Energy Efficient ICT Infrastructure for future Smart City Deployments

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Outline of the Presentation

- What is a Smart City?
- Role of the ICT in future smart cities.
- Growth of ICT services and energy consumption.
- ICT systems to improve energy efficiency.
- Future energy optimised ICT systems.
- Final Remarks.

What is a Smart City?

- Many definitions exists
- According to the BusinessDictionary.com:
  - A developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure.
- According to the IEEE (Institute of Electrical & Electronics Engineer) A **smart city** brings together technology, government and society to enable the following characteristics:
  - SMART (Economy, Mobility, Environment, People, Living and Governance)

Smart City Components

Source: www.linkdedin.com

Role of the ICT in a Smart City

- ICT offers the enabling technologies and framework to collect and process all necessary information to make key decisions
- Key components of a smart city infrastructure:
  - Smart Buildings
  - Smart Living
  - Smart Transportation
  - Smart Energy
  - Smart Communications
  - Smart Networks
  - A Self-Aware Digital Hub
  - Environmental Awareness (i.e. changing weather conditions; human defined changes)
- Above components of a sustainable city will require diversified ICT based systems to introduce the "**smartness**" factor

ICT Infrastructure for a Smart Building

- In cities 40% of energy is used by building infrastructure
- A smart building can be defined by following attributes:
  - Energy efficient
  - Fully secured
  - Self healing
- Energy efficiency example; building based on a microgrid:
  - A building can generate its own energy from distributed energy generators located within its own premise
  - Schedule appliance operations to maximise usage of onsite generated energy
  - Lighting and climate controls to maximise comfort and minimise cost
- Use of sensors & actuators, communication networks, building environment controller (data server)

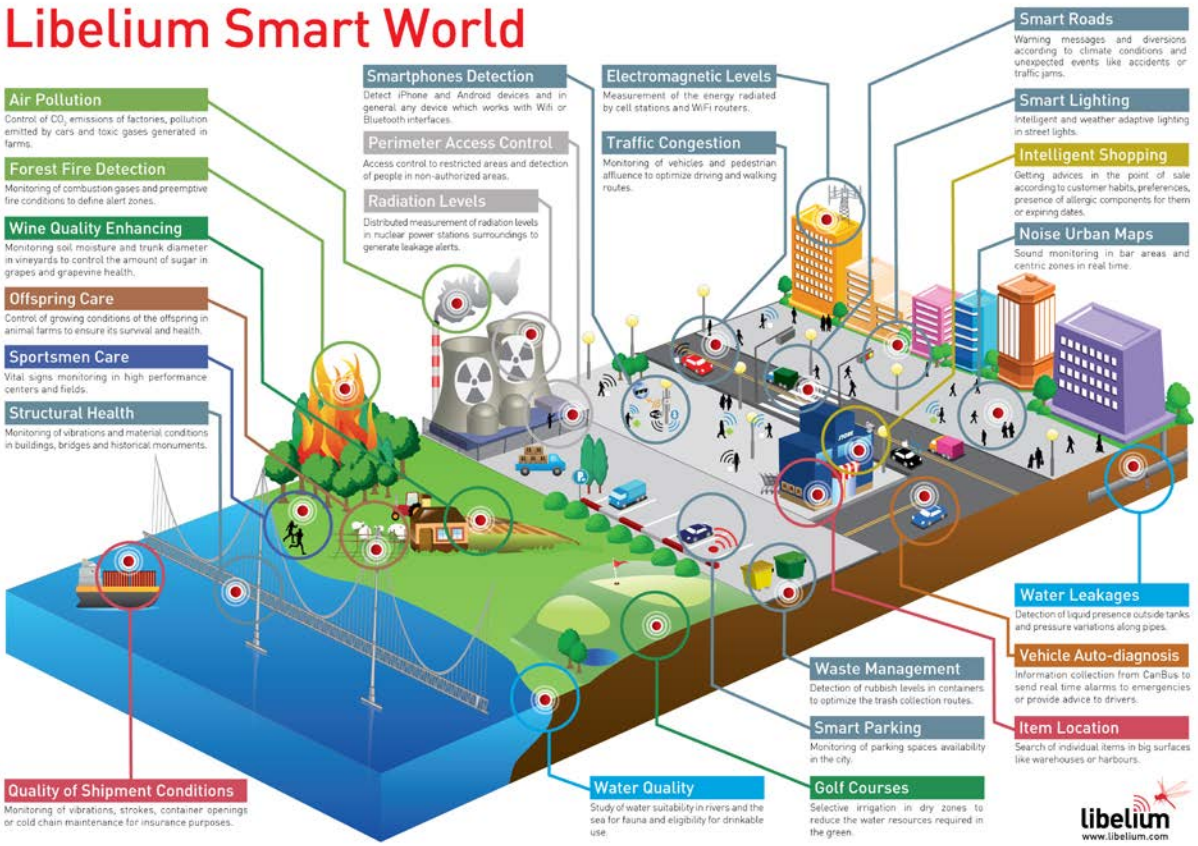
ICT for Future Intelligent Transport Systems

