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# Creating The First Secure Service Delivery Infrastructure For The Internet of Things (IoT)

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# Typical Views of IoT: Generalized

Building Automation

Smart City

Smart Lighting

Smart Grid

Smart Health

Industrial Automation

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# Or You Get a Lot of Talk About M2M With the Smart Devices Controlling the Universe

# What's Wrong With This Picture?


Or ….Traditional network developers talking about Internet of Things, think this represents a
typical edge node
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...or this

# IoT is More Than M2M


Machine to Machine

Machine to Infrastructure

Machine to Environment

Machine to Human

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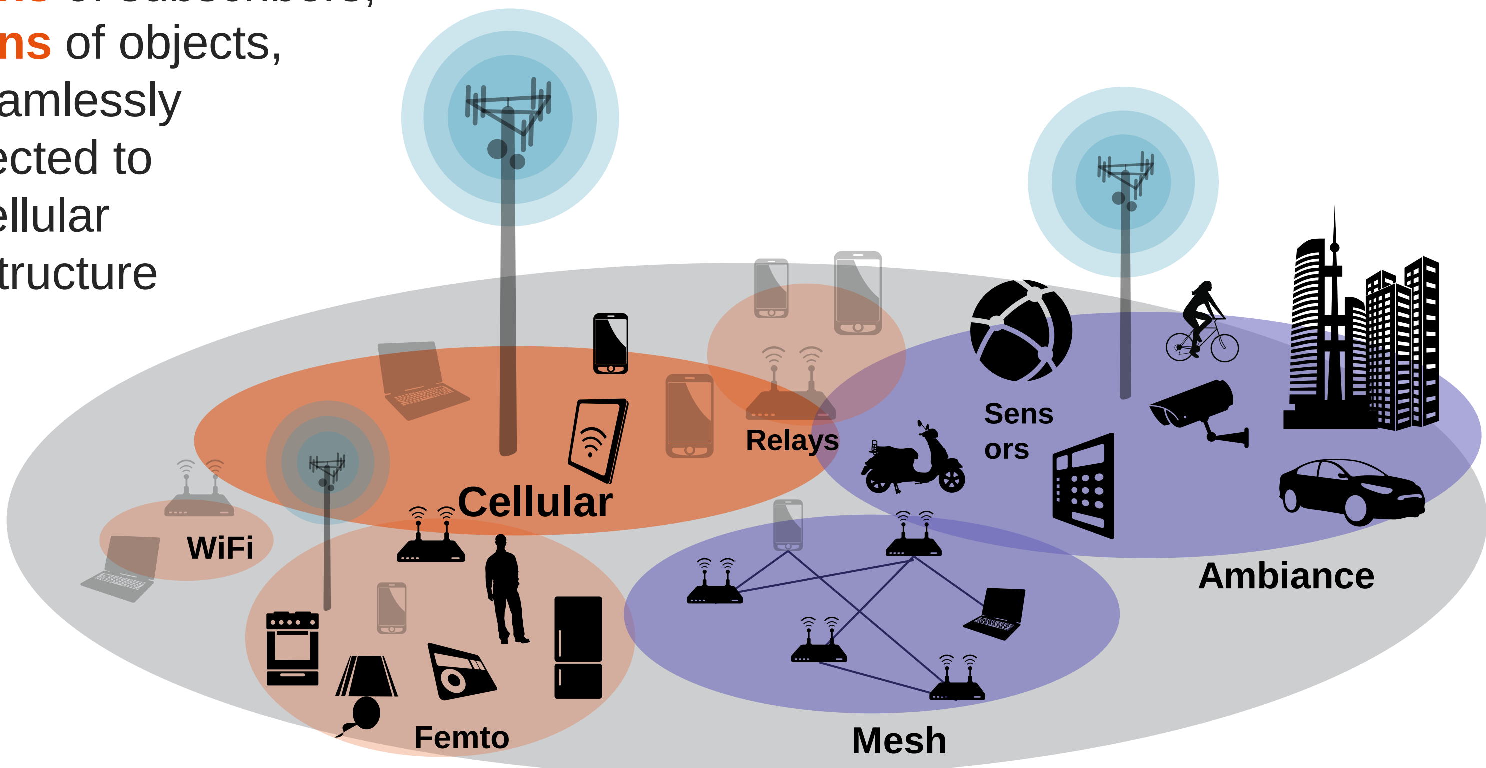
# Cellular-Centric View

**Billions** of subscribers,
**trillions** of objects,
All seamlessly
connected to
the cellular
infrastructure

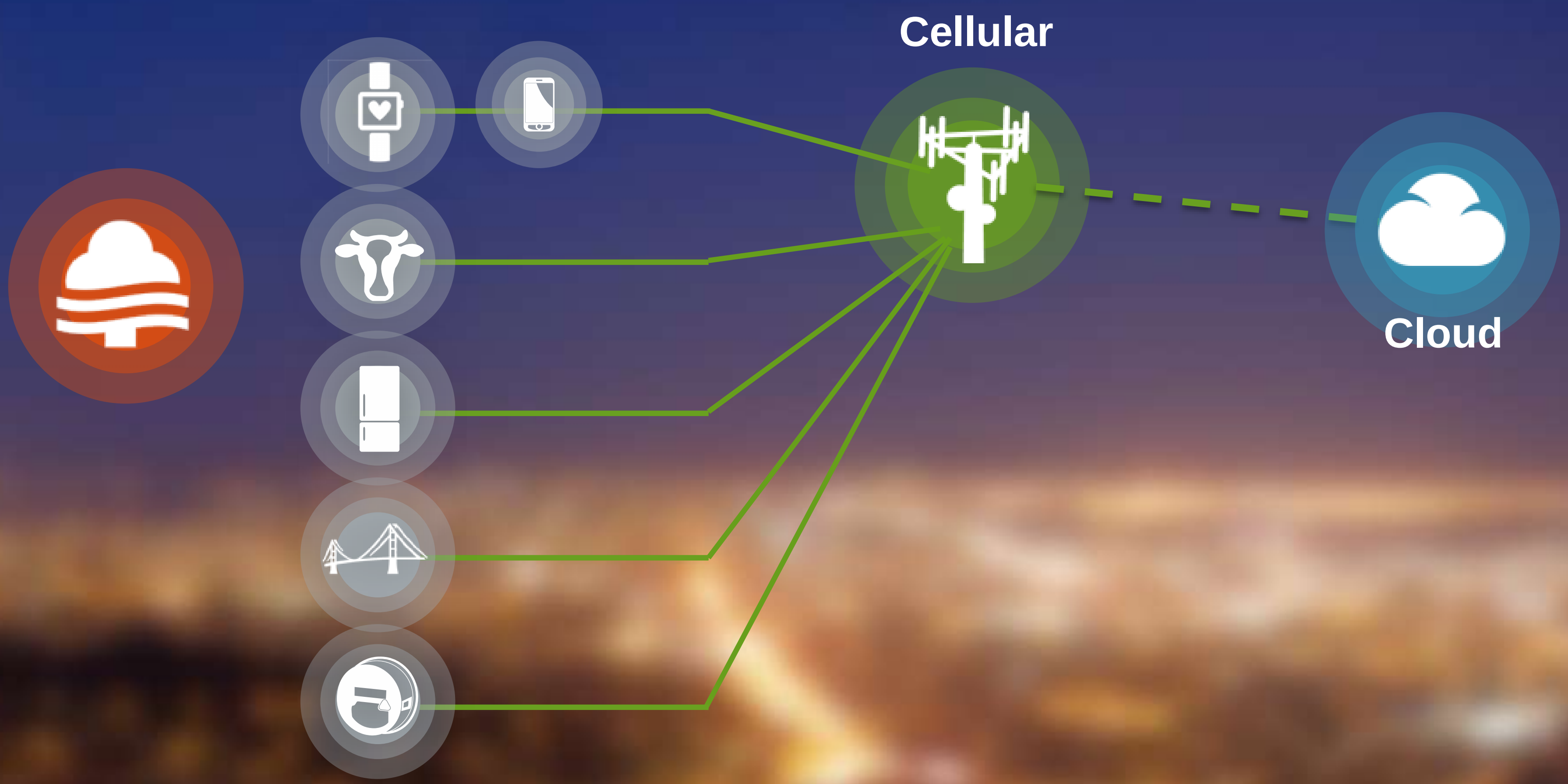


# Second View
## Pervasive Remote Monitoring and/or Control

New breed of heirarchical **gateways** connecting tiny sensing nodes to the Cloud using the most efficient ways to make the connection

