IFA511 Komunikasi Antar Perangkat (Internet of Things - IoT)

# Introduction of Internet of Things (IoT)

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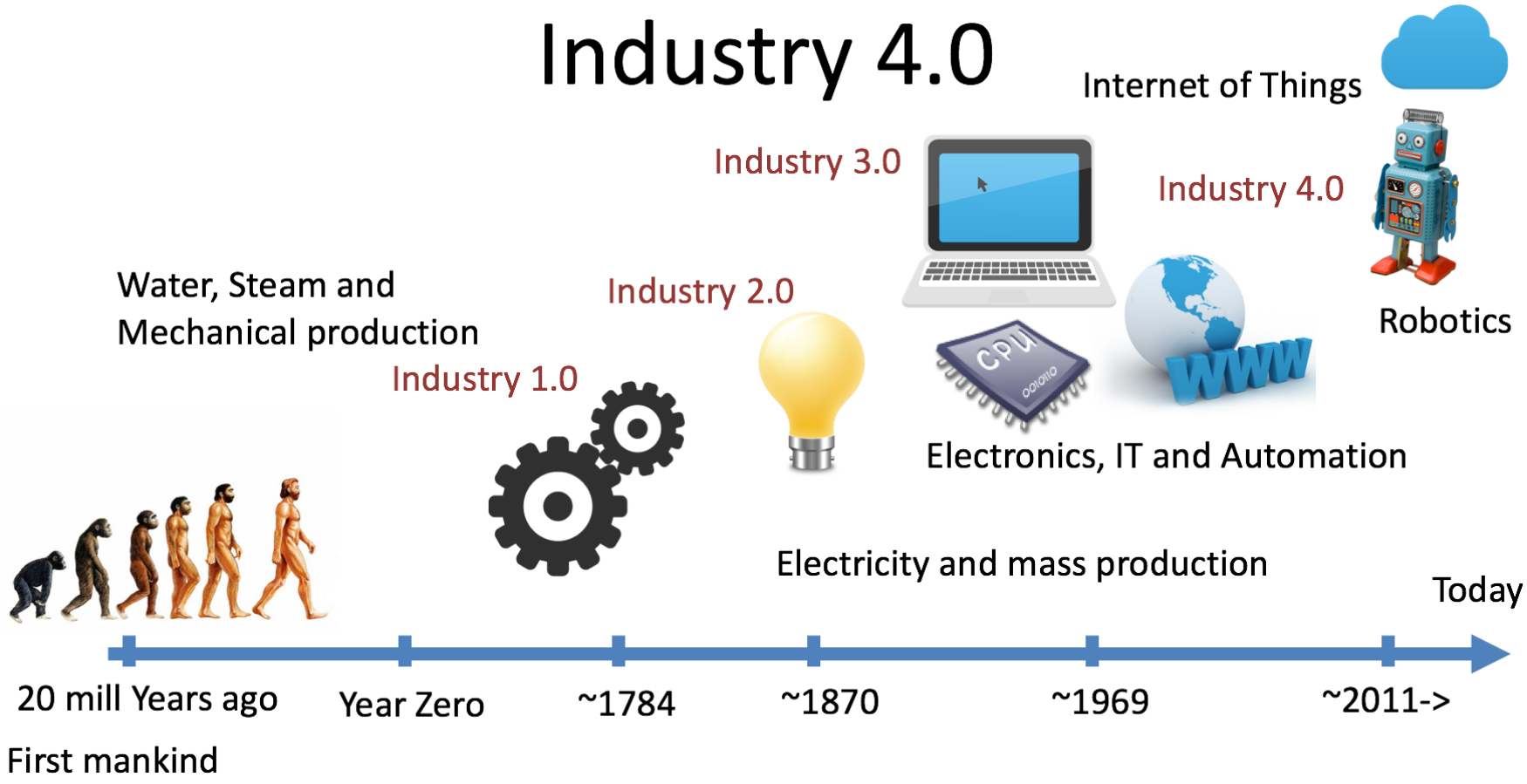
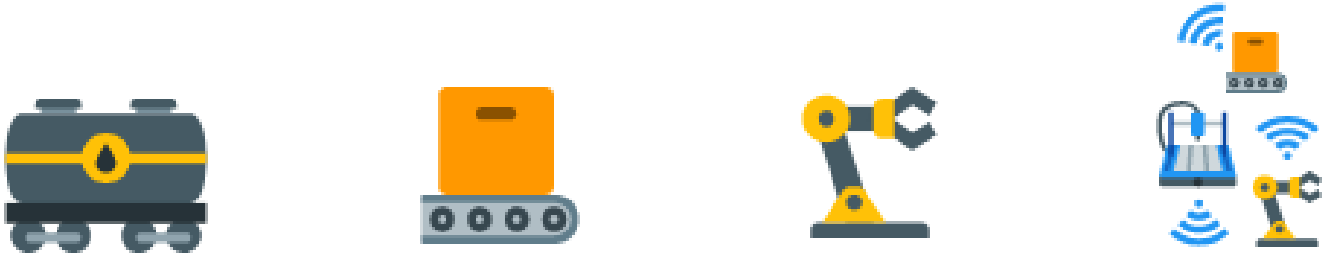
# Industrial Revolutions (#1)



# Industrial Revolutions (#2)



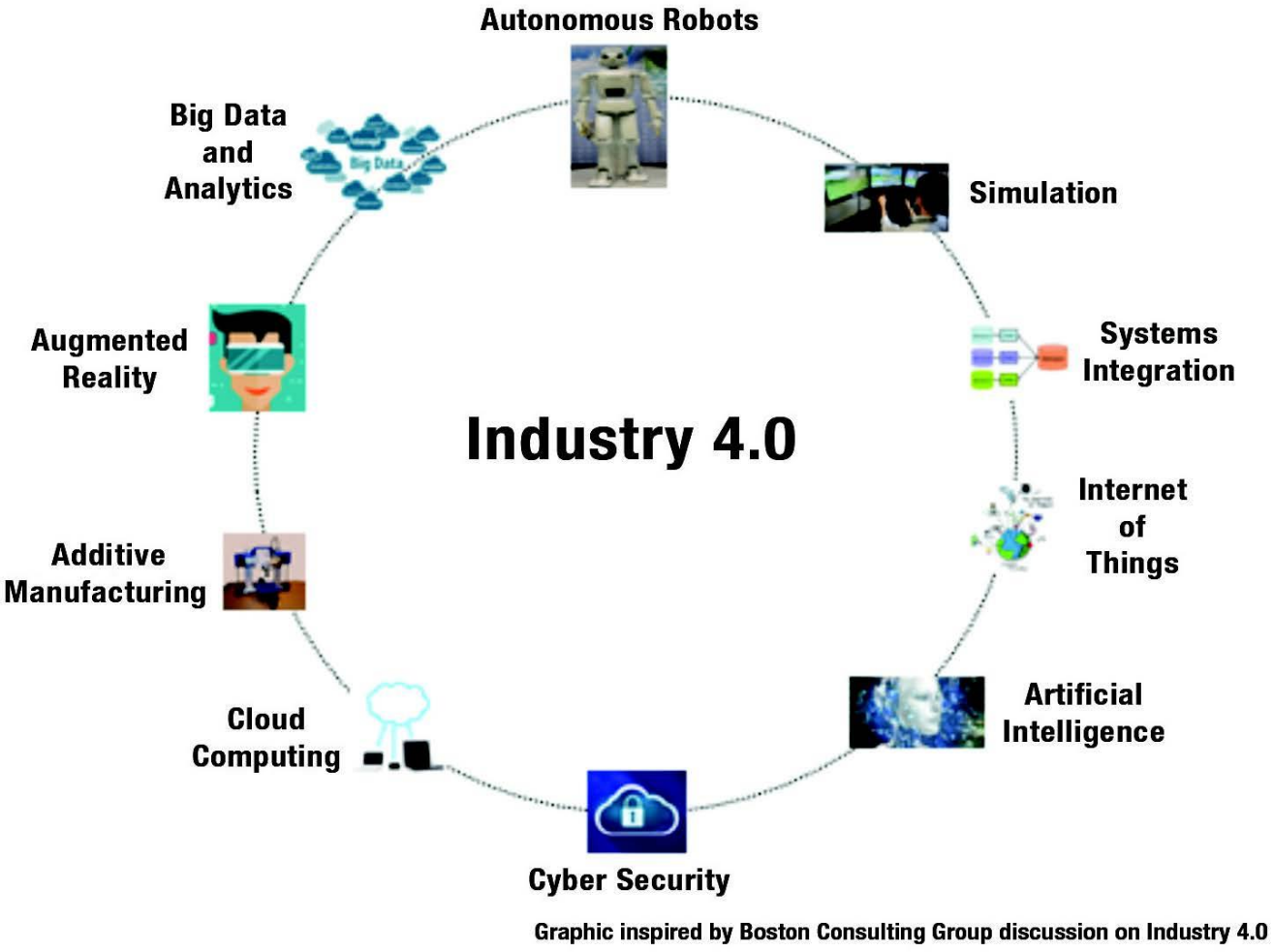
| INDUSTRY 1.0 | INDUSTRY 2.0 | INDUSTRY 3.0 | INDUSTRY 4.0 |
|---|---|---|---|
| 18th century | 19th century | Mid 20th century | Today |
| Steam power | Electricity | ICTs<br>Electronics | Advanced robotics<br>3D printing<br>Internet of Things<br>Artificial Intelligence<br>Big data |
| Mechanical production, moving away from cottage industry | Mass production and assembly line | Automated and networked production | Intelligent, flexible and distributed production |

