IDTechEx

The Internet of Things: Show me the Money!

November 11, 2015

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Agenda

- IoT Drivers and Applications
- IoT System Choices
- Technology bottlenecks
- Who are the big spenders in IoT?
- Displays and IoT

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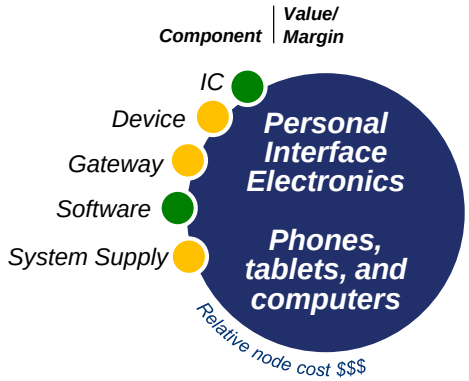
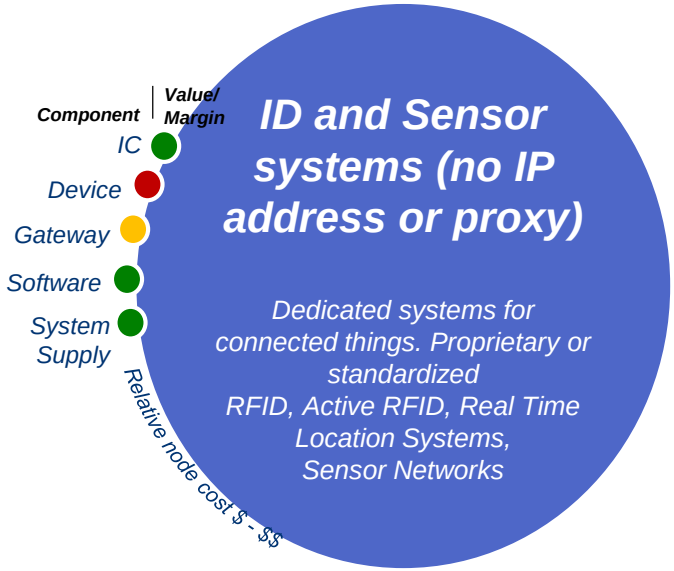
Two Worlds of Systems



- Smart phones, tablets, smart TV, computers…
- Communicate and access information anywhere
- Large, mature
- Relatively high cost per device (av. $400?)
- Over 2 billion phones, tablets, computers etc bought yearly
- $1.6 Trillion /Year, CAGR single digit



- Tagging animals, cargo containers, clothing, assets…
- Locate, track, verify, report
- Fragmented, siloed, application focused
- Typically very low cost per device (RFID tag sub $0.10)
- 10 billion identification tags bought yearly
- $10 Billion / Year, CAGR double digit

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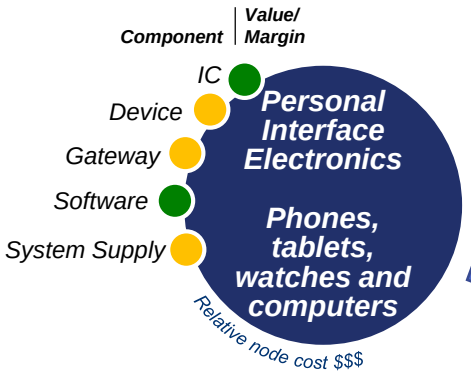
Two Worlds of Systems Converge



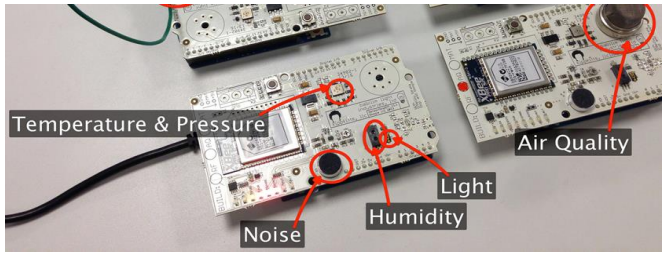
Consumer Applications

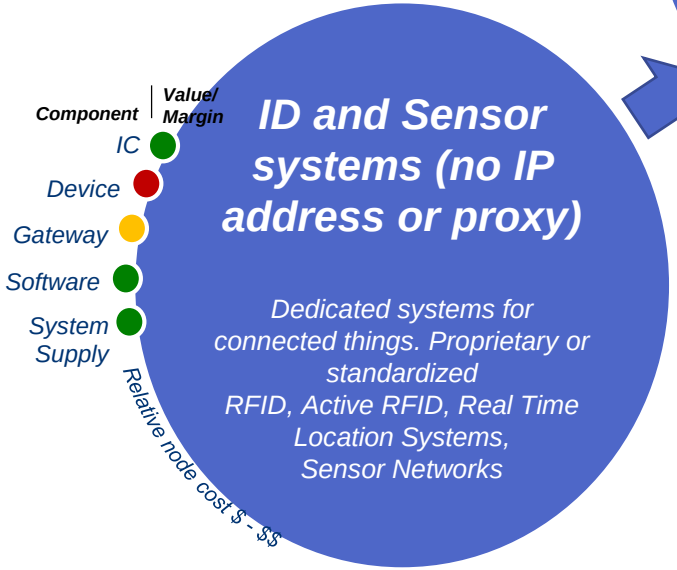
Drivers: *Consumer needs, usually new business models*

- Wearable technology
- Home automation
- Healthcare, fitness, assisted living
- Consumer services and infotainment
- Vehicles

Internet Connected (IP address)

Sense, learn, adapt, communicate and co-operate and control over the internet with no human interaction.





Industrial & government applications

Drivers: *Governments or specific problems*

- *Infrastructure monitoring/ smart cities*
- *Lighting*
- *Transportation monitoring*
- *Energy monitoring/smart grid*
- *Process automation*
- *Security*
- *Agriculture*

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IoT: Why now?

- Low-priced microcontrollers, sensors and networking
- Consumers have something to read/control them – smart phones, tablets etc
- IP addresses now effectively infinite – IPv6
- Internet access more widespread. 900MHz 80211ah WiFi for reliable M2M
- Big investors and hungry wealthy suppliers eg Cisco, Google, Samsung.
- Large government investment in smart cities in China. Funding increasing from other governments e.g. UK

