Mobile Crowdsensing enabled IoT frameworks: harnessing the power and wisdom of the crowd

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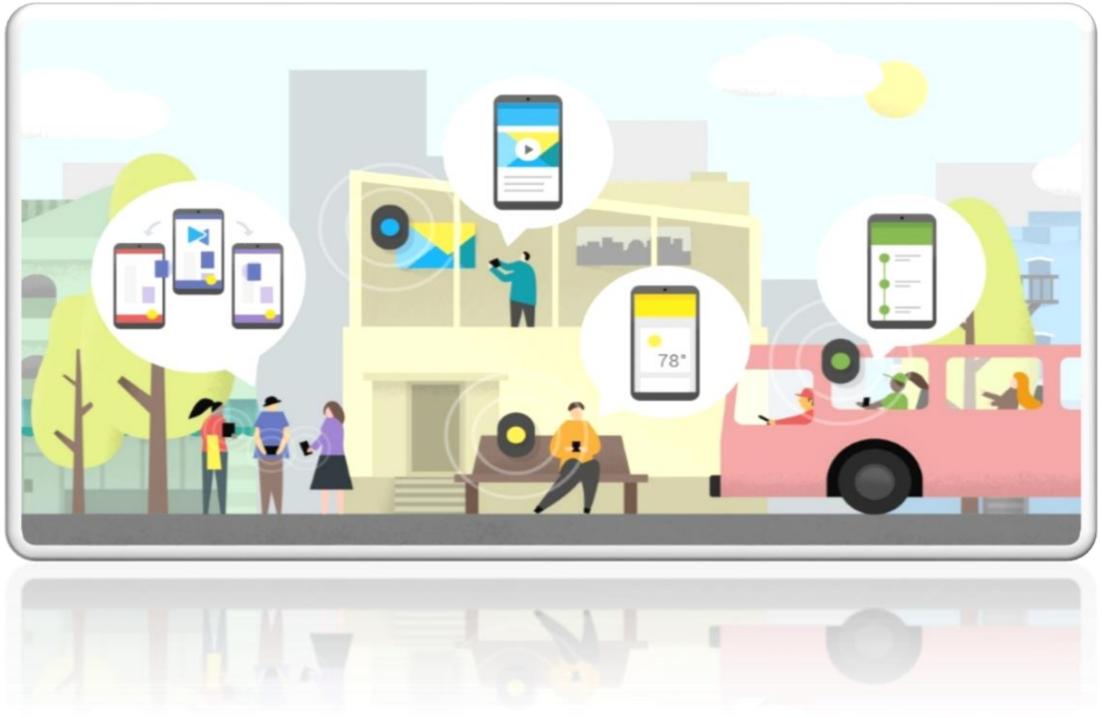
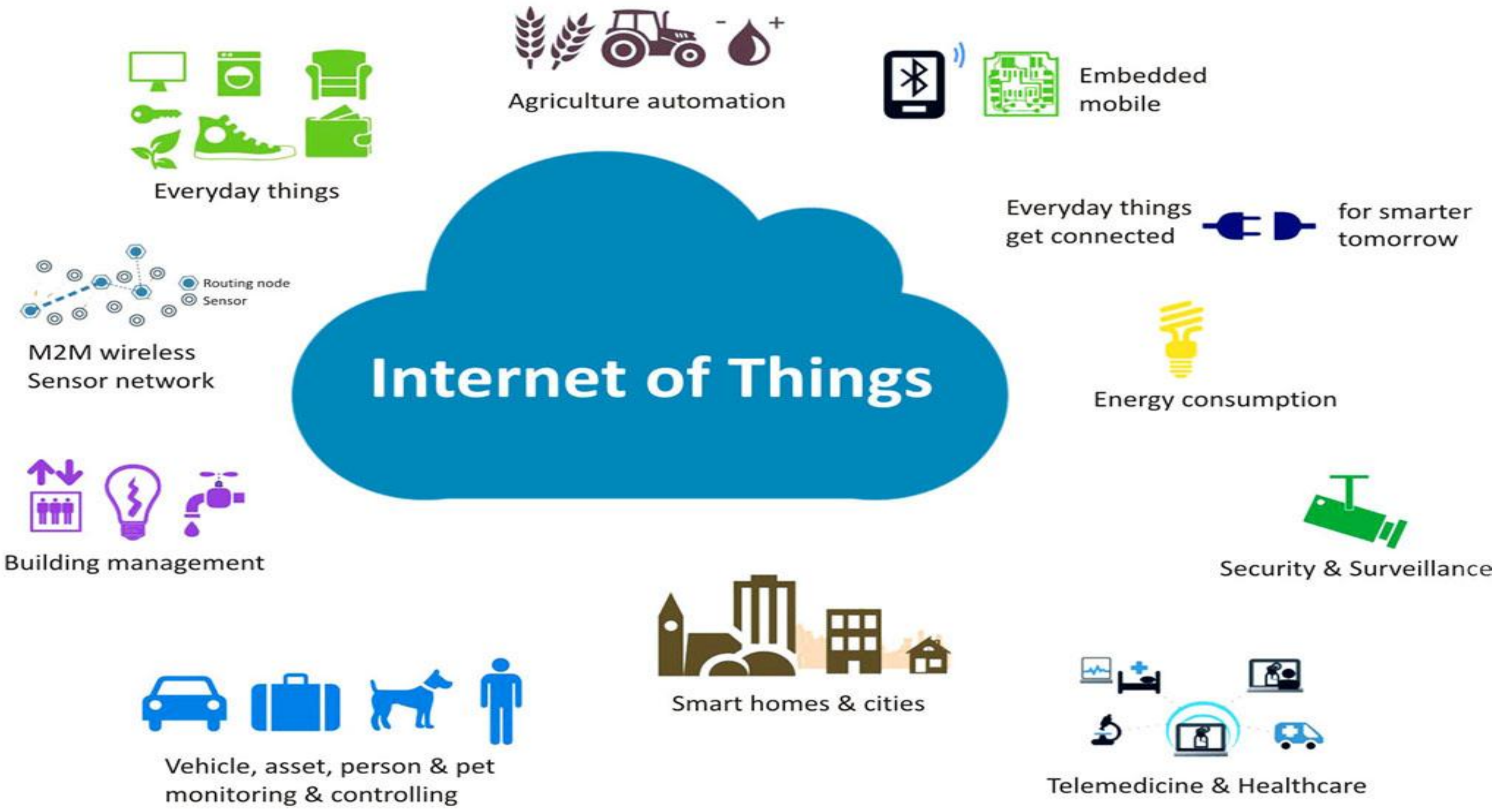