# Keywords of Industrial Revolutions

- Industrial revolution 1: Mechanisation
- Industrial revolution 2: Electrification
- Industrial revolution 3: Digitalisation
- Industrial revolution 4: Cyber-physical systems (intelligence & connectivity)

Cybernetics: the science of control and communications in the animal and machine

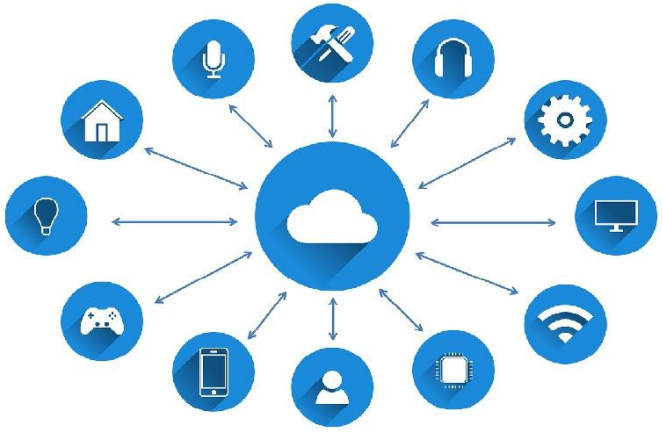
# Industry 4.0


Autonomous Robots
Simulation
Systems Integration
Internet of Things
Artificial Intelligence
Cyber Security
Cloud Computing
Additive Manufacturing
Augmented Reality
Big Data and Analytics
Industry 4.0
Graphic inspired by Boston Consulting Group discussion on Industry 4.0

# Internet of Things (IoT)

- The Internet of Things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.

- By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention.

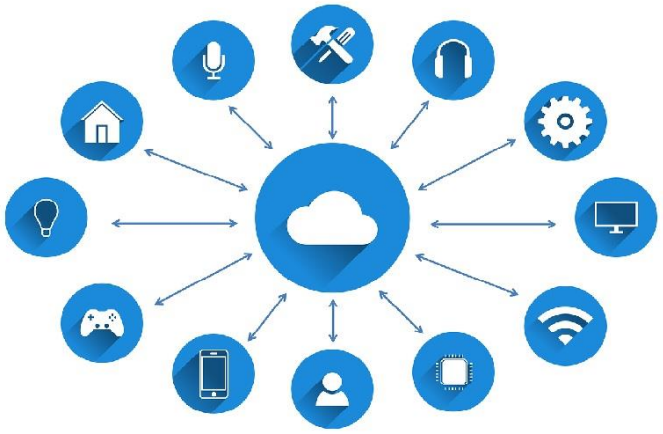


https://www.oracle.com/internet-of-things/what-is-iot/

# What technologies have made IoT possible?

While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies has made it practical:

- Access to low-cost, low-power sensor technology.
- Connectivity.
- Cloud computing platforms.
- Machine learning and analytics.
- Conversational artificial intelligence (AI)



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# What is the Internet-of-Things?

# How Does My Fridge Do That?

- You are leaving the home (sense user)
- There’s no milk in fridge (sense object)
- Use this information to make a decision (process)
- Inform user of decision (communicate)

# How Does My Fridge Do That?

- **You are leaving the home (sense user)**
  - What type of sensor?
  - Distinguish between parent and child
  - Identify reason for leaving home
  - Identify other contexts (e.g., store hours)
- There's no milk in fridge (sense object)
- Use this information to make a decision (process)
- Inform user of decision (notify)

# How Does My Fridge Do That?

- You are leaving the home (sense user)
- **There's no milk in fridge (sense object)**
  - What type of sensor?
  - Is milk needed?
  - No milk or "little" milk? (prediction)
- Use this information to make a decision (process)
- Inform user of decision (notify)

# How Does My Fridge Do That?

- You are leaving the home (sense user)
- There's no milk in fridge (sense object)
- **Use this information to make a decision (process)**
  - Where is processor?
  - What are the rules?
  - Fixed rules versus dynamic rules (learning)
- Inform user of decision (notify)

# How Does My Fridge Do That?

- You are leaving the home (sense user)
- There's no milk in fridge (sense object)
- Use this information to make a decision (process)
- **Inform user of decision (notify)**
  - How?
  - When?
  - Privacy?
  - Subtleness?
  - Information overflow?

# Internet-of-Things (IoT)

Physical object (“thing”)

+

Controller (“brain”)

