X O N Δ

**Internet of Things
Where are we at ?**

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January 2015

Agenda

> IoT Overview

> A look at applications

> Market overview

> Technologies

> IoT Platforms

> How Xona can help

> About Xona Partners

Complementary whitepaper on IoT:

Internet of Things - Coming of Age is available for download at this link

Prologue

› IoT is represent the next evolution of the Internet

› Large and small companies are vying for a share of the IoT value chain: IoT strategy is central for many corporations

› IoT is wide and encompasses multiple applications and use cases that drive different technology solutions

› IoT is unleashing new business models as breadth, fragmentation and complexity are driving partnerships and coalitions

› This overview highlights some aspects of IoT – it 'scratches the surface' of the 'tip of the iceberg'!
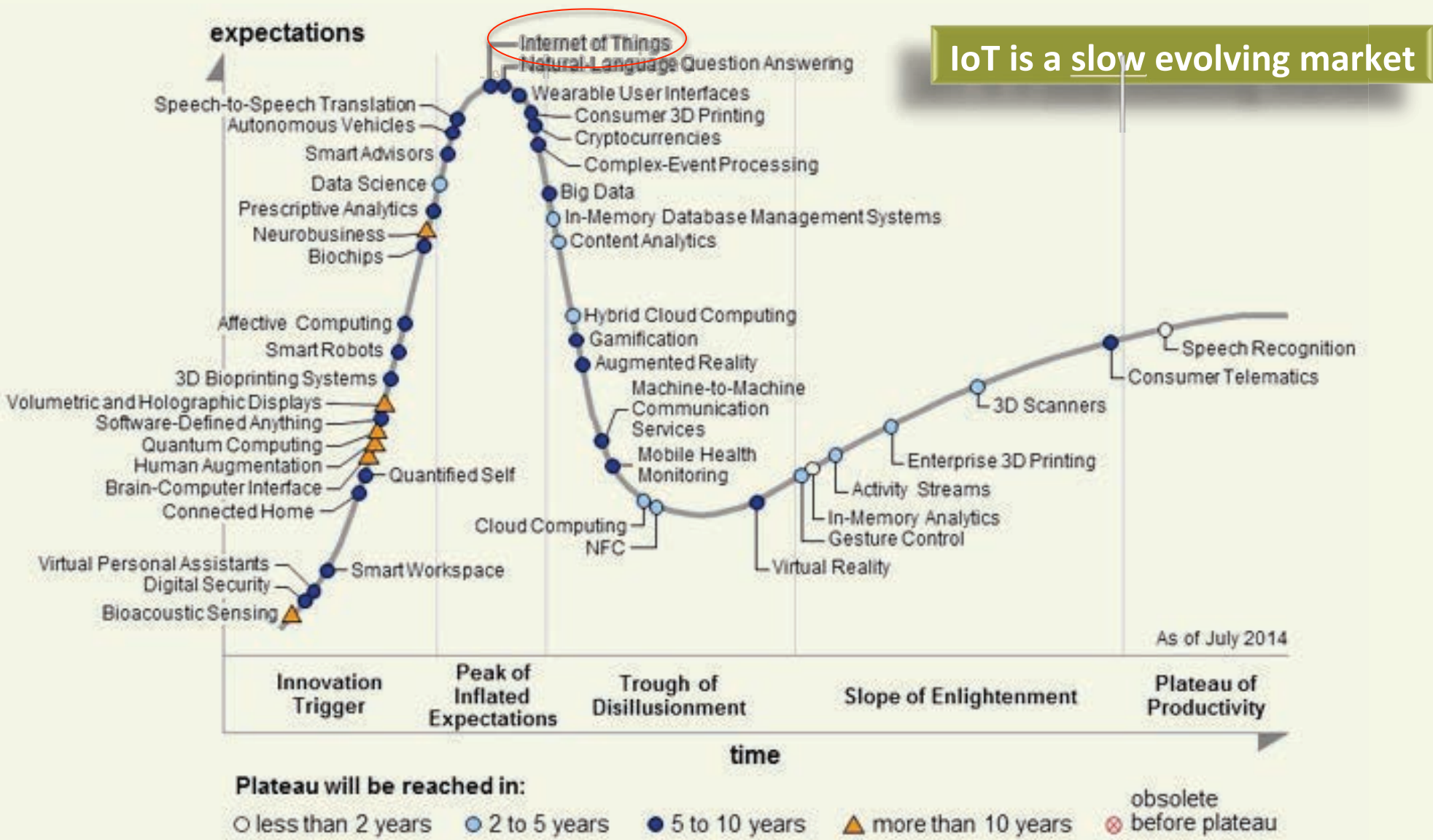
Section 1

OVERVIEW

The World of the Internet of Things

M2M: Machine to machine
M2H: Machine-to-human
M2APS: Machine-to-application-server
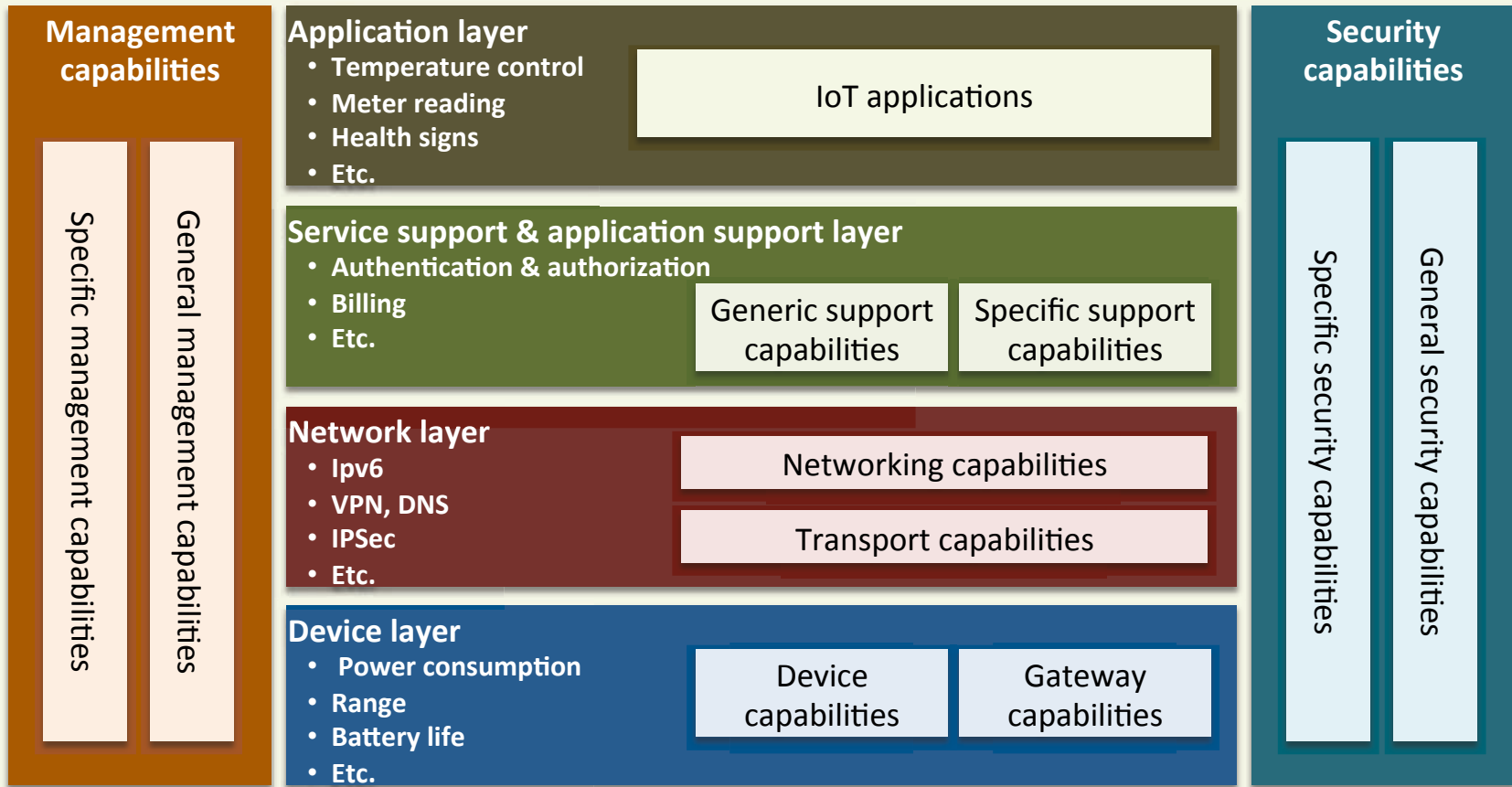
IoT

M2H

M2APS

M2M
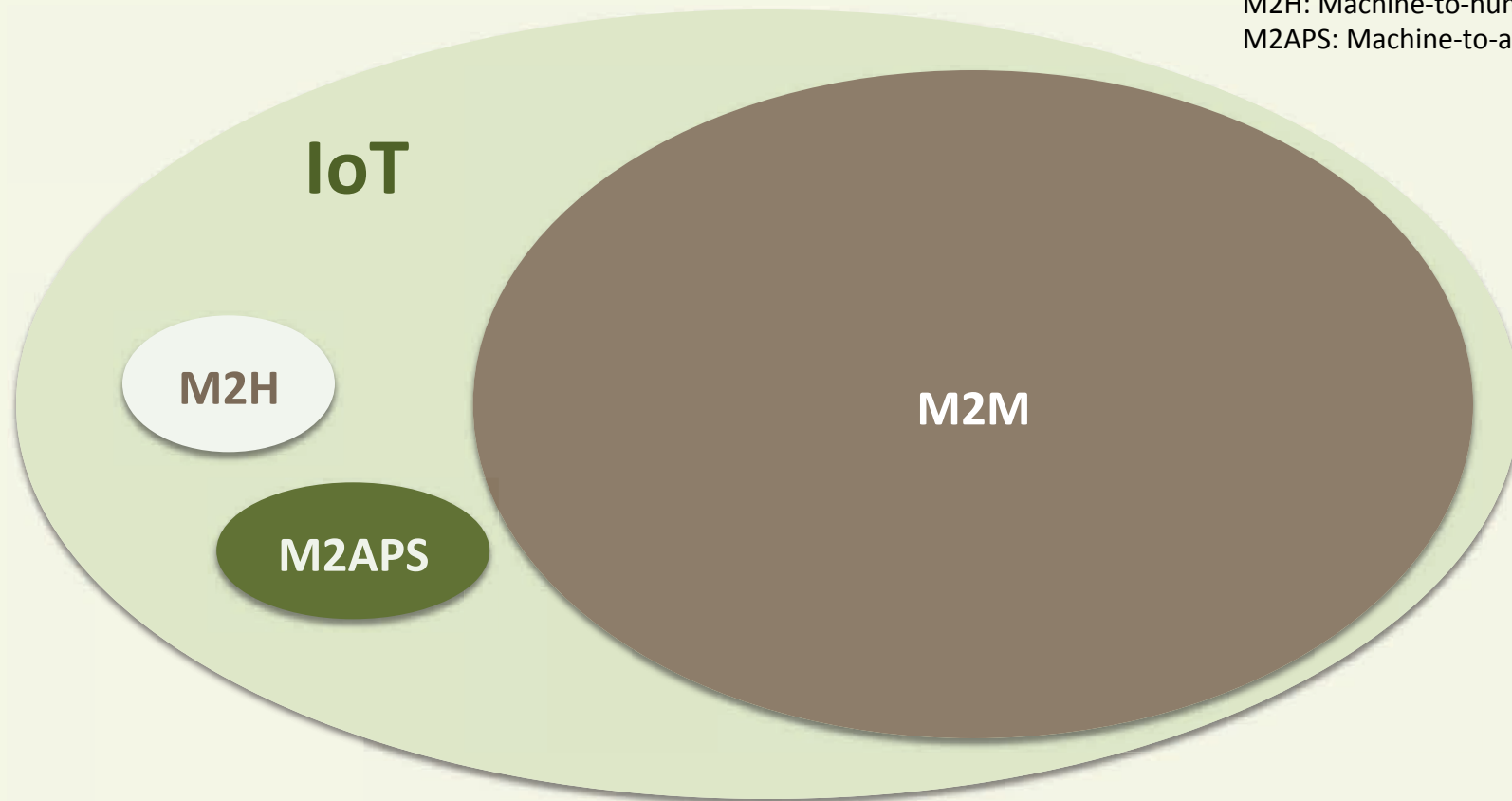
Internet of Things (IoT) is a broad term that started as Machine to Machine (M2M) but now has a wider scope than machine connectivity: it is complex and combines multiple disciplines!

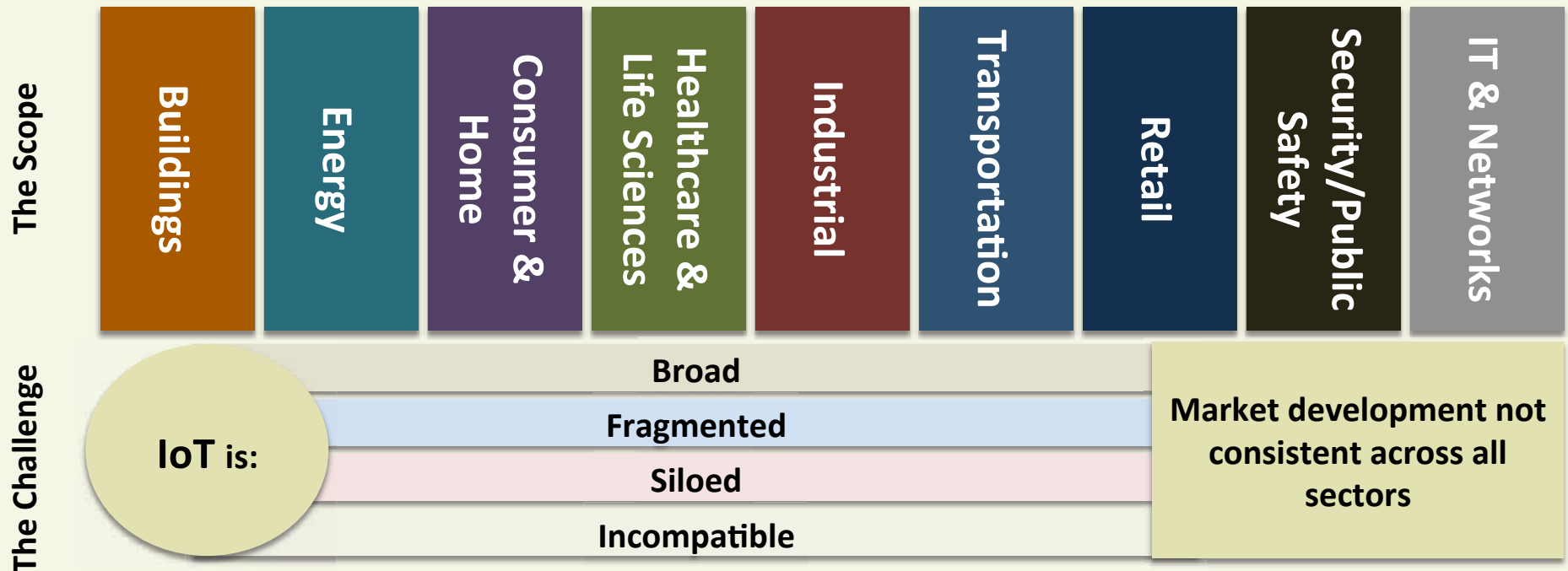# IoT: 10 Years to Reach Plateau of Productivity

IoT is a slow evolving market

Source: Gartner, 2014

What IoT Encompass?

