Chapter 14:
Green Internet of Things (IoT)

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Outline

1. Abstract
2. Internet of things
3. Toward green internet of things
4. Technologies supporting the green internet of things
5. Future internet of things
6. Conclusion
7. Reference

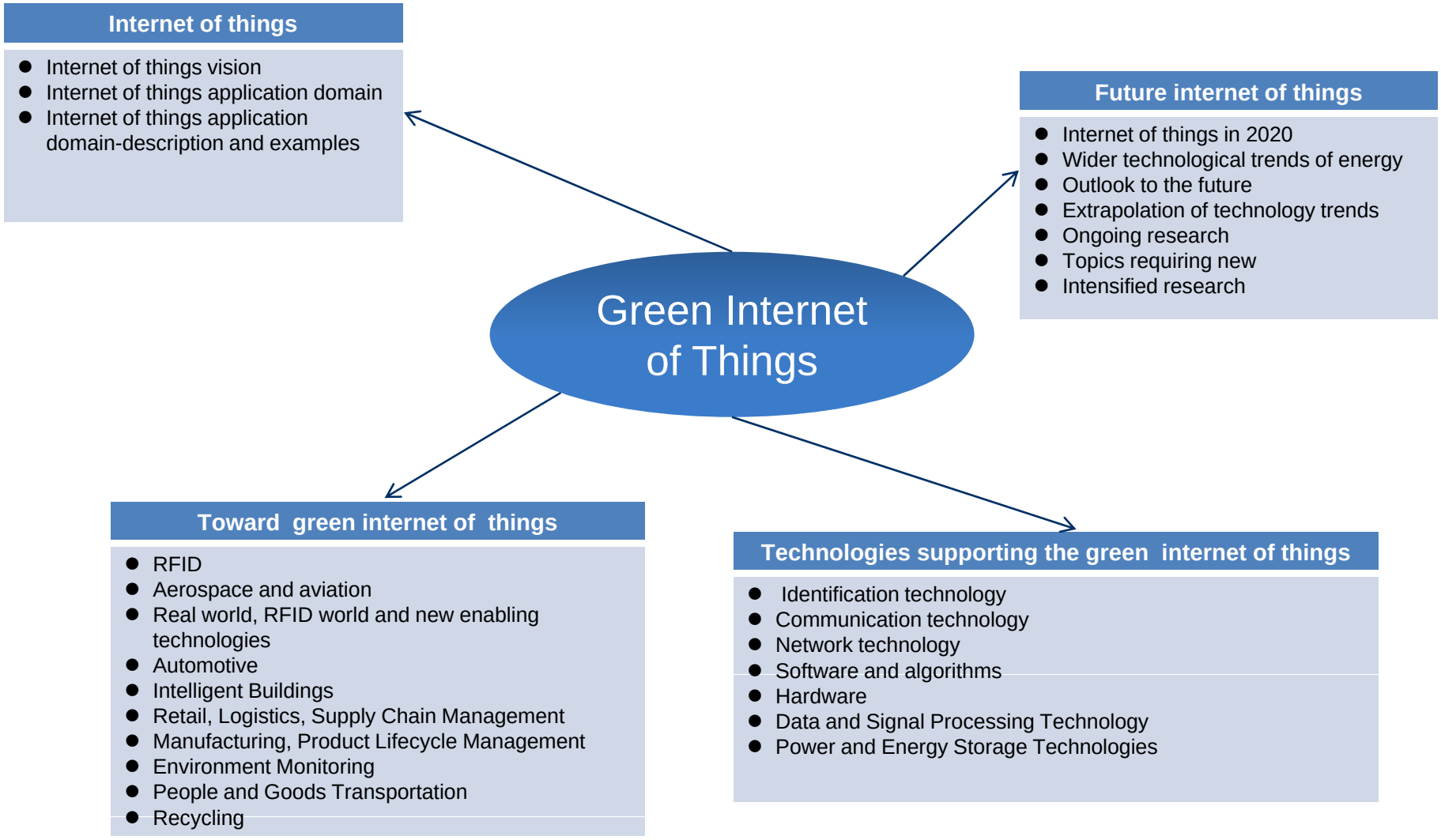
1.Abstract

- It is foreseeable that any object will have a unique way of identification in the coming future, what is commonly known in the networking field of computer sciences as “Unique Address“, creating an addressable continuum of computers, sensors, actuators, mobile phones;
- Radio Frequency Identification techniques (RFID) and related identification technologies will be the cornerstone of the upcoming Internet of Things (IoT).

Definition of green internet of things

- Internet of thing is that things can communicate to each other without human. The things communicate directly between each other can save the communication energy with user.
- ICT(Information and communications technology) : it accounts for about two percent of global CO_2 emissions and with the same ICT including IoT technologies and applications have a direct effect on lowering CO_2 emissions.

