



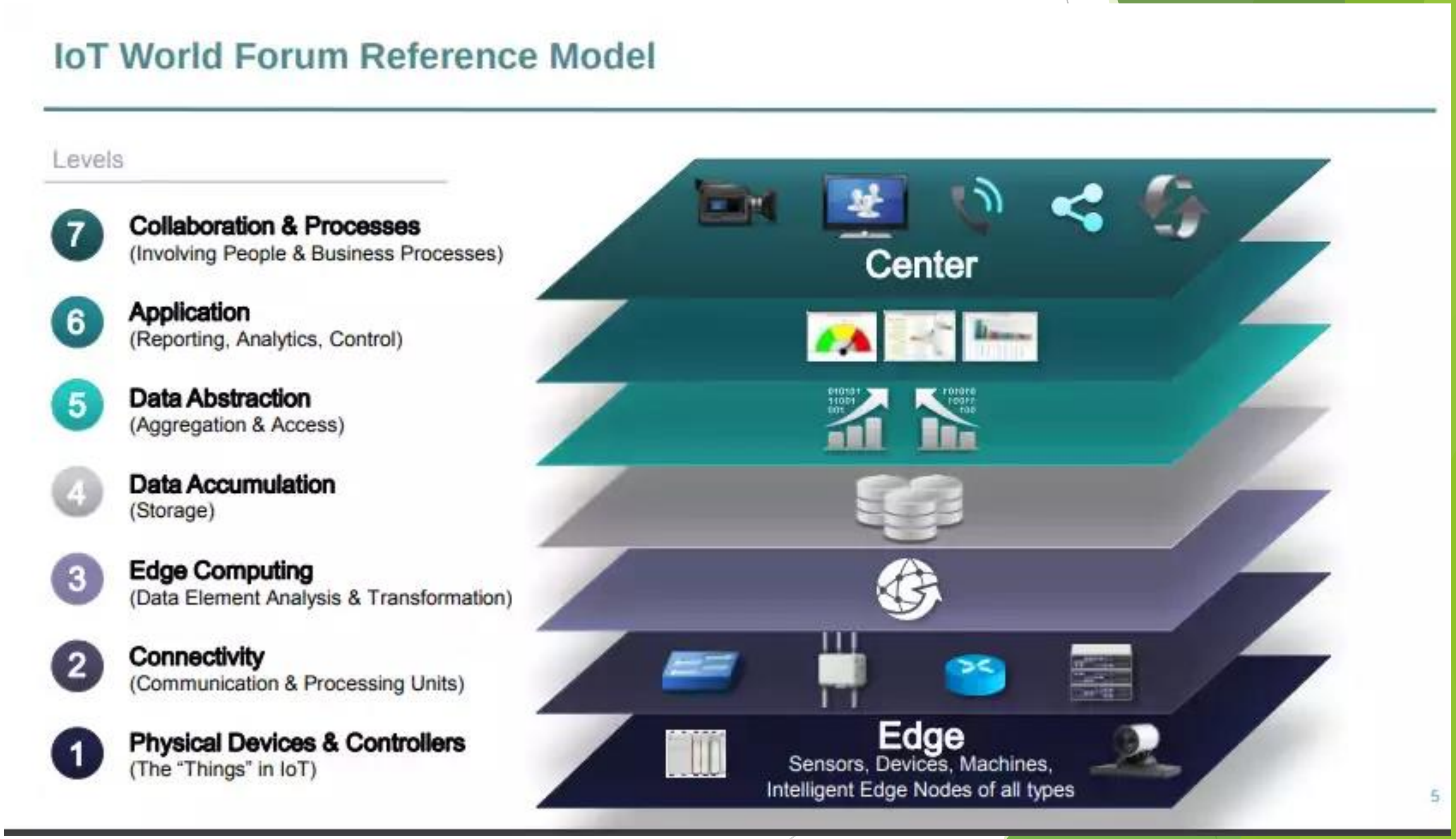
架构
Architecture

- Besides the three-layer architecture to describe an IoT project, a popular one is called the five-layer architecture, which includes Transport (replacing the Network), Processing, and Business layers, in addition to the Perception and Application layers from the three-layer architecture model.
- Transport: This layer describes the transfer of data between the sensors in the Perception layer and the Processing layer through various networks.
- Processing: Sometimes referred to as the Middleware layer, this one stores, analyzes, and pre-processes the data coming from the Transport layer. In modern software applications, this is often located on the edge of the cloud for low latency communications.
- Business: This layer is often referred to as the Business Intelligence layer. Located at a higher level than the Application layer, the Business layer describes everything that has to do with the stakeholders. Decision-making will be done here based on the data found and consumed at the Application layer.