+

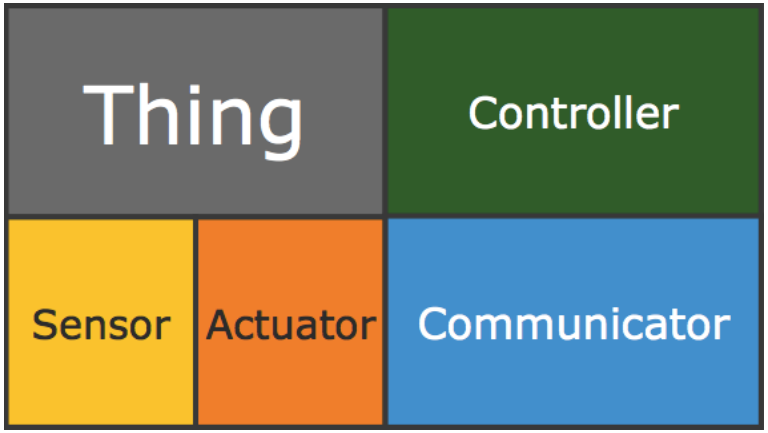
Sensors

+

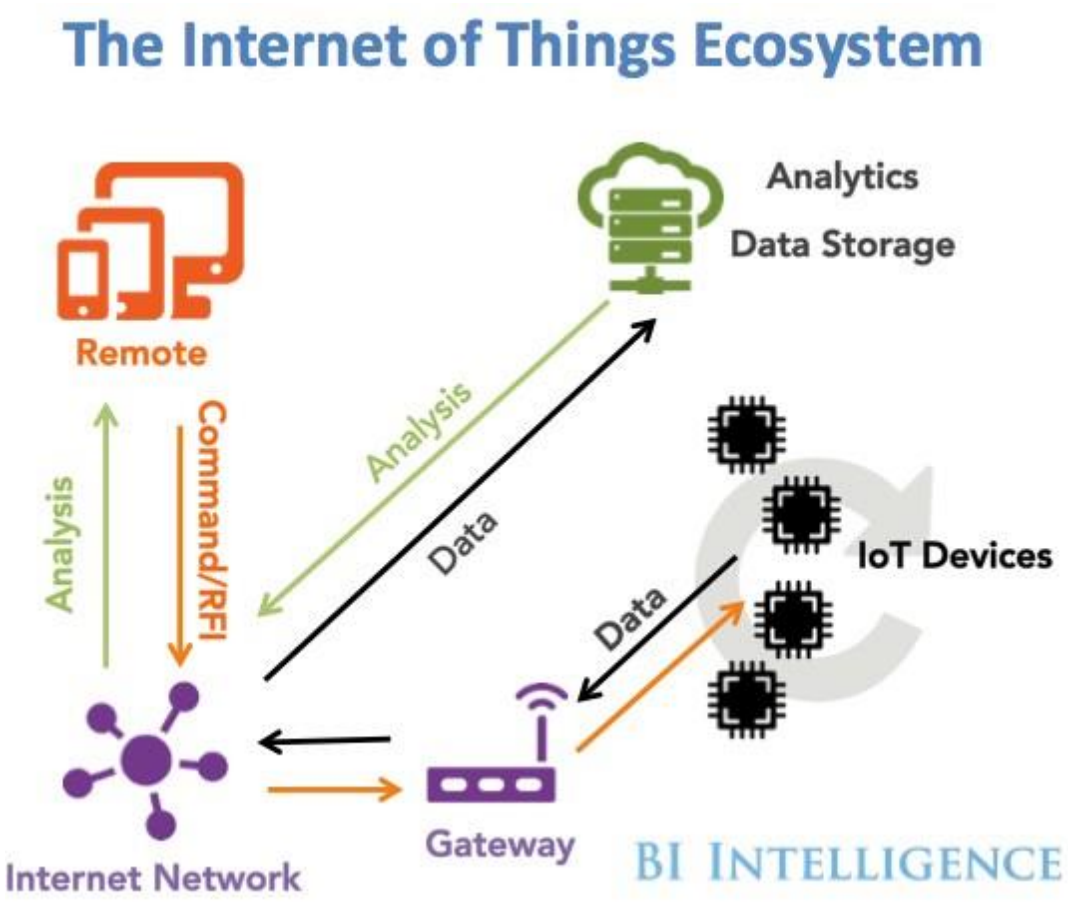
Actuators

+

Networks (Internet)



# Internet-of-Things (IoT)

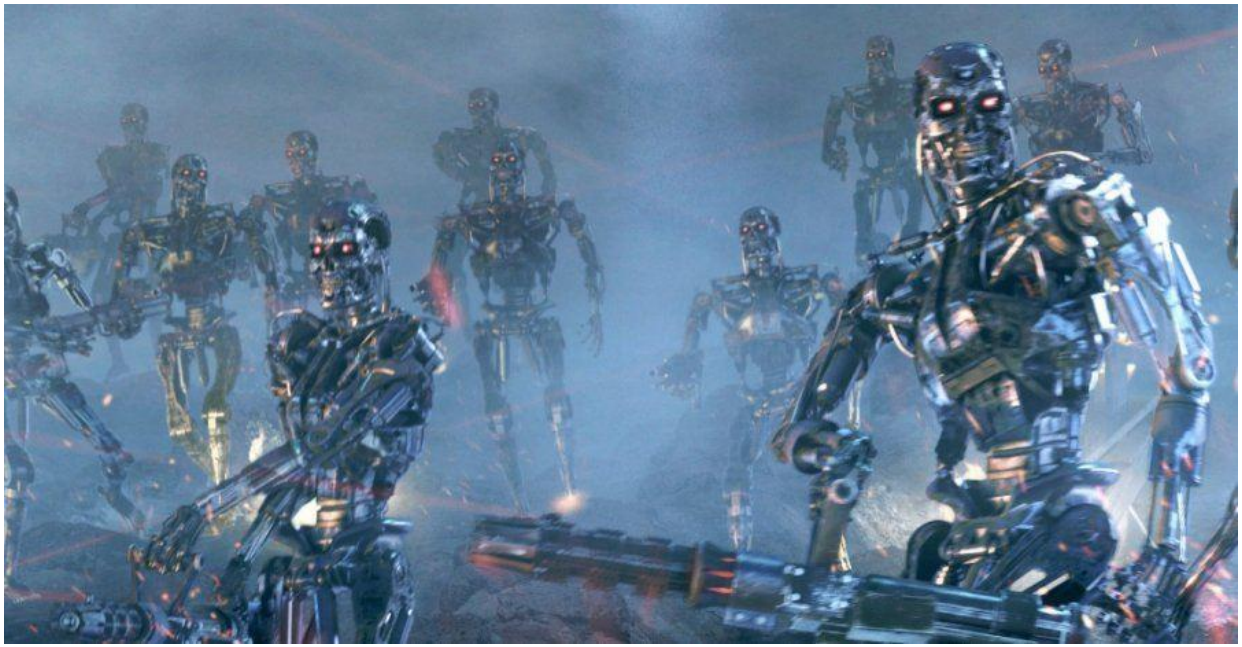


# Related Areas/Terminology

- **Embedded systems**: not necessarily connected
- **Sensor networks**: collection of sensor devices connected through wireless channels
- **Cyber-physical systems**: focus on interaction between physical and cyber systems. A cyber system is an integration of computation and networking.
- **Real-time systems**: focus on time constraints
- **Pervasive/ubiquitous computing**: focus on anytime/anywhere computing

# Related Areas

- Machine-to-machine (M2M) communications
- Internet of Everything (Cisco Systems)
- “Skynet” (Terminator movie)



# “Internet-of-Things”

- Term coined by British entrepreneur Kevin Ashton, while working at MIT Auto-ID Labs
- Referred to (and envisioning) a future global network of objects connected specifically by RFID (radio-frequency identification)
- Complete automation of data collection
- First article about IoT in 2004 from MIT; called “Internet 0”

# Internet-of-Things Vision & Growth

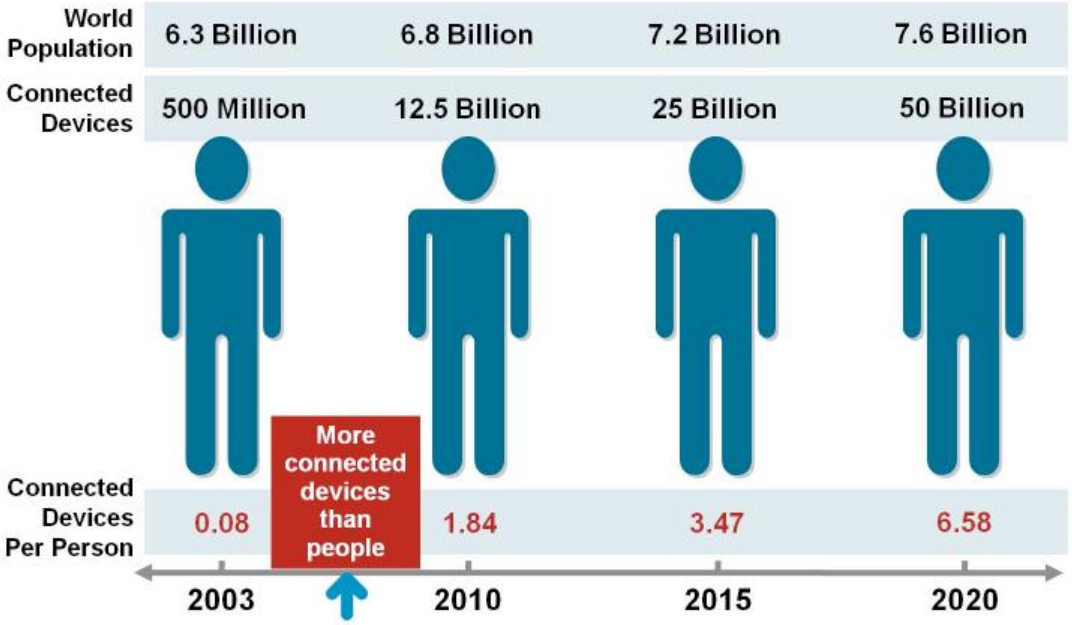
## THE INTERNET OF THINGS

Connected devices (billions)


| | 15 billion | 28 billion | CAGR 2015–2021 |
|---|---|---|---|
| Cellular IoT | 0.4 | 1.5 | 27% |
| Non-cellular IoT | 4.2 | 14.2 | 22% |
| PC/laptop/tablet | 1.7 | 1.8 | 1% |
| Mobile phones | 7.1 | 8.6 | 3% |
| Fixed phones | 1.3 | 1.4 | 0% |
| | 2015 | 2021 | |