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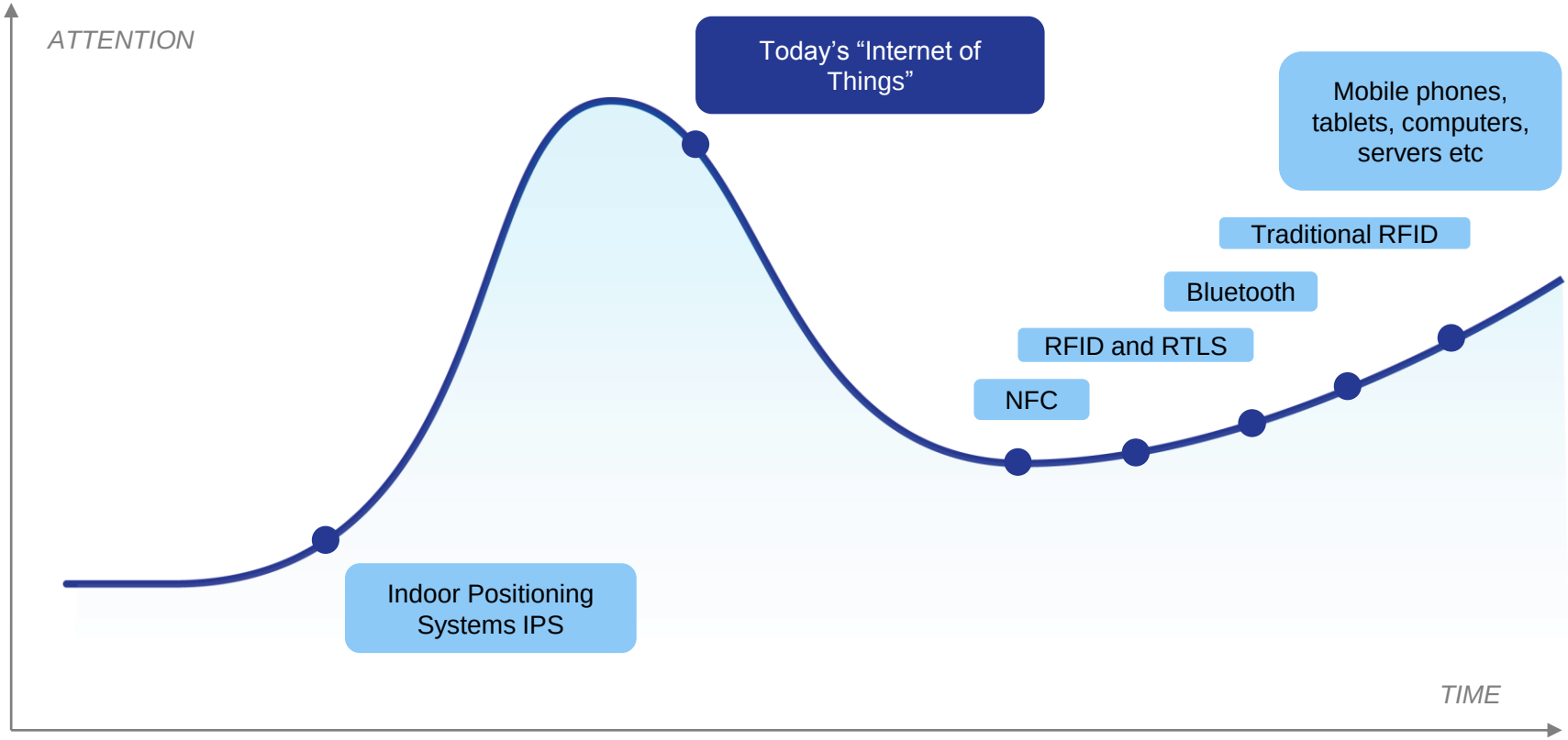
Reality sets in

- 2011 – many analyst forecasts put the opportunity at 50-100 billion devices in 2020. Now it is 26 to 30 billion devices in 2020!
- Who is even negotiating for 100 million IoT nodes let alone 1 billion?
- 5 years away from enduring profit for many?



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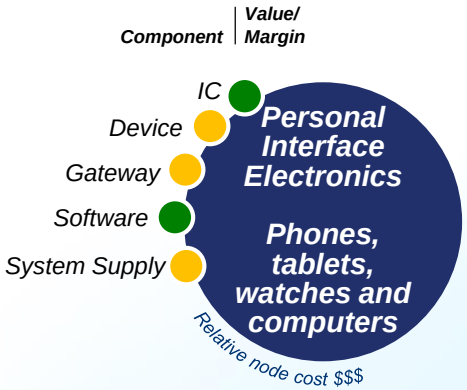
Personal Electronics to IoT: Very Different Drivers



Consumer and office electronics with devices bought on their own.

VERSUS

Industrial, commercial, medical etc with devices rarely bought on their own

Large, mature, usually bought for personal convenience, essential tool – not a payback, value chain and value add is well understood.

VERSUS

Small, new, paybacks little understood, sometimes done for safety and security but most likely to be payback driven, fragmented value chain

Internet Connected (IP address)

Sense, learn, adapt, communicate and co-operate and control over the internet with no human interaction.

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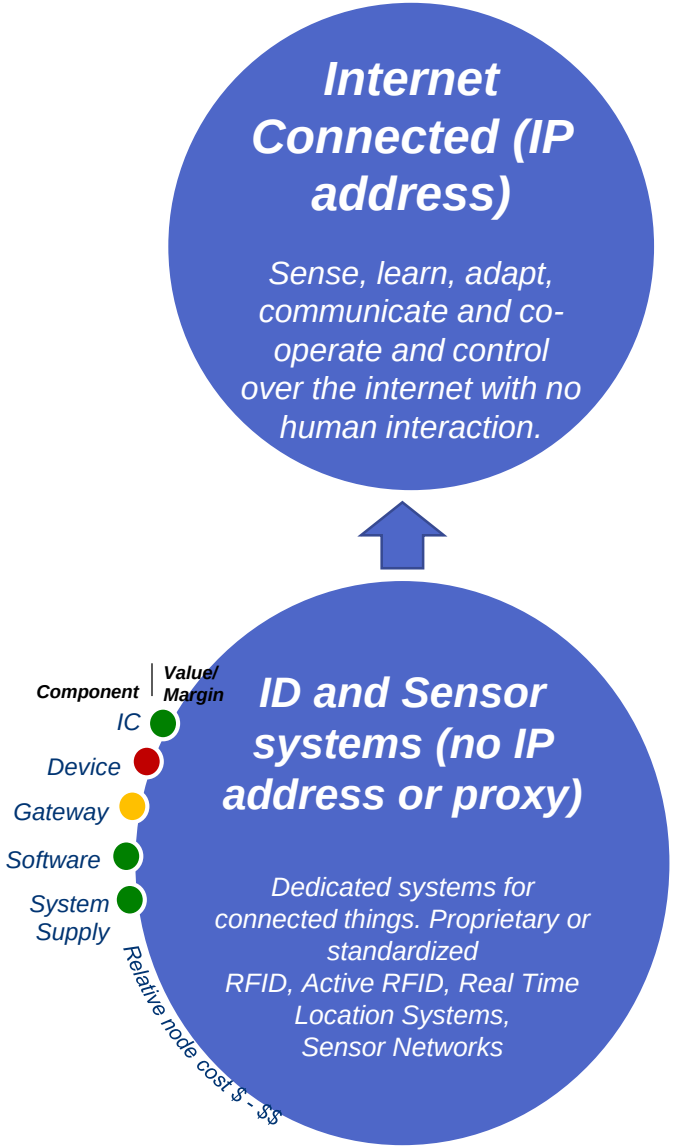
Why some existing sensor networks will not convert

- Why should they? Legacy systems that may already work well – what is the driver for change unless they need replenishment?
- The $10 billion RFID business consists mainly of passive RFID with disposable dumb tags, very price critical e.g. 6 cents. Ultra low cost tags are needed for the highest volume applications. However, many RFID networks have internet backhaul.
- Wireless sensors. Where installed, owners rarely have the budget or the business case to change. However, many wireless networks have internet backhaul.



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Examples of Applications

Connected Vehicles, Infrastructure

- Real time product feedback for faster development
- Monitor failures, update remotely
- Change performance based on external parameters e.g. weather, fuel price, other cars etc

Media

Example: London taxis always point to nearest McDonalds

Source: Eyetease Media

Home Automation

- Leader is NEST, at an estimated $500 million sales in 2015, acquisition price at $3.2 billion
- Alertme acquired by Centrica for $100 million in 2015, used in over 100,000 homes
- Apple developing HomeKit