架构
Architecture

- 更有甚者，思科、IBM和英特尔在2014年物联网世界论坛上推出的参考模型多达七层。
- Further, the Reference Model introduced in 2014 by Cisco, IBM, and Intel at the 2014 IoT World Forum has as many as seven layers.



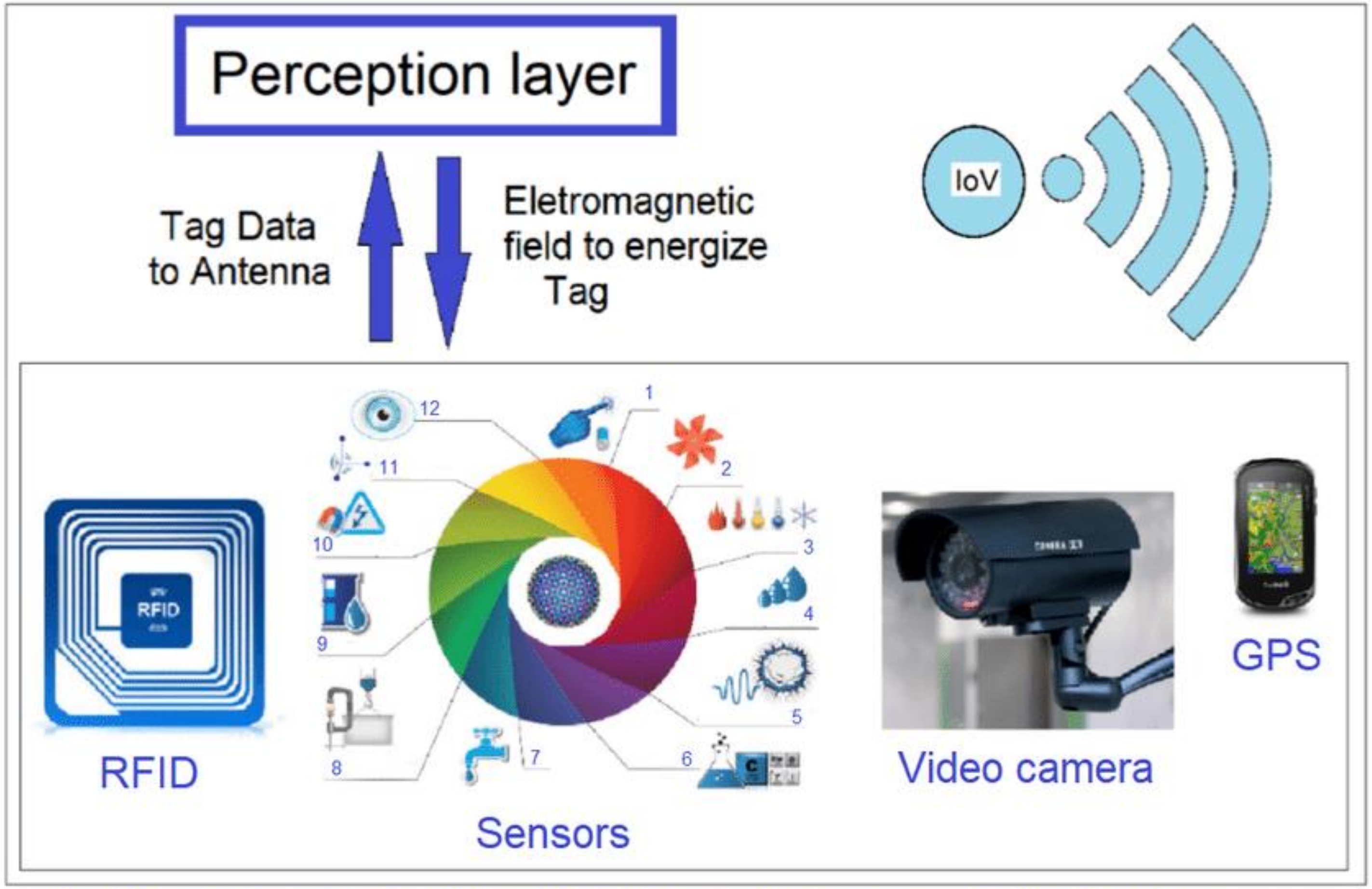
感知层
Perception Layer

- 任何物联网系统的底层都包含各种端点设备，它们的形式和大小各不相同，从微小的硅芯片到大型车辆，充当了现实世界和数字世界之间的桥梁。根据其功能，物联网设备可以分为以下几大类。
  - 传感器，如探头、仪表、仪表等。它们收集温度或湿度等物理参数，将其转化为电信号，并将其发送到物联网系统。物联网传感器通常很小并且消耗很少的功率。
  - 执行器，将来自物联网系统的电信号转换为物理动作。执行器用于电机控制器、激光器、机械臂。
  - 连接到传感器和执行器或将它们作为整体部件的机器和设备。
- 注意，物联网架构对其组件的范围或其位置没有任何限制。边缘层可以包括物理放置在一个房间中的一些“东西”或分布在世界各地的无数传感器和设备。

