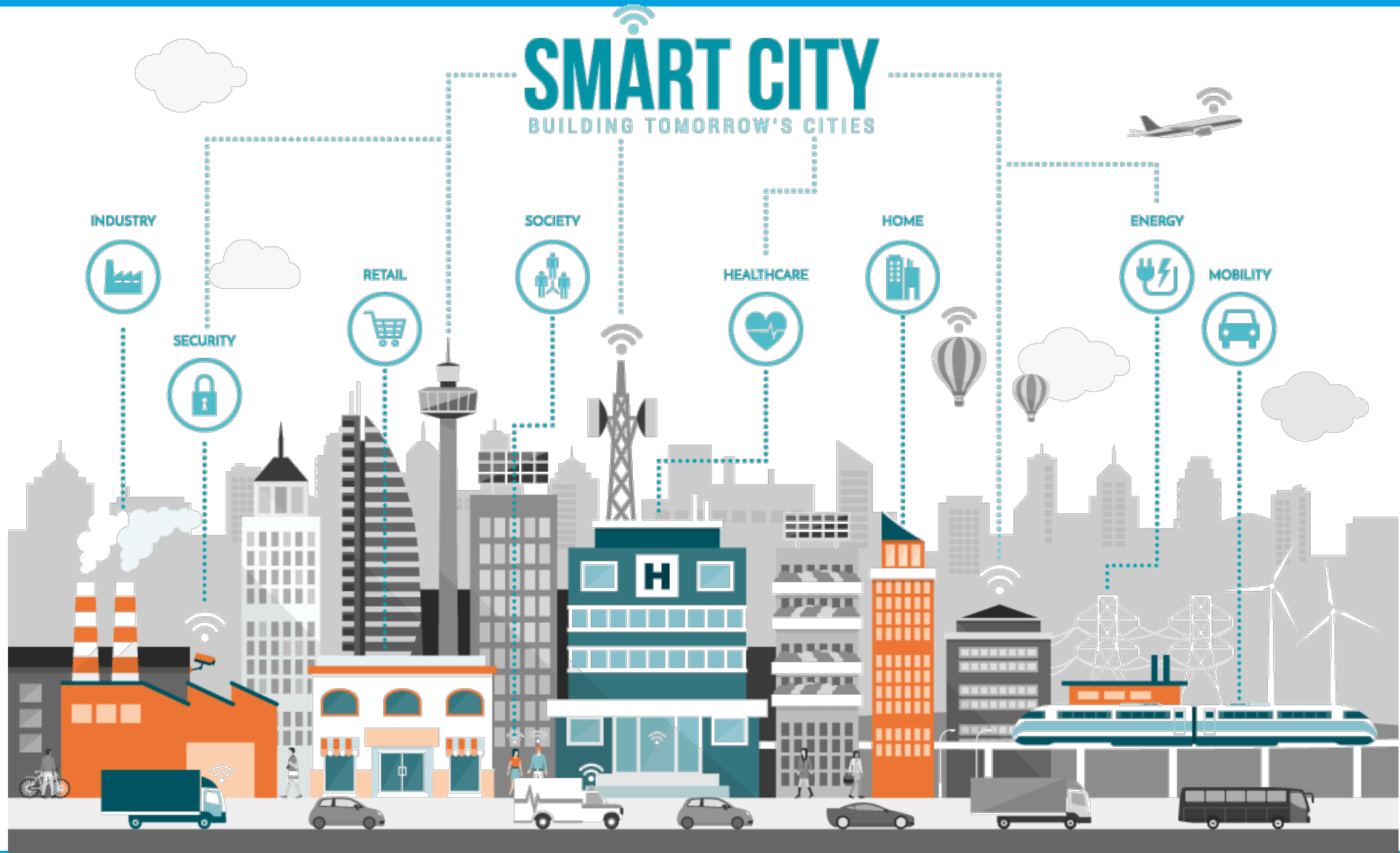# Crowdsourced Systems: A people-led paradigm

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ITU Webinars
Digital transformation for cities and communities
2 November 2021

# Technological Enablers

- **Internet of Things**     will sense

- **The Edge**     will react

- **Artificial Intelligence**     will think

- **Blockchain**     will remember

# ITU Definitions

**Smart City Platform** ([ITU-T Y.4472 (08/2020)](#)): A city platform that **offers direct integration** of city platforms and **systems**, or through open interfaces between city platforms and third parties, in order **to offer urban operation and services** supporting the functioning of city services, as well as **efficiency, performance, security and scalability**.

