

IoT-based Systems of Systems

We present:

- Common characteristics between IoT and SoS
- The concept of Emergent Configurations (ECs)
- IoT based System of Systems as a System of Emergent Configurations (SoECs)

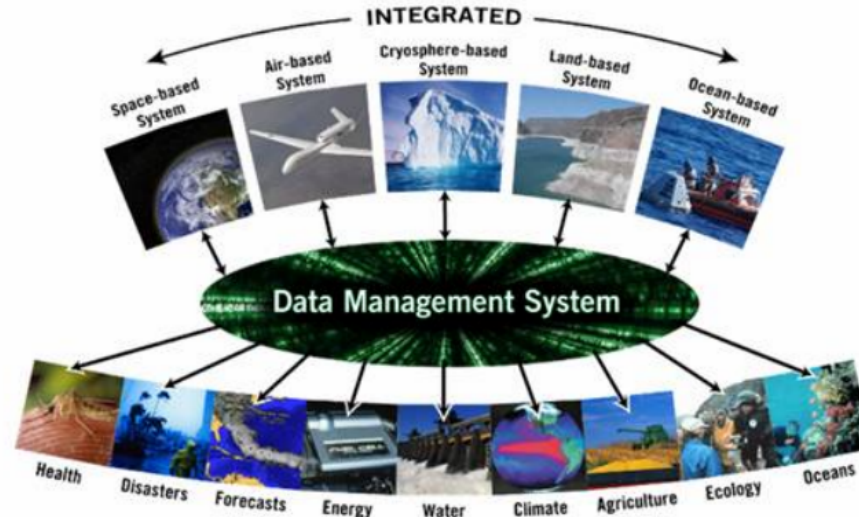
The Internet of Things (IoT)

- IoT enables heterogeneous and distributed smart objects to connect, communicate and collaborate to achieve common goals
- The number of objects connected to the Internet is exponentially increasing (life aspects?)



System of Systems (SoS)

The concept System of Systems (SoS) involves the dynamic collaboration of distributed and heterogeneous systems to achieve common goals



Global earth observation SoS

IoT as a System of IoT-based Systems

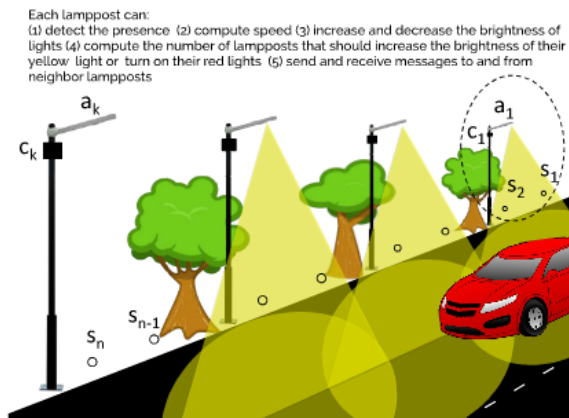
- IoT and SoS share some major characteristics:
 - Like SoS, IoT components are heterogeneous, autonomous, able to communicate, often distributed, operational and managerial independent
 - Both domains are evolving and operate in dynamic situations leading to emergent behaviours

Emergent Configurations (ECs)

- In the context of IoT, we refer to the term Emergent Configurations (ECs) of Connected Systems as “a set of **things** with their functionalities and services that **connect** and **cooperate temporarily** to achieve a **goal**”
- Within SoS, the emergent behaviour concept has been defined as “the **behaviours** that arise as a result of the synergistic **collaboration** of **constituents**”