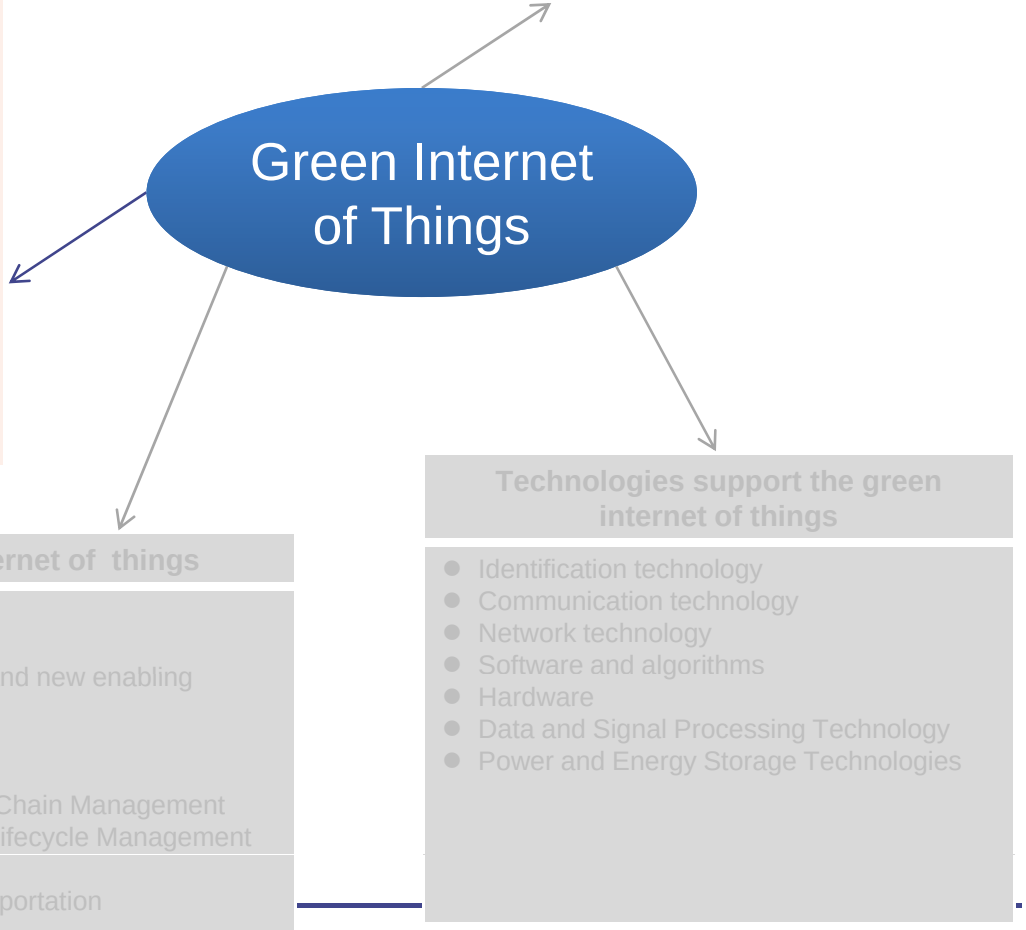
Green internet of things



2.Internet of things

Internet of things

- Internet of things vision
- Internet of things application domain
- Internet of things application domain-description and examples



