Towards the Internet of Remote Things: Vision, Challenges and Solutions

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The technical and industrial revolutions

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Innovation Push

today	**Industry 4.0** IT-based analysis: digital, automized, anticipatory
as of 1950	**Digital Revolution** Computer performance and emergence of distributed networks
as of 1750	**Industral revolution** Machines and factories create economies of scale arising from synergies
before 1750	**Start of Industry** People and products

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Industry 4.0 Enabling Technology: the Internet of Things

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- The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

- IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.

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IoT Key Functions

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- Internet of Things is not the result of a single novel technology, instead, several complementary technical developments provide capabilities that taken together help to bridge the gap between the virtual and physical world. These capabilities include:
  - Communication and cooperation
  - Addressability
  - Identification
  - Sensing
  - Actuation
  - Embedded information processing
  - Localization
  - User interfaces

History of Internet of Things

1800s
The first electronic communication devices are created, including the telegraph, fax machine, and radio

1926
Nikola Tesla envisions a wirelessly interconnected world

"When wireless is perfectly applied the whole earth will be converted into a huge brain."

1989
Tim Berners-Lee proposed the **World Wide Web**

1990
The first connected devices are created – a toaster and drink machine

MID 1990s
The **rise of the Internet** and more experimental devices

- 1993 *Trojan Room Coffee Pot*
- 1998 *inTouch Project*
- 1998 *Mark Weiser's Stock Market Water Fountain*

1999
Kevin Ashton coins **'Internet of Things'** and founds the **MIT Auto-ID Center**

2000
LG announces plans for the first Internet refrigerator

2002
Ambient Orb is released, which displays Dow Jones, personal finance, and weather information based on Internet data

2005
The United Nations first mentions IoT in a published **International Telecommunications Union** report

A new dimension has been added to the world of information and communication...from anytime, anyplace connectivity for anyone, we will now have connectivity for anything. Connections will multiply and create an entirely new dynamic network of networks – an Internet of Things.

2008
IPSO alliance launches to promote the use of Internet Protocol (IP) in connected devices

2011
Internet Protocol version 6 (IPv6) launches, which allows around 340 undecillion IP addresses (340,282,366,920,938,463,463,374,607,431,768,211,456)

"We could assign an IPV6 address to every atom on the surface of the earth, and still have enough addresses left to do another 100+ earths."

2013
Intel launches 'Internet of Things Solutions Group'

More Connected Devices Than People

	2003	2010	2015	2020
World Population	6.3 Billion	6.8 Billion	7.2 Billion	7.6 Billion
Connected Devices	500 Million	12.5 Billion	25 Billion	50 Billion
Connected Devices Per Person	0.08	1.84	3.47	6.58

More connected devices than people

[Source: Cisco IBSG, April 2011]

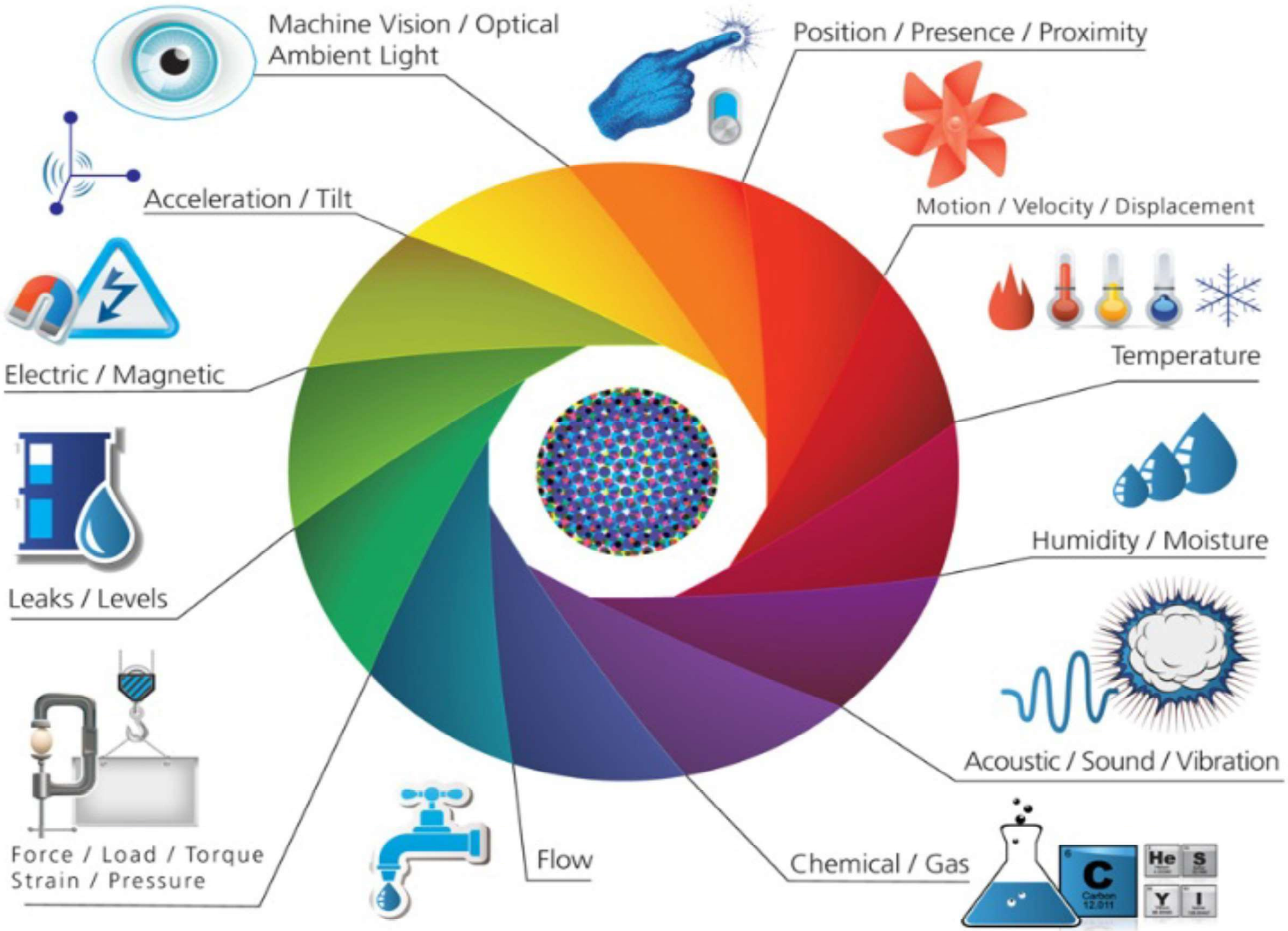
Smart Systems and the Internet of Things are driven by a combination of:

1. **SENSORS** & ACTUATORS
2. **CONNECTIVITY**
3. **PEOPLE & PROCESSES**

[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]

1 SENSORS & ACTUATORS

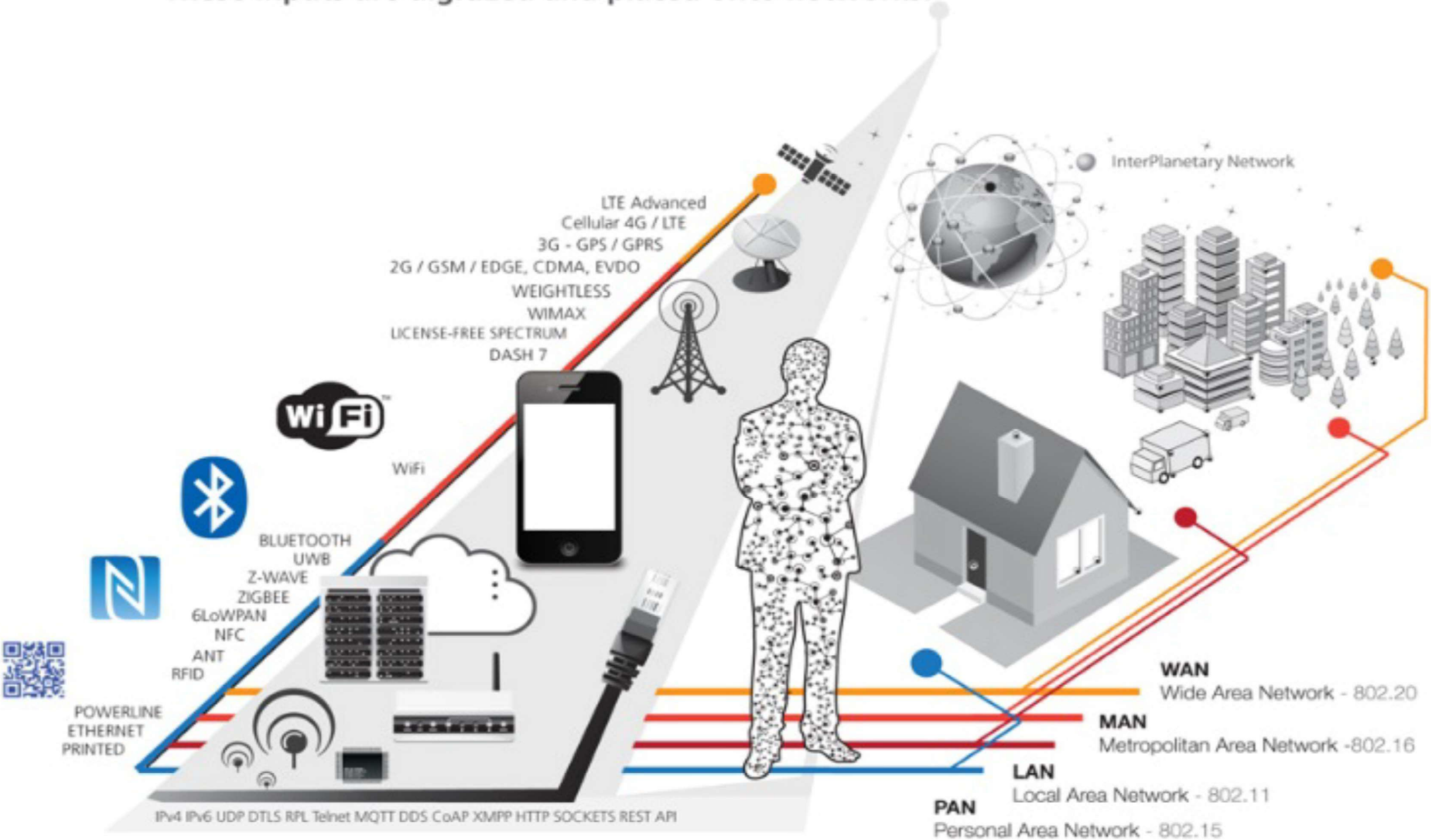
We are giving our world a digital nervous system. Location data using GPS sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure changes.