- New services are appearing in the road traffic management areas current systems are mainly used to support advanced localised signalling systems and traffic monitoring systems
- With the emergence of vehicular networks and autonomous cars the transport system will be evolve significantly toward more safer, efficient and low emission systems
- Vehicular networks (VANET) will allow cars to communicate with neighbouring cars to update each other to avoid collisions
- 80% traffic accidents happens due drivers unawareness
- Cars and other vehicles will be fitted with WiFi like communication transceivers through which information will be exchanged
- These vehicles can also communicate with road side units to gather additional information
- For example, school zone lights could transmit speed limit information which can be directly used by the engine controller to limit its speed

New ICT Paradigm for Future Systems: IoT

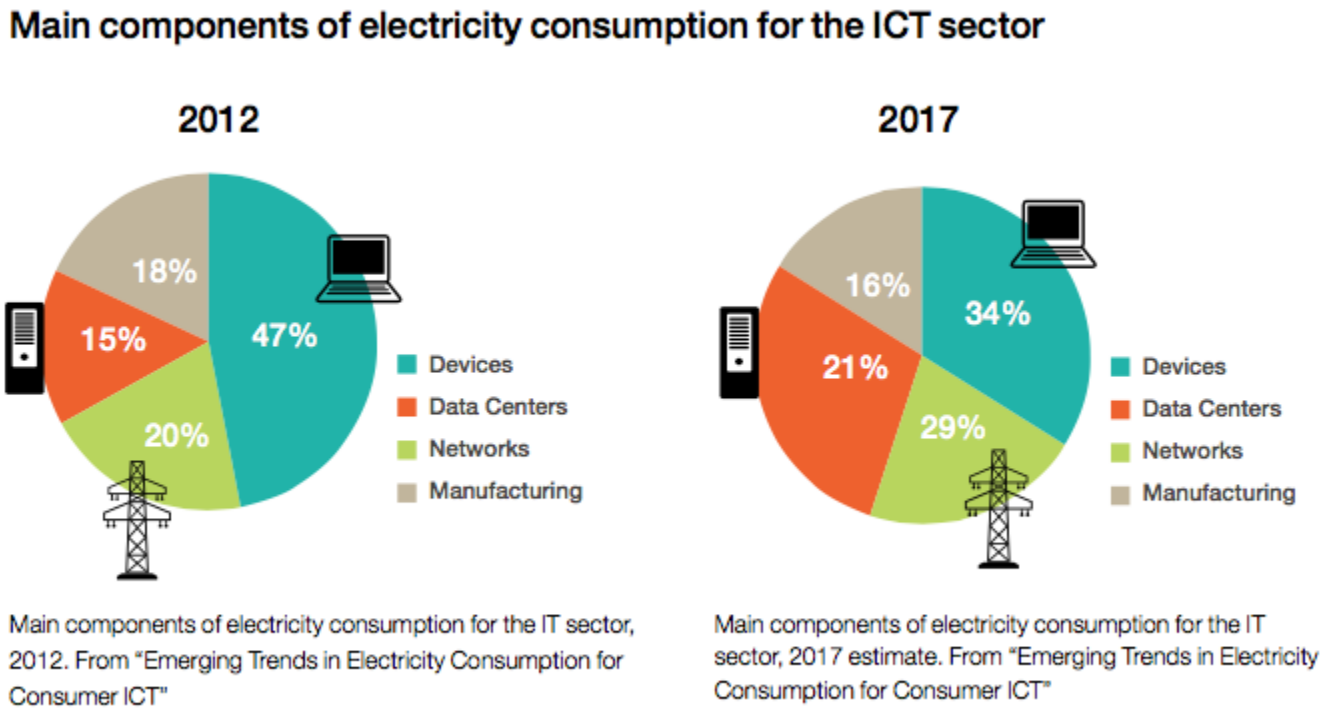
- Significant transformation is underway in the ICT sector
- New technologies are emerging under the umbrella of Internet of Things (IoT)
- In the IoT environment machine to machine communication will help us to develop most smart city applications
- In the IoT environment intelligent sensors, controllers and actuators will interact with each other in a seamless manner without any human intervention using the theme of *Sense, Share, Collaborate and Act*
- *How can we realise above intelligent systems?*
- Integration of smart sensors & actuators, wireless communications, distributed and cloud computing support could enable such systems
- What is the cost of widespread deployment of ICT systems?
- Among other costs Energy is a major deployment cost which affects the sustainability