# Fundamental Difference

## Existing ISP Providers Believe in this Model

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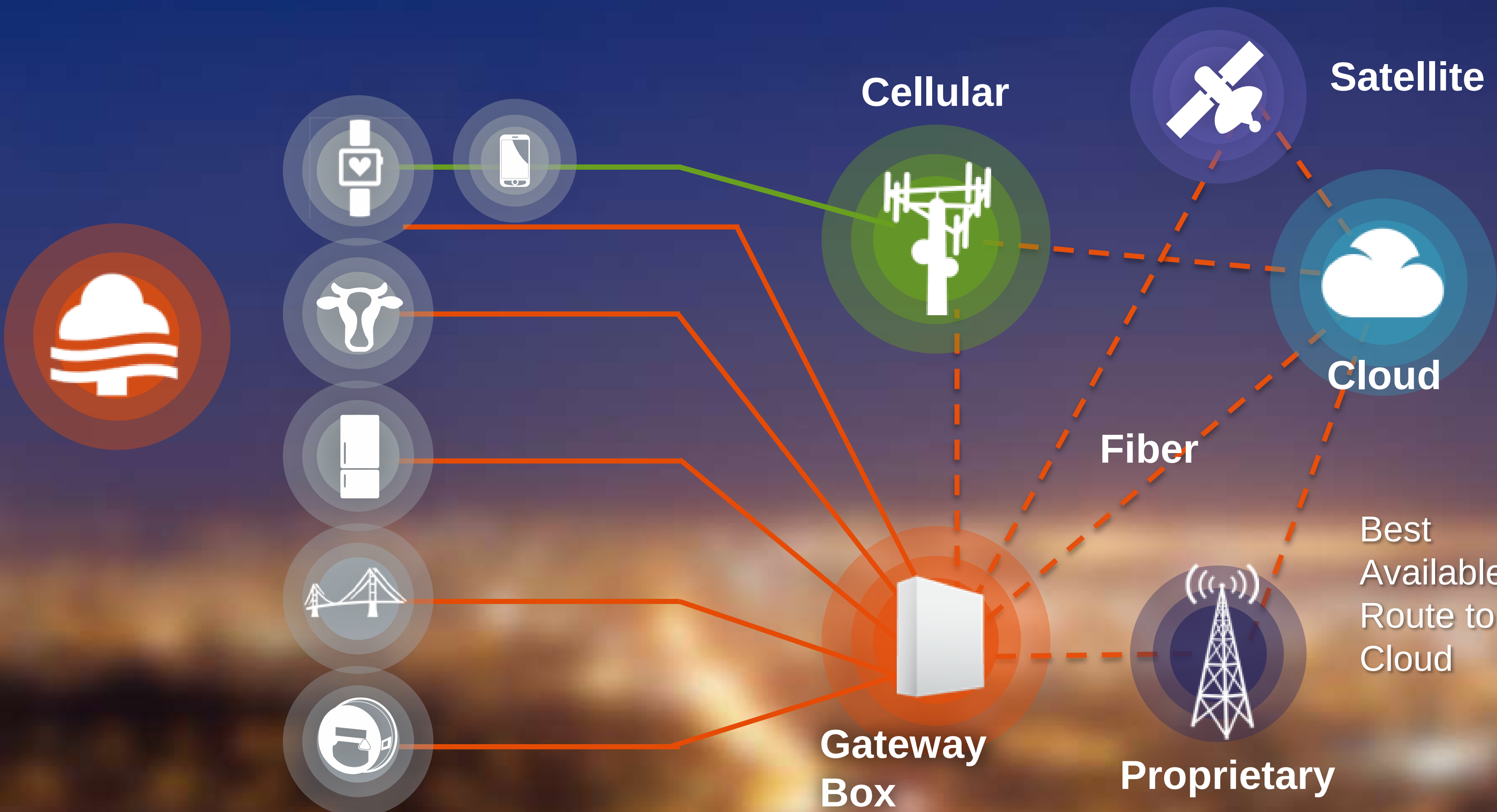
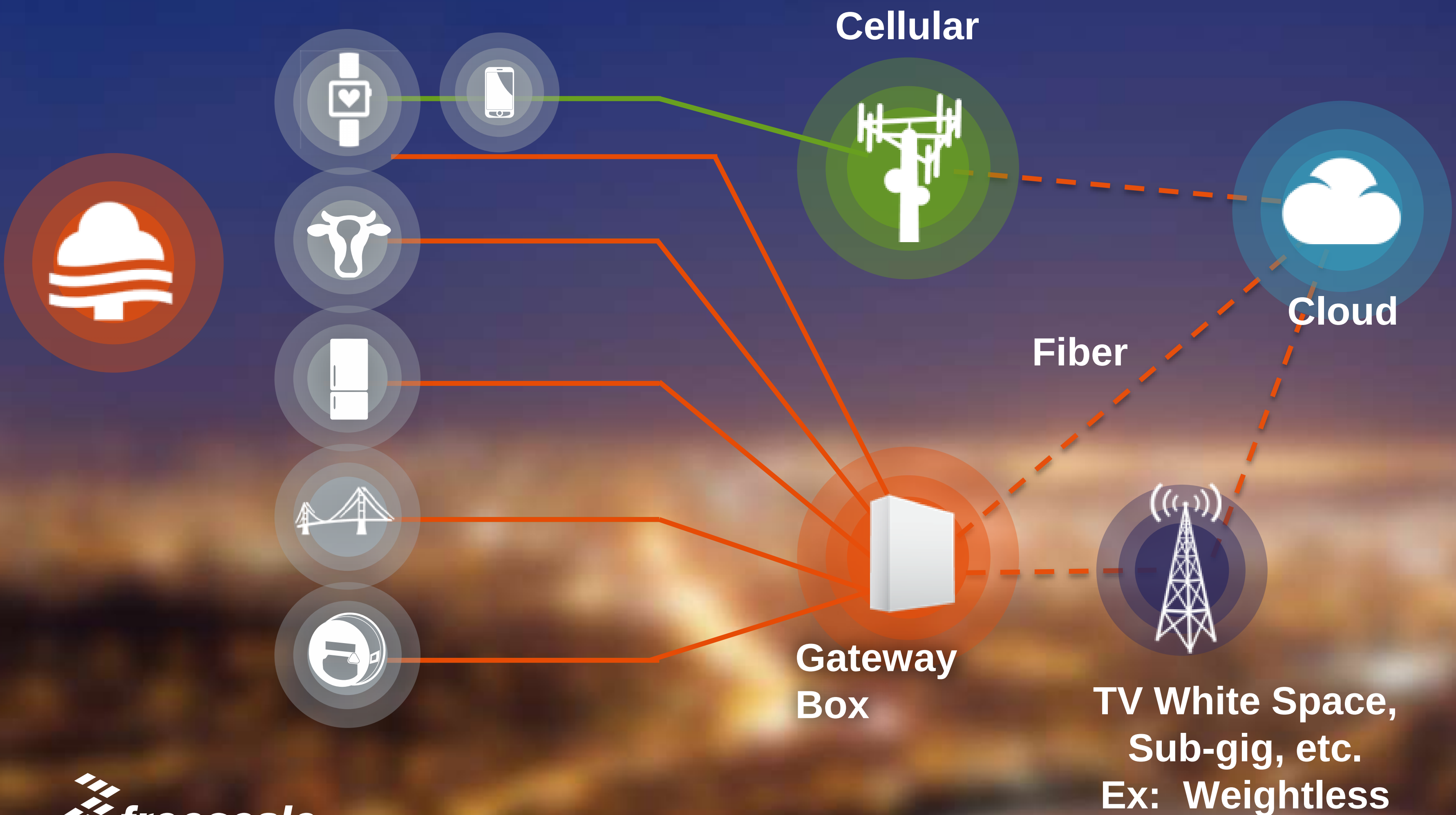
# Typical Views of IoT: Generalized

## Today We Believe the Model Should Look Like



# Typical Views of IoT: Generalized

## In the Future We Believe the Model Will Look Like



# We Sell Hammers, So Everything Looks Like a Nail to Us

**Cellular "pipes" issues for IoT:**

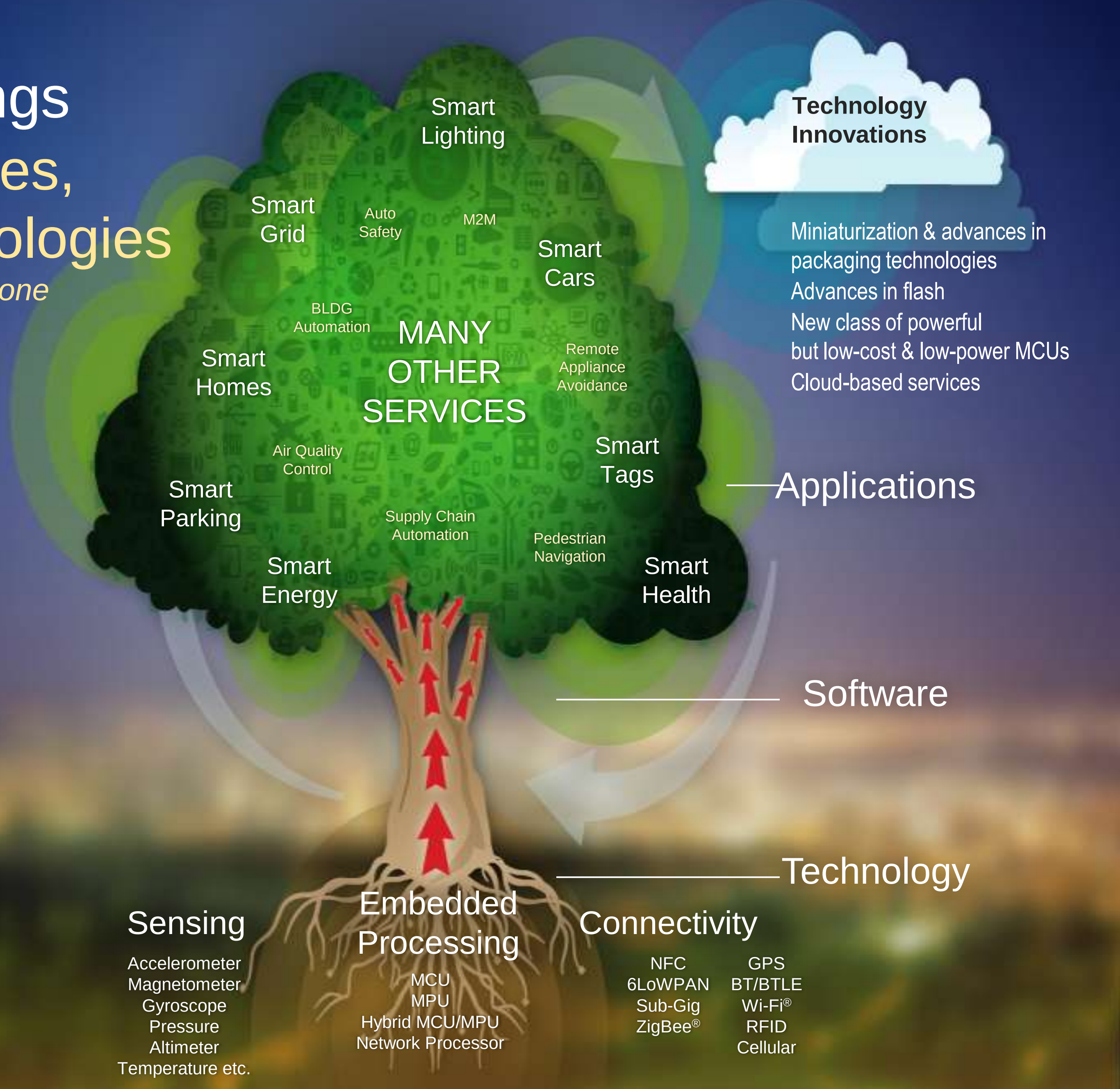
- **Laws of Physics:** frequency, range, BW, data rates, power, in-building penetration, etc.
- Spectrum cost
- Capacity
- Field deployment for battery operation (total cost of ownership)
- Cost of devices
- Others

