جهاد دانشگاهی
۱۳۵۹
واحد علامه طباطبایی

دهمین نشست تخصصی همگرایی اینترنت اشیاء ، داده های حجیم و رایانش ابری

گروه آموزشی و پژوهشی سیب

شهریور نود و هفت

Internet Of Things

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Z Koohnavard

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فهرست

- آشنایی با اینترنت اشیاء
- معماری اینترنت اشیاء
- معرفی لایه اول
- معرفی لایه دوم
- معرفی زیرلایه دسترسی
- معرفی تکنولوژی ها و پروتکل های لایه ارتباط

تعریف کلی اینترنت اشیاء

IOT فناوری مدرنی است که در آن برای هر موجودی اعم از انسان، حیوان و یا اشیاء، قابلیت ارسال داده از طریق شبکه های ارتباطی (اینترنت یا اینترانت) فراهم می‌شود و جهانی را توصیف می‌کند که در آن هر چیزی، از جمله اشیای بی‌جان، برای خود هویت دیجیتال دارند و به کامپیوترها اجازه می‌دهند آنها را ساماندهی کنند.

“Thing” connected to the internet

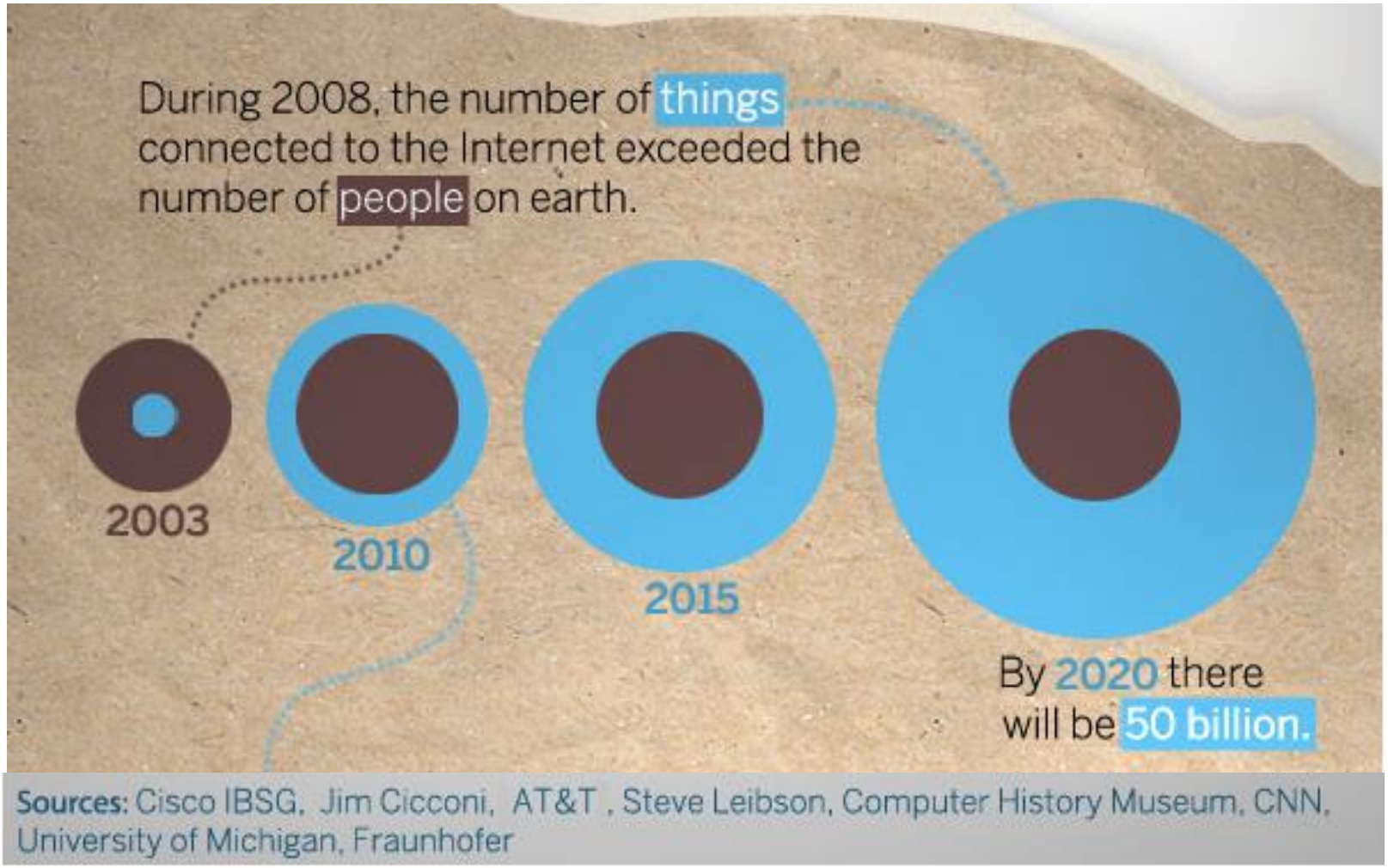
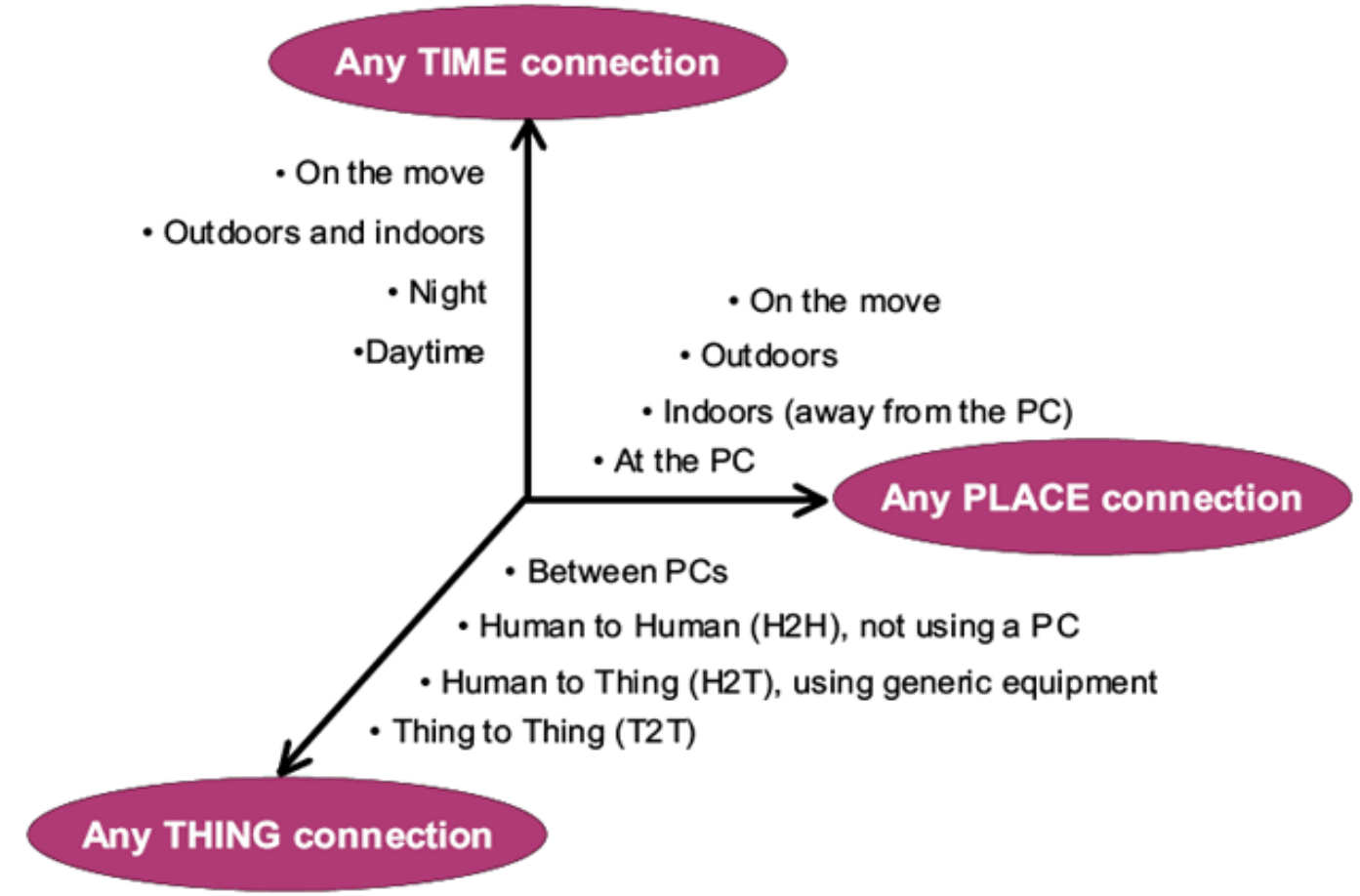