Management capabilities

Specific management capabilities

General management capabilities

Application layer
- Temperature control
- Meter reading
- Health signs
- Etc.

IoT applications

Service support & application support layer
- Authentication & authorization
- Billing
- Etc.

Generic support capabilities

Specific support capabilities

Network layer
- Ipv6
- VPN, DNS
- IPSec
- Etc.

Networking capabilities

Transport capabilities

Device layer
- Power consumption
- Range
- Battery life
- Etc.

Device capabilities

Gateway capabilities

Security capabilities

Specific security capabilities

General security capabilities

IoT is a complex multidisciplinary combination of different aspects of communication, security, management and data functions

Based on ITU-T Y.2060, 2012

IoT Spans Consumer & Industrial Applications: Speed of Adoption Depends on Application

The Scope

Buildings	Energy	Consumer & Home	Healthcare & Life Sciences	Industrial	Transportation	Retail	Security/Public Safety	IT & Networks

The Challenge

IoT is:
- Broad
- Fragmented
- Siloed
- Incompatible

Market development not consistent across all sectors

The Opportunity

USD 7.3 Trillion
Technology & service revenue by 2017*

Automotive	202 ($, b)
Healthcare	97 ($, b)
Consumer electronics	445 ($, b)
Utilities	36 ($, b)

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*Source: IDC, 2014 (link).

Characteristics of IoT Market

› Breadth
  – The Internet of Things as the name implies has a broad scope to connect different type of devices and enable remote control, management and sensing in a diverse set of 'dumb' devices

› Fragmentation
  – Multitude of existing and competing products, platforms, standards and proprietary protocols

› 'Siloing'
  – Market verticals driving different implementations
    • Automotive, digital home, healthcare, utilities, education, consumer electronics

› Incompatibility
  – Fragmentation and siloing result in incompatible solutions that contribute to keeping prices high

IoT in the Technology Lifecycle

We are in a new phase of IoT development: companies need to be active in staking out positions in IoT to secure future competitiveness

Drivers for a new IoT development phase

1. Smartphone maturity, adoption rate and penetration
2. Evolution of cloud services especially those based on open source
3. Advancements in compute power and costing that enable application of data sciences on wide scale
4. Silicon technologies for low-power low-cost modems and sensors

Vertical 1: Intelligent Home
Apple HomeKit for Connected Home applications is built around the iPhone as control platform for home appliances leveraging Bluetooth connectivity

Vertical 2: Connected Car
Ford maintains its Synch platform despite application interworking with iOS and Android-based phones to provide additional value

Startups
Investments into platform and device plays (gadgets); cloud technologies and data sciences by institutional and corporate VCs.

Acquisitions:
Companies actively shoring up positions of strength as well as moving into adjacent areas through acquisitions and investments. Example: Qualcomm / CSR, Samsung / SmarThings, GE / Quircky, IBM / SoftLayer, Intel / Basis Science.

Alliances
Industry groupings and alliances are beginning to emerge to fight out the standards wars for supremacy in different verticals: AllSeen, IOC

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Challenges in IoT

› Interoperability
  – Highly dimensional (many devices, sensors, equipment, etc.), heterogeneous (diverse purpose & applications), dynamic and non-linear (new things are entering and exiting the environment), hard to describe & model (many data formats)

› Standardization

› Privacy & security

› Regulatory
  – Example is in e/mHealth where required regulatory changes to accelerate the market have been slow to develop leading to slower adoption of certain applications
  – Regulatory intervention in Smart Grid technologies has been key to enabling the business case of applications including smart metering
  – Regulatory mandates on eCall in Europe will accelerate the adoption of this and other applications

› Socio-ethical considerations

Simplifying IoT: The Ecosystem 'Stack'

Services
- IoT Service in specific domain
- Managed & Professional Services

Platforms
- Infrastructure enablement: security, provisioning, business/operations support, data analytics, etc.
- Traditional telecom or Internet driven functions

Applications
- IoT use cases in specific verticals
- e.g. in-car entertainment, remote function control, vital health sign reporting, etc.

Connectivity
- Wireless, wireline; direct, tethered, mesh
- Open or proprietary standards
- Multiple protocol option at all layers of protocol stack

Devices
- Sensors, identifiers, embedded processors
- Data processing and/or communication capability
- Direct or indirect network connection

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Key Takeaways

› **Devices can be anything.** Ranging from consumer products such as a watch (or a shirt!), to industrial and commercial applications such as utility meters and airplane engines

› **Connectivity can be anything.** Wireline technologies such as PLC or wireless such as Bluetooth, Zigbee, Wi-Fi, LTE, or Weightless (and many others!)

› **Applications and services can be anything.** Well, almost… as long as they bring benefit and value to the end user, the opportunities are limitless in what IoT can potentially provide, much as in today's Internet

IoT is a game changer that is beginning to reshape market alliances and is energizing investment into new technologies and business models in a evolving space

Section 2

A LOOK AT APPLICATIONS

Evolving Applications: Connected Car

M2M

HMI

Applications in the connected car will have different requirements for interfaces

Applications for In-Car Connectivity

Consumer demand (infotainment and navigation) and regulatory mandates (eCall) will result in higher growth for these applications
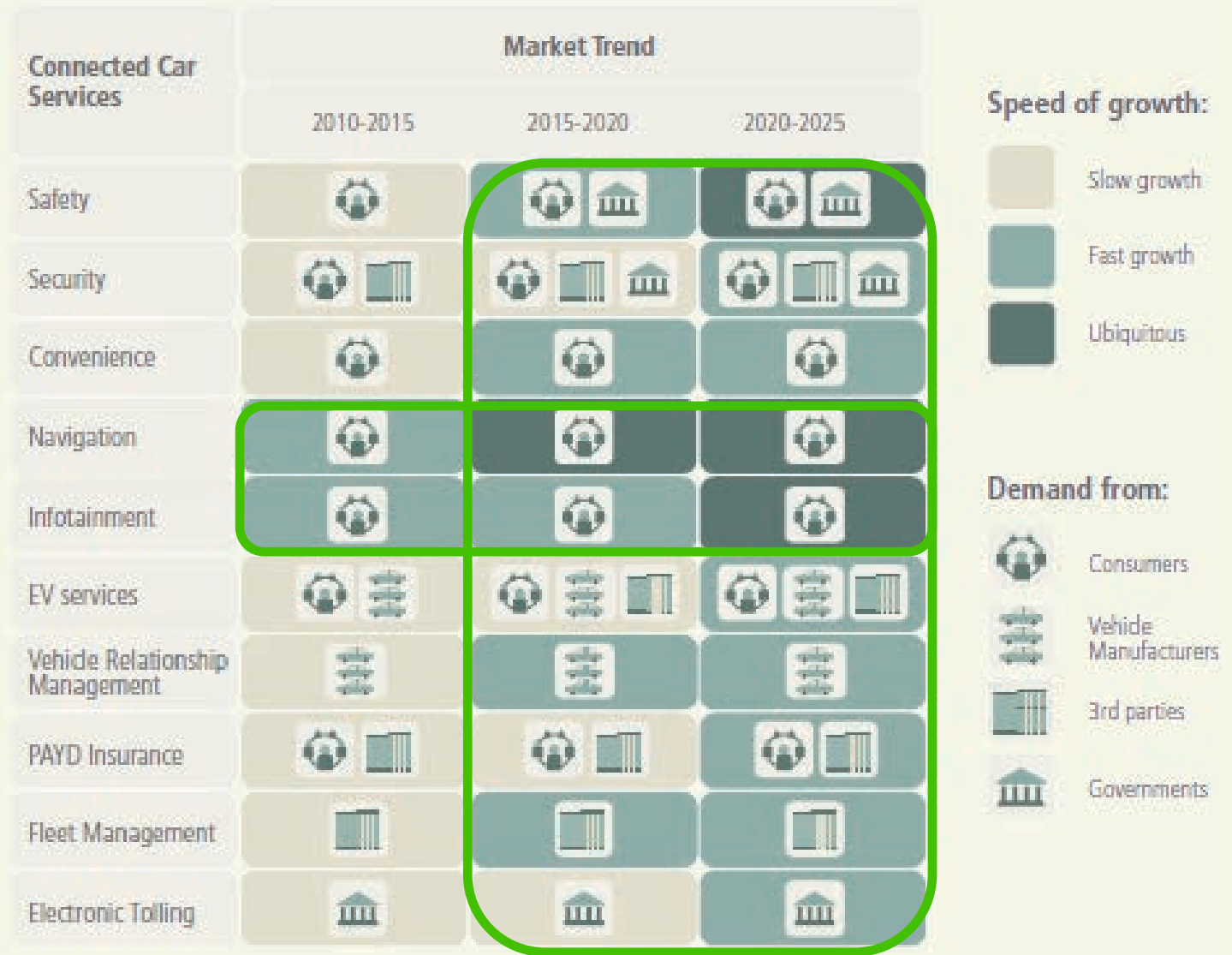
Intelligent Home Applications

Home SW framework (e.g. Apple HomeKit)

belkin

STAPLES connect — powered by Linksys

revolv

SmartThings

DIY Connectivity
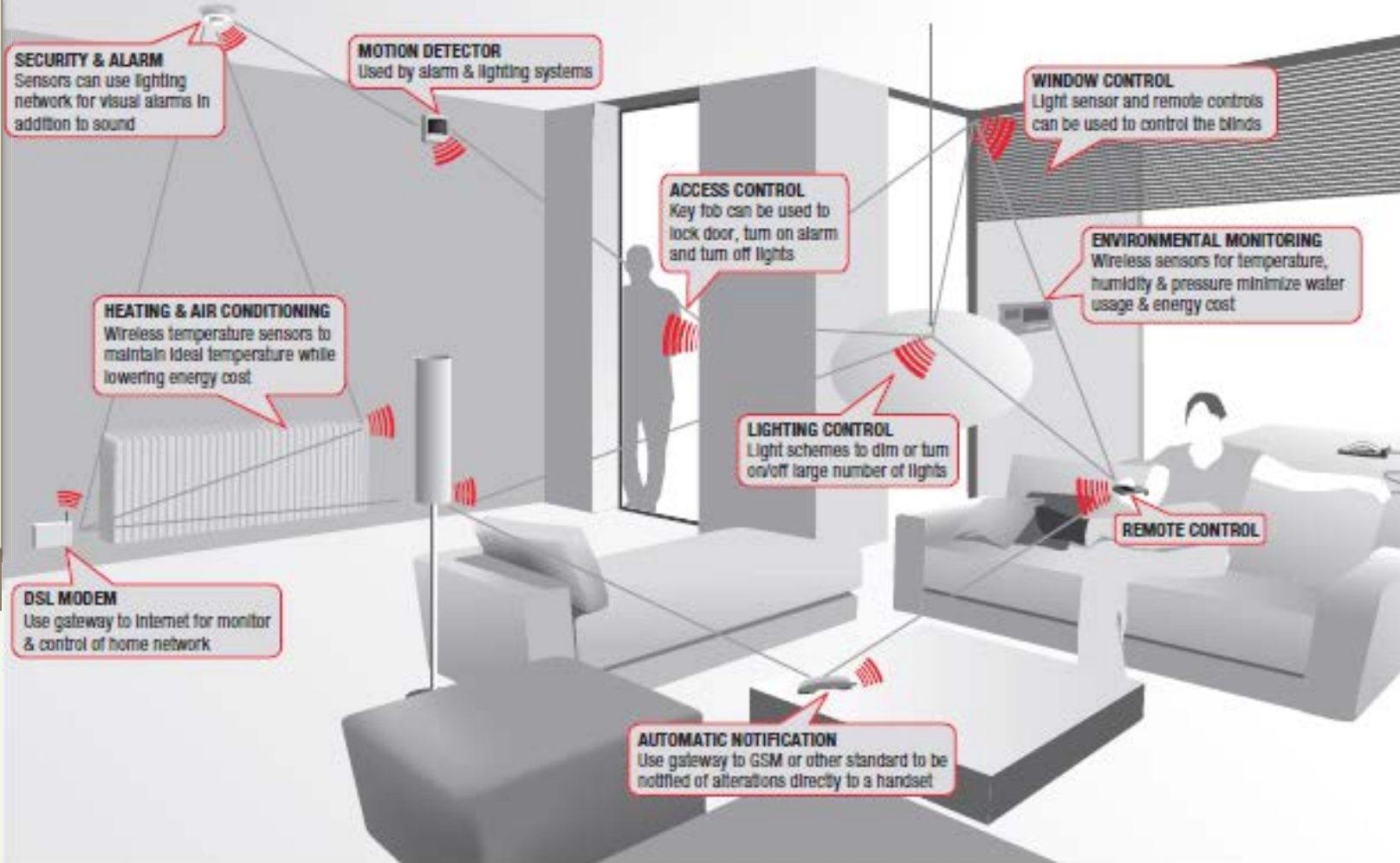
Note: Samsung acquired SmartThings
DIY = Do it yourself