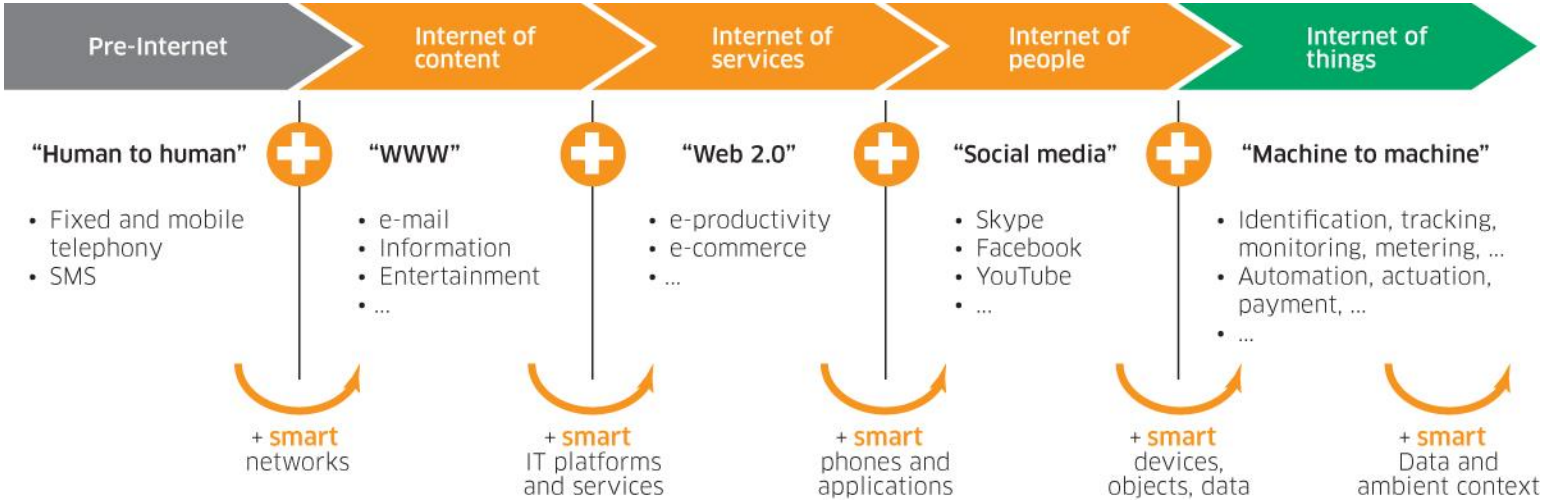
# Internet-of-Things Vision & Growth

Figure 1. The Internet of Things Was "Born" Between 2008 and 2009




Source: Cisco IBSG, April 2011

# Internet-of-Things Vision & Growth



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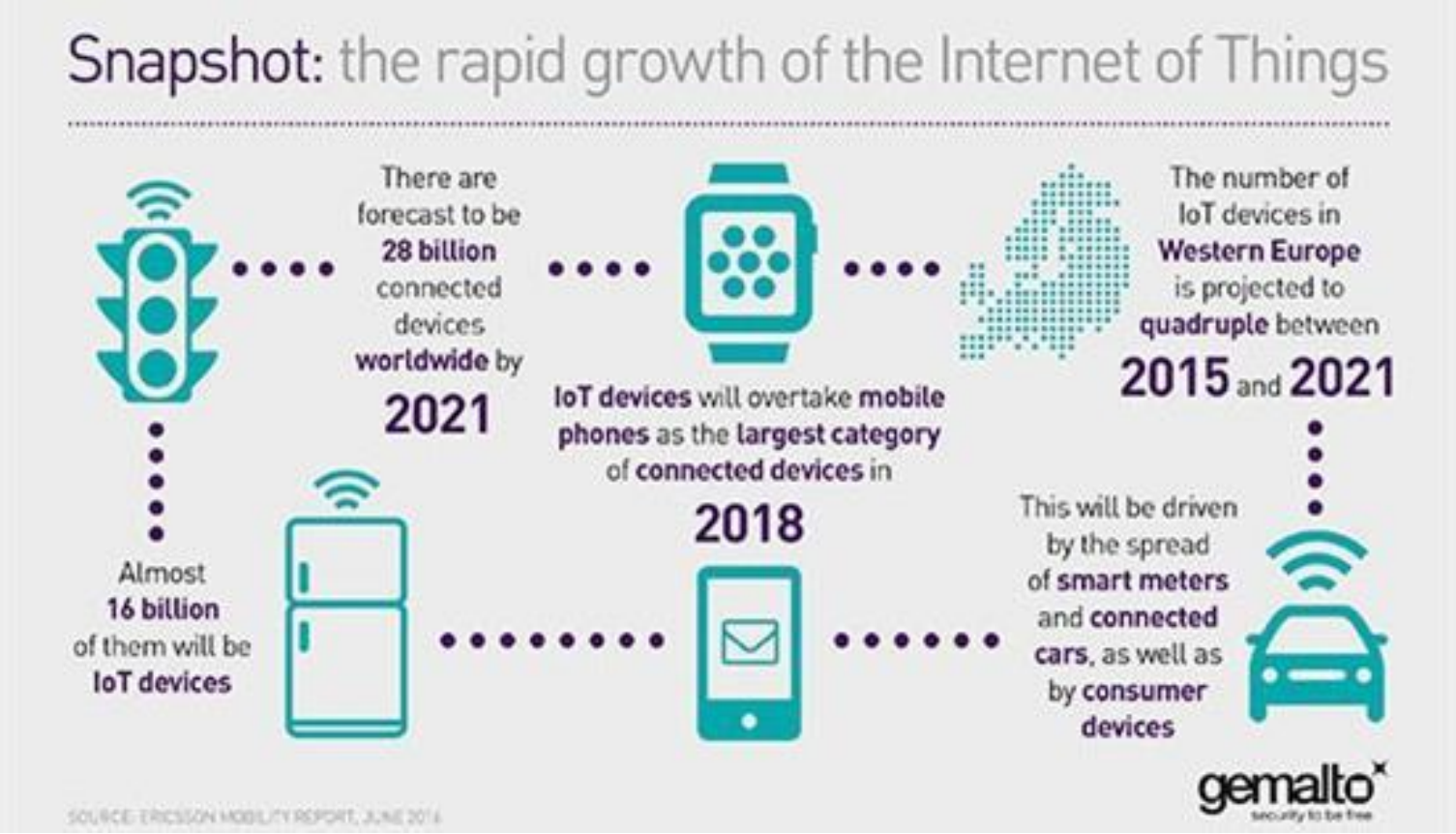