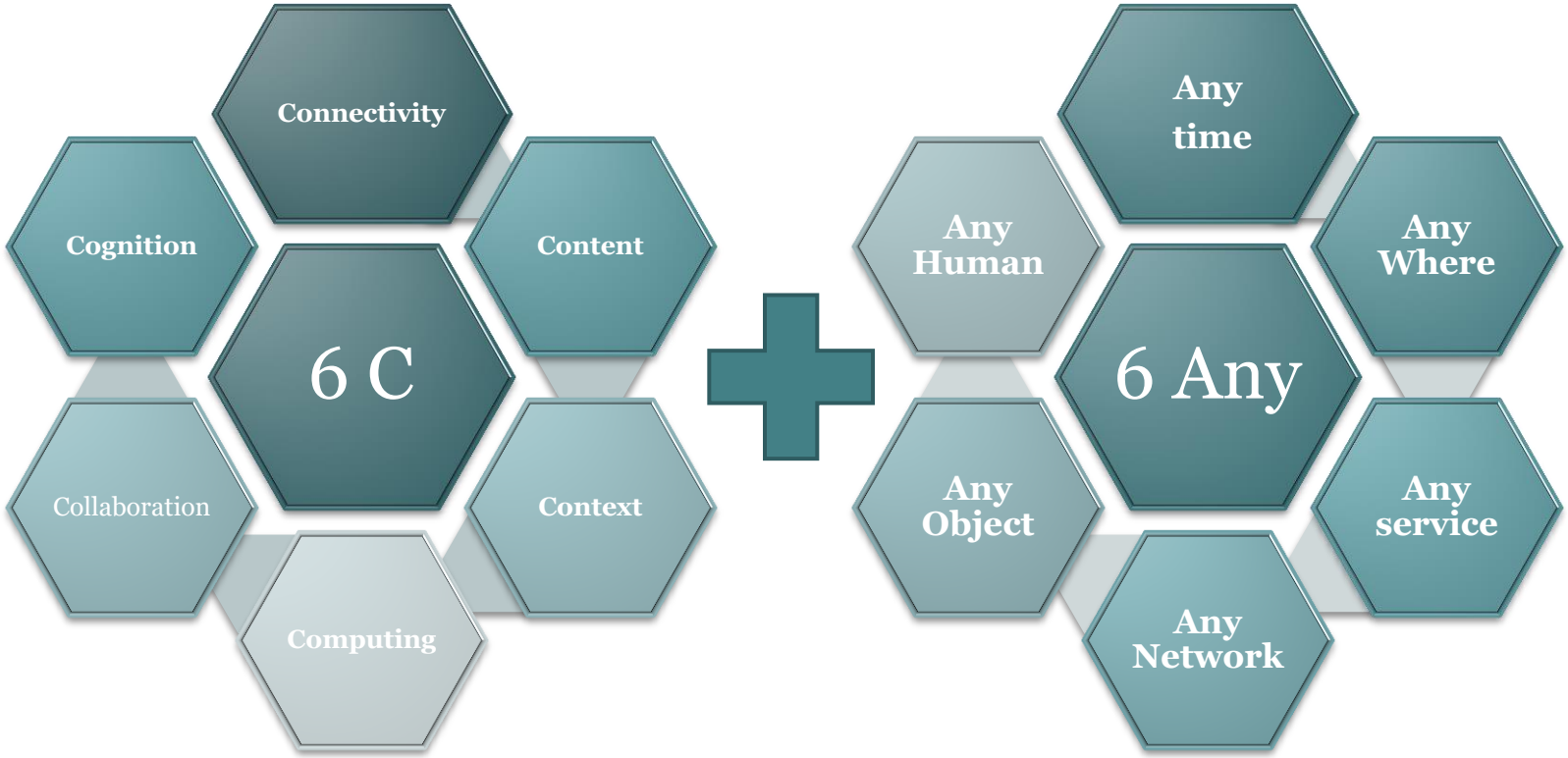
Image Courtesy: : CISCO

Future Networks

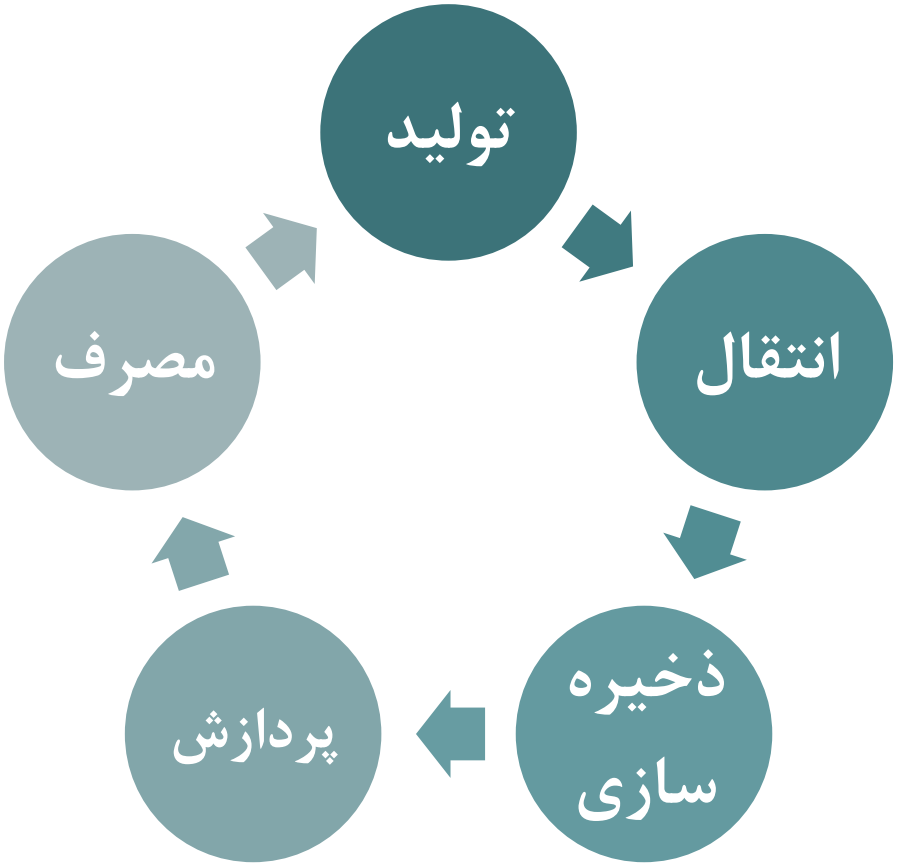


Source: ITU adapted from Nomura Research Institute

جامعه آکادمیک 6 C و 6 Any برای اینترنت اشیاء متصور است



چرخه اطلاعاتی در اینترنت اشیاء

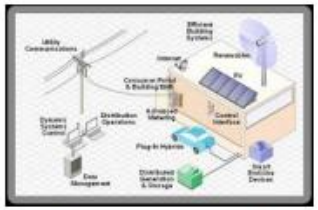


What's smart?

- Old: Smart = Can think ⇒ Computation
  = Can Recall ⇒ Storage
- Now: Smart = Can find quickly, Can Delegate ⇒
  Communicate = Networking

Not-Smart Smart

کاربردهای اینترنت اشیاء

 Smart Grid	 Smart Health	 Smart Home
 Smart Cities	 Smart Industries	 Smart TV
 Smart Watch	 Smart Car	 Smart Kegs