**Internet of Things** ([ITU-T Y.4000/Y.2060 (06/2012)](#)): A global infrastructure for the information society, **enabling advanced services by interconnecting (physical and virtual) things** based on existing and evolving interoperable information and communication technologies.

**Wireless Sensor Network** ([ITU-T X.1313 (10/2012)](#)): A network that consists of a base station and **a large number of sensor nodes with wireless transmission capability** in the sensor networking domain of the USN.

**Sensor network node** ([ITU-T X.1313 (10/2012)](#)): **A device that contains at least one sensor** and zero or more actuators, with the capability of 1) using internal sensor data to control any actuators present, or 2) **sending sensor data** and receiving actuator commands **over the network**.

# Smart Personal Devices

## How Many Sensors are in a Smartphone?

- Light
- Proximity
- 2 cameras
- 3 microphones
- Touch
- Position
  - GPS
  - WiFi (fingerprint)
  - Cellular (tri-lateration)
  - NFC, Bluetooth (beacons)
- Accelerometer
- Magnetometer
- Gyroscope
- Pressure
- Temperature
- Humidity

- **Truly portable and personal** devices have been introduced (smartphones, tablets, smart wearables, etc.)

- People are now connected **anytime-anywhere**

- **Paradigm shift** in interpersonal relations and the interaction with our immediate environment

# Mobile Crowdsensing Systems

**Crowdsourcing sensing infrastructure**
- Instead of deploying fixed infrastructure, we crowdsource it!
- Scalable and financially viable way of covering large areas



Analysis

Gamification, Money

Sensor Database

Sensor Data
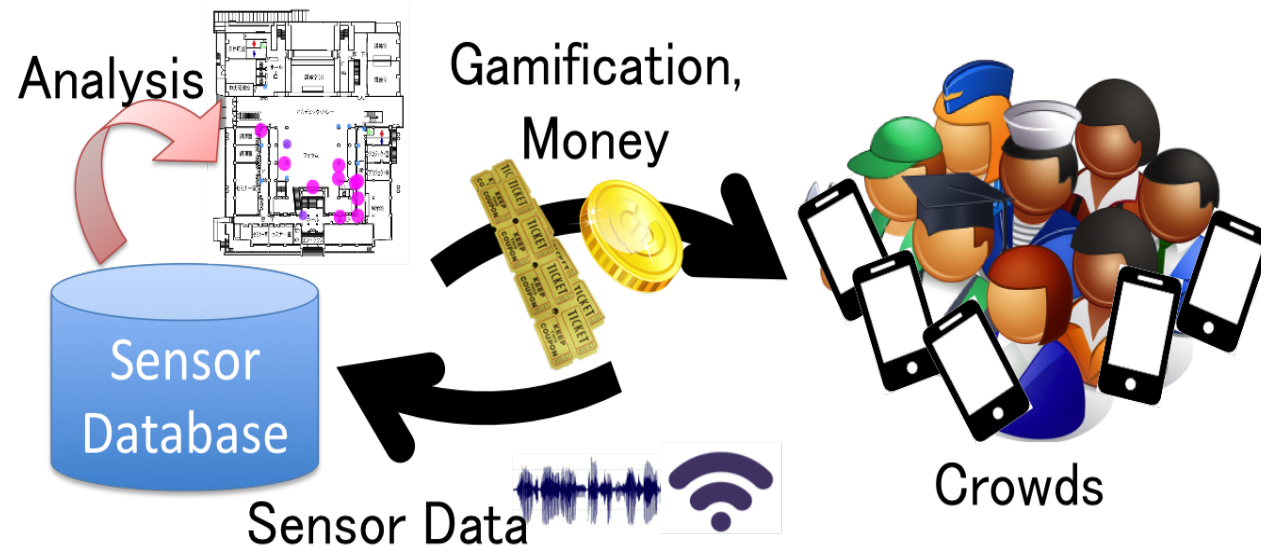
Crowds

Shimosaka Research Group

**Differences from other sensory systems (e.g. WSN)**
- Significant computational capabilities
- Significant communication capabilities – agile architectures
- System Dynamics
- The human factor!