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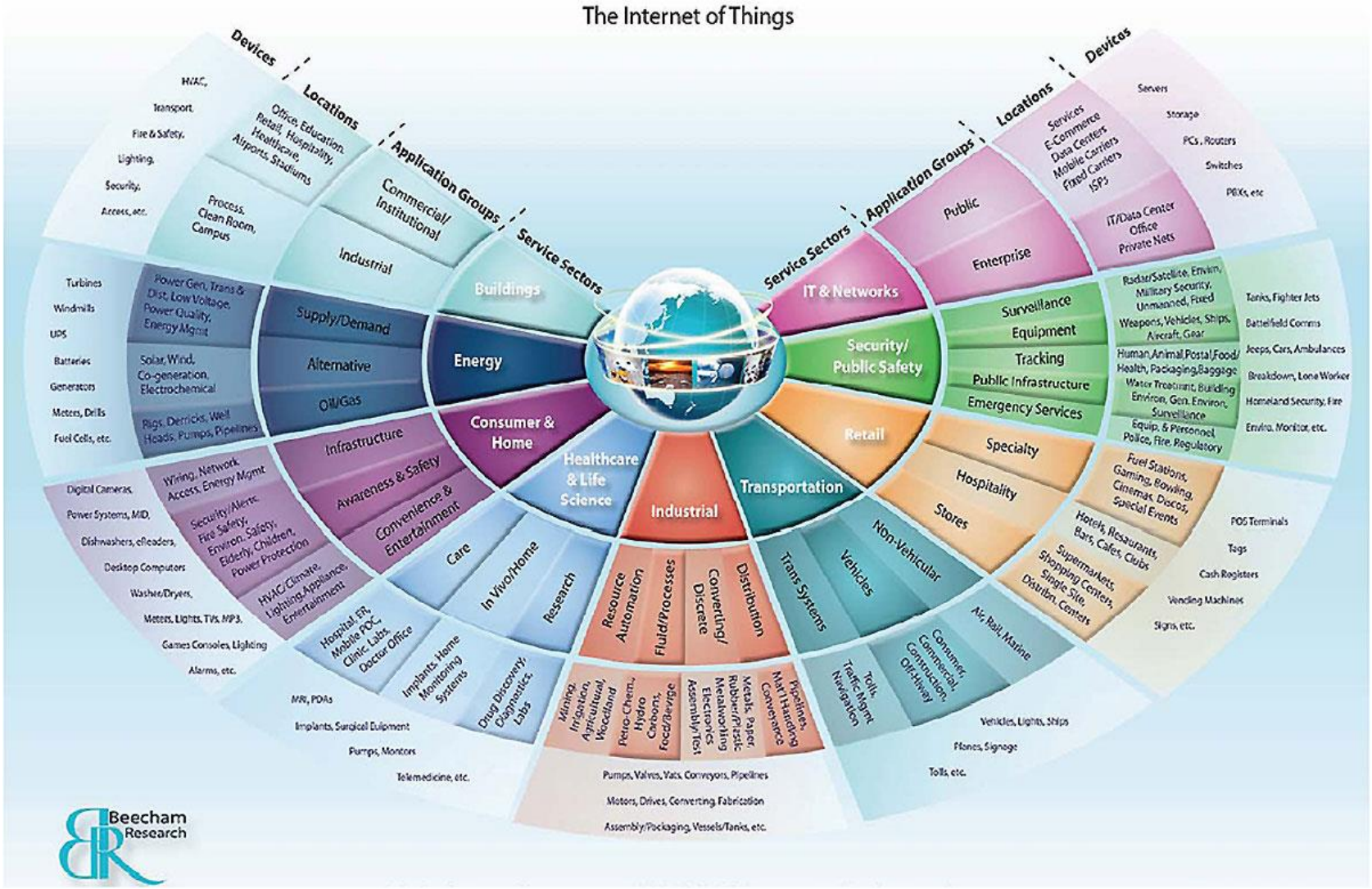


# Augment Existing Things



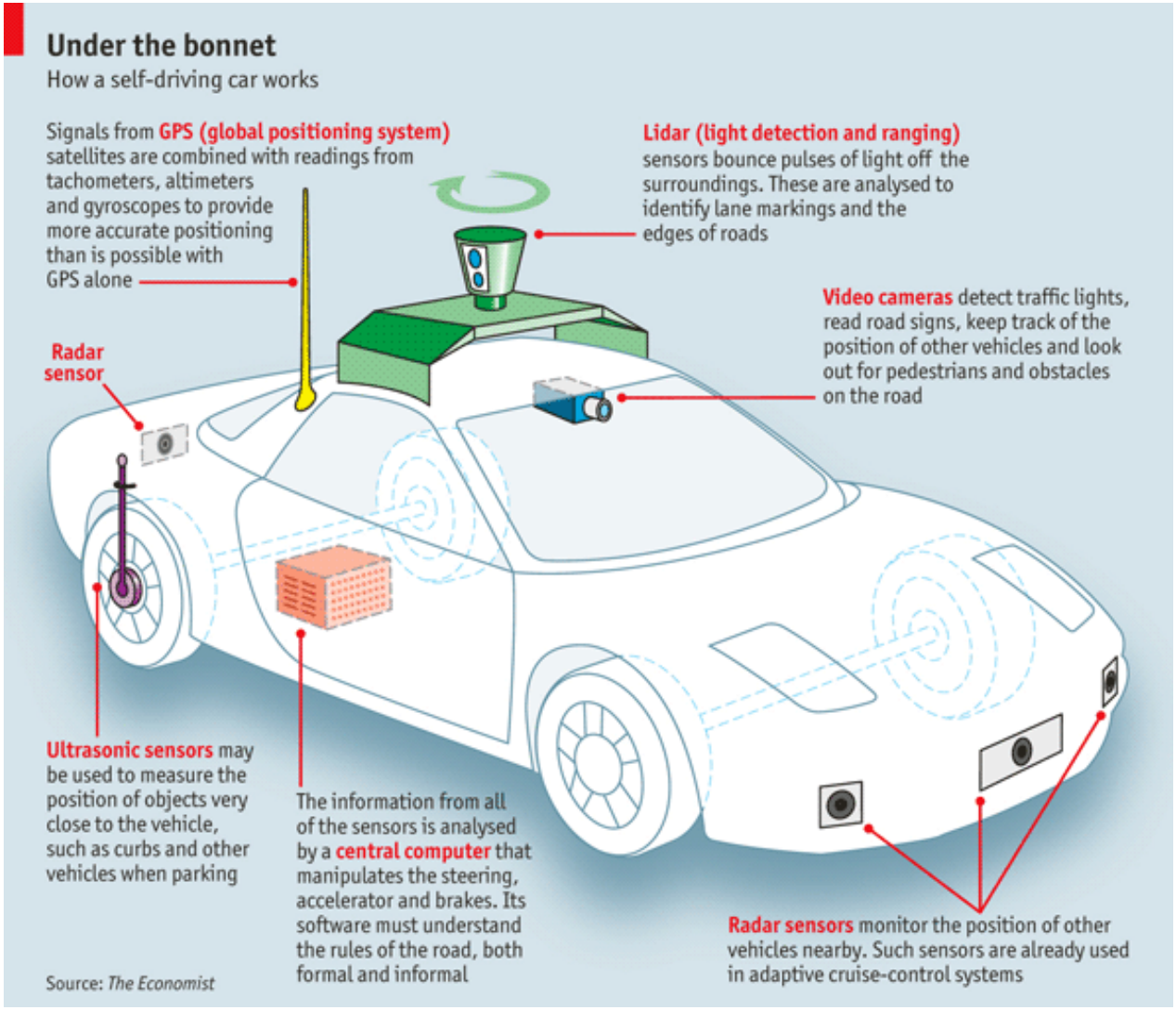

# Augmenting Life With New Things

- Smart City
- Smart Car
- Smart Me (healthcare, fitness, wellness)