Evolving Applications: Mobile Health

$24 Billion in 2017

28%

30%

30%

5%

7%
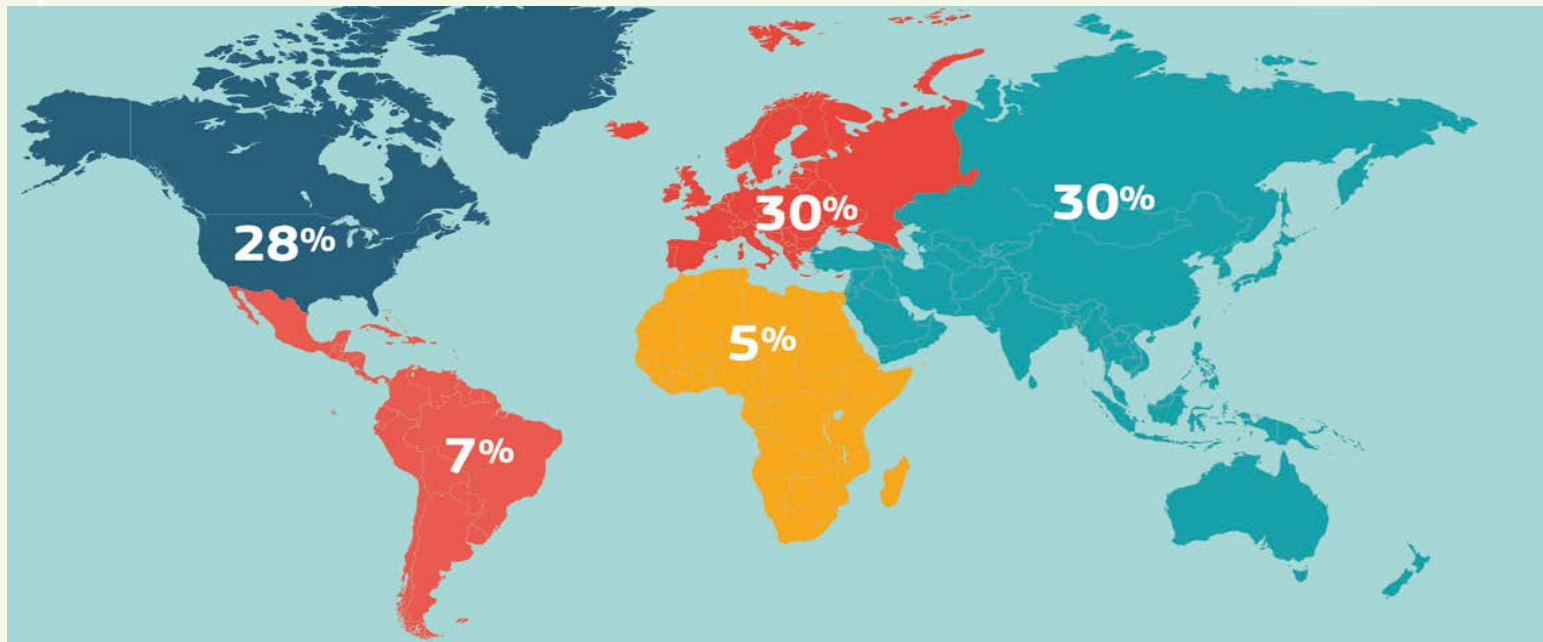
Challenges to resolve

Data protection and trust

Safety of apps
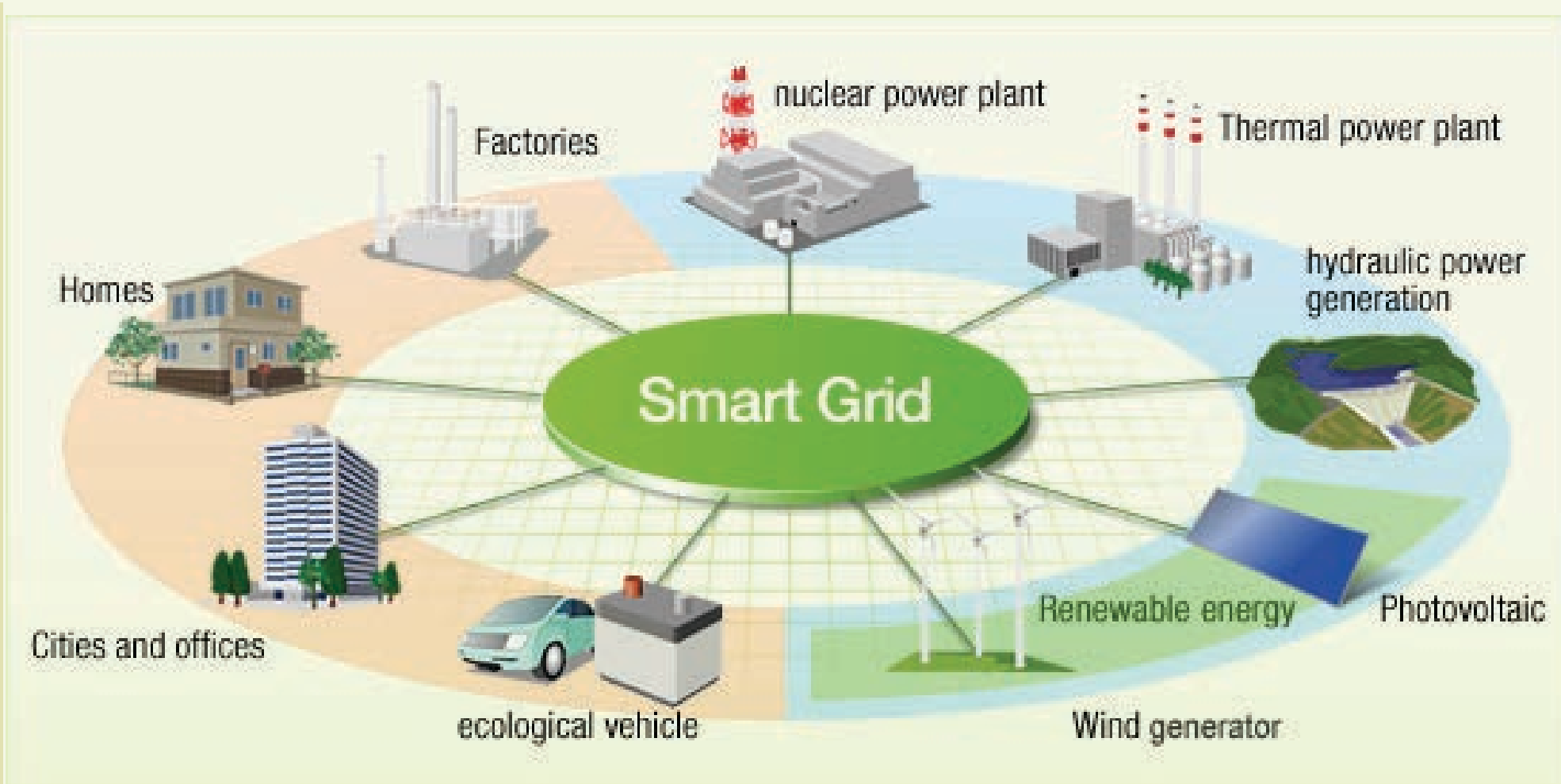
Interoperability between health care providers

Knowledge of legal framework

Applications in mobile health are subject to requirements in protection, trust within context of a legal framework
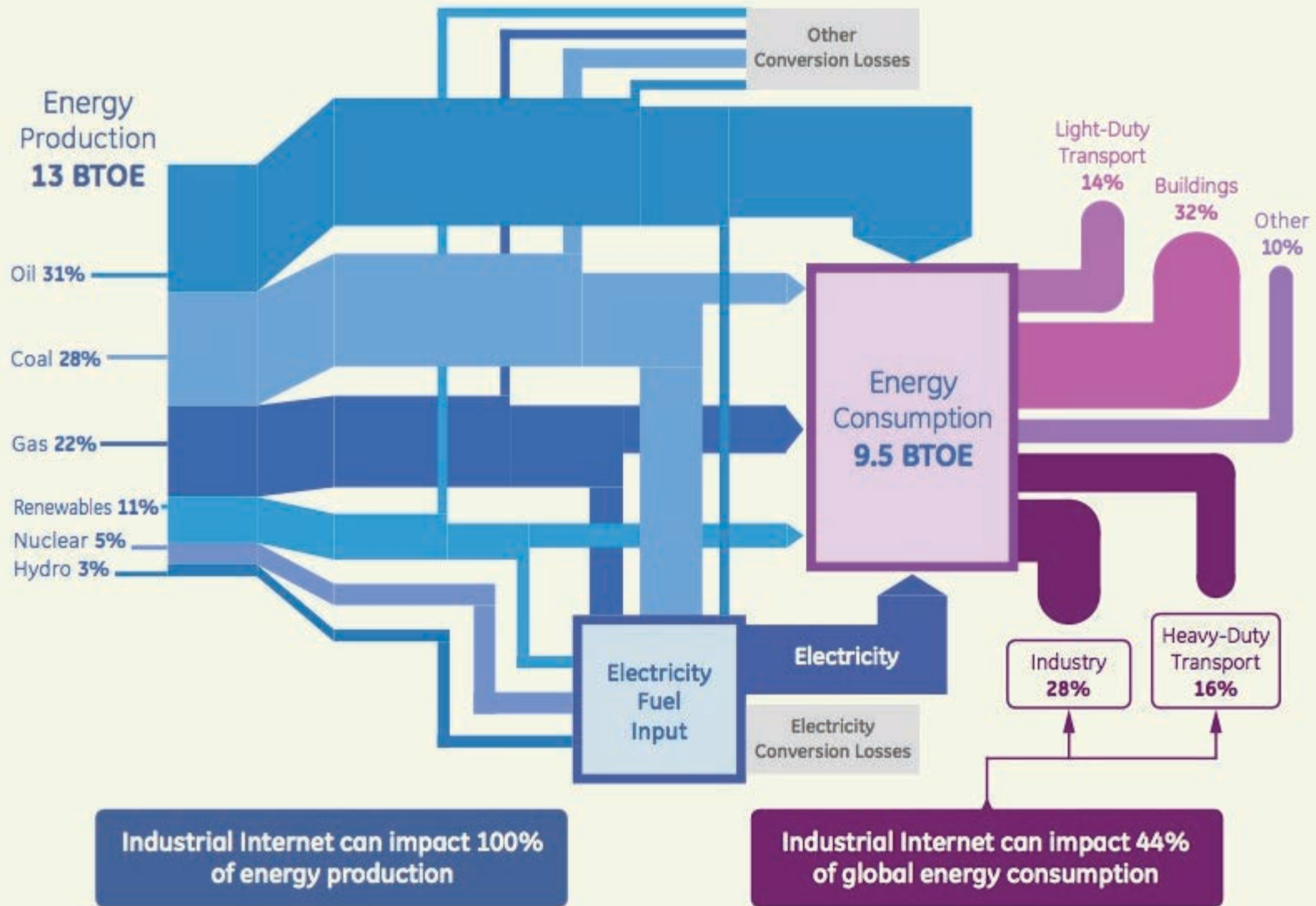
Smart Cities
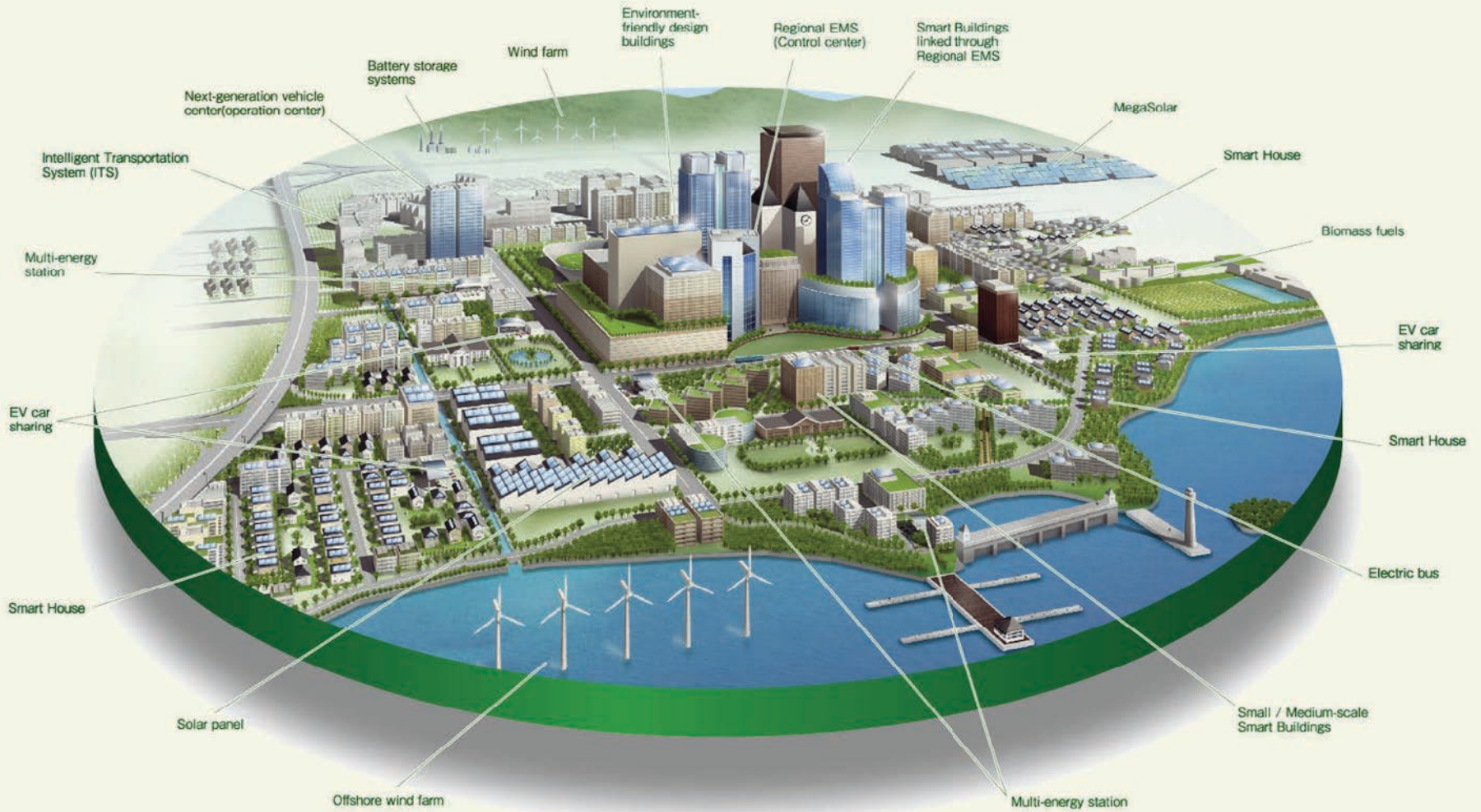
Smart Grids