# Wisdom of the Crowd

Collective intelligence can outperform individual experts, *under some conditions.*

**Underlying Mechanism**
Individual contributions can be seen as sampling points of a probability distribution with the true answer as its mean value (statistical sampling)



- James Surowiecki, **"The Wisdom of Crowds"**, Doubleday, 2004

# Wise Crowds Characteristics

Statistical sampling interpretation provides hints towards a wise crowd (e.g. homogeneous coverage of sampling space, stochastic independence of trials, etc.)

**Characteristics of a Wise Crowd**

- Diverse Crowd

- Independent individuals

- Decentralization – Local Knowledge

- Aggregation => Collective Decision

If these conditions are not met, there is a high risk of crowd failure

- Individuals conform rather than think and the crowd is transformed into a mob

- James Surowiecki, **"The Wisdom of Crowds"**, Doubleday, 2004

# Examples of crowd wisdom

The concept of Crowdsourcing is not new:

- Several judicial systems provision **juries**

- In 1906, 800 people estimated the weight of an ox; error <1%   (Francis Galton)

**More recently:**

- **Wikipedia**

- **Tripadvisor**

- **Lego** – new designs are proposed and evaluated by people; *creator receives a 1% royalty on the net revenue*.

- **Kickstarter** - Crowdfunding

# Requirements for ICT Systems

Requirements drawn in analogy to Wise Crowds

- **Diverse Crowd =>** Not specialized H/W; Not application specific; Support of heterogeneous/diverse set of services

- **Independent individuals =>** ephemeral connections; no central nodes; no dependencies provisioned (e.g. gateways)

- **Decentralization =>** P2P, ad-hoc networks – no central orchestration either in networking or in application developing

- **Aggregation =>** Collective decision making (e.g. population protocols?)

# Recommendation ITU-T Y.4205 (02/19)

**Requirements and Functional Architecture of IoT-related Crowdsourced Systems**

*This Recommendation provides **definitions for crowdsourced and crowdsensing systems**. It also outlines the **requirements and general characteristics** of IoT-related crowdsourced systems for the support of IoT applications and services. It **identifies the risks and challenges** that a crowdsourced system should take into consideration, its **reference model** as well as considerations regarding security, privacy and trust.*

## Definitions

**Crowdsourcing:** The practice of obtaining needed services, ideas, content or other system resources by soliciting contributions from a **large**, **open** and **potentially undefined group of people** [..].

**Crowdsensing:** The practice of employing crowdsourcing in **collecting sensory data**.

**Crowdsourced System:** Systems that employ crowdsourcing in order **to augment their constituent infrastructure** and the **set of provided services** or **collected information**.

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# Y.4205: Reference Architecture