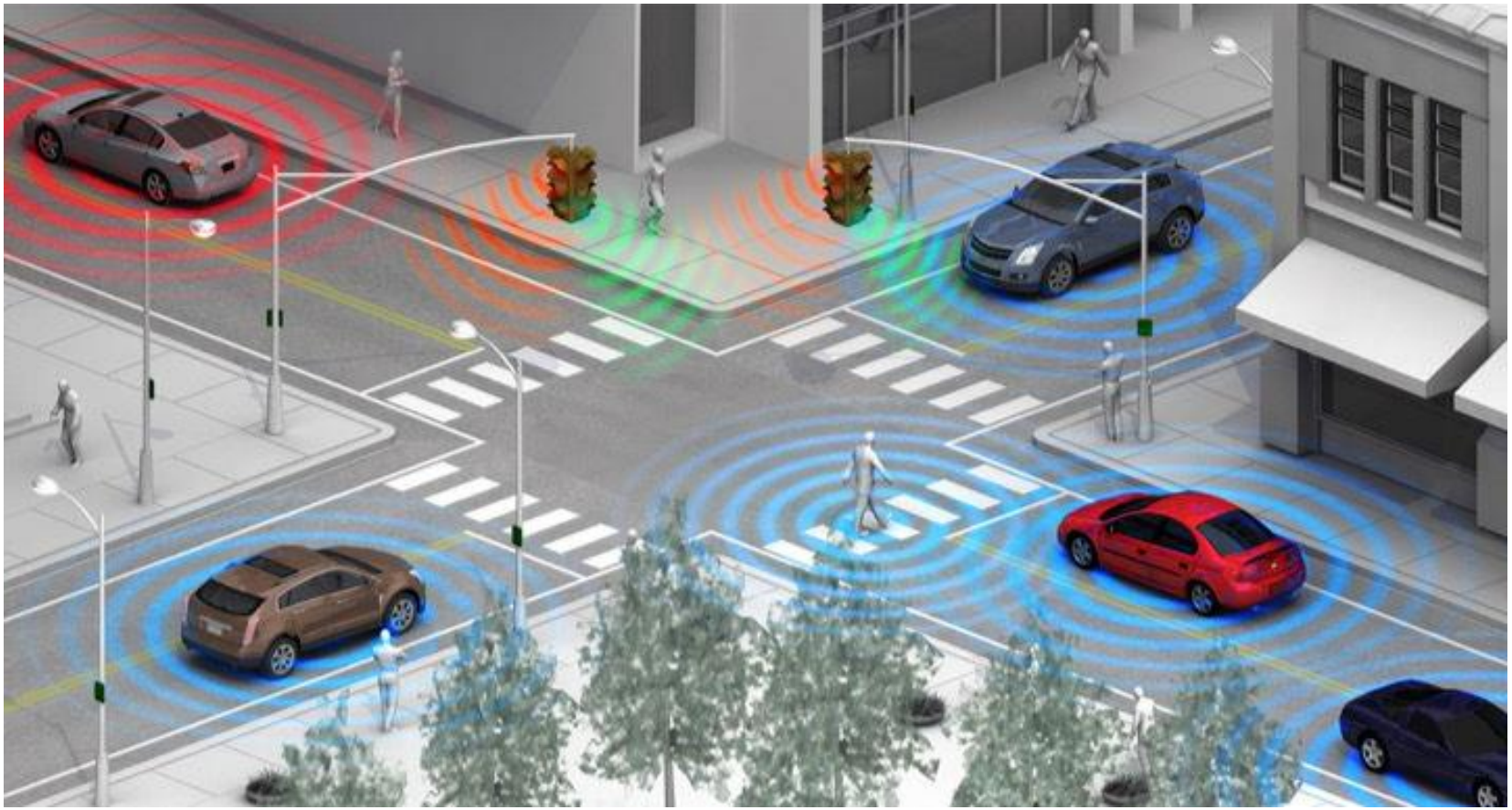
# Example: Connected Roadways

- US DoT Statistics for 2012:
  - 5.6million crashes
  - About 31,o00 fatalities (26,500 in EU)
  - Over 1.6M injuries
- 1trillion USD in economic loss
- 5.5billion hours of travel delays per year
- CO2 emissions

# Example: Connected Roadways



# Example: Connected Roadways



State of Self-Driving Car

# Example: Connected Factory

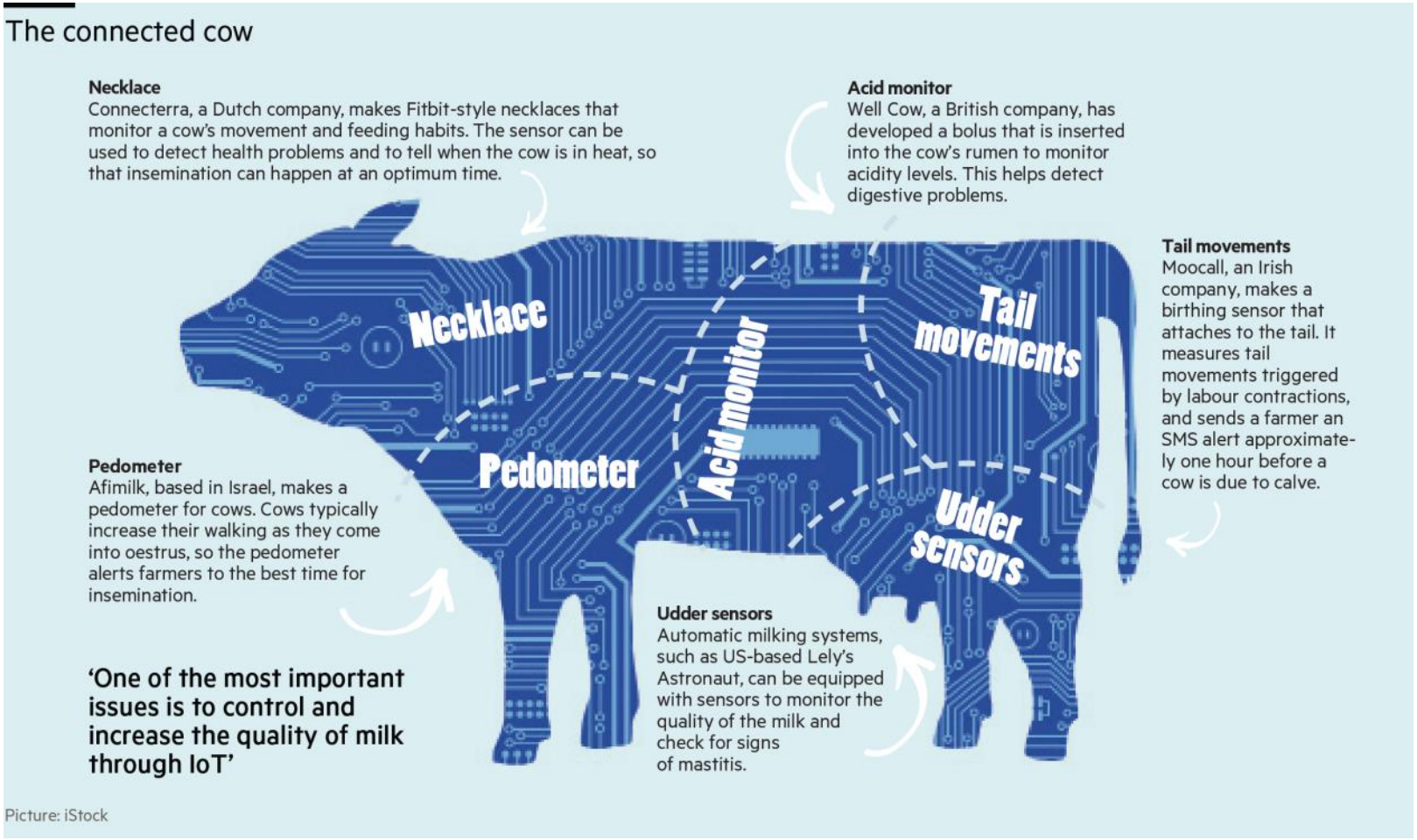
# Example: Connected Factory

- New product and service introductions faster
- Increasing production, quality, uptime
- Mitigating unplanned downtime
- Protecting from cyber threats
- Worker productivity and safety

