ITU-SUDACAD Regional Forum on
Internet of Things for Development of Smart and Sustainable Cities"
Khartoum, Sudan 13-14 Dec 2017

The Internet of Things for development of SSC: From standards Point of View

Role of standards and standards defining organizations (SDOs)

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Dec 2017

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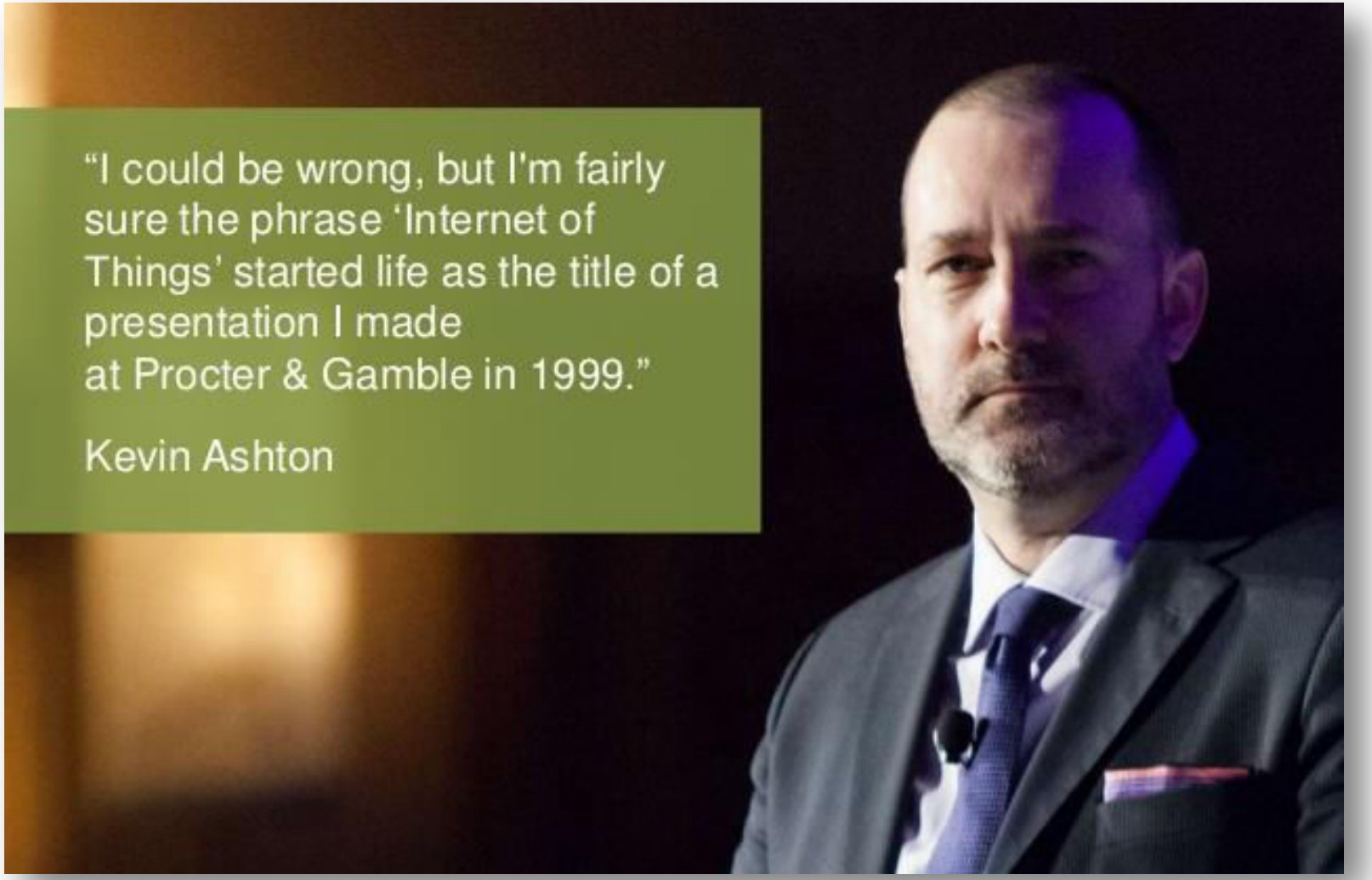
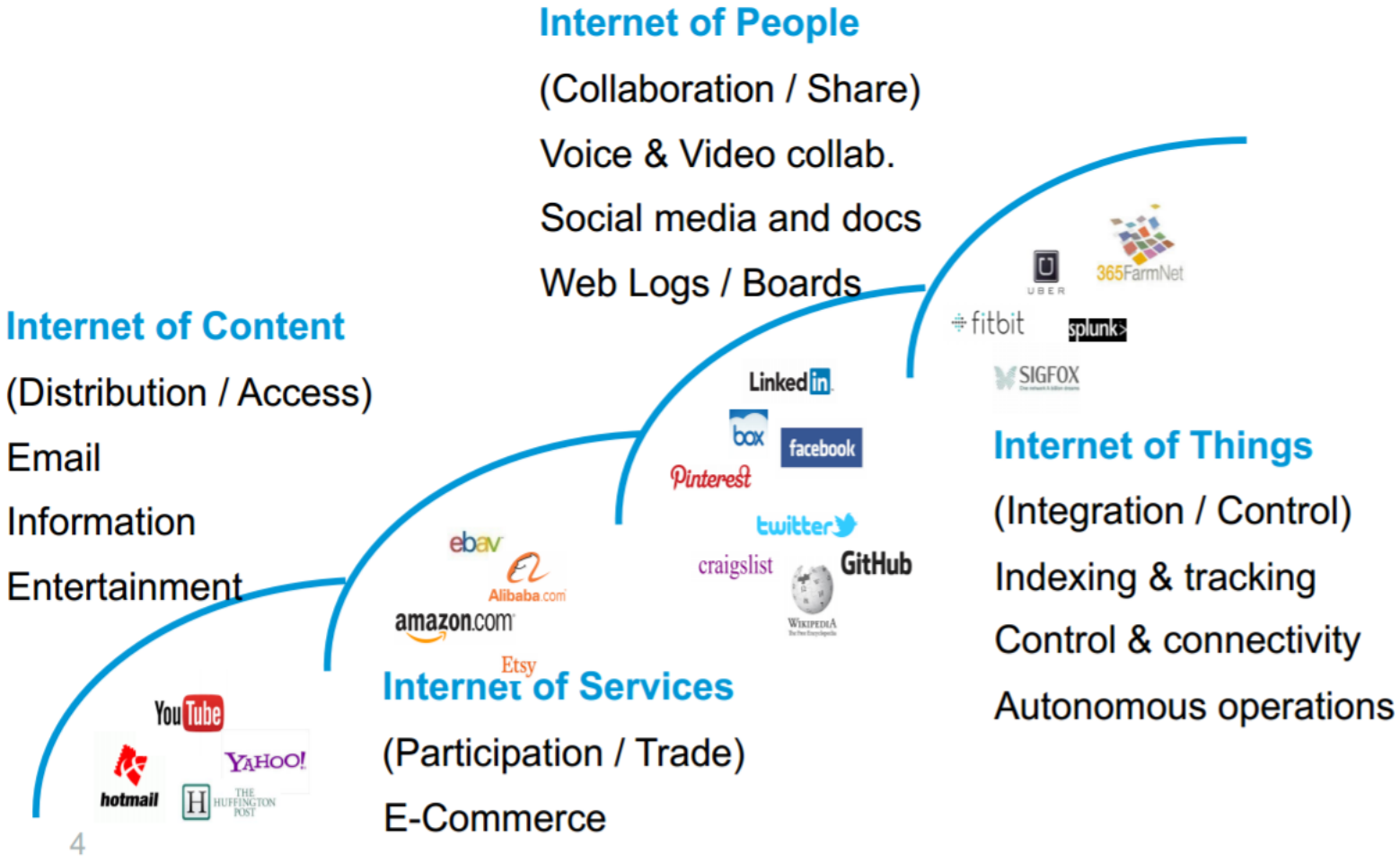
Internet of Things … The origin



IoT is the current wave of Internet

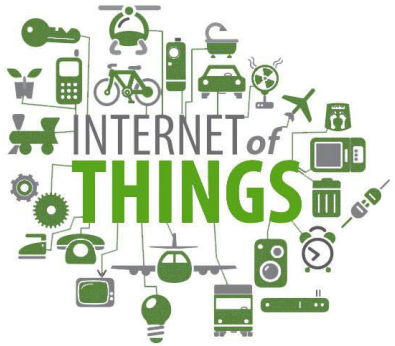
From Internet of People to Internet of Things

IoT is the current wave of Internet



Source: Forum on Internet of Things: Empowering the New Urban Geneva, Switzerland, 2015

So, What is IoT?



What is the Internet of Things (IoT)?

The Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data.

Different Names for the same Thing!!!

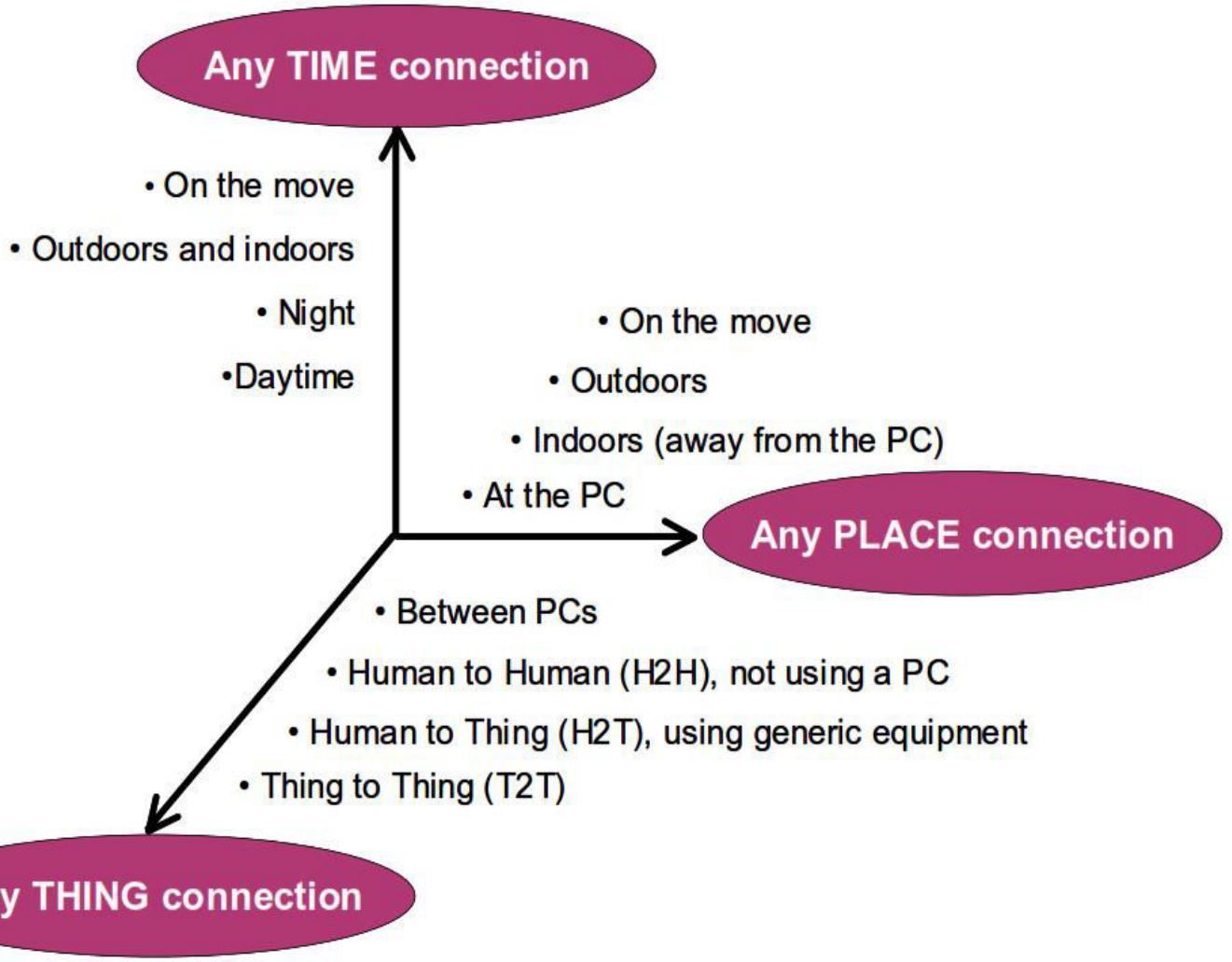
Different Names for the same Thing

- M2M (Machine To Machine)
- "**Internet of Everything**" (Cisco Systems)
- "**World Size Web**" (Bruce Schneier)
- "**Skynet**" (Terminator movie)

Internet of Things (IoT) …. A new dimension

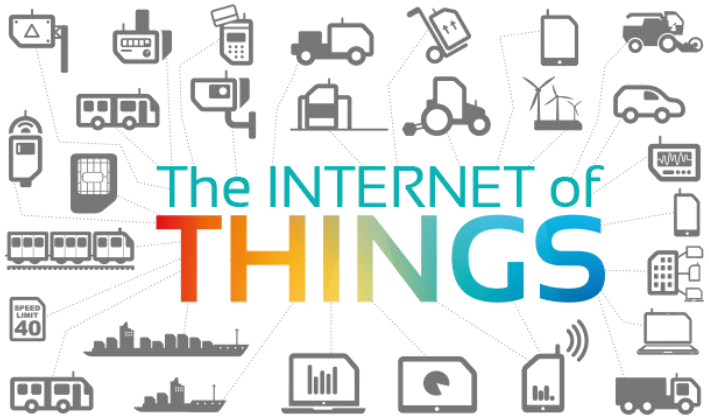
Internet of Things (IoT) …. A New Dimension

From any time ,any place connectivity for anyone, we will now have connectivity for anything!