[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]

2 CONNECTIVITY

These inputs are digitized and placed onto networks.



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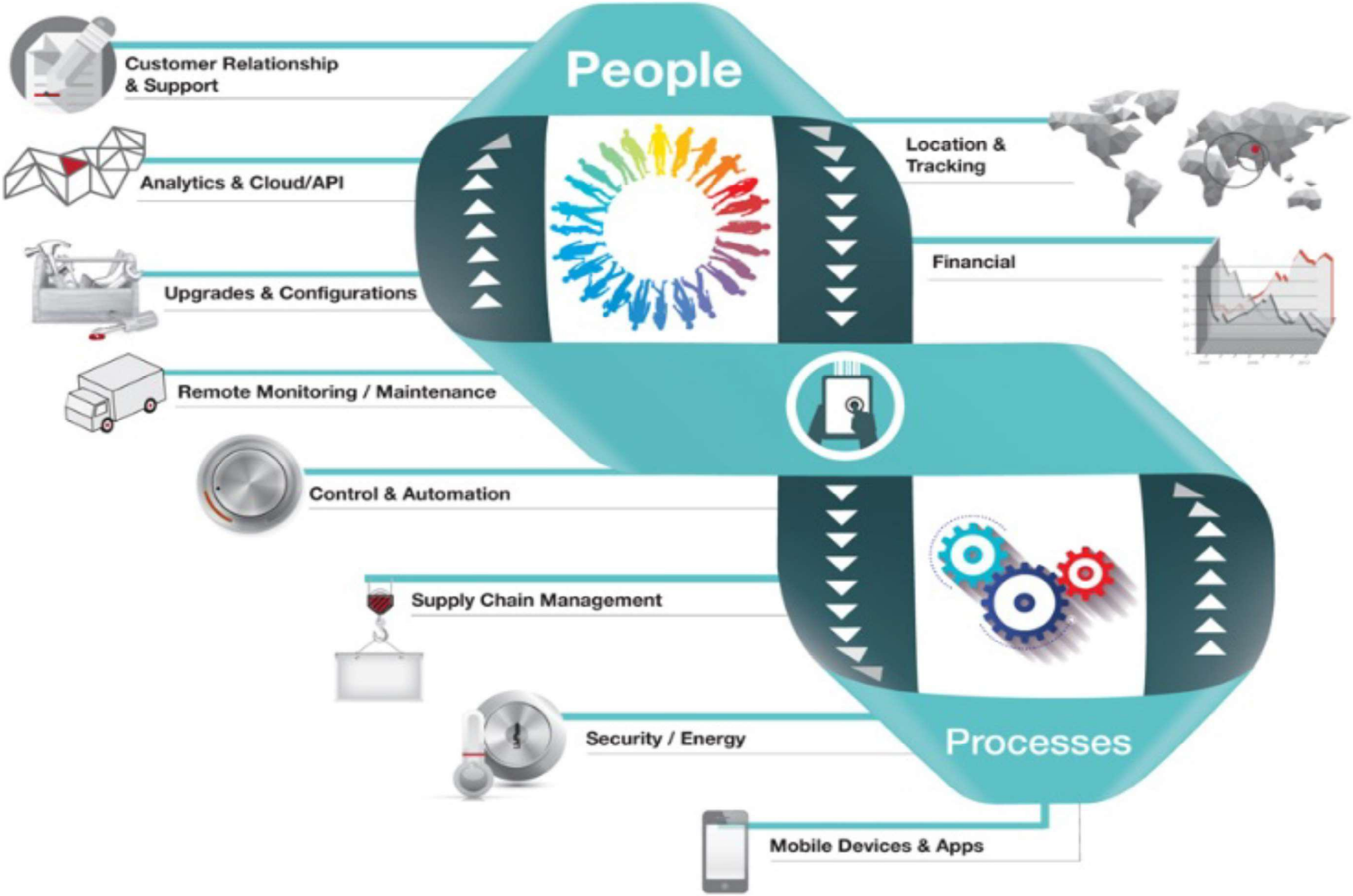
3 PEOPLE & *PROCESSES*

These networked inputs can then be combined into bi-directional systems that integrate data, people, processes and systems for better decision making.



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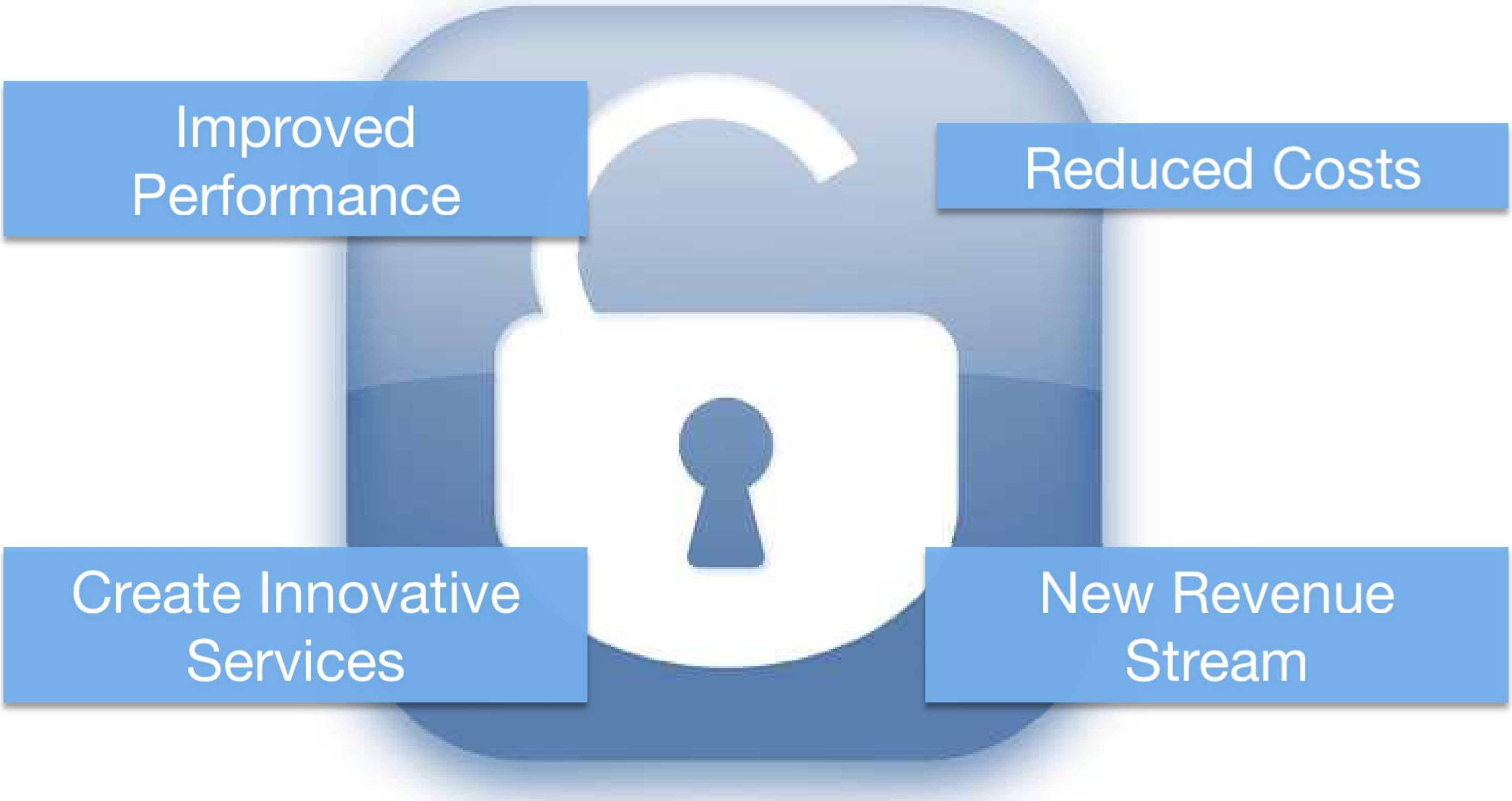
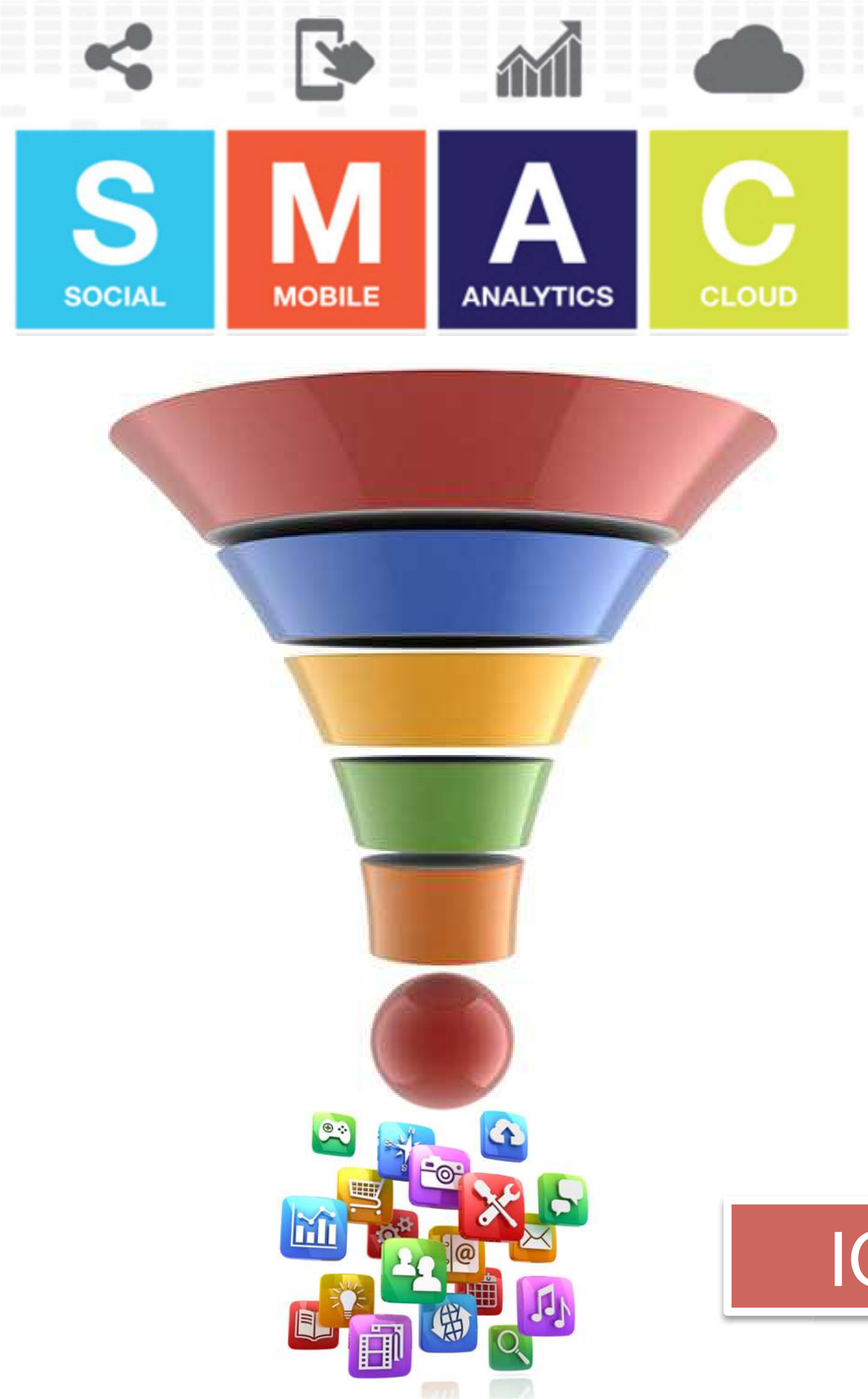
Unlocking the Massive Potential of IoT





Convergence of Technology Trends

IOT Applications

The interactions between these

SENSORS + CONNECTIVITY + PEOPLE + PROCESSES

entities are creating new types of smart applications and services.