感知层
Perception Layer

- The initial stage of any IoT system embraces a wide range of “things” or endpoint devices that act as a bridge between the real and digital worlds. They vary in form and size, from tiny silicon chips to large vehicles. By their functions, IoT things can be divided into the following large groups.
  - Sensors such as probes, gauges, meters, and others. They collect physical parameters like temperature or humidity, turn them into electrical signals, and send them to the IoT system. IoT sensors are typically small and consume little power.
  - Actuators, translating electrical signals from the IoT system into physical actions. Actuators are used in motor controllers, lasers, robotic arms.
  - Machines and devices connected to sensors and actuators or having them as integral parts.
- It’s important to note that the architecture puts no restriction on the scope of its components or their location. The edge-side layer can include just a few “things” physically placed in one room or myriads of sensors and devices distributed across the world.

感知层
Perception Layer



1 Position/Presence/Proximity; 2 Motion/Velocity/Displacement; 3 Temperature; 4 Humidity/Moisture;
5 Accustic/Sound/Vibration; 6 Chemical/Gas; 7 Flow; 8 Force/Load/Torque/Strain/Pressure; 9 Leaks/Levels;
10 Electric/Magnetic; 11 Acceleration/Tile; 12 Machine Vision/Optical/Ambiente light

网络层
Network Layer

- 网络层负责构成物联网基础设施的设备、网络和云服务之间的所有通信。 物理层和云之间的连接通过两种方式实现：直接，使用 TCP 或 UDP/IP 堆栈；通过网关—硬件或软件模块执行不同协议之间的转换以及物联网数据的加密和解密。

  The network layer is in charge of all communications across devices, networks, and cloud services that make up the IoT infrastructure. The connectivity between the physical layer and the cloud is achieved in two ways: directly, using TCP or UDP/IP stack; via gateways — hardware or software modules performing translation between different protocols as well as encryption and decryption of IoT data.

- 设备与云服务或网关之间的通信涉及不同的网络技术，包括但不限于无线上网，NFC（近场通信）、蓝牙、LPWAN（低功耗广域网）、蜂窝网络等。

  The communications between devices and cloud services or gateways involve different networking technologies, including but not limit to WiFi, NFC (Near Field Communication), Bluetooth, LPWAN (Low-power Wide-area Network), ZigBee, Cellular networks, etc.

网络层
Network Layer

- 一旦物联网解决方案的某些部分联网，它们仍然需要消息传递协议来跨设备和与云共享数据。物联网生态系统中最流行的协议有：
  - DDS（数据分发服务）直接将物联网事物相互连接，并与满足实时系统要求的应用程序连接；
  - AMQP（高级消息队列协议）旨在服务器之间的点对点数据交换；
  - CoAP（受限应用协议），一种为受限设备设计的软件协议——内存和功率受限的终端节点（例如，无线传感器），其类似HTTP，但使用的资源更少；
  - MQTT（消息队列遥测传输），一种建立在TCP/IP堆栈之上的轻量级消息传递协议，用于从低功耗设备集中收集数据。

Protocol	Req.-Rep.	Pub.-Sub.	Standard	Transport	QoS	Security
REST HTTP	✓		IETF [41]	TCP	-	TLS/SSL
MQTT		✓	OASIS [42]	TCP	3 levels	TLS/SSL
CoAP	✓	✓	IETF [43]	UDP	Limited	DTLS
AMQP	✓	✓	OASIS [44]	TCP	3 levels	TLS/SSL
DDS		✓	OMG [45]	TCP/UDP	Extensive	TLS/DTLS/DDS sec.
XMPP	✓	✓	IETF [46]	TCP	-	TLS/SSL
HTTP/2.0	✓	✓	IETF [47]	TCP	-	TLS/SSL

网络层
Network Layer

- Once parts of the IoT solution are networked, they still need messaging protocols to share data across devices and with the cloud. The most popular protocols used in the IoT ecosystems are:
  - DDS (the Data Distribution Service) which directly connects IoT things to each other and to applications addressing the requirements of real-time systems;
  - AMQP (the Advanced Message Queuing Protocol) aiming at peer-to-peer data exchange between servers;
  - CoAP (the Constrained Application Protocol), a software protocol designed for constrained devices — end nodes limited in memory and power (for example, wireless sensors). It feels much like HTTP but uses fewer resources;
  - MQTT (the Message Queue Telemetry Transport), a lightweight messaging protocol built on top of TCP/IP stack for centralized data collection from low-powered devices.