The Smart Street Light Case

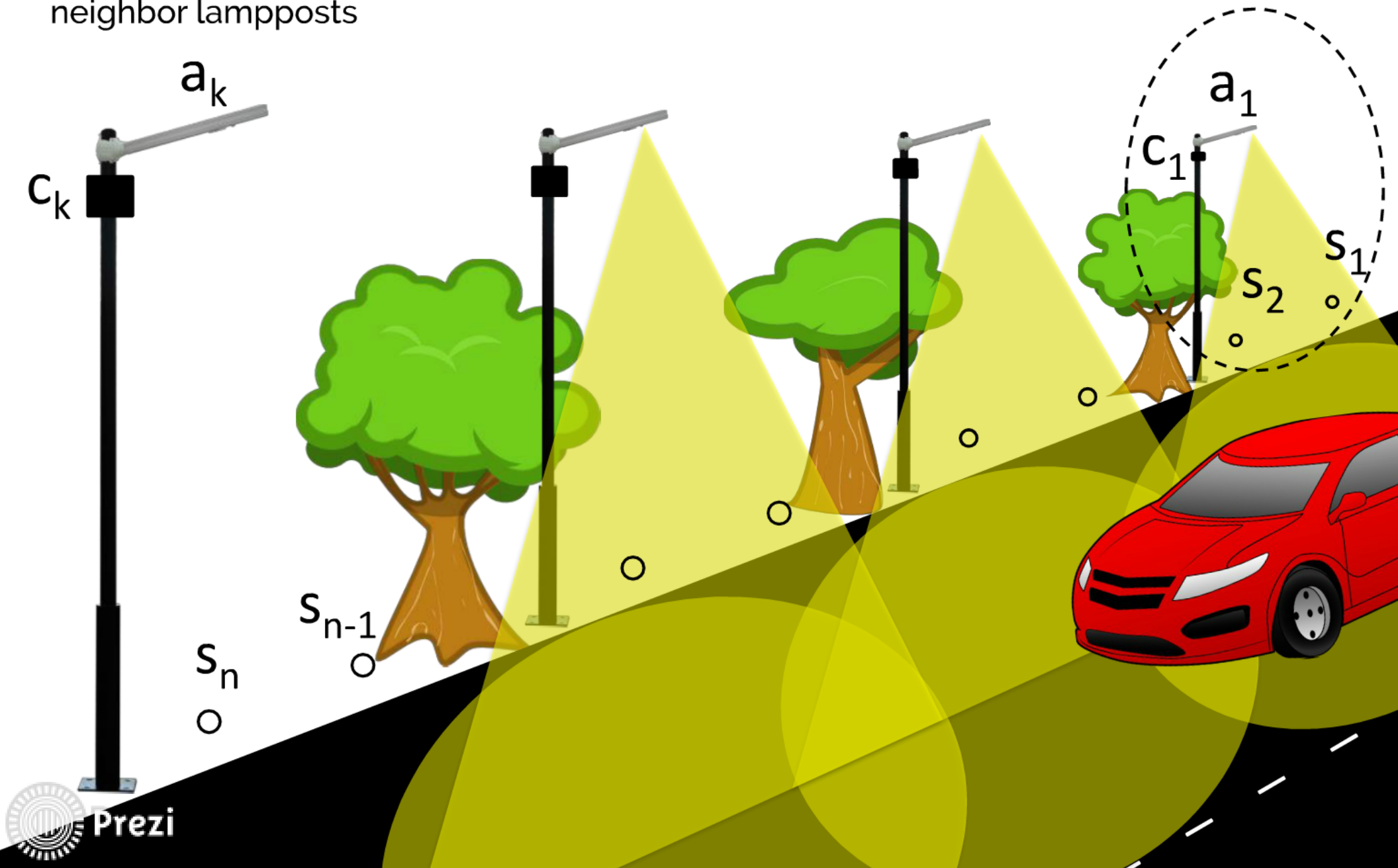
Goal: Saving energy and increasing traffic safety by having your own sphere of light



The Smart Street Lights case is a validated running prototype of the ECOS project

Each lamppost can:

(1) detect the presence (2) compute speed (3) increase and decrease the brightness of lights (4) compute the number of lampposts that should increase the brightness of their yellow light or turn on their red lights (5) send and receive messages to and from neighbor lampposts