INTERNET OF THINGS

- The **Internet of things** (IoT) is an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment.
- The **IoT** can also be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things, by providing unique identity to each and every object.

IoT APPLICATIONS

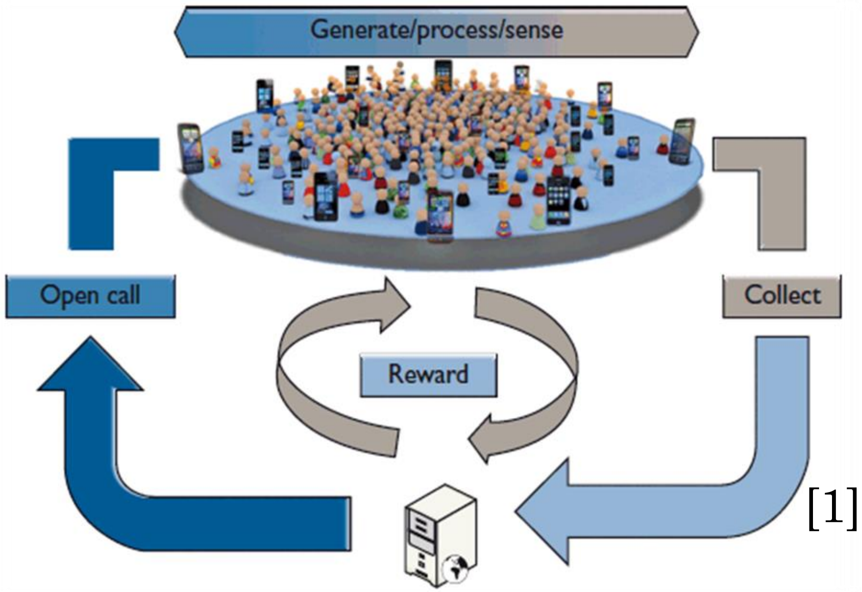


IoT and MCS

- **Mobile crowdsensing** (MCS) creates a new way of perceiving the world to extend the service of **IoT** and explore a new generation of intelligent networks, interconnecting things-things, things-people and people-people.

- ***MCS*** leverages on the power and wisdom of the crowd jointly with the sensing capabilities of various mobile devices, exploiting human intelligence, ubiquity and mobility features.

- **MCS** empowers the crowd to contribute data sensed from their mobile devices, enabling efficient monitoring of large-scale phenomena for the common benefit of the crowd.