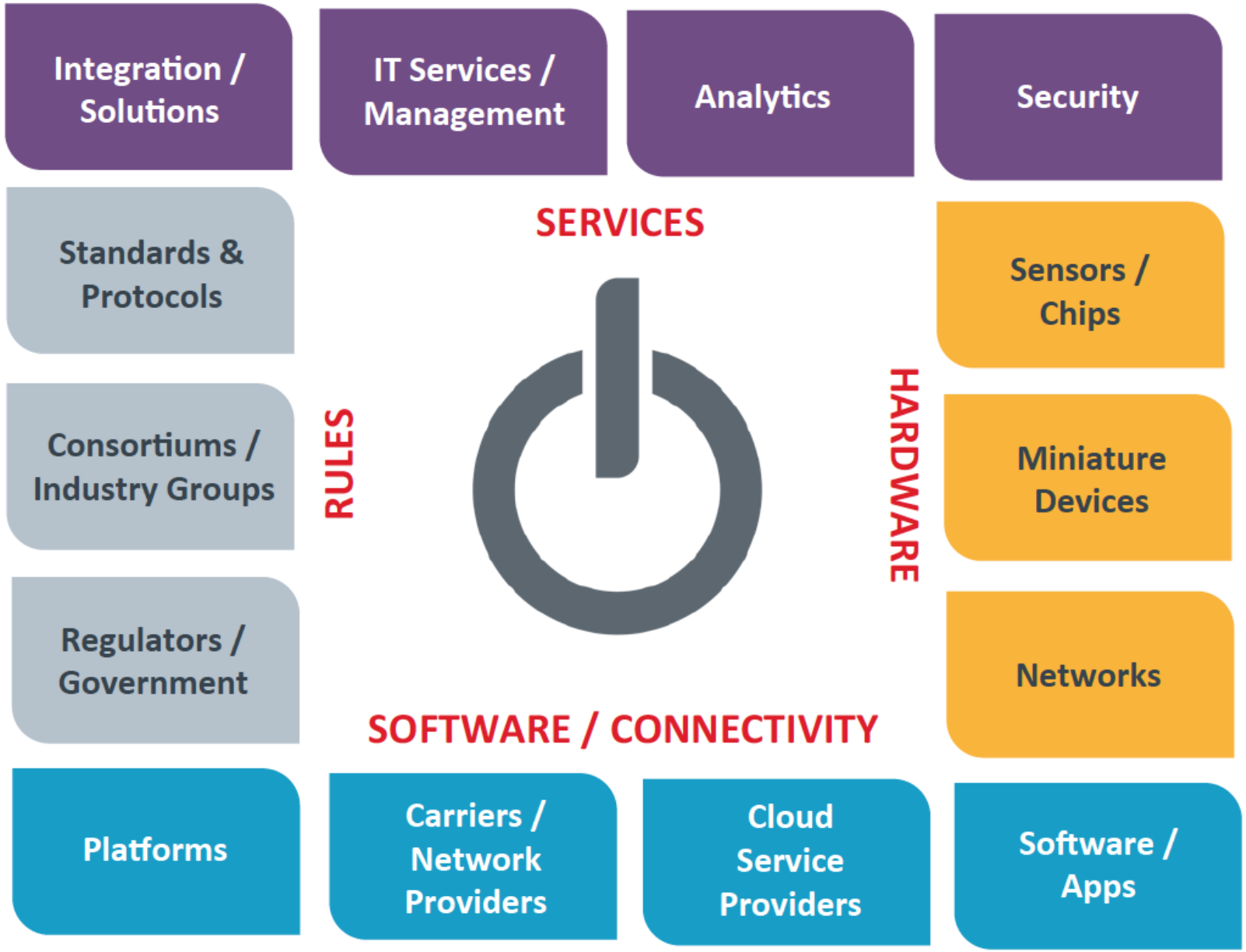


Source: *ITU adapted from Nomura Research Institute*

IoT ecosystem

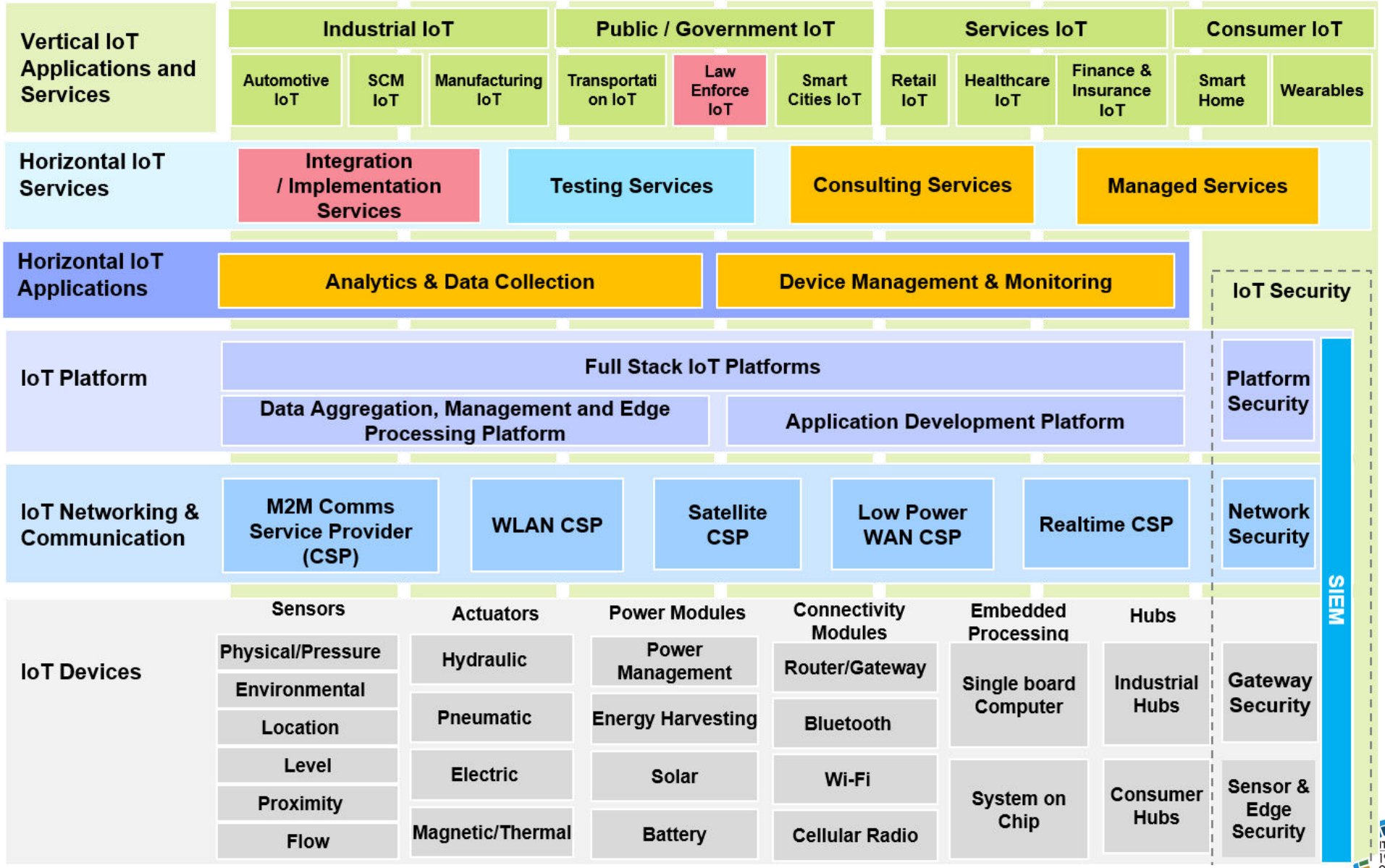


The Evolving IoT ecosystem



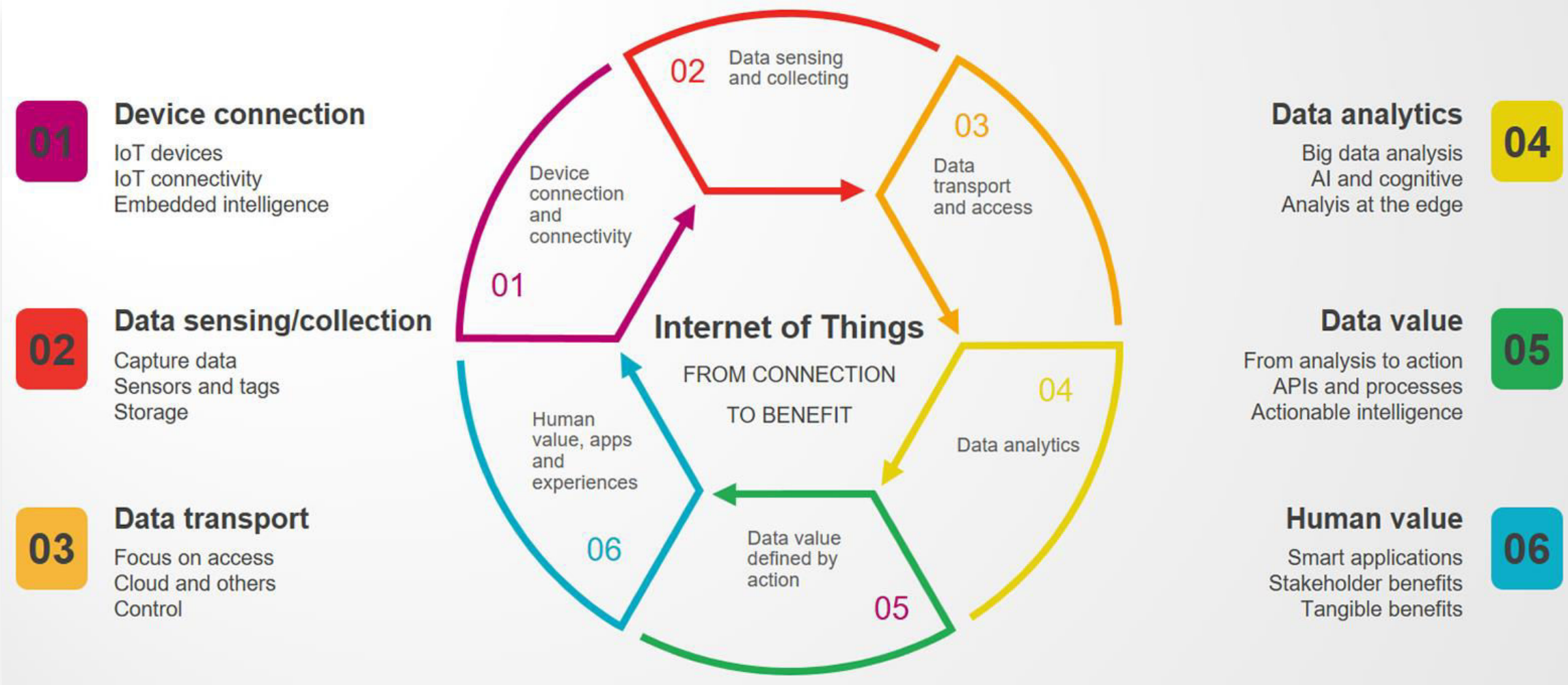
Source: *CompTIA*

IoT ecosystem Technology Stack view



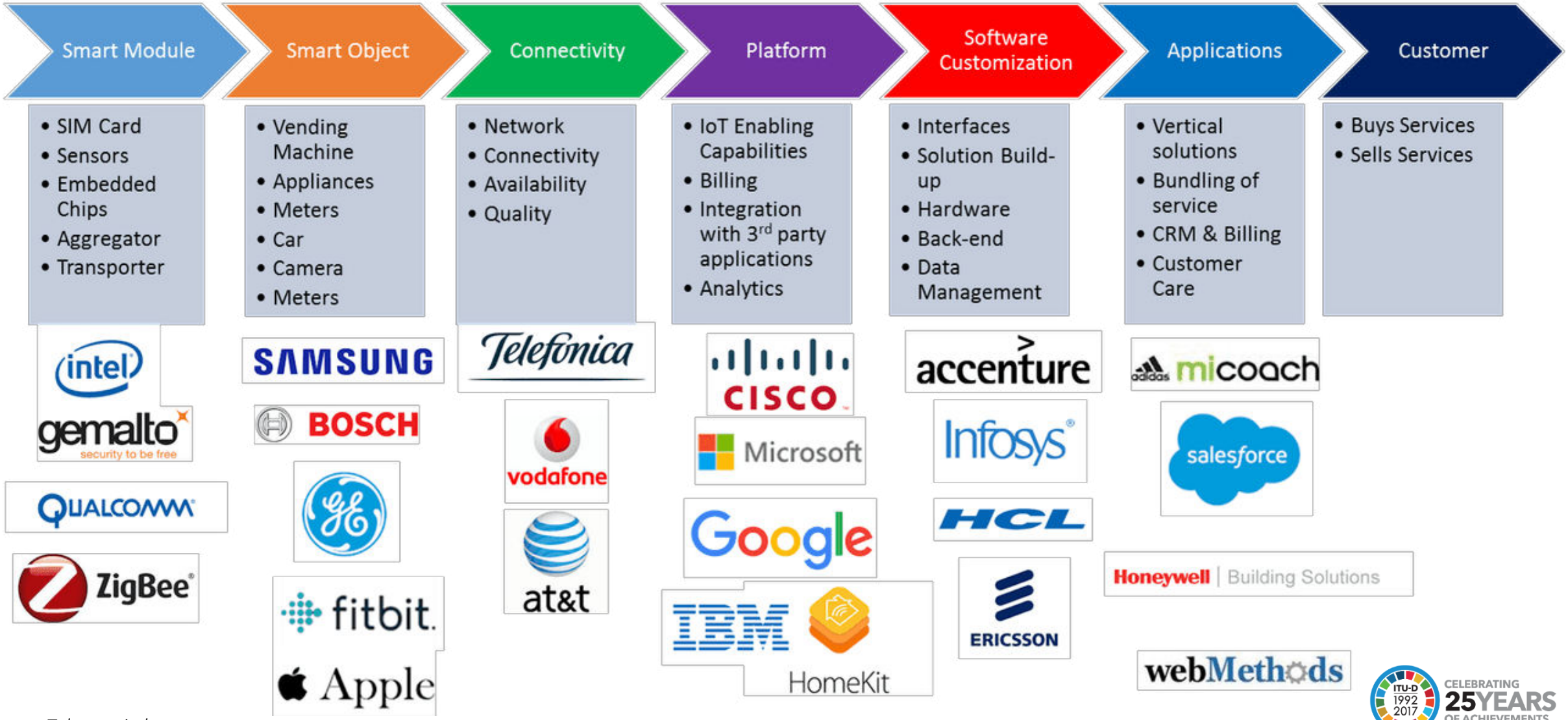
Source: *Boston Analytics*

IoT from Connecting Devices to Human Value



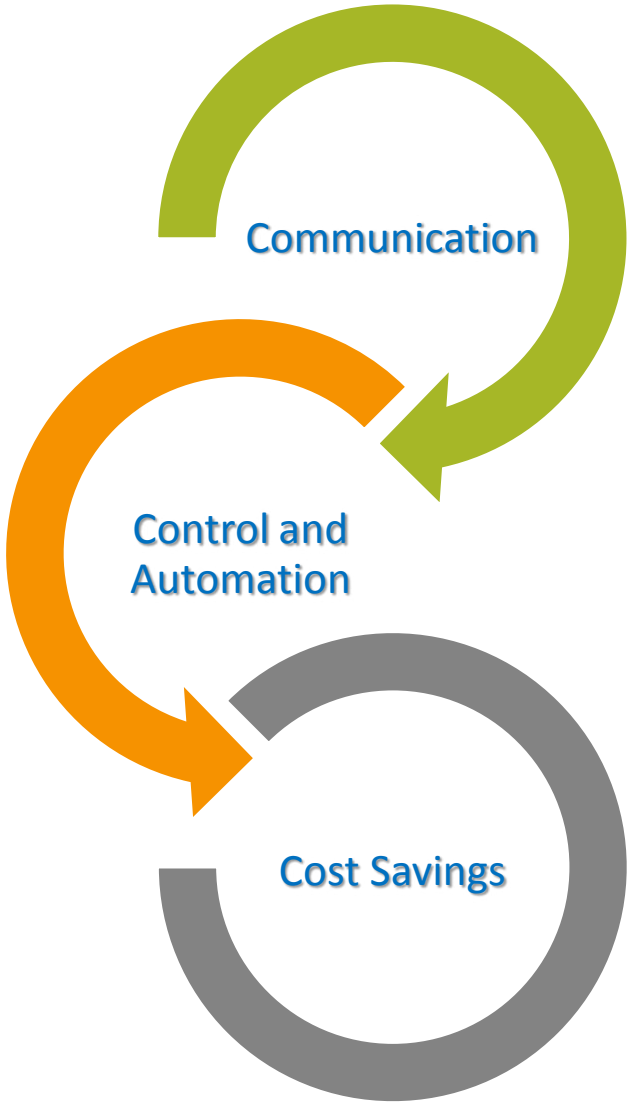
Source:

IoT Value Chain

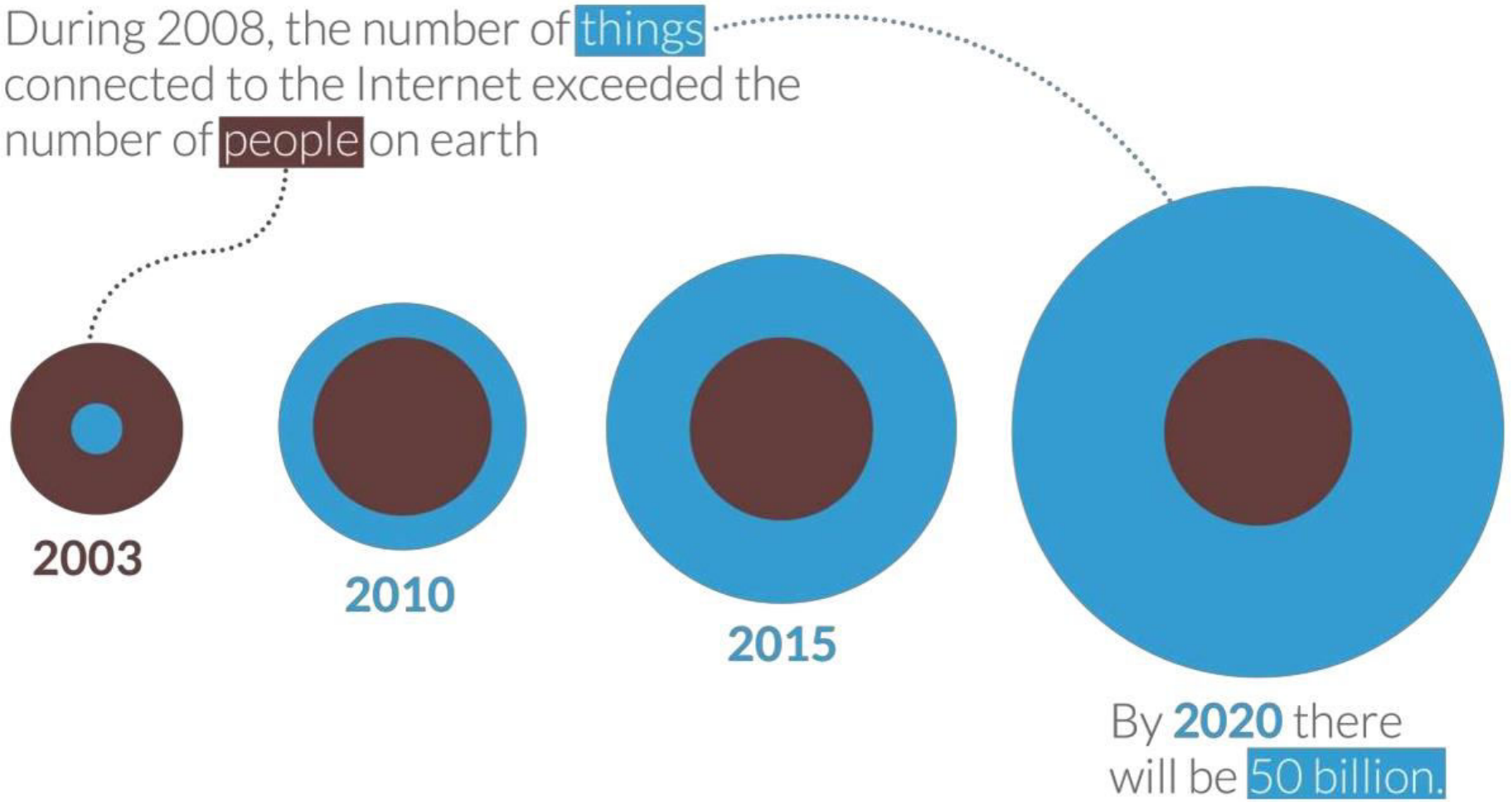


Source: *Telecomcircle.com*

The Three Cs of IoT

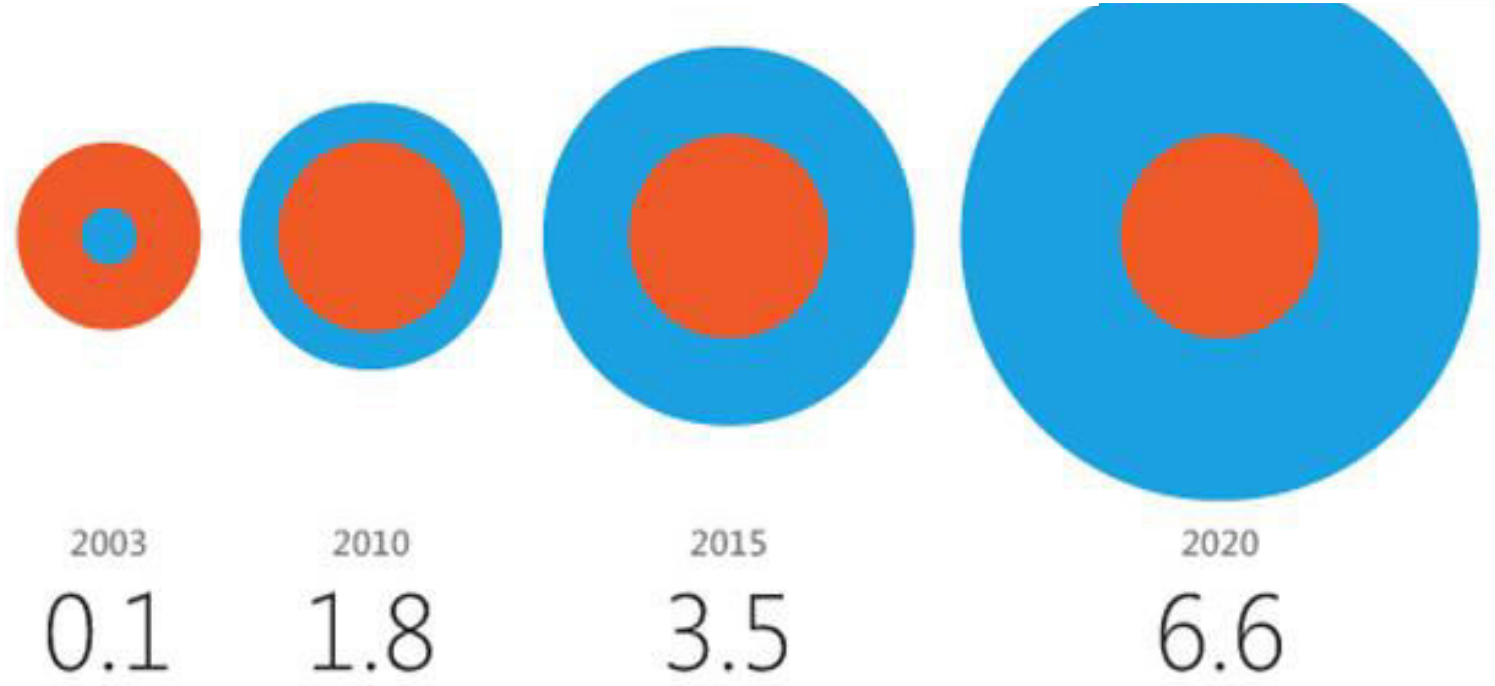


IoT Forecast



Source: *Cisco*

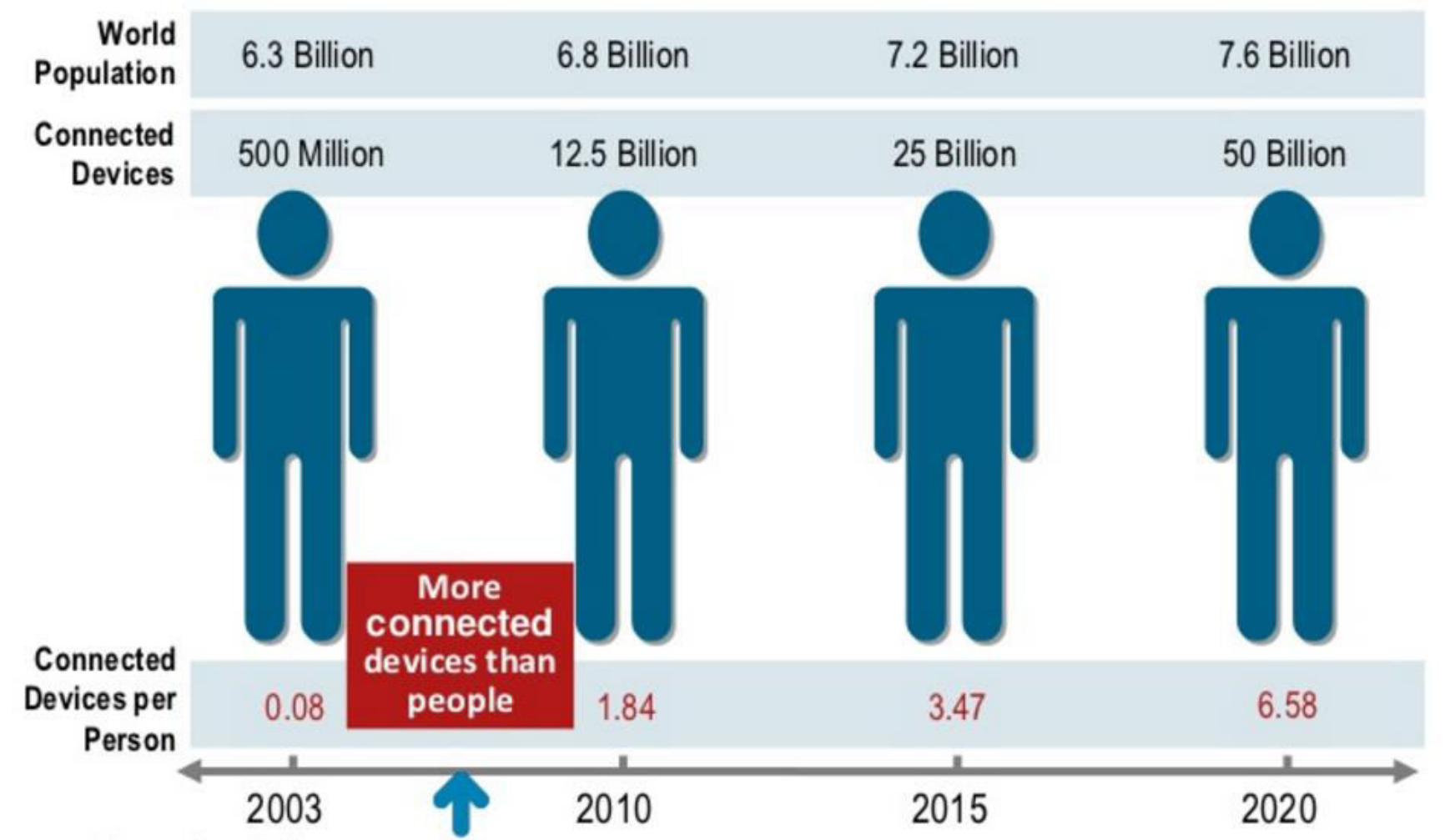
Number of People vs connected Devices



*Connected **devices** per **person***

Source: *Cisco*

IoT Forecast



Source: *Cisco*

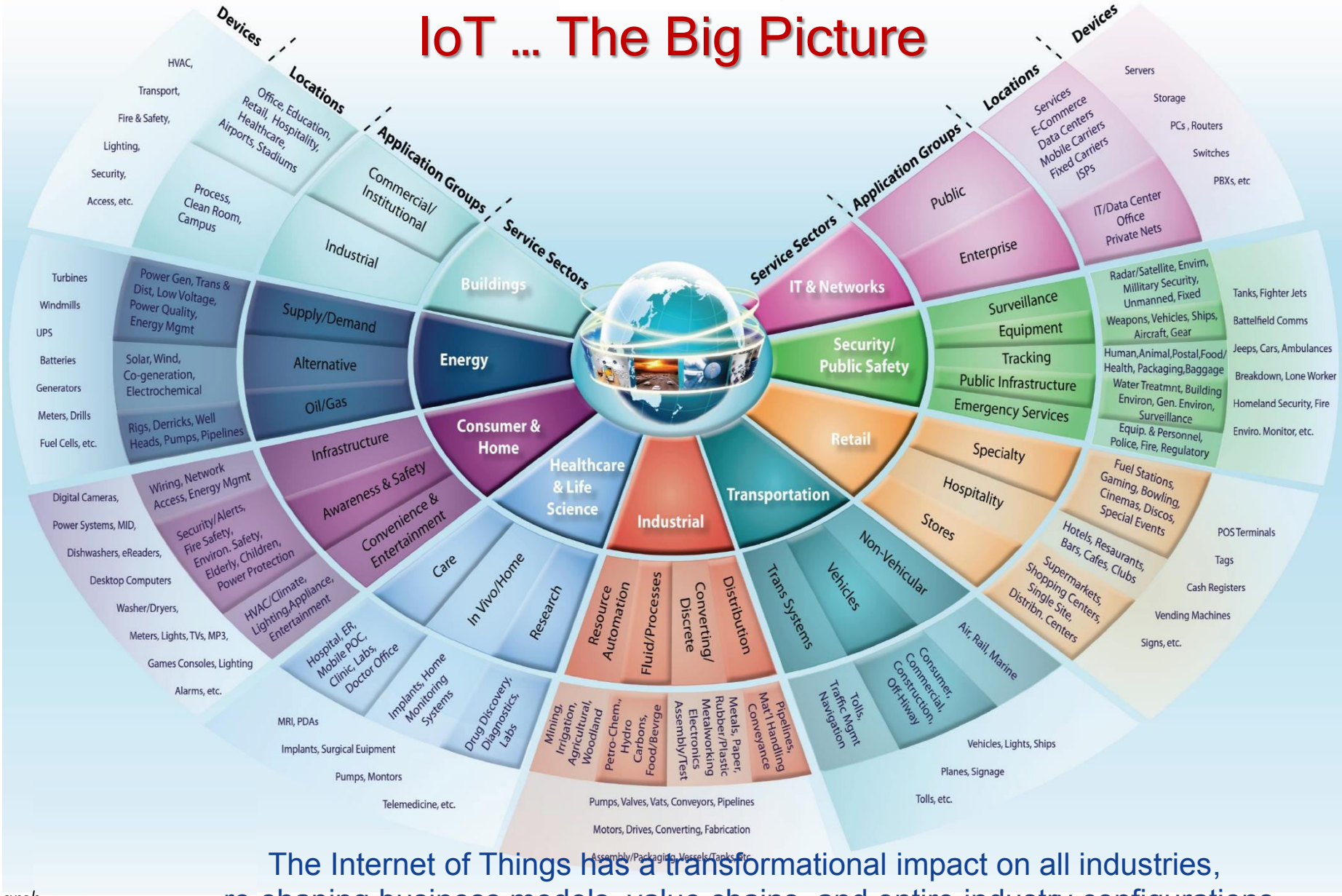
IoT main Investors

Intel Capital	1	AeroScout, Airware, Api.ai, Arrayent, Avegant, BASIS Science, Bocom Int. Network, Body Labs, Braigo Labs, Enlighted, EyeSmart, FreedomPop, GainSpan Corporation, Grid Net, Guangdong Appscomm, iControl Networks, Impinj, Inrix, JouleX, Mark One, NewAer, OrCam, Peloton Technology, Performance Lab, Prism Skylabs, Razer, Recon Instruments, Sanjet, Sano Intelligence, Skully Helmets, SnowCookie, Sotera, Stratoscale, Thalmic Labs, Tuneec
Qualcomm Ventures	2	3D Robotics, Airstrip Technologies, AliveCor, August, Avaak, Consert, Fitbit, Ineda Systems, LIFX, LiveScribe, Ollo Wearables, Panoramic Power, Placemeter, Skycatch, Sotera, Streetline, Telcare, Waze, Whistle Labs
Foundry Group	3	3D Robotics, Cuseum, Dragon Innovation, Fitbit, ivee, littleBits, Loop Labs, MakerBot, OnTheGo Platforms, Orbotix, Pie Digital, Rachio, Revolar, Revolv, Sifteo, SnowShoe Food, U Grok It
Kleiner Perkins Caufield & Byers	3	Airware, Dropcam, Enlighted, iControl Networks, Inrix, Jawbone, Kinsa, mCube, MODE, Motiv, Nest Labs, Quirky, Relayr, Telogis, Verdiem, Waze, Wearable Intelligence
Andreessen Horowitz	5	Airware, Anki, Automatic Labs, goTenna, Halo Neuroscience, IFTTT, Jawbone, Leap Motion, Lockitron, Osito, Prism Skylabs, Quirky, Ringly, Shapeways, Thync, Wearable Intelligence