# Internet of Things

## Different Services, Different Technologies

*Different Meanings for Everyone*

And the Word "SMART" Is Everywhere!

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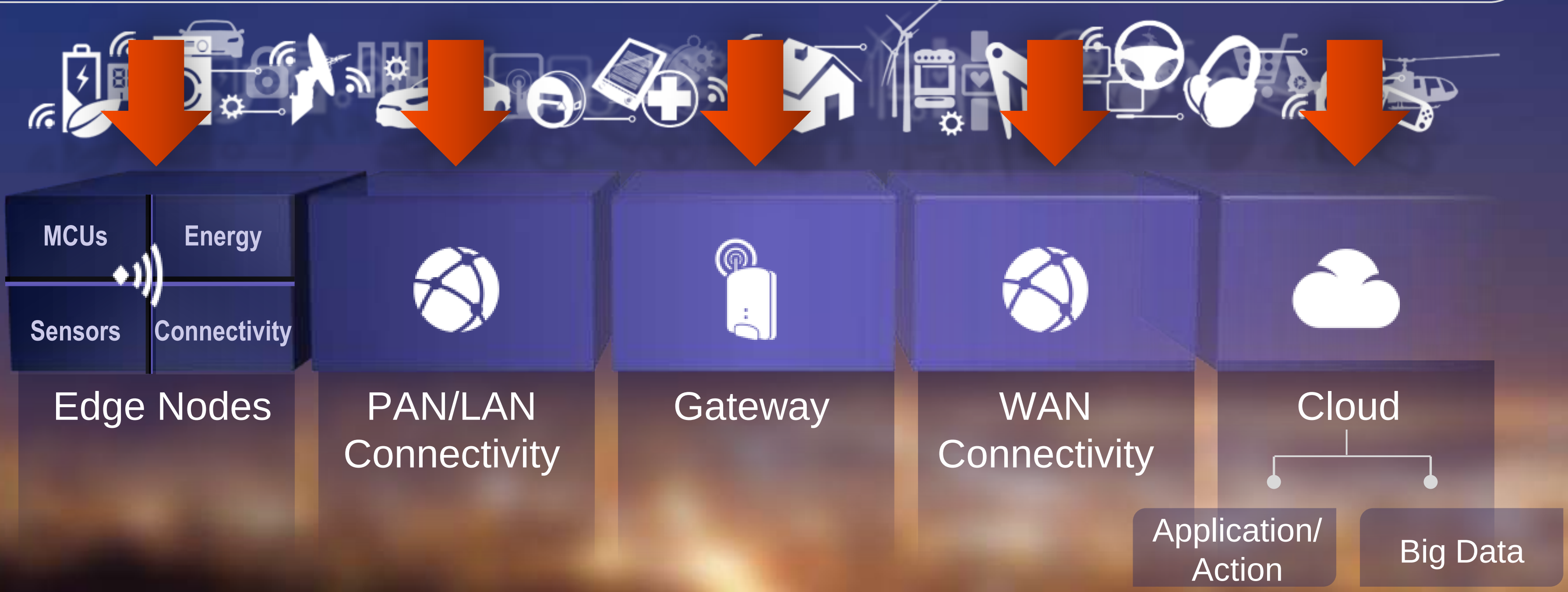
# Infrastructure of the Internet of Things

# Infrastructure of the Internet of Things

## The Challenge

Most parts of this infrastructure and, to the greatest extent, the edge nodes use different technology nodes, different tool sets, different development environments, different levels of security competence and resources, even different programming languages

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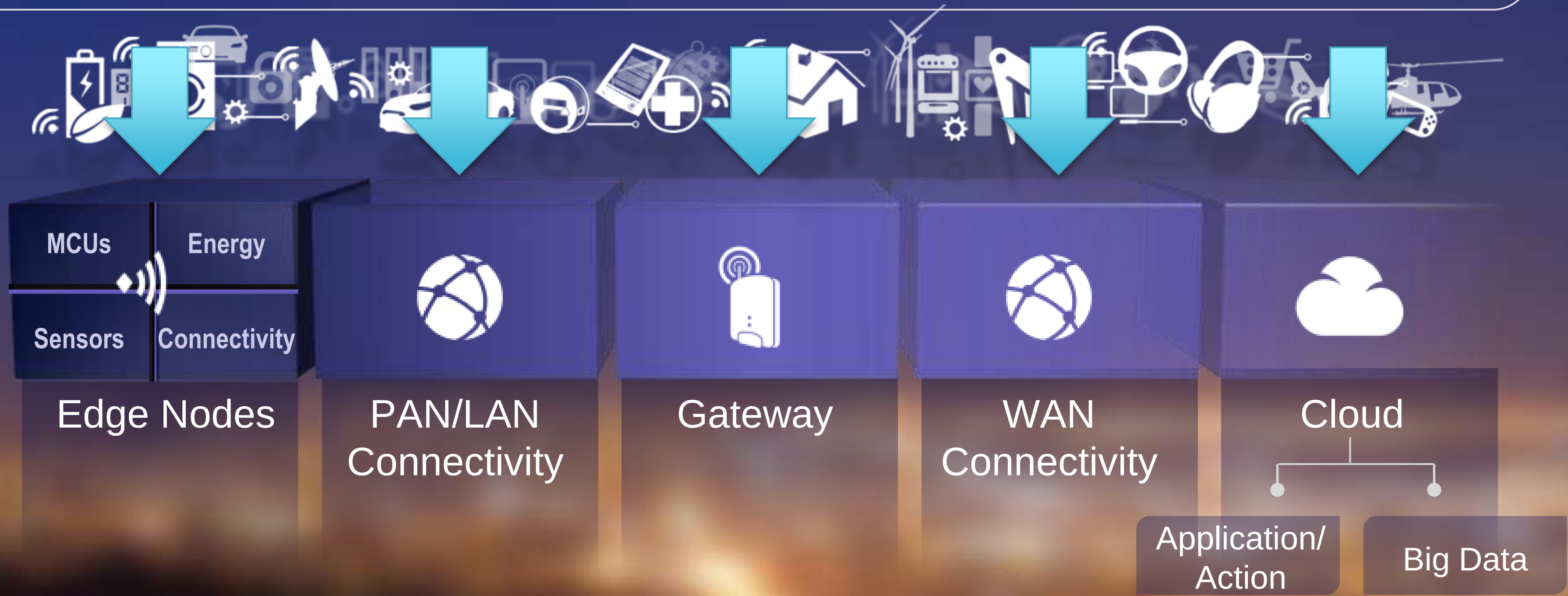
# Infrastructure of the Internet of Things

## The Solution

Java technology to embrace the entire system and unify the Internet of Things, even down to the tiniest and most resource-constrained edge/sensing nodes

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# Edge Nodes

Java to enable the developers of the edge nodes with the same solution categories as the rest of the network

# Edge Nodes

There are as many types of edge nodes as there are applications, however all could/would include:

- An MCU
- Sensors (and actuators)
- Integrated connectivity
- Energy source

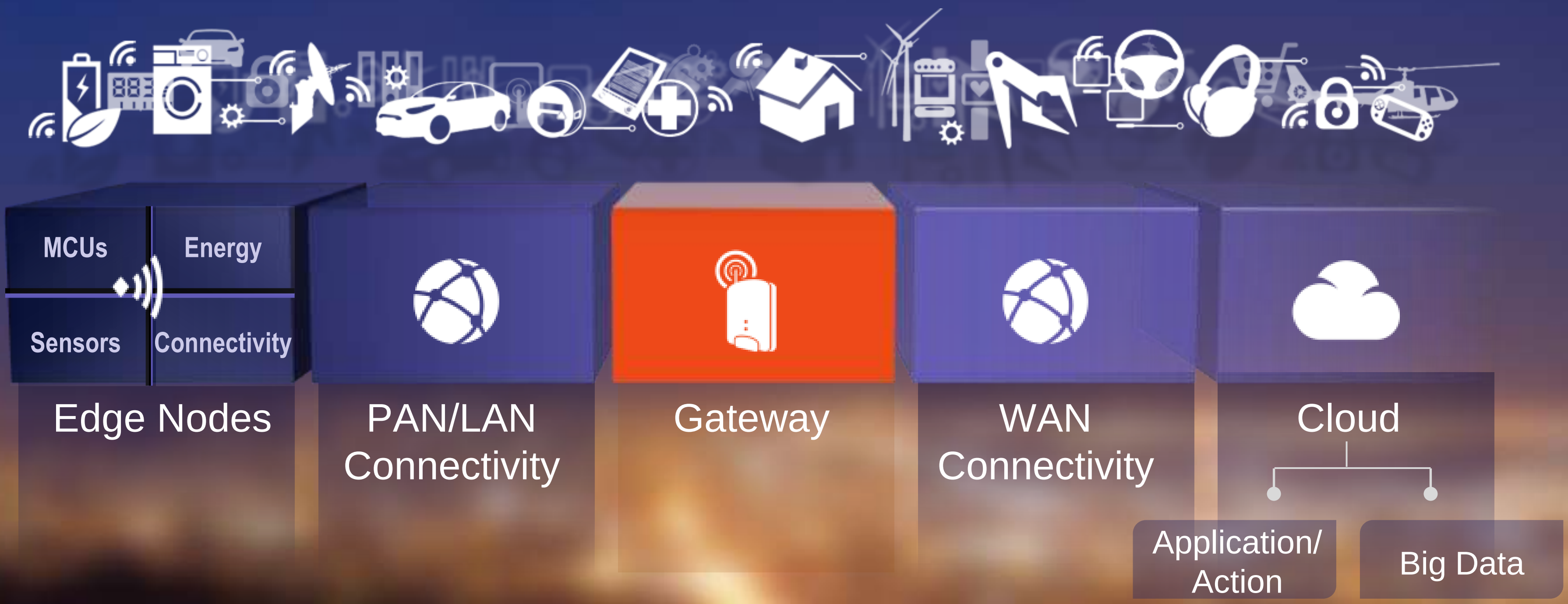
These nodes need to be:

- Very small
- Low cost
- Low power
- Low complexity
- Industrial-grade and robust

# MCUs

Performance
200 MHz
100 MHz
50 MHz
32 KB
Embedded Flash Memory
2M
Cars – Powertrain
Solar Inverters
Factory Automation
Wearables
Point of Sale
Insulin Pump
Motor Control
Meters
Blood Glucose Monitors
2-Way Radios
Appliances
Smart Home
Lighting

# One Box: Connecting the Cloud to the Tiniest Sensing/Edge nodes

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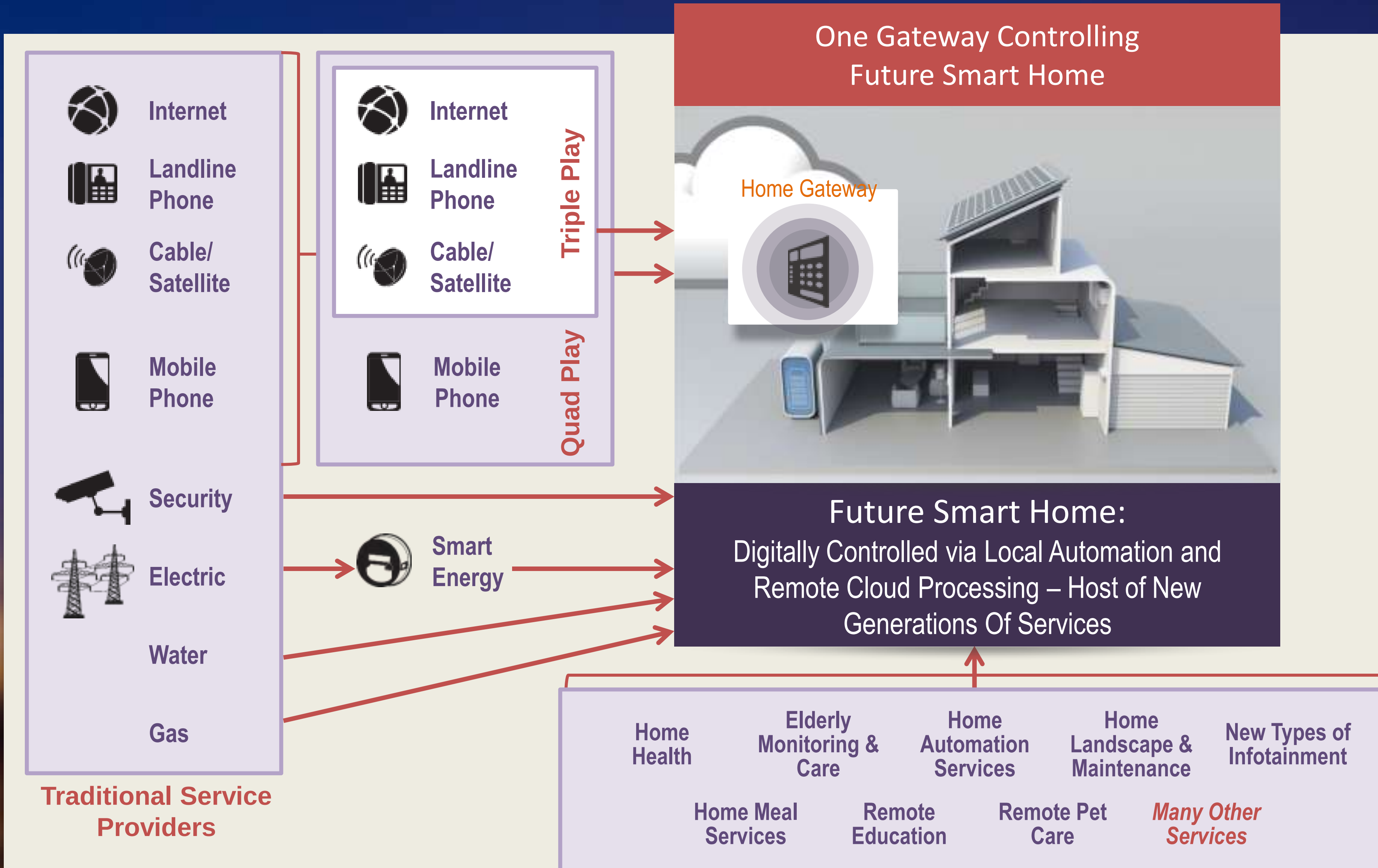
# Diversity Of Service Providers For The Smart Home



# One Box Means Integrating All "Boxes" Into One:

## Connecting the Cloud to the Tiniest Sensing Devices

**BAN/PAN/LAN/HAN Side Superset of Standards**

**Display**

**NAN/WAN Side Superset of Standards**

Collection of edge/sensing node devices

Bluetooth

Zigbee, 802.15.4

WiFi, DASH7, ISA100

Wireless HART, EnOcean

Wireless MBus

Ethernet, EtherCAT, Profinet, Modbus,

HPGP

Etc.

Wired & Wireless

Switching & Routing

Protocol Conversion

Firewall & VPN

Security

One Box Gateway

Storage

Wired & Wireless

UART, SPI, I2C, USB, X10, RS-485, RS-422, RS-232, etc.

Ethernet / Fiber

Weightless

802.11ah

Cellular

Sub Gig

Satellite

PLM/PLC (G3, Prime, etc.)

Etc.

Cloud

What Devices to Monitor/ Control

What Short-range Device Access Link

Targeting CPE

What Cloud Access Link

Optimize the communications, processing, and storage requirements of all stakeholders (i.e. telco providers, security, utility, energy, automation, control, and other future service providers), @Home, @Factory, @Hospital, or other target facilities / environments