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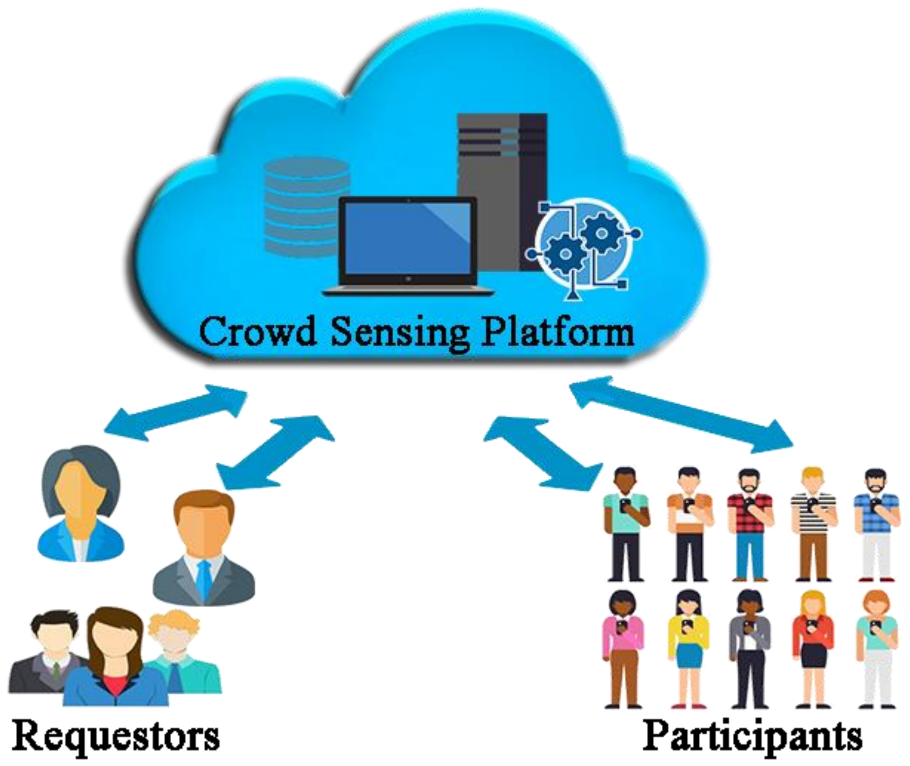
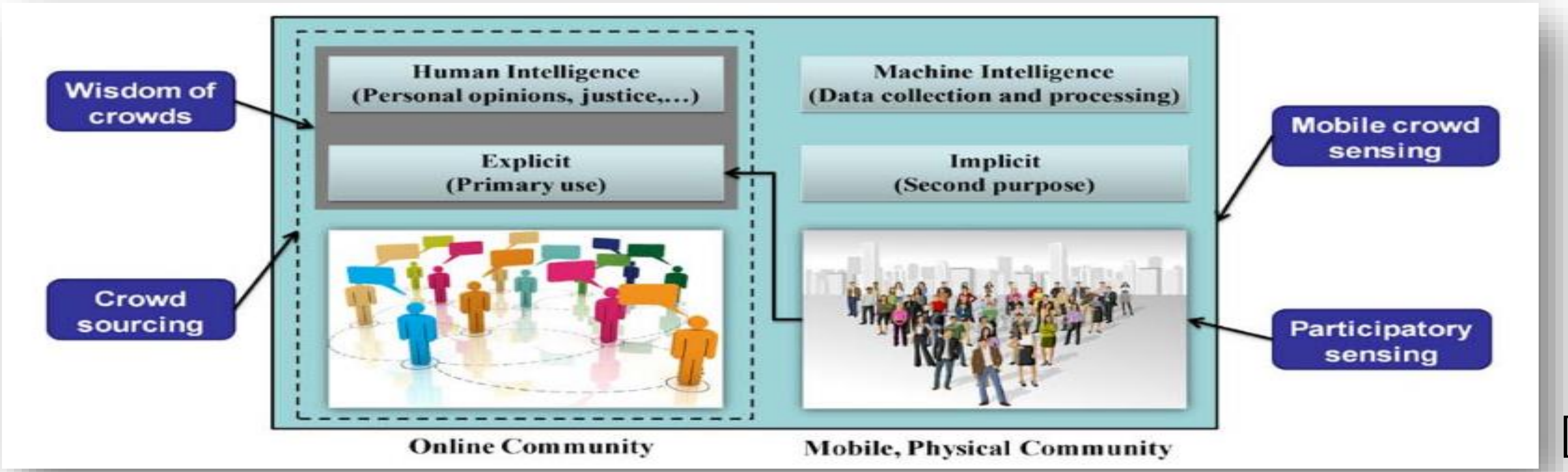
MCS ARCHITECTURAL DESIGN