Starting with popular connected devices already on the market

SMART THERMOSTATS

nest

Save resources and money on your heating bills by adapting to your usage patterns and turning the temperature down when you're away from home.

CONNECTED CARS

CAR 2GO

Tracked and rented using a smartphone. Car2Go also handles billing, parking and insurance automatically.

ACTIVITY TRACKERS

BASIS

Continuously capture heart rate patterns, activity levels, calorie expenditure and skin temperature on your wrist 24/7.

SMART OUTLETS

belkin

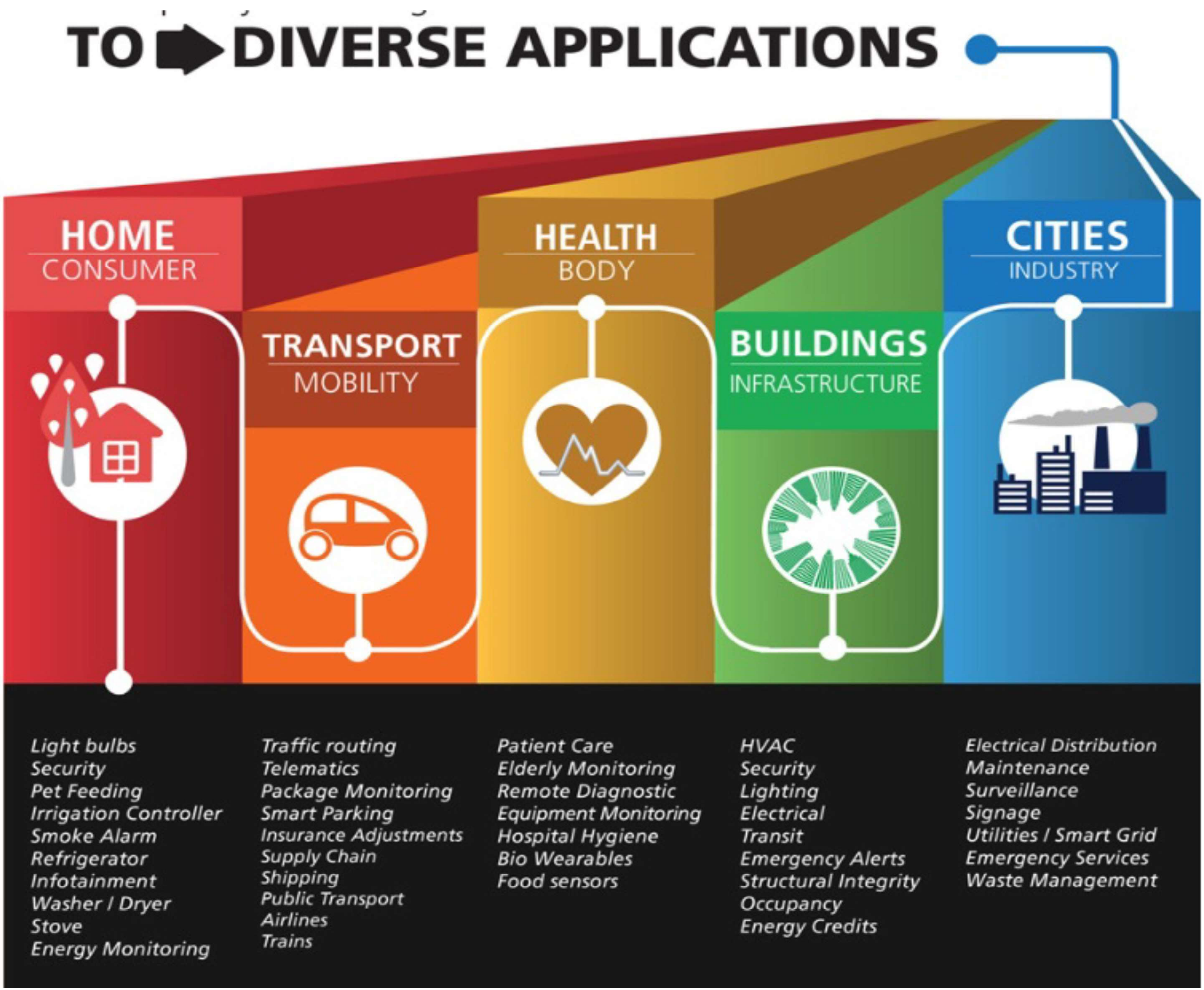
Remotely turn any device or appliance on or off. Track a device's energy usage and receive personalized notifications from your smartphone.

PARKING SENSORS

STREETLINE
CONNECTING THE REAL WORLD

Using embedded street sensors, users can identify real-time availability of parking spaces on their phone. City officials can manage and price their resources based on actual use.

[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]



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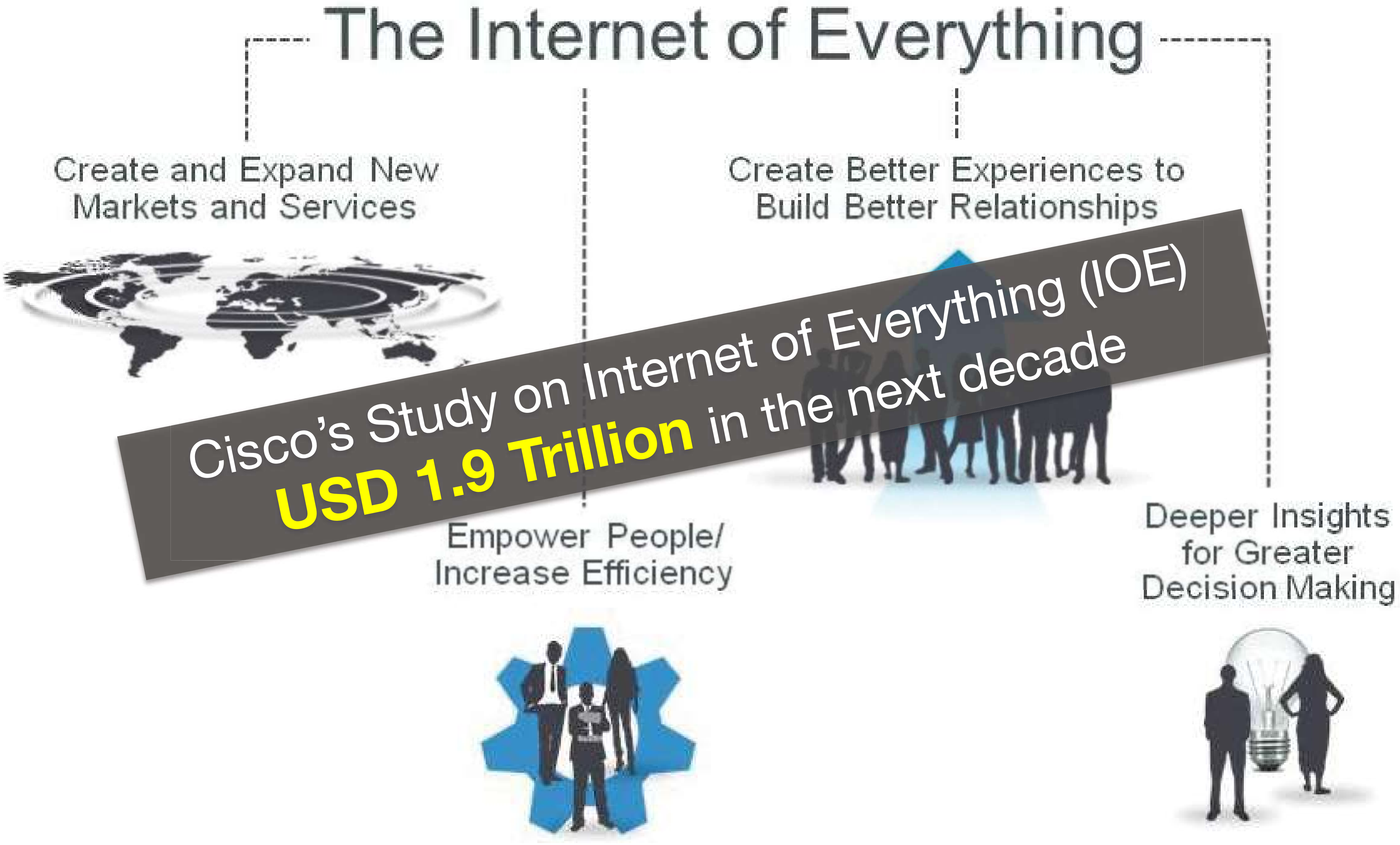
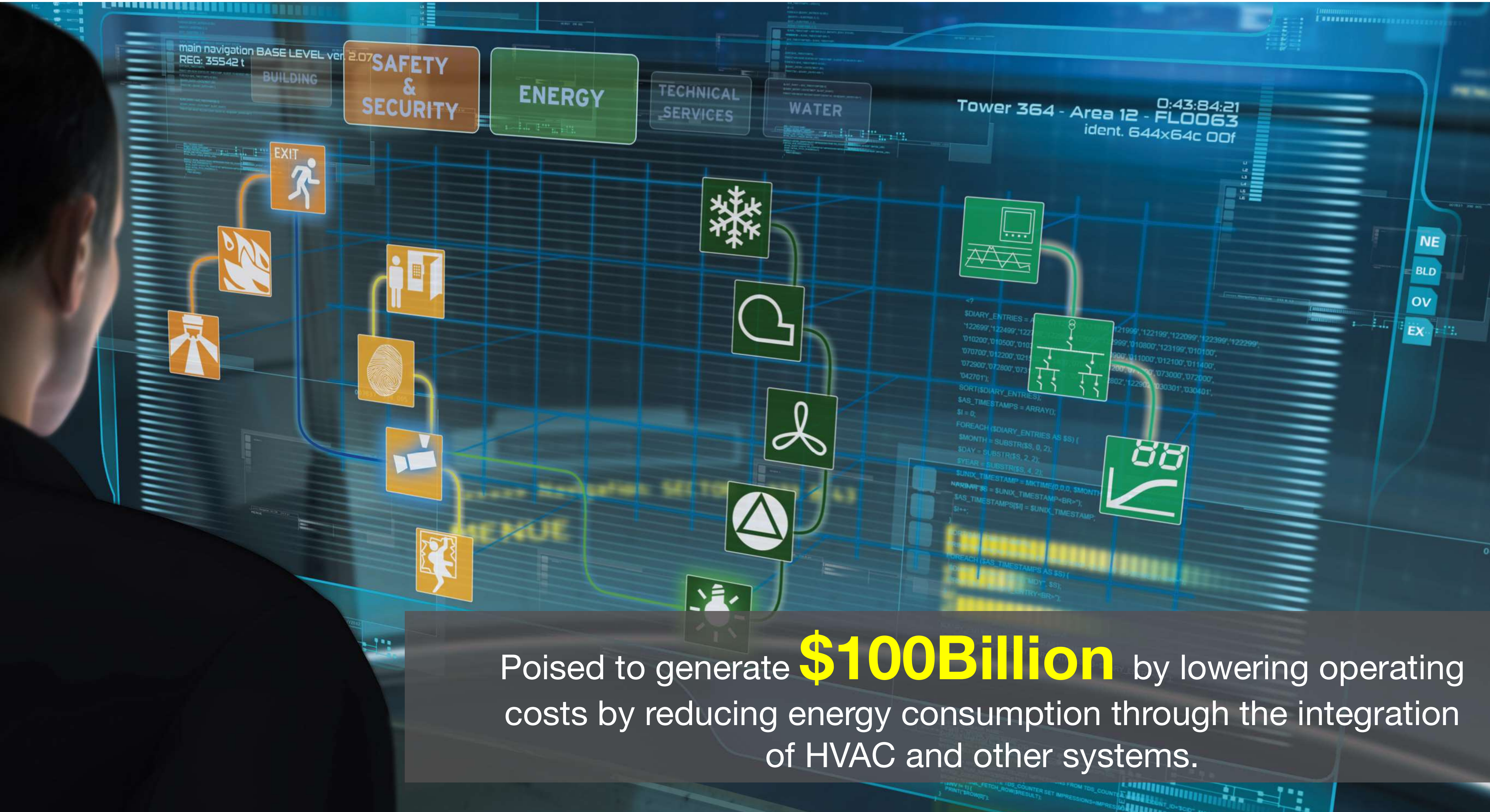