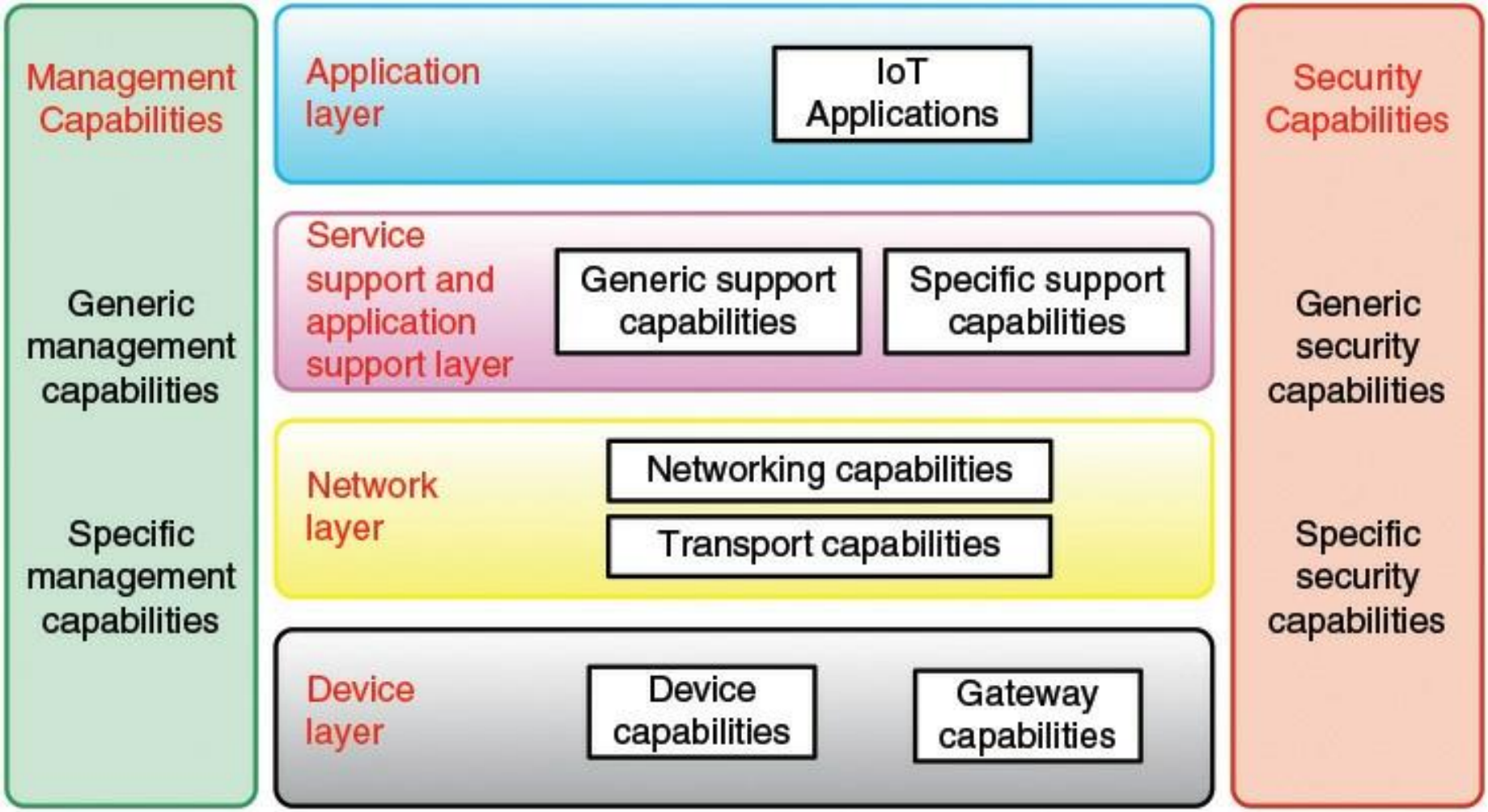
چالش‌های اینترنت اشیاء

- مدیریت داده‌ها
- داده‌کاوی
- حریم خصوصی
- امنیت
- هرج و مرج

معماری اینترنت اشیاء

- تهیه چک لیست
- راهنما برای توسعه دهندگان
- فریمورکی جهت استاندارد سازی، افزایش سطح تعامل و کاهش هزینه

مدل مرجع ITU-T



مدل مرجع ITU-T

لایه توانایی‌های مدیریتی

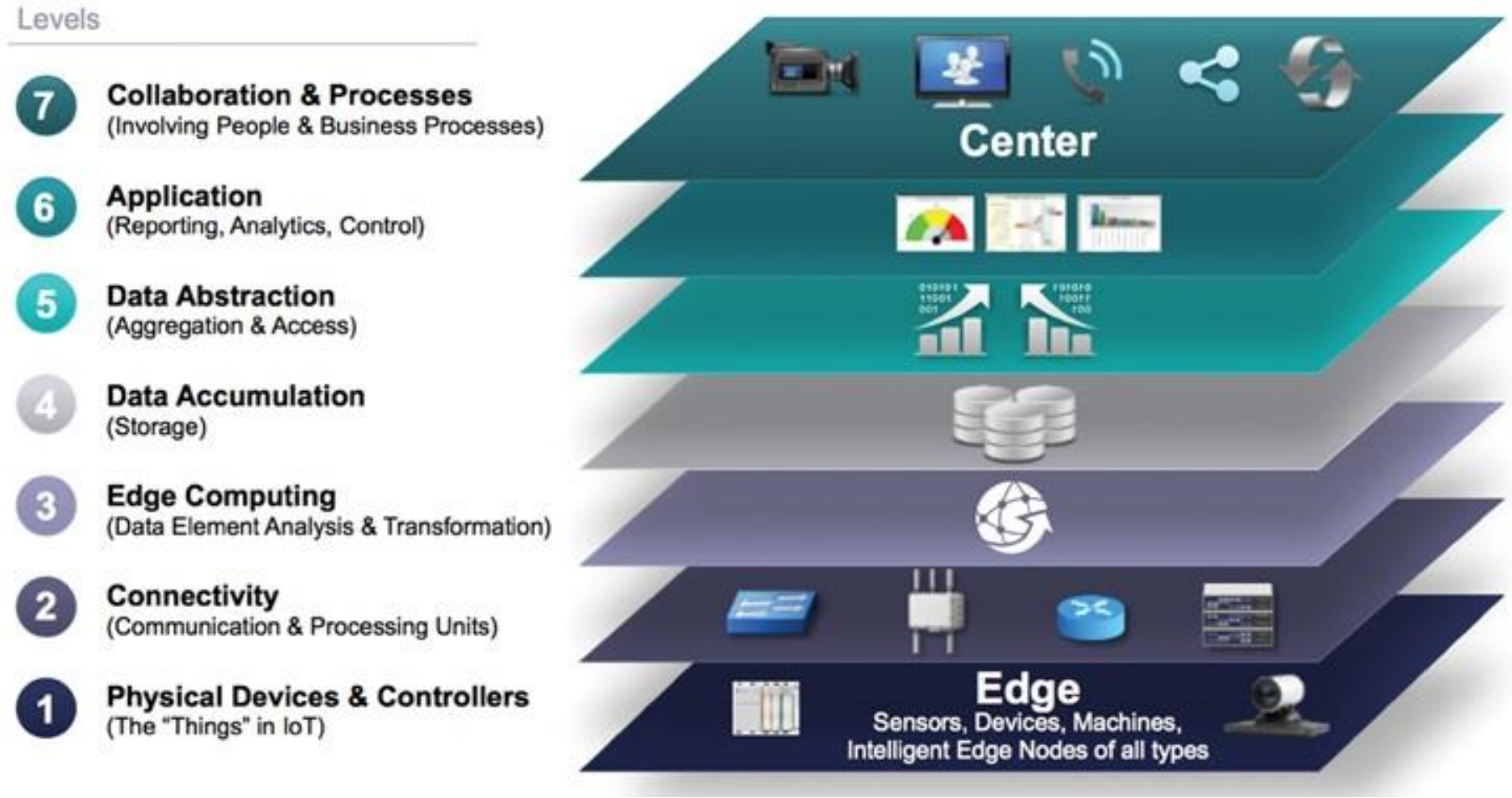
- توانایی‌های عمومی
  - مدیریت دستگاه
  - مدیریت توپولوژی شبکه محلی
  - مدیریت ترافیک و تراکم
- توانایی‌های اختصاصی

مدل مرجع ITU-T

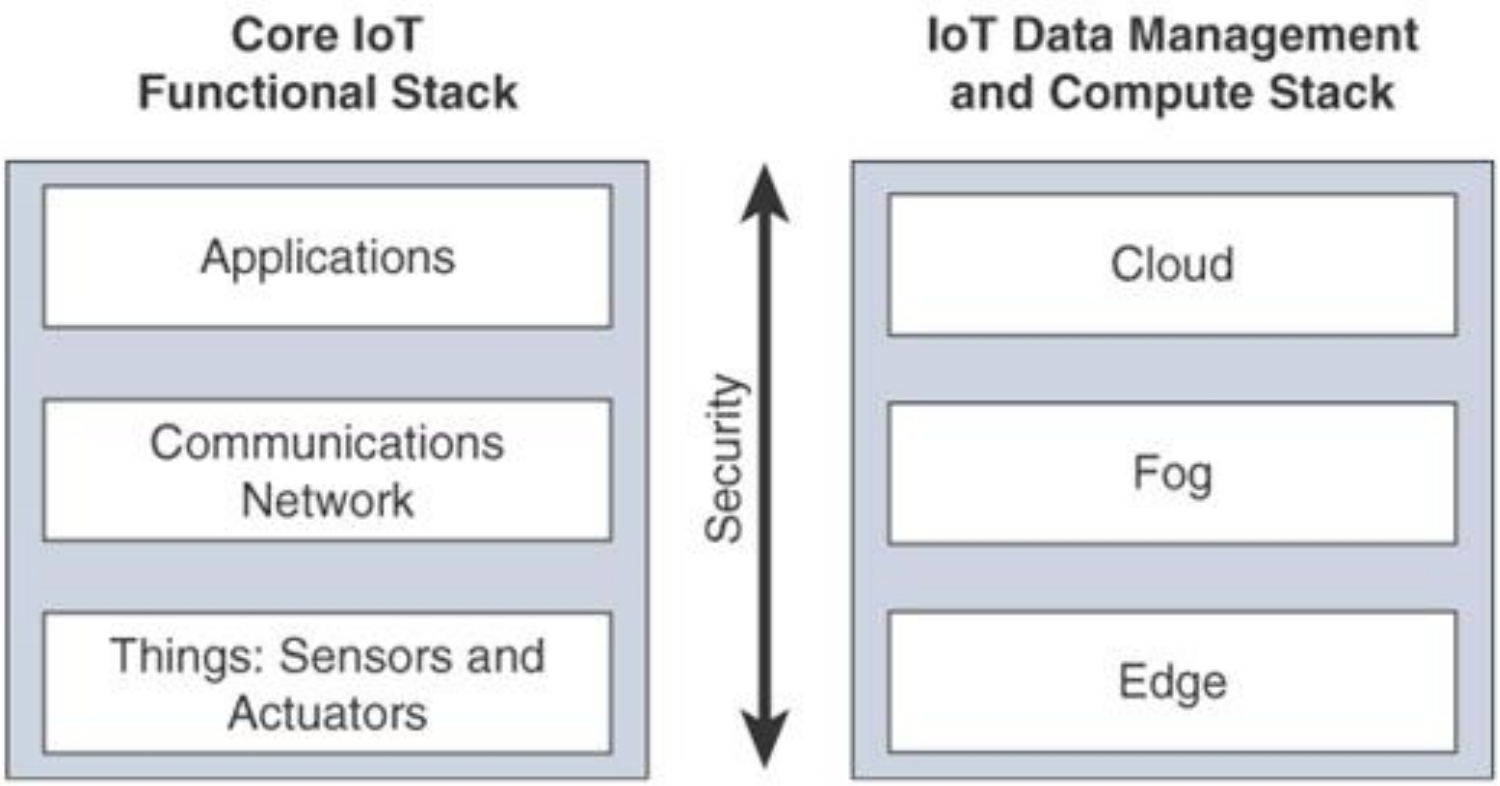
لایه توانایی‌های امنیتی

- توانایی‌های عمومی
- لایه برنامه‌های کاربردی
- لایه شبکه
- لایه دستگاه
- توانایی‌های اختصاصی