Khosla Ventures	5	AliveCor, Canary, CellScope, Ginger.io, Helium Systems, Jawbone, littleBits, Misfit, Momentum Machines, Narrative, ParStream, Quanttus, Theatro, Thync, Tile, View
True Ventures	5	3D Robotics, Athos Works, Fitbit, Ginger.io, littleBits, MakerBot, Narrative, OpenROV, Ring, Sano Intelligence, Sifteo, SoundHawk, Streetline, Technical Machine, Valencell, Veniam
Cisco Investments	8	AeroScout, Ayla Networks, Bit Stew Systems, Cohda Wireless, Control4, EVRYTHNG, Grid Net, iControl Networks, Ineda Systems, Phunware, Relayr, Sensity Systems, smart-FOA, Stratoscale, Worldsensing
New Enterprise Associates	9	APX Labs, Cuff, Glacier Bay, IFTTT, Kaazing, Little Labs, MetroMile, Ollo Devices, Orange Chef, Placemeter, Senseonics, SmartDrive Systems, Topera Medical
Sequoia Capital	10	Airstrip Technologies, DJI Innovations, eMeter, Jasper Technologies, Jawbone, LIFX, Nod Labs, Romotive, SimpliSafe, Strava, SynapSense, Telcare
First Round Capital	11	Airware, Electric Objects, MetroMile, Nomi, Ring, Ringly, SmartThings, Sproutling, Stickybits, Thalmic Labs, Wearable Intelligence
SV Angel	11	Electric Objects, Helium Systems, IFTTT, LIFX, Lily, MetroMile, Nervana Systems, Nomi, Prism Skylabs, Romotive, SmartThings
CrunchFund	13	Avegant, IFTTT, Iotera, Lark, Ollo Devices, ParStream, Prism Skylabs, Romotive, SmartThings, Weaved
Felicis Ventures	13	Airware, CyPhy Works, Dropcam, Fitbit, InteraXon, Mark One, MetroMile, PlotWatt, Romotive, Sano Intelligence

Source: *www.cbinsight.com*

Source: Beecham Research

IoT … The Big Picture



The Internet of Things has a transformational impact on all industries, re-shaping business models, value chains, and entire industry configurations

Source: *Beecham Research*

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What is the Smart Sustainable City? SSC

A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.