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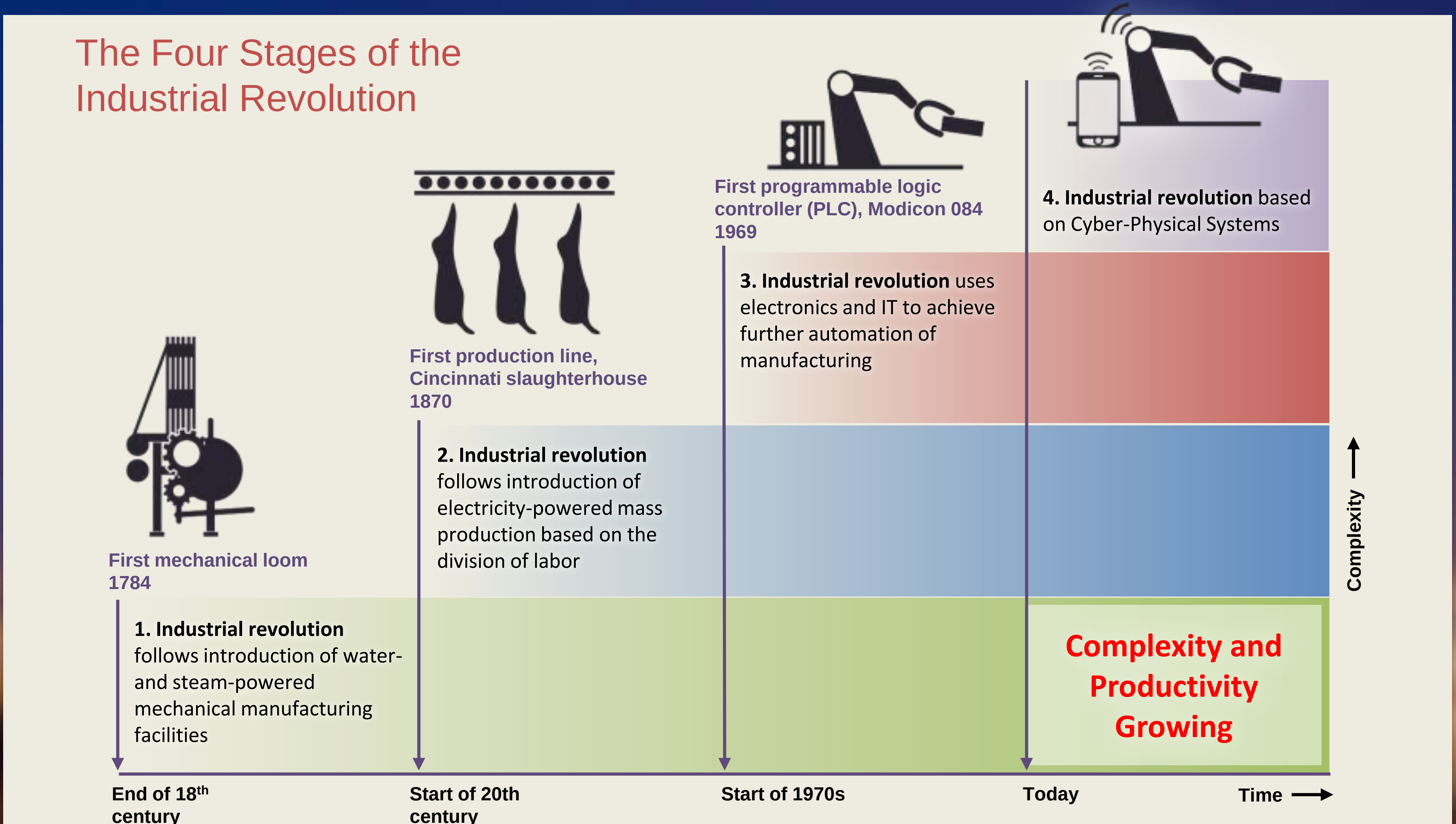
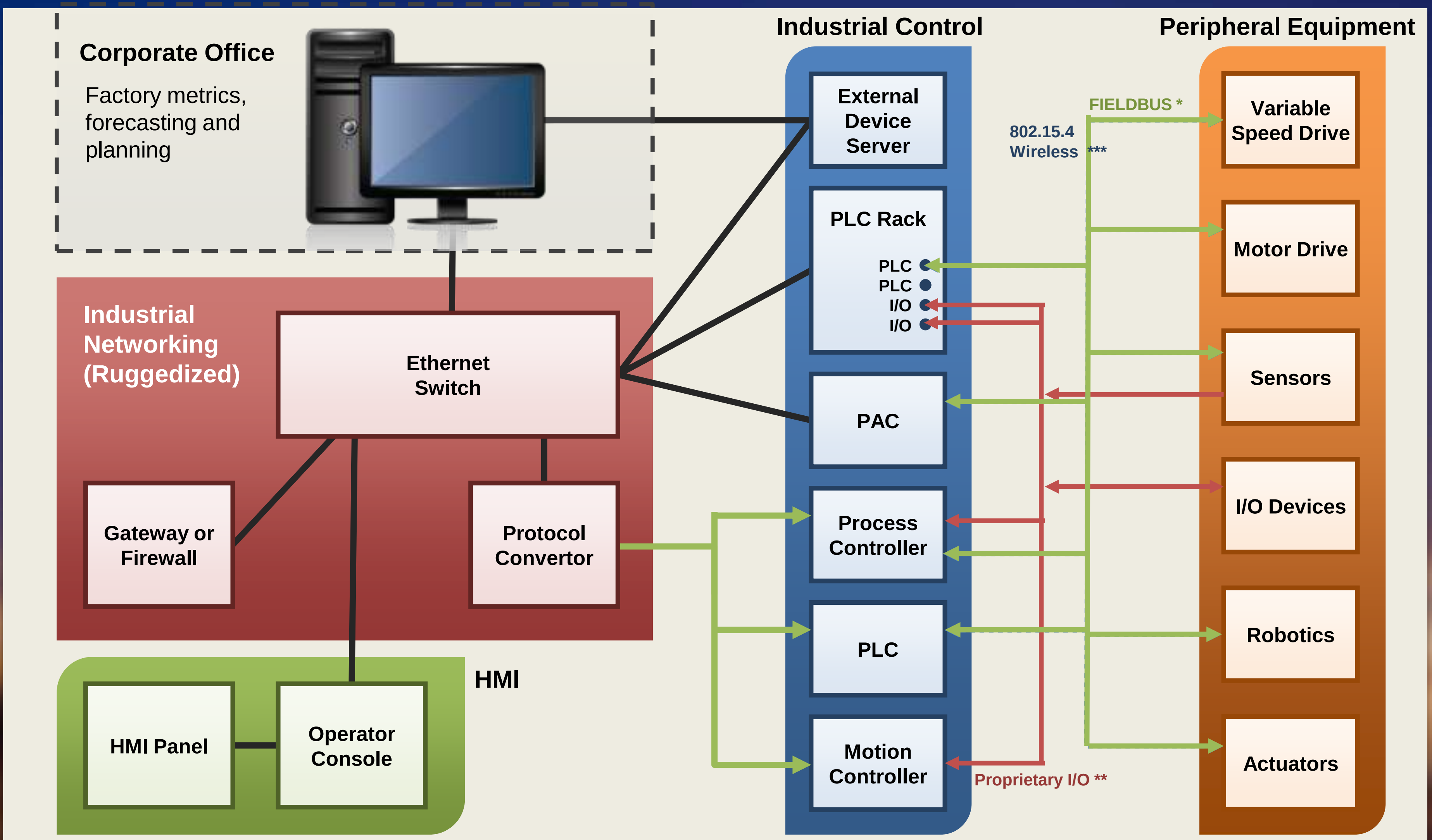
# Industry 4.0: Germany Leading Manufacturing IoT




Source: Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Germany's Forschungsunion, acatech, April 2013, Augmented with the red graphics

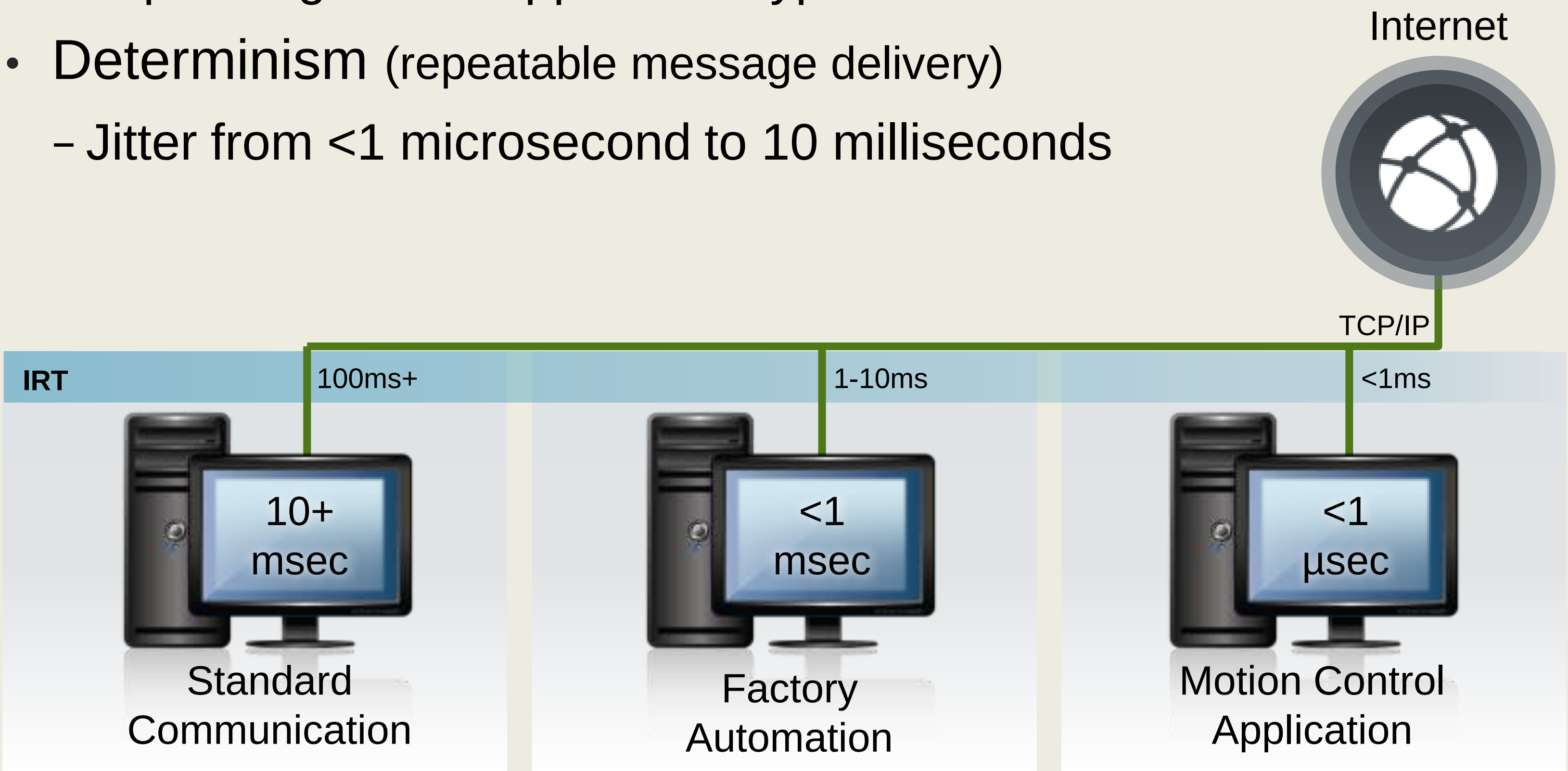
# Industrial Automation and Control Network Topology