مدل مرجع IOT World Forum



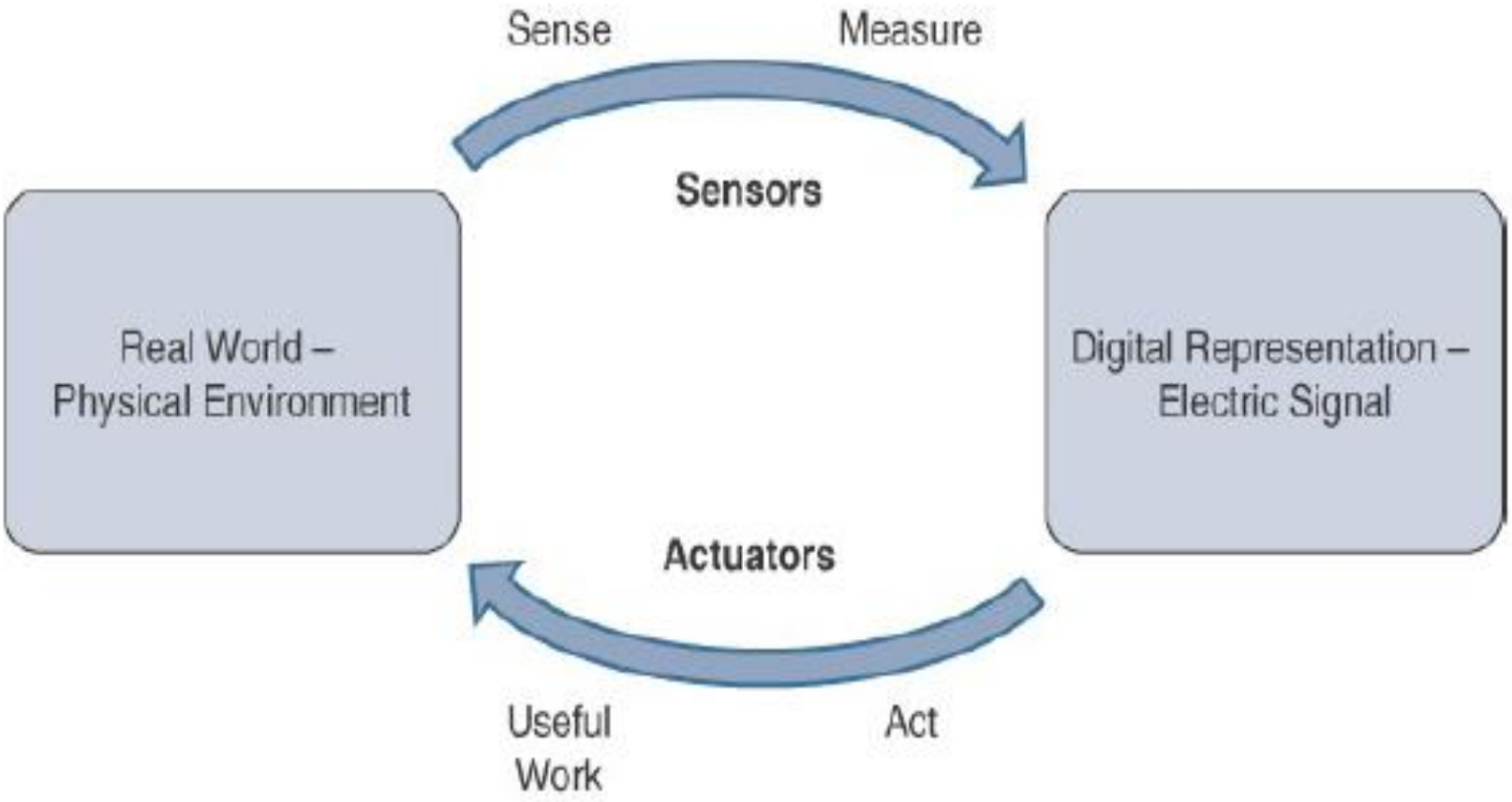
معماری ساده شده از اینترنت اشیاء



پروتکل های مطرح در اینترنت اشیاء

Session	MQTT, SMQTT, CoRE, DDS, AMQP , XMPP, CoAP, IEC, IEEE 1888, …	**Security**	**Management**
Network	Encapsulation 6LowPAN, 6TiSCH, 6Lo, Thread… Routing RPL, CORPL, CARP	IEEE 1888.3, TCG, Oath 2.0, SMACK, SASL, EDSA, ace, DTLS, Dice, …	IEEE 1905, IEEE 1451, IEEE 1377, IEEE P1828, IEEE P1856
Datalink	WiFi, Bluetooth Low Energy, Z-Wave, ZigBee Smart, DECT/ULE, 3G/LTE, NFC, Weightless, HomePlug GP, 802.11ah, 802.15.4e, G.9959, WirelessHART, DASH7, ANT+, LTE-A, LoRaWAN, ISA100.11a, DigiMesh, WiMAX, …		

حسگر و عملگر


Sense
Measure
Sensors
Real World –
Physical Environment
Digital Representation –
Electric Signal
Actuators
Useful
Work
Act

لایه شبکه ارتباطی

- Access network sublayer
- Gateways and backhaul network sublayer
- Network transport sublayer
- IoT network management sublayer

زیرلایه شبکه دسترسی

- تکنولوژی شبکه ارتباطی اینترنت اشیاء
- روش دسترسی به شبکه مبتنی بر تکنولوژی
- تکنولوژی بر اساس:
  - اتصال چگونه بر قرار میشود؟
  - اتصال کجا بر قرار میشود؟
  - چه داده ای ارسال میشود؟
  - داده ها در چه فاصله زمانی ارسال میشود؟
  - ...

الگوهای ارتباطی

- Device-to-device within same network
- Device-to-cloud
- Device-to-ALG (to cloud or another local network)
- Back-end data sharing

Device-to-Device Pattern

- Device talks directly to another local device (often smart phone or a wearable)
- Security & trust often based on direct relationship between the devices (pairing)
- Rarely uses IP today but apps instead directly sit over link layer protocol
  - Bluetooth, Z-Wave, ZigBee, …

مثال

Hearing Aid

Suunto Ambit 3

StickNFind

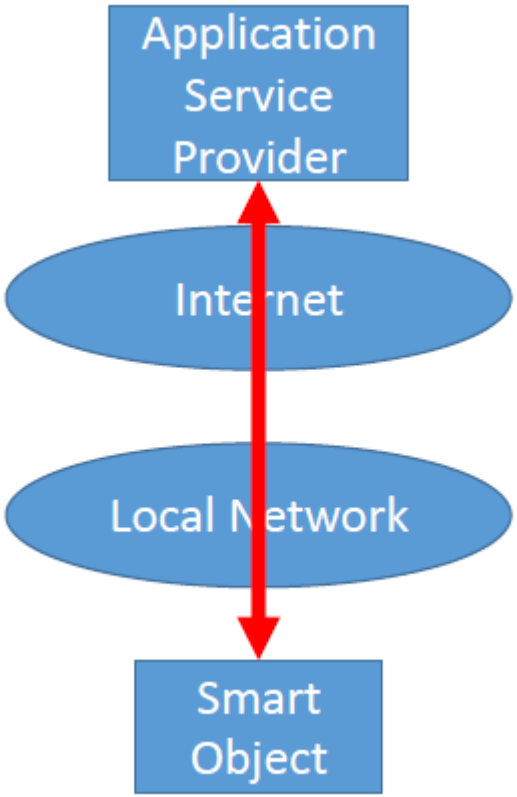
Beacons

Parrot

Cadence Sensor

Device-to-Cloud Pattern

- Device connects directly to some cloud service
- Allows users to access data/device from anywhere
- Requires choosing L2 already widely deployed, e.g. WiFi
- Often service and device are from same vendor