# Example: Smart & Connected Buildings

- Energy management
- Lighting
- Safety
- HVAC
- Building automation
- Smart spaces

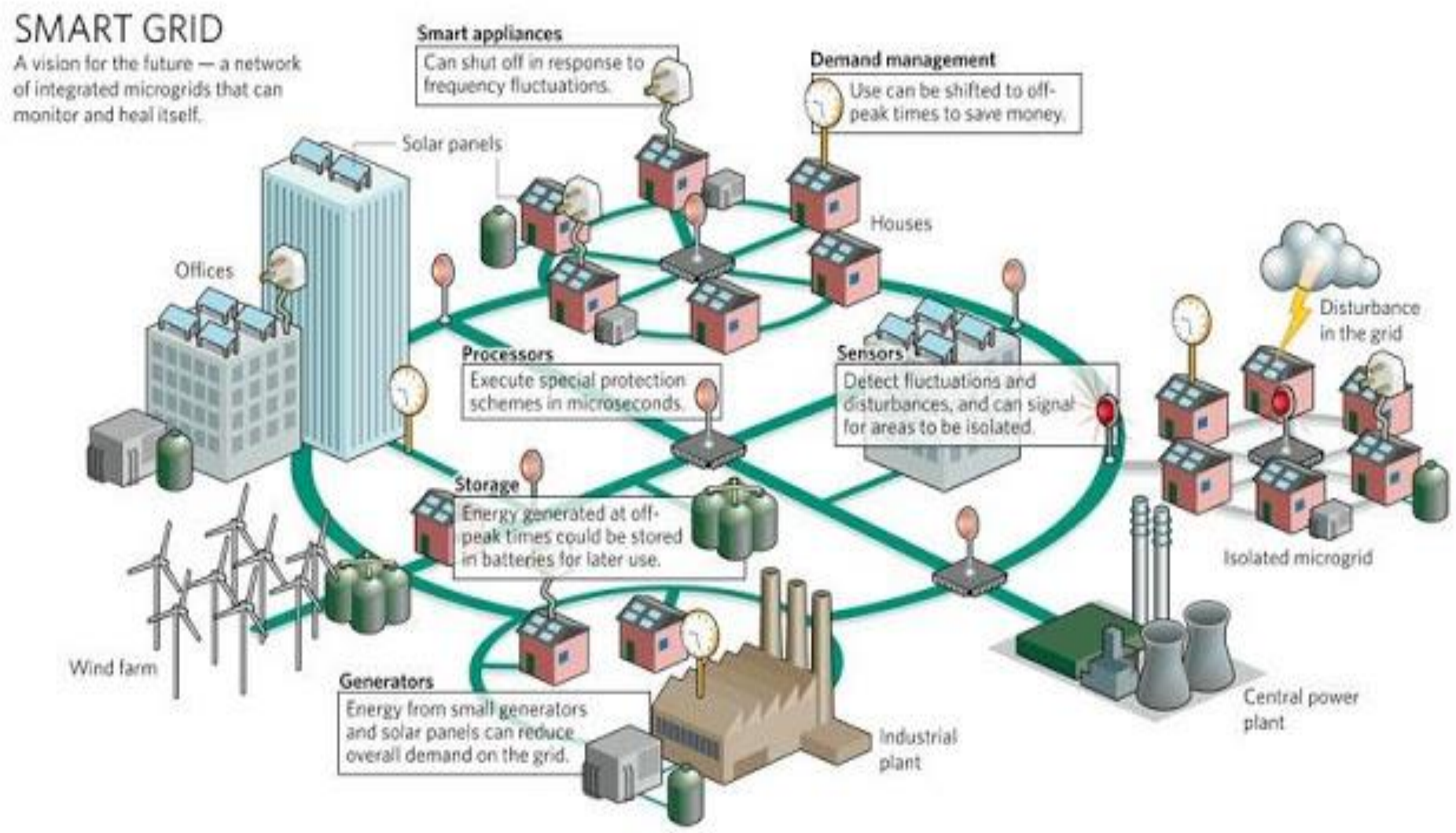
# Example: Smart Creatures



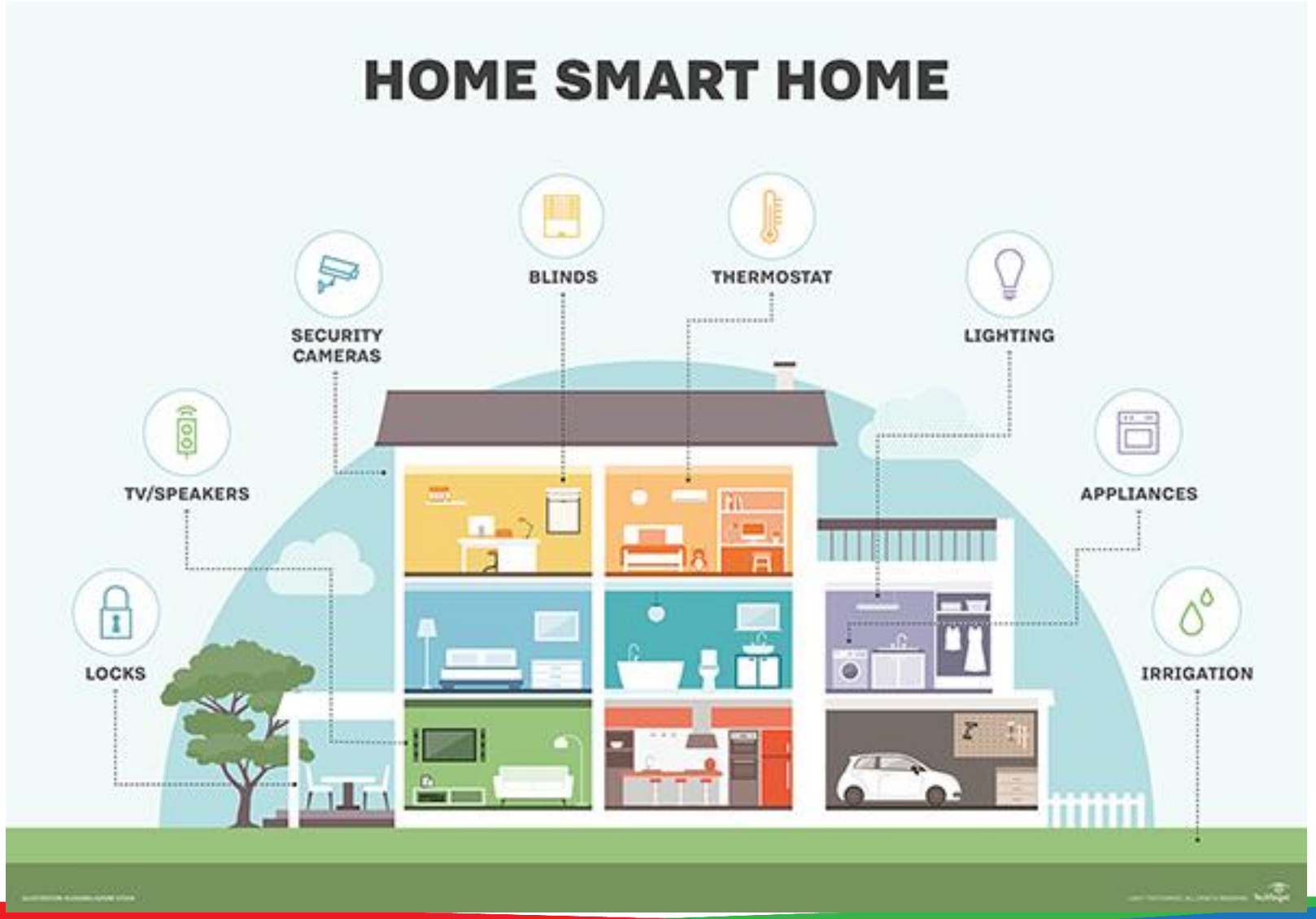
# Example: Fight Poverty

- Try to get more shoppers from Warden Road to Dharavi in Mumbai

# Example: Smart Grid



# Example: Smart Homes



# Example: Smart Lighting

- Tunable light, 16 million colors
- Activated by smartphone or over Zigbee wireless
- Can serve as alarm clock
- Can synch colors to movies or possibly music