- The general architectural design of an MCS system comprises the following main entities:
  - **Requestors**, initiate targeted data collection process by publishing a task pertinent to their interests to the crowdsensing platform and exploit the collected data from the Workers.
  - **Workers** are assigned several tasks pertinent to data collection, thus are the main source of information and play a major role in data collection
  - **Crowdsensing Platform** is the main communication link between Requestors and Workers. The platform stores, processes and analyzes data provided by Workers and the Requestors.



MCS CHARACTERISTICS

- Humans are involved in the loop for data collection, processing, analysis and sharing, that will ultimately lead to a combination of human and machine intelligence. The optimization of this mixture is considered as a significant design issue for MCS.
- Concerning data collection, MCS involves both implicit and explicit user participation with *opportunistic sensing* to *participatory sensing*.
- Data are collected both from the physical world as well as from online communities.
- Data from different communities present different characteristics, often being complementary. Thus, the data is exchanged across online and offline communities.



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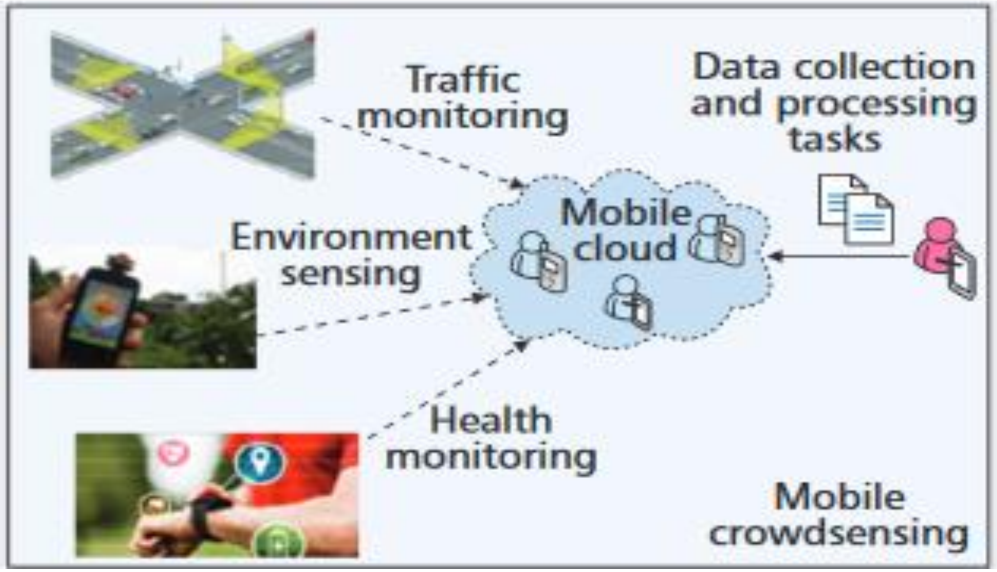
MCS APPLICATIONS

- MCS has recently attracted the attention of researchers with designed applications ranging from:
  - ✓ environmental monitoring,
  - ✓ smart cities,
  - ✓ public safety,
  - ✓ healthcare,
  - ✓ traffic planning,
  - ✓ smart parking.



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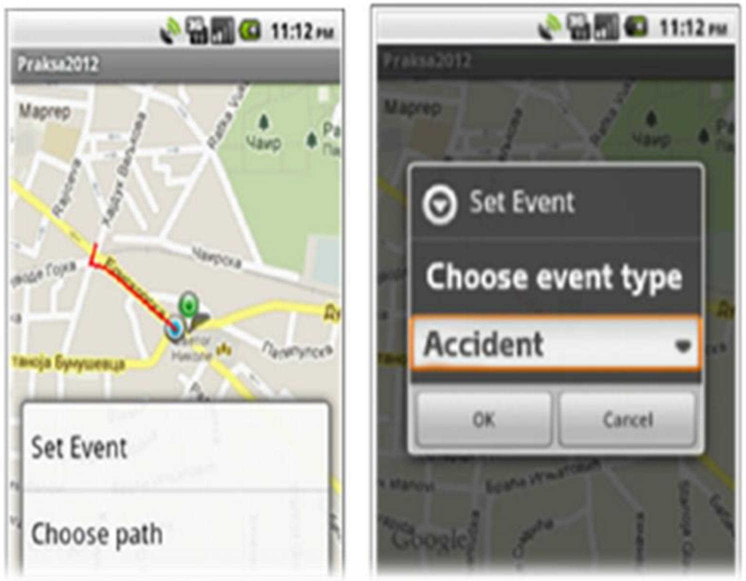
MCS APPLICATIONS

- Traffic prediction is achieved by estimating the amount of vehicles located within the same road segment and their average speed but also with the active participation of users, who are able to contribute data and notify the other drivers about car accidents, traffic jams, road structure changes, road hazards and many other phenomena.