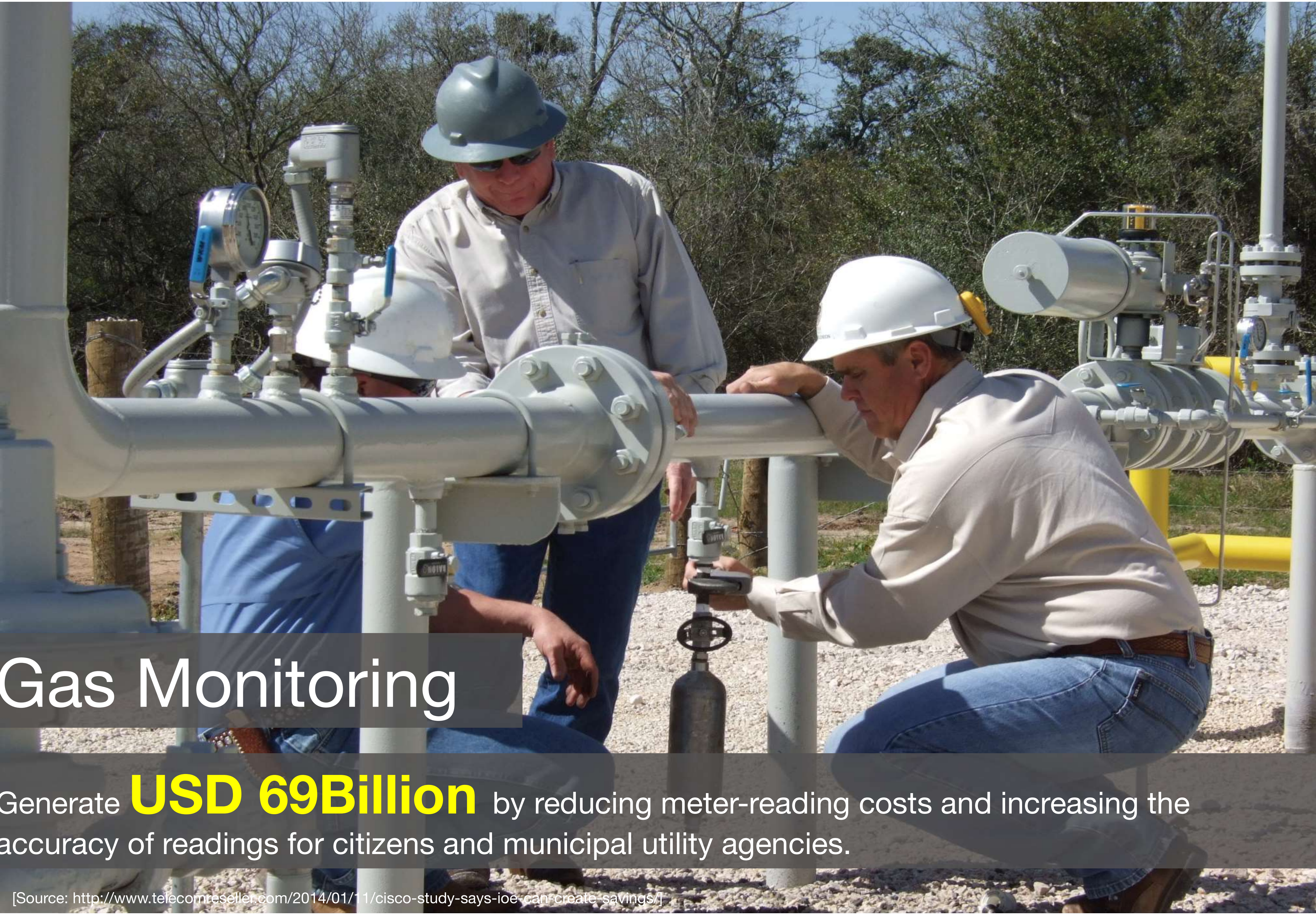
[Source: http://www.telecomreseller.com/2014/01/11/cisco-study-says-ioe-can-create-savings/]

Smart Building



Poised to generate **$100Billion** by lowering operating costs by reducing energy consumption through the integration of HVAC and other systems.

[Source: http://www.telecomreseller.com/2014/01/11/cisco-study-says-ioe-can-create-savings/]



Gas Monitoring

Generate **USD 69Billion** by reducing meter-reading costs and increasing the accuracy of readings for citizens and municipal utility agencies.

[Source: http://www.telecomreseller.com/2014/01/11/cisco-study-says-ioe-can-create-savings/]

Smart Parking

Create **USD 41Billion** by providing visibility into the availability of parking spaces across the city.

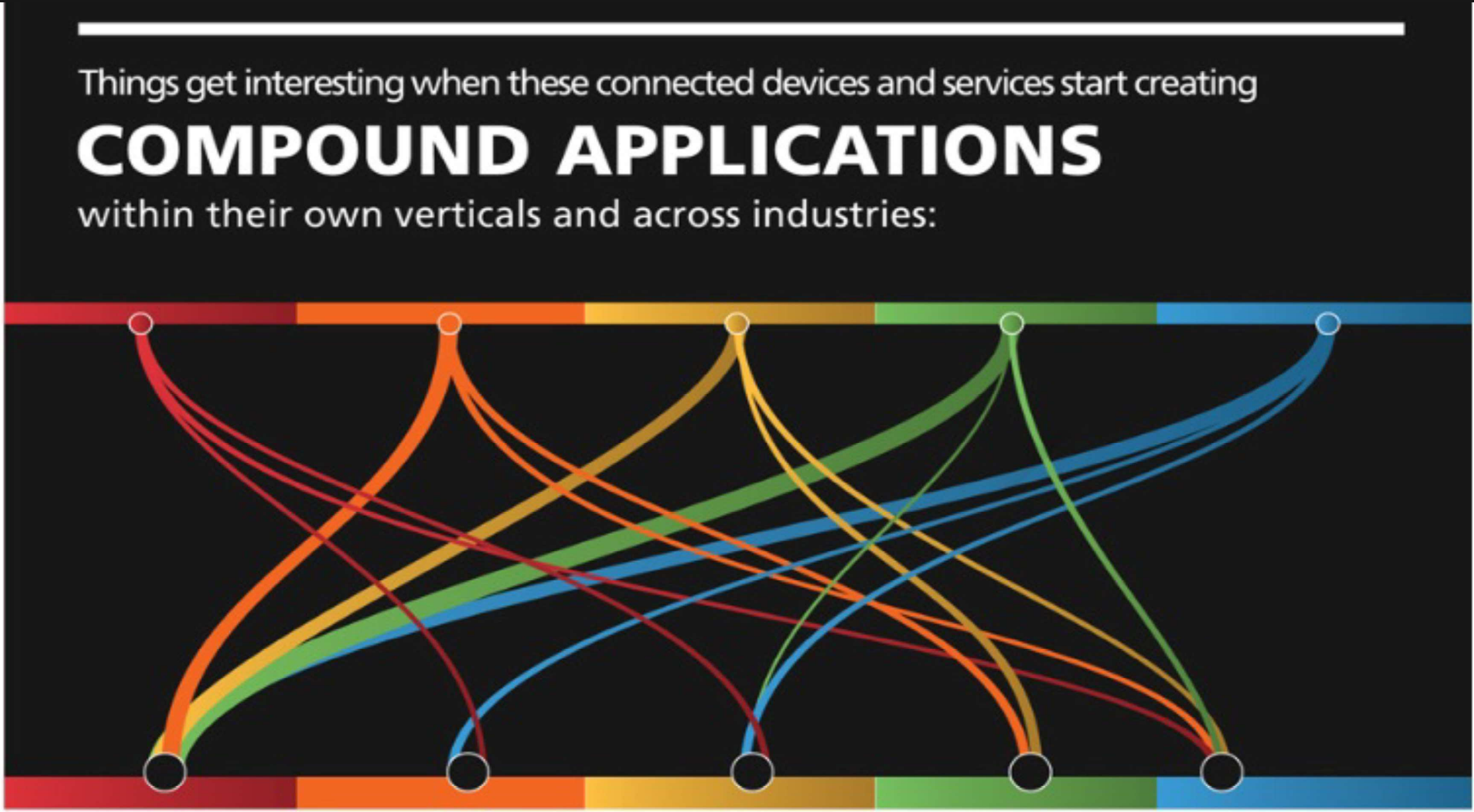
Residents can identify and reserve the closest available space, traffic wardens can identify non-compliant usage, and municipalities can introduce demand-based pricing.