Wearable IoT…

Process Control / Manufacturing / Industry…

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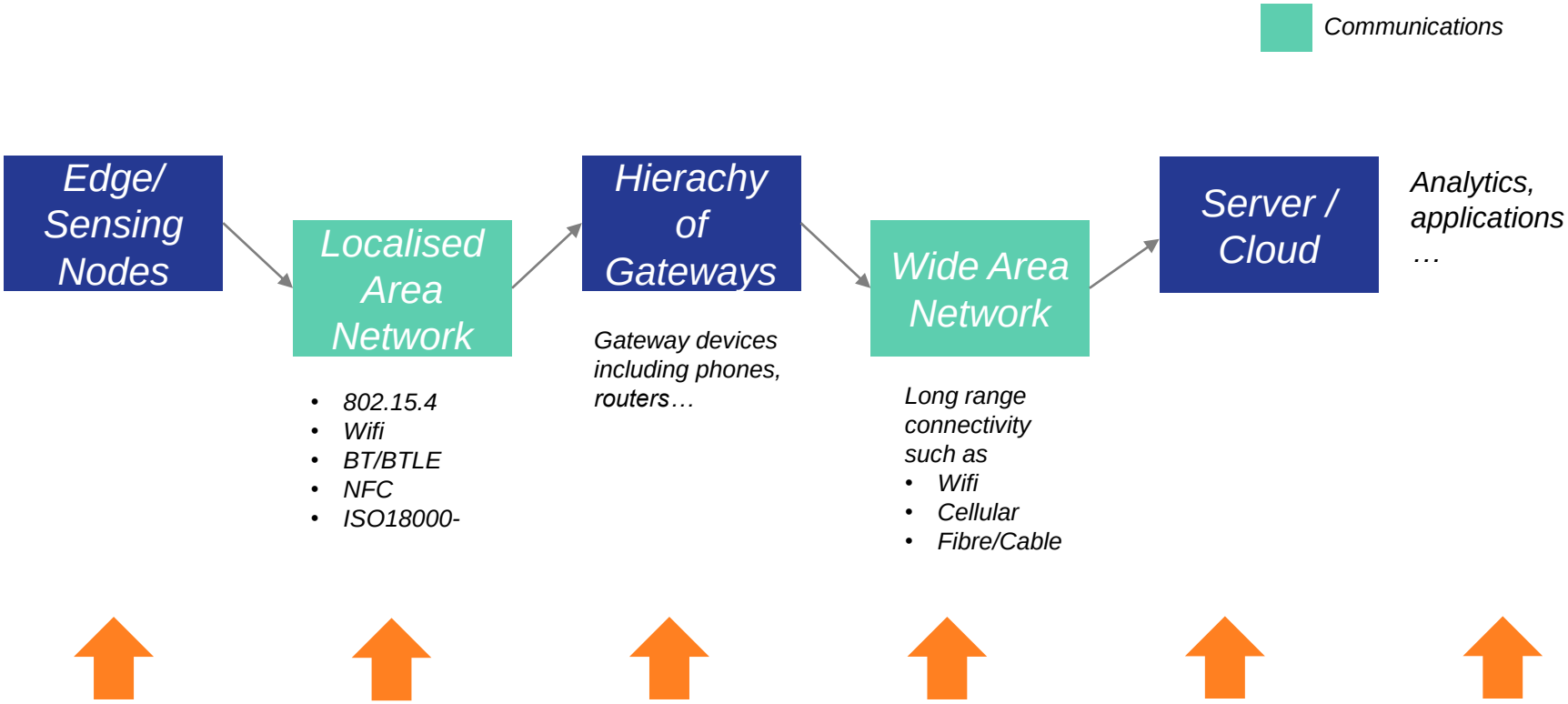
Infrastructure of IoT



Many different technologies, suppliers, networking options, security options, standards, environments, tool sets etc are involved

Input from Atmel

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Edge/Sensing Nodes

Temp sensor, activity tracker
- Connectivity
- Sensing Platform
- Power

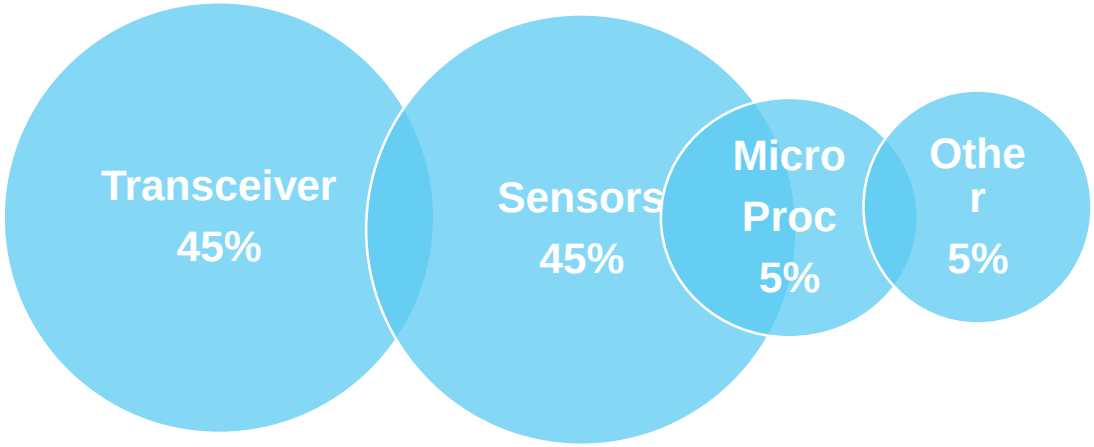
Door lock, thermostat
- Connectivity
- Sensing platform
- Power
- Control unit

Smart metering, utilities, cars
- Connectivity
- Sensing platform
- Power
- Processor MCU/MPU

Identification
- *Connectivity*

Edge/ Sensing Nodes

- *MCU/MPU*
- *Sensor/Actuator*
- *Power source*
- *Connectivity*



MCU/MPU developed separately from transceiver can develop issues of security, cost, space, power consumption etc Not a centralized Development environment. But merging on one chip is hard – it goes out of date as new developments occur.

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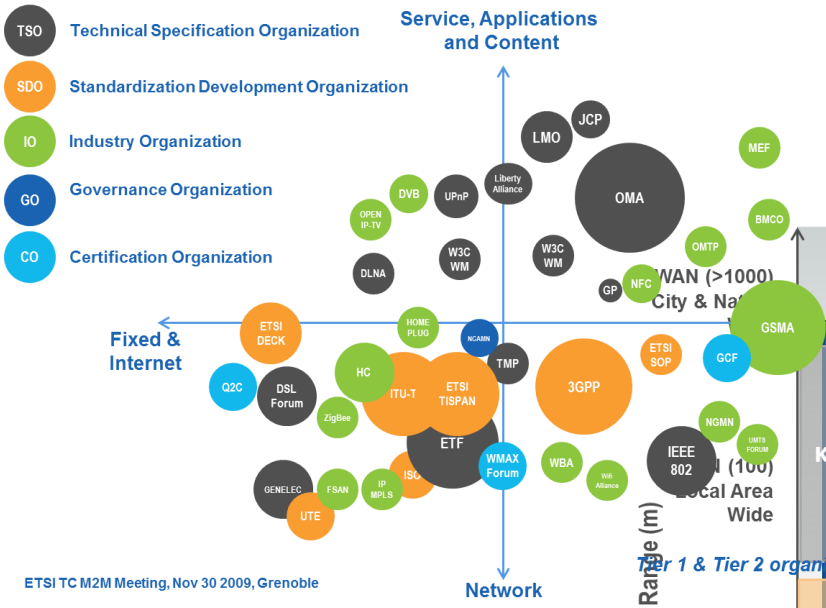
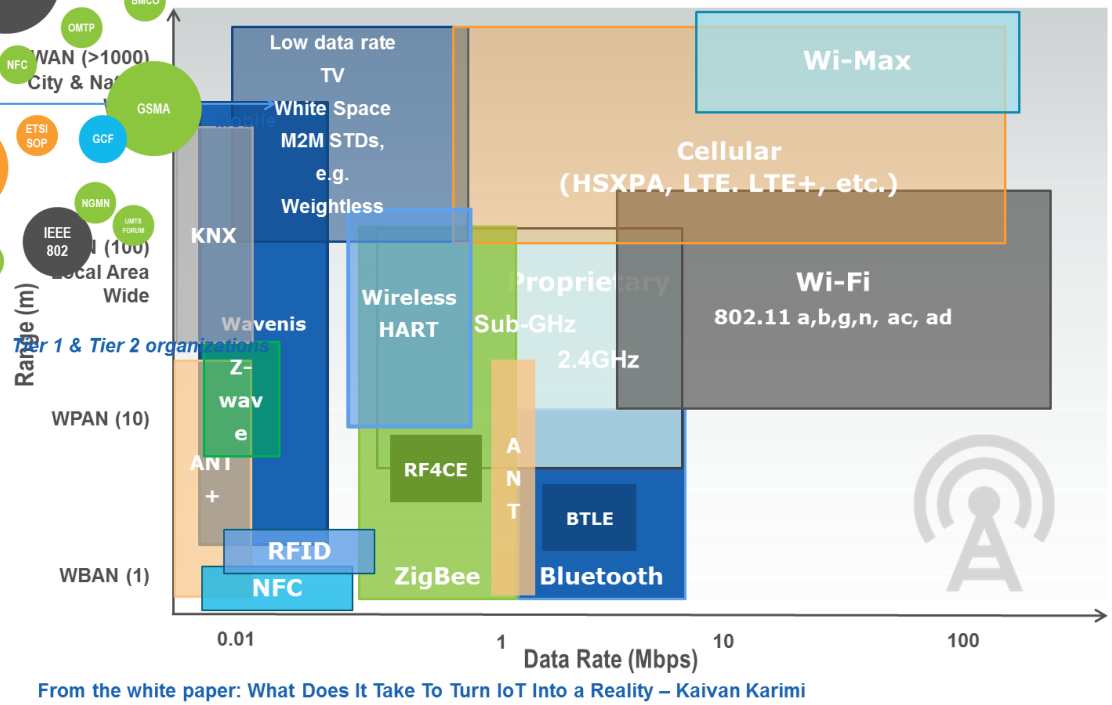
Soup of Technologies and Quagmire of Standards and Standards Bodies