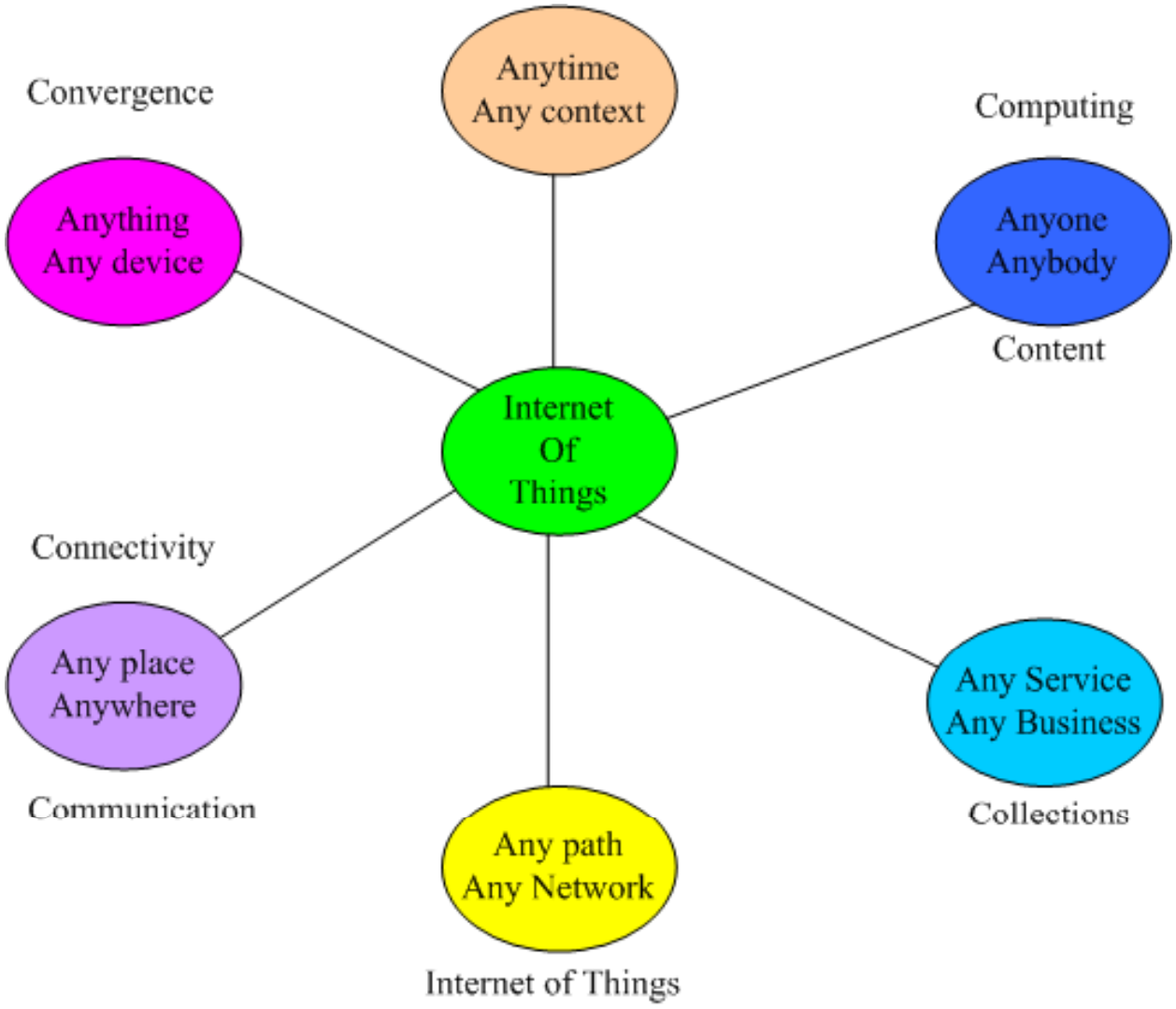
Overview of internet of things

- Internet of Things (IoT) is an integrated part of Future Internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities. They use intelligent interfaces, and are seamlessly integrated into the information network.

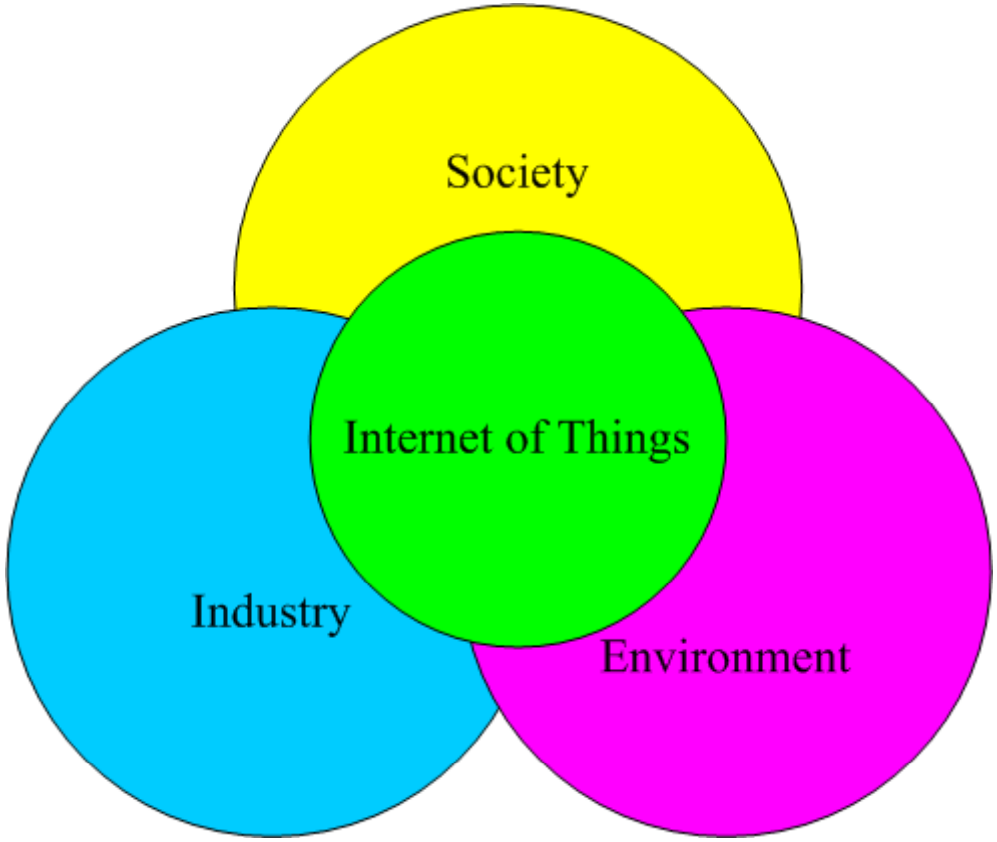
Internet of things vision

- The Internet of Things allows people and things to be connected **A**nytime, **A**nyplace, with **A**nything and **A**nyone, ideally using **A**ny path/network and **A**ny service.
- This implies addressing elements such as **C**onvergence, **C**ontent, **C**ollections (Repositories), **C**omputing, **C**ommunication, and **C**onnectivity in the context where there is a seamless interconnection between people and things and/or between things and things so the **A** and **C** elements are present and addressed.

Internet of things vision(cont.)



Internet of things application domain



Internet of things application domain-description and examples

Domain	Description	Indicative examples
Industry	Activities involving financial or commercial transactions between companies, organizations and other entities	Manufacturing, logistics, service sector, banking, financial governmental authorities, intermediaries, etc.
Environment	Activities regarding the protection, monitoring and development of all natural resources	Agriculture & breeding, recycling, environmental management services, energy management, etc.
Society	Activities/ initiatives regarding the development and inclusion of societies, cities, and people	Governmental services towards citizens and other society structures (e-participation), e inclusion (e.g. aging, disabled people), etc.

3. Toward green internet of things

Internet of things

- Internet of things vision
- Internet of things application domain
- Internet of things application domain-description and examples

Future internet of things

- Internet of things in 2020
- Wider technological trends of energy
- Outlook to the future
- Extrapolation of technology trends
- Ongoing research
- Topics requiring new
- Intensified research

Green Internet of Things

Toward green internet of things

- RFID
- Aerospace and aviation
- Intelligent Buildings
- Retail, Logistics, Supply Chain Management
- Environment Monitoring
- People and Goods Transportation
- Recycling