[Source: http://www.telecomreseller.com/2014/01/11/cisco-study-says-ioe-can-create-savings/]

Water Management

Could generate **USD 39Billion** by connecting the household water meter over an IP network to provide remote information on use and status

[Source: http://www.telecomreseller.com/2014/01/11/cisco-study-says-ioe-can-create-savings/]



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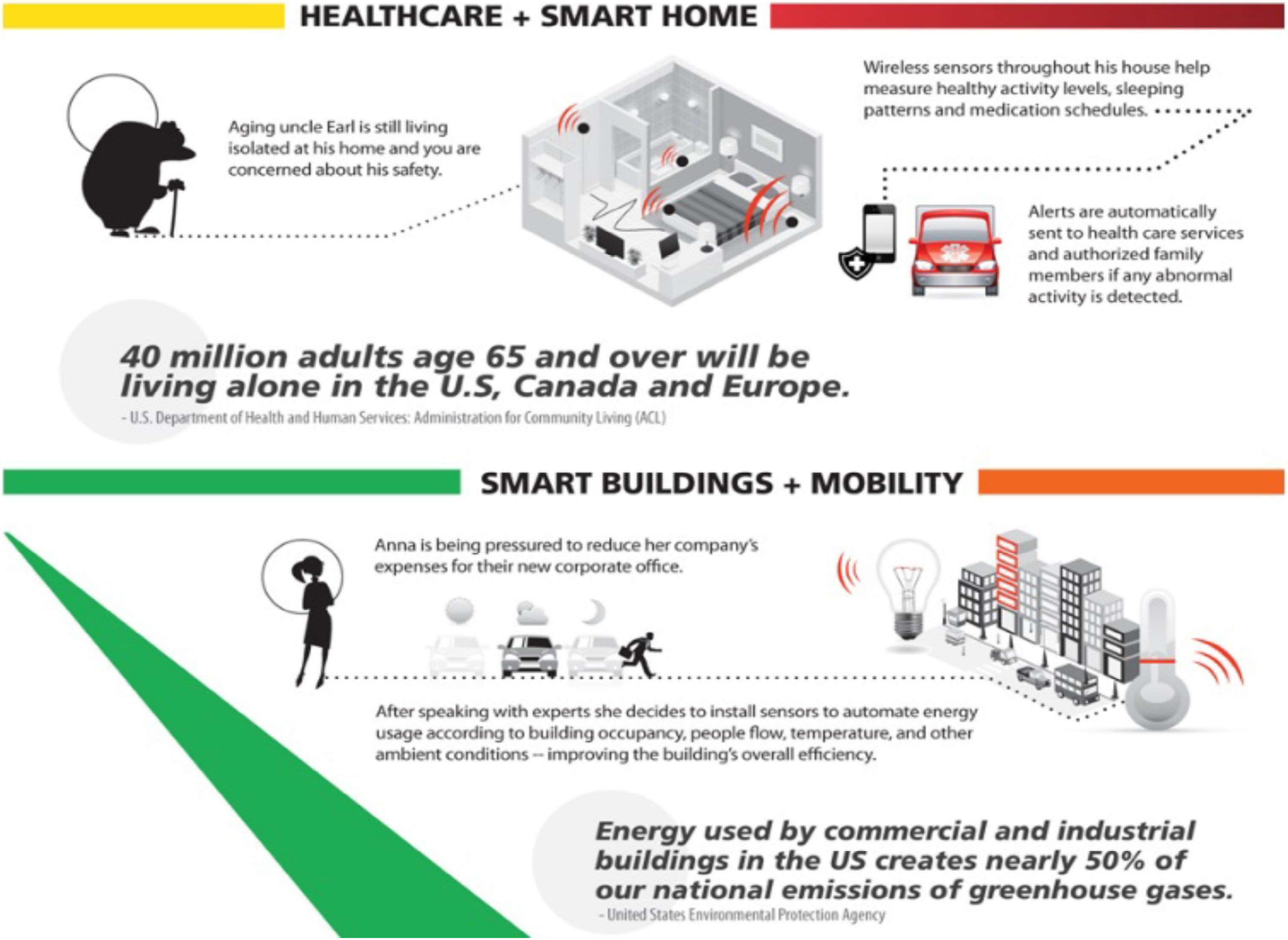
FOR EXAMPLE

[Source: Postscape - http://postscapes.com/what-exactly-is-the-internet-of-things-infographic]



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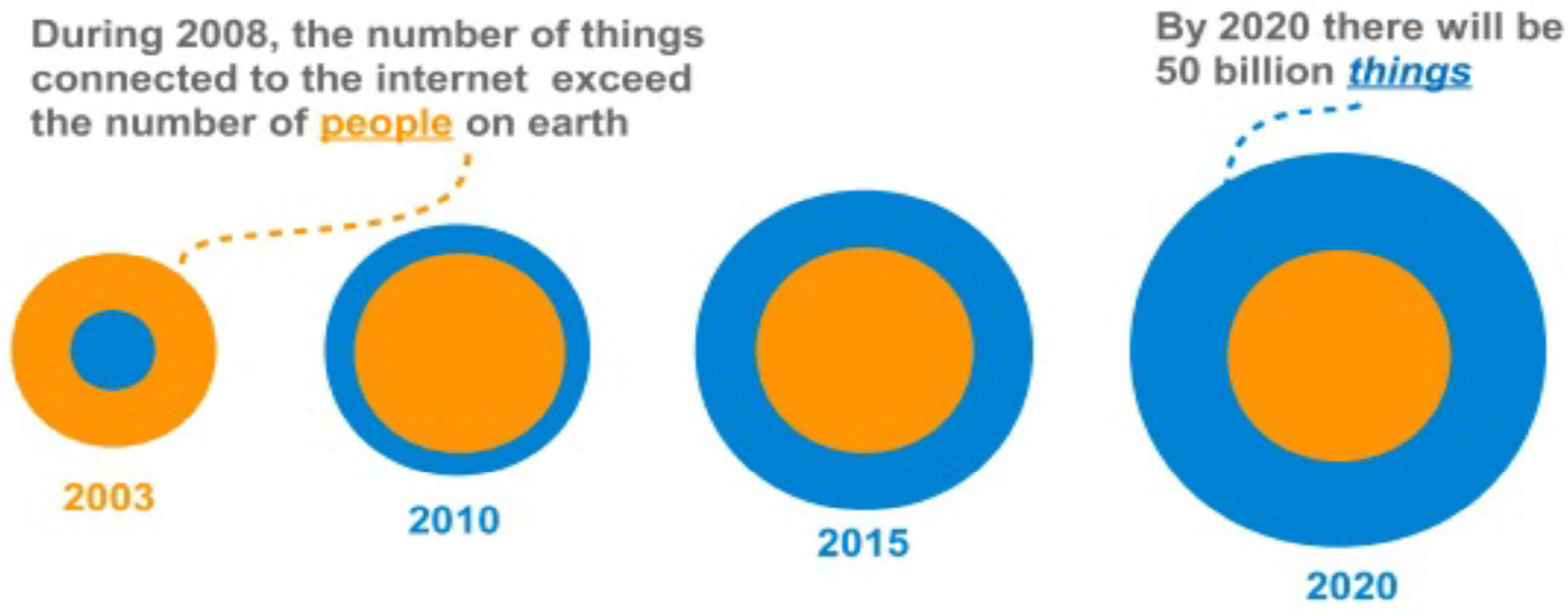
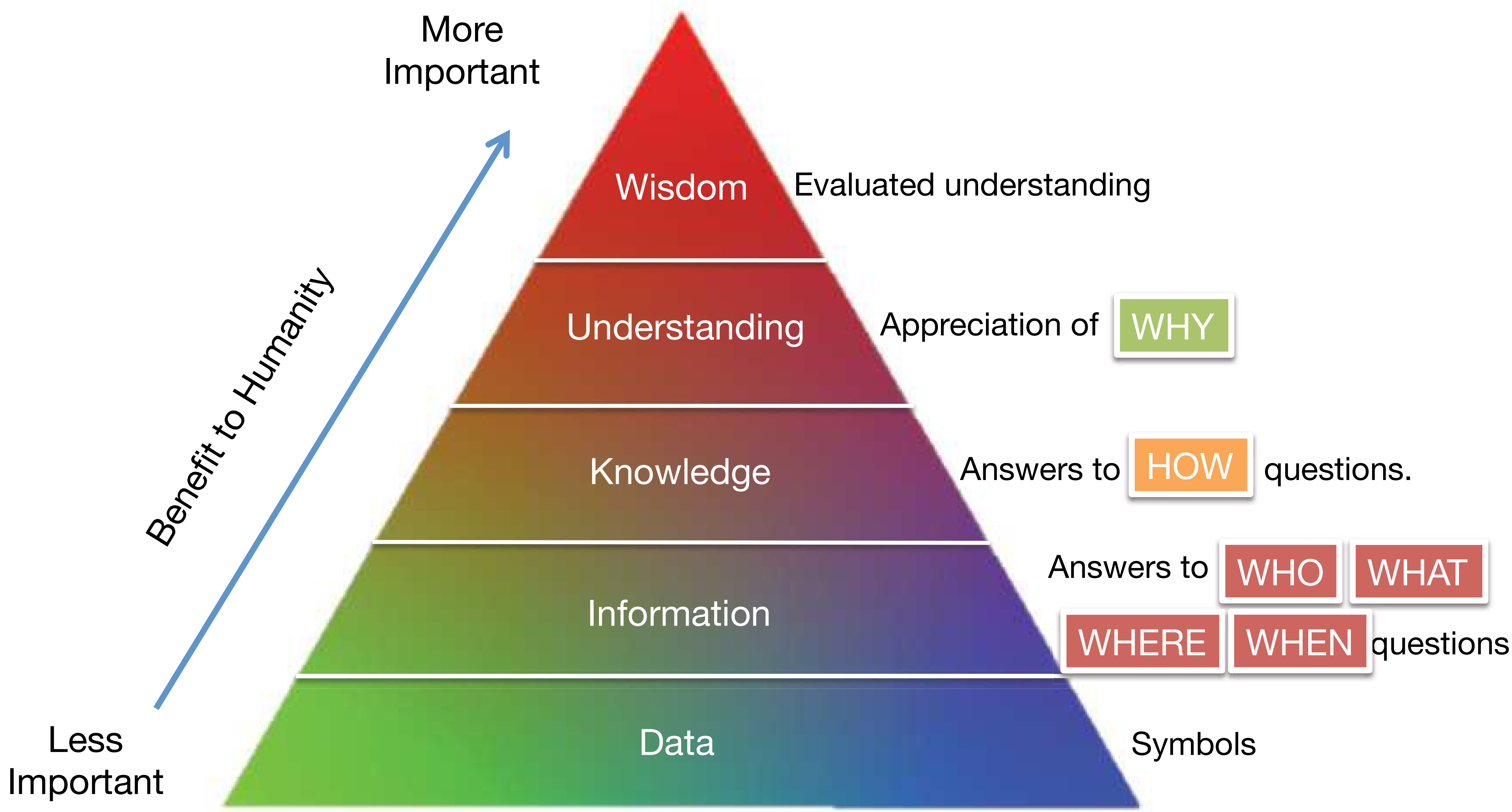
Growth of "Things" Connected to the Internet