Source: ETSI TC M2M Meeting, Nov 30 2009, Grenoble



From the white paper: What Does It Take To Turn IoT Into a Reality – Kaivan Karimi

From the white paper: What Does It Take To Turn IoT Into a Reality – Kaivan Karimi

Oh, and proprietary helps lock in customers. Then there is Allseen, OIC, Apple HomeKit, Thread…

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Large Investments Announced To Secure Position

Google acquires Nest and Dropcam, total $3.7 Billion

Processor/Controller/Device companies move into wireless radios:

- Atmel acquires Newport Media for $140 million+
- Huawei acquires Neul
- Qualcomm buys CSR for $2.5 Billion

Samsung acquires SmartThings for $200million

Sigfox raises $115 million

Dialog Semiconductor acquires Atmel for $4.6 Billion

Cisco invests heavily in IoT: $1 Billion to startups over 5 years, according to v3.co.uk

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Impediments to mass rollout of IoT

- Business case, particularly for open systems with multiple stakeholders who may have legacy systems
- Energy source: enduring power to the devices
- Education
- Execution: Getting people to set it up or link existing systems today, experience
- Availability of the network
- Security and privacy issues
- Affordability
- Device form factors
- Standards confusion: vast array of applications and types of node technologies and interfaces
- Legacy systems
- Fragmented supplier base
- Industrial grade products
- Creative product design – coming up with the must-have products that I don't yet know that I really want

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Security

- Nodes may last for more than ten years. Need to be protected from threats now and in the future. Upgradeable software? How do you regain control of a node that has been taken over? Bin and replace is not an option.
- Cyber attacks on infrastructure could become a risk to society
- Governments are concerned: CPNI (UK). Dept. Homeland Security (USA), Executive Order 13636 - Improving Critical Infrastructure Cybersecurity, Council on Cybersecurity – Global NGO
- A system level approach is usually needed, from sensing nodes all the way through to the cloud. Different systems offered by different vendors such as Allseen Alliance, Open Internet Consortium, Thread Group
- Vendors and some users implementing own security because there is no one size fits all

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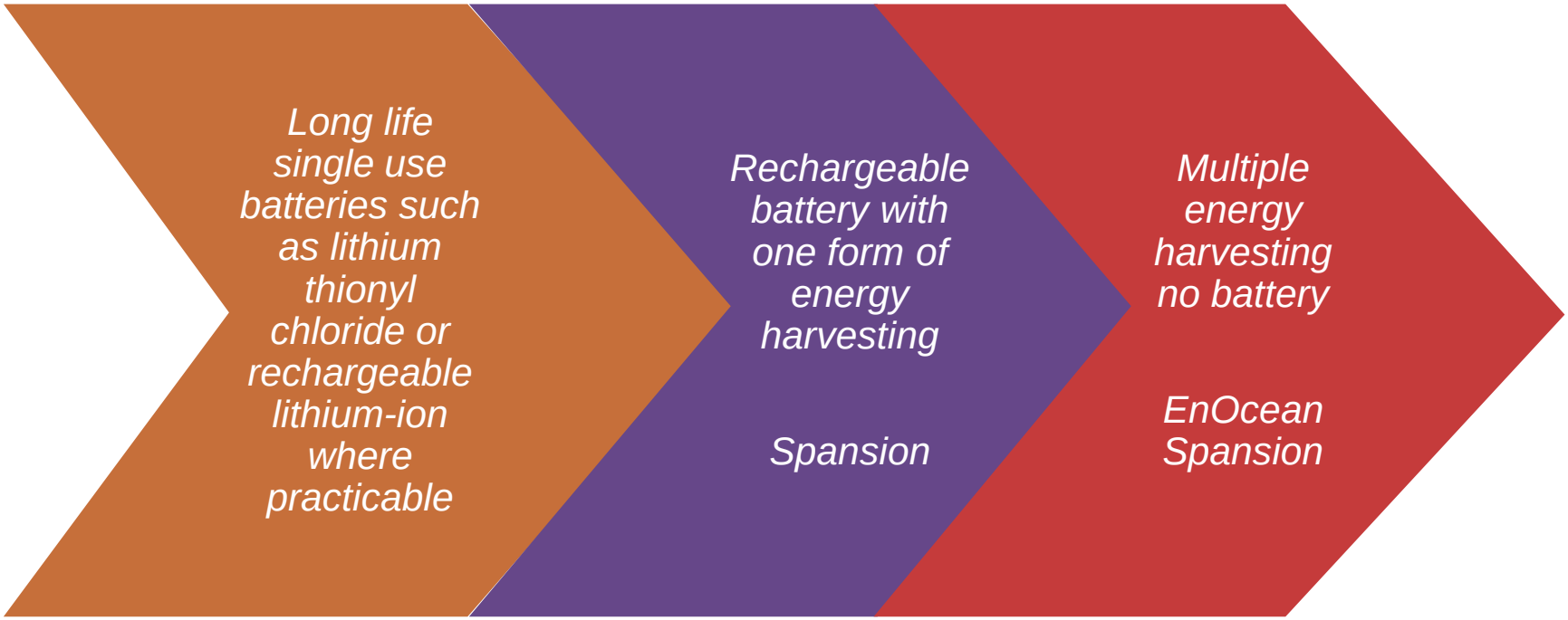
Energy harvesting as a key enabling IoT technology

- Many IoT devices today are powered by direct wiring, such as smart meters, smart lighting, thermostats
- Untethering the device will be enable a huge volume opportunity, but who will find the sensors again to replace the batteries when they die in a few years?