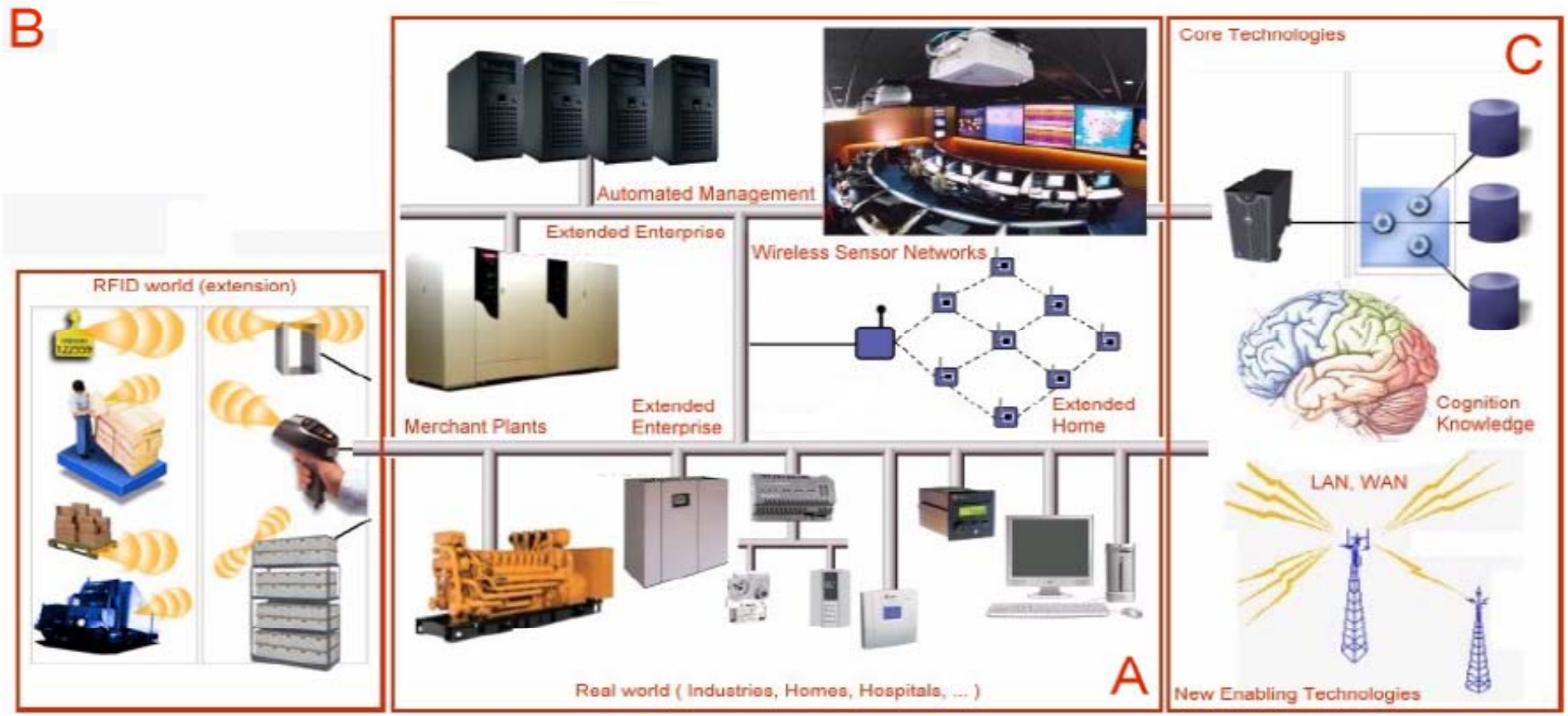
Technologies supporting the green internet of things

- Identification technology
- Communication technology
- Network technology
- Software and algorithms
- Hardware
- Data and Signal Processing Technology
- Power and Energy Storage Technologies

Definition of RFID

- Radio-frequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. Some RFID tags can be read from several meters away and beyond the line of sight of the reader.
- The application of bulk reading enables an almost-parallel reading of tags.

Real world, RFID world and new enabling technologies



Overview of real world, RFID world and new enabling technologies

- The “traditional” ubiquitous world is represented by the component (A) including industries and all other realities.
- The extension of the above-mentioned reality by new enabling and emergent technologies is represented by the component (C).
- The (B) component shows the missing element, making possible such scenario, which might be the RFID, transforming real life members into digital things, ready to enter into the Internet of Things.

Aerospace and aviation (systems status monitoring, green operations)

- The ‘on-condition’ wireless monitoring of the aircraft by using intelligent devices with sensing capabilities available within the cabin or outside and connected to the aircraft monitoring systems is another emerging application area that forms the basis for ubiquitous sensor networks.
- The nodes in such a network will be used for detecting various conditions such as pressure, vibrations, temperature etc.
- The data collected gives access to customized usage trends, facilitates maintenance planning, allows condition-based maintenance, reduces maintenance and waste and will be used as input for evaluating and reducing the energy consumption during aircraft operations.

Intelligent Buildings (automatic energy metering)

- In conjunction with modern home entertainment systems, which are based on general-purpose computing platforms, they could easily be combined with other sensors and actors within a building, thus forming a fully interconnected, smart environment. Sensors for temperature, humidity provide the necessary data to automatically adjust the comfort level and to optimize the use of energy for heating or cooling.

Retail, Logistics, Supply chain management

- With RFID-equipped items and smart shelves that track the present items in real time, a retailer can optimize many applications, like automatically checking of goods receipt, real time monitoring of stocks, tracking out-of-stocks or the detection of shoplifting.
- The logistic processes from supply chains in many industry sectors can profit from exchanging RFID data, not only those in the retail sector.
- Moreover, environmental issues can be better tackled. e.g. the carbon footprint of logistics - and supply chains more generally - processes can be optimized based on the availability of dynamic, fine-grained data, collected in the real world directly by some of the “things”.