مثال

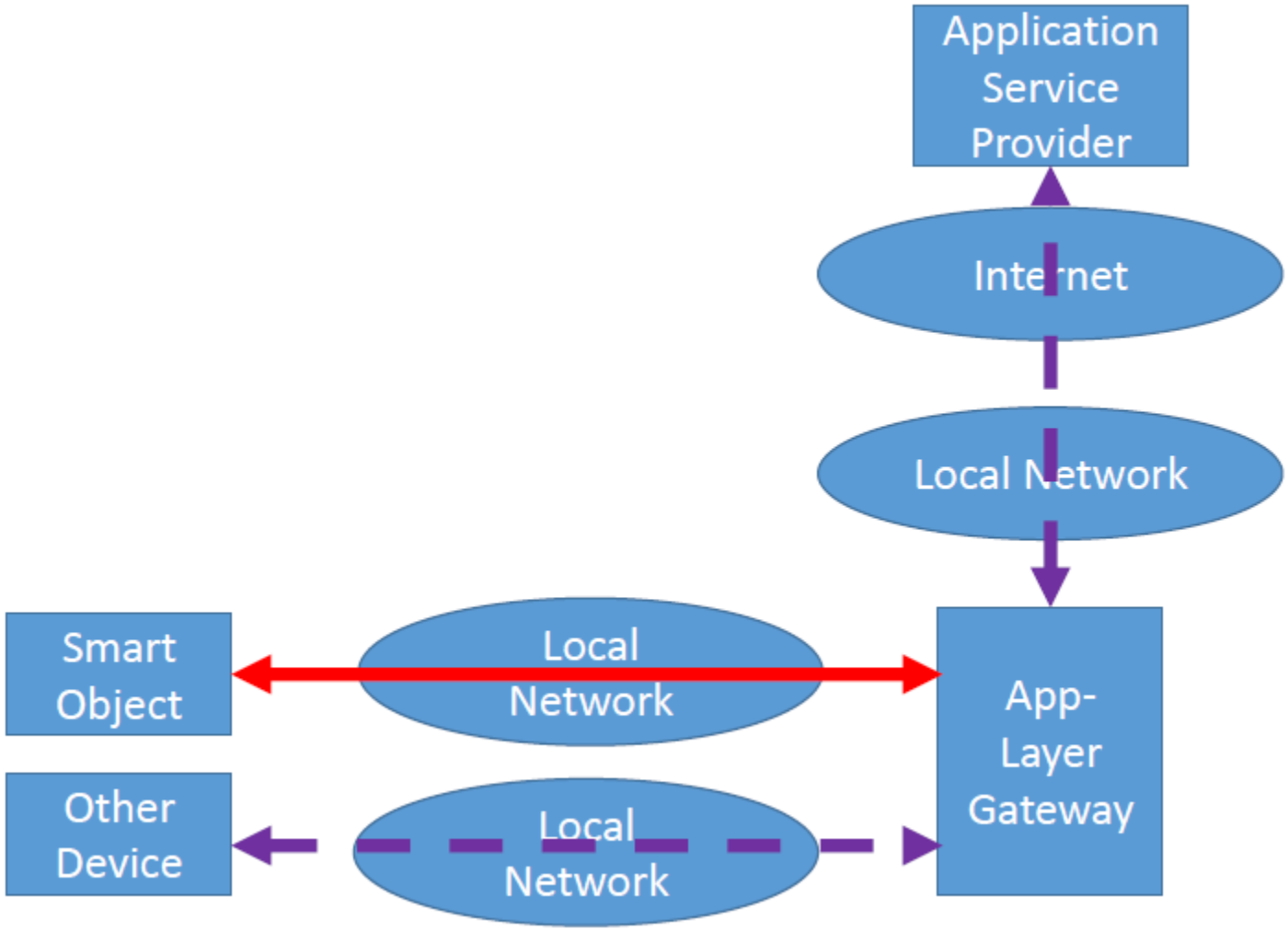
Tractive

Withings Scale

Device-to-ALG Pattern

- Typically used in any of these cases:
  - Uses L2 media not already ubiquitous (e.g., 802.15.4)
  - Special local authentication/authorization is required
  - Interoperability needed with legacy non-IP devices
- Often ALG and device are from same vendor

Device-to-ALG Pattern cont'd



مثال

NXP Janet-IP

Nest

Revolv Smart Home Gateway

Philips Hue

تلفن همراه در نقش ALG

Zepp Golf
Sensor

Oral-B Toothbrush

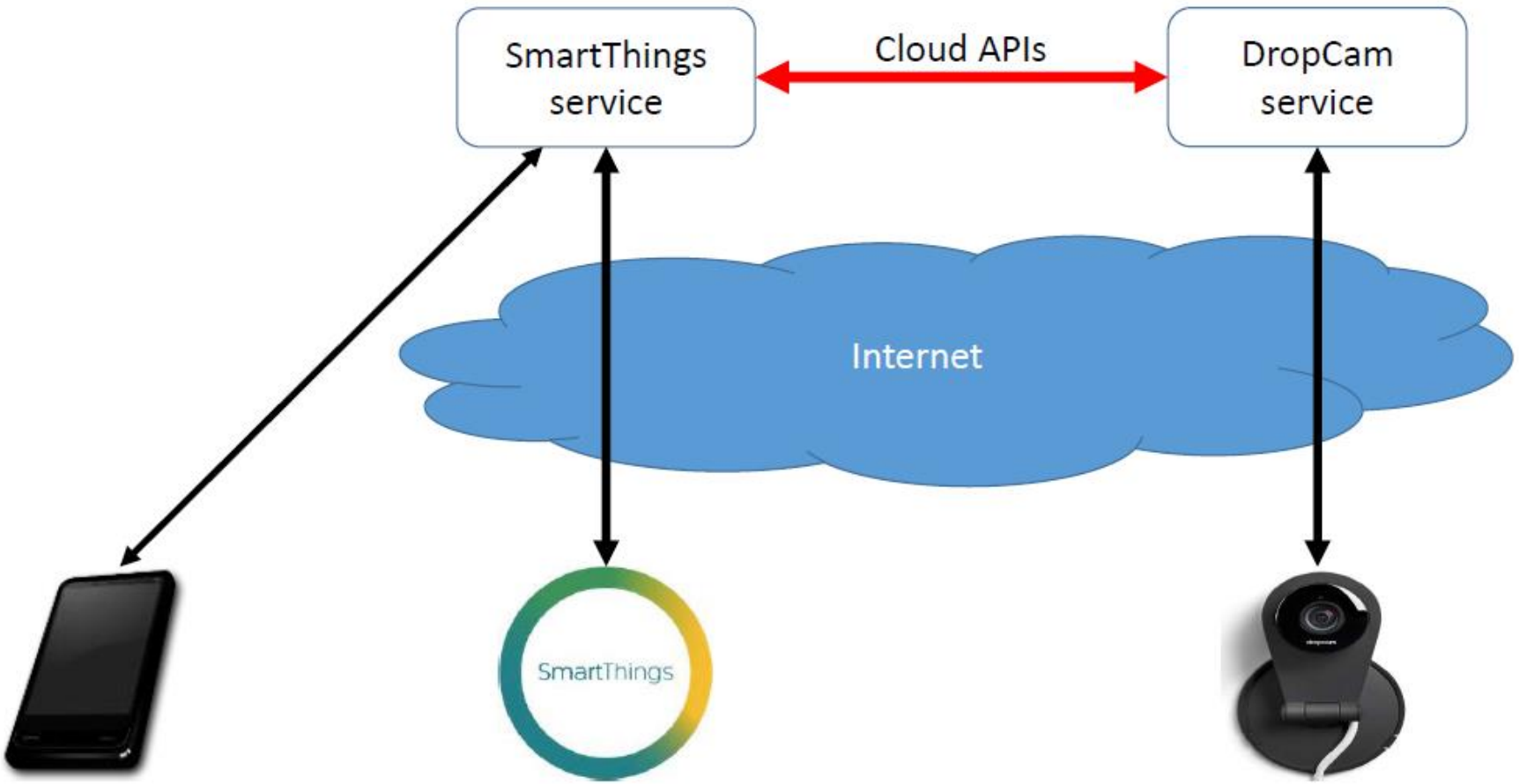
Fitbit

Garmin
Forerunner 920XT

Back-end Data Sharing Pattern

- Intentionally or simply due to lack of any standardization
- Many usage scenarios need data/devices from multiple sources
- Results in federated cloud services and/or (often RESTful) cloud APIs
- Standard protocols (HTTP, OAuth, etc.) help but are not sufficient
- Standardized information models generally outside scope of IETF