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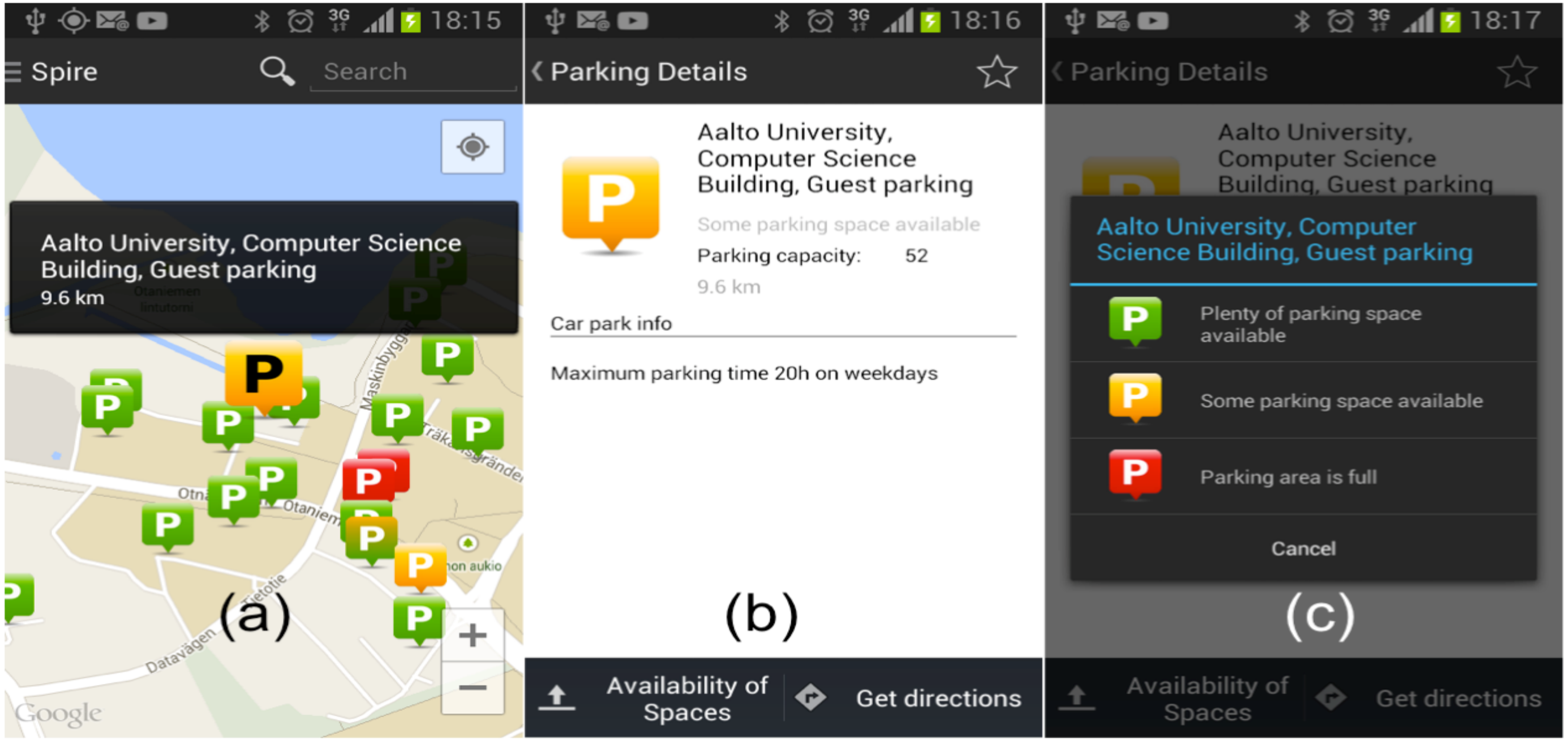
MCS APPLICATIONS

- Smart Parking takes advantage of IoT and mobile devices to find car parks based on the availability, distance and context and require the users to perform observation on the parking availability on top of their location.