Retail, Logistics, Supply chain management(cont.)

- In the shop itself, IoT offers many applications like guidance in the shop according to a preselected shopping list, fast payment solutions like automatically check-out using biometrics, detection of potential allergen in a given product, personalized marketing if accepted, verification of the cool chain, etc. Commercial buildings will of course benefit from smart building functionalities as described above.

Walmart

- Walmart—uses RFID technology throughout its supply chain, reducing CO_2 emissions.

Walmart Wikipedia

Walmart(Cont.)

- Wal-Mart Stores, Inc. (NYSE: WMT), branded as Walmart since 2008 and Wal-Mart before then, is an American public multinational corporation that runs chains of large discount department stores and warehouse stores.
- Walmart's pilot RFID implementation to replace its bar code system reduced its CO_2 emissions by 3.2 percent because its distribution trucks made fewer trips owing to better product visibility and tractability and improved inventory management.

Environment monitoring

- Environment surveillance: earth quakes, tsunami, forest fires, floods, pollution (water and air).
- Wireless identifiable devices and the utilization of IoT technologies in green related applications and environmental conservation are one of the most promising market segments in the future, and there will be an increased usage of wireless identifiable devices in environmentally friendly programmed worldwide.
- In the mean time, operators are looking beyond the capital expenditure costs of running RFID networks to minimizing operational costs such as power consumption and site costs.

People and Goods Transportation

- Monitoring traffic jams through cell phones of users and using intelligent transport systems (ITS) will improve and make the transportation of goods and people more efficient.
- Transportation companies would become more efficient in packing containers when those containers can self scan and weigh themselves. This would reduce resource consumption by optimizing the flow of goods in transporting.
- Optimal route planning will reduce the number of kilo meters driven, and better control systems for the car will make the ride more energy efficient. All of these individual factors will contribute to reduced emissions and less pollution.

DHL Smart Truck

- DHL and its majority-owned Indian subsidiary Blue Dart are piloting a new “intelligent” pick-up and delivery vehicle in Bengaluru, India.

DHL and Blue Dart pilot intelligent delivery trucks in India
Tuesday, August 16th, 2011

DHL Smart Truck(cont.)

- The vehicle includes various technologies such as a route planner, using real-time GPS systems and local traffic data to calculate an ideal sequence of deliveries, with the flexibility to allow for last-minute pick-ups.
- DHL says the vehicle reduced the number of miles driven by 15% during its test in Germany, cutting both fuel consumption and carbon dioxide emissions.