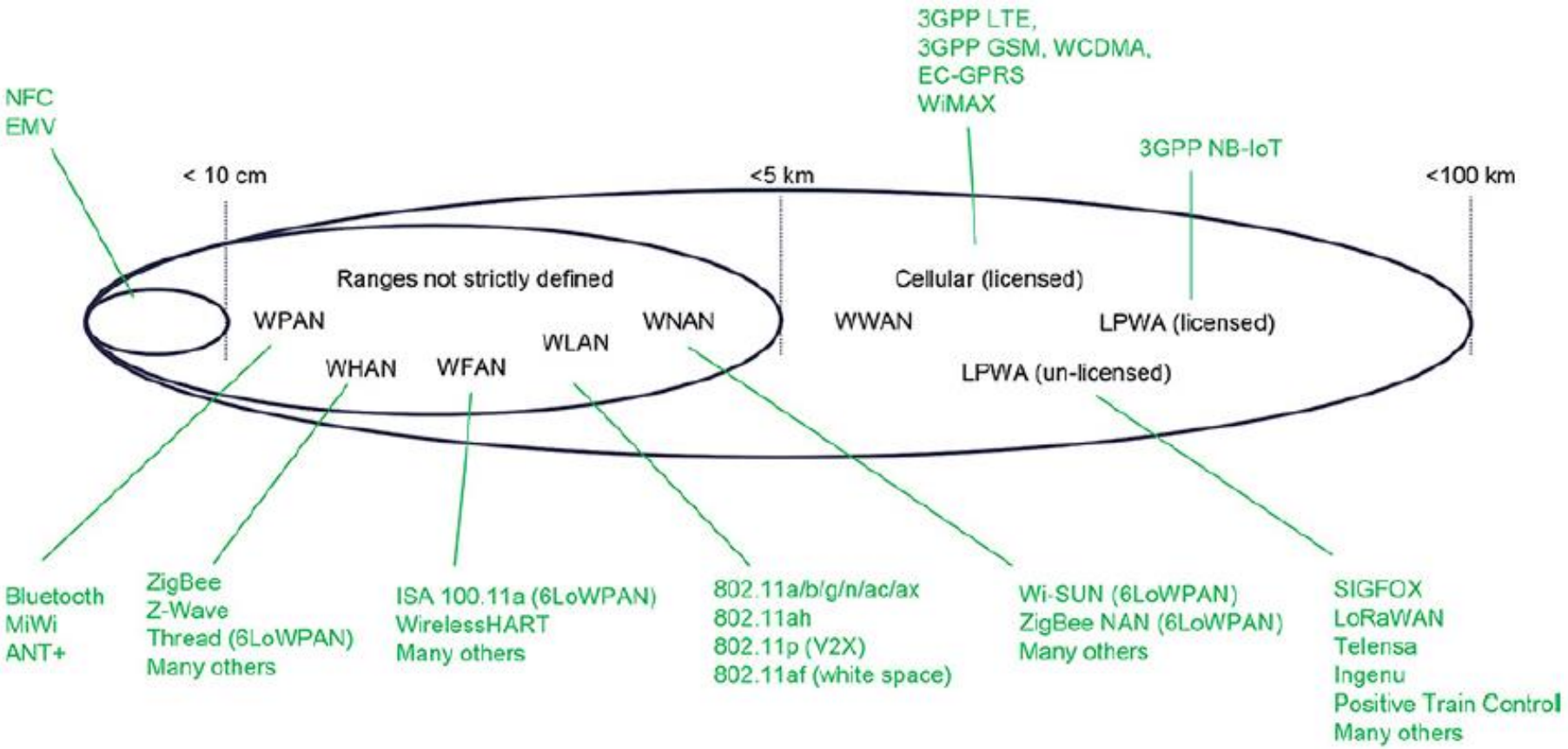
مثال


SmartThings service
Cloud APIs
DropCam service
Internet
SmartThings

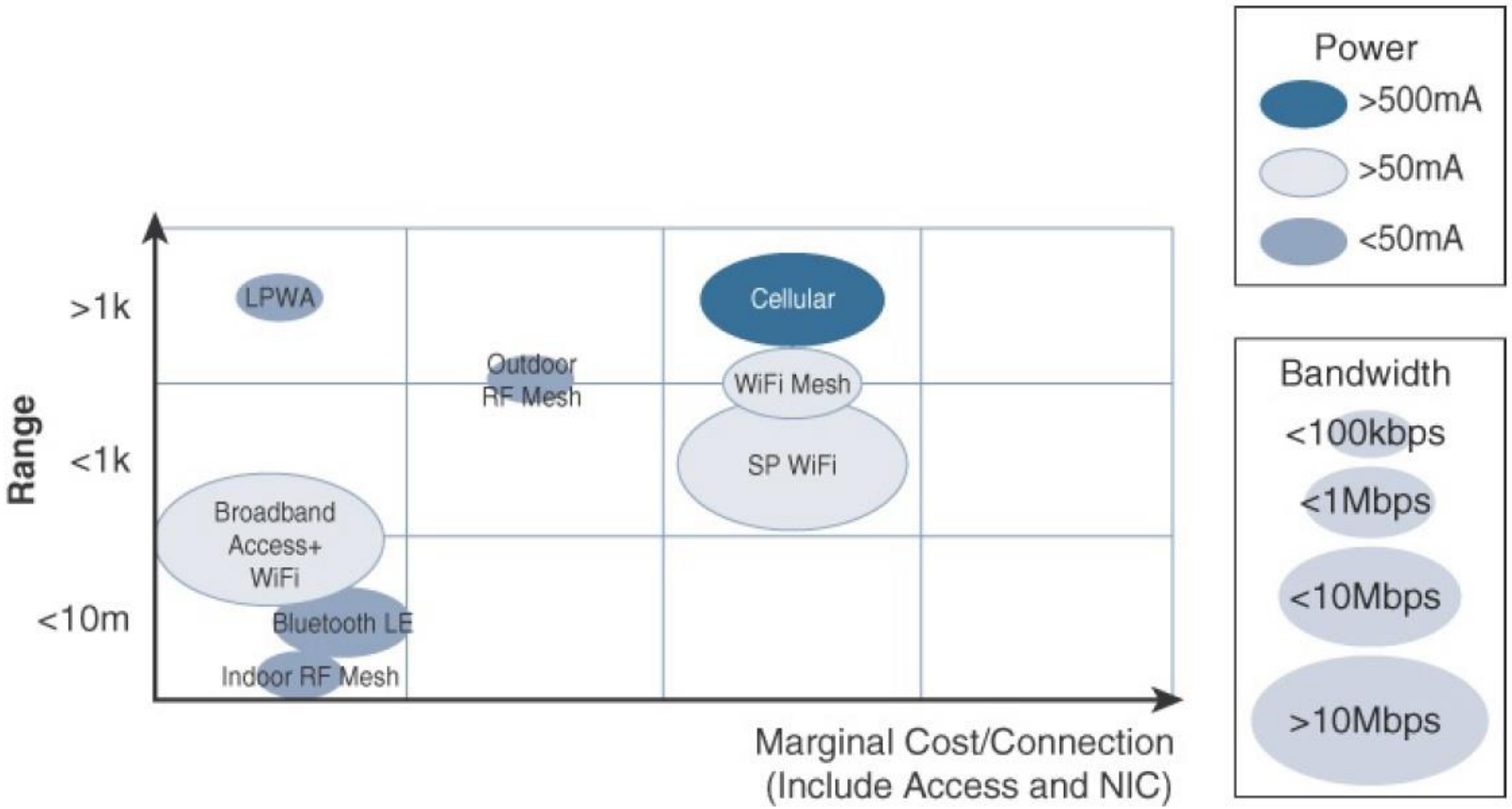
شبکه های اینترنت اشیاء بر اساس محدوده

- PAN (personal area network)
- HAN (home area network)
- NAN (neighborhood area network)
- FAN (field area network)
- LAN (local area network)

تکنولوژی های دسترسی



ارتباط محدوده با هزینه، توان، پهنای باند



انواع ساختار ارتباط

- Point-to-point topologies
- Point-to-multipoint topologies

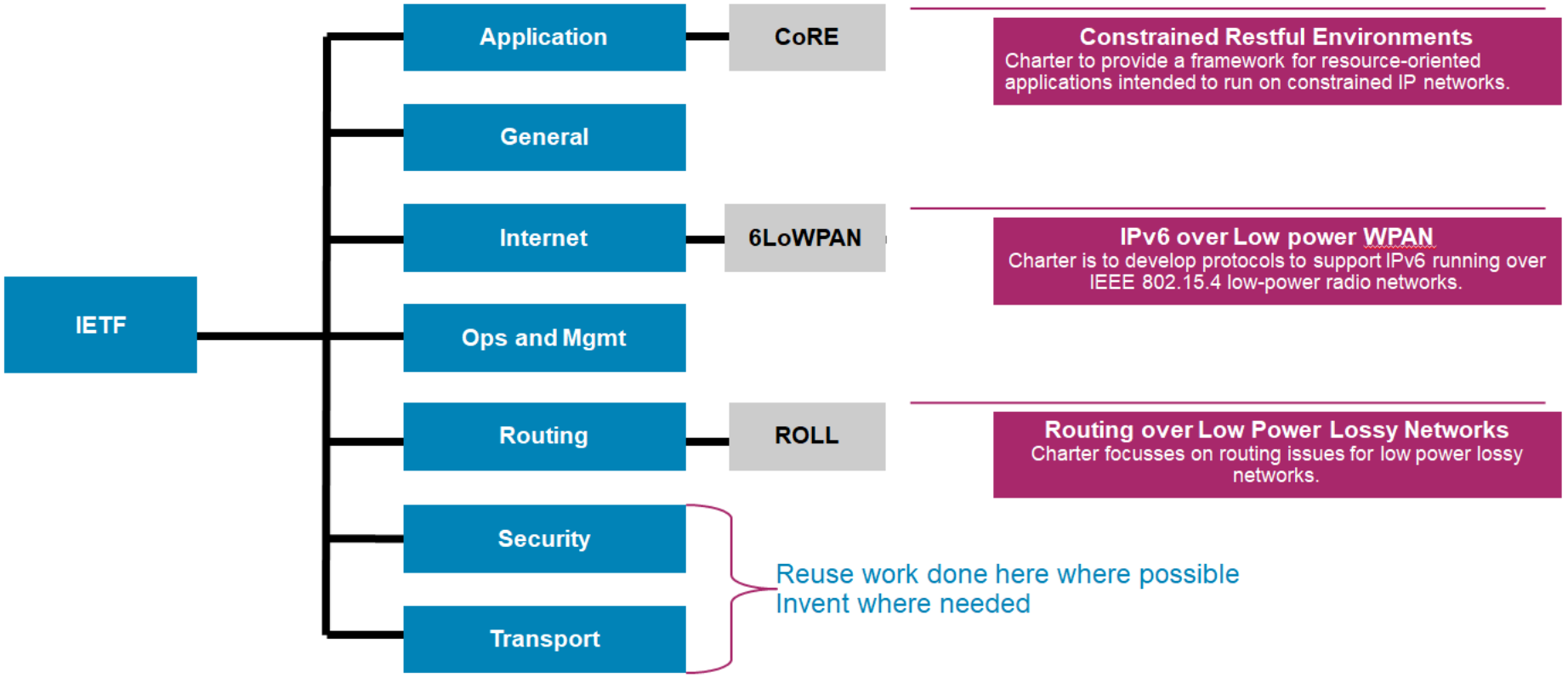
Low Power Lossy Network (LLN)

