The Socio-Technical Superorganism Vision

Franco Zambonelli
Dipartimento di Scienze e Metodi dell'Ingegneria
Universita di Modena e Reggio Emilia
franco.zambonelli@unimore.it

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Abstract
We sketch the future vision of socio-technical superorganisms and overview two emerging application area heading towards the vision. Following, we identify the key challenges in engineering self-organizing ICT systems that can work as a superorganism.

ACM Classification Keywords
D.2.2 [Software Engineering]: Design Tools and Techniques; F.1.1 [Computation by Abstract Devices]: Models of Computation

The Superorganism and Its Applications
In the near future, a very large number of inter-connected agents, whether human or ICT ones, can be potentially exploited to create what – in biology – has been usually defined a superorganism [1, 3]. That is, a large ensemble of individual organisms capable of behaving in a collectively orchestrated way to serve the good of the ensemble itself. In particular, closing the sensing, computing, and actuating capabilities in a loop, and making such activities collaborative ones, it is possible to realize coherent collective behaviours, as it is observed in many natural situations, e.g., in ant colonies.

Among many capabilities that future superorganisms will exhibit, the first that we expect to be in place, and for which we already observe embryonic examples around, will relate to urban mobility [2]. Specifically, it will relate to the capability of sensing, predicting, and affecting (i.e., steering) the movements of vehicles or pedestrians, thus improving overall efficiency of urban mobility, but also making it possible for every citizen to dynamically satisfy at the best its mobility needs. A variety of sensors already exist to detect the conditions of traffic or crowd in urban environments. In addition, users are increasingly given the possibility to contribute to such sensing activities by posting information on social networks or by opening access to their navigators and smart phone sensors. All this information can be used to understand how to improve traffic flow or how to avoid congestions. To this end: actuators such as traffic lights and digital traffic signs can be put at work for vehicles; public (wall mounted) displays and private (smart phone) displays can be exploited to suggest directions to pedestrians. However, one could push the capabilities of superorganisms much beyond. For instance, one can think at dynamically matching the similarity of the planned routes of vehicles, pedestrians, and merchandises to be delivered, in order to dynamically self-organize very flexible ride sharing and shipment services.

As an additional example of the capabilities of future socio-technical superorganisms relates to wearables devices. We can imagine that in the near future we will wear dozen of computer-based devices to monitor our physical and physiological conditions in a continuous way. For people with disabilities, we can also imagine a variety of actuators capable of supplying physical actions and help them towards a "normal living". All these devices will have to carefully interact and coordinate with each other to serve global level goals for the person they are assisting.

Challenges

The vision of socio-technical superorganisms raises a number of challenges that can hardly be dealt by present networking and middleware architectures. In particular: *(i)* An infrastructure for future superorganisms should be able to support a general model for representing different classes of services and their specific features, as well as a general model to invoke them and properly collect their results; *(ii)* A general model for superorganisms and the supporting infrastructure should support dynamic discovery of individual components and dynamic reconfiguration; *(iii)* There is need of development methodologies in which the bottom-up and self-adaptive endeavor of nature-inspired self-organizing systems can become part of a more traditional top-down approach to software engineering.

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