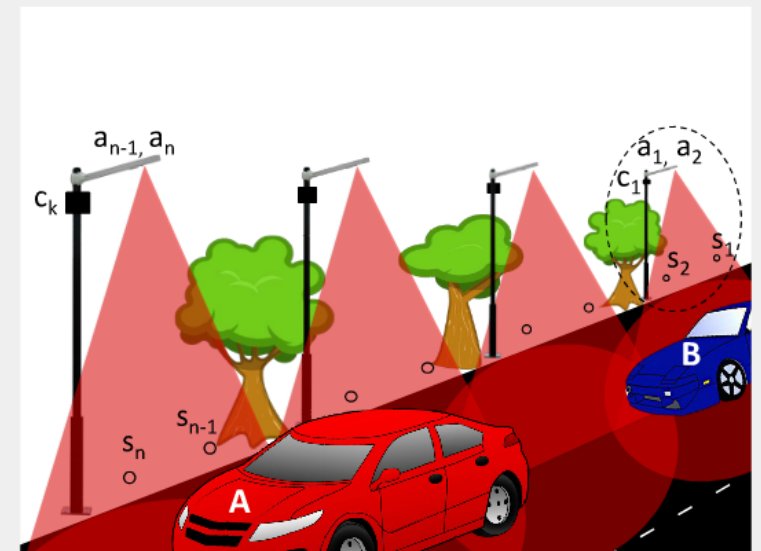


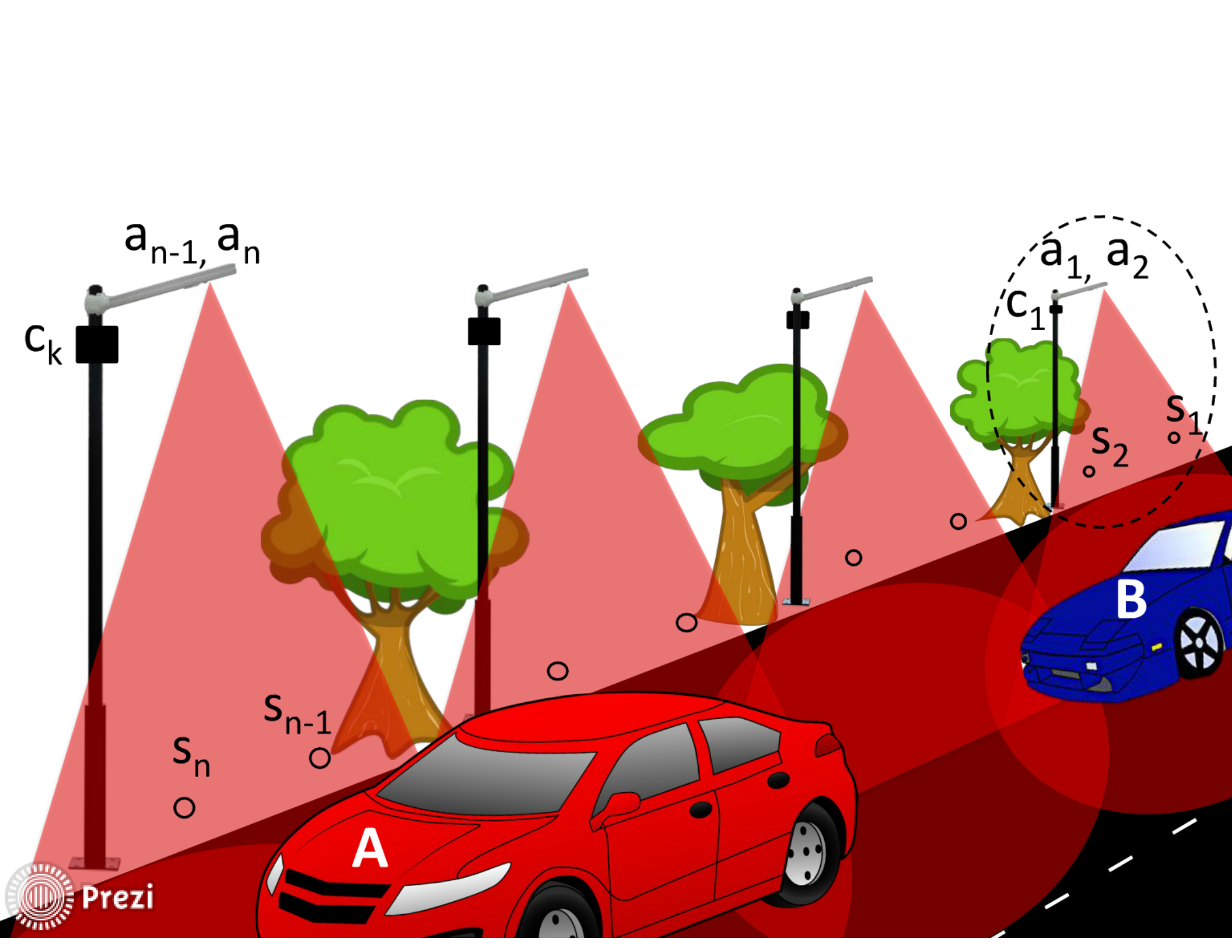
The Smart Street Light Case

- *Emergent Configuration*: a set of lampposts that temporarily connect and cooperate to form the sphere of light accompanying a road user
- The infrastructures are grouped into areas, each having an *Area Reference Unit* (ARU) providing storage capacity and powerful computation capabilities.

The Smart Street Light Case

Emergent property: when a car traveling over the speed limit is approaching another road user, the latter gets a heads-up through the red lights





The Smart Street Light Case

"Proposed Scenario"

- Lampposts collaborate with ARUs to detect accidents through the GPS technology
- An ARU reports an accident to the relevant Health Management System including the location and number of cars involved
- The driver of car A suffers from serious heart disorders, so she/he puts on wearable health monitoring sensors regularly.
- These sensors report her/his medical status to the HMS
- The HMS specifies the number of ambulances needed and redirect the closest ones. Meanwhile, a specialist in the operations room analyzes the data being received from the driver's health monitoring sensors.

Conclusion

- IoT and SoS share common and major characteristics
- IoT-based SoS can be seen as a System of Emergent Configurations (SoECs)

Future Work: - Investigate and contribute to engineering of SoS
- Research the mixture of IoT and SoS technologies in the future

- Future Work:* - Investigate and contribute to engineering of SoS
- Research the mixture of IoT and SoS technologies in the future

**ECOS: Emergent
Configurations of Connected Systems
(an IoTaP project)**



<http://iotap.mah.se/ecos/>

THANK YOU
FOR YOUR
ATTENTION



References

- G. Morabito L. Atzori (Eds.) D. Giusto, A. Iera. The Internet of Things. Springer, 2010.
- Federico Ciccozzi and Romina Spalazzese. Mde4iot: Supporting the iot with mde. In 10th International Symposium on Intelligent Distributed Computing.
- J. Fitzgerald J. Woodcock C. Nielsen and, P. Larsen and J. Peleska. Systems of Systems Engineering: Basic Concepts, Model-Based Techniques, and Research Directions.
- Md. Amin ; M. Bhuiyan ; M. Ibne Reaz ; S.Nasir. Gps and map matching based vehicle accident detection system. Research and Development (SCORED), 2013 IEEE Student Conference on, 2013.