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Edison “Make Energy Where it is Needed”

Application	Technology	Energy storage
Windmills to wind turbines	Wind energy harvesting	Capacitor conditioning
Gas lighters	Piezoelectric	None
Bicycle dynamo lighting	Electrodynamic	None or capacitor
Satellites	Photovoltaic	Rechargeable battery
Garden lights, toys	Photovoltaic	Rechargeable battery
Wristwatch	Electrodynamic or photovoltaic	Rechargeable battery or capacitor
Road furniture	Photovoltaic, wind	Rechargeable battery
Building controls	Piezoelectric, electro-dynamic, photovoltaic	None or battery
Flashlight	Electrodynamic	None or rechargeable battery
Sensors on motors	Electrodynamic (vibration)	Supercapacitor
Regenerative braking	Electrodynamic	Capacitor

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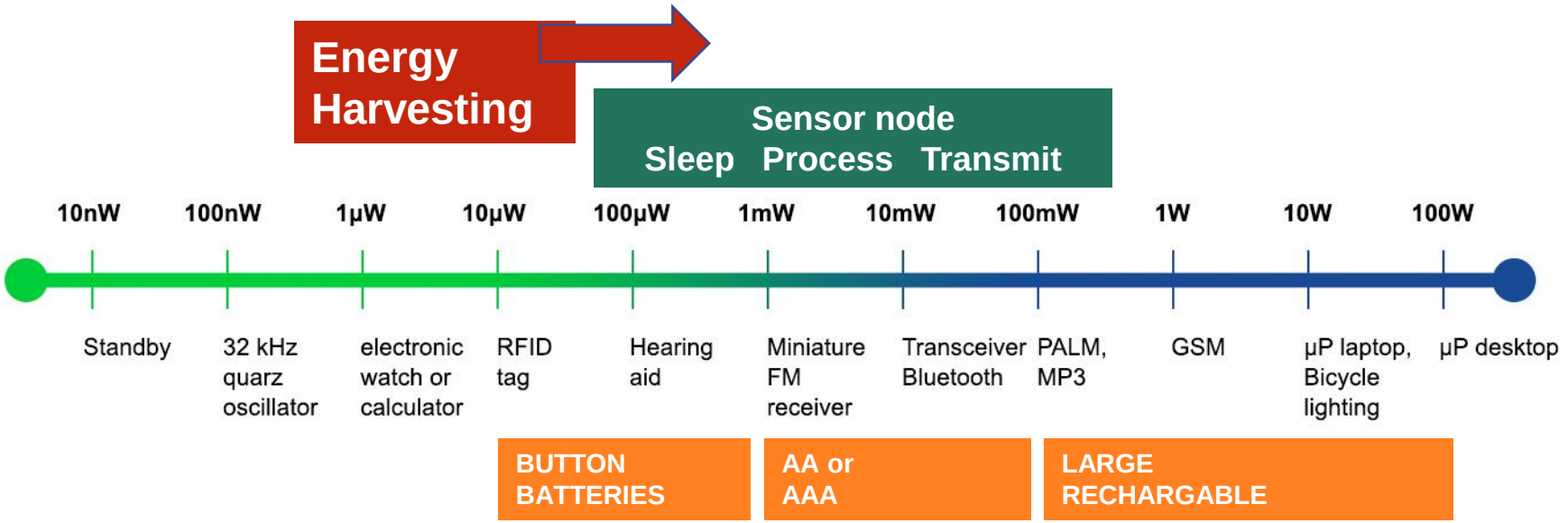
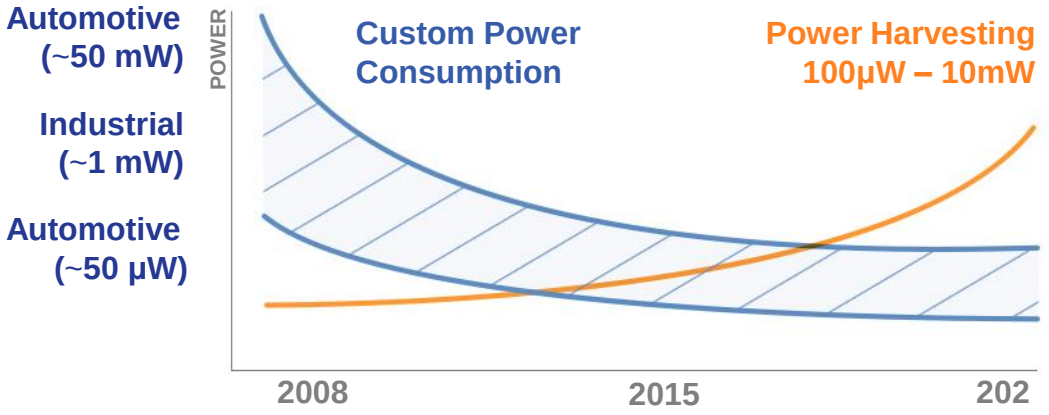
Power needs versus energy harvester performance



Energy harvesters are becoming more powerful, while electronics are becoming lower power



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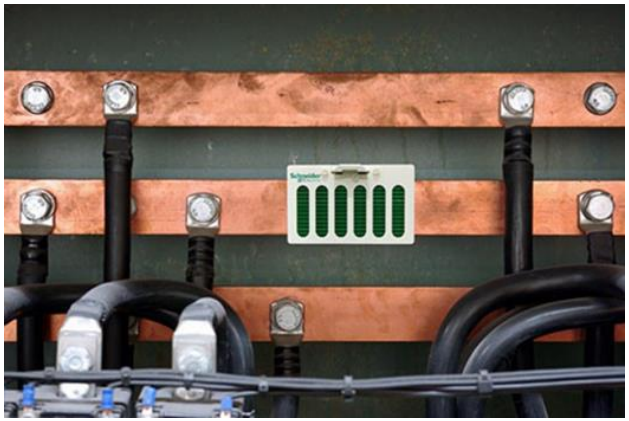
Energy Harvesting Powered IoT

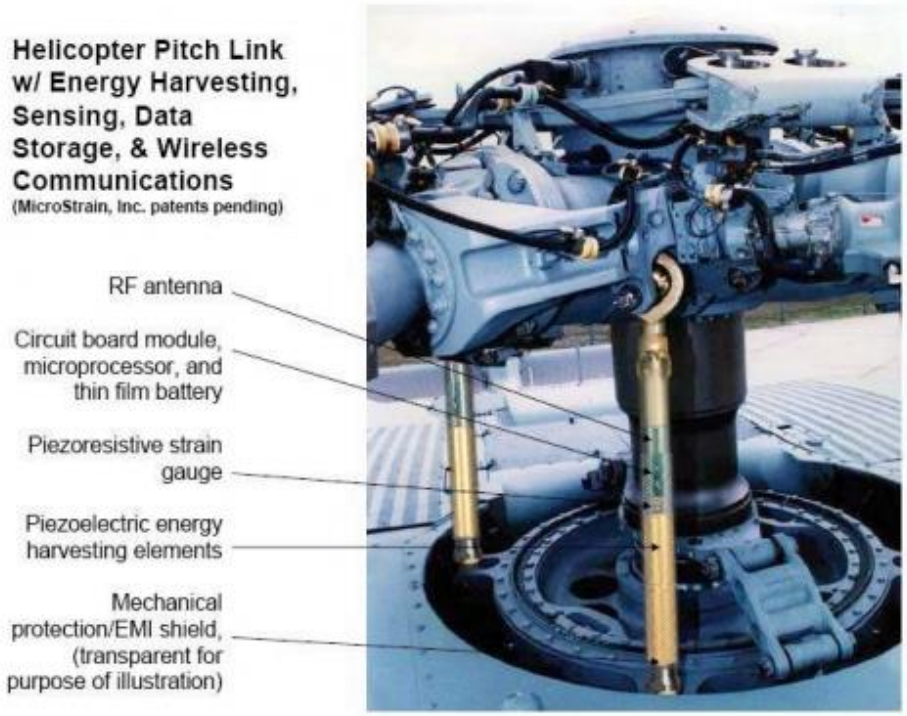
Source: EnOcean

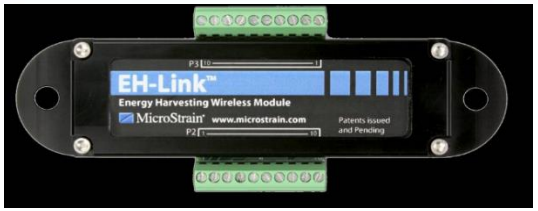
Enocean – light switches to mouse traps to window locks. Installed in over 250,000 buildings