Industrial Internet
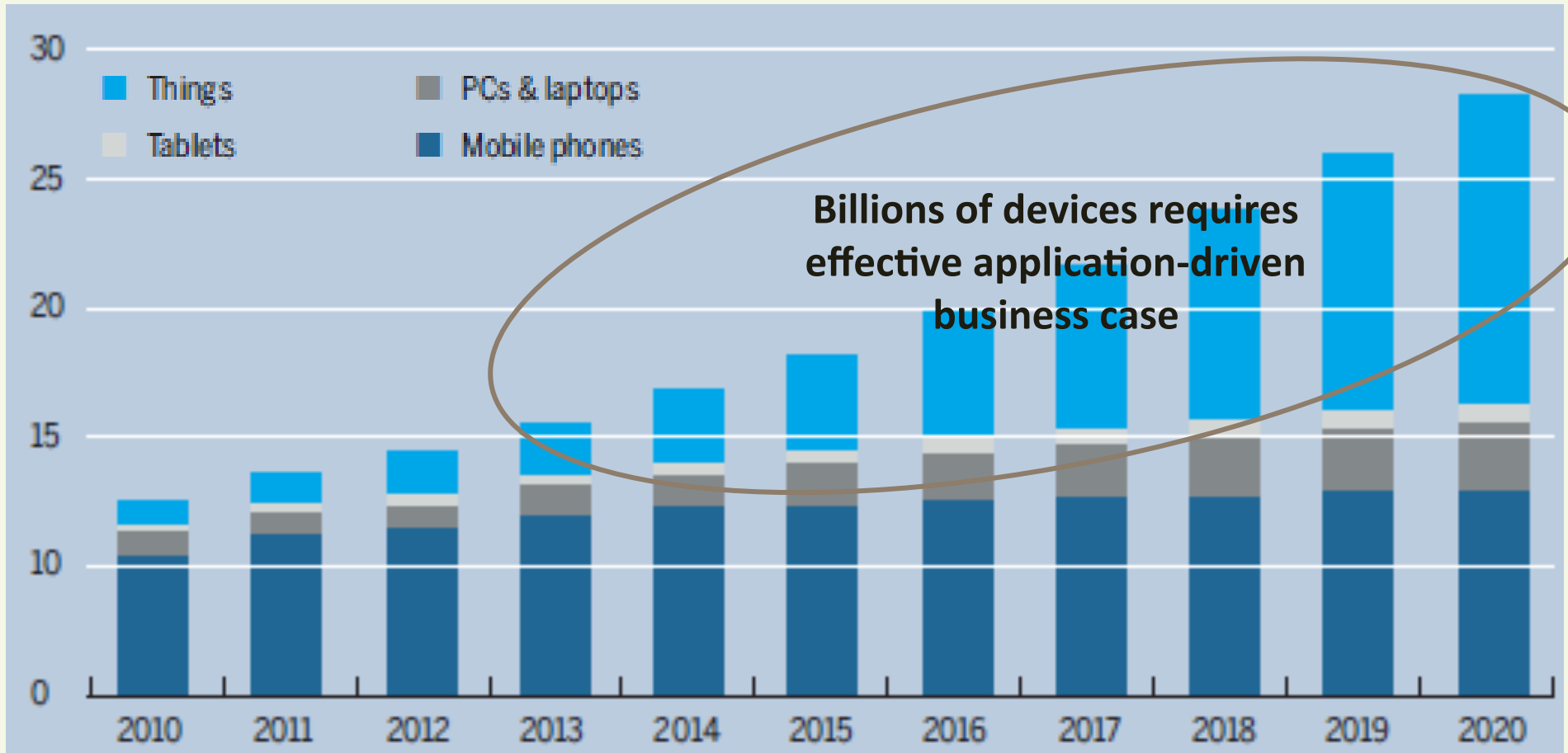

Source: GE, Global Strategy & Planning Estimates, 2011

Section 3

MARKET OVERVIEW

25 – 50 Billions of Connected Devices by 2020*

Per type of device

Billions of devices requires effective application-driven business case

IoT business case challenge is in controlling costs and quantifying multi-lateral benefits: external drivers such as regulations and subsidies are key in certain sectors

* By 2020 Gartner estimates 26 billion; Ericsson estimates 50 billion
Source: MIT Technology Review, July 2014
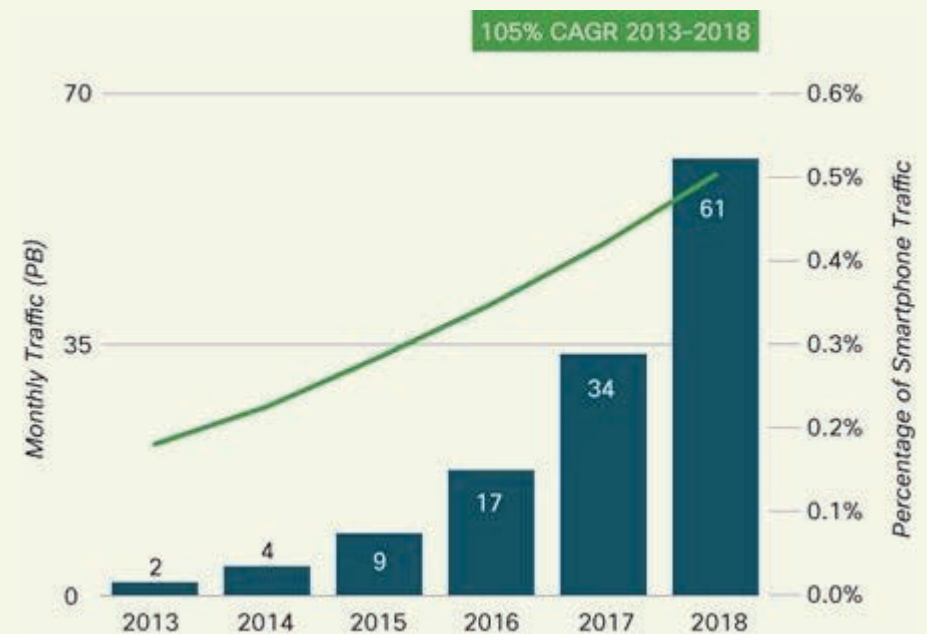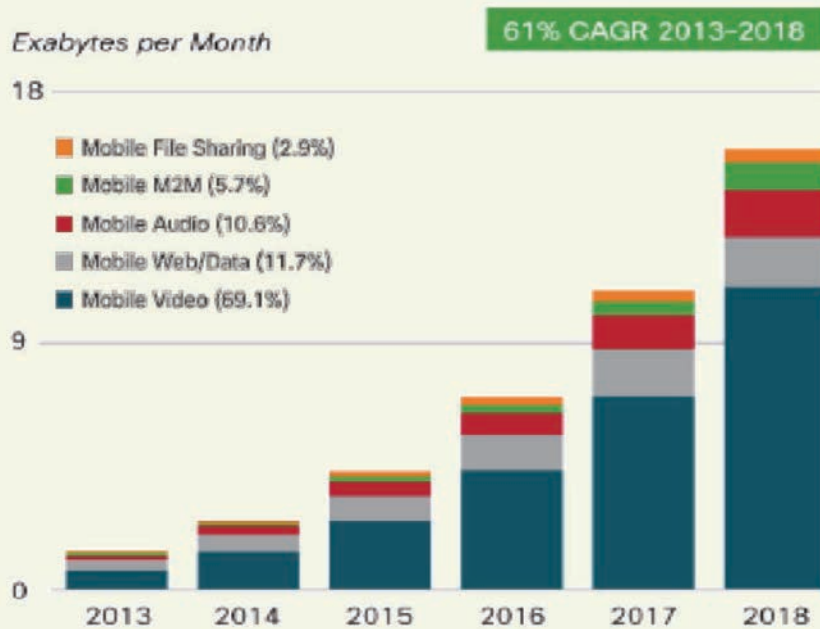
IoT in Mobile Wireless Networks: Today

› **~$16 billion in service revenues** for wireless providers in 2013 (~5% of revenue), and this should double by 2017.

› **195 million global M2M connections** in 2013, growing at almost 38% CAGR between 2010 and 2013

› **Accounts for 2.8% of all global mobile connections**, double the 1.4% share in 2010

› **428 mobile operators offer M2M services** across 187 countries: ~40% of the world's mobile operators

› **One in ten mobile connections in North America is M2M**: the highest proportion of M2M connections on a regional basis

IoT in Mobile Wireless Networks: Tomorrow

M2M traffic is expected to account for only 5.7% of total traffic in 2018

Traffic from wearables will account for 0.5% of smartphone traffic by 2018. or 0.4% of total mobile traffic

Exabytes per Month

61% CAGR 2013–2018

18

- Mobile File Sharing (2.9%)
- Mobile M2M (5.7%)
- Mobile Audio (10.6%)
- Mobile Web/Data (11.7%)
- Mobile Video (69.1%)

9

0

2013 2014 2015 2016 2017 2018

105% CAGR 2013–2018

70   0.6%

                                      0.5%

Monthly Traffic (PB)   Percentage of Smartphone Traffic

                                      0.4%

35   0.3%

                                      0.2%

                                      0.1%

                              61

              34

          17
0   2   4   9   0.0%

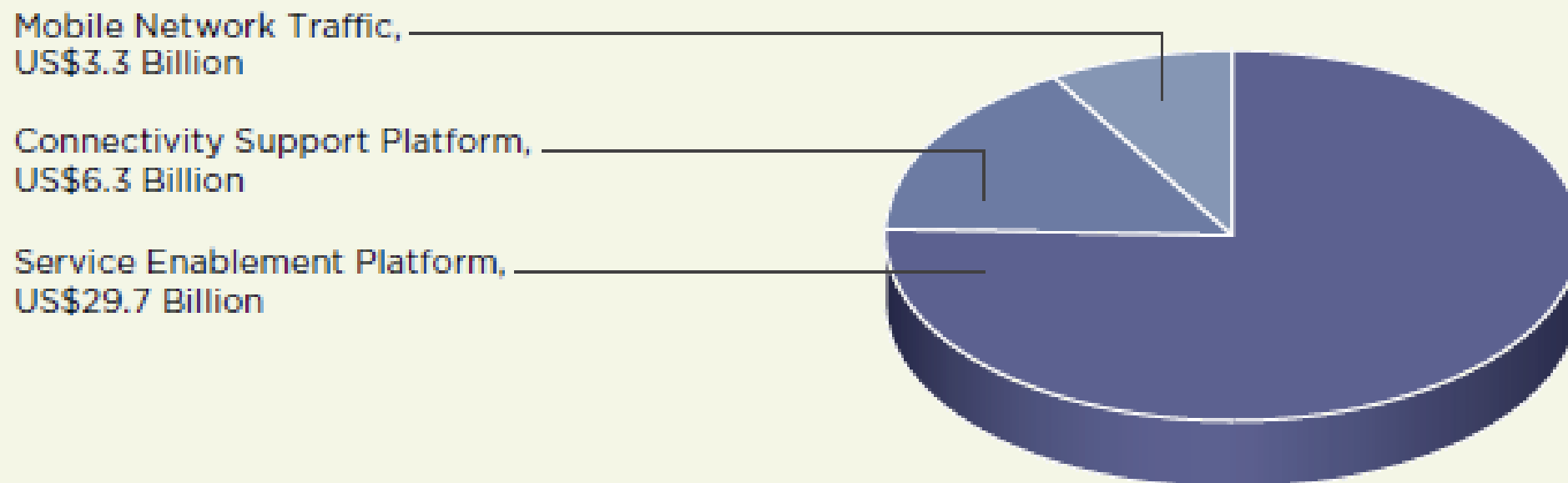2013 2014 2015 2016 2017 2018

**The key impact of M2M in wireless networks will be in signaling
A large opportunity in M2M lies beyond mobile networks**

Source: Cisco VNI 2014`

The Future of M2M: Where's The Money

M2M Connectivity revenue expected to reach US$39.3 bil in 2022

Mobile Network Traffic,
US$3.3 Billion

Connectivity Support Platform,
US$6.3 Billion

Service Enablement Platform,
US$29.7 Billion

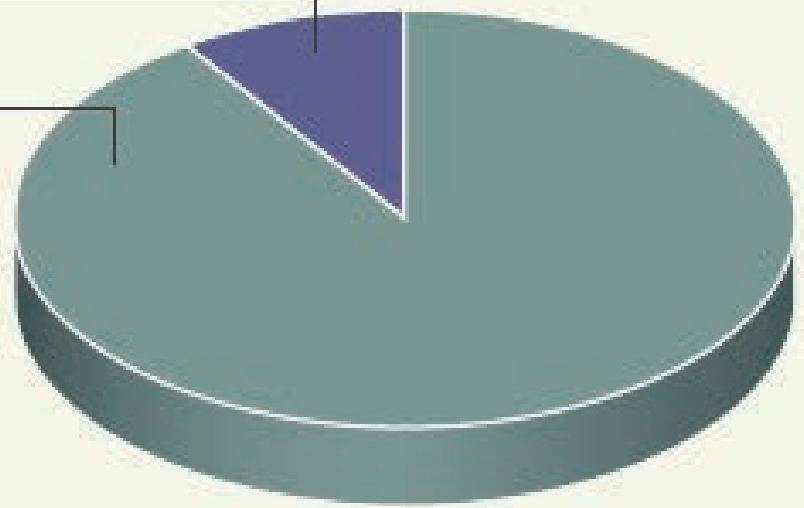**76% of M2M connectivity revenue will come from service enablement platforms**

Source: Machina Data / GSMA Connected Living, Understanding the Internet of Things, July 2014

The Future of M2M: Where's The Money

Overall M2M market revenue to reach US$422.6 bil in 2022

Connectivity Services,
US$39.3 Billion

Service Wrap,
US$383.3 Billion

91% of M2M overall market revenue will come from service wrap*

The 'Service Wrap' comprises the service that the end customer pays

Source: Machina Data / GSMA Connected Living, Understanding the Internet of Things, July 2014

Key Takeaways

› **New business models will emerge.** The smartphone is a powerful tool for IoT services as a tether to the Internet. But who will appropriate the value from IoT services: wireless operators or Internet players? New business opportunities will emerge as a consequence

› **New networks will evolve.** Mobile networks will provide improved support for IoT services (e.g. signaling, power consumption) but there are fundamental conflicts in application requirements that open the door for new networks and services with far reaching consequences (regulatory, technical, commercial, etc.)