Sensor Network Based Smart City



Source: www.libidium.com

Current ICT sector Energy Consumptions



Main components of electricity consumption for the IT sector, 2012. From "Emerging Trends in Electricity Consumption for Consumer ICT"

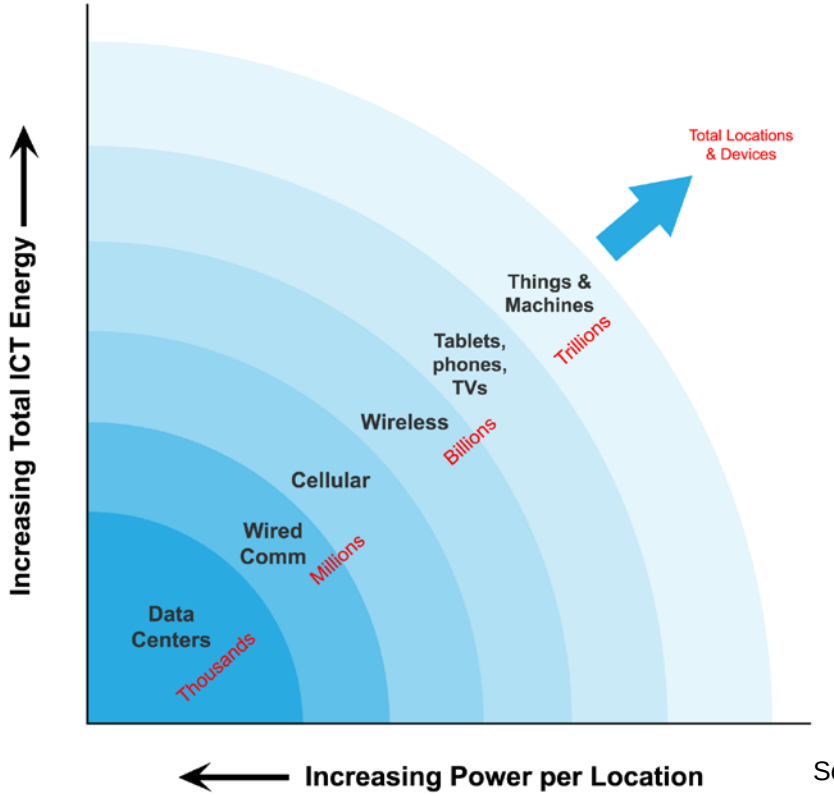
Main components of electricity consumption for the IT sector, 2017 estimate. From "Emerging Trends in Electricity Consumption for Consumer ICT"

Source: http://stc-sustainable-computing.ieee.net/

Energy Efficient ICT Infrastructure for Smart Cities

- Cost of computing and communications is measured in watts/bit or joules/bit
- To support smart city applications millions to billions of sensors and actuators need to be distributed over large geographical areas
- At the same time data needs to be collected from these devices and process in timely manners
- On top of powering the conventional computing and communications infrastructure millions to billions of additional sensors and actuators need to be powered
- How to power these devices?
- They can't be mains connected, replacement of batteries will be a nightmare for city civic authorities
- Solution is to develop green ICT infrastructure based on the Energy Scavenging