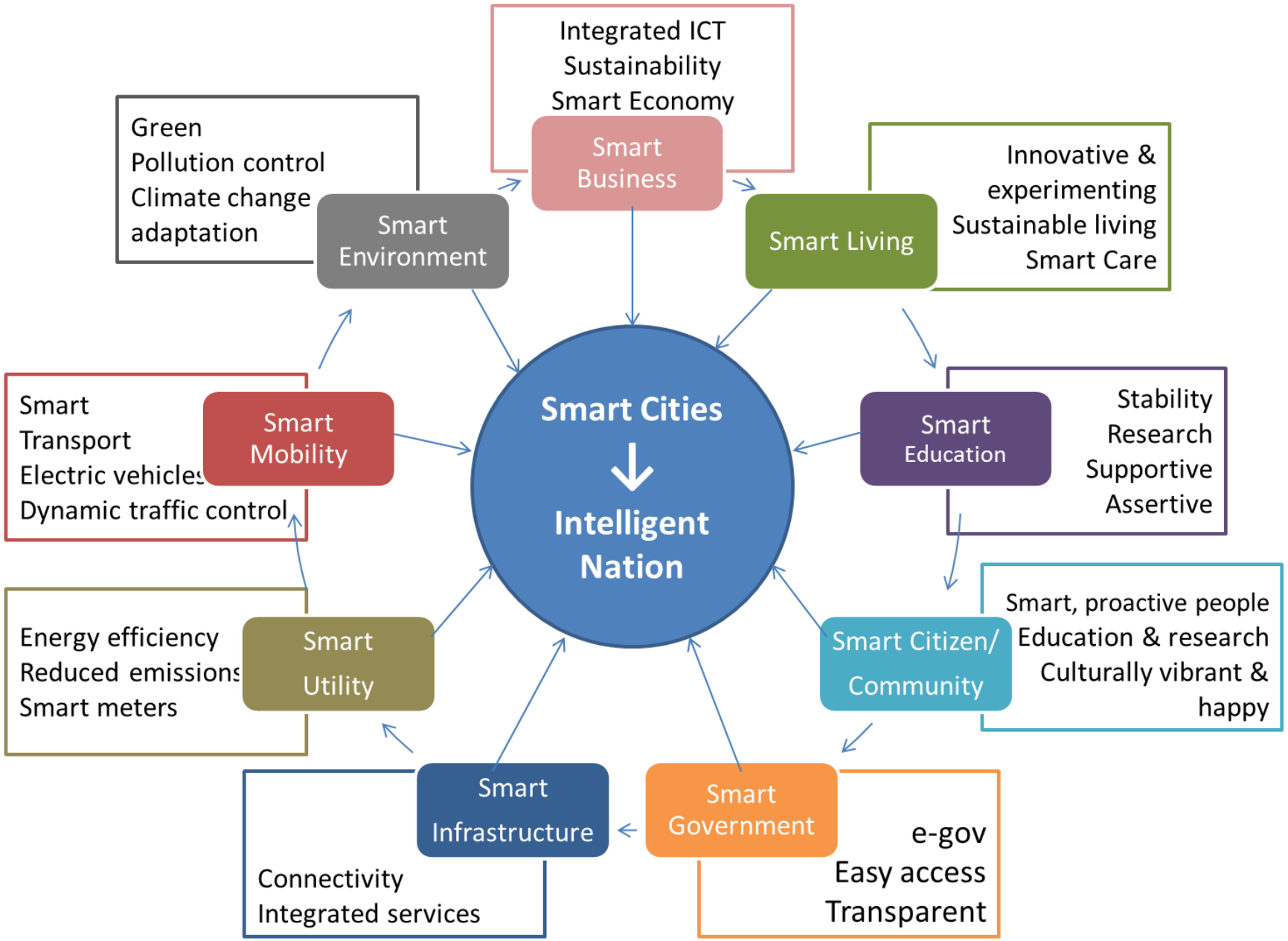
Source: *ITU – Smart Sustainable Cities*

What is the Smart Sustainable City? SSC

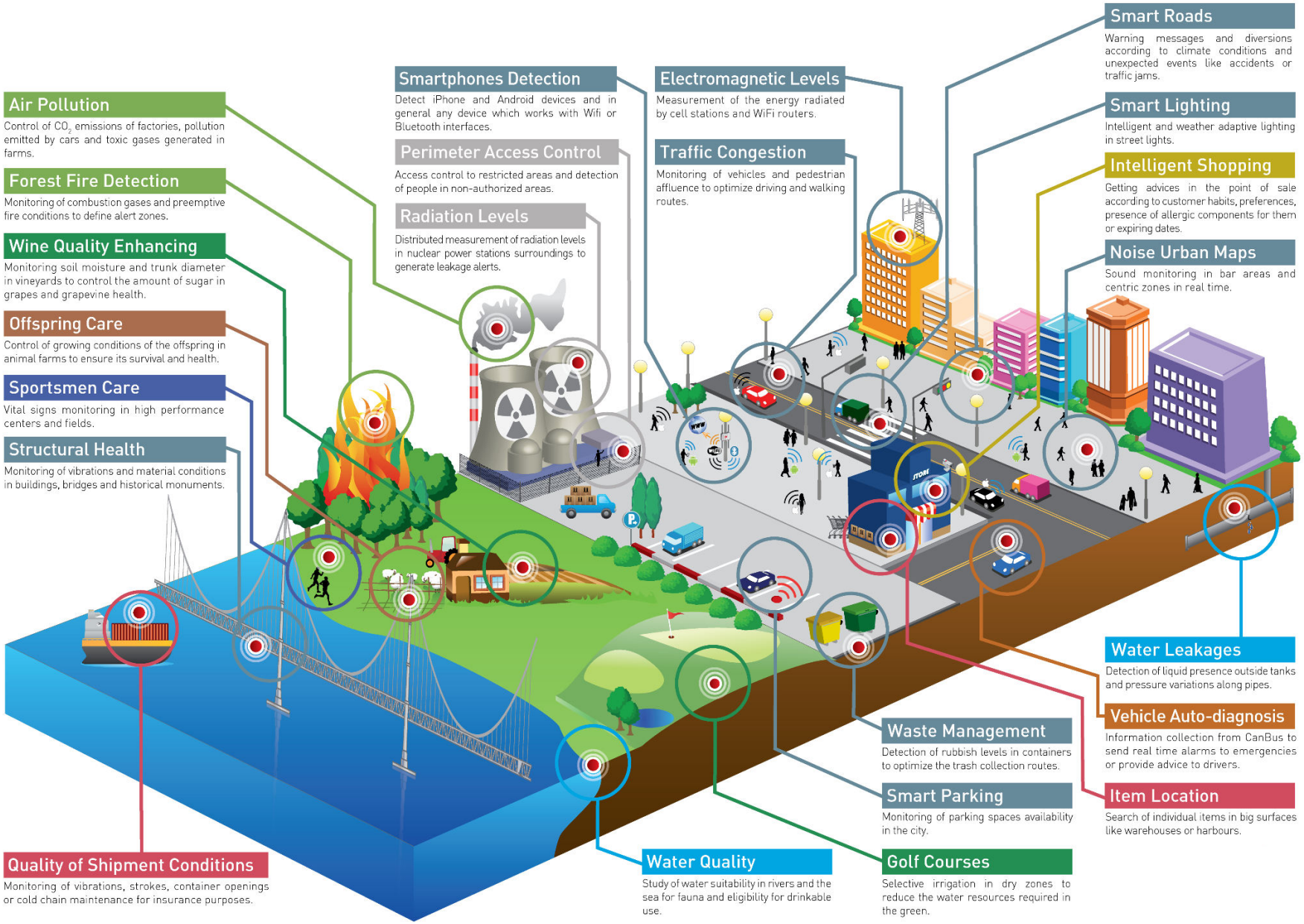
The main goal for SSC is to enhance the quality of life of citizens across multiple, interrelated dimensions, including (but not limited to) the provision and access to water resources, energy, transportation and mobility, edu cation, environment, waste management, housing and livelihoods (e.g. jobs), utilizing ICTs as the key medium.

Source: *ITU – Smart Sustainable Cities*

A Model of a Smart City



A Model of a Smart City



Source: *Libelium*

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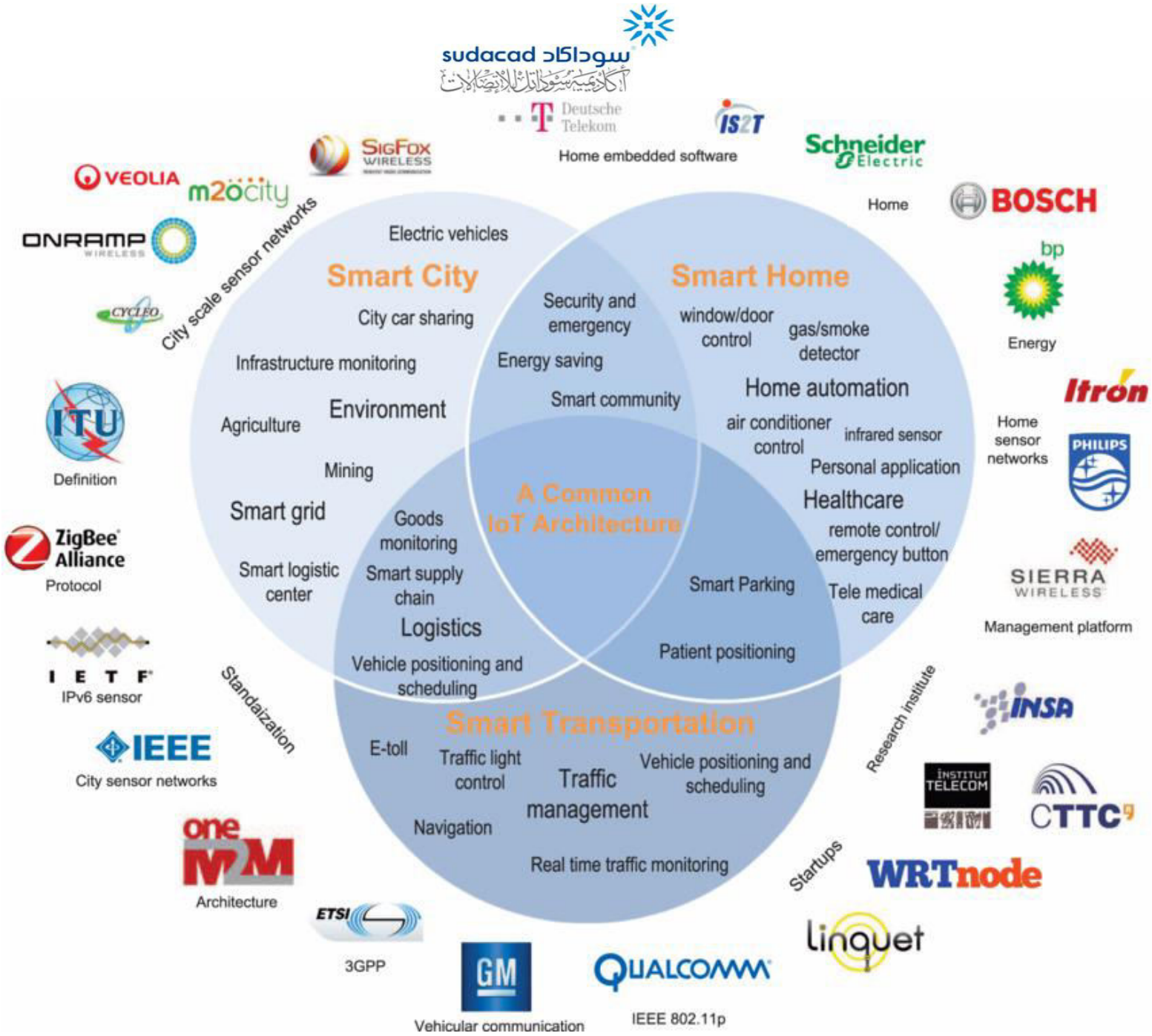
Smart Cities Standard bodies