- LLNs comprise a large number of highly constrained devices (smart objects) interconnected by predominantly wireless links of unpredictable quality
- LLNs cover a wide scope of applications
  - Industrial Monitoring, Building Automation, Connected Home, Healthcare, Environmental Monitoring, Urban Sensor Networks, Energy Management, Asset Tracking, Refrigeration

Characteristics of LLNs

- LLNs operate with a hard, very small bound on state
- In most cases LLNs optimized for saving energy
- Traffic patterns can be MP2P, P2P and P2MP flows
- Typically LLNs deployed over link layers with restricted frame-sizes
  - Minimise the time a packet is in the air hence the small frame size
  - The routing protocol for LLNs should be adapted for such links
- LLN routing protocols must consider efficiency versus generality

IETF LLN Related Workgroups



IEEE Wireless Standards

- 802.11 – Wireless Local Area Networks (WiFi)
  - 802.11a, 802.11b, 80211g, 802.11n
- 802.15 – Wireless Personal Access Networks (WPAN)
  - Task Group 1 – Bluetooth (802.15.1)
  - Task Group 2 – Co-existence (802.15.2)
  - Task Group 3 – High Rate WPAN (802.15.3)
  - Task Group 4 – Low Rate WPAN (802.15.4 or 802.15 TG4)
  - Task Group 5 – Mesh Networking (802.15.5)
- 802.16 – Wireless Metropolitan Area Networks (WiMax)
- 802.20 – Mobile Broadband Wireless Access (Mobile-Fi) - Defunct
- 802.22 – Wireless Regional Access Network (WRAN)
  - Utilise free space in the allocated TV spectrum

IEEE 802.15.4 Features

- Designed for low bandwidth, low transmit power, small frame size
  - More limited than other WPAN technologies such as Bluetooth
  - Low bit rate and packet size to ensure reasonably low packet error rates
  - Packet size (127 bytes) reflects minimal buffering capabilities in Smart Objects
  - Low power allows batteries to last for years
- Data rates of 250 kbps, 40 kbps, and 20 kbps
- Two addressing modes; 16-bit short (local allocation) and 64-bit IEEE (global allocation)
- Communicates over multiple hops
  - Range is in tens of metres, reduces transmission power
- 3 possible unlicensed frequency bands
  - (Europe 868-868.8 MHz – 3 chans , USA 902-928 MHz – 30 chans, World 2400-2483.5 MHz – 16 chans)

IEEE 802.15.4 Node Types

- Full Function Device (FFD)
  - Can operate as a PAN co-ordinator (allocates local addresses, gateway to other PANs)
  - Can communicate with any other device (FFD or RFD)
  - Ability to relay messages (PAN co-ordinator)
- Reduced Function Device (RFD)
  - Very simple device, modest resource requirements
  - Can only communicate with FFD
  - Intended for extremely simple applications

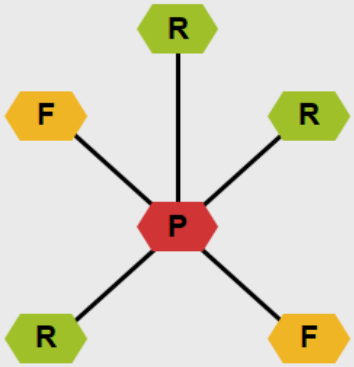
Main Characteristics of Access Technologies

Characteristic	IEEE 802.15.4	IEEE 802.15.4g and IEEE 802.15.4e	IEEE 1901.2a	IEEE 802.11ah	LoRaWAN	NB-IoT
Wired or wireless	Wireless	Wireless	Wired	Wireless	Wireless	Wireless
Frequency bands	Unlicensed 2.4 GHz and sub-GHz	Unlicensed 2.4 GHz and sub-GHz	Unlicensed CENELEC A and B, FCC, ARIB	Unlicensed sub-GHz	Unlicensed sub-GHz	Licensed
Topology	Star, mesh	Star, mesh	Mesh	Star	Star	Star
Range	Medium	Medium	Medium	Medium	Long	Long
Data rate	Low	Low	Low	Low–high	Low	Low

IEEE 802.15.4 Topologies

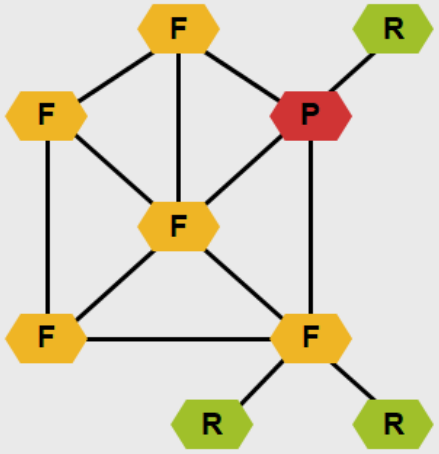
Operates at Layer 2

- Star Topology



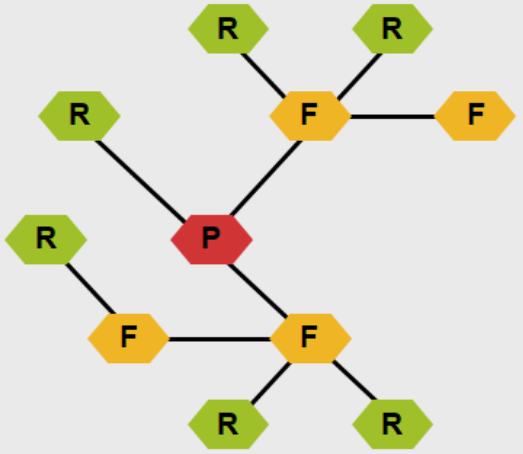
- All devices communicate to PAN co-ordinator which uses mains power
- Other devices can be battery/scavenger