IoT will unleash new business and technology paradigms as players in telecom and Internet compete for value in the Internet of Things
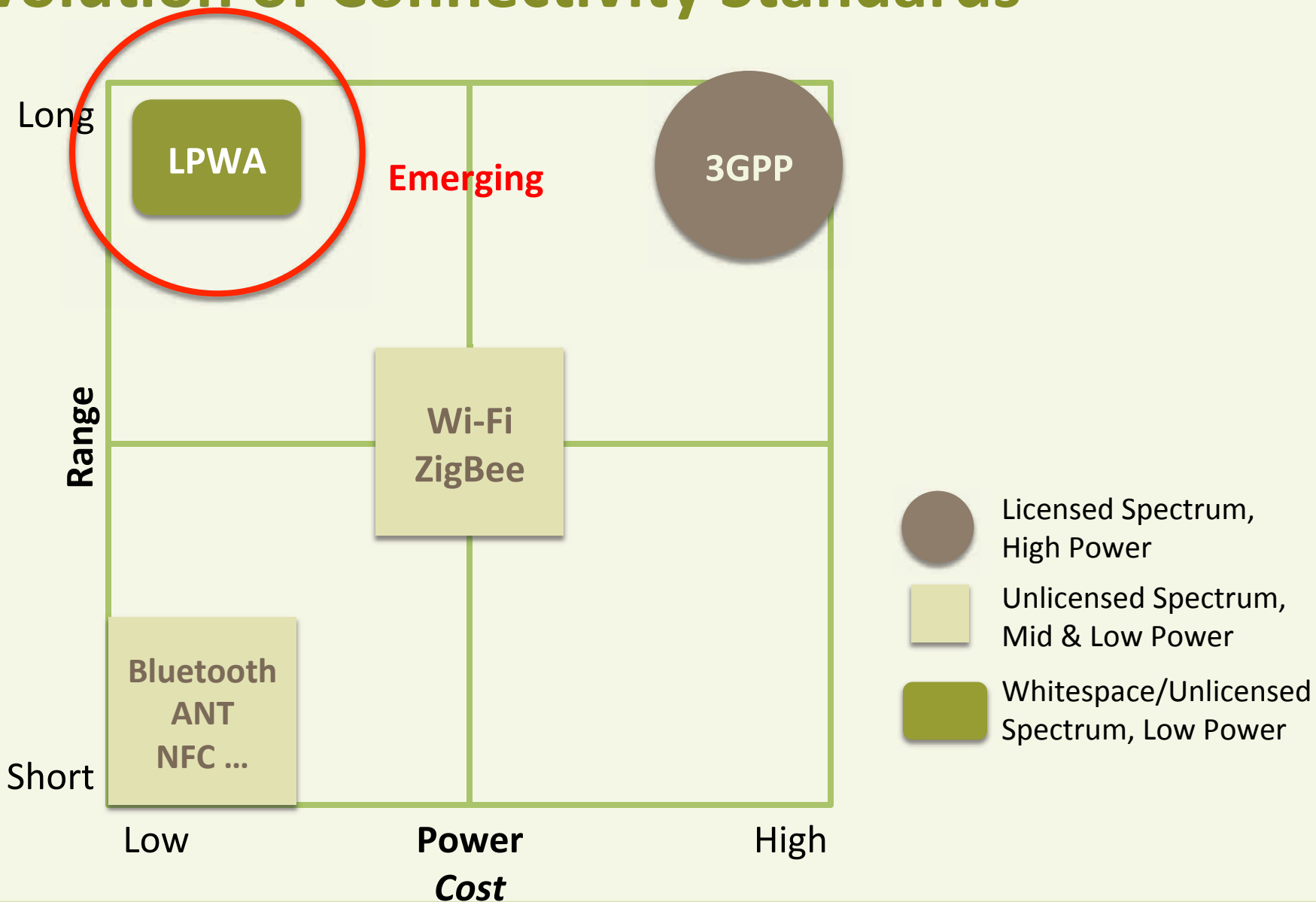
Section 4

A LOOK AT TECHNOLOGY

Heterogeneous Standards Environment in IoT
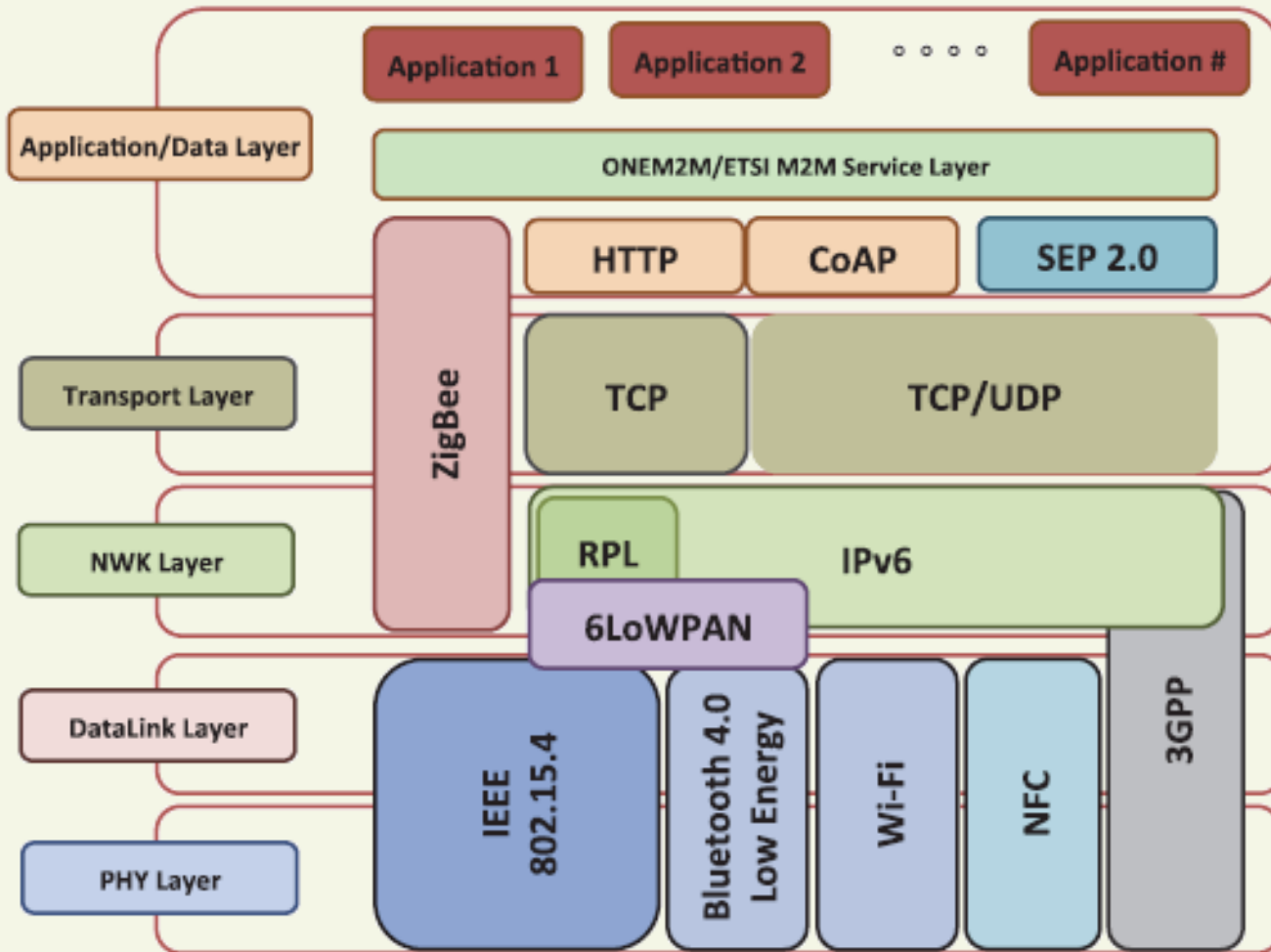
IoT brings a confluence of proprietary and open standards to enable connectivity between devices and services over the network of things
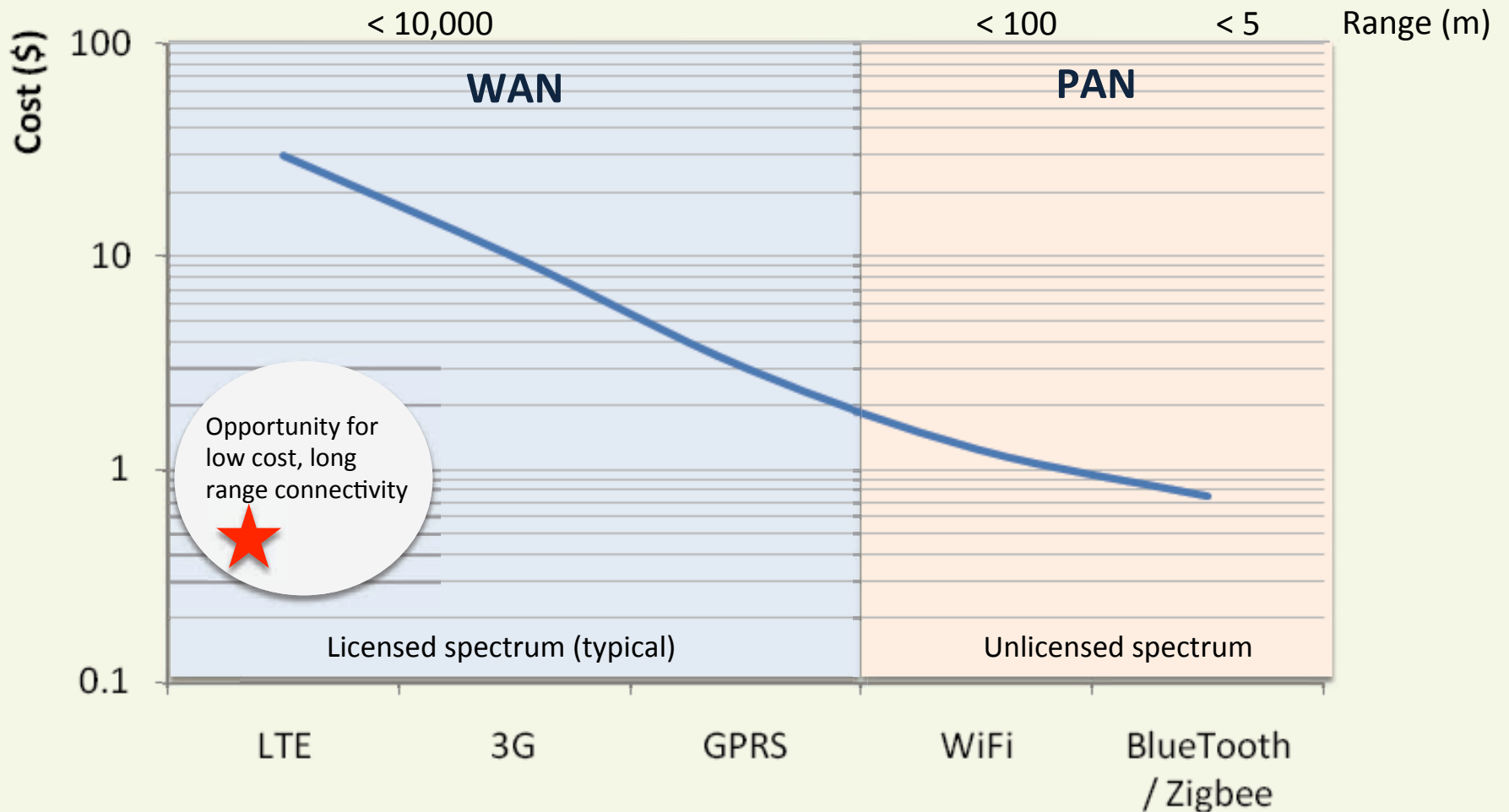
Evolution of Connectivity Standards

Low Power Wide Area protocols emerging are in addition to existing standards

Accelerated Adoption for PAN
Room for New Connectivity Solutions

Cost is critical: new space open for wide-area low power connectivity

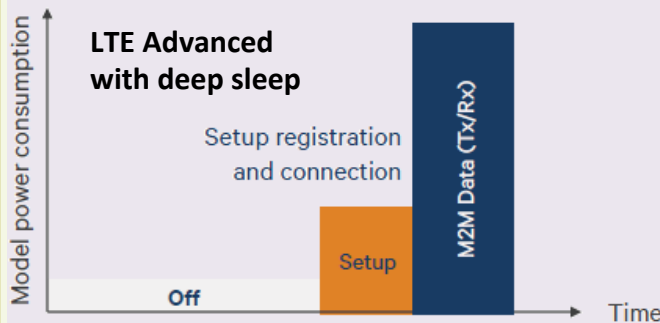# LTE-MTC: Very Limited Market Awareness

Technology challenges
› High power consumption
› High overhead signaling proportional to M2M traffic
› Overhead to manage mobility services inefficient with fixed M2M applications
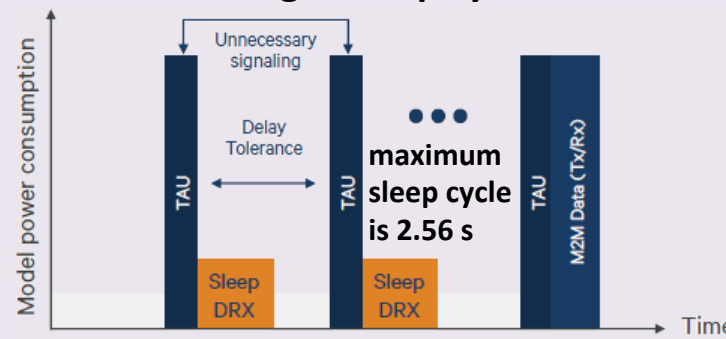
Commercial challenge:
Module cost ~$30

LTE designed for personal broadband communications NOT for M2M applications
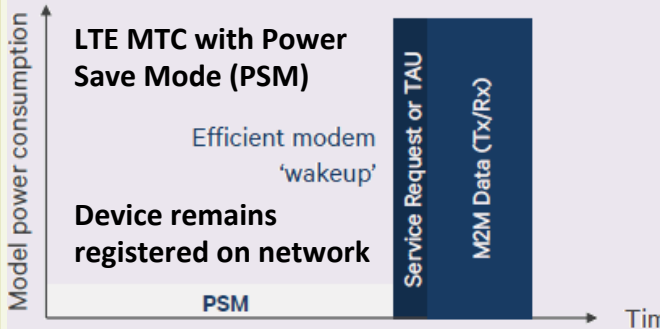
LTE MTC: 3GPP Release 13:

New Power Save Mode (PSM)
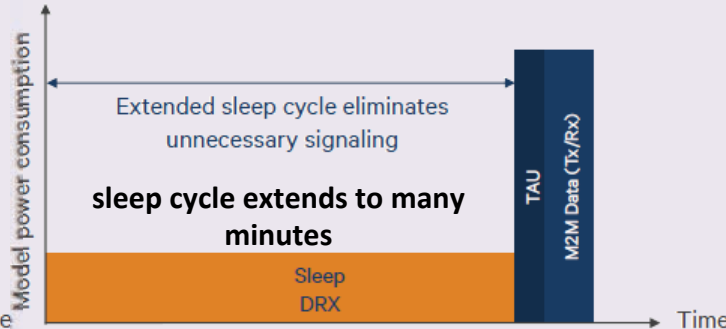

LTE Advanced with deep sleep
Setup registration and connection
Setup
Off
M2M Data (Tx/Rx)
Model power consumption — Time