Energy Profile and Distributed Computing and Communications



Source: www.forbes.com

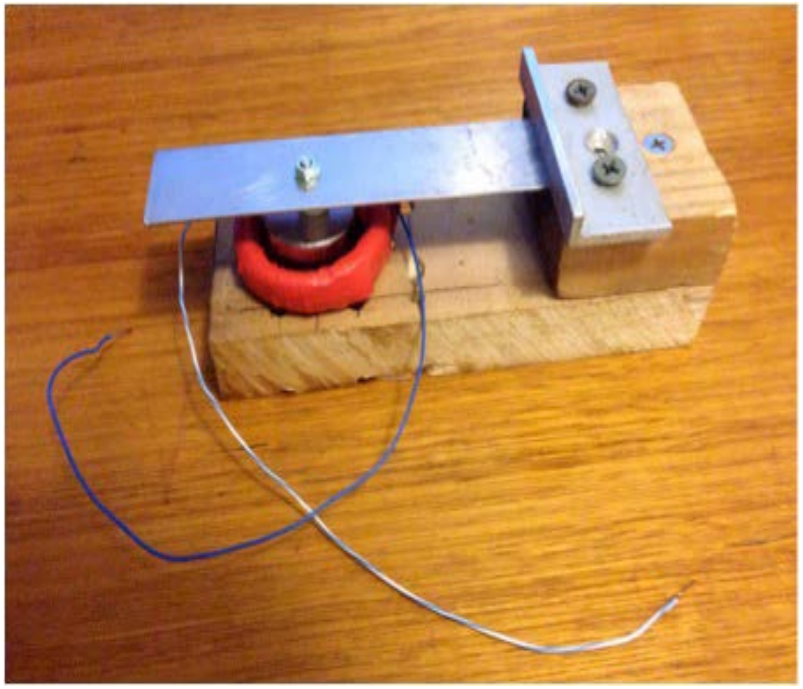
Energy Scavenging IoT Hardware

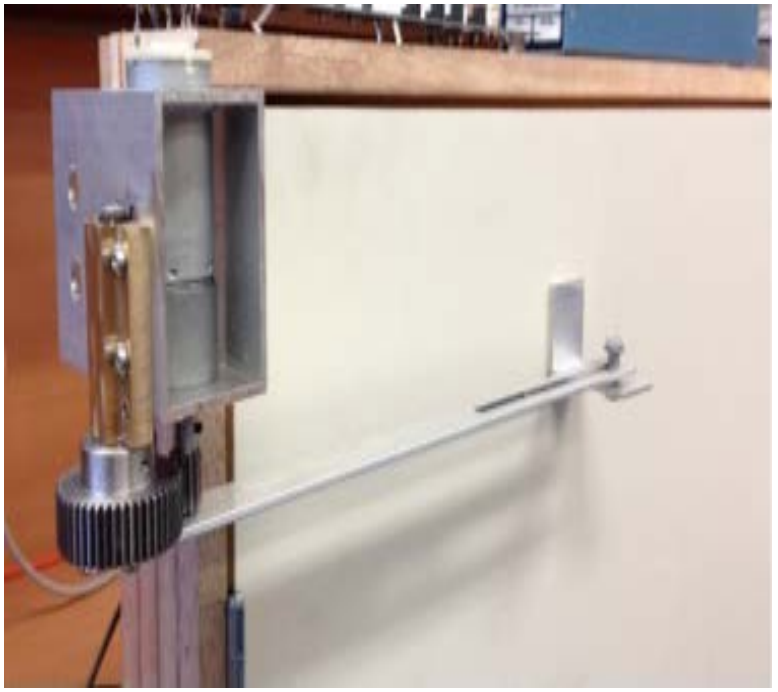
- Billions of distribute devices needs to find their own energy and operate for a longer period of time
- Renewable energy will be a good choice, city parking meters are already using
- Beyond conventional renewable energy sources other type of sources need to be looked at
- Development of battery less hardware will be very important for IoT applications
- New IC technology will also reduce operating energy requirements

Future Energy Efficient ICT

- Reduction of Joules/bit is one of the main objective for the computing environment
- Scavenging energy from its operating environments could be a vital move towards a sustainable ICT system
- Source of energy:
  - Conventional renewable sources: Solar, Wind, Ocean current, etc.
  - Heat sources
  - Water/liquid flows
  - Vibration/noise
  - Human and Vehicle movements
  - Radio Signals
- Distributed ICT devices should be able to scavenge energy from its operating environments to power own devices, also these systems must schedule its computing and communication tasks

Low Cost Energy Harvesters Designed in Network Laboratory





Final Remarks

- ICT systems are constantly evolving to support new services and applications
- ICT systems are becoming main stream civic infrastructure for future sustainable cities
- However there is an environmental cost due to massive deployment of ICT devices
- Significant R&D efforts are necessary to develop innovative ICT solutions for the future sustainable cities
- Significant OPEX and CAPEX cost savings could be achievable through the R&D work, which could also stimulate home grown new age industries
- Multi-disciplinary efforts are required to ICT systems for future sustainable cities

Thank you

DISCUSSION

A presentation to Future Smart Cities 2015
2 October 2015