- Mesh Topology



- Devices can communicate directly if within range

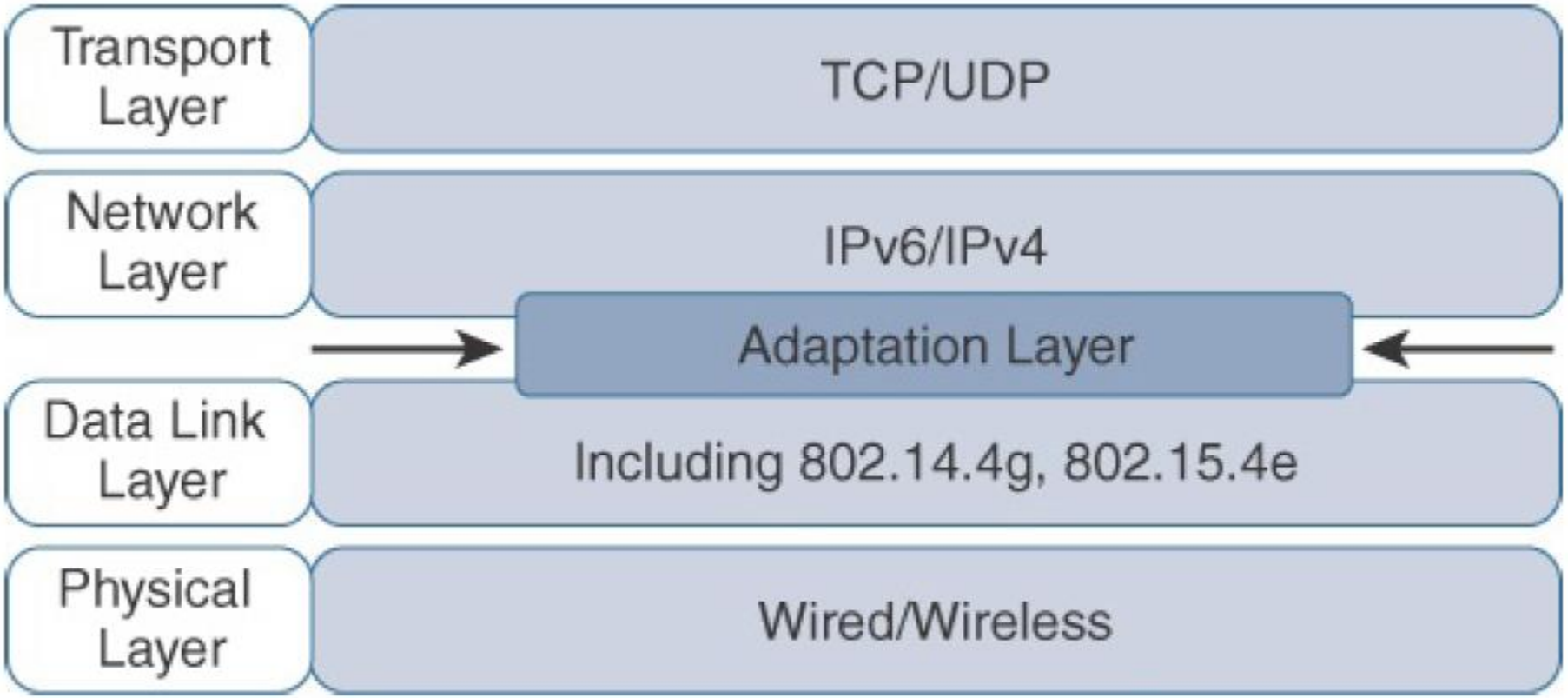
- Cluster Tree



- Higher layer protocols like RPL may create their own topology that donot follow 802.15.4 topologies

Single PAN co-ordinator exists for all topologies

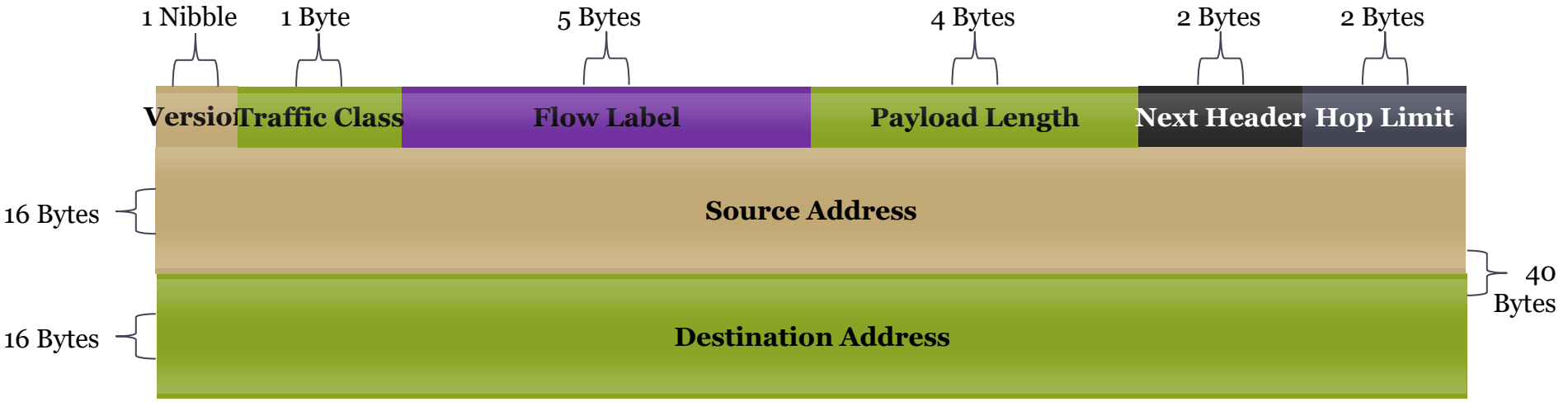
Optimizing IP for IoT Using an Adaptation Layer



6LoWPAN

- IPv6 over Low power Wireless Personal Area Networks
  - An adaptation layer for IPv6 over IEEE 802.15.4 links
- Why do we need an adaption layer?
  - IEEE 802.15.4 MTU is only 127 bytes, IPv6 minimum MTU is 1280 bytes
  - IPv6 does not do fragmentation, left to end nodes or lower layers
- Performs 3 functions each with its own 6LoWPAN header
  - IPv6 Header compression
  - IPv6 packet fragmentation and re-assembly
  - Layer 2 forwarding (also referred to as mesh under)

Basic IPv6 Header

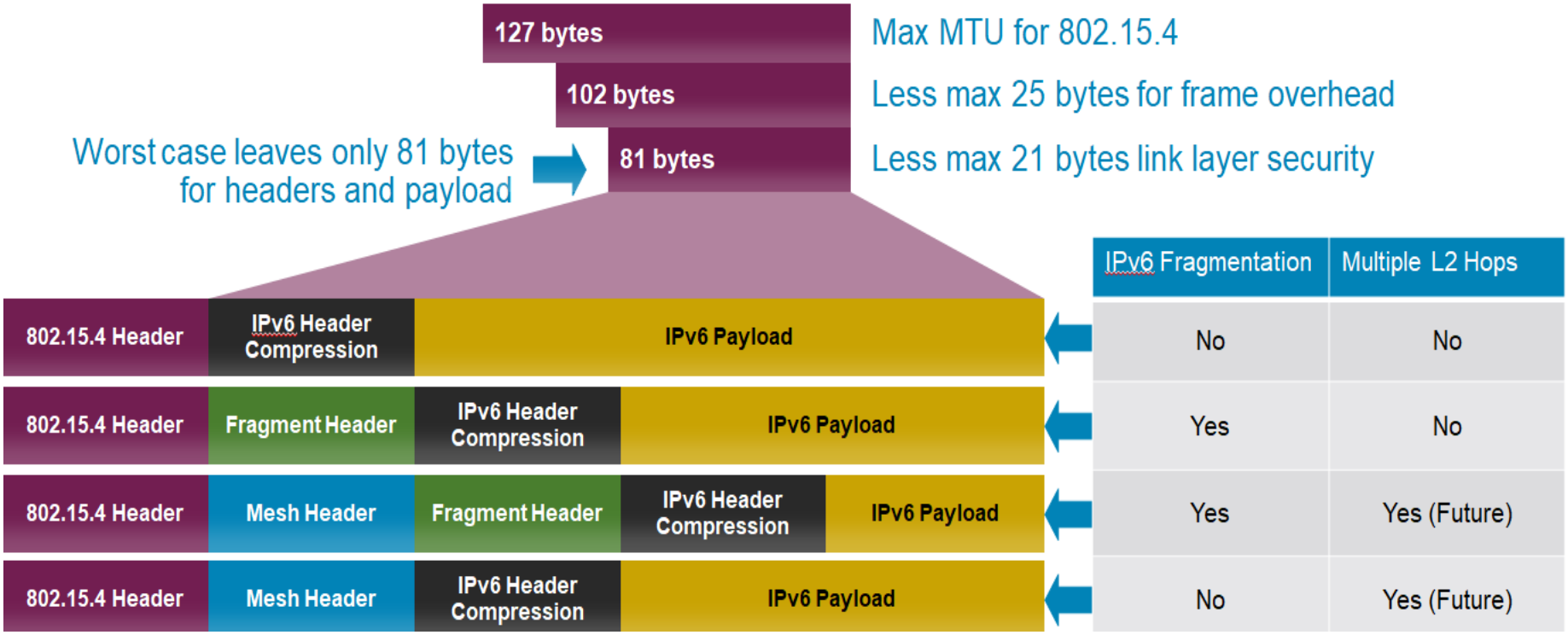


- Minimum size is 40 bytes (double that of IPv4)
- Can be extended by additional headers
- Fragmentation must be performed by end nodes

Typical 6LoWPAN Header Stacks

- 6LoWPAN headers included only when needed
  - IPv6 compression header
  - Fragmentation header (eliminated if single datagram can fit entire IPv6 payload)
  - Mesh or Layer 2 forwarding header (currently not used/implemented)

Typical 6LoWPAN Header Stacks



IPv6 Fragmentation	Multiple L2 Hops
No	No
Yes	No
Yes	Yes (Future)
No	Yes (Future)

RPL - Routing Protocol for LLNs

- RPL is an extensible proactive IPv6 distance vector protocol
  - Builds a Destination Oriented Directed Acyclic Graph (DODAG)
  - RPL supports shortest-path constraint based routing applied to both links and nodes
  - Supports MP2P, P2MP and P2P between devices (leaves) and a root (border router)
- RPL specifically designed for “Lossy” networks
  - Should not be categorised as a WSN routing protocol
  - Agnostic to underlying link layer technologies (802.15.4, PLC, Low Power Wireless)
- RPL supports different LLN application requirements
  - RFC 5548 (Urban) RFC 5673 (Industrial) RFC 5826 (Home) RFC 5867 (Building)

Thanks for listening!
Any questions?