LPWA (Low Power Wide Area) Connectivity Solutions

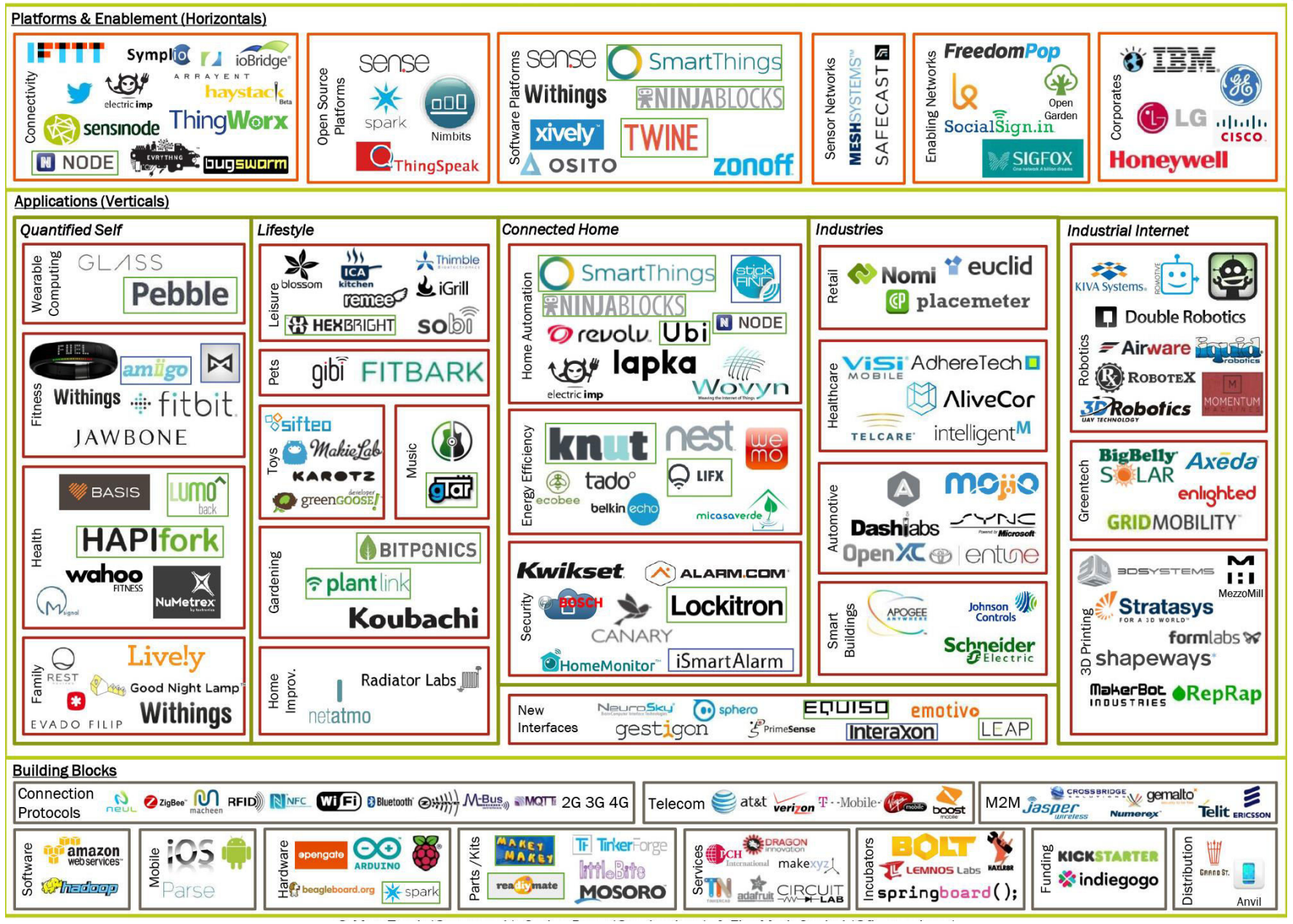
- Zigbee
- BLE
- Clean -Slate
- 6LoWPAN
- oneM2M
- 2G
- Z-Wave
- LTN
- 3G
- Sigfox
- Thread
- 4G
- Weightless
- 802.11ah
- 5G?

LPWA Solutions: Non-standard IoT vs. Cellular IoT

	Standard /Global ecosystem	Band	System Bandwidth	Coverage	Module cost	Battery life	Capacity	Time to market (years)
SigFox	✗	**Unlicensed**	250KHz~ ?MHz UL 100Hz	GSM 14dB+	X	●	Lower than NB- IoT	✓
LoRa	✗	**Unlicensed**	7.8k~500kHz	GSM 18dB+	X	●		✓
EC-GSM (R13)	✓	**GSM Band**	2.4MHz	GSM ~20dB+	2X	◔	About 1/10 of NB - IoT per unit BW	1~2
eMTC (R13)	✓	**LTE Band**	1.4MHz	LTE 15dB+	3~10X	◑	Similar as NB- IoT	1~2
NB-IoT (standalone)	✓	**G/U/L MSR /dedicated**	200KHz	GSM 25dB+	X	●	>50k/cell/ 200kHz	1~2
NB-IoT (guard-band)	✓	**LTE Band**	200KHz	GSM 20dB+	X	●		1~2
NB-IoT (in-band)	✓	**LTE Band**	200KHz	GSM 17dB+	X	◔		1~2

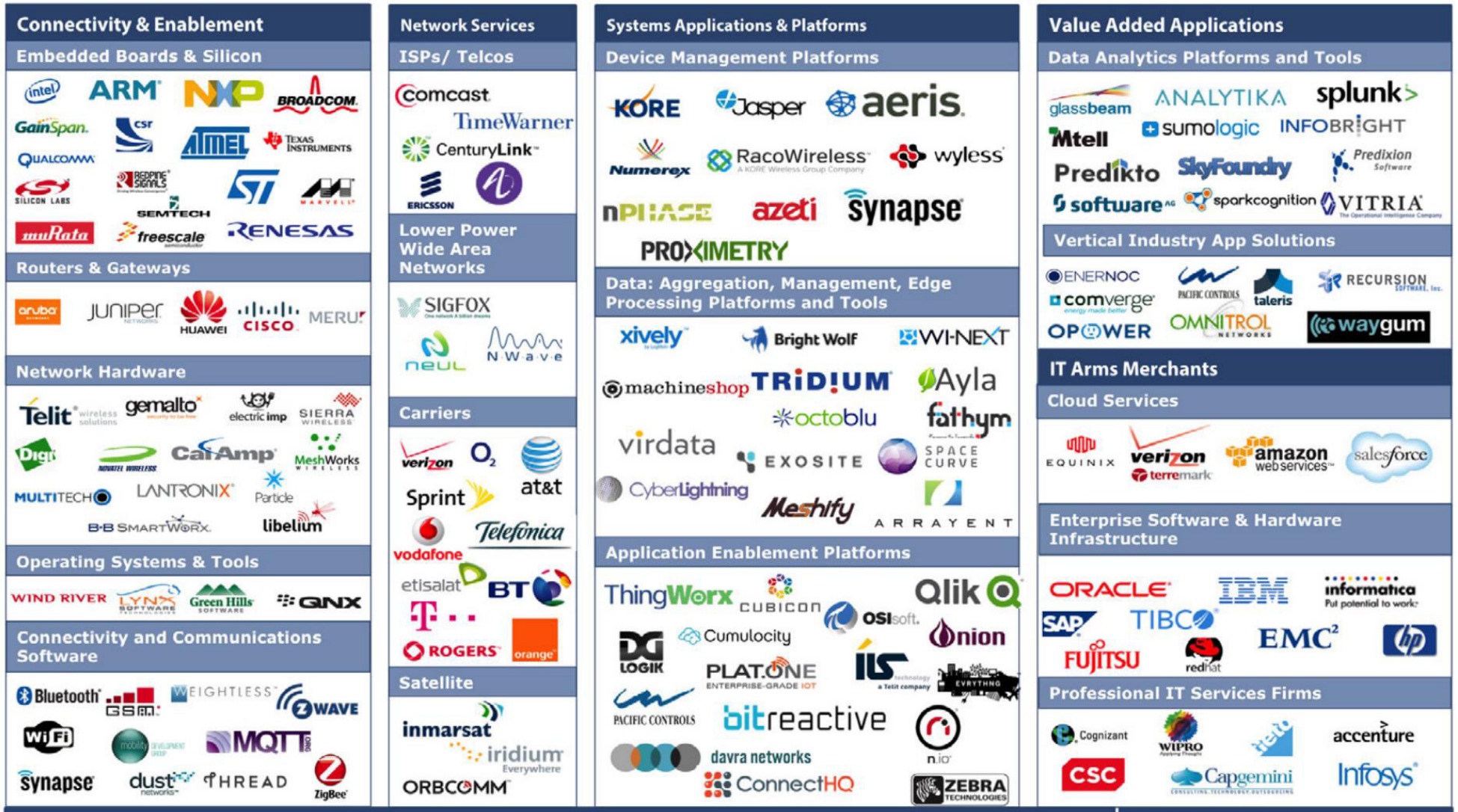
LPWA (Low Power Wide Area)

IoT Landscape



Source: *Mark 2013*

IoT Landscape

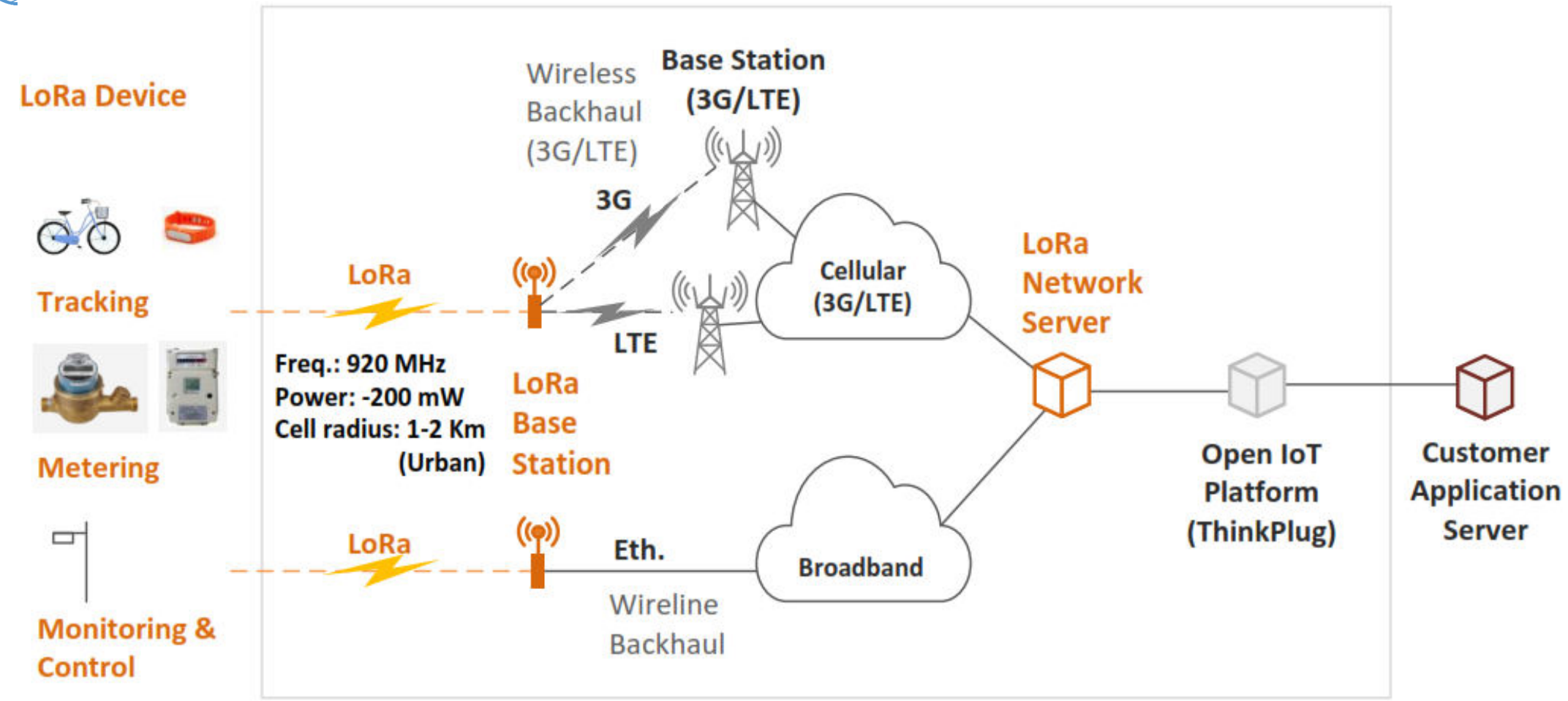


Source: *Harbor Research_16*

LoRa (Long Range) for IoT

LoRa (Long Range) IoT

Ra



LoRa device: Collects data from sensor and transmits it using LoRa standards
LoRa base station: Forwards RF packets from LoRa devices to a LoRa server
LoRa network server: Processes LoRa MAC protocols, authenticates and manages devices, and interworks with SK Telecom's IoT platform (oneM2M)

Source: *Netmanias*

Benefits of LoRa

	LoRa	Sigfox	NB-IoT	LTE-M
Band to use	Unlicensed band (920 MHz)	Unlicensed band (920 MHz)	LTE licensed	LTE licensed
Standardized by	LoRa Alliance	ETSI	3GPP (Rel.13: Q2 2016)	3GPP
Cell coverage*	- 10 Km	- 10 Km	- 10 Km	- 5 Km
Data rate*	- 5.4 Kbps	100 - 600 bps	- hundreds of Kbps	10/5 Mbps (DL/UL) (Cat.1 + PSM)
Commercialization	Yes	Yes	To be commercialized in H1 of 2017	Yes
Ecosystem	Open	Closed	Open	Open
Battery life*	- 10 years	- 10 years	- 10 years	- 10 years
Module** price	$5	$5	$5	$10
Note	Most affordable Commercialization ready	Closed elements	Not ready for commercialization yet	Expensive