Source: Micropelt



Schneider Electric & Micropelt Qnode: Wireless busbar monitor: Temperature sensor, powered by temperature gradient





Source: LORD MicroStrain

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Multi-modal energy harvesting

- Multi-modal energy harvesting from KCF technologies:
- Piezoelectric
- Solar
- Thermoelectric

- Versatility in deployment in various operating environments

Source:KCF Technologies

Source:Spansion

Agriculture Monitoring

Power Source	Multi Solar Cell
Sensor	Temp. and Illumination
RF	2mJ /10s
Capacitor	1000uF
Coin Battery Lifetime	4 months
Lifetime w/ Energy Harvesting >10 years	

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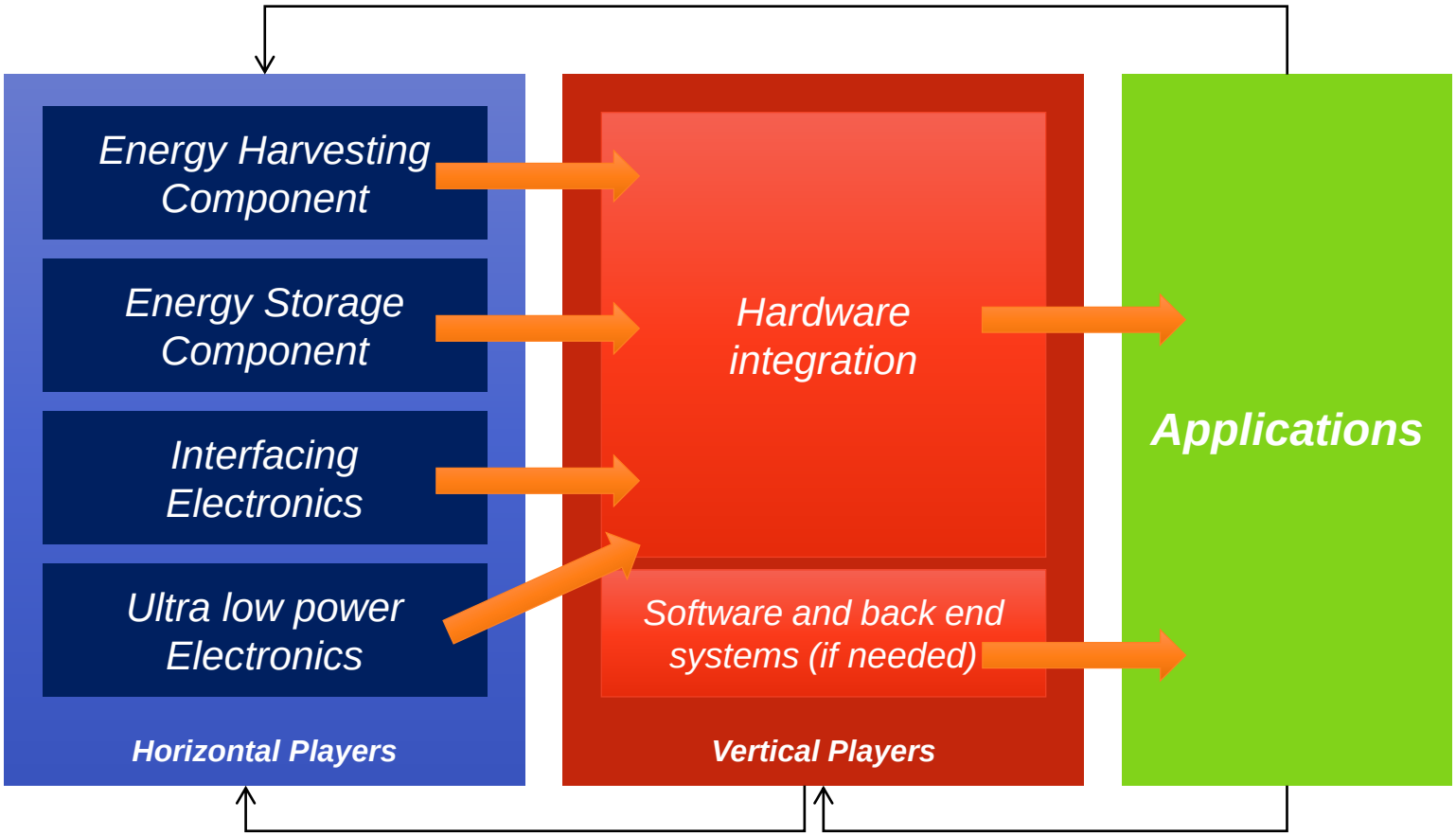
EH powered IOT: Challenges



No "one fit all" solution – feedback needed

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Who is buying and why

- Industry/enterprise seeks ROI, needs to fix a problem and have low appetite for payback experiments
  - Passive RFID “tag everything” scenario failed – sharing cost vs payback with many partners did not work
  - Industry adoption of WSN and RTLS has been much lower than anticipated
  - **Emerging IoT: smart lighting, process/manufacturing control**

- Governments have been huge driver of wireless sensors/tagging
  - Animal tracking, ePassports, Transit systems – ticketing, ZigBee in smart meters
  - **Emerging IoT sectors: energy, transport, cities, agriculture**

- Consumer markets have huge potential for rapid growth by creating benefits that consumers are willing to pay for
  - Remote car access control, toys etc.
  - Need a “next big thing” as phones and tablets saturate(?) – and cash rich
  - Only very few get the product concept right and can be rapidly commoditised (think fitness trackers)
  - **Emerging IoT: home automation, connected vehicles**

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IoT: Show me the Money!

Government-led

- US VA - $543 million RTLS contract to HP
- About 500 million smart meters installed so far. Smart grids – often government enforced/kickstarted
- US military spent over $1 billion on RFID and linked systems
- EU research projects in IoT $145 million to 2013, now more funding available – another $215million in smart cities alone over two years
- Australian government: $91 million to trial smart grid
- US smart cities initiative $160 million
- India – developing 100 smart cities with an initial investment of $1.2 billion

Consumer

- Nest leads in home automation, sales of $500 million approx. and strong growth
- Vehicle connectivity gaining momentum
- Wearables

Enterprise

- Legacy install base of control and automation systems
- New IoT sensor systems deployed to replenish old systems slowly or address problems
- Predictive maintenance
- Energy utilization
- Embedded systems

Utility / Energy applications, Wearables and Healthcare will dominate over the next few years