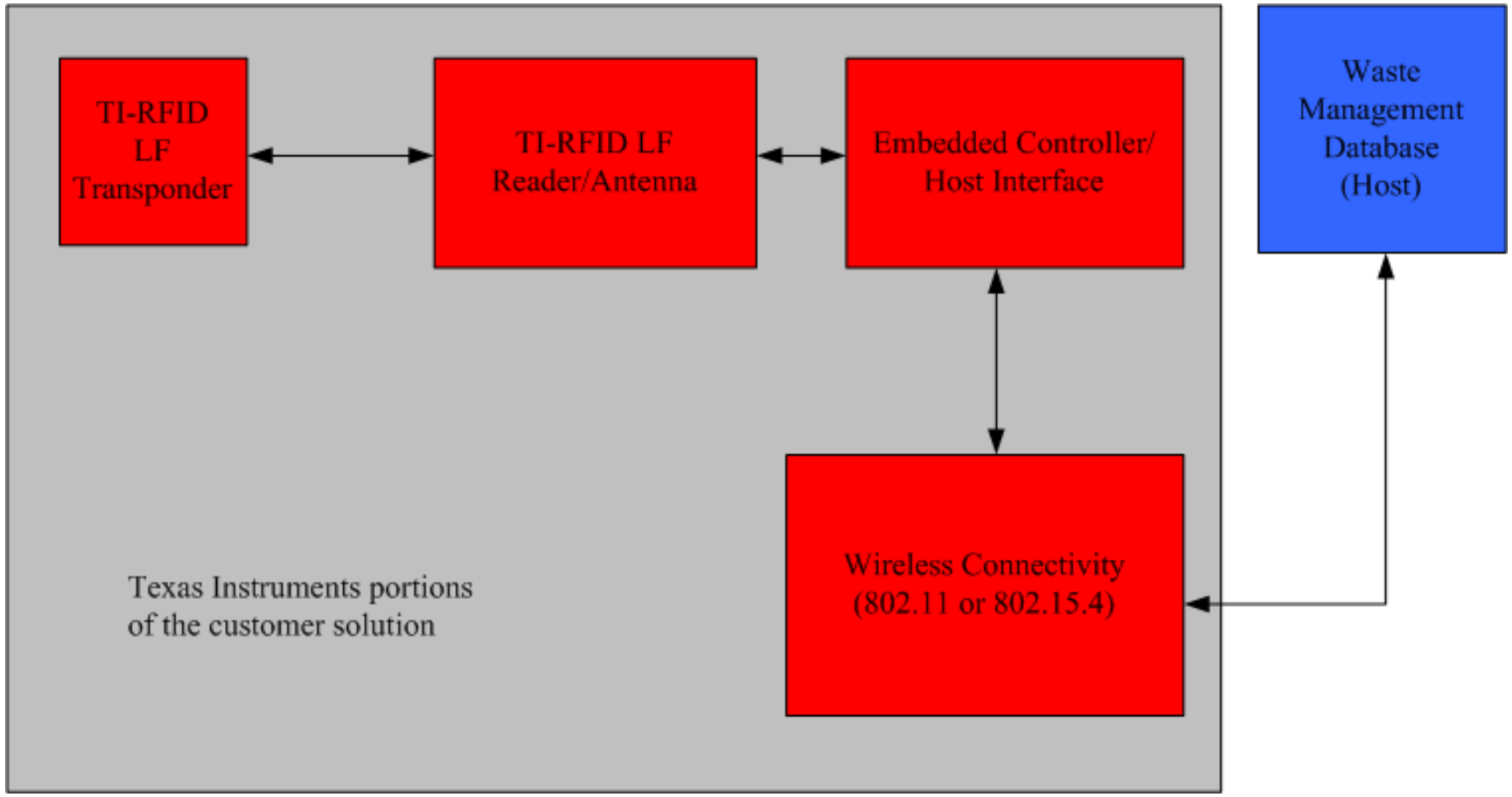
Recycling

- IoT and wireless technologies can be used to advance the efficiency and effectiveness of numerous important city and national environmental program, including the monitoring of vehicle emissions to help supervise air quality, the collection of recyclable materials, there use of packaging resources and electronic parts, and the disposal of electronic waste (RFID used to identify electronic subcomponents of PCs, mobile phones, and other consumer electronics products to increase the reuse of these parts and reduce e-waste).

Recycle bank

- Recycle Bank—employs an RFID system in trash bins to allow municipalities to measure the amount of recycling done by a household and give them rewards in return.

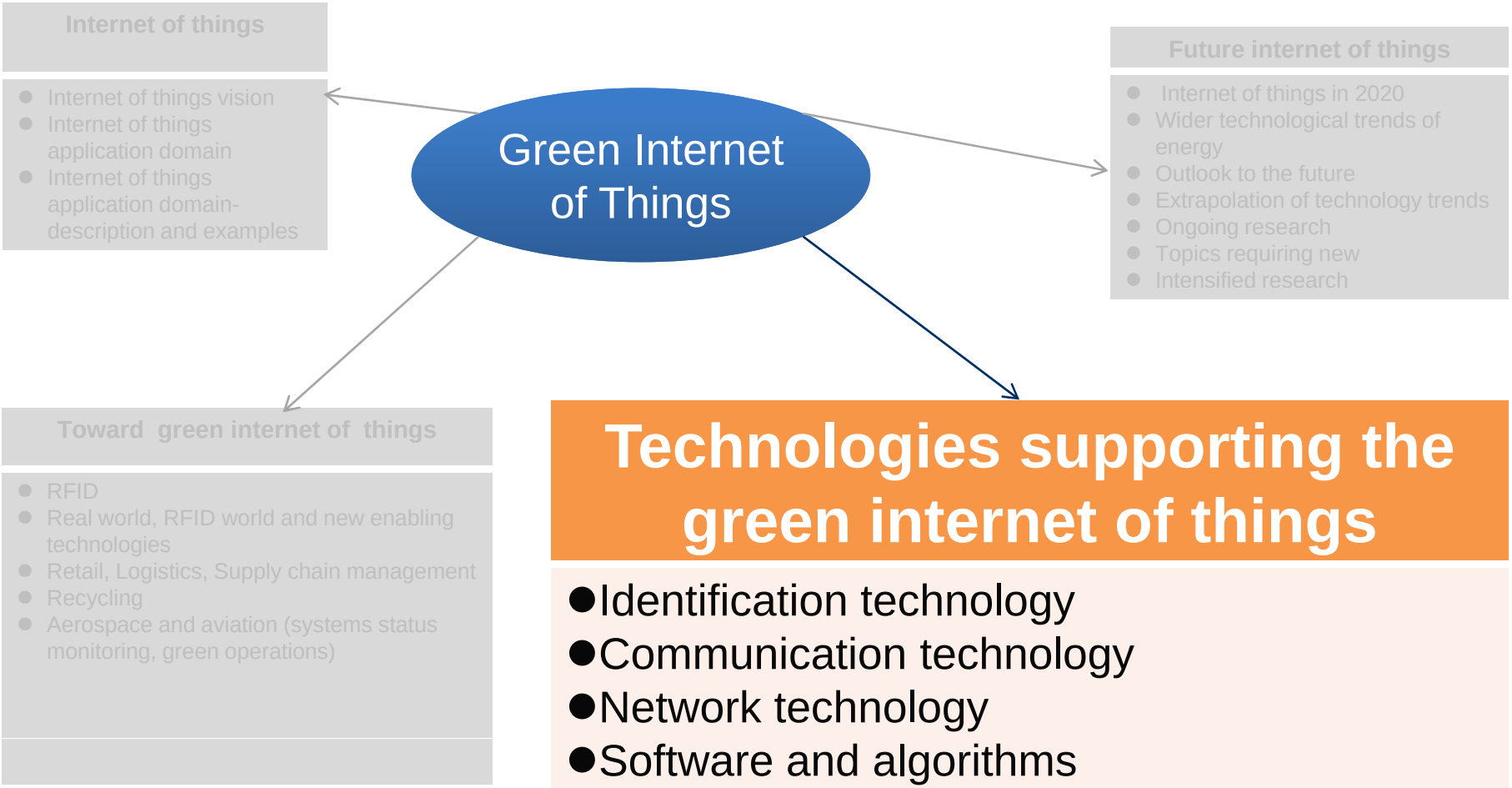
Recycle bank architecture



Recycle bank architecture(cont.)

- As designed and implemented for Recycle Bank, the TI RFID tag stores a serial number, the tag is read, and data is sent to the recycling truck's internal computer.
- The data collected is then uploaded back to Recycle Bank's data collection and processing systems.
- Only a serial number is captured which then goes into Recycle Bank's secure database.