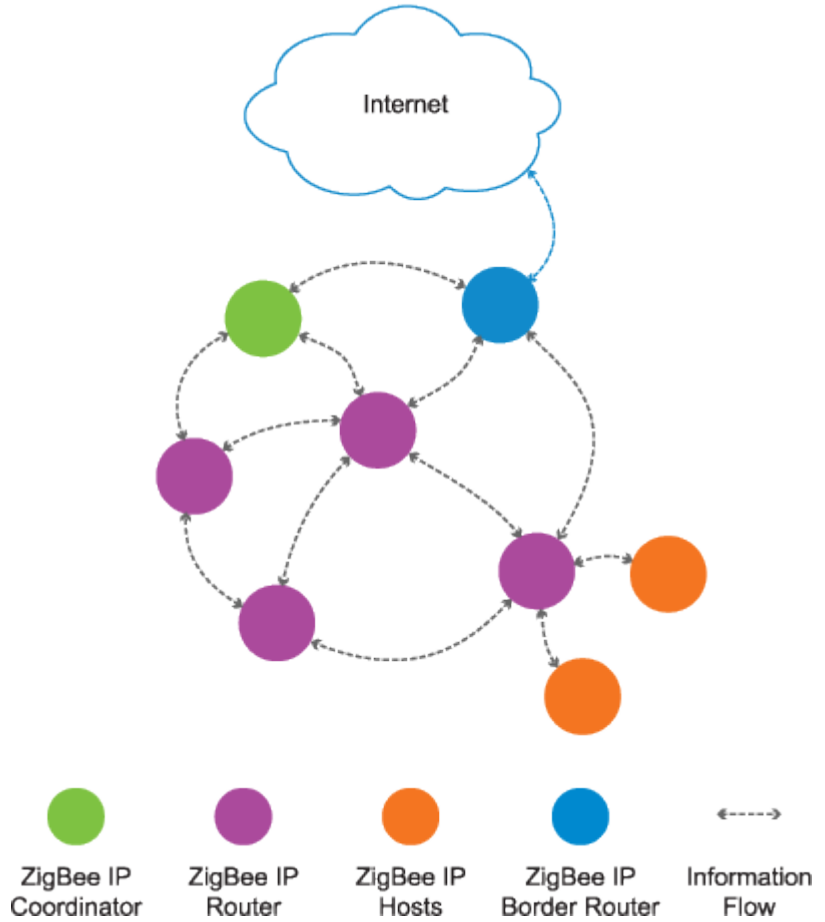
Source: *Netmanias*

ZigBee NW Topology & Protocol stack

zigbee

Zigbee is the only complete IoT solution, from mesh network to the universal language that allows smart objects to work together. Certified by the Zigbee Alliance.

Zigbee consolidated app layer	**Application Standard**
Zigbee PRO (with Green Power)	**Network**
IEEE 802.15.4 - MAC	**Media Access Control**
IEEE 802.15.4 - 2.4 GHz (worldwide) sub-GHz 800-900 MHz (regional)	**Physical Layer**



IoT LPWA Technology Space & connectivity

	SIGFOX	LoRa	NB IoT (NB LTE)	eMTC (LTE-M)	EC-GSM Rel. 13	5G (Targets)
Range **MCL**	<12km 160 dB	< 10km 157 dB	<15km 164 dB	< 10km 156 dB	< 15km 164 dB	<12km 160 dB
Spectrum **Bandwidth**	Unlicensed 900MHz 100Hz	Unlicensed 900MHz <500kHz	Licensed 7-900MHz 200 kHz shared	Licensed 7-900MHz shared	Licensed 8-900MHz shared	Licensed 7-900MHz shared
Data rate	<100bps	<10 kbps	<200 kbps	< 1 Mbps	10kbps	< 1 Mbps
Battery life	10+ years	10+ years	10+ years	10+ years	10+ years	10+ years
Use case	Smart Grid/City/ Monitoring	Smart Grid / City/ Monitoring	Smart Grid/City/ Monitoring	Sm. Grid / City / Monitor./ vehic	Sm. Grid / City / Monitor./ vehic	Sm. Grid / City / Monitor./ vehic.
Module cost	4.00$ (2015) 2.64$ (2020)	4.00$ (2015) 2.64$ (2020)	4$ (2015) 2-3$ (2020)	5.00$ (2015) 3.30$ (2020)	4.5$ (2015) 2.97$ (2020)	<$2
Availability	Today	Today	2016	2016	2016	> 2020

Source: *Nokia*

LPWA: Low-Power Wide-Area
LoRa : Long Range
NB – IoT : Narrow Band IoT

eMTC :
LTE-M : Long Term Evolution Machine Type Connection
EC – GSM : Extended Coverage GSM

IoT Connectivity Spectrums

Name	IEEE Standard	Frequency Band	Data Rate
ZigBee		2.4 GHz (worldwide) 915 MHz (U.S.) 868 MHz (Europe)	20 to 250 kbps
LoRaWAN		915 MHz (U.S.) 868 MHz (Europe)	0.3 to 50 kbps
Z-Wave		908.42 MHz (U.S.) 868.42 MHz (Europe)	Up to 100 kbps
THREAD		2.4 GHz	250 kbps
SIGFOX		915 MHz	Very Low
NFC		13.56 MHz	424 kbps
WirelessHART		2.4 GHz	250 kbps
Weightless		< 1 GHz	Up to 10 Mbps
LTE Cat-1		Cellular bands	Up to 10 Mbps
LTE Cat-0/ LTE-M		Cellular bands	Up to 1 Mbps
Narrowband IoT (NB-IoT)		Cellular bands	Tens of kbps

Source: Rohde & Schwarz

IoT is a major driver for the evolution towards 5G

Massive Broadband

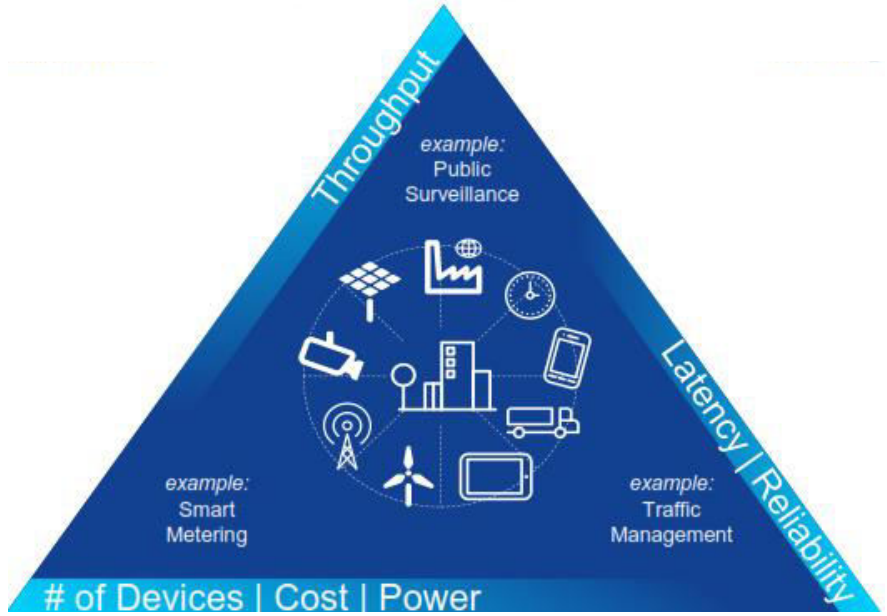
>10 Gbps
peak data rates

100 Mbps
average throughput

10-100
x more devices

10 000
x more traffic

M2M
ultra low cost



10 Years
On Battery

Massive Machine Type
Communication
(LTE-M)