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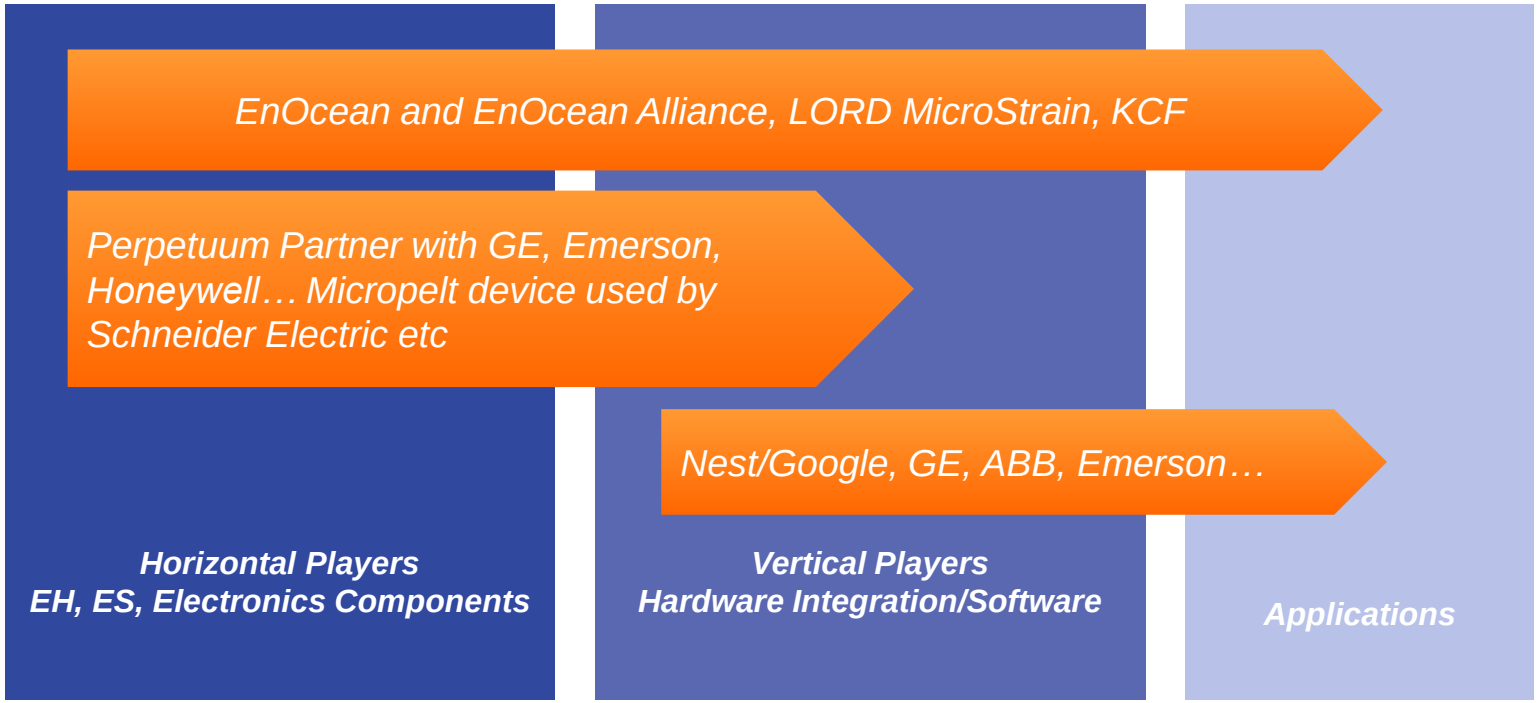
Enterprise and consumer IoT: many realize they have to be solution providers and software providers



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Problems that are Opportunities

- High level of customization is often needed for hardware and infrastructure – opportunity for services, design and benchmarking

- Many technology choices. So called interoperable systems are sometimes not. Some vendors want lock-in. Standards may not be optimal. In enterprise, he successes are typically in small, closed loop installations with proven ROI rolled out in a “cookie cutter” approach.

- Start-ups that became successful tend to have a strong software and hardware offering, provide a complete solution, and do some integration.

- New forms factors are not yet being exploited e.g. flexible PV, flexible/embeddable thin film batteries. These new possibilities could command premium pricing and move away from competing on cost – create new markets instead. Integration of these products is also a challenge

- Upfront cost. New models such as subscriptions, leasing, payback split…

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Examples of IoT opportunities

- **Small memory, ultra low cost edge nodes (not internet connected directly)** – Thinfilm Electronics
- **Low power, ultra small microprocessors**
  Intel, Atmel, Texas Instruments, Samsung, ARM
- **Microcontroller sensor platforms, small, low power**
  Intel, Texas Instruments, Samsung, Arduino
- **Software development environments to create the software to work with the hardware used in the Internet of Things.** ThingWorx, Raco Wireless, nPhase, Carriots
- **Converting legacy networks on proprietary protocols to IP-based networks** – Cisco
- **System integration and facilities management.** IBM, Cisco, GE
- **Vertical specialist knowledge – know and address sector challenges e.g. Asset Management, Healthcare systems, Automotive etc**

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IDTechEx position on IoT

Over the next few years IoT will mainly consist of a large number of small projects.

IoT will be big but later than most people predict. Consumer applications will be biggest – particularly where completely new markets are created, followed by Government funded or mandated applications initially. Enterprise needs a problem to fix, but will be helped by being kickstarted by Government funded projects.

Easy to talk about the application visions in the future but getting there is a huge challenge. These take time for standards, collaboration, technology development, business cases and large sums of money.

Hardware will be quickly commoditized. Largest opportunity therefore is software and services.

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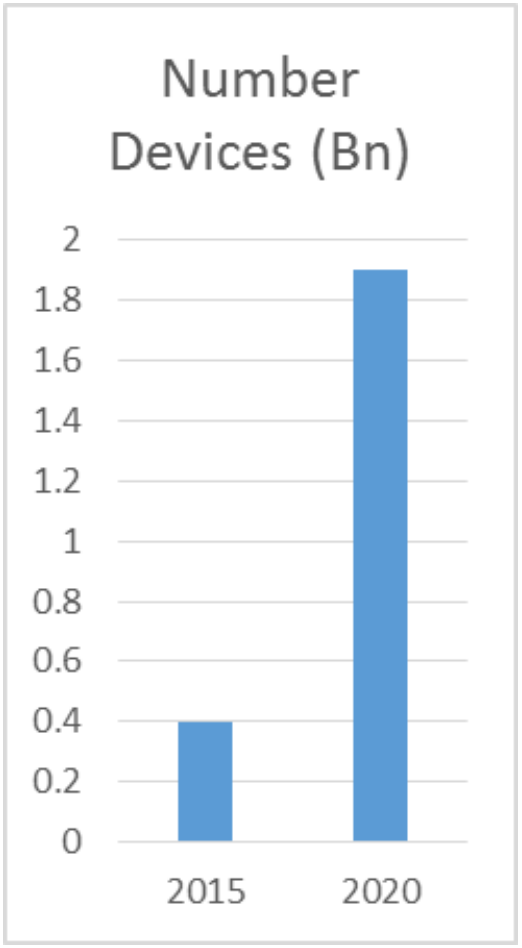
Building it up from the Bottom up – wireless IoT



Existing personal electronics– smart phones, tablets, notebooks
2015: 2.1 Billion to 2020: 2.6 Billion

Wearable Technology – fitness, medical, smart watches skin patches etc (wireless devices)
2015: 0.12 Billion to 2020: 0.6 Billion

Other IoT IP nodes
2015: 0.1 Billion to 2020: 0.9 Billion

Active RFID – car clickers to wireless sensors
2015: 0.15 Billion to 2020: 0.4 Billion

Total 2.5 Billion 2015 >> 4.6 Billion 2020

Notes:
Excludes wired devices and gateways such as interrogators, routers, servers, TVs and consoles
These are new node sales, not cumulative number of connected devices.
More things but nodes stay fitted for a longer time, personal electronics replenished more often
Passive RFID is 9 Billion 2015 >> 25.4 Billion 2020 (tags sub $0.10 asp)

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Displays and IoT

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Opportunities that IoT will create for displays

- IoT will create new markets for displays, initially in devices that did not have them before or had smaller/limited displays (think thermostats)
- Many IoT nodes will be embedded - fit and forget – no display needed
- Existing displays will increasingly become IoT connected (beginnings in smart TV but now media/advertising, information displays etc). Opportunity for value add downstream for display systems
- Low power displays will be desirable for IoT and necessary for untethered nodes. Opportunities for bistable and other low power technologies
- Simple, low cost displays / indicators will be desirable in highest volume products.