4. Technologies supporting the green internet of things



Identification technology

- Further research is needed in the development, convergence and interoperability of technologies for identification and authentication that can operate at a global scale.
- This includes the management of unique identities for physical objects and devices, and handling of multiple identifiers for people and locations and possible cross-referencing among different identifiers for the same entity and with associated authentication credentials.
- The IoT will include a very large number of nodes, each of which will produce content that should be retrievable by any authorized user regardless of its or if is a person of his/her position.

Communication technology

- Billions of connected devices are pushing current communication technologies, networks and services approaches to their limits and require new technological investigations.
- Research is required in the field of Internet architecture evolution, wireless system access architectures, protocols, device technologies, service oriented architecture able to support dynamically changing environments, security and privacy.
- Research is required in the field of dedicated applications integrating these technologies within complete end-to-end systems.

Network technology

- Wireless network technologies have gained more focus due to their ability to provide unobtrusive wire-free communication.
- They have also become the leading area of research when combined with data collecting technologies used for environmental and object monitoring.
- In this regard, wireless sensor networks promise low power, low cost object monitoring and networking, constituting a fundamental technology for the evolution towards a truly embedded and autonomous Internet of Things.
- Design objectives of the proposed solutions are energy efficiency, scalability since the number of nodes can be very high, reliability, and robustness and self healing.

Software and algorithms

- Only with appropriate software will it be possible that the Internet of Things comes to life as imagined, as an integral part of the Future Internet.
- It is through software that novel applications and interactions are realized, and that the network with all its resources, devices and distributed services becomes manageable.
- For manageability, the need for some sort of self-configuration and auto-recovery after failures is foreseen.

Hardware

- The developments in the area of IoT will require research for hardware adaptation and parallel processing in ultra low power multi processor system on chip that handle situations not predictable at design time with the capability of self-adaptive and self-organization.
- Research and development is needed in the area of very low power field-programmable gate array hardware where the configuration (or parts of it) is changed dynamically from time to time to introduce changes to the device.

Data and Signal Processing Technology

- By 2020, trillions of networked sensors will be deployed around the planet, in the spaces we inhabit, the systems we use, the devices we carry, and inside our bodies.
- Sensors are a key enabling technology; with detection, measurement, computation, and communication, they can make passive systems active.
- Sensors will be used to measure everything from acceleration and location to temperature, energy use, soil chemistry, air pollution, and health conditions.

Power and Energy Storage Technologies

- Energy storage has become one of the most important obstacles to the miniaturization of electronic devices, and today's embedded wireless technologies such as Wireless Sensor Networks and Active RFID suffer from either bulky packaging to support large batteries or from short life times, that will require recharging or replacement of the integrated batteries.

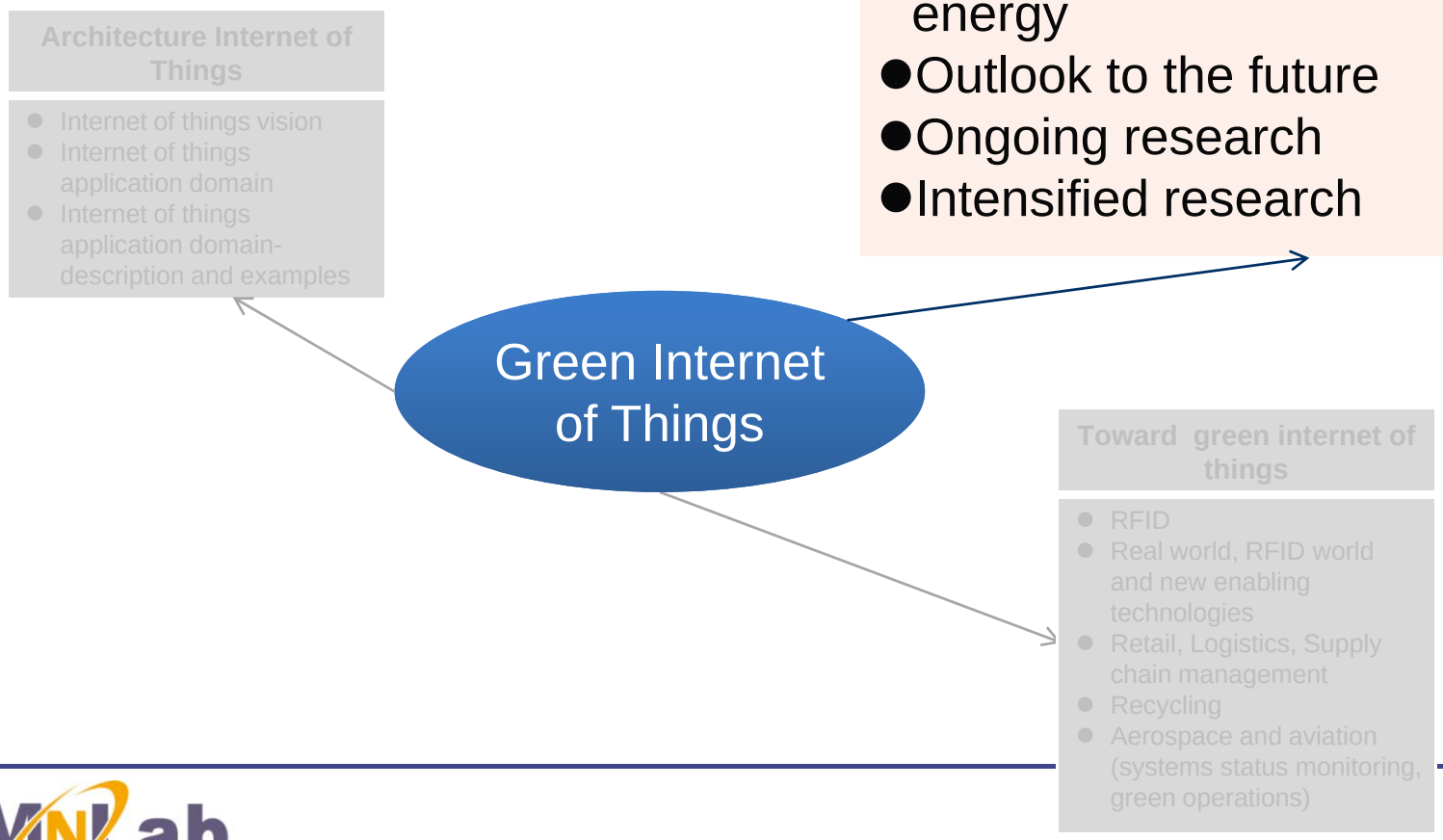
Power and Energy Storage Technologies(cont.)