Critical Machine
Type Communication

<1 ms
latency

(Low power) Wide area

Crowd

Outdoor

Ultra-dense

A trillion of devices with different needs

GB transferred in an instant

Mission-critical wireless control and automation

e2e Security

Telco –grade Reliability

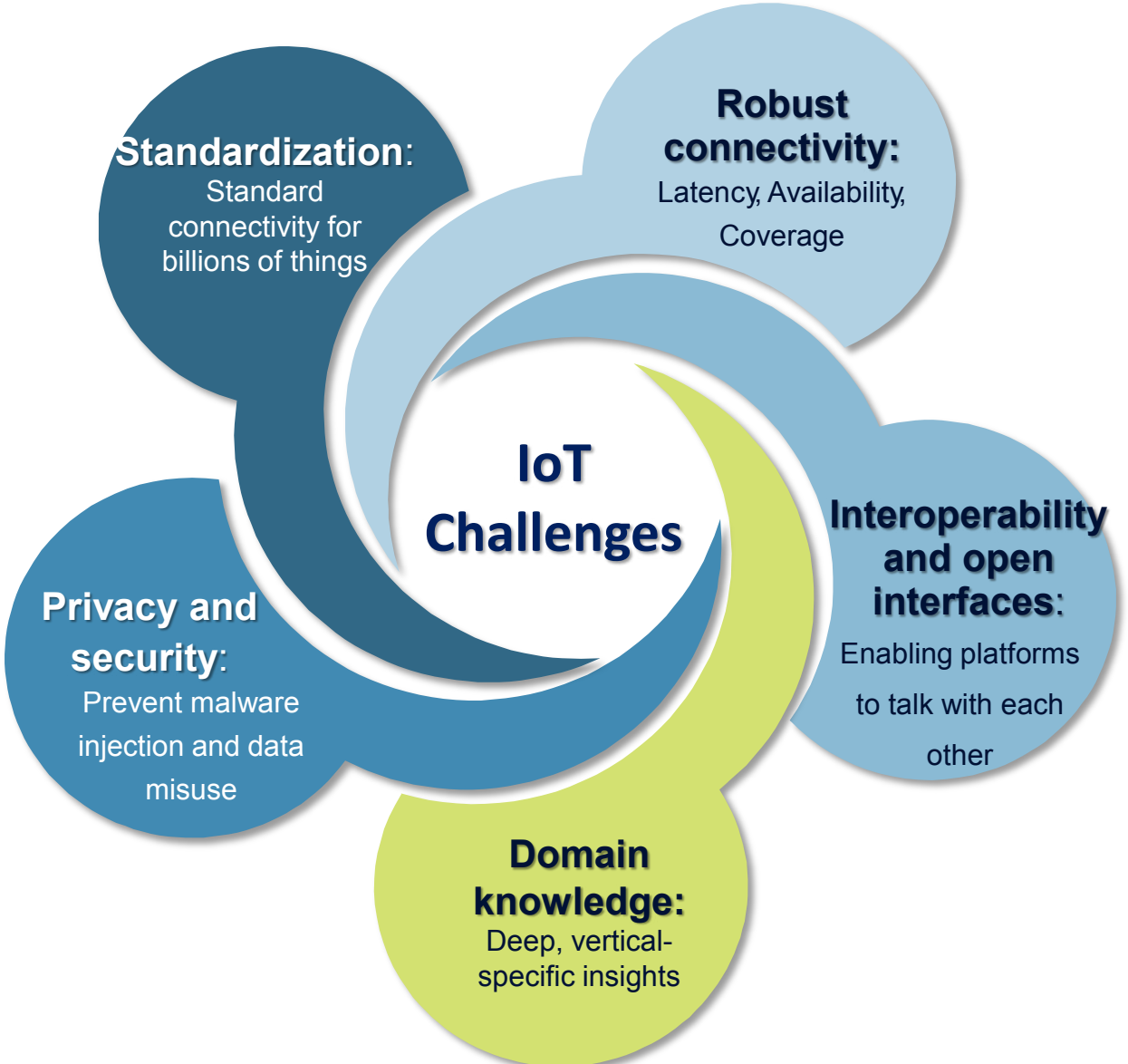
Service Flexibility

Massive Scalability

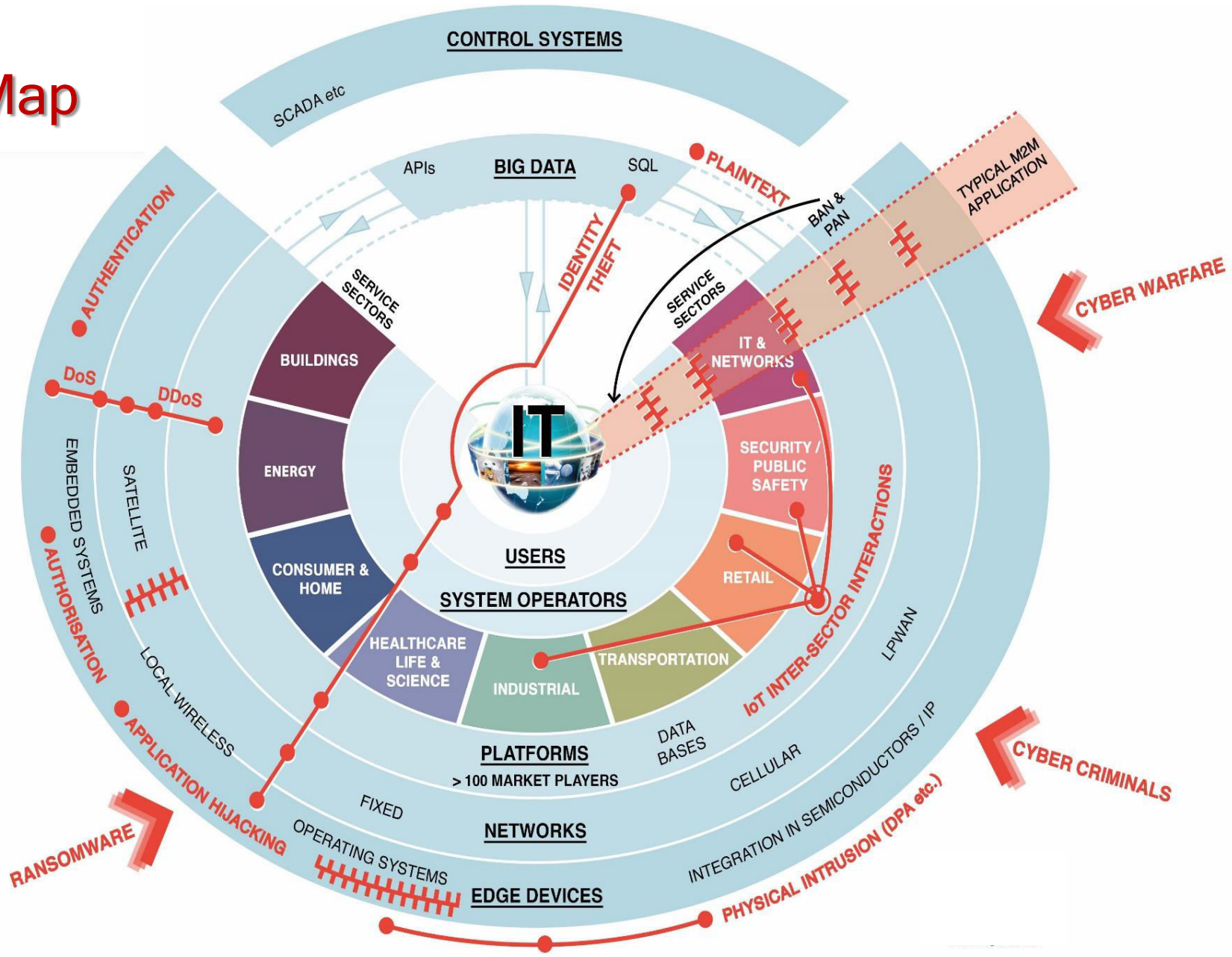
Source: Nokia


Capacity
>10 Gbps
peak data rates
100 Mbps
whenever needed
"Unlimited experience"
10 000
x more traffic
Latency
1,000,000
devices per km²
<1 ms
radio latency
Extreme
Mobile
Broadband
5G
Massive
machine
communication
Critical
machine
communication
Ultra low cost
for massive
machine coms.
Ultra
reliability
< 10⁻⁵ E2E outage
Connectivity
Reliability
10 years
on battery
"For everything"
"Instant action"
Zero
mobility
interruption

Challenges of Internet of Things (IoT)



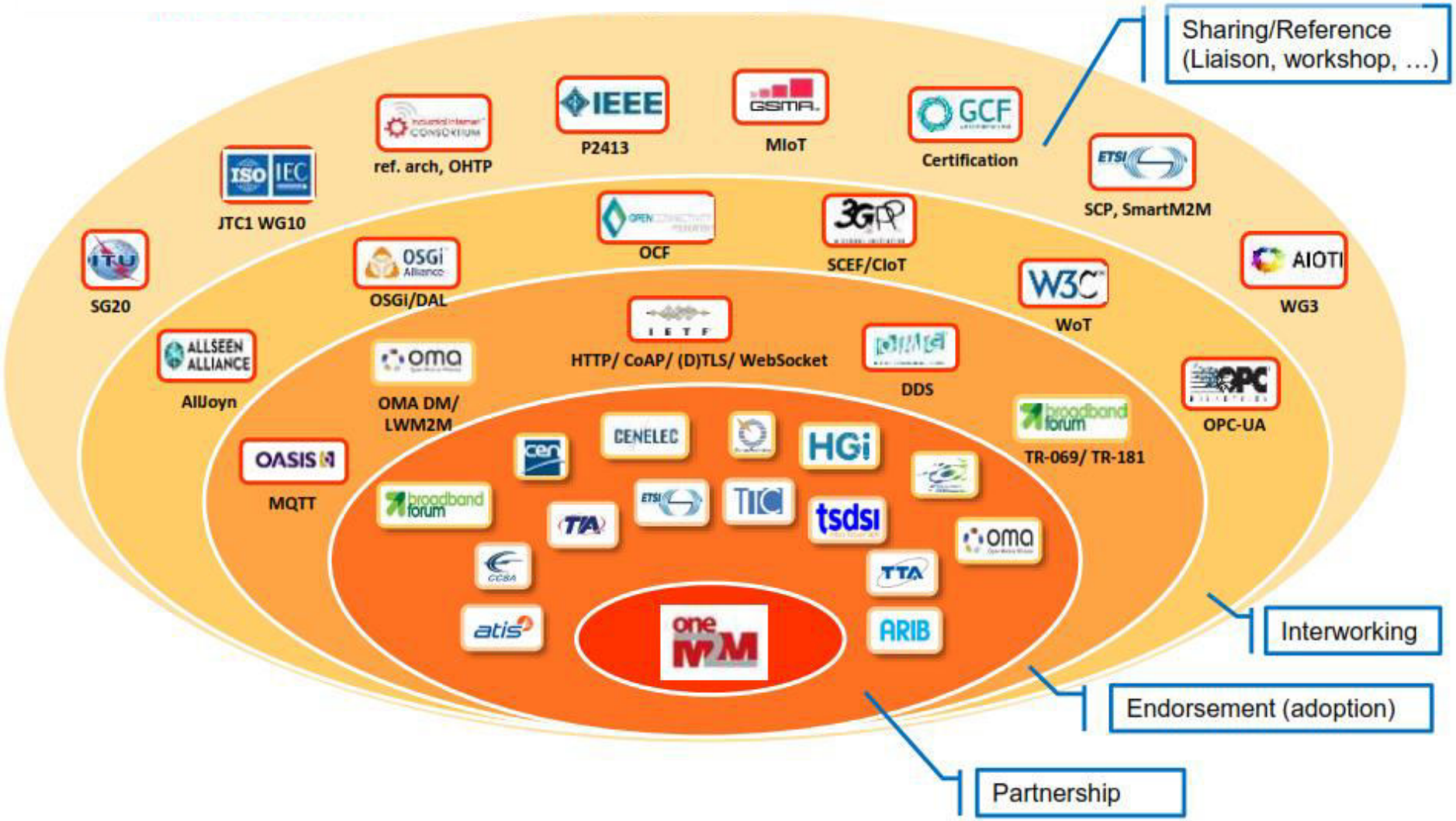
IoT security Map



Source: *Beecham Research*

(Too) many different IoT standards development organizations and industry alliances are competing with each other

oneM2M Partnership Project



Smart Sustainable Cities SSC, Standards & Framework

Smart Sustainable Cities SSC, Standards & Framework

- The traditional standards related to SSC have been mostly developed by technical-specific organizations through "Vertical" approaches.

- As a result, those standards only cover the technical aspects of SSC, which undermines their authority and leads to questions about their validity.

Source: *ITU – Smart Sustainable Cities*

Smart Sustainable Cities SSC, Standards & Framework

- Moreover, the original models of the "digital city", "wireless city", "broadband city" or "optical city" had a strong technical focus on information and communication technologies (ICTs). These models were not following a broad and horizontal strategy, and sector-specific vertical approaches were based on separate infrastructures, not interworking with each other while often physically overlapping.
- None of these models can satisfy the complex and comprehensive requirement of future urban management and sustainable development.

Source: *ITU – Smart Sustainable Cities*

Framework for SSC standards

Buildings and physical infrastructure:

- Urban planning;
- Low carbon design and construction;
- Intelligent building systems;
- Building information modelling (BIM);
- Traffic systems;
- urban pipeline network.

Information and communication technology (ICT):

- ICT framework, architecture and information model;
- Network and information security, availability and resilience;
- Application and support layer;
- Data layer;
- Communication layer;
- Sensing layer.

Smart City management and assessment:

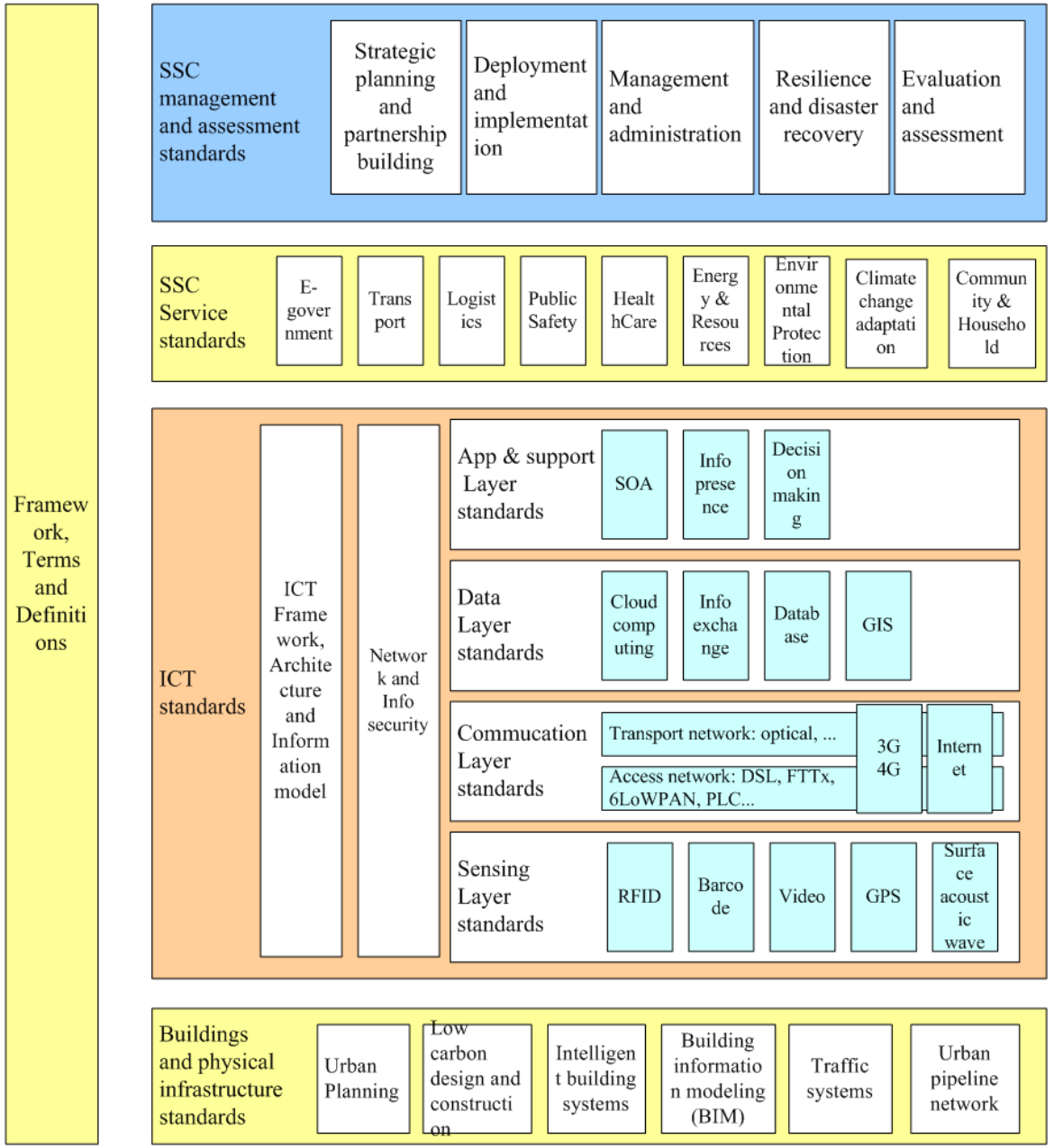
- Strategic planning and partnership building;
- Deployment and implementation;
- Management and administration;
- Resilience and disaster recovery;
- Evaluation and assessment.

SSC services:

- e-government;
- Transport;
- Logistics;
- Public safety;
- Health care;
- Governance of urban infrastructure;
- Energy and resources management;
- Environmental protection;
- Climate change adaptation;
- Community and household.

Source: *ITU – Smart Sustainable Cities*

Framework for SSC standards



Source: *ITU – Smart Sustainable Cities*

Smart Sustainable Cities SSC, Standards & Framework

Conclusion & Recommendation:

- The original digital systems, as well as the traditional ICT standards, should be improved or redesigned from a broader and higher level perspective, to achieve the transformational impact that smart sustainable cities ought to bring about.

- Therefore, the development of SSC standards should be accomplished through cooperation among standards organizations and the adaption of existing standards, fulfilling the principle of openness, compatibility and versatility.

Source: *ITU – Smart Sustainable Cities*


Thank You