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MCS APPLICATIONS

- It allows blind users to call for help, and a crowd of sighted people will respond (whoever is available) and tell the blind user what he or she sees through the rear-facing camera.

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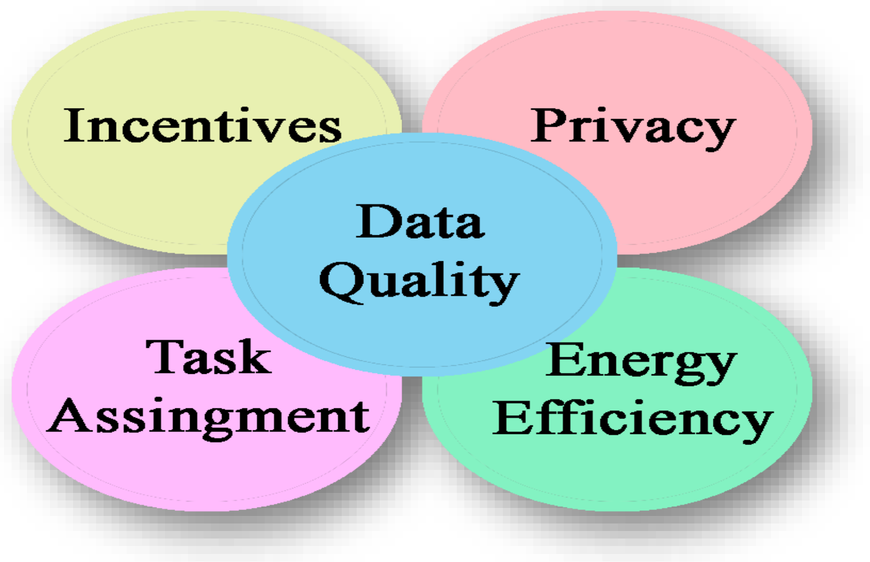
MCS CHALLENGES

- Task Assignment
- Energy Efficiency
- Data Quality
- Privacy – Security
- Incentives



CHALLENGE 1: TASK ASSIGNMENT

1. The set of mobile devices, their sensing, computation, storage and communication capabilities can vary significantly due to the device mobility, variations in their energy levels, the conditions of the communication channels as well as to owners' preferences.

2. Selecting the right set of participants to execute the required tasks and scheduling sensing tasks across multiple devices with diverse sensing capabilities and resource availabilities / limitations, while guaranteeing maximum coverage and high sensing quality is a quite complex and challenging issue to address.

CHALLENGE 2: ENERGY-EFFICIENCY

- Given the limited resources on the mobile devices, the data collection needs to be performed in a highly energy efficient manner.
- Thus, improving on the data quality level, while minimizing the consumption of resources necessitated is another challenging issue to solve.
- Local processing of the collected data on mobile devices, prior to their aggregation and processing at the backend in order to reach a form suitable for consumption by applications, may also be a solution to devices' resource limitations, as produced intermediate results necessitate lesser energy and bandwidth for their transmission.

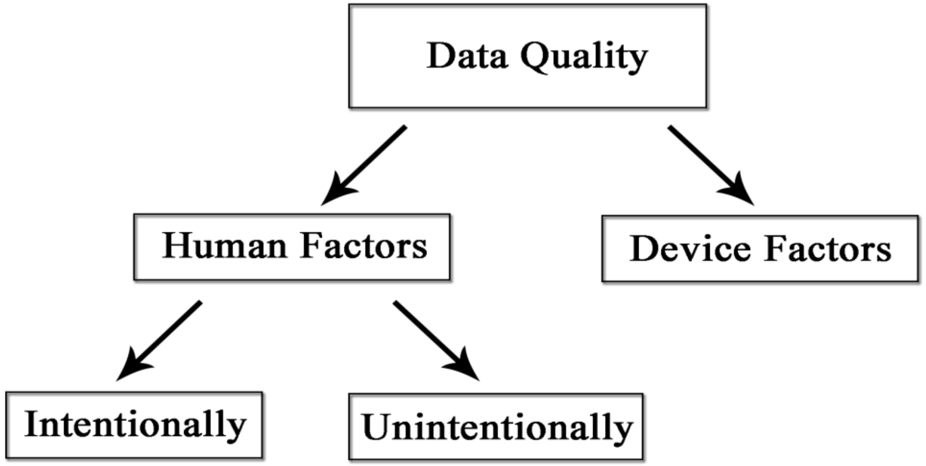
CHALLENGE 3: DATA QUALITY

- MCS applications could suffer from inaccurate data provisioning due to their inherent open nature. MCS architecture should rake into account and efficiently address the case of potentially inaccurate / erroneous data.