**Philips never anticipated the demand - sold out in 3 months at Apple stores!**

# More Smarts

- Smart bathroom cabinet for medicine
- Smart refrigerator
- Smart toilet
- Smart history (in museums)
- Smart health (sensors in running shoes)
- Smart buying (beacons)
- Smart shirt (seal wounds)
- Smart helmet (detect concussion)
- …

# Enablers: Portability

- Reducing the size of hardware to enable the creation of computers that could be physically moved around relatively easily

# Enablers: Miniaturization

- Creating new and significantly smaller mobile form factors that allowed the use of personal mobile devices while on the move

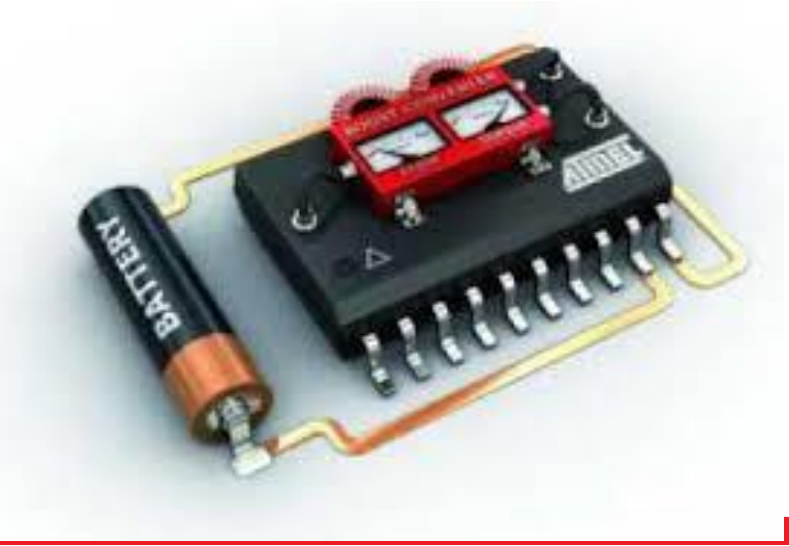

50mm x 50mm


35mm x 35mm

15mm x 15mm

# Enablers: Low Power and Low Heat

- Low power architectures
- Low power radios
- Sleep modes
- Energy harvesting



# Enablers: Connectivity

- Developing devices and applications that allowed users to be online and communicate via wireless data networks while on the move


Wi Fi

Bluetooth®

4G LTE

# Enablers: Convergence

- Integrating emerging types of digital mobile devices, such as Personal Digital Assistants (PDAs), mobile phones, music players, cameras, games, etc., into hybrid devices

# Enablers: Divergence

- Opposite approach to interaction design by promoting information appliances with specialized functionality rather than generalized ones



# Enablers: Ecosystems

- The emerging wave of *digital ecosystems* is about the larger wholes of pervasive and interrelated technologies that interactive mobile systems are increasingly becoming a part of

# Example: Smartphone

- Portability: carry it anywhere you want
- Miniaturization: make it possible to build device to fit in your pocket
- Connectivity: Wi-Fi, LTE/4G, cellular, Bluetooth
- Convergence: phone, camera, gaming device, movie streaming, music player, …
- Digital Ecosystem: cloud, social networks, software development kits, app stores, big data, standardization …

# IoT Issues & Challenges

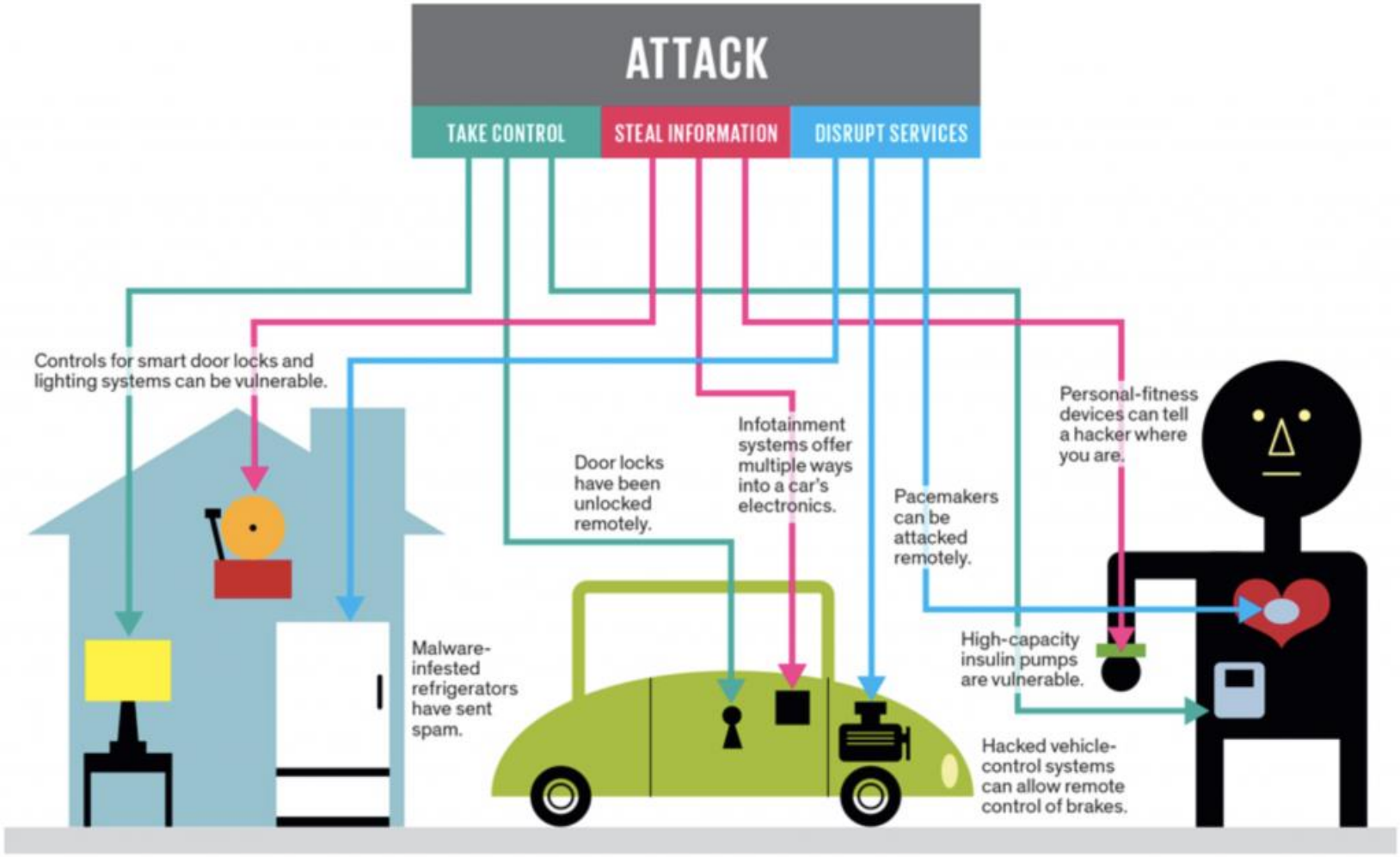



Illustration: J. D. King