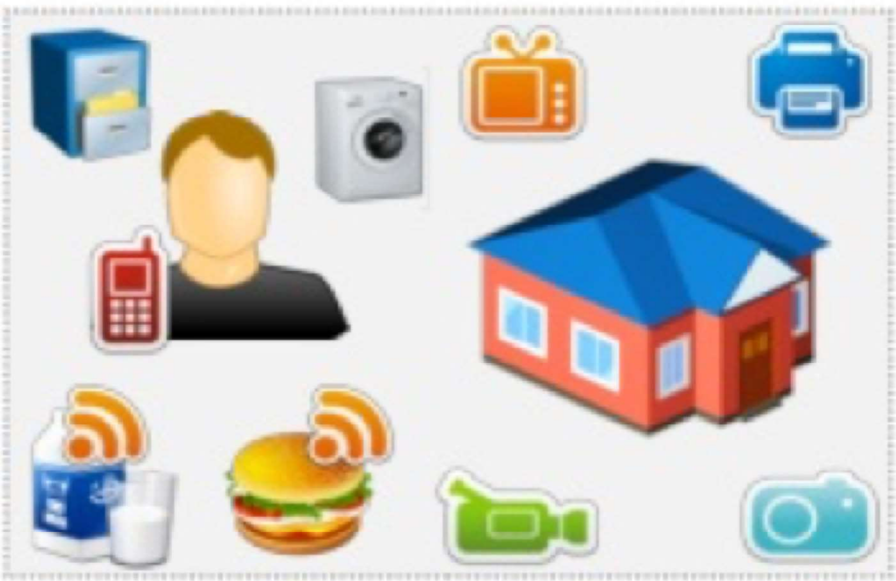




The more data that is created, the better understanding and wisdom people can obtain.

Sensor Classification Scheme Based on Ownership

Personal and Households



All personal items, such as mobile phones, wrist watches, spectacles, laptops, soft drinks, food items and household items, such as televisions, cameras, microwaves, washing machines, etc

Organizations

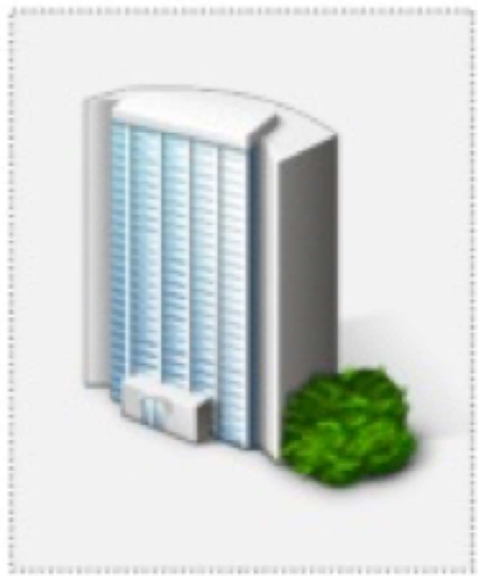
Private

Private business organization has the right to take the decision whether to publish the sensors attached to those items to the cloud or not.

Public

Public infrastructure such as bridges, roads, parks, etc. All the sensors deployed by the government will be published in the cloud depending on government policies.

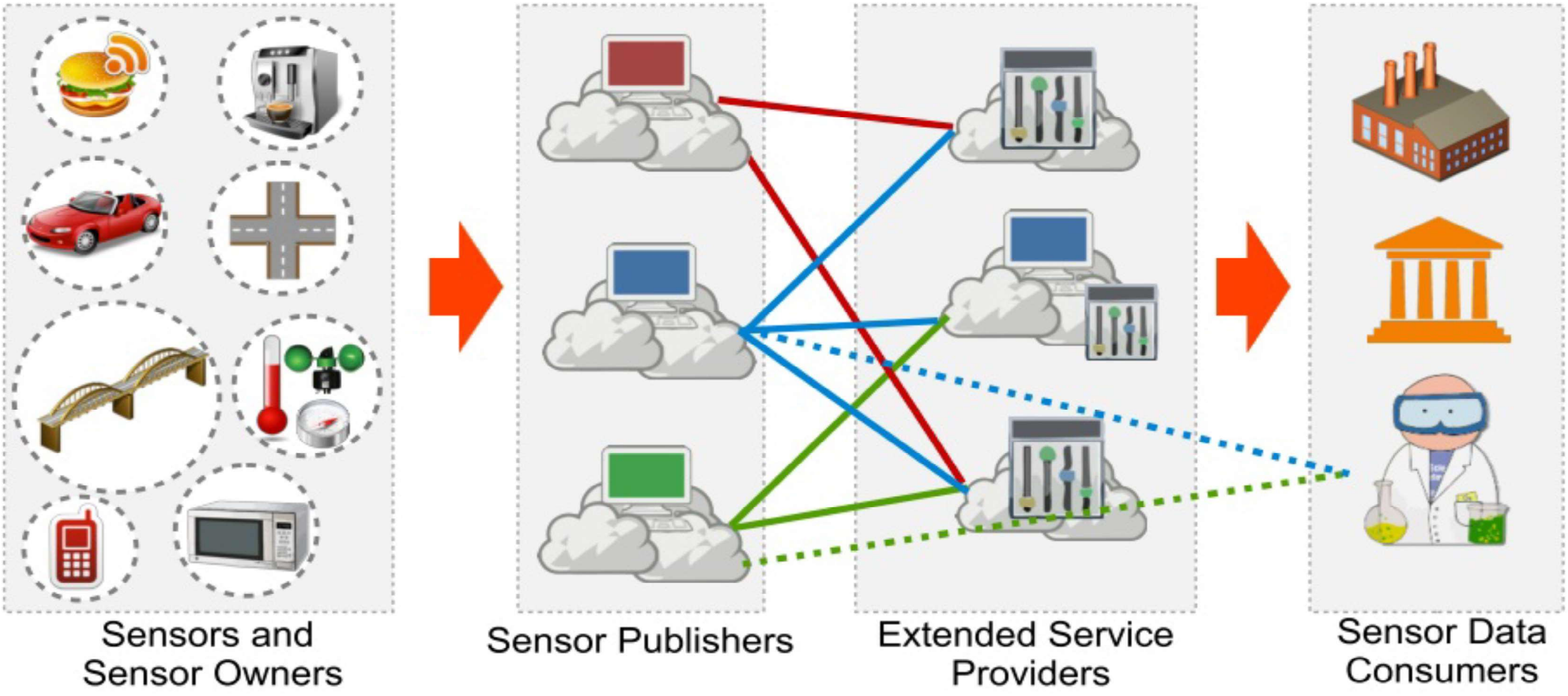
Commercial Sensor Data Providers



Business entities who deploy and manage sensors by themselves by keeping ownership. They earn by publishing the sensors and sensor data they own through sensor publishers.

[Source: “Sensing as a Service Model for Smart Cities Supported by Internet of Things”, Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

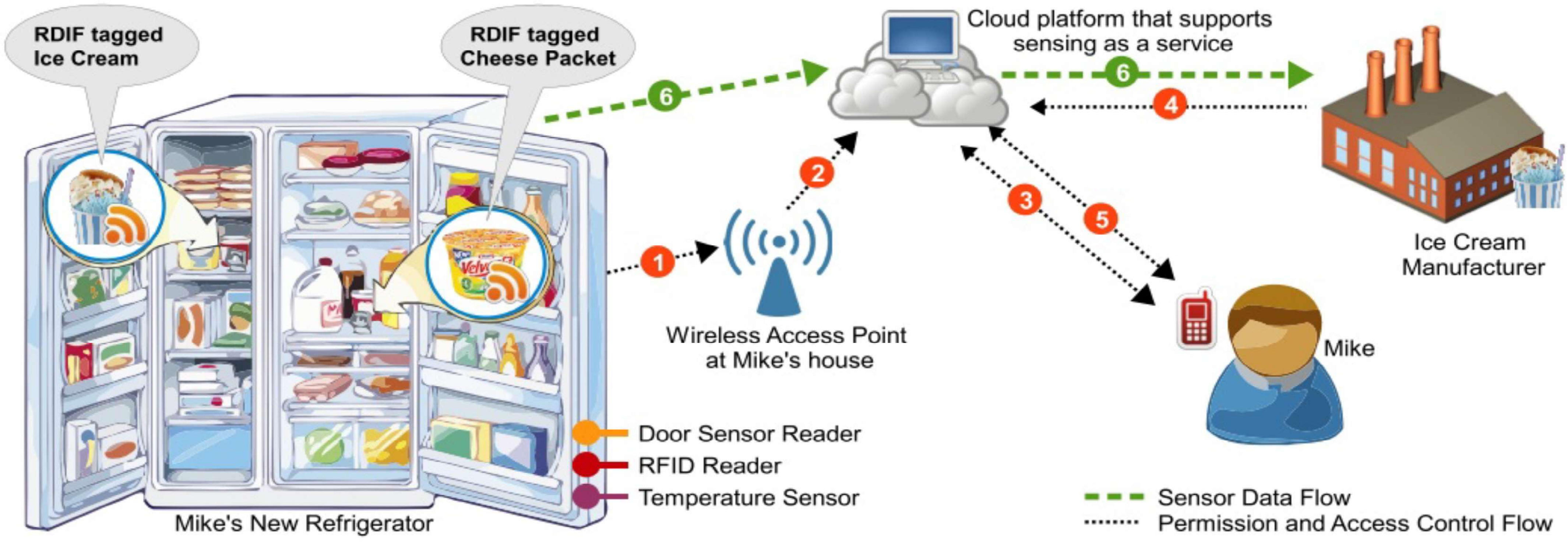
The Sensing-as-a-Service Model



[Source: “Sensing as a Service Model for Smart Cities Supported by Internet of Things”, Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