LTE MTC with Power Save Mode (PSM)
Efficient modem 'wakeup'
Device remains registered on network
PSM
Service Request or TAU
M2M Data (Tx/Rx)
Model power consumption — Time

efficiently turn on/off modem for device-originated or scheduled applications

Longer sleep cycles

Unnecessary signaling
Delay Tolerance
maximum sleep cycle is 2.56 s
TAU
Sleep DRX
M2M Data (Tx/Rx)
Model power consumption — Time

Extended sleep cycle eliminates unnecessary signaling
sleep cycle extends to many minutes
Sleep DRX
TAU
M2M Data (Tx/Rx)
Model power consumption — Time

Other battery life enhancements
- **Extended Discontinuous Reception:** Longer sleep cycles for delay-tolerant, device-terminated applications
- **Connectionless Random Access Channel (RACH):** Data transmissions via common channel for more efficient transition between states

Reduce complexity and simplify hardware
- Narrowband (~1 MHz)
- Reduced Data Rate (<2 Mbps peak)
- Single receive antenna
- Half Duplex Operation

Other features
- Redundant UL/DL transmissions – same data in consecutive TTIs
- Single Frequency Network (SFN) Multicast - same broadcast signal from all cells

Competing Technologies in Sub 1 GHz Connectivity

Sub 1GHz Standard /Properties	Weightless	IEEE 802.22	IEEE 802.11af	IEEE 802.11ah	IEEE 802.15.4
Frequency (MHz)	470 – 790	54 – 862	470 - 790	755 - 928	868, 915
Modulations	16-QAM, QPSK, BPSK, DPSK, FH	OFDM	OFDM, 16-QAM, 64-QAM	OFDM,256QAM, 64QAM,16QAM, QPSK, BPSK	CSMA-CA, BPSK, OQPSK
Maximum Range (KM)	10	30		1	0.075
Maximum Downlink Throughput (MHz)	16	18	18.1	6	0.04
Uplink Throughput (MHz)	0.5	0.384	-	0.14	-
Structure	Cellular	Cellular	White -Wi-Fi	Wi-Fi - like	Star, Mesh
Bandwidths (MHz)	6, 7, 8	6, 7, 8	-	1 - 8	2
Proposed Application	M2M Communications / internet of things	Wireless broadband in rural and remote areas	-	Wireless sensor network	Wireless Sensor Network
Applications of Cognitive Radio (CR)	No but uses frequency hopping	Yes	Yes	No	No

Operation in sub 1 GHz band and narrower channel bandwidth are characteristic of emerging sub 1 GHz M2M connectivity standards

Technology Comparative Analysis
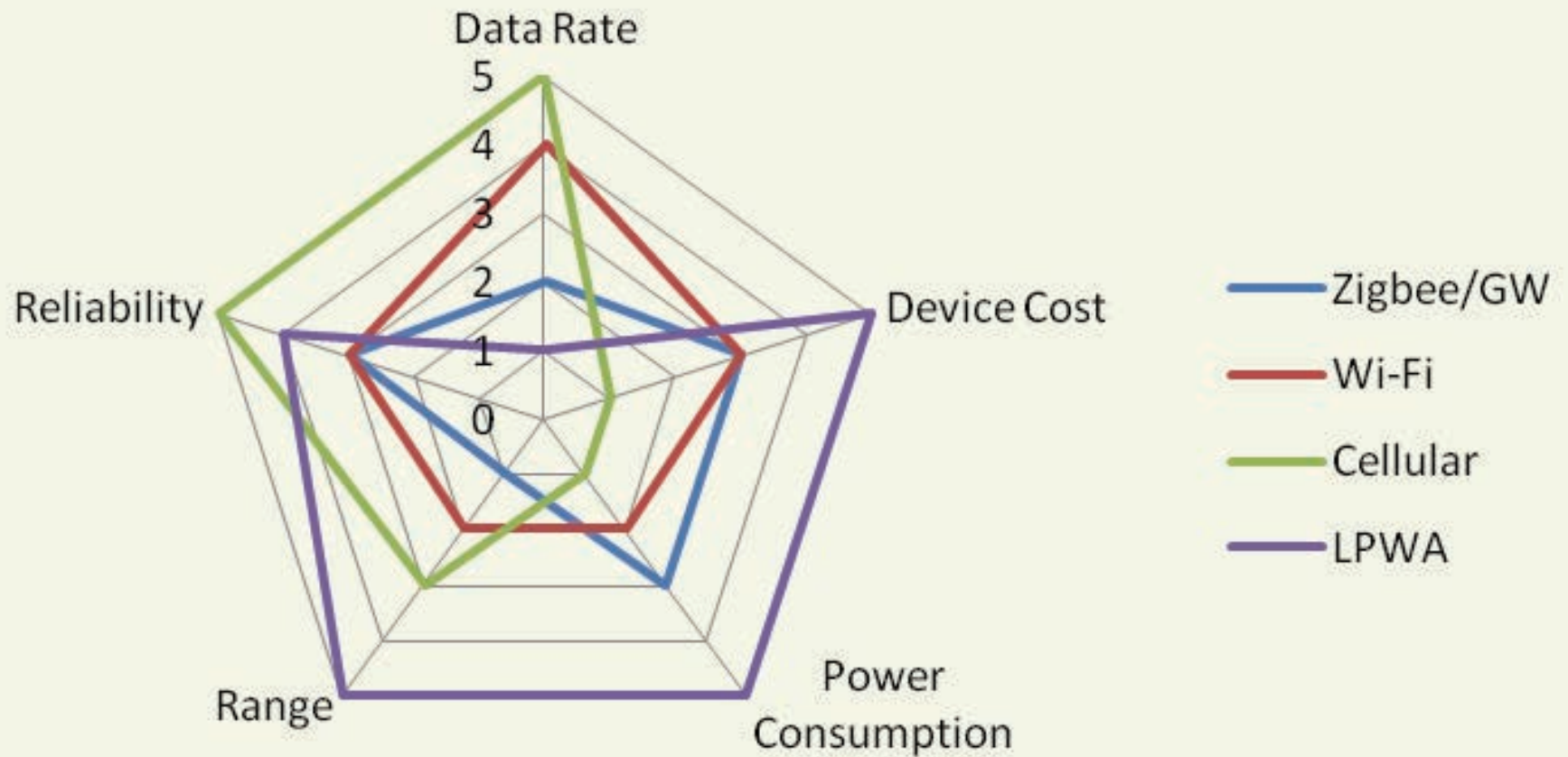
IoT and Signaling Network - Diameter Signaling Controller Deployment Scenario

In CORE
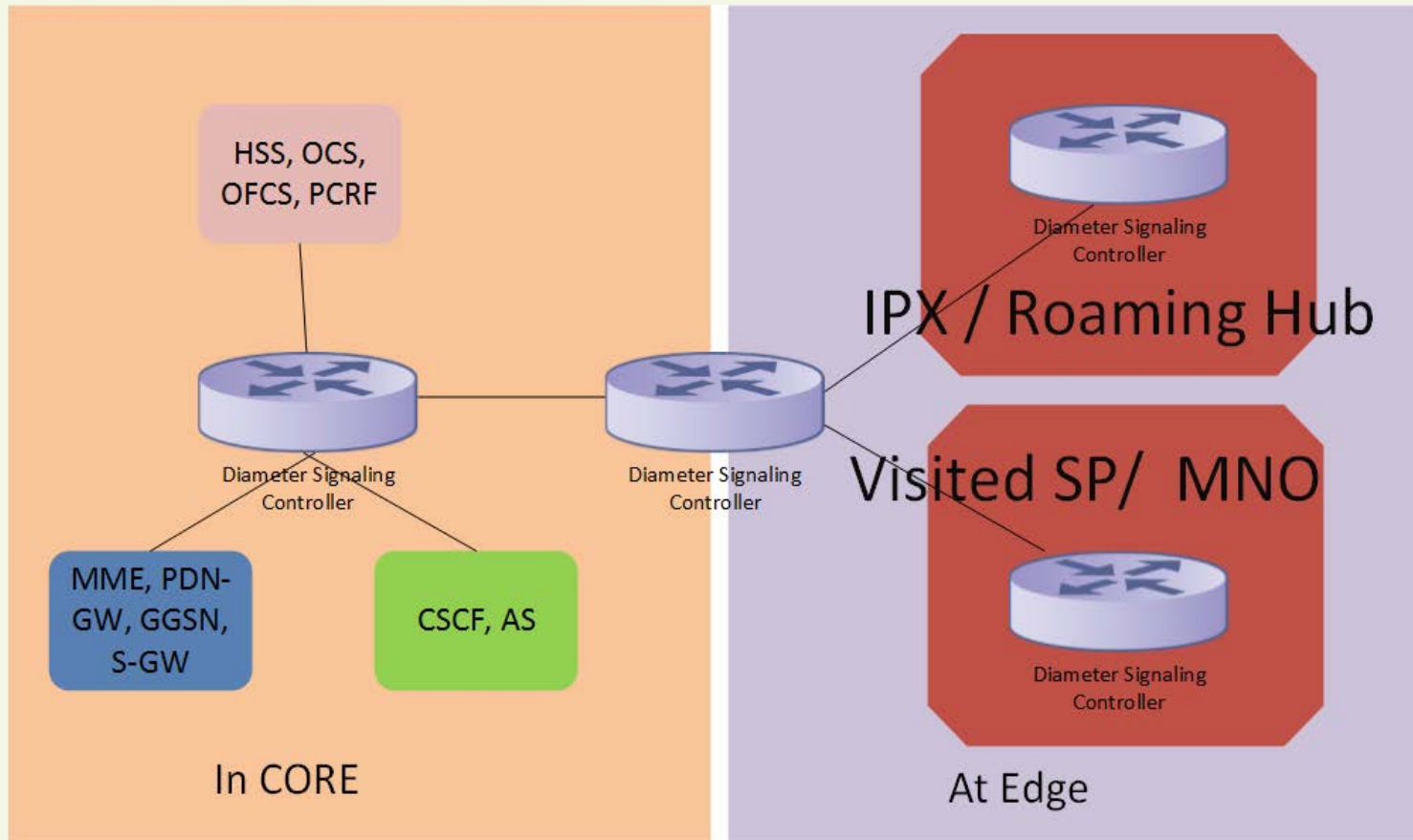
- › Aggregation router
- › OCS/OFCS/AAA/PCRF proxy
- › Interoperability

At Edge

- › Data roaming
- › VoLTE roaming
- › Service federation
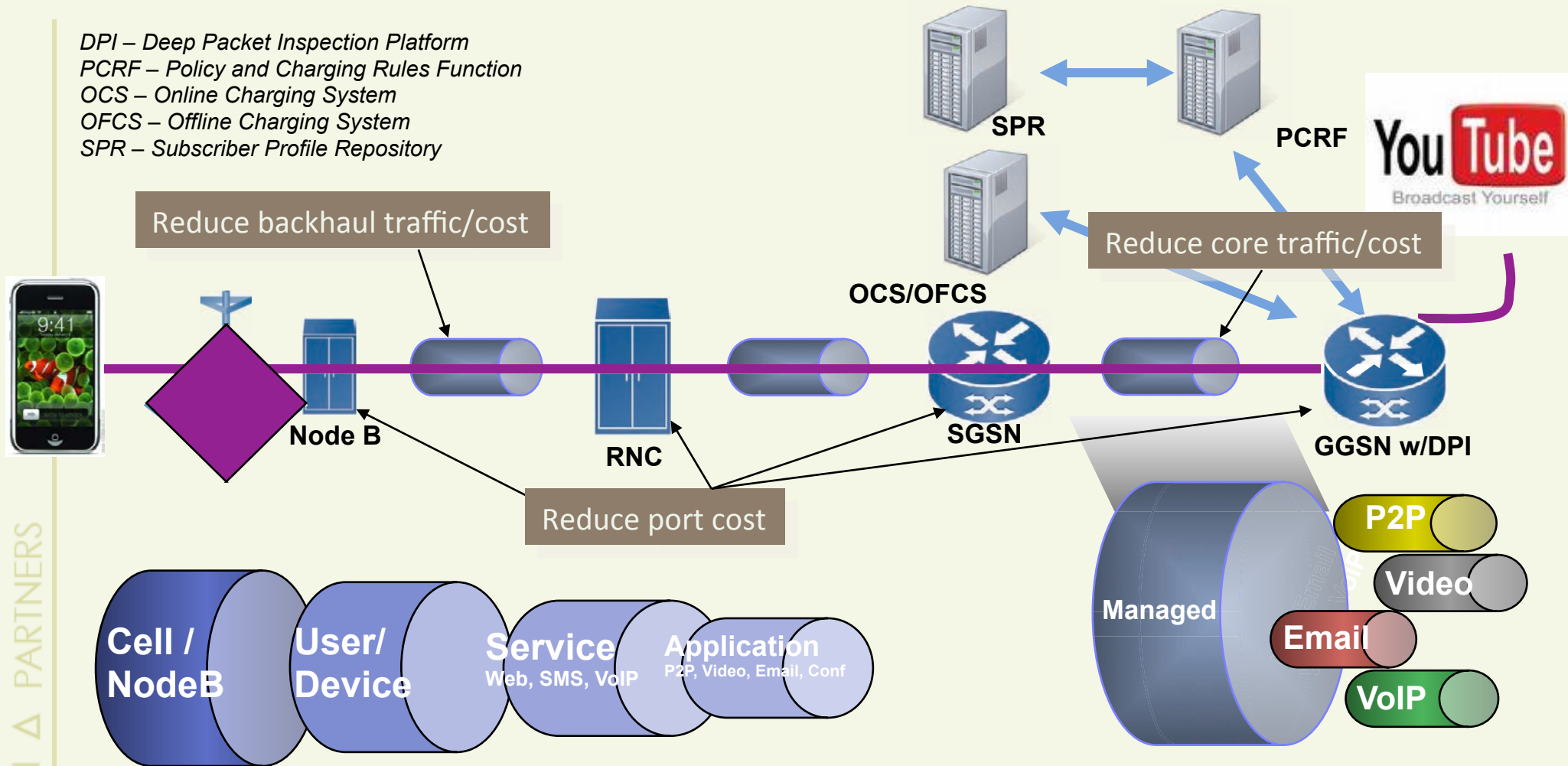
Security: 3GPP Security Standard