- Inaccurate information provisioning may take place:
  - Unintentionally: There are participants who contribute poor quality data (noisy and obsolete data, faults, low quality of the wireless link, low resource levels of the mobile device, limited capabilities of the sensors, less qualified Workers, environmental uncertainties and outdated data).
  - Intentionally: There are participants who provide on purpose low quality, erroneous and falsified information in purpose so as to minimize their own cost in terms of effort put and resources consumed and maximize their reward specified for task execution.

CHALLENGE 3: DATA QUALITY

- Device Factors: Because mobile devices typically have different sensing and processing capabilities, the quality of the data that each device will contribute differs.



CHALLENGE 4: PRIVACY-SECURITY

- Sensed data, tagged with spatio-temporal information, could be exploited in order to infer users' daily routines and habits.
- Thus, it is imperative to preserve the privacy of the individuals. A generic privacy / security framework should be in place independently of the MCS application considered or the nature of the data shared.

CHALLENGE 5: INCENTIVES

- Users are involved in the loop for data collection, processing, analysis and sharing.
- To do so, users may incur energy and computational related resource consumption, monetary cost or are required to spend their time and put explicit effort in order to complete successfully their mission.
- Appropriate incentive mechanisms need to be in place so as to promote users cooperation and motivate users to submit data of high quality.
- User incentives may be broadly categorized in the following three categories:
  - financial incentives,
  - interest and entertainment,
  - social and ethical reasons.

MCS architectural frameworks

Each system / application is based on quite different assumptions, while the architectural framework considered varies significantly in many aspects such as:

a) pull vs. push model for task assignment
b) centralized vs. distributed model adopted for data collection,
c) design of the sensing campaign, task specification and the overall task assignment process,
d) data pre-processing on mobile devices and its related implications,
e) incentive mechanism design for encouraging and retaining user participation in MCS tasks,
f) addressing inconsistent / inaccurate data provisioning, considering the highly dynamic MCS environment in the presence of selfish and malicious users,
g) user privacy,
h) energy efficiency in different sub-problems,
i) types of data collected and integrated, and
j) MCS application collaboration.

MCS architectural frameworks

The MCS architecture should be:

- ✓ general,
- ✓ flexible,
- ✓ robust,
- ✓ scalable,
- ✓ secure (from both the end-user’s and the system’s side),
- ✓ energy efficient,
- ✓ incentive-aware
- ✓ context-aware and self-adaptive with advanced cognitive capabilities,

and should also:

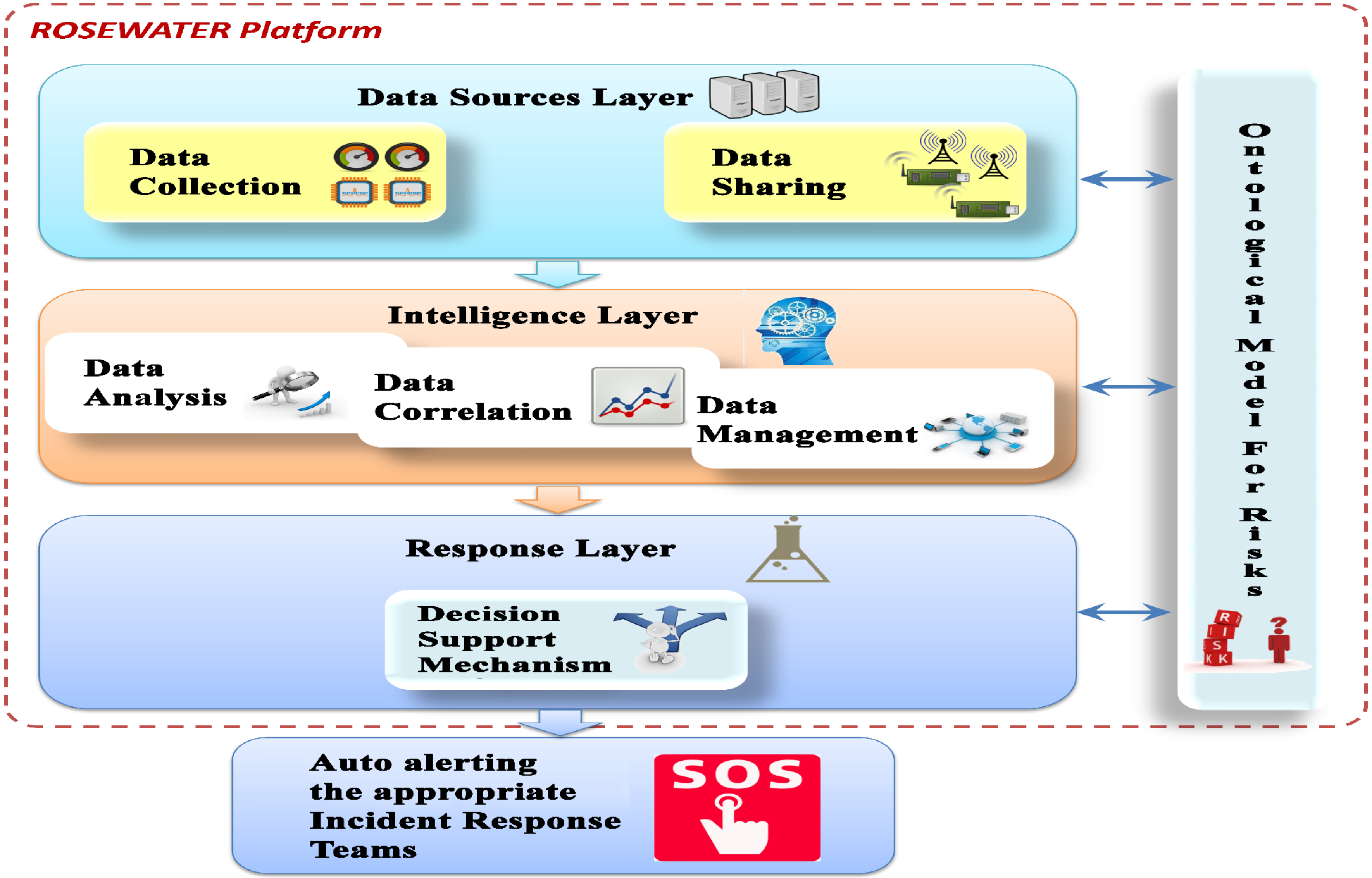
- ✓ defer the heterogeneity of hardware and software platforms,
- ✓ enable the collaboration of different MCS applications,
- ✓ allow the easy development and deployment of MCS applications in a generic way and
- ✓ allow for code re-usage.

Each problem / challenge should take into account potential inter-dependencies of MCS key features.

ROSEWATER PLATFORM

A platfoRm fOr SEcuring WATer critical infrastructure in the IoT ERa

- ROSEWATER will design, implement and test a federated platform that will set all these features together as a complete service that:
  - Allows efficient monitoring and data collection (logs and events) concerning water infrastructure and associated elements from different system sources
  - Performs data analysis and processing in order to detect and prioritize risks
  - Identifies potential cascading events
  - Recommends appropriate response actions
  - Produces various security alerts


ROSEWATER Platform
Data Sources Layer
Data Collection
Data Sharing
Intelligence Layer
Data Analysis
Data Correlation
Data Management
Response Layer
Decision Support Mechanism
Ontological Model For Risks
Auto alerting the appropriate Incident Response Teams
SOS


THANK YOU

References

- [1]. Bin Guo, Zhiwen Yu, Daqing Zhang, Xingshe Zhou, “From Participatory Sensing to Mobile Crowd Sensing”, in Proc. of the 12th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshop), pp.593-598, Budapest, Hungary, 2014.

- [2]. Georgios Chatzimiloudis, Andreas Konstantinidis, Christos Laoudias, Demetrios Zeinalipour-Yazti, “Crowdsourcing with Smartphones”, IEEE Internet Computing, vol.16, issue.5, pp-36-44, 2012

- [3]. J. Ren, Y. Zhang, K. Zhang, X. Shen, “Exploiting mobile crowdsourcing for pervasive cloud services: challenges and solutions”, IEEE Communications Magazine, vol. 53, issue. 3, pp. 98-105, 2015.

- [4]. https://www.bemyeyes.com

- [5]. D. Stojanovic, B. Predic, N. Stojanovic, “Mobile crowd sensing for smart urban mobility”, European Handbook of Crowdsourced Geographic Information, vol. 371, 2016.

- [6]. M. Rinne, S. Törmä, D. Kratinov, “Mobile crowdsensing of parking space using geofencing and activity recognition”, in 10th ITS European Congress, pp. 16-19, Helsinki, Finland, 2014.