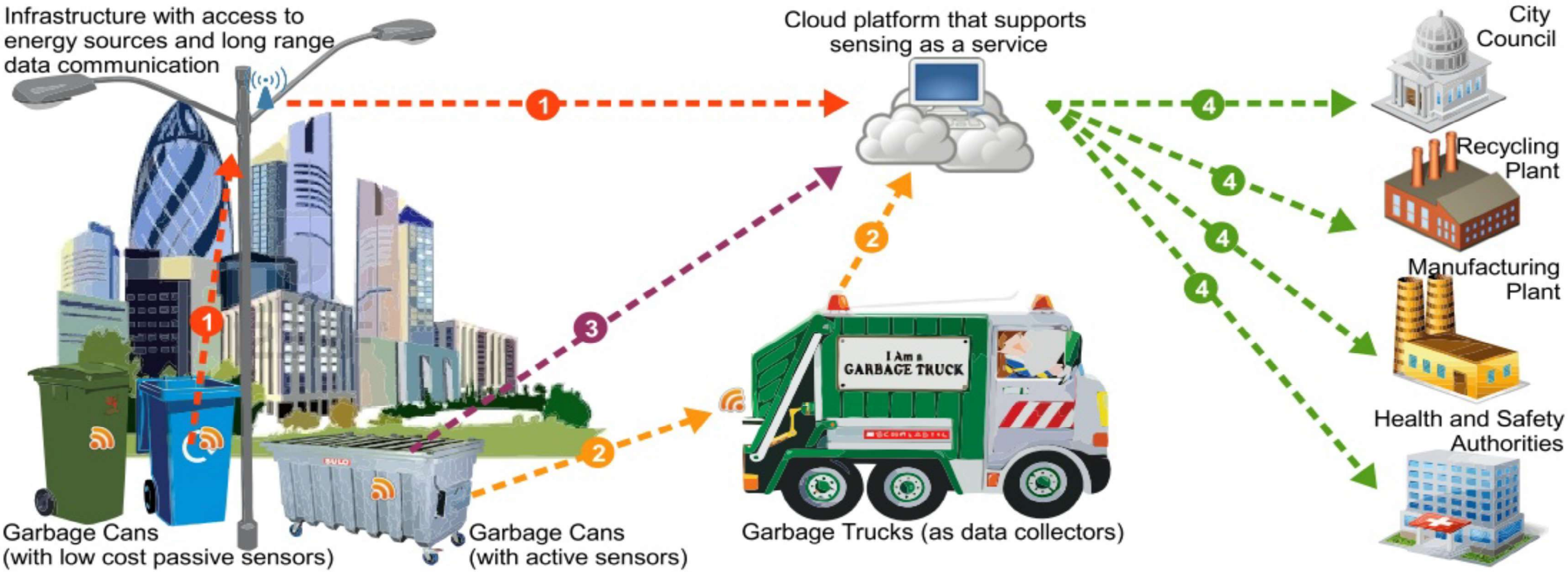
IoT Applications - Examples

Smart Home Scenario – Interactions in Sensing-as-a-Service Model



[Source: "Sensing as a Service Model for Smart Cities Supported by Internet of Things", Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

Efficient Waste Management in Smart Cities Supported by the Sensing-as-a-Service



[Source: "Sensing as a Service Model for Smart Cities Supported by Internet of Things", Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

IOT Application Scenario - Shopping

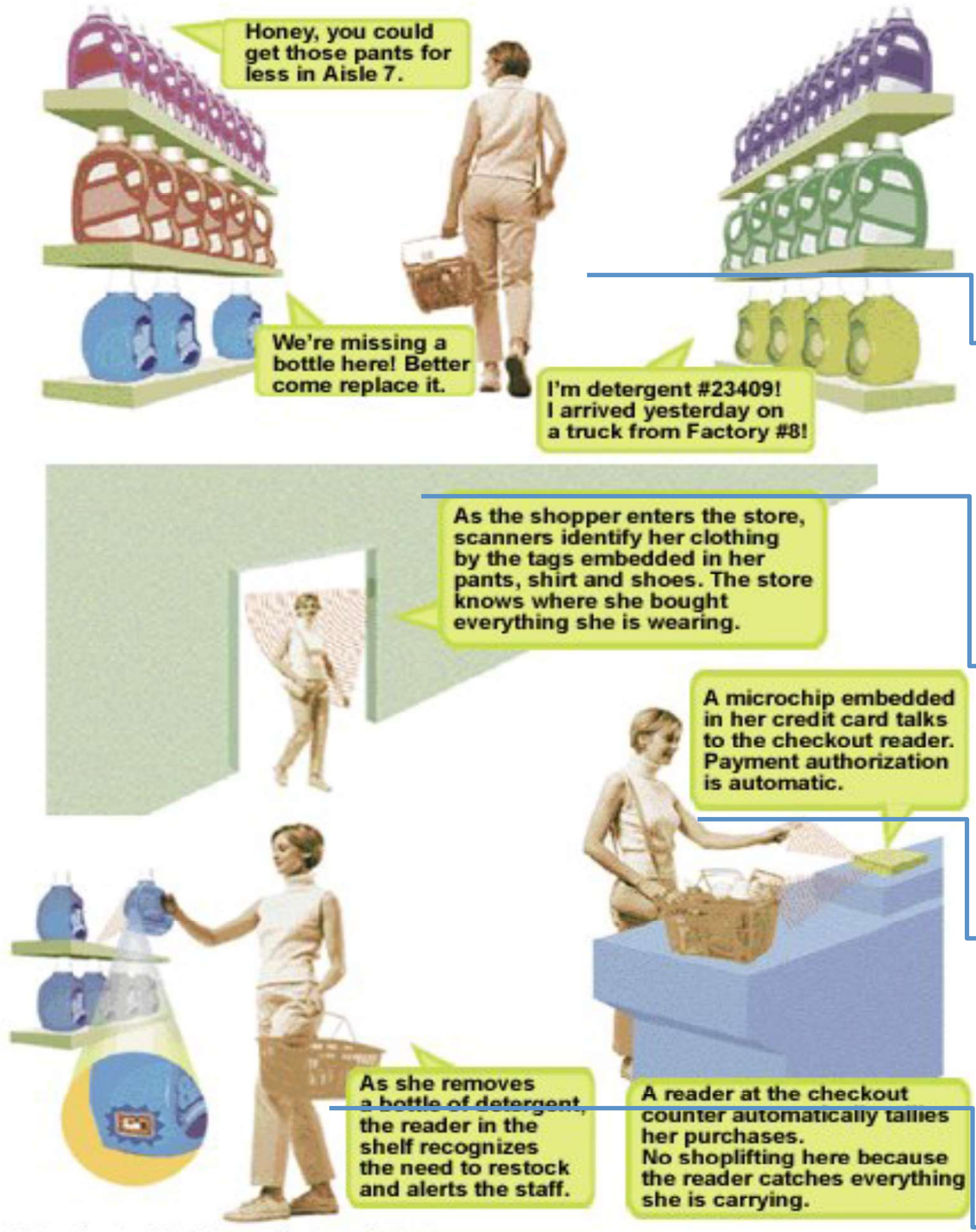


Illustration by Lisa Knouse Braiman for Forbes

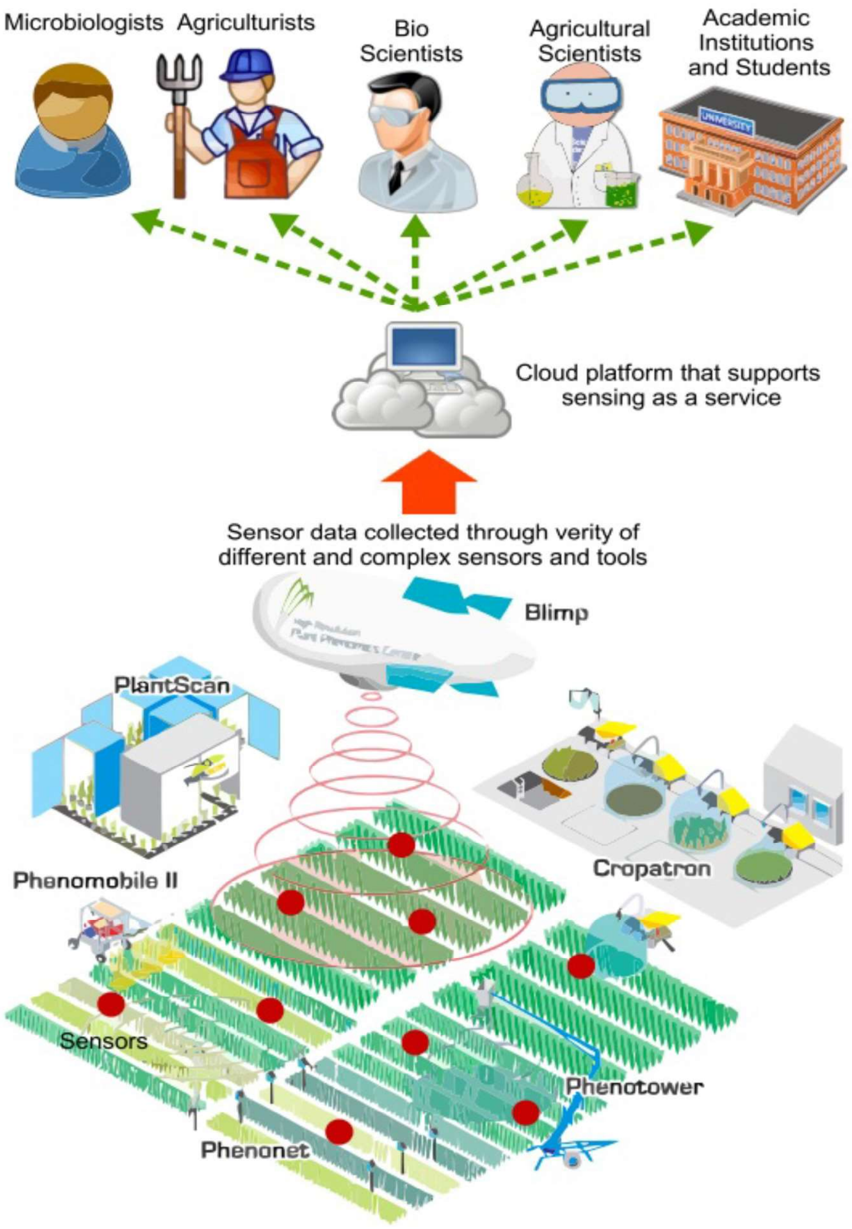
(2) When shopping in the market, the goods will introduce themselves.

