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IoT Overview
What’s IoT?

Source: http://www.itworld.com/
Next Step for the Internet Evolution

Pre-internet

“HUMAN TO HUMAN”
- Fixed & mobile telephony
- SMS

Internet of CONTENT

“WWW”
- e-mail
- Information
- Entertainment
- ...

Internet of SERVICES

“WEB 2.0”
- e-productivity
- e-commerce
- ...

Internet of PEOPLE

“SOCIAL MEDIA”
- Skype
- Facebook
- YouTube
- ...

Internet of THINGS

“MACHINE TO MACHINE”
- Identification, tracking, monitoring, metering, ...
- Semantically structured and shared data...
- ...

+ smart networks
+ smart IT platforms & services
+ smart phones & applications
+ smart devices, objects, tags
+ smart data & ambient context

Source: Alcatel-Lucent

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THINGS AS A SERVICE (TaaS)
e.g. Thing Registration, Thing Virtualization, Thing Discovery
Data-Oriented IoT

DATA AS A SERVICE
(DaaS)

IoT Small/Big Data
Data Generation, Data Collection, Data Cleaning, Data Aggregation, Data Mining, Data Analytics
Service-Oriented IoT

Common Service Platform

Service Sources
- Smart Transportation System
- Smart Grid System
- Smart Health System

Enabling Technologies:
- WSDL: Web Service Description Language
- UDDI: Universal Description Discovery and Integration
- SOAP: Simple Object Access Protocol
- AMQP: Advanced Message Queuing Protocol
- MQTT: Message Queuing Telemetry Transport

Service Consumers
- eHealth Application
- Energy Applications
- Transportation Applications
IoT Protocols
IoT Protocols and Standards

**SDO**
- oneM2M, ETSI M2M, OMA, W3C, IEEE

**PROTOCOL STACK**
- APPLICATION
- SERVICE LAYER
- APPLICATION PROTOCOL LAYER
- TRANSPORT LAYER
- NETWORK LAYER
- LINK LAYER

**STANDARDS & PROTOCOLS**
- oneM2M RoA/SoA
- ETSI TC M2M SCL
- OMA GwMO, DMNG, M2M Interface, LWM2M
- W3C WSDL
- IEEE NGSON
- HTTP, CoAP, XMPP
- MQTT, AMQP
- Security: DTLS, TLS
- 6LoWPAN (Neighbor Discovery, Header Compression)
- ROLL (Routing)
- 6TiSCH (Path Schedule)
- 3GPP MTC
- 802.15.x (e.g. 1, 2, 4, 8, etc.)
## IoT Protocol Stack (1/2)

<table>
<thead>
<tr>
<th>ISO/OSI Reference Model</th>
<th>IoT Protocol Stack</th>
<th>TCP/IP Protocol Stack</th>
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<tbody>
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<td>Application Layer</td>
<td>Applications</td>
<td>Application Layer</td>
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<td>Service Layer</td>
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<tr>
<td></td>
<td>(oneM2M, ETSI M2M, OMA, BBF)</td>
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<tr>
<td>Presentation Layer</td>
<td>Application Protocol Layer</td>
<td>Transport Layer</td>
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<tr>
<td></td>
<td>(HTTP, CoAP, XMPP, AMQP, MQTT)</td>
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<tr>
<td></td>
<td>(NETCONF, SNMP, mDNS, DNS-SD)</td>
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<tr>
<td>Session Layer</td>
<td>Transport Layer</td>
<td>Internet Layer</td>
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<tr>
<td></td>
<td>(TCP, MPTCP, UDP, DCCP, SCTP)</td>
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<td></td>
<td>(TLS, DTLS)</td>
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<tr>
<td>Network Layer</td>
<td>Network Layer</td>
<td>Link Layer</td>
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<tr>
<td></td>
<td>(IPv4, IPv6, 6LoWPAN, ND, DHCP, ICMP)</td>
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<tr>
<td>Data Link Layer</td>
<td>PHY/MAC Layer</td>
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<tr>
<td>Physical Layer</td>
<td>(3GPP MTC, IEEE 802.11, IEEE 802.15)</td>
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</tr>
</tbody>
</table>
Messaging Protocols for IoT