* FIELDBUS = PROFIBUS, Modbus RTU, DeviceNet  ** I/O = Discrete, Analog, Thermocouple, Other  ***Wireless = WirelessHART, ISA100, ZigBee

# Industrial Ethernet Requirement: Determinism

- Speed
  - Sub-millisecond to over 100 milliseconds for message delivery, depending on the application type
- Determinism (repeatable message delivery)
  - Jitter from <1 microsecond to 10 milliseconds



# BAN/PAN/LAN/HAN Wireless Connectivity

| | LAN / BAN / PAN / HAN | Topology | Power | Modulation Scheme | Operating Band | # of nodes | Data Rate | Range | Application | Cost Adder | Standard |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumer | *Bluetooth* | Star | Low | GFSK and 8DPSK | 2.4-2.48G | 8 | 700kbs | < 30m | Network for data exchange, headset | low | IEEE 802.15.1 |
| | *Bluetooth Low Energy (BTLE)* | Star | Very Low | DSSS | 2.4-2.5G | App specific | 1Mbps | 5-10m | Health and Fitness | low | Bluetooth v4.0 |
| | *Z-wave* | Mesh | Very Low | GFSK | 908M | up to 232 | 40Kbs | 30m | Residential lighting and automation | low cost | NA |
| | *DASH7* | P2P - BLAST | Very low | GFSK or FSK | 433MHz | up to 8 | < 200kbps | < 2km | Wireless sensor; Building automation, Smart energy | medium | ISO/IEC 18000-7 |
| | *EnOcean* | Mesh | Very low | Amplitude SK | 315MHz, 868.3MHz | 1000s | 125kbps | 30-300m | Energy harvesting applications | low | ISO/IEC 14543-3-10 |
| Consumer & Industrial | *ZigBee* | Mesh, Star, Tree | Very Low | DSSS and PSK | 2.4G | up to 250 | 250kbs | 10-300m | Sensor Networks, Building & Industrial Automation | medium | IEEE 802.15.4 |
| | *Wi-Fi* | Star, P2P (wifi direct) | Low-High | DSSS | 2.4G-5.8G | 32 | 11-100Mbs | 4-200m | Internet, multimedia | medium | IEEE 802.11a, b, g, n, ah |
| Industrial | *ISA100.11a* | Mesh, star | Very low | TDMA, channel hopping, *Configurable time slot* | 2.4GHz | Unlimited (IPv6 addresing) | 250kbps | 200m | Industrial wireless networks (process control, asset tracking, ID) | High | ANSI/ISA100.11a-2011 |
| | *Wireless HART* | Mesh, Star | Very Low | TDMA, channel hopping, *Fixed time slot* | 2.4GHz | < 30,000 devices | 250kbps | 200m | Wireless communication for process control | High | IEC 62591-1 |
| | *Wireless Mbus* | Linear, Star | Low | FSK | 169MHz, 433MHz, 868Mhz | Up to 250 | 2.4kbps | 300m-1km | Smart grid, smart metering | medium | EN13757-4:2005 and 2012 |

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# NAN/WAN Wireless Communications

| | WAN / NAN | Topology | Power | Modulation Scheme | Operating Band | # of nodes | Data Rate | Range | Application | Cost Adder | Standard |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumer and Industrial | Weightless (TV White Space) | Mesh | very low | Time-division Duplex (TDD) | Unused TVWS | 96 | 0.1-16Mbs | up to 10Km | Smart machines to Internet | low | Weightless SIG |
| | ETSI-TV White Space | Mesh | very low | OFDM | Unused TVWS (470-790MHz) | Many | 1.6Mbps | up to 10Km | Smart machines to Internet | low | ETSI EN 301 598 |
| | 802.15.4m (TV White Space) | Peer-peer or Star | very low | FSK, OFDM, OFDM Narrow Band | Unused TVWS (54-862MHz) | Many | 50k-1.6Mbps | up to 10Km | Smart machines to Internet | low | IEEE 802.15.4m/D3 |
| | Wi-Fi | Star, P2P (wifi direct) | Low-High | DSSS | 2.4G-5.8G | 32 | 11-100Mbs | 4-200m | Internet, multimedia | medium | IEEE 802.11a, b, g, n, ah |
| | Wimax | Mesh | High | Scalable OFDM | 2.3G, 2.5G, 3.5G | 1000's | 11-100Mbs | 50km | Metro area broadband internet connectivity | high | IEEE 802.16 |
| | Sub Ghz & 2.4GHz | Star, Mesh | Very Low to Low | Varies | 433/868/900 MHz; 2.4GHz | 10-1000 | 250kbs | 10-70m | point to point connectivity | medium | N/A |
| | Cellular | Star | High | CDMA, GMSK, OFDMA, MF-TDMA | 800M-2.7GHz | Varies | 28kbps (1G) to 100Mbps (LTEA) | up to 30km | Cellular communications - voice and data | high | 1G, 2G, 3G, 4G LTE, LTEA |

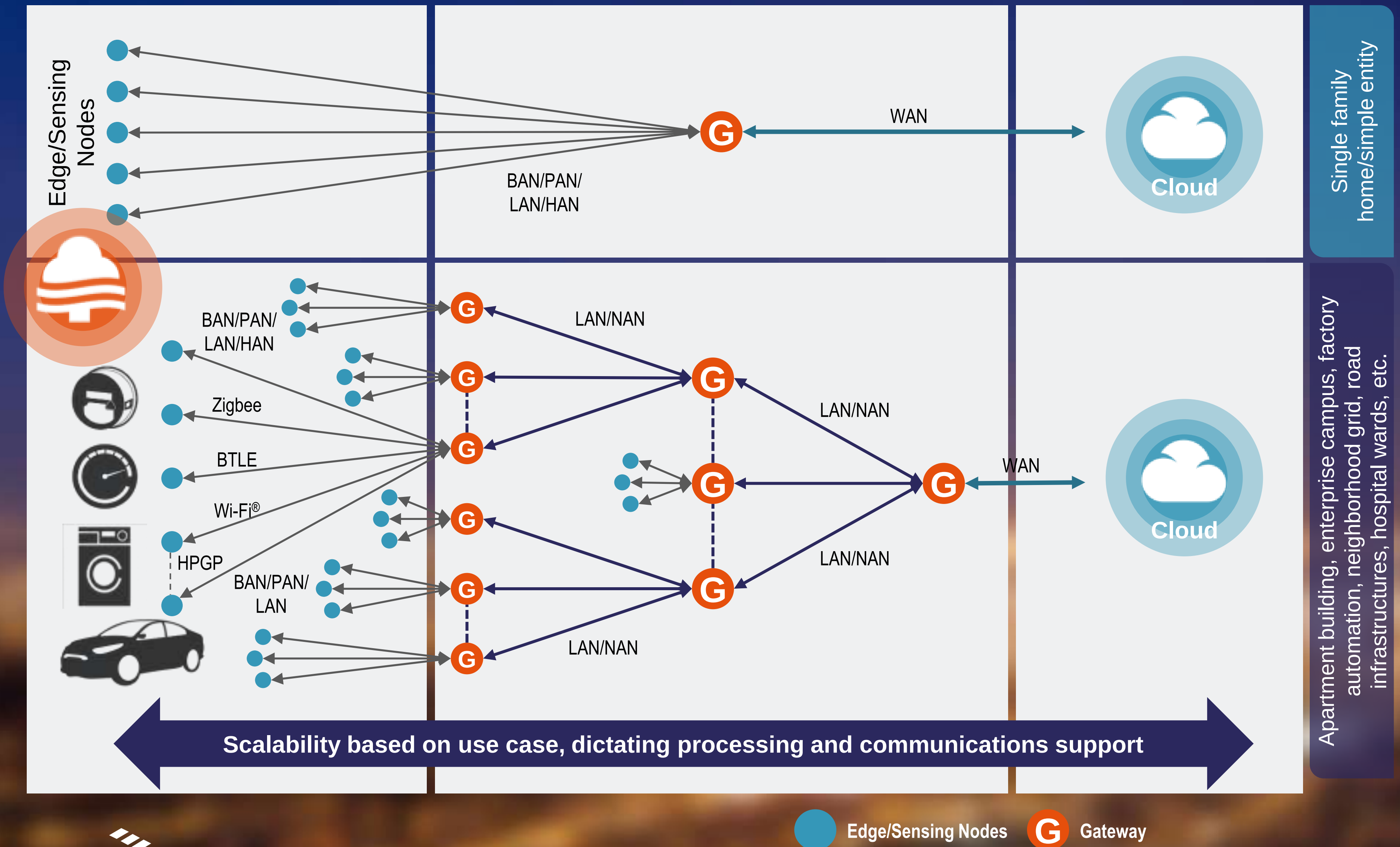
# Wired Connectivity (1)