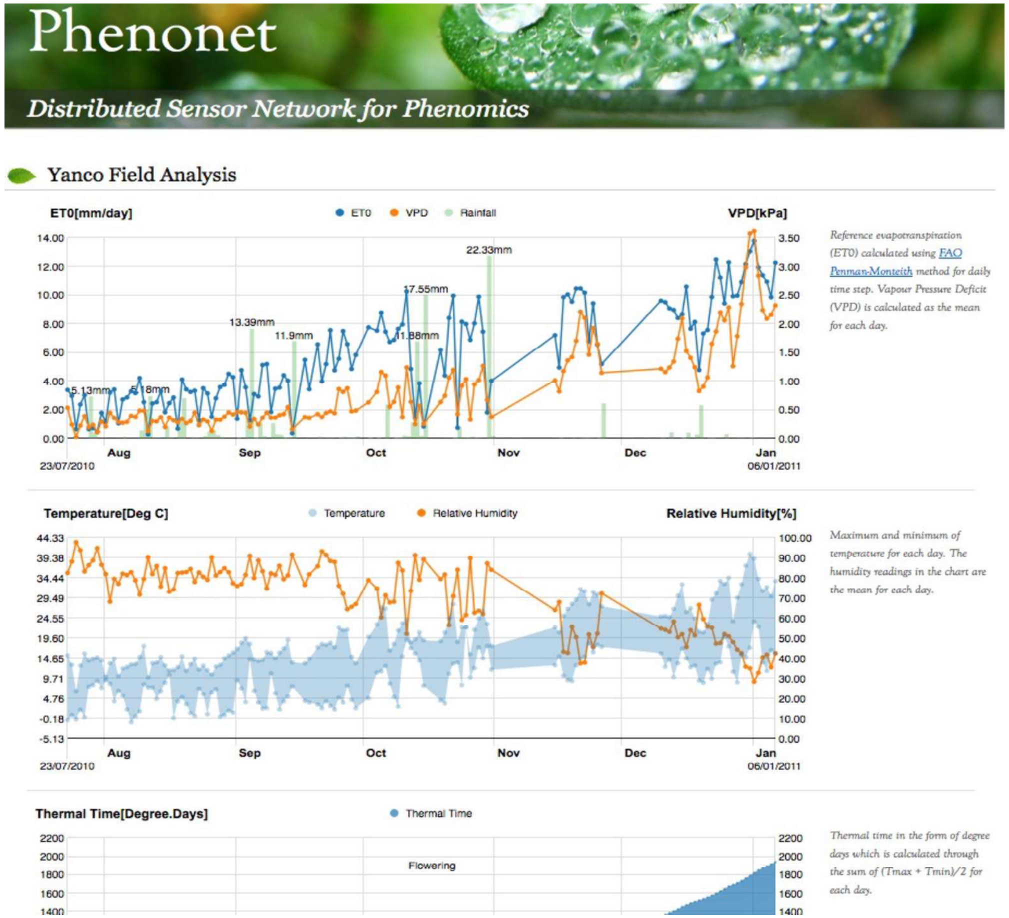
(1) When entering the doors, scanners will identify the tags on her clothing.

(4) When paying for the goods, the microchip of the credit card will communicate with checkout reader.

(3) When moving the goods, the reader will tell the staff to put a new one.

Efficient and Effective Collaborative Research Supported by Sensing-as-a-Service Model





The sensing-as-a-service model allows researchers to share resources across borders and understand phenomenon which are not available in their own countries.


Crowdsensing

Smartphone as Your “Sensing Assistant”

Sensors:

- Camera – “Eyes”
- Audio – “Ears”
- Accelerometer – “Speed”
- GPS – “Location”
- Gyroscope – “Movement”
- Compass – “Direction”
- Proximity – “Closeness”
- Ambient light – “Eyes”
- Others…

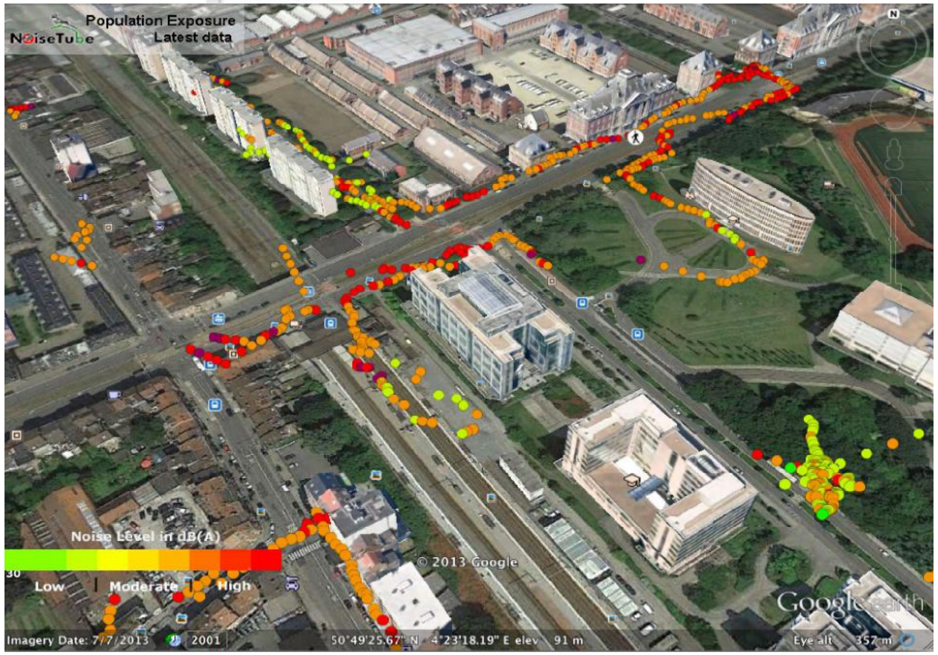
Crowdsourcing Via Crowdsensing

Context

1. **Spatial** – Location / Speed Orientation
2. **Temporal** – Time / Duration
3. **Environmental** – Temperature / Light / Noise Level
4. **User Characterization** – Activity (Mobility Pattern) / Social (Friends, Interactions)
5. **Resource Availability** – Storage / Memory / Computational / Battery

NoiseTube – Crowdsourcing of Pollution Data Using Smartphones. What Motivates?

- Citizens and Communities concerned with noise
  - Measure your daily sound exposure in dB(A) with your mobile phone
  - Tag noisy sources to inform the community about them
  - Visualize your measurements on a map and contribute to the creation of collective, city-wide noise maps
  - Compare your experience with that of others
- Local governments / city planners
  - Improve decision-making by understanding local and global noise pollution in your city using maps and statistics
  - Get immediate feedback and opinions from citizens
  - Give immediate feedback to citizens
- Researchers
  - Get access to and analyze (anonymized) collective noise data
  - Find out what is important in soundscape perception
- Developers
  - Extend our mobile app in whichever way you see fit
  - Use our environmental sensor web API to do your own web mashups



[Note: See Google Map View]

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The Satellite Role in the IoT

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Challenges

- Customer Lack of Knowledge
- Operator Lack of Domain Experience
- Complex Value Chain
- Terrestrial Competition
- Resistance to Change – Chicken & Egg problem
- Security/Data Ownership
- Interoperability

Also:

- Limited certified devices for hazardous areas
- Various field device integration technologies

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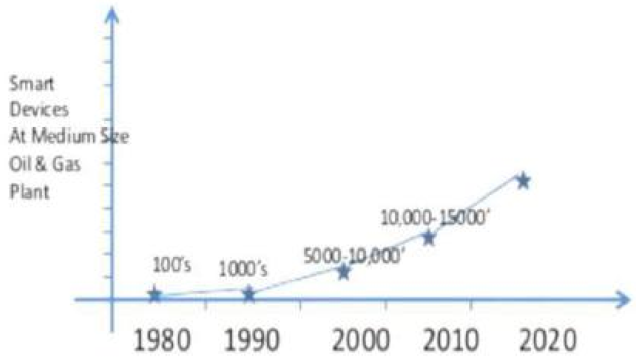
Opportunities

#1: HTS Satellites

- Improved throughput and cost will drive multiple sectors to embrace satellite IoT for operational efficiency e.g. in Maritime

#2: Explosion of intelligence in remote sites

- Will drive using higher frequencies (Ku/Ka) instead of L-band



Ref: Trust technical services

#3: Development of ground terminals

- e.g. low cost, multi-technology mobile devices

#4: Need of ubiquitous network coverage

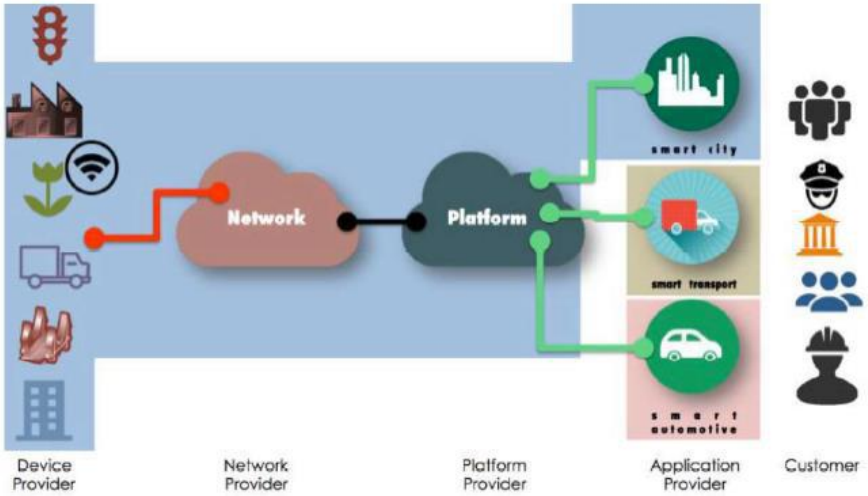
e.g. for smart connected cars

Opportunities

#5: Service Reliability
- e.g. for remote asset monitoring

#6: Cost
- Cost effective solution for IoT if different service packages are implemented

#7: Hybrid Business Models
- Spanning the whole value chain



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Challenges for R&D

Sensing in Complex Environment

- Poor sensor data quality due to sensor quality, environment and maintenance issues

Energy Consumption

- Resource and power constraints

Security

- Multiple points of vulnerability

Scalability & Interoperability

- Data tsunami with thousands to millions of Devices

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The End

Thank you for your attention!!

Thank you to the Speaker Prof. Mario Marchese

Questions? Please send emails to
igor.bisio@unige.it