1	Network Access	Security in Radio Access
2	Network Domain	Network security for signaling & user data
3	User Domain	Security for mobile
4	Application Domain	User & Apps security
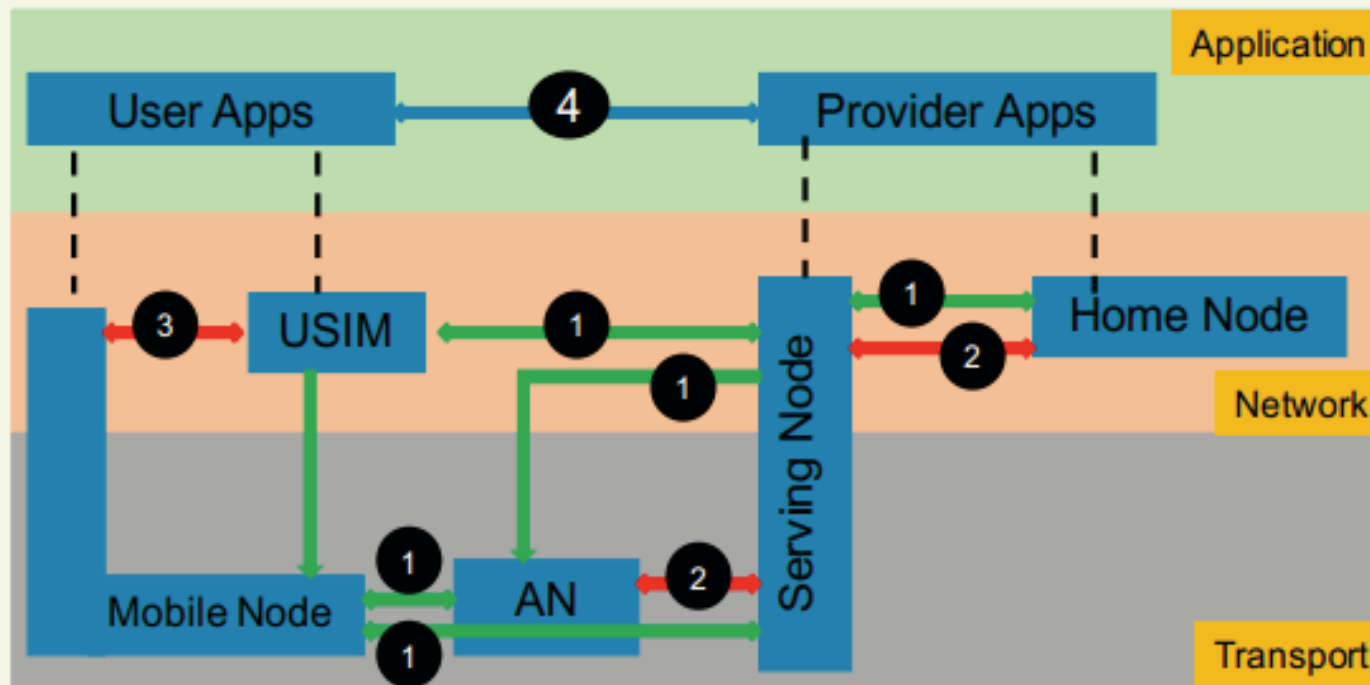
Security in the IoT context has emerged as a key area of focus

IoT and End-to-End Traffic Management

DPI – Deep Packet Inspection Platform
PCRF – Policy and Charging Rules Function
OCS – Online Charging System
OFCS – Offline Charging System
SPR – Subscriber Profile Repository

SPR

PCRF

Reduce backhaul traffic/cost

Reduce core traffic/cost

OCS/OFCS

Node B

RNC

SGSN

GGSN w/DPI

Reduce port cost

Cell / NodeB

User/ Device

Service
Web, SMS, VoIP

Application
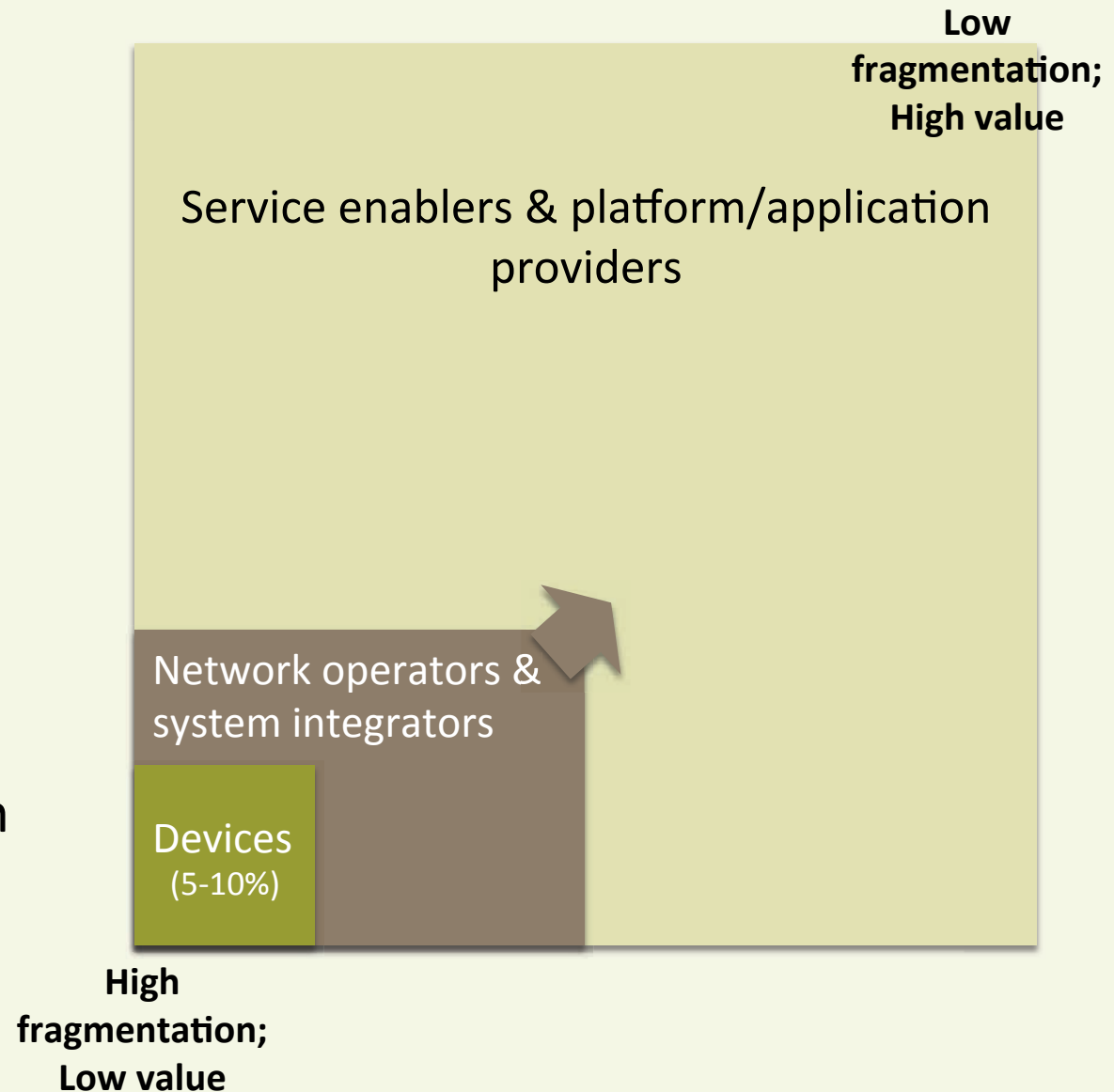P2P, Video, Email, Conf

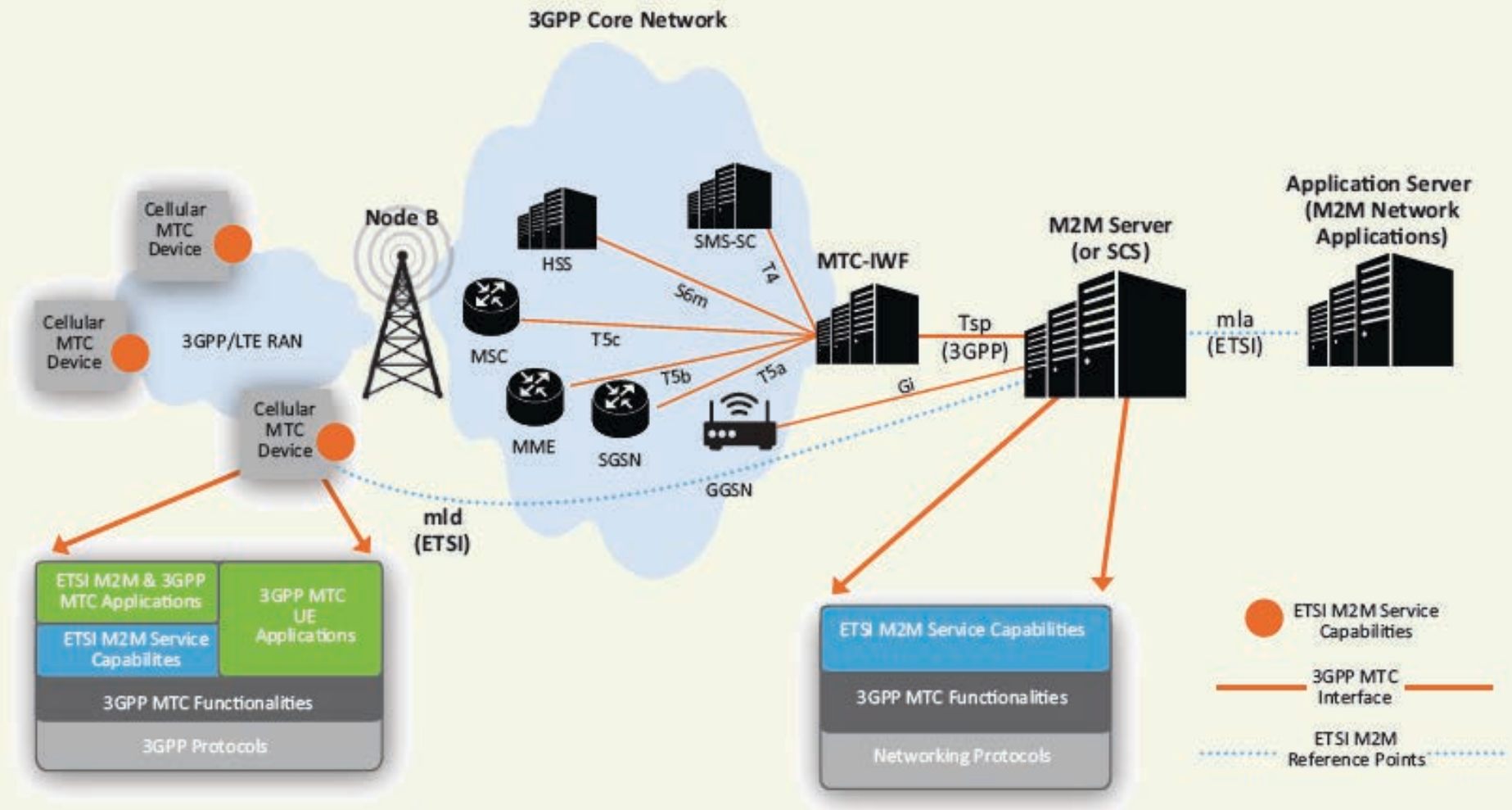**Managed**

P2P

Video

Email

VoIP

Section 5

IOT PLATFORMS

IoT Value Concentration

› Value is expected to concentrate with service enablers and platform and/or application providers

› Network operators expected to appropriate a smaller share of total value: they will migrate towards other roles

› Goal to play a role in migration strategy: question is how to do that?

Low fragmentation; High value

Service enablers & platform/application providers

Network operators & system integrators

Devices (5-10%)
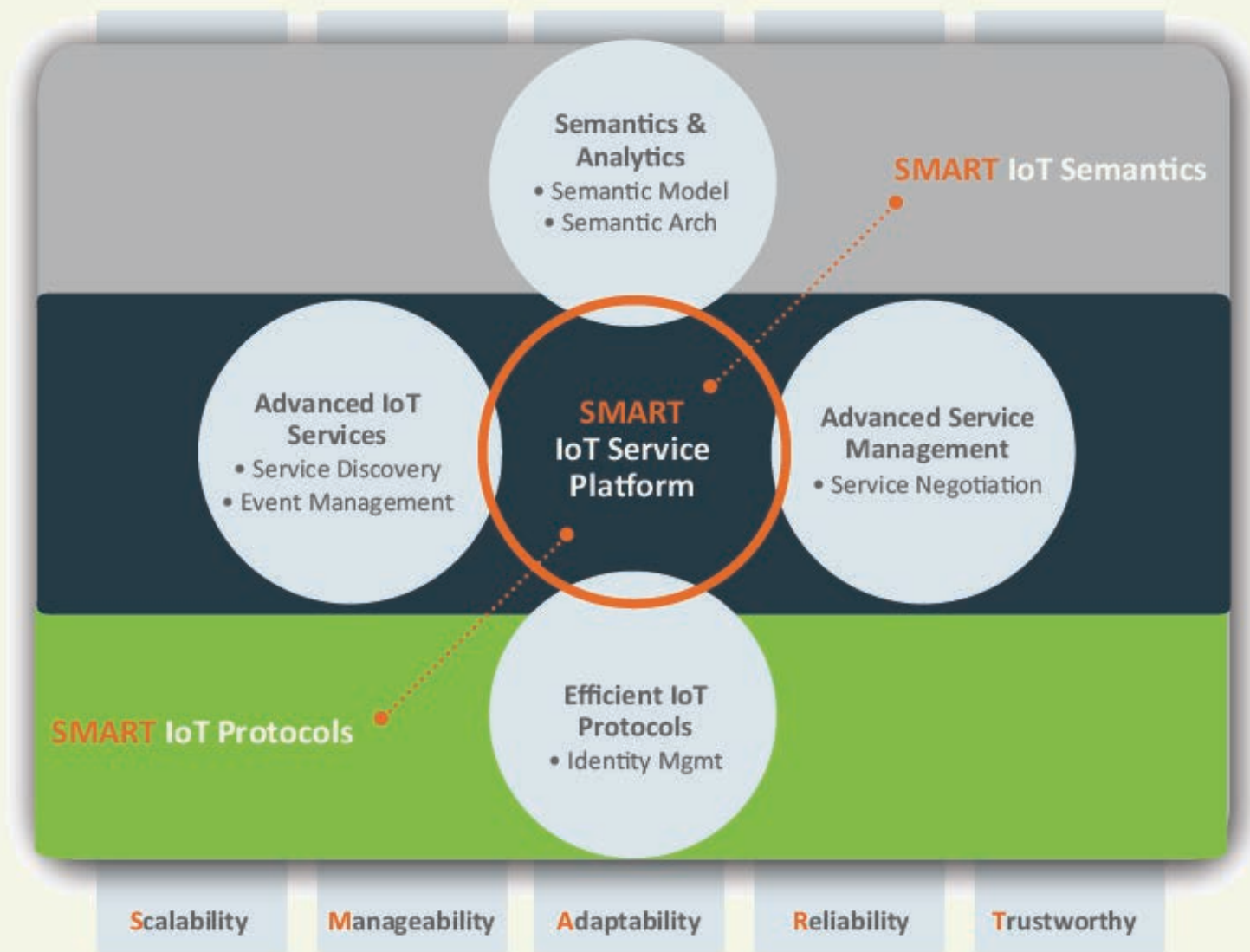
High fragmentation; Low value