Source: NEST

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Case Study: Electronic Shelf Edge Labels

- Electronic Shelf Labels (ESLs) are a rapidly growing market. Widespread adoption initially in countries where there are heavy fines for incorrectly labelled products.
- Brick and mortar stores can be more competitive with online retailers
- NFC enabled
- SES developed low power flashing LCD technology. They also use E-ink technology for spot color and larger areas.

Source: SES

Source: SES

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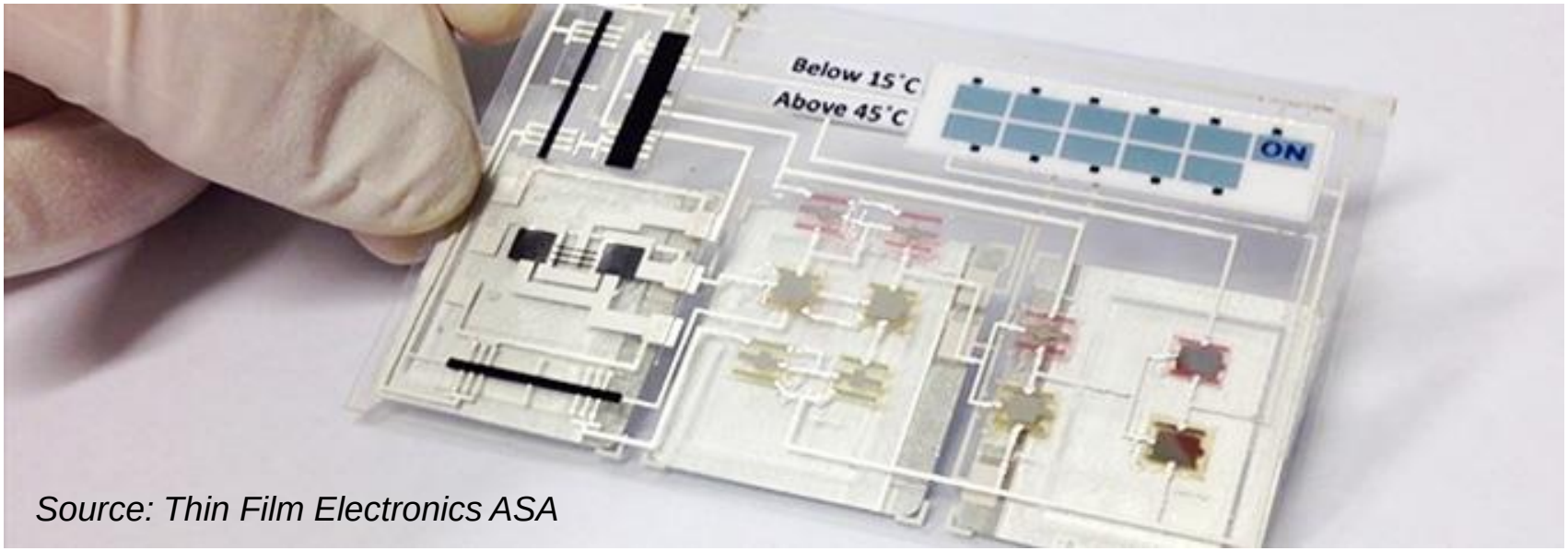
The Ultimate IoE End Game?
Case Study: Ultra Low Cost Displays



Source: Thin Film Electronics ASA

- Integration of printed display, printed sensor, printed memory and organic logic
- Versions to be NFC compatible
- Low-cost sensor compatible with applications in IoT – when you have no machine available to read the data

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Case Study: Ultra Low Power Displays

- Status indicators, wirelessly powered sensors and displays…

Source: Intel Wisp

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Case Study: Connected displays – information follows us from device to device and physically

Source: Eyetease Media

- MS Windows 10 supports IoT.
- Media and advertising

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Summary

- A whole new range of services will be enabled by IoT
- Security and privacy are ongoing concerns
- There will also be lots of options of standards and technologies, but a shakeout will occur
- Expect a large number of small projects over the next few years, while Governments mandate or pay for bigger projects. Consumer IoT rising fast but prone to commoditization
- Certain opportunities for more displays, potentially for a wider range of display technologies, from premium to very low cost, large area (advertising) to indicator (switches)

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- Energy Storage
- Hybrid & Pure Electric Vehicles
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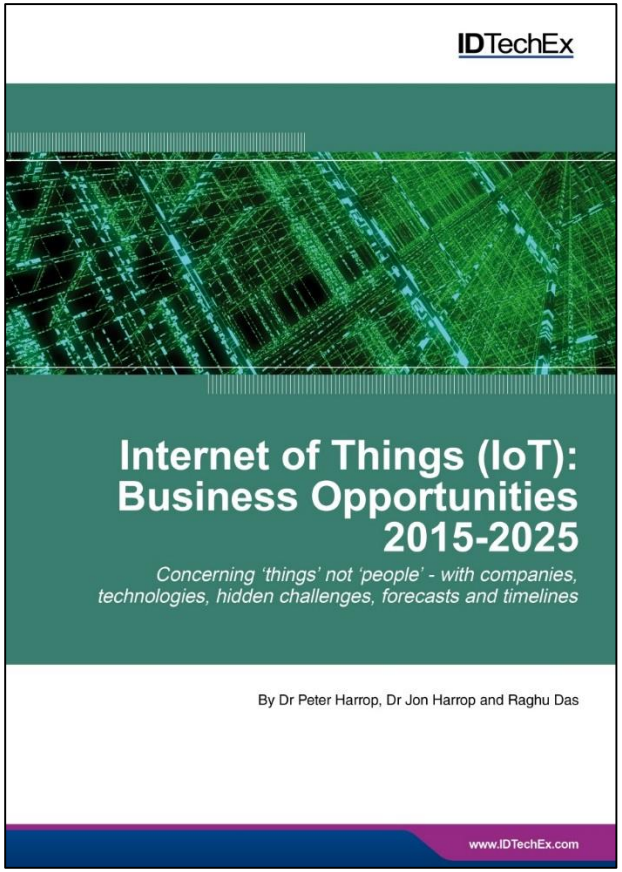

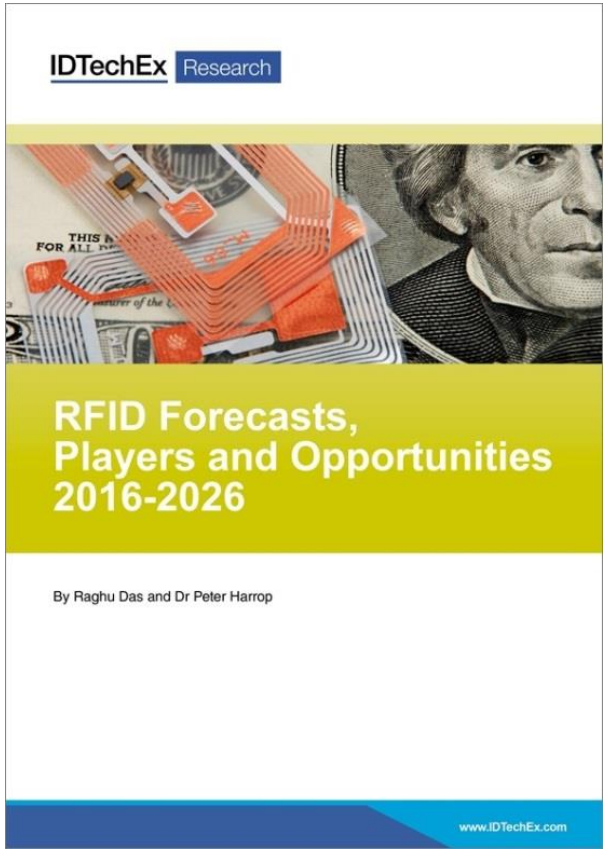

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