- In order for the IoT to succeed in providing truly embedded and digital object participation, it is necessary to continue with the research on miniature high-capacity energy storage technologies.
- A solution that could bypass the short comings of energy storage is the harvesting of energy from the environment, which would automatically recharge small batteries contained in the objects.
- Energy harvesting is still a very inefficient process that would require a large amount of research. Sources for energy harvesting in embedded devices could include, among others, vibration, solar radiation, thermal energy, etc.

5.Future internet of things

Future Internet of Things

- Internet of things in 2020
- Wider technological trends of energy
- Outlook to the future
- Ongoing research
- Intensified research



Internet of things in 2020

- It is therefore expected that the Internet of things will become a reality over the next 20 years; with omnipresent smart devices wirelessly communicating over hybrid and ad-hoc networks of devices, sensors and actuators working in synergy to improve the quality of our lives and consistently reducing the ecological impact of mankind on the planet.

Wider technological trends of energy

- Energy issues such as energy harvesting and low-power chipsets are central to the development of the IoT.
- There is a need to research and develop solutions in this area, having as objective a level of entropy as close as possible to zero.
- Current technology seems inadequate for the processing power and energy limitation of the forthcoming future.

Wider technological trends of energy(cont.)

- The development of new and more efficient and compact energy *storage* like batteries, fuel cells, and printed/polymer batteries etc; as well as new energy *generation* devices coupling energy transmission methods or energy harvesting using energy conversion will be the key factors for implementing autonomous wireless smart systems.

Outlook to the future

- The technology trends foreseen for the next 20 years are outlined in the following tables. While the first table concentrates on developments that can be foreseen within current research priorities, and can be seen as an evolution of the current technological advancements, the second one focuses on more radical and ground breaking technology trends.

Ongoing research

	Before 2010	2010-2015	2015-2020	Beyond2020
Vision technology	• Connecting objects	• Networked objects	• Executable object/semi-intelligent objects	• Intelligent object
Use	• RFID adoption in logistics, retail and pharmaceutics.	• Increased interoperability	• Decentralised code execution • Global applications	• Unified network that connects people, things and services • Integrated industries
Devices	• Smaller and cheaper tags, sensors and active systems	• Increasing memory and sensing capacities	• Ultra high speed	• Cheaper materials • New physical effects
Energy	• Low power chipsets • Reduced energy consumption	• Improved energy management • Better batteries	• Renewable energy • Multiple sources	• Elements of energy harvesting

Intensified research

	Before 2010	2010-2015	2015-2020	Beyond 2020
Vision technology	• Low power and lows cost	• Ubiquitous integration of tags and sensor networks	• Code in tags and object	• Smart objects everywhere
Use	• Interoperability framework (protocols and frequencies)	• Distributed controls and database • Ad-hoc hybrid networks • Harsh Environments	• Global applications • Self-adaptive systems • Distributed memory and processing	• Heterogeneous systems
Devices	• Smart multi-band antennas • Smaller and cheaper tags • Higher frequency tags • Miniaturised and embedded readers	• Extended range of tags and readers and higher frequencies • Transmission speed • On-chip antennas • Integration with other materials	• Executable tags • Intelligent tags • Autonomous tags • Collaborative tags • New materials	• Biodegradable devices • Nano-power processing units
Energy	• Low power chip sets • Thin batteries • Power optimized systems (energy management)	• Energy harvesting (energy conversion, photovoltaic) • Printed batteries • Ultra low power chip sets	• Energy harvesting(biology, chemistry, induction) • Power generation in hash environments • Energy recycling	• Biodegradable batteries • Wireless power

6. Conclusion

- 這個章節主要的內容是在討論IoT的能源效率，以達到Green IoT。
- 由Real World, RFID World and New Enabling Technologies這張圖可以知道，IoT與RFID息息相關，我們舉出兩個RFID節省能源例子。
- 在IoT的環境下，目前已經提出相關設備減少能源消耗的方法，有些已被實作出來，運用在現實社會中。
- 由未來20年的技術發展趨勢概可知，如何降低能源消耗也是IOT的一個重要議題。

7. Reference

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5. “DHL and Blue Dart pilot intelligent delivery trucks in India Tuesday”, August 16th, 2011
6. A. Brintrup, D.C. Ranasinghe, S. Kwan, A. Parlikad, K. Owens, “Roadmap to Self-Serving Assets in Civil Aerospace” in *Proc. Of CIRP IPS2 Conference, Cranfield, UK, April 1st-2nd 2009,* pp. 323–331.

Homework #14:

1. Describe the vision of Internet of things.
2. Describe some technologies which support green internet of things.
3. List some examples for toward green internet of things.