**SYNCHRONOUS REQUEST / RESPONSE (HTTP)**

- **Server (Resources)**
  - Request
  - Response

- **Client (Requester)**

**ASYNCHRONOUS REQUEST / RESPONSE (CoAP)**

- **Server (Resources)**
  - Request
  - Acknowledgement
  - Response

- **Client (Requester)**

**STREAMED REQUEST / RESPONSE (XMPP)**

- **Server (Resources)**
  - Connection Establishment
  - Message Exchange
  - Disconnection

- **Client (Requester)**

**SUBSCRIPTION/ NOTIFICATION (MQTT, AMQP, CoAP)**

- **Server (Resources)**
  - Subscription
  - Broker / Queue
  - Notification
  - Response

- **Client (Requester)**
C6-based SMART IoT

Creating the Living Network
M2M Evolution to IoT

M2M is communication among machines to manipulate content/data

Current M2M
- Connectivity: connection for machines;
- Content: massive raw data from things;

Evolution to IoT
- Cloud: cloud service and XaaS for IoT;
- Context: context-aware design;
- Collaboration: collaborative services;
- Cognition: semantics and autonomous system adjustment

IoT is communication to/from things which offer new services via cloud/context/collaboration/cognition technologies

M2M Service Platform → IoT Service Platform with C6 Capabilities
Creating the Living Network

SMART = Scalable + Manageable + Adaptable + Reliable + Trustworthy

C6 = Content+Context + Connectivity+Cloud + Collaboration+Cognition
Smart IoT Protocols
Context-Aware Neighbor Discovery Protocol

1. Router Solicitation (Multicast or Unicast)
   \[\text{SLLAO + CIO}\]

2. Process CIO Option

3. Router Advertisement (Unicast)
   \[\text{PIO + 6CO + ABRO + SLLAO + CIO}\]

4. Process CIO Option

5. Router Advertisement (Periodical Multicast)
   \[\text{PIO + 6CO + ABRO + SLLAO + CIO}\]

How to find matching 6LNs and 6LRs?

6LoWPAN

- **Feature**: Potentially high traffic load
  - **Expect**: 6LRs closer to the 6BR

- **Feature**: Low mobility, temperature sensor
  - **Expect**: 6LRs supporting data aggregation

- **Feature**: High mobility and battery-powered
  - **Expect**: 6LRs supporting mobility and 6LoWPAN ND

Support: Data Aggregation, Various ND (Legacy ND, 6LoWPAN ND, etc.)

Expect: 6LNs with temperature sensors and low mobility

Support/Feature: Mobility, 6LoWPAN ND, Closer to 6LBR, etc.

Expect: 6LNs with high traffic load and high mobility

Support/Feature: Low mobility, temperature sensor

Expect: 6LRs supporting data aggregation

Support/Feature: Potentially high traffic load

Expect: 6LRs closer to the 6BR

Support/Feature: High mobility and battery-powered

Expect: 6LRs supporting mobility and 6LoWPAN ND

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Expect: 6LRs closer to the 6BR

Support/Feature: High mobility and battery-powered

Expect: 6LRs supporting mobility and 6LoWPAN ND
Future Directions & Challenges

Creating the Living Network
**IoT over ICN: In-Network IoT Data Caching?**

**Tradeoff between Freshness and Communication Cost**

- **IoT Data Source**
- **Measurement & monitoring**
  - Temperature
  - Humidity
  - Wind speed

- **ICN as Transport**

- **IOT Services**

- **IOT Data/Content**

- **Underlying Networks**

- **Requester Application**
  - Weather forecast/news website
  - Mobile app.

- **End-user**
  - Smart phone
  - Home/office computer
  - Automation centre computer

- **Content Router**

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Social IoT: Humans in the Loop

Interactions between IoT and Social Networks

- Internet of Bodies
- Internet of Vehicles
- Internet of Cities

Social Relation among Things

Physical-to-Cyber (P2C) Interface

Cyber-to-Social (C2S) Interface

Physical-to-Social (P2S) Interface
Based on social connectivity or relations with other things, Clock can interact with different things (e.g., flight schedule), for instance, to intelligently manage and adjust people’s other activities (e.g., meetings). This will be heavily relied on the cognition that IoT systems can provide.
“Google and Nest have the potential to do great things together for users and consumers, but don’t expect that to happen without users giving up some more of their precious data to the search giant. All that remains to be seen is how that will happen, and what people get in exchange for that access.”
Thank You!

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