Y.4205(19)_F01
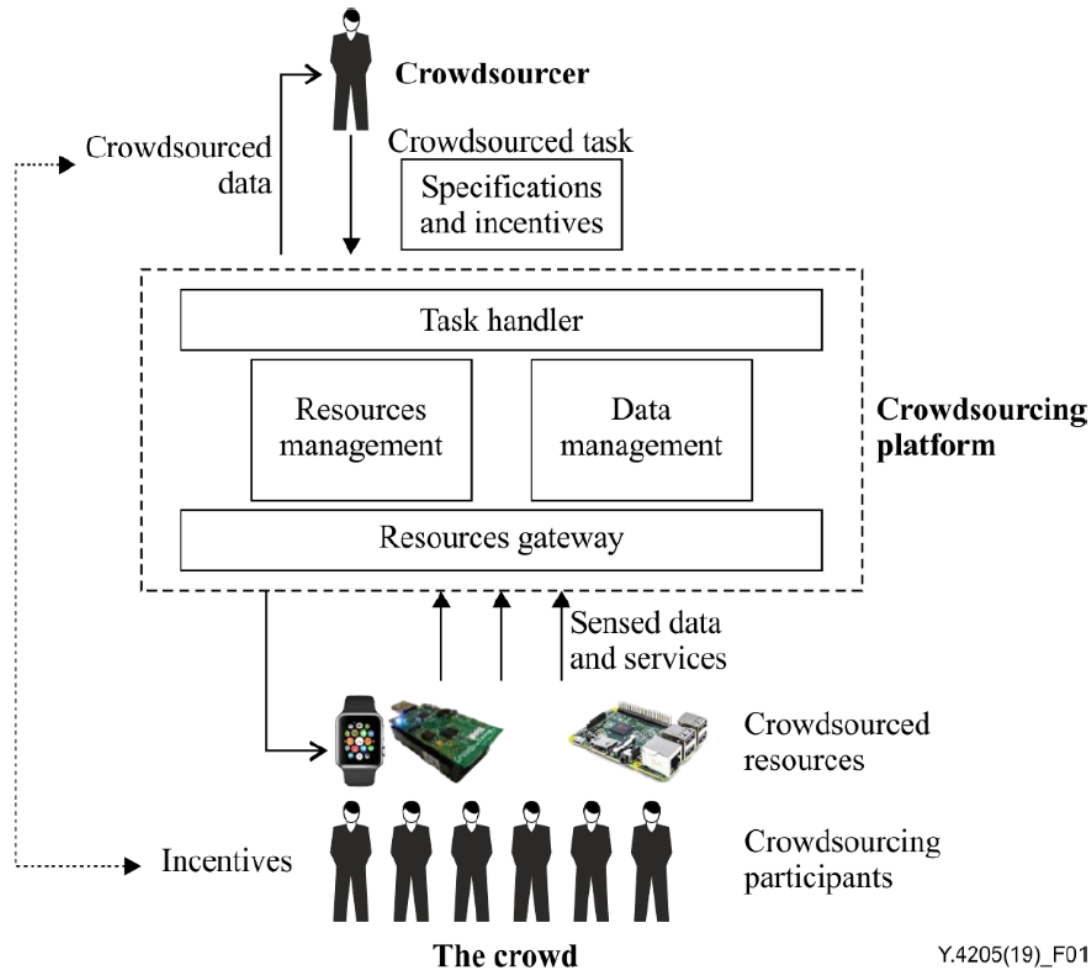
**Crowdsourcer:** Seeks to exploit the resources of the Crowd (e.g. sensor data, collective intelligence, computational power of devices, etc)

**The Crowd:** Open and undefined group of people contributing resources to the system (e.g. via smartphones, Raspberry Pi's, etc)

**Incentives:** Can be **extrinsic** (e.g. monetary or service based) and/or **intrinsic** (e.g. social ones and entertainment)