应用层
Application Layer

- 应用层累积、存储和处理来自前一层的数据，通常通过两个主要阶段进行处理，即数据积累阶段和数据抽象阶段；然后，由软件分析以应对关键业务问题的信息。注意到物联网应用程序的复杂性和功能各不相同，使用不同的技术堆栈和操作系统。目前，应用程序可以直接构建在物联网平台之上，这些平台提供软件开发基础设施以及用于数据挖掘、高级分析和数据可视化的现成工具；物联网应用程序也可以使用API与中间件集成。最后，前面过程生成的信息只有带来解决问题的解决方案和实现业务目标才能带来价值，即在信息的基础上进行决策。
- The application layer accumulates, stores, and processes data that comes from the previous layer. All these tasks are commonly handled via IoT platforms and include two major stages, aka, data accumulation stage and data abstraction stage; Then, information is analyzed by software to give answers to key business questions. Note that IoT applications that vary in complexity and function, using different technology stacks and operating systems. Currently, applications can be built right on top of IoT platforms that offer software development infrastructure with ready-to-use instruments for data mining, advanced analytics, and data visualization. IoT applications can also use APIs to integrate with middleware. The information generated at the previous stages brings value if only it results in problem-solving solution and achieving business goals. Which means decisions are made based on the previous analyzed information.

开发工作
Development Work

- 典型的物联网系统通过实时收集和交换数据来工作，面向业务的物联网开发中，通常包含以下三个方面的工作：
- 智能设备：
  - 设计适配业务场景、具有计算能力的设备，以便从环境、用户输入或使用模式中收集数据，并通过互联网与物联网应用程序进行数据通信，并根据要求执行特定操作进行响应。
- 物联网应用物联网应用程序：
  - 设计特定的服务和软件的集合，能集成从各种物联网设备接收到的数据，并考虑使用机器学习或人工智能 (AI) 技术来分析这些数据并做出决定。同时这些决定能被传回物联网设备，保证物联网设备对输入做出智能响应。
- 图形用户界面：
  - 设计与业务契合的可以对物联网设备或设备群进行管理图形用户界面，例如，可用于注册和控制智能设备的移动应用程序或网站。

开发工作
Development Work

- A typical IoT system works through the real-time collection and exchange of data. Developing an IoT system usually means three kinds of work to do:
- Smart devices
  - To design a device with computing capabilities catering to the business requirement. It can collect data from its environment, user inputs, or usage patterns and communicates data over the internet to and from its IoT application and perform operations.
- IoT application
  - To implement a collection of services and software that integrates data received from various IoT devices. Considering to use machine learning or artificial intelligence (AI) technology to analyze this data and make informed decisions. Make sure these decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.
- A graphical user interface
  - To design a graphical user interface via which to manage the IoT device or fleet of devices. Common examples include a mobile application or website that can be used to register and control smart devices.

教育物联网
IoT in Education

- 在过去的几年里，教育已经通过许多改革措施得到发展。“教育”一词不仅仅限于教科书，还与儿童/个人接受教育的环境有关。技术极大地帮助提升了“学习”的质量和氛围，在改善教育方面取得了进展。如通过技术引入了数字阅读形式，帮助在课堂上成功实施了数字图书。因此，教育中的技术充当了学习的催化剂。但技术本身是一个巨大的概念，而最有影响力的方面之一是物联网。在物联网的有力支持下，教育行业已显式地攀登着成功的阶梯。
- Education has been developed by a series of reforms and measures over the past few years. The term ‘Education’ is not only limited to text books, but also is connected to the environment from where a child/individual is getting education from. Technology has helped tremendously in elevating the quality and ambience of ‘learning’, have made headway for the betterment of the Education sector. For example, the technology has introduced the digital form of reading and has helped in the successful implementation digital books in the classrooms. Hence, technology, in Education acts as a catalyst for learning. However, technology is a huge concept in itself. One of the most impactful aspects of technology is IoT. With the unbending support of IoT, the education sector has noticeably climbed the ladder of ascending success.

教育物联网
IoT in Education

- 将物联网应用于教育的例子有：交互式屏幕、智能黑板、语音转文字技术、考勤、教室网络摄像头、安全、电子手环、头部传感器、移动应用和平板、个人助理、智慧教室等。

  Application of IoT in the education sector includes interactive screens, smart boards, voice-to-text technology, attention to attendance, webcams in classrooms, safety, electronic bracelets, head sensors, mobile applications and tablets, assistant, smart classrooms, etc.

- 物联网在教育中的主要益处包括：改善学校管理、实时数据收集、全球覆盖、有趣的学习形式、组织流程的数字化、减少情绪压力、增强安全性、远程教育、改善学习体验、非接触式支付、个性化方法，密切监测学生健康，更好的资源管理。

  Key benefits of IoT in education includes: improved school management, real-time data collection, worldwide coverage, a fascinating learning format, digitalization of the organizational process, less emotional pressure, enhanced security, remote education, improved learning experience, contactless payments, individual approach, closely monitoring of the student health, better resource management.