| | LAN / BAN / PAN / HAN | Topology | Power | Modulation Scheme | # of nodes | Data Rate | Range | Application | Cost Adder | Standard |
|---|---|---|---|---|---|---|---|---|---|---|
| Consumer | HomePlug Green PHY (HPGP) | Mesh | Medium (4W) | Repeating node/OFDM | up to 1155 | 4Mbps | 100m (excellent) | Building control and automation, EV charging | high | IEEE 1901 |
| | HomePlug AV | Mesh | High (15W) | Point-ponit OFDM | up to 1155 | 120Mbps | 100m (excellent) | Multi-media | Very high | IEEE 1901 |
| | UART (serial communication) | Simplex, full-duplex | Medium | Non-Return to Zero (NRZ) | | < 3Mbps | 1-10m | Periphery - computer | medium | EIA, RS-232, RS-422, RS-485 |
| | USB (serial communication) | Simplex, full-duplex | Medium | Spread Spectrum | < 128 | 480Mbps (USB 2.0) 5Gbps (USB 3.0) | 2-5m | Periphery - computer | medium | USB Standard |
| Consumer & Industrial | Ethernet | Line, Star, Tree | High | PAM or PWM | Many | 10Mbps-1Gbps (futrue: 10-100Gbps) | < 100m (100, 1000Base-T), < 250m (10Base-T) | Factory, Home, Industrial | medium | IEEE 802.3 |
| | BACnet (MS-TP) and BACnetIP (Ethernet) | Line, Star | low-high | PAM or PWM | Many | 1-100Mbps | 10-150m (data rate dependent) | Building Automation and Control | medium | ISO 16484-5 |
| | KNX | Line, Star | High | FSK | up to 64 on one bus | 9.6Kbps | < 350m | Home automation and smart metering | medium | EN 50090, ISO/IEC 14543 |
| | LONWorks (Local Operating Network) | Free | Medium | Differential Manchester Encoding FM | 32,000 nodes/domain | 3.6-5.4Kbps | < 130m | Building automation/ building management | medium | IEEE 1473-L |
| | DALI (Digital Addressable Lighting Interface) | Bus and/or Star | Low | Manchester Encoding | upto 64 | 1200bps | 300-600m | Lighting control and building automation | low | IEC 60929 |

# Wired Connectivity (2)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industrial | ***PRIME (Power Line*** | Mesh, dual-mesh | Low (2W) | Repeating node/OFDM | up to 65535 | 40-125Kbps | 1km (good) | Industrial control and smart grid | medium | ITU T G.9904 |
| | ***G3 (PLC)*** | Mesh, dual-mesh | Low (2W) | Repeating node/OFDM | up to 65535 | 40-125Kbps | 1km (good) | Industrial control and smart grid | medium | ITU G.9955 |
| | ***IEEE 1901.2 (PLC)*** | Mesh, dual-mesh | Low (2W) | Repeating node/OFDM | up to 65535 | 125Kbps | 1km (very good) | Industrial control and smart grid | high | IEEE 1901.2 |
| | ***PROFINET (PROcess FIeld NETwork)*** | Tree, Star, Ring, Bus | Medium | Ethernet IEEE 802.3 | Many | 10Mbps | < 100m | Office, Factory and process automation | high | IEC 61158 and IEC 61784 |
| | ***EtherCAT (Control Automation*** | Line, Star, Tree | High | Ethernet IEEE 802.3 | up to 65535 | > 100Mbps | < 100m | Factory and process automation | medium | IEEE 802.3 |
| | ***EtherNET/IP (Industrial Protocol)*** | Line, Star, Tree | High | Ethernet IEEE 802.3 | Many | 10M-1Gbps | 100-250m | Industrial automation and commumnication | medium | IEEE 802.3 |
| | ***Ethernet POWERLINK*** | Line, Star, Tree, daisy chain | High | Ethernet IEEE 802.3 | Many | 10M-1Gbps | 100-250m | Factory and process automation | medium | IEEE 802.3 |
| | ***IO-Link*** | Point-point | low | RS232 | point to point | 230Kbps | 20m cable | industrial sensors and actuators | low | IO-Link |
| | ***PROFIBUS*** | Bus, Tree, point-point | low | RS485 differential | 127 | up to 12Mbps | 100m-1.2Km (data rate dependent) | Factory and process automation | high | IEC61158 |
| | ***CAN Open*** | Line | low | CAN bus | < 2000 | 1 Mbps | 50m full speed andup | Factory and process automation | medium | CAN |
| | ***AS-interface*** | Line, tree, star | high | Alternating Pulse Modulation | 62 | 1.2 kbps | 100m segments | Factory and process automation | high | IEC 364, etc |
| | ***HART*** | multidrop | low | 4/20mA; 8PSK | up to 15 | 1.2kbps | up to 3 km (load dependent) | Factory and process automation | high | HART |
| | ***RS-485*** | Point-point, multi-drop | Medium | FSK, others possible | 32 | 35Mbps | 1.2km | Industrial controls, Building automation | low | ANSI/TIA/EIA-485-A-1998 |

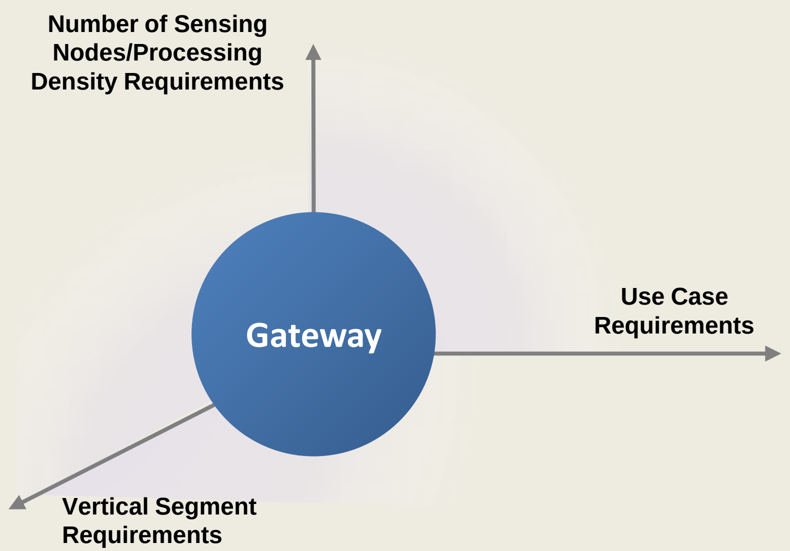
# Communication Topologies Across Hierarchies



# Scalability, Segment and Use Case Requirements

## Processing Density Requirements

- Single dwelling vs. apartment building, enterprise campus or distributed factory automation
- Position in the hierarchy of the gateway topology
- Application specific requirements (e.g., video surveillance vs. moisture monitoring sensors in the field)
- Legacy technology support vs. green field




## Vertical Market Requirements

- Low-latency for real-time control vs. delay tolerant applications
- Consumer and home vs. industrial and manufacturing environment
- Choice of standards for each, wired and wireless communication technologies
- Legacy standards support vs. new up-and-coming standards
- Memory management requirements

## Use Case Requirements

- Inside home or office vs. in the field
- Consumer specifications vs. industrial, automotive, etc.
- Home and office vs. rail systems, inside oil tankers or extreme environmental conditions, etc.
- Associated specs related to environmental conditions related to the quality of service and longevity

# Additional Considerations

- **Co-existence With Legacy Standards**
  - Almost all of the existing markets have entrenched legacy standards
  - The evolutionary path in non-green-field markets means a transition period were existing and future standards both need to be supported
  - Gateway box needs to support both, and have a “Protocol Conversion” function that supports various topologies, depending on use cases
  - It also needs to have modularized HW and SW that can easily support a cost reduction path with only the newer targeted standards
- **Flexible memory scheme to offload some of data center functionalities**
  - Not just data aggregation, but local command and control processing based on pre-set conditions, and communication with the cloud in case of:
    - Exception handling
    - Upload of data for history on an infrequent basis, and meta data for big Data Analytics
    - Added memory to support data collection
- **Local Data Analytics**

# Overlapping Services/Functions

**Smart Home**
Focus on home automation, but includes energy management

**Smart Car**
Charging electric vehicles (EV) can be done in the home garage, making the car a part of the grid

**Smart Energy**
Focus on reducing energy consumption at a variety of facilities, including at home

**Smart Grid**
Focus on optimizing grid utilization

IoT services will tie some of the overlapping functions together:

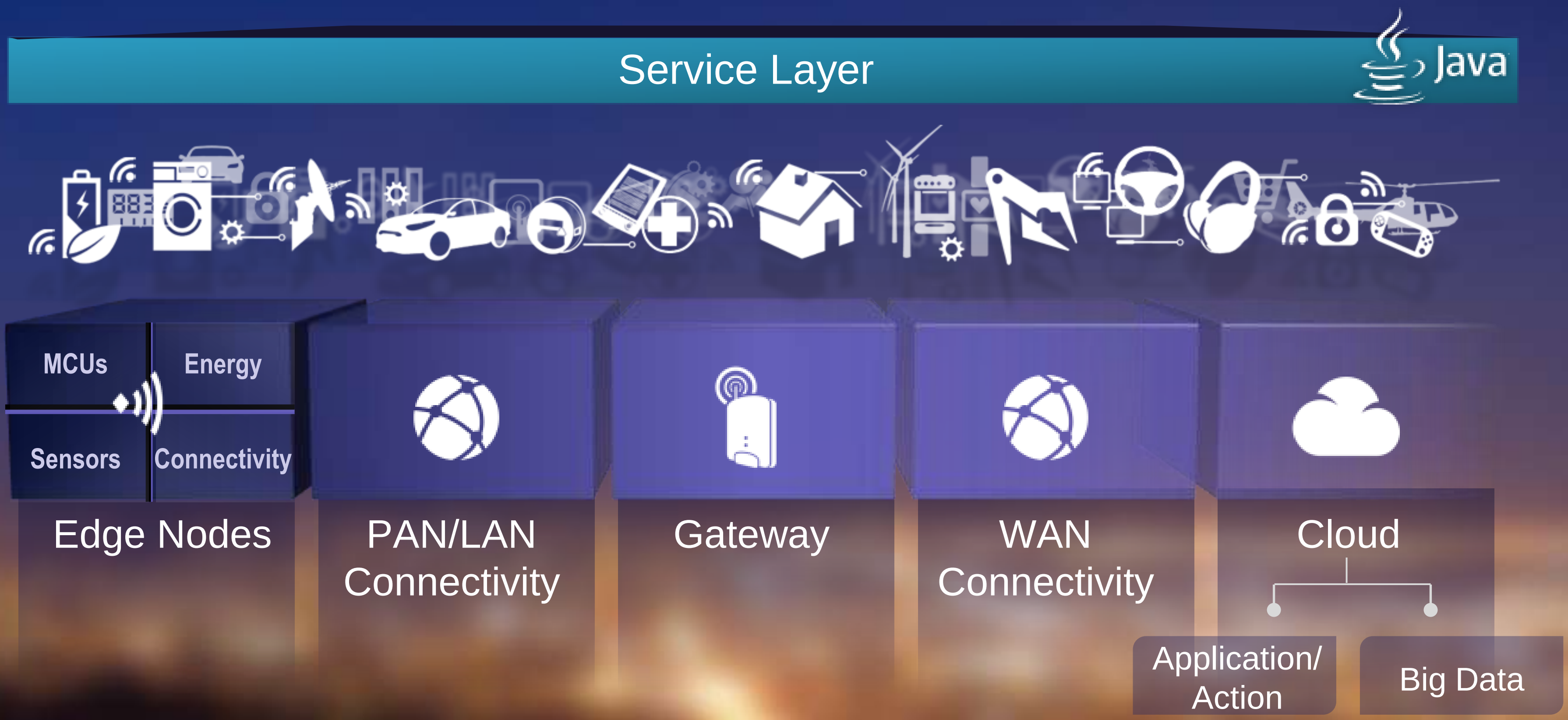
- The **Smart Car** will use the home garage charging station to charge up overnight
- **Home Automation** service provider becomes aware of this, based on the home gateway communication, and passes on the message to the **Smart Grid** service provider to ensure enough capacity in the neighborhood (in case of multi-vehicle charging)
- **Home Energy Management (HEM)** service provider logs the energy usage and works with the **Smart Car** gateway to coordinate with other appliances at home, as well as potentially available energy from solar or wind harvesting at home

# Smart Phone: 120,000+ Apps Now


**Doesn’t Everyone Deserve More Than One Service Provider?**

# The Need for a Secure Service Delivery Infrastructure

World's first IoT secure service delivery infrastructure based on open platforms



# Need for Security, as Stakes are Very High

**Best-in-Class Security**

Freescale's extensive portfolio of secure, scalable embedded processing solutions +

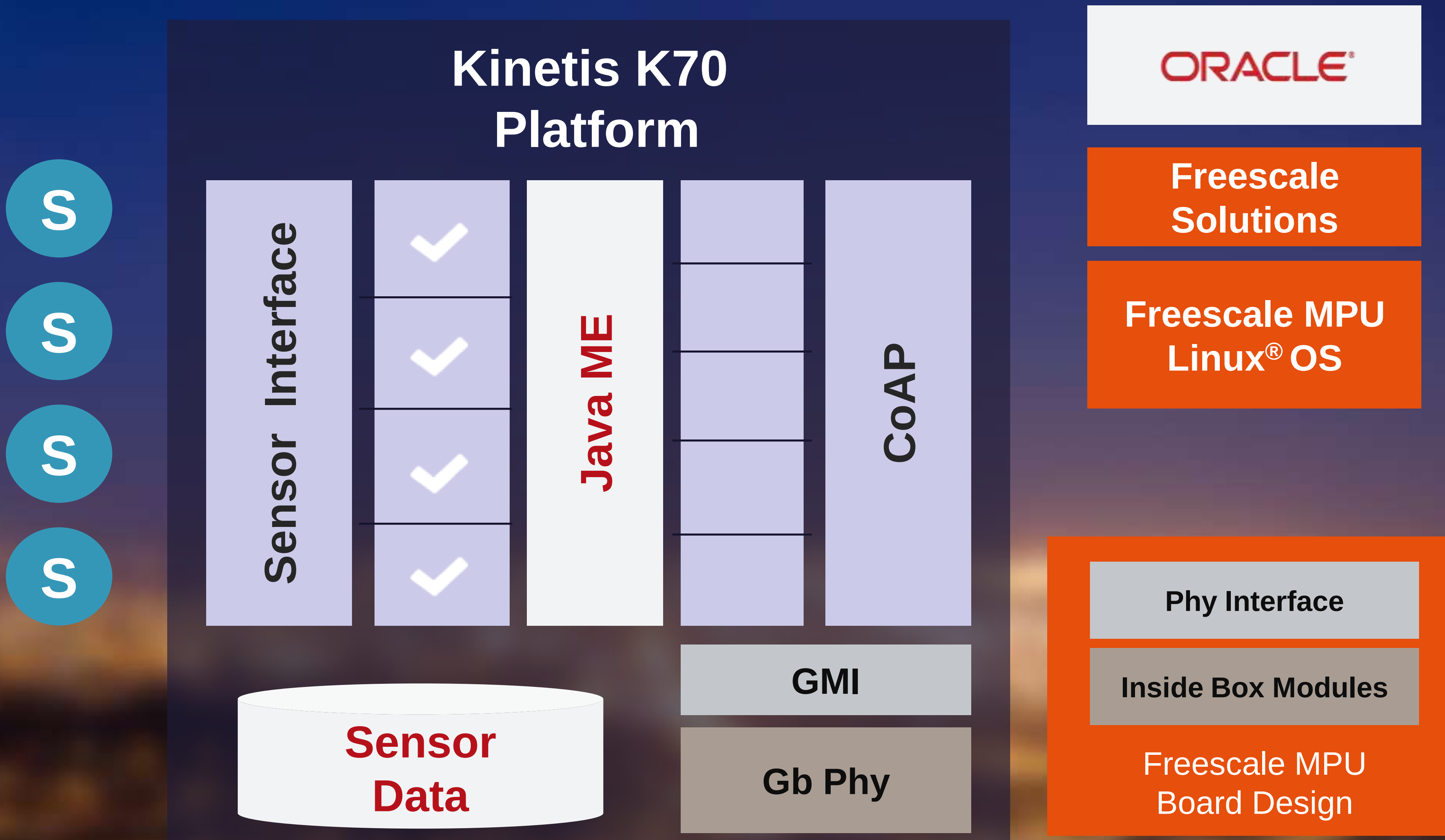
Java's industry-leading security +

System-level security optimizations +

Use-case based best practices =

**Secure Service Delivery Infrastructure**

# Edge/Sensing Node Software/Hardware Platform



# One Box Software/Hardware Platform

**Oracle Event Processing Embedded for Java Embedded**

JAVA SE Aggregator Local & Complex Events

JAVA SE Apps Wrapper

Local Directory

JAVA Embedded Suite (JES)

VLAN, DNS,IPS

Encrypted Data Open SSL, DTLS

TR69 Remote Provisioning

FSL openWRT AP-WLAN Wireless Router Gateway Platform

JAVA VM (SE)

Sensor Data

ZigBee Data

Wi-Fi Data

Bluetooth LE Data

JAVA Database

FSL MPU Linux-SDK BSP Software Drivers

ZigBee 1.0 | ZigBee 2.0 | Gb Enet | Bluetooth 4.0 | Wi-Fi

| USB2 | USB2 | GMI | SDIO | FLASH |
|---|---|---|---|---|
| USB2 Think-Eco | USB2 802.15.4 | Gb Phy | SDIO Silex - Module | On-board 8 GB Flash |

# scale IoT Offerings


## Xtrinsic Sensing
*Intelligent Contextual Sensing.*

The right combination of intelligent integration, logic and customizable software on the platform to deliver smarter, more differentiated applications.

**For IoT it provides Context: Identity, Activity, Location, & Time**

## Connectivity
**BAN/ PAN/ LAN**

Fully integrated Short Range radios with best in class power performance, and Powerline Communications

**Edge products:**
- Very small
- Low cost
- Low power
- Low complexity
- Industrial grade & robust

## Kinetis Microcontrollers
*Design Potential. Realized.*

Industry's most scalable ultra-low-power, mixed-signal MCU solutions based on the ARM® Cortex™-M and Cortex™-M0+ architectures.

## Vybrid Controller Solutions
*Rich Apps in Real Time.*

Real-time, highly integrated solutions with best-in-class 2D graphics to enable your system to control, interface, connect, secure and scale.

## i.MX Applications Processors
*Your Interface to the World.*

Industry's most versatile solutions for multimedia and display applications, with multicore scalability and market-leading power, performance & integration.

## QorIQ Processors Built on Layerscape Architecture
*Accelerating the Network's IQ.*

Industry's first software-aware, core-agnostic networking system architecture for the smarter more capable networks of tomorrow – end to end.

**Scalable Industry Standard Solutions, Software and Development Ecosystem**

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## A balanced approach is needed to establish the right infrastructure for IoT

**Freescale + Oracle Introducing The World’s First Secure Service Delivery Infrastructure Based on Open Platforms**


Making the World a Smarter Place.
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