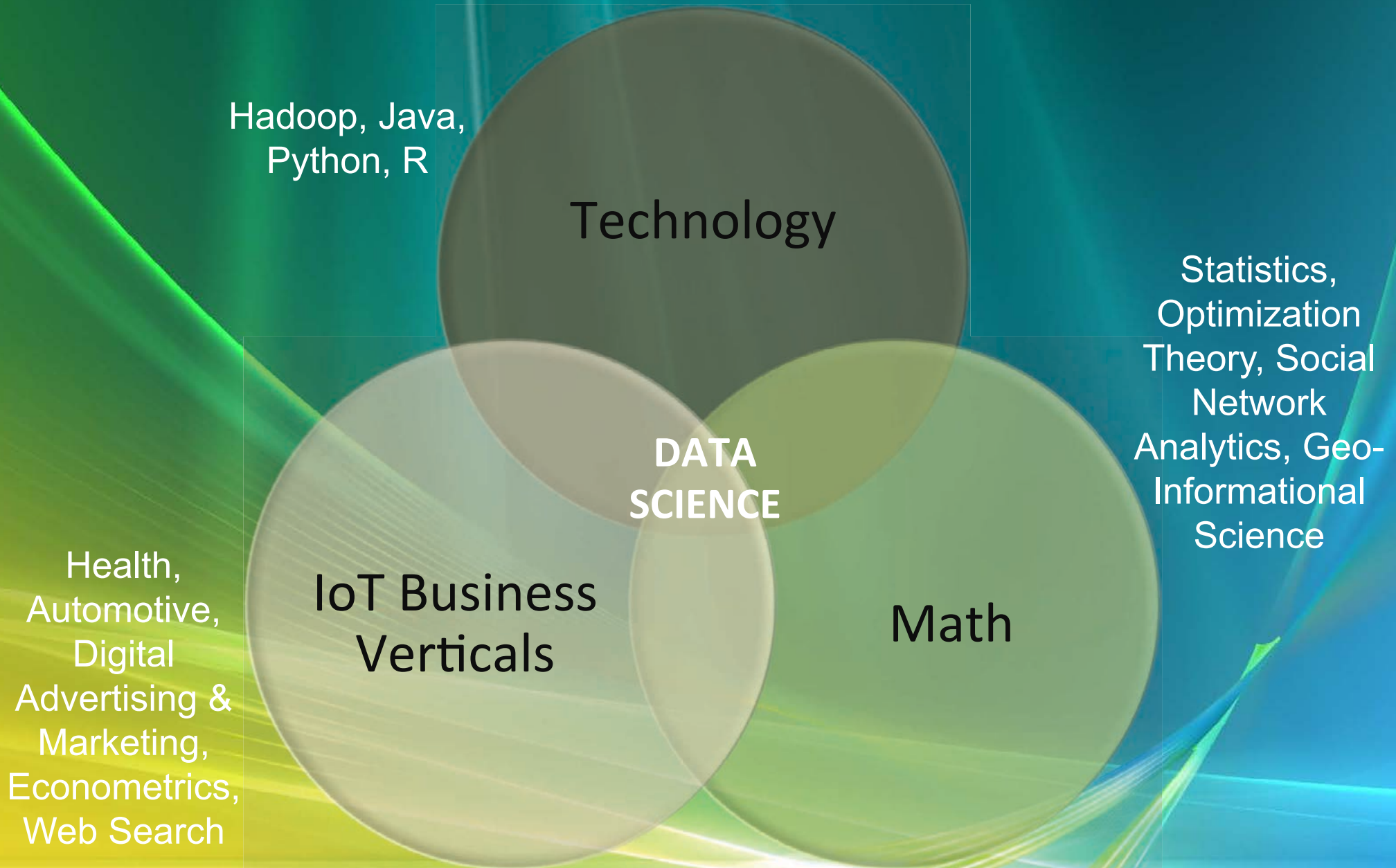# Classic Platform Approach: Telco Infrastructure Inspired

Disruptive Approach: Internet Infrastructure Inspired

Conceptual IoT Framework with Cloud Computing at the Center

Data Sciences as an IoT Service Enabler

Hadoop, Java, Python, R

Technology

Statistics, Optimization Theory, Social Network Analytics, Geo-Informational Science

DATA SCIENCE

Health, Automotive, Digital Advertising & Marketing, Econometrics, Web Search

IoT Business Verticals

Math

Master of Big Data Management (Third Party Partners Angle)
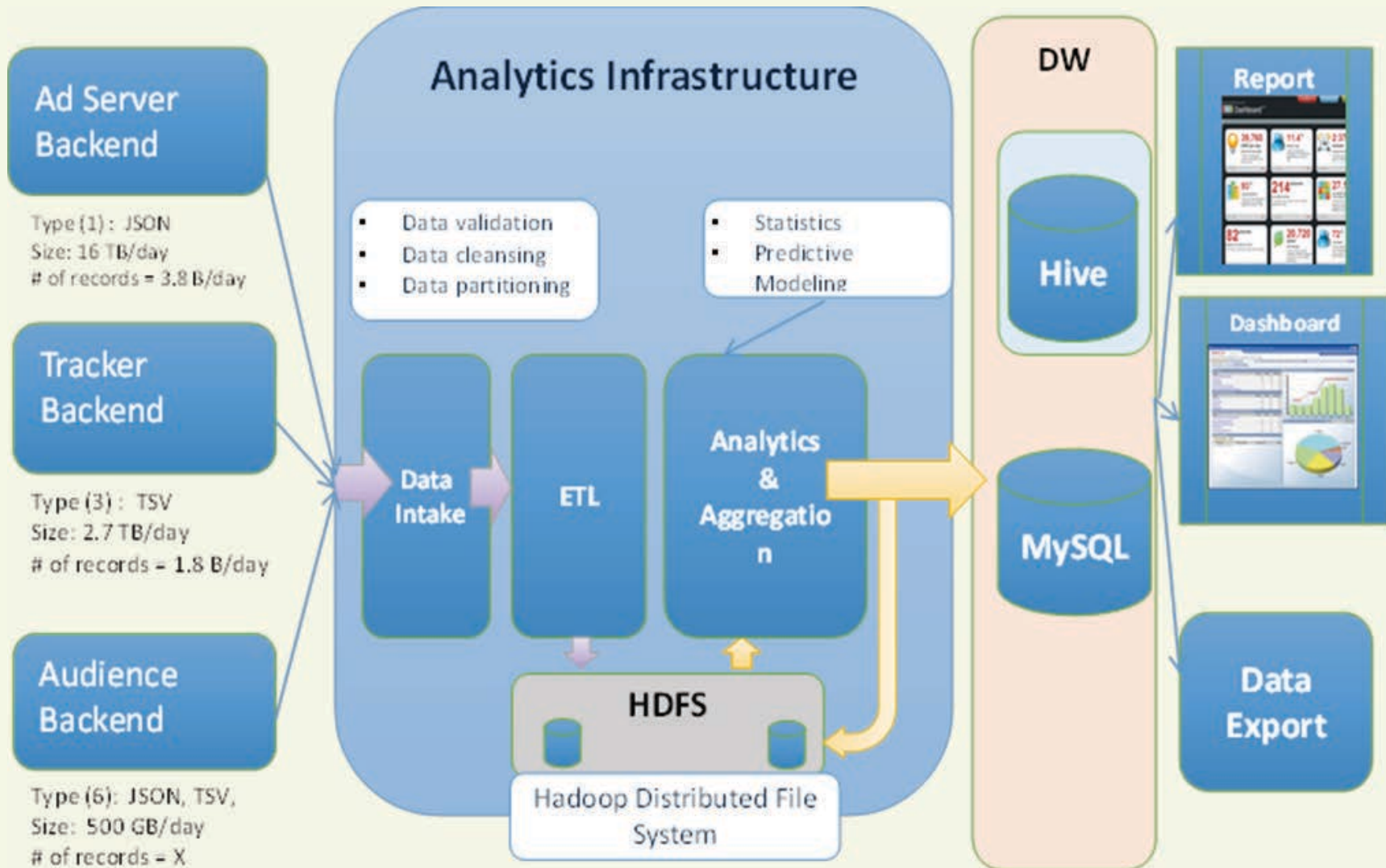
Section 6

HOW CAN XONA HELP

Xona Can Help

› Define IoT strategy throughout the IoT ecosystem stack related to

– Technology evaluation and selection

– Business model development and go-to-market strategy

– Solution definition and positioning

› Provide integrative approach across different IoT silos

– Connectivity protocols and standards

– Security

– Core networks and signaling

– Data science and analytics

– Cloud services

Section 7

A WORD ABOUT XONA PARTNERS

Team

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Mano Vafai
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Ottawa

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Calcutta

Ananda Sen Gupta
New Delhi, San
Francisco,Hong Kong

Dr. James Shanahan
San Francisco,
London, Beijing

Malik Si Hassen
Paris, Dubai,
London

New Business Incubation & Growth

› Incubate new business ventures in adjacent and disruptive markets

› Leverage existing assets to generate new revenue streams
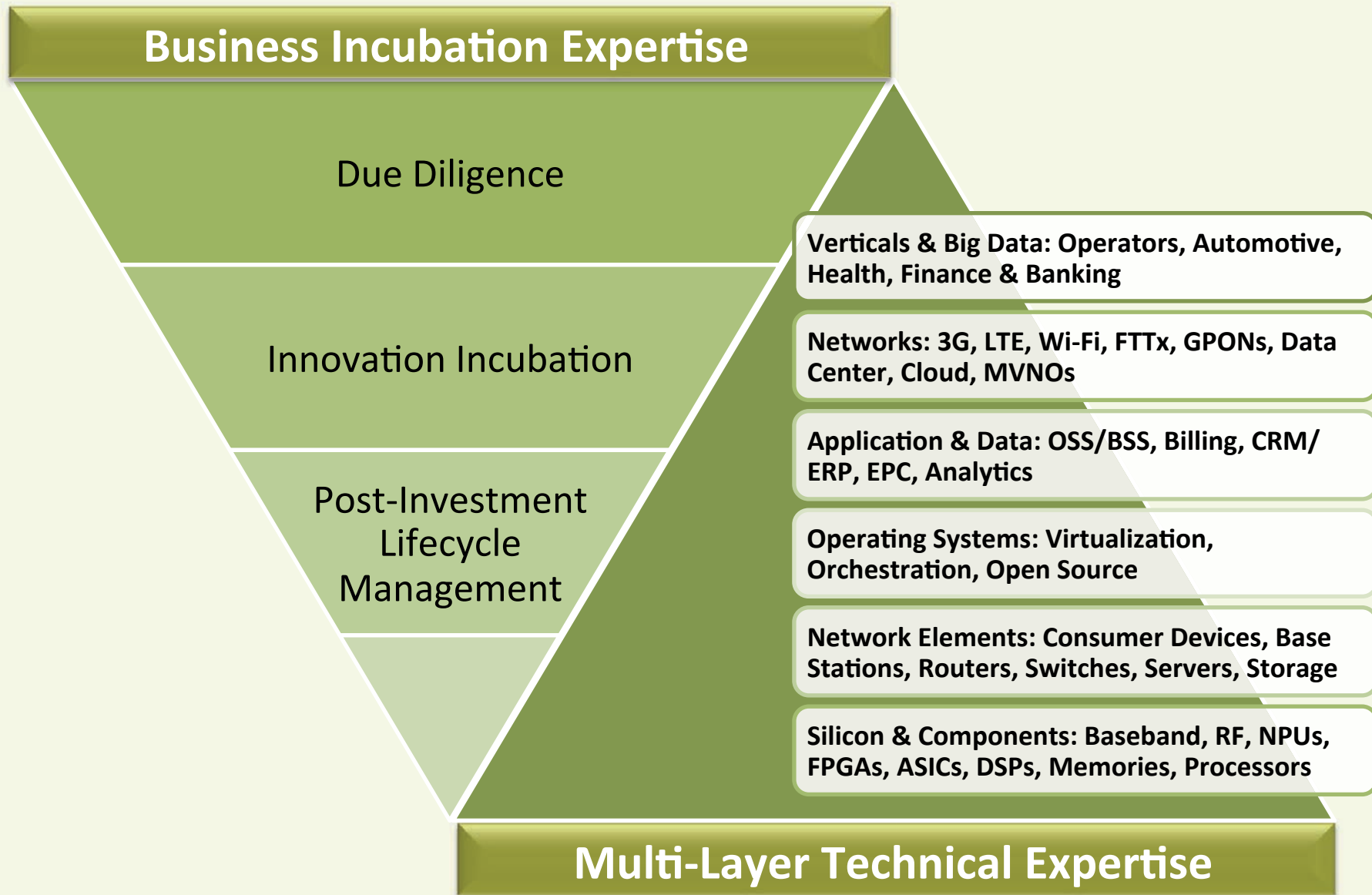
› Define and enact new growth and innovation strategies

New Revenue

Current Revenue

Spin-in's Acquisitions Re-structuring Partnerships

Enable growth under a shared risk-reward model

Expertise Through the Value Chain

Business Incubation Expertise

Due Diligence

Innovation Incubation

Post-Investment Lifecycle Management

Verticals & Big Data: Operators, Automotive, Health, Finance & Banking

Networks: 3G, LTE, Wi-Fi, FTTx, GPONs, Data Center, Cloud, MVNOs

Application & Data: OSS/BSS, Billing, CRM/ERP, EPC, Analytics

Operating Systems: Virtualization, Orchestration, Open Source

Network Elements: Consumer Devices, Base Stations, Routers, Switches, Servers, Storage

Silicon & Components: Baseband, RF, NPUs, FPGAs, ASICs, DSPs, Memories, Processors

Multi-Layer Technical Expertise

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