**Task Handler** and **Resources Gateway:** north and southbound abstraction layers.

**Crowdsourced Resources:** Can be smartphones, smart wearable or DIY computer platforms (e.g. Raspberry Pi's, Arduinos)

# Y.4205: Requirements of IoT-related crowdsourced systems

- **Openness**
  - Crowd Accessibility
  - Hardware and Software Design
  - Data
- **Affordability** and **availability** of components
- **Anonymity** of crowdsources
- **Aggregation** mechanisms
- **Abstraction** mechanisms
- **Incentive** mechanisms
  - Intrinsic
  - Extrinsic
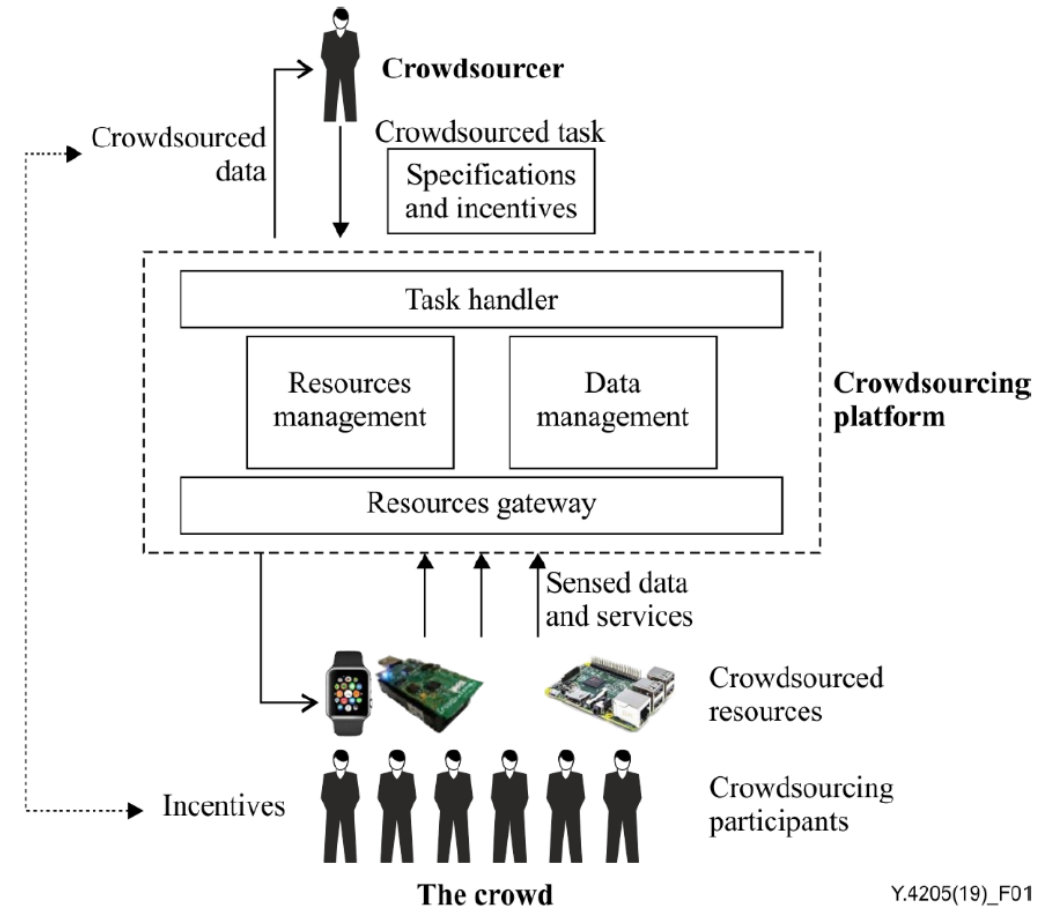
# Example of a Crowdsourced System

## Safecast   (http://blog.safecast.org/)



- Enables citizens to build their own DIY radiation monitoring sensor kits by employing open source and open data methodologies
- Developed after the devastating earthquake and tsunami which struck eastern Japan in 2011, and the subsequent meltdown of the Fukushima Daiichi Nuclear Power Plant
- Crowd monitors, collects, and openly shares information on environmental radiation and other pollutants



- Data is aggregated and visualised in radiation maps

# Follow up Work Items

ITU-T Y.CS-framework "**Service requirements and capability framework for IoT-related crowdsourced systems**" (SG20/Q2)

"[..] service requirements of IoT-related crowdsourced systems, in addition to the requirements of IoT-related crowdsourced system [ITU-T Y.4205] and the common requirements of IoT [ITU-T Y.4100]. Based on these requirements, capability framework of IoT-related crowdsourced systems is developed."

ITU-T YSTR.P2P-CC "**Current state of P2P crowd charging platforms and corresponding market needs**" (SG20/Q5)

"[..] a review and an analysis of the current state of P2P crowd charging systems in terms of currently available technological solutions, ongoing research, and recent and ongoing standardisation activities in this area. The aim of the analysis will be to identify existing gaps and market needs in the area of P2P crowd charging systems